Addendum 1
July 11, 2018

615504 - BRIDGE ELECTRICAL SYSTEM

Description:

The work under this Section shall consist of furnishing all labor, materials, plant and equipment, and performing all work necessary to furnish and install electrical equipment and controls for operation of the bascule span and its auxiliaries, all as specified herein and indicated on the Contract Drawings.

Any incidental apparatus, appliance, material, or labor not specifically mentioned or included in the Contract Documents that may be found necessary to comply with the requirements of the related documents and referenced standards or codes shall be furnished by the Contractor at no additional cost to the Delaware Department of Transportation (DelDOT).

Standards

All electrical equipment and its installation shall conform to the requirements of the latest revision of the following codes and standards, except as may be otherwise provided herein:

1. American Association of State Highway and Transportation Officials (AASHTO)
2. National Electrical Code (NEC)
3. American Society for Testing and Materials (ASTM)
4. American National Standards Institute (ANSI)
5. National Electrical Manufacturers Association (NEMA)
6. National Electrical Contractors Association (NECA)
7. InterNational Electrical Testing Association (NETA)
8. Underwriters Laboratories, Inc. (UL)
9. National Fire Protection Association (NFPA)
10. Institute of Electrical and Electronic Engineers (IEEE)
11. Occupational Safety and Health Administration (OSHA).
12. Insulated Power cable Engineers Association (IPCEA).

BR 3-153, Rehoboth Avenue Bridge

E1. Control Cabinets

The work under control cabinets shall include the following:

1. Furnish and install new components on a new back panel(s) as specified and shown on the plans and mount in the existing enclosures.
2. Furnish and install a new enclosure to house the PLC (Programable Logic Controller) and associated equipment and install in the Switchboard Room as specified and as shown on the plans.
3. Program and make adjustments to the PLC system as specified herein and submit ladder logic for review and approval.
4. Furnish spare parts as specified herein and deliver to DelDOT.
5. Develop shop drawings related to the new back panel and new cabinet including component cut sheets and submit for review and approval.

E2 Control Desk

The work under control desk shall include the following:

1. Develop shop drawings including component cut sheets related to the new control desk and submit for review and approval.
2. Furnish and install new control desk in the Control Room as specified and shown on the plans.
3. Furnish spare parts as specified and deliver to DelDOT.
4. Coordination of the PLC system with the TMC network.

E3 Flux Vector Drive

The work under flux vector drive shall include the following:

1. Develop shop drawings including component cut sheets related to the new drive system and submit for review and approval.
2. Furnish and install new flux vector drive and associated accessories on a new back panel(s) and mount in the existing enclosure as specified and shown on the plans.
3. Program and make adjustments to the drive system as specified herein and submit key programing parameters.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E4 Automatic Transfer Switch

The work under automatic transfer switch shall include the following:

1. Develop shop drawings including component cut sheets related to the ATS system and submit for review and approval.
2. Furnish and install new Automatic Transfer Switch (ATS) and associated equipment in a new enclosure in the Generator Room as specified and shown on the plans.
3. Furnish spare parts as specified herein and deliver to DelDOT.

E5 Limit Switches

The work under limit switches shall include the following:

1. Furnish and install the following limit switches and sensors as specified and shown on the plans: resolver, fully closed, over travel, speed switch, span manual operation, span locks interlocking, span lock manual operation.
2. Adjust all limit switches with the settings as shown on the plans. Readjustment will be required for proper operation during final testing.
3. Furnish spare parts as specified herein and deliver to DelDOT.
4. Develop shop drawings including component cut sheets and mounting details related to the limit switches and submit for review and approval.

E6 Motors

The work under motors shall include the following:

1. Develop shop drawings including component cut sheets related to the motors and submit for review and approval.
2. Furnish span motor and span lock motors as specified.
3. Perform motor shop testing as specified for all motors supplied.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E7 Motor Brakes and Machinery Brakes

The work under brakes shall include the following:

1. Develop shop drawings including component cut sheets related to the brakes and submit for review and approval.
2. Furnish two new motor brakes to replace the existing units as shown on the plans.
3. Furnish and install new brake released, brake hand released, and brake set limit switches as specified and connect as shown on the plans.
4. Furnish spare parts as specified and deliver to DelDOT.

E8 Modifications to Warning and Barrier Gates

The work under modifications to warning and barrier gates shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the warning and barrier gate modifications and submit for review and approval.
2. Reconnect existing and new equipment for the gates as shown and indicated on the plans.
3. Replace all existing wiring within the gate housing with single conductor No. 12 AWG.
4. Furnish and install flashers for each barrier and warning gate as specified inside the housing of each gate and connect as shown on the plans.
5. Furnish and install new flexible cables for gate arm lights to accommodate 2 flashing circuits and one steady circuit plus a ground conductor.
6. Reconnect existing warning and barrier gate motor for 480VAC, 3 phase operating voltage.
7. Furnish and install new door switches as specified and connect as shown on the plans.
8. Furnish and install disconnect switch as specified and connect as shown on the plans.
9. Connect existing heater and receptacle circuits to the new panelboards.
10. Furnish spare parts as specified herein and deliver to DelDOT.

E9 Motor Disconnect Switches

The work under motor disconnect switches shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the motor disconnect switches and submit for review and approval.
2. Furnish and install motor disconnect switches in sight of each motor as specified and connect as shown on the plans.
3. Furnish spare parts as specified herein and deliver to DelDOT.

E10 Electrical Cable, Wire and Connections

The work under electrical cable, wire and connections shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the electrical wire and cable and submit for review and approval.
2. Furnish and install new wiring inside conduit, wireways and other raceways as specified and shown on the plans.
3. Furnish and install ground systems and conductors as specified and shown on the plans.
4. Furnish and install new flexible droop cables as specified and shown on the plans.
5. Install security system wiring furnished by others in coordination with DelDOT's contractor for security and camera systems (only where installed in common raceways).
6. Coordinate with DelDOT's security contractor on their installation of wiring where not installed in common raceways.
7. Test, tag and connect each conductor at termination points inside control enclosures, the control desk, and termination boxes.

E11 Electrical Conduit, Fittings and Boxes

The work under electrical conduit, fittings and boxes shall include the following:

1. Furnish and install new conduit, wireways, troughs, boxes, vaults, junction wells and fittings as specified and shown on the plans. Remove and dispose of existing conduit, wire, junction wells, etc as shown on the plans.
2. Furnish and install new conduit and box supports as specified and shown on the plans.
3. Clean the interior of each section of new and existing conduit prior to installation of wire.
4. Core drill through walls and floors to accommodate new conduit and associated equipment.
5. Patch existing holes and openings after removal of existing conduit and raceways systems.
6. Saw cut existing sidewalk and repair to accommodate new conduit or roadway equipment.
7. Furnish and install trenches as required to accommodate new conduit.
8. Furnish and install new back panels in the specified terminal boxes as specified and shown on the plans.
9. Tag each conduit with a designation number noted in the approved conduit shop drawings
10. Develop shop drawings including component cut sheets, mounting and installation details, and conduit block diagram related to the electrical conduit, fittings, and boxes and submit for review and approval.
11. Coordinate with DelDOT's security contractor for installation of conduit associated with the security system.

E12 Incoming Service and Generator Modifications

The work under incoming service and generator modifications shall include the following:

1. Develop shop drawings including component cut sheets related to the incoming service and generator modifications and submit for review and approval.
2. Coordination with local electrical utility company, Delmarva Power & Light (DPL) to furnish, install, connect and energize new 480VAC incoming service.

3. Provide DPL with access to the bridge, roadway and surrounding areas to furnish and install conduit, wire and other related incoming service equipment which may include road closures, MOT and other safety measures and equipment.
4. Coordination with stand-by generator manufacturer and reconnection of generator and all accessories with 480VAC, 3 phase system.
5. Adjustment of all generator control parameters to meet new requirements.
6. Furnish and install the generator fuel sensor and connect to PLC.
7. Replace fuel lines in-kind between the generator, fuel tank, overflow tank and fuel supply fill location.
8. Fill the generator fuel tank with a minimum of 225 gallons of diesel fuel at project completion and provide fuel as required to maintain generator operation.

E13 Field Measuring

The work under field measuring shall include the following:

1. Field verification and measurements of dimensions, sizes, and/or features to achieve the proper fit-up of new and/or existing components and equipment.
2. Note any existing dimensions or features which in the opinion of the Contractor deviate from the contract documents or as-built drawings and which may impact the installation or alignment of machinery or electrical components.
3. At the direction of the Engineer, note any existing dimensions or features which deviate from the contract documents or as-built drawings and which may impact the installation or alignment of machinery or electrical components.
4. Measure and verify locations for lights, switches and receptacles.
5. Measure and verify locations for control cabinets and back panels, supports, and boxes.
6. Measure and verify entry pathways for installing equipment.
7. Measure and verify locations for conduit runs and boxes.
8. Measure and verify locations for disconnect switches, cabinets, control desk, AC unit, heating units, panels, and other enclosures.
9. Measure and verify submarine cable conductors, terminal cabinets, and support locations.
10. Measure and verify locations for droop cables, support and boxes.
11. Measure and verify locations for limit switches.
12. Measure and verify locations for motors, brakes, disconnect switches, panels, and other enclosures.
13. Measure and verify fender locations for conduit, navigation lights, marker and air horn
14. Measure and verify locations for roadway equipment and operation.
15. Measure and verify locations of incoming service, pole, meter and disconnect switch.
16. Measure and verify existing warning gates and barrier gates for proposed modifications.

E14 Bridge Operation during Construction

The work under bridge operation during construction shall include the following:

1. Develop shop drawings related to the bridge operation during construction including component cut sheets for any temporary equipment along with operation and maintenance procedures and submit for review and approval.
2. Coordination with all trades and work throughout the duration of the contract to maintain operability of the bridge.

3. Furnish and install mechanical and electrical equipment required to operate the bridge in a temporary fashion as specified.
4. Provided qualified and trained bridge operators and other personnel to operate the bridge in accordance with USCG requirements.
5. Testing of temporary bridge operations using approved methods and equipment in the presence of DelDOT and the Engineer.
6. Maintenance of new and existing mechanical and electrical equipment per manufacturers recommendations and DelDOT's latest Operation and Maintenance Manuals for the bridge until completion of the contract.

E15 Miscellaneous Equipment

The work under miscellaneous equipment shall include the following:

1. Develop shop drawings including component cut sheets related to the miscellaneous equipment noted below and submit for review and approval.
2. Furnish and install receptacles, switches, lights, hot water heater, electric heaters, panelboards, and transformers as specified and shown on the plans.
3. Furnish and install electronic thermostats, as specified for each room to control the heating system.
4. Reconnect existing roadway lighting to new power system at 277V. Verify whether existing LED ballasts or drivers are configured for 277V operation and make adjustments as needed (setting DIP switches, rewiring, etc.).
5. Furnish and install photo cells for roadway lighting and navigation lighting.
6. Furnish and install new span and fender navigation lights to replace existing units.
7. Furnish and install marine air horn on the control house.
8. Furnish and install fire alarm system, as shown on the plans, and specified herein.
9. Furnish spare parts, as specified herein, and deliver to DelDOT.

E16 Testing

The work under testing shall include the following:

1. Submit for review and approval test procedures and forms to be used during factory and field testing. Following successful testing, submit all completed forms and procedures.
2. Perform the specified factory inspection and testing on the control system, including drives, control enclosures, PLC's and motors.
3. Perform insulation resistance testing on all motors, wires and cables
4. Perform factory load testing using actual motors and drives connected to a dynamometer.
5. Perform field acceptance testing on the completed mechanical and electrical system as specified.
6. Perform testing of the PLC alarms with the TMC network.

E17 Technical Manuals and Training

The work under technical manuals and training shall include the following:

1. Perform training as specified on operational, maintenance and troubleshooting of mechanical and electrical equipment.

2. Compile cut sheets, manufacturer's literature, maintenance instructions, test data, shop drawings, contact information for mechanical and electrical equipment and submit for review and approval.
3. Develop an operational manual covering all modes of operation and submit for review and approval.
4. Develop and compile as-built drawings for mechanical and electrical equipment and systems and submit for review and approval.

E18 Removal of Electrical Equipment

The work under removal of electrical equipment shall include the following:

1. Removal and disposal of existing electrical equipment which is designated to be replaced in these contract documents and where removal may not be explicitly noted.
2. Removal and disposal of indicated existing electrical equipment noted in the plans or specifications to be removed.
3. Travel to and from disposal sites by the Contractor to dispose of equipment
4. Shipping and/or travel cost to deliver indicated equipment to DelDOT.
5. Disposal costs to deliver and unload existing equipment .
6. All equipment and access means to properly remove indicated equipment.

BR 3-154, Savannah Road Bridge

E19. Control Cabinets

The work under control cabinets shall include the following:

1. Develop shop drawings including component cut sheets related to the new cabinets and submit for review and approval.
2. Furnish and install new control enclosures in the Switchboard Room as specified and shown on the plans.
3. Program and make adjustments to the PLC system as specified herein and submit ladder logic for review and approval.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E20 Control Desk

The work under control desk shall include the following:

1. Furnish and install new control desk in the Control Room as specified and shown on the plans.
2. Furnish spare parts as specified and deliver to DelDOT.
3. Develop shop drawings including component cut sheets related to the new control desk and submit for review and approval.
4. Coordination of the PLC system with the TMC network.

E21 Flux Vector Drive

The work under flux vector drive shall include the following:

1. Develop shop drawings including component cut sheets related to the new drive system and submit for review and approval.
2. Furnish and install new flux vector drives and associated accessories in a new enclosure in the Switchboard Room as specified and shown on the plans.
3. Program and make adjustments to the drive system as specified herein and submit key programming parameters.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E22 Automatic Transfer Switch

The work under automatic transfer switch shall include the following:

1. Develop shop drawings including component cut sheets related to the ATS system and submit for review and approval.
2. Install existing/new Automatic Transfer Switch (ATS) in a new enclosure in the West Machinery Room with new associated equipment as specified and shown on the plans.
3. Modify the existing ATS to operate with 480VAC, 3 phase system or provide new ATS switch as specified.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E23 Limit Switches

The work under limit switches shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the limit switches and submit for review and approval.
2. Furnish and install the following limit switches and sensors as specified and shown on the plans: resolver, span position, fully closed, over travel, speed switch, span manual operation, tail lock manual operation, tail lock interlocking.
3. Adjust all limit switches to achieve the settings as shown on the plans. Readjustment will be required for proper operation during final testing.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E24 Motors

The work under motors shall include the following:

1. Develop shop drawings including component cut sheets related to the motors and submit for review and approval.
2. Furnish span motor and tail lock motors as specified.
3. Perform motor shop testing as specified for all motors supplied.
4. Furnish spare parts as specified herein and deliver to DelDOT.

E25 Motor Brakes and Machinery Brakes

The work under motor brakes and machinery brakes shall include the following:

1. Develop shop drawings including component cut sheets related to the brakes and submit

for review and approval.
2. Furnish new motor brakes and machinery brakes as specified and shown on the plans.
3. Furnish and install new brake released, brake hand released and brake set limit switches as specified and as shown on the plans.
4. Furnish spare parts as specified and deliver to DelDOT.

E26 Modifications to Warning Gates

The work under modifications to warning gates shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the warning and barrier gate modifications and submit for review and approval.
2. Reconnect existing and new equipment for the gates as shown and indicated on the plans.
3. Replace all existing wiring within the gate housing with single conductor No. 12 AWG.
4. Furnish and install one flasher unit for each warning gate inside the housing of each gate as specified and as shown on the plans.
5. Furnish and install new flexible cables for gate arm lights to accommodate 2 flashing circuits and one steady circuit plus a ground conductor.
6. Furnish and install new traffic signal supports, signage and signal heads as shown on the plans.
7. Furnish and install new door switches as specified and as shown on the plans.
8. Furnish and install disconnect switches as specified and as shown on the plans.
9. Furnish and install new traffic stop lines at the traffic signals as specified.
10. Connect existing heater and receptacle circuits to the new panelboards.
11. Furnish spare parts as specified herein and deliver to DelDOT.

E27 Motor Disconnect Switches

The work under motor disconnect switches shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the motor disconnect switches and submit for review and approval.
2. Furnish and install motor disconnect switches in sight of each motor as specified and as shown on the plans.
3. Furnish spare parts as specified herein and deliver to DelDOT.

E28 Electrical Cable, Wire and Connections

The work under electrical cable, wire and connections shall include the following:

1. Develop shop drawings including component cut sheets and mounting details related to the electrical wire and cable and submit for review and approval.
2. Furnish and install new wiring inside conduit, wireways and other raceways as specified and shown on the plans.
3. Furnish and install ground systems and conductors as specified and shown on the plans.
4. Furnish and install new flexible droop cables as specified and shown on the plans.
5. Install security system wiring furnished by others in coordination with DelDOT's contractor for security and camera systems (only where installed in common raceways).
6. Coordinate with DelDOT's security contractor on their installation of wiring where not

installed in common raceways.

7. Test, tag and connect each conductor at termination points inside control enclosures, the control desk, and termination boxes.

E29 Electrical Conduit, Fittings and Boxes

The work under electrical conduit, fittings and boxes shall include the following:

1. Furnish and install new conduit, wireways, troughs, boxes, vaults, junction wells and fittings as specified and shown on the plans. Remove and dispose of existing conduit, wire, junction wells, etc as shown on the plans.
2. Furnish and install new conduit and box supports as specified and shown on the plans.
3. Clean the interior of each section of new and existing conduit prior to installation of wire.
4. Core drill through walls and floors to accommodate new conduit and associated equipment.
5. Patch existing holes and openings after removal of existing conduit and raceways systems.
6. Furnish and install trenches as required to accommodate new conduit.
7. Furnish and install new back panels in the specified terminal boxes as specified and shown on the plans.
8. Tag each conduit with a designation number noted in the approved conduit shop drawings
9. Develop shop drawings including component cut sheets, mounting and installation details, and conduit block diagram related to the electrical conduit, fittings, and boxes and submit for review and approval.
10. Coordinate with DelDOT's security contractor for installation of conduit associated with the security system.

E30 Incoming Service and Generator Modifications

The work under incoming service and generator modifications shall include the following:

1. Develop shop drawings including component cut sheets related to the incoming service and submit for review and approval.
2. Coordination with local electrical utility company, Lewes BPW to connect and energize new 480VAC incoming service.
3. Provide Lewes BPW with access to the bridge, roadway and surrounding areas to furnish and install conduit, wire and other related incoming service equipment which may include road closures, MOT and other safety measures and equipment.
4. Coordination with stand-by generator manufacturer and reconnection of generator and all accessories with 480VAC, 3 phase system.
5. Adjustment of all generator control parameters to meet new requirements.
6. Fill the generator fuel tank such that it is 75% full of propane fuel at project completion and provide fuel as required to maintain generator operation.

E31 Field Measuring

The work under field measuring shall include the following:

1. Field verification and measurements of dimensions, sizes, and/or features to achieve the proper fit-up of new and/or existing components and equipment.
2. Note any existing dimensions or features which in the opinion of the Contractor and/or the Engineer deviate from the contract documents or as-built drawings and which may impact the installation or alignment of machinery or electrical components.
3. Measure and verify locations for lights, switches and receptacles.
4. Measure and verify locations for control and back panels, supports, and boxes.
5. Measure and verify entry pathways for installing equipment.
6. Measure and verify locations for conduit runs and boxes.
7. Measure and verify locations for disconnect switches, cabinets, control desk, AC unit, heating unit, panels, and other enclosures.
8. Measure and verify submarine cable conductors, terminal cabinets, and support locations.
9. Measure and verify locations for droop cables, support and boxes.
10. Measure and verify locations for limit switches.
11. Measure and verify locations for motors, brakes, disconnect switches, panels, and other enclosures.
12. Measure and verify fender locations for conduit, navigation lights, marker and air horn
13. Measure and verify locations for roadway equipment and operation.
14. Measure and verify locations incoming service, pole, meter and disconnect switch
15. Measure and verify existing warning gates and barrier gates for proposed modifications

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E32 Bridge Operation during Construction

The work under bridge operation during construction shall include the following:

1. Develop shop drawings including component cut sheets and procedures related to the bridge operation during construction and submit for review and approval.
2. Coordination with all trades and work throughout the duration of the contract to maintain operability of the bridge.
3. Furnish and install mechanical and electrical equipment required to operate the bridge in a temporary fashion as specified.
4. Provided qualified and trained bridge operators and other personnel to operate the bridge in accordance with USCG requirements.
5. Testing of temporary bridge operations using approved methods and equipment in the presence of DelDOT and the Engineer.
6. Maintenance of new and existing mechanical and electrical equipment per manufacturers recommendations and DelDOT's latest Operation and Maintenance Manuals for the bridge until completion of the contract.

E33 Miscellaneous Equipment

The work under miscellaneous equipment shall include the following:

1. Develop shop drawings including component cut sheets and procedures related to miscellaneous equipment and submit for review and approval.
2. Furnish and install receptacles, switches, lights, hot water heater, electric heaters, panelboards, and transformers as specified and shown on the plans.
3. Reconnect existing roadway lighting to new power system at 277V. Verify whether existing LED ballasts or drivers are configured for 277V operation and make adjustments

as needed (setting DIP switches, rewiring, etc.).
4. Furnish and install photo cells for roadway lighting and navigation lighting.
5. Furnish and install new span and fender navigation lights to replace existing units.
6. Reconnect existing lighting and other miscellaneous equipment to remain.
7. Furnish and install marine air horn on the control house.
8. Furnish and install fire alarm system as shown on the plans and specified herein.
9. Furnish spare parts as specified herein and deliver to DelDOT.

E34 Testing

The work under testing shall include the following:

1. Perform the specified factory inspection and testing on the control system including drives, control enclosures, PLC's and motors.
2. Perform insulation resistance testing on all motors, wires and cables
3. Perform factory load testing using the actual motors and drives using a dynamometer.
4. Perform field acceptance testing on the completed mechanical and electrical system as specified.
5. Submit, for review and approval, test procedures and forms to be used during factory and field testing. Following successful testing submit all completed forms and procedures.
6. Perform testing of the PLC alarms with the TMC network.

E35 Technical Manuals and Training

The work under technical manuals and training shall include the following:

1. Perform training as specified on operation, maintenance, and troubleshooting of mechanical and electrical equipment.
2. Compile cut sheets, manufacturer's literature, maintenance instructions, test data, shop drawings, and contact information for mechanical and electrical equipment and submit for review and approval.
3. Develop operational manual covering all modes of operation and submit for review and approval.
4. Develop and compile as-built drawings for mechanical and electrical equipment and systems and submit for review and approval.

E36 Removal of Electrical Equipment

The work under removal of electrical equipment shall include the following:

1. Removal and disposal of existing electrical equipment which is designated to be replaced in these contract documents and where removal may not be explicitly noted.
2. Removal and disposal of indicated existing electrical equipment noted in the plans or specifications to be removed.
3. Travel to and from disposal sites by the Contractor to dispose of equipment.
4. Shipping and/or travel cost to deliver indicated equipment to DelDOT.
5. Disposal costs to deliver and unload existing equipment.
6. All equipment and access means to properly remove indicated equipment.

Materials:

General Requirements

All equipment and materials to be furnished shall be new unless otherwise specified elsewhere. All equipment, materials, and workmanship shall be first class in every particular and shall be manufactured and erected to the satisfaction of the Engineer. Any piece of equipment which is found to be defective or damaged in any way must be replaced at no additional cost to DelDOT.

The Contractor shall warrantee the in service working of the electrical installations for one year or the manufacturer's warranty period, whichever is greater, following project acceptance by DelDOT. If the Contractor has any objection to any feature of the electrical equipment as designed or arranged, he must state his objection in writing to the Engineer prior to submittal of shop drawings, otherwise his objection will not be accepted if offered as an excuse for malfunctioning of the equipment or for defective or broken apparatus. Changes shall be made at the discretion of the Engineer.

Prior to installation, electrical equipment shall be stored in a temperature and humidity controlled environment. Damage to electrical equipment caused by moisture and/or weather conditions will require replacement. Once the equipment is installed but prior to acceptance of the bridge by DelDOT the Contractor will be responsible for maintaining the equipment in like-new condition and follow all manufacturer maintenance requirements. Equipment which is damaged in any way at the Engineers discretion shall require replacement at no additional cost to DelDOT.

Each piece of electrical equipment and apparatus shall have a corrosion resistant nameplate screwed in place on which is stamped the name of the manufacturer, rating or capacity of the equipment or apparatus, catalog number, serial number, etc.

All metal parts of the installation, except structural steel, shall be of corrosion resisting material, such as bronze or stainless steel. Cast iron, malleable iron or steel with a hot-dip galvanized finish shall be used where specified herein.

In general, all mounting hardware and all wire and cable terminals shall be vibration resistant. If any departures from the Contract Plans or Specifications are deemed necessary by the Contractor, details of such departures, and the reasons for such departures shall be submitted for approval as soon as practicable. No such departures shall be made nor work started without the written approval of the Engineer.

Sole Source Equipment

The Contractors attention is directed to the various sole source items for PLC equipment (Allen Bradley Control Logix), span drive equipment (Allen Bradley Power Flex 753 or Control Techniques M700) and general control equipment (Square D). Information regarding sole source products are specified elsewhere. No substitutions shall be granted for these items other than alternate part and model numbers that may be required due to obsolescence of equipment or to adjust the specified equipment for proper operation.

Bridge Control System Vendor.

All apparatus and equipment comprising the bridge control system, including, but not limited to,

motor brakes, motors, motor encoders, speed switches, limit switches, back panels, cabinets, drives, control desk, resolvers, PLC equipment, transformers and other apparatus required to provide a complete functioning system, shall be manufactured and/or furnished, assembled and integrated by a single qualified control system vendor. The vendor shall assemble all panels and cabinets at an Underwriters Laboratory approved facility in accordance with UL 508.

The control system vendor shall have experience in providing electrical control systems for movable highway bridges of various types, including bascule, vertical lift, and/or swing bridges with PLC control systems, including flux vector control of vector-duty motors. Such experience shall be demonstrated by identifying a minimum of five (5) movable bridges for which the system vendor has provided similar systems within the past five (5) years. Pre-approved vendors are listed below.

(a) Panatrol Corporation (630-655-4700)
(b) EHM (954-981-0023)
(c) TSR Electric (410-355-8700)

The control system vendor shall assume complete system responsibility for the integrated functioning of all components to provide a satisfactory assembled system operating in accordance with specified requirements. The control system vendor shall be responsible for the detailed schematics and fabrication of the total control and power distribution system to ensure compatibility of equipment and suitability for the intended system functionality, including testing and tuning portions of the existing electrical system which must interface with the new equipment. The vendor shall provide supervisory assistance in the installation of equipment at the bridge site to ensure correct field wiring, maximum reliability, and ease of maintenance.

The system vendor shall provide a field service staff having the capability of providing services for field coordination of construction and final adjustments to the bridge control systems. Upon final acceptance of the bridge by DelDOT, the system vendor's staff shall provide on call warranty service for a period of one year.

The Contractor shall provide written certification of compliance with specified requirements for his control system vendor. Include documentation of conformance with these requirements. Provide references as needed to allow the Engineer to verify conformance with these requirements. This certification shall be submitted immediately after award of the contract and shall be subject to approval by the Engineer. No payments to the Contractor shall be made prior to submission and approval of the certification of compliance for the control system vendor.

Control Apparatus and Miscellaneous Equipment

Circuit Breakers: All branch circuits from the buses shall be protected by molded case circuit breakers. All breakers shall be compact and have quick-make, quick-break contacts and the mechanism shall be trip-free and trip indicating. Frame sizes shall be not less than 100 amperes. The breakers shall be equipped with thermal-magnetic trips or adjustable instantaneous magnetic trip units. Circuit breakers shall have a minimum interrupting capacity rating of 35 kAIC.

Minatare Circuit Breakers: Circuit breakers for control circuits shall be single pole miniature type and meet the requirements of UL 489. The miniature circuit breakers shall be din railed mounted in the control panels and shall have a trip curve of D.

Motor Starters and Magnetic Contactors: The continuous current rating of contactors and starters

shall be adequate for the connected inductive loads, and no starter shall be smaller than the size specified. All contact poles shall be provided with arc chutes, and contactors rated 150-amperes and above shall be equipped with magnetic blowouts. Motor protective circuit breakers shall be provided for motor protection. The motor protective circuit breakers shall function as an overload and circuit breaker as one combined unit with plug in trip block modules. The motor protective units shall be of the automatic reset type unless otherwise specified. Contactors and circuit breakers, overload modules shall be provided with the required auxiliary contacts as shown on the Contract Plans. Reversing contactors shall be electrically and mechanically interlocked. All motor starters and circuits breakers shall be connectable to a bus bar system, both manufactured by a single manufacturer. All contactors shall be provided with surge suppressors. Motor protective circuit breakers and contactors shall be type GV2P03 and LC1/LC2 as manufactured by Schneider Electric.

Industrial Control Relays shall be multi-contact magnetic relays with contacts rated at 10 amperes, 600 volts on a continuous basis. All relays shall be provided with surge suppressors. Time delay relays shall be provided through a delay attachment to the specified control relays. The time delays shall be electronic type providing time delay intervals as required with a linear timing range in the ratio of 1:10. The number and type of poles shall be as shown on the Contract Plans. Relays shall be type CAD as manufactured by Square D.

Safety Control Relays: Industrial control safety relays shall be multi-contact magnetic machine tool relays with contacts rated at 10 amperes, 600 volts on a continuous basis. Relays shall feature mechanically linked double break contacts on each pole and shall be specifically designed for safety applications. Tamper resistant covers shall be provided on each relay. Each safety control relay shall be equipped with surge suppression. Safety relays shall be type 700S as manufactured by Allen Bradley or approved equal.

Terminal Blocks: Terminal blocks for conductors of Size No. 2 AWG and smaller shall be screw type din rail mountable terminals rated for a maximum voltage of 690 VAC/115 Amperes. Each terminal requiring a splice or jumper shall be provided with pin jumper connectors which are mountable to the terminal block. The terminal blocks assembly shall be provided with ground terminals, screw terminals, din rail, end plates, separators, pin connectors and any other required accessory. The terminal blocks shall wire connections for use insulated wire ferrule connectors. Factory printable corrosion resistant marking strips shall be provided for conductor identification. At least ten percent spare terminals shall be provided. Terminal blocks shall be Phoenix Contact UT4 or approved equal.

Power Distribution Terminal Blocks: Power distribution blocks shall be used for conductor sizes No. 6 and larger and shall be UL listed. Terminal blocks shall be suitable for use with copper wire and shall provide a withstand voltage rating of 750 volts per IEEE switchgear standards. Corrosion resistant marking strips shall be provided for conductor identification. At least ten percent spare terminals shall be provided. Terminal blocks shall be Gould Shawmut Power Distribution Blocks - Heavy Duty Series 68000 or approved equal.

Terminal Connectors: Connectors shall be seamless, heavy-duty insulated wire ferrules or flanged fork terminal lugs where specified. Terminal lugs shall be installed per lug manufacturer recommendations using the proper tools approved by the manufacturer. Under no circumstance will splicing of wires be permitted without the use of a terminal block.

Nameplates: Nameplates, where required, shall be made of laminated phenolic plastic with white front and back and black core and shall be not less than 0.094 inches thick. The lettering shall be etched

through the front layer to show black engraved letters on a white background. Lettering shall be not less than ¼ inch high, unless otherwise detailed on the Contract Plans. Nameplates shall be securely fastened to the equipment with stainless steel screws.

Control Desk Key Operated Selector Switches, Selector Switches, Indicating lights and Push-buttons: Control switches, key operated switches, selector switches, indicating lights and push-buttons on the control desk shall be heavy-duty NEMA type, 1.2 inch diameter base (30mm), oil-tight contact blocks operated by glove handle (pistol grip) selector knobs or push-buttons as indicated in the Plans. All switches, indicating lights and pushbuttons shall be equipped with escutcheon plates as shown on the plans. All lenses shall be glass, with color as shown on the plans. Lamps for indicating lights shall be LED type. Contacts shall be fine silver, capable of interrupting 6 amperes at 120 volts AC and of continuously carrying 10 amperes. Key operated switches shall be wired and configured such that the key can only be removed in the off position. Pilot devices for the control desk shall be Square D 9001 series.

Local Control Switches, Key Operated Switches, Selector Switches and Push-buttons: Control switches, key operated switches, selector switches and push-buttons on the front of the drive enclosure for local operation shall be heavy-duty NEMA type, 0.866 inch diameter base (22mm), oil-tight contact blocks operated by selector knobs or push-buttons as indicated in the Plans. All switches and pushbuttons shall be equipped with escutcheon plates as shown on the plans. Contacts shall be fine silver, capable of interrupting 6 amperes at 120 volts AC and of continuously carrying 10 amperes. Key operated switches shall be wired and configured such that the key can only be removed in the off position. Pilot devices for the control desk shall be Square D Harmony XB4 Series.

Emergency Stop Push-button: Emergency stop push-buttons shall be heavy-duty, 1.2 inch diameter base, 2.25 inch diameter mushroom head, oil-tight contact blocks operated by pushing in and pulling out the button mushroom head as indicated in the Plans. The Emergency Stop button shall illuminate when the button mushroom head is pulled out to clearly indicate the emergency stop button has been de-activated. Pulling out the button mushroom head shall deactivate the emergency stop condition. The pushbutton shall be equipped with an escutcheon plate as shown on the plans. Contacts shall be fine silver, capable of interrupting 6 amperes at 120 volts AC and of continuously carrying 10 amperes. The quantity of contacts shall be as shown on the plans. The push-button shall be equipped with surge suppression. Emergency Stop push-buttons shall be Square D 9001 series.

24VDC Power Supplies: All 24V DC power supplies shall be rated for 120VAC input at 60 hertz, and 10A, 24V DC output. The power supplies shall be single output, regulated linear DC power supply. The power supply shall be convection cooled, constant voltage, short circuit proof, current limiting (automatic reset) unit with an output voltage adjustment of +/- 5%, and input/output isolation of 1,000 mega-ohms DC. The power unit shall operate over a temperature range of 0° Celsius through 55° Celsius. Units shall be DIN rail mountable and finger safe. Power supplies shall be Square D Phaseo Easy power supplies.

Control Transformers: Control transformers shall be 2-KVA, 480-volt primary, 120-volt secondary, low impedance with copper windings and high voltage regulation. The control transformer shall be located as shown on the plans in the ATS enclosure. The transformer shall be Square D Type T, 60 HZ, 2 KVA Class 9070 Industrial Control Transformer.

Enclosed Control Cabinet

Freestanding Control Cabinets and back panels shall be furnished and installed in the control house where shown on the Plans. Circuit breakers, switches, contactors, starters, relays, buss bar system, PLC system, touchscreen, UPS and other apparatus as shown on the Plans shall be mounted and enclosed in free standing cabinets. The arrangement and line-up of the individual control cabinets shall be as shown on the Plans.

All equipment in each control cabinet shall be mounted on sheet-steel bases, and each device shall be front-connected, front-wired, and removable from the front. The equipment in all cabinets shall be arranged for ease of access and for safety and convenience of operation. Special care shall be taken to obtain a systematic and neat arrangement of the equipment. Each device shall be suitably named and plainly marked by a laminated nameplate mounted near the device on the panel. Each nameplate shall show an approved descriptive title for the apparatus, together with the device designation appearing on the schematic wiring diagrams. Nameplates shall meet the requirements as specified under Control Apparatus and Miscellaneous Equipment. Each relay shall be identified with letter designations shown on the plans and numerically as installed in the cabinet from left to right starting at the upper left corner of the cabinet. The vendor shall provide a typewritten, laminated directory with relay number associated alphanumeric designation and descriptive function listed in alphabetical order such that relays can be located by numerical position.

Each new control cabinet shall be a NEMA Type 12 enclosure where installed indoors and NEMA 4X stainless steel when installed outside the control house. Enclosures shall be constructed of No. 12 gauge sheet-steel or stainless steel and shall be reinforced with steel angles or channels so as to provide a rigid, freestanding structure. The control cabinets shall be provided with continuous stainless steel door hinges on the front of each panel section. Each door cabinets shall be gasketed and shall be provided with three-point, vault-type latches. Ventilating louvers shall be provided at the top of each enclosure. All hardware shall be corrosion resistant. Thermostatically controlled strip heaters shall be provided in each cabinet to prevent build-up of excess moisture. Each panel shall be provided with suitable interior light fixtures and a duplex receptacle.

Each Cabinet enclosure and back panel shall be as shown on the plans. The Contractor shall modify the dimensions shown on the plans to accommodate the required equipment at no additional cost to DelDOT. The dimensions of each cabinet and back panel shall be such as to permit mounting in the available space along the walls of the control house as shown on the Plans. If the final cabinet dimensions, as established by the manufacturer, should necessitate rearrangement or modification of the equipment in order to fit in the available space, such rearrangement or modifications shall be made at no additional cost. The final arrangement of all equipment in the Control House shall be subject to the approval of the Engineer.

The cabinet enclosures and all metal reinforcing shall be painted inside with two coats and outside with three coats, consisting of one coat of primer followed by one coat of gray or white enamel on the inside surfaces and two coats of gray enamel outside. The finish exterior coat shall be ANSI 61 light gray enamel.

All contactors, relays, and other devices shall be of required current carrying and interrupting capacity. All wiring installed within each cabinet shall be flame-retardant, ethylene-propylene insulated, switchboard wire, Type SIS. Conductors shall be stranded copper not smaller than No. 14 American Wire Gauge.

For each assembled control cabinet and back panel, all outgoing wire, No. 8 AWG or smaller,

shall be connected to terminal blocks installed at the sides of the cabinet. The control cabinets and back panels shall also provide sufficient extra terminals to allow connection of all wires coming from limit switches and other devices that go on to the bridge control desk and other locations as required, even though these wires do not connect to apparatus on the control cabinet. Spare terminals totaling at least 10 percent for power conductors and 20 percent for control conductors of those actually used shall be provided. Each terminal shall be identified per wire number shown on the Contractor's schematic wiring diagrams.

All cabinet and back panel wiring shall be arranged systematically so that circuits can be readily traced. The wiring shall be installed in a network of troughs consisting of horizontal and vertical sections securely bolted to the cabinets and back panels. The troughs shall be fabricated from heavy-duty Noryl plastic shaped into a channel cross-section. After installation of the wiring, an insulated, flanged cover shall be fitted over the open side of each trough section.

PLC Equipment

Bridge control logic functions shall be performed by a programmable logic controller system, which shall provide for operation of the bridge and its auxiliaries in accordance with the system functioning specified herein and the control logic shown on the Plans.

The programmable logic controller (PLC) shall be an Allen Bradley (AB) ControlLogix brand PLC with components, hardware and remote input/output drops. No substitutions shall be accepted. The PLC shall be of modular construction, provide high-speed peer-to-peer networking, and be programmable with ladder logic.

The PLC system will consist of two redundant 1756-L72 CPU's. Only one CPU will be in use at a time, and the other CPU will be offline and de-energized. The remote PLC equipment furnished inside the control desk shall be of the same make and manufacturer as that provided for the PLC Cabinet. A selector switch mounted on the control desk, specified elsewhere will select the CPU in use.

HMI (Touchscreens) shall be furnished and installed as shown on the plans. The touchscreens shall be a 15" display with solid state hard drive and be of the same manufacturer as the PLC system. Each touchscreen shall be used to display alarms, equipment status and be capable of operating the bridge via password.

For each control desk, the lower touchscreen shall be the primary control for the bridge and shall include buttons to operate each component as specified. The PLC system shall be capable of operating the bridge should either or both touchscreens fail using hardwired push-buttons and selector switches located as shown on the plans.

All PLC equipment for the control desk including power supplies, I/O cards, modules, switches and all accessories shall be mounted inside the control desk base on a back panel

1. The PLC shall be provided with the following features:
   a. 1.5M of battery backed static RAM.
   b. 1.5M of Nonvolatile RAM.
   c. Ethernet communication
2. Each PLC remote input/output rack will be connected to both CPUs by means of a communication bus that will use Ethernet as the method of communication.

3. Each PLC rack shall be supplied with a ControlLogix chassis as shown on the plans.
4. Each input and output card shall be equipped with cage clamp removable terminal blocks wiring arms, oversized housings, and covers. The contractor shall provide terminal blocks as needed.
5. Each PLC chassis shall be provided with an Allen Bradley power supply.
6. All parts shall be as shown on the plans.
7. The Contractor shall furnish and install active line filters as shown on the plans to protect the PLC equipment and controls. The noise filter shall be a series connected high frequency noise filter with transient protection. It shall offer hard wired connection to all critical loads and be rated for use in an industrial environment. It shall reduce mode transients to +/- 2 volts, have a surge capacity of 45,000 amps, provide transient protection in all modes (line to neutral, line to ground, and neutral to ground), have an LED power indication, and be UL approved. The 120VAC MCOV shall be rated 150 VRMS. The line frequency response time shall be less than 0.5 nanoseconds. The operating temperature shall be -40°C to 45°C at full load. The unit shall be capable of protecting against a peak surge current of 15,000 amps in all modes.
8. Furnish and install Ethernet switches as required in the control enclosures. The switches shall be Rockwell Automation Allen Bradley Stratix Switch with fiber optic connections and a minimum of 10 Ethernet ports.
9. Furnish and install a touchscreen as part of the PLC equipment to be mounted in the switchboard room. The touchscreen shall be a 15" display (12" for Rehoboth Avenue Drive Cabinet) with solid state hard drive and be of the same manufacturer as the PLC system. The switchboard room touchscreen shall be used to display alarms, equipment status and be capable of operating the bridge as a back-up to the control desk equipment.

Computer and Software

Provide a laptop computer with specified software suitable for programming the PLC, PanelView, and variable frequency drive systems. The computer shall be the latest commercially available unit and contain, as a minimum requirement, an IBM compatible Intel Core i5 processor operating at 3 GHz or better. The random access memory (RAM) shall contain a minimum capacity of 4 GByte and be expandable to 8 GByte. The hard disk drive shall have a storage capacity of 512 GBytes or more. The DVD/CD drive shall be a 40x RW/DVD +/-R/+/-RW dual layer combo drive. The unit shall have 15 inch class color display, 2 USB ports, and programming cables for the PLC, Panel View, and drive. The unit shall serve as an intelligent terminal, functioning both as a PLC/vector drive programming and data monitoring terminal. It shall permit PLC programming, including loading, editing, and monitoring ladder diagram programs in memory by entering through the keyboard and track pad and monitoring on the display. PLC program instructions shall be in ladder logic.

The Contractor shall include two licenses for each software application that is provided. The following software applications shall be loaded onto the computer and made fully operational by the Contractor:

The latest version Windows compatible operating system supported by the PLC, PanelView, and drive programming software. Contractor shall verify all software can operate properly on the operating system and coordinate with the software vendors and the operating platform requirements to select the proper software version.

Studio 5000 Logix Designer - Latest programming software for Allen Bradley ControlLogix

Processors. Software shall be compatible with the Contractor supplied version of Microsoft Windows.

RSNetworks for ControlNet - 32-bit graphical network management configuration tool for the ControlNet network. Configures network-wide parameters such as network update time (NUT), schedules I/O data transfers and peer-to-peer messaging for PLC processors. Software shall be compatible with the Contractor supplied version of Microsoft Windows.

FactoryTalk View - Panel View programming software. Software shall be compatible with the Contractor supplied version of Microsoft Windows.

Variable Frequency Drive monitoring software to program and monitor the warning and barrier gate variable frequency drives. Software shall be compatible with the Contractor supplied version of Microsoft Windows.

Power Monitor software to program the Automatic Transfer Switch and monitor the incoming power at the Automatic Transfer Switch. Software shall be compatible with the Contractor supplied version of Microsoft Windows.

The Contractor shall demonstrate operation and use of the software as part of the personnel training.

Control Desk

Each control desk shall be of neat, substantial construction. The desk shall be fabricated from No. 11 gauge sheet-steel, properly formed and suitably reinforced to provide adequate strength. The desktop shall be fabricated of No. 10 gauge, Type 304, stainless steel sheet with a non-glare, satin finish. Removable doors shall be provided in the front and side panels of the desk, pivoted on 90-degree hinges, and secured with flush type, three-point latches. The desk shall be neatly fitted up with close joints, all rough edges or corners shall be ground off smooth, and all projecting edges rounded off. All metal hardware shall be of substantial construction and shall have a satin-chrome plate finish. All equipment mounting screws and bolts shall be stainless steel.

The sheet-steel portions of the desk and all metal reinforcing shall be painted inside with two coats and outside with three coats of paint, consisting of one coat of primer followed by two coats of enamel on the outside surfaces and one coat of white enamel inside. The finish coat shall be of a color to match the house interior. Color samples shall be submitted for approval to the Engineer. The stainless steel desktop shall not be painted.

The control desk interior shall be suitably lighted and controlled by a switch mounted near the front doors. One duplex receptacle shall be mounted in the desk's interior and one duplex receptacle shall be flush mounted exterior to the desk. The light and receptacles shall be powered from the lighting panel board as shown on the drawings.

The control desk shall be provided with selector switches, push-buttons, indicating lights and touchscreens as shown on the plans. The primary control method shall be performed through the lower touchscreen which shall include buttons to operate the equipment. The upper touchscreen shall be for monitoring purposes only and shall match the function and operation of the switchboard touchscreen as specified herein.

All contact blocks for control switches, pushbuttons, and other control devices shall be mounted within the body of the desk. The operators for these devices shall protrude through the desktop. The indicating lights for each operation shall be mounted as shown on the plans.

Indicating lights shall be mounted on the control desk to show that the various steps in the sequence of operation have taken place so that the operator may proceed to subsequent steps at the proper time. The functions to be indicated and the color of the lenses shall be as shown on the Plans.

Flux Vector Drive

The Contractor shall furnish Flux Vector-Controlled Variable Frequency Drives (FVD's) with operating voltages and current rating as shown on the plans. FVD Systems shall be UL508 listed. The complete control system as specified including the FVD must be assembled and warranted by a single manufacturer. Third party assemblers are not acceptable.

It is the intent of this specification to describe the minimum performance requirements the FVD systems. Any deviation shall be detailed in writing and submitted to the Engineer for approval at least two weeks prior to bid time.

The flux vector drives shall be sized as part of a span drive system for each bridge. The motor, drive, and dynamic braking resistor system shall meet the following torque, braking, and overload requirements:

	Rehoboth Avenue	Savannah Road
Normal Running Torque	358.5 ft lb	115 ft lb
Overload Torque Capacity	150% for 60 seconds	150% for 60 seconds
Never to Exceed Capacity	180%	180%
Motor Full Load Speed	875 RPM	685 RPM
Motor Creep Speed	50 RPM	50 RPM
Worst Case Dynamic Braking	100% for 90 seconds	100% for 90 seconds
Input Voltage	480 VAC	480 VAC
Drive Minimum HP	60 HP	20 HP*
Typical Duty Cycle (On/OFF)	90 seconds/5 minutes**	90 seconds/5 minutes**

*The Contractor shall oversize the drive to meet the breakaway torque requirements for the new motor and to be capable of operating the load in sensorless vector mode.
**The duty cycle includes 90 seconds of operation for raise and 5 minutes until the lower operation is initiated. The average time between bridge openings is typically measured in weeks and months although repeated operations is plausible during inspections and other non-typical openings.

The FVD system shall be sized for a normal bridge operation as follows:

	Rehoboth Avenue	Savannah Road
Fully Closed to Fully Open	90 seconds	77 seconds
Full Open to Fully Closed	90 seconds	77 seconds
Ramp from Zero to Full Speed:	10 seconds	10 seconds
Ramp from Full to Creep Speed:	10 seconds	15 seconds

The above ratings shall be the minimum drive ratings for the system equipment. During start-up the Contractor shall tune the drive, but may use lower settings for initial drive start up. The Contractor shall then tune the drive to meet these standards in the field.

The FVD System shall be compatible with the squirrel-cage type, phasor-type construction, induction leaf motor and shall be sized to ensure the motor full load amps (FLA) do not exceed the FVD's continuous current rating, with an overload capability of 150% for 60 seconds. The FVD drive shall be capable to provide 180% starting torque capability. If the FVD manufacturer's standard product is current rated at 8khz carrier frequency or below, a derating factor of 20% minimum shall be used to derive the maximum continuous current rating of the FVD.

The FVD's shall be IEEE 519 compliant for allowable harmonic distortion at the power distribution point of service, including line notching and transients. In the event that the FVD's produce Total Harmonic Distortion (THD) in excess of the prescribed limits of the utility company, the Contractor shall provide additional active or passive line-side filtration devices to reduce such harmonics to the allowable limits at no additional expense to the Owner.

To minimize the impact during construction and make optimum use of training and spare parts resources, supply responsibility shall be as follows:

1. One manufacturer shall supply specified FVD's.
2. Like components of all FVD Systems, although for different services, shall be interchangeable products of one manufacturer.
3. All FVD Systems shall be the same model series of one manufacturer. The complete FVD system must be manufactured and warranted by the FVD manufacturer. Third party assemblers are not acceptable.

FVD Systems shall include but not be limited to the following features:

1. Be 32 bit microprocessor based, closed loop, fully transistorized with a conservatively rated 3 phase, full wave diode bridge input and a PWM sine coded output waveform. The input diode bridge shall offer complete immunity against voltage dips, line noise and harmonics. The output transistors must be of the IGBT type (Insulated Gate Bipolar Transistor) to facilitate noiseless motor operation.
2. FVD shall be capable to run in speed and torque mode with adjustable torque limits in all four quadrants. FVD will be supplied with an encoder feedback card compatible with the supplied encoder and the phasor-type construction, induction leaf motor. The drive shall be capable of auto-tuning to the actual motor without any unwarranted service interruption during normal drive operation.
3. The Savannah Road Bridge FVDs shall operate in sensor-less vector mode and operate as

noted without the use of a motor encoder. The Rehoboth Avenue Bridge FVD shall operate in closed loop vector control with a connected motor mounted encoder.

4. The FVD shall not "cog" at any frequencies with a 1,000:1 speed regulation. There shall be no sudden frequency shifts and associated acoustical noise shifts as the output frequency is varied between 0 and 60Hz. Motor and FVD shall be able to produce full torque at zero speed.
5. The FVD's input displacement power factor shall be 0.95 or better over the entire operating frequency and load range. Efficiency shall be measured 97% minimum at rated load.
6. Solid state output ground fault protection shall be provided.
7. Adaptive electronic motor overload protection shall be provided which shall protect both the motor and the FVD at all frequencies. This overload must be UL approved. Electronic thermal overload circuits, which only protect the motor at full speed, shall not be acceptable. The FVD shall sense the load and speed and shall recalibrate the thermal trip curve to insure low speed motor protection. The initial trip point shall be adjustable from at least 40% of the FVD continuous rating to account for motor magnetizing current.
8. Input surge protection shall be provided by MOVs (metal oxide varistors) in accordance with ANSI Specification C63.41 1980.
9. Input and output phase loss detection must be provided and protect the FVD.
10. Output short circuit protection must be provided.
11. Provide ethernet communication and compatibility with the Rockwell Automation Allen Bradley PLC Control Logix equipment. The drive shall communicate with and be fully compatible with the Control System as described in the specification section regarding the Bridge Control System.
12. Provide programmable Ethernet inputs for Open, Close, Full Speed, Enable, Reduced Speed, Creep Speed, Reduced Torque, Drive Fault and Spare. Provide one dry contact input for Emergency Stop
13. Provide five programmable digital Ethernet outputs for Drive Trouble, Drive Running, Drive Ready, Proof of Torque, and a Spare.
14. Programmable current limit
15. Remote drive reset contact
16. Minimum of 1,000:1 controllable constant torque speed range. Speed regulation shall be 0.01% or better over the entire speed range.
17. Minimum of 2 second power loss ride-through capability. In the event of a loss of three-phase power lasting 2 seconds or less, the FVD must maintain operation and prevent nuisance trips upon return of power.
18. Provide digital ammeters and voltmeters on the panels and control desk, as shown on the contract plans.
19. The 'Drive Trouble' fault condition shall cause the FVD to shut off and shall be annunciated to the PLC control system through the Ethernet communication network (as described above). The conditions that shall cause a fault condition are as follows:
    a. Blown fuse.
    b. Instantaneous overcurrent trip.
    c. DC bus overvoltage.
    d. DC bus undervoltage.
    e. Excessive ambient FVD heatsink overtemperature.
    f. External fault input.
    g. Internally diagnosed, control failure.
    h. Motor thermal overload.

i. FVD thermal overload.

20. FVD operation options shall be programmable via a door mounted digital keypad and custom pilot devices, and include as a minimum the following functions:
    a. Password security
    b. Local/Remote for selecting operation either from the digital operators control station or from a remote location. Both start/stop and speed reference signals shall be selected by a single switch.
    c. Jog push button.
    d. Reset push button.
    e. Start push button.
    f. Stop push button
    g. Non-auto raise push button
    h. Non-auto lower push button
    i. Emergency stop
21. The drive shall be capable of local operation from the pilot devices located on the front of the drive cabinet door. The switches shall be lockable and prevent normal usage. When manual mode is selected the Ethernet control of the drive shall be disabled. Similarly when in automatic mode the manual control of the drive shall be disabled.
22. Red LED's shall be supplied as a standard on the digital operators station for indication of Hand, Auto, Running, stopped, and drive running with no speed reference signal applied (zero speed). All drive functions shall be programmable from the door mounted keypad. The keypad shall be equipped with non-volatile EEPROM and be removable permitting the parameters to be downloaded into another drive.
23. The FVD's shall be supplied with AC input line reactors with a minimum impedance of 5% to smooth the input current waveform and reduce harmonics. Typically this is provided as part of the drive internally.
24. The FVD shall be provided with a dV/dT filter mounted and wired in the FVD enclosure or the FVD must have a dV/dT internal circuit. The manufacturer must guarantee the motor/drive system with motor cable lengths of 700 feet.
25. The FVD shall be provided with an output contactor to disconnect the load from the drive when the drive is not running and to allow an emergency stop. The output contactor and drive system shall be rated to disconnect the motor while shutting off the drive instantaneously. Contactors must be NEMA rated for across the line motor starting.
26. The FVD drive system shall be capable of being used with a local motor disconnect switch. The FVD drive shall be rated to safely shutdown when the disconnect switch is opened and sense when the disconnect switch is open in order to not operate. An auxiliary contact in the disconnect switch shall be provided to the PLC to prevent the PLC from operating the drive with the disconnect switch in the disconnected position.
27. The drive shall be equipped with a minimum of three pre-set speeds and each shall have a unique speed ramp. The speed shall be identified as Full Speed, Reduced Speed, and Creep Speed. Full speed and creep speed shall be as listed above. Reduced speed shall be available, but not initially required. All control set points, logical control and connections with the PLC control system shall be coordinated with requirements and equipment specified under "Control Cabinets" and as shown on the Plans. The drives shall be equipped with speed ramps from full speed to creep speed and zero speed to full speed as shown on the drive sizing table. The drive shall be equipped with a speed ramp of one second from either creep speed or reduced speed to full stop.
28. The FVD shall be capable of operating in two distinct torque limiting modes as dictated by PLC Ethernet inputs. The motor torque shall be either limited by the capability of the

drive or the torque of the motor shall be limited to zero torque output of the rated motor HP. The reduced torque setting shall initially be set to zero and shall be adjusted in the field at the direction of the Engineer. This reduced torque limit shall be field adjustable from zero percent to 100% of motor output. The drive manufacturer shall provide all hardware and programming necessary to provide reduced torque function.

29. The FVD shall be capable of handling and controlling overhauling loads on the leaf motors. Independent speed and torque controls shall be provided for each of the four quadrants of motor operation. Dynamic braking resistors and associated interface cards shall be provided by the drive manufacturer such that the drive can operate in the regenerative mode for the entire open or close cycle at full speed and may last for approximately 90 seconds. The dynamic brakes shall be sized for operation and cooling. If additional cooling, such as fans, are required then fan starting contactors and controls shall be provided as part of the FVD system.
30. The drive shall be provided with a programmable digital Ethernet output for proof of torque which shall not release the brakes until torque in the motor shaft has been verified.

FVD Systems shall be furnished with the options as shown on the contract drawings and as specified herein. FVD Systems shall be either Allen-Bradley Heavy Duty Powerflex 753 or Control Techniques M700 Unidrive. No substitutions are permitted.

Automatic Transfer Switch

An automatic transfer switch shall be furnished and installed in each ATS enclosure. The unit for Rehoboth Avenue Bridge shall be a new unit as specified below. For Savannah road the existing unit may be reused with modifications as shown on the plans and specified herein or a new unit furnished as specified below. All work required for the fabrication of the ATS and enclosure shall be performed by the control system vendor which includes shipping on existing components to the control system vendors facility.

Each automatic transfer switch shall consist of an inherently double throw power transfer switch unit and a microprocessor controller, interconnected to provide complete automatic operation. The entire transfer switch assembly shall be the product of the same manufacturer.

Each unit shall be electrically operated and mechanically locked without the use of hooks, latches, magnets or springs. The electrical operator shall be a single-solenoid mechanism, momentarily energized. Main operators which include overcurrent disconnect devices will not be accepted. The switch shall be mechanically interlocked to ensure only one of two possible positions, normal or emergency.

The switch shall be positively locked and unaffected by momentary outages so that contact pressure is maintained at a constant value and temperature rise at the contacts is minimized for maximum reliability and operating life.

All main contacts shall be of silver composition. Switches shall have segmented, blow-on construction for high withstand current capability and be protected by separate arcing contacts.

Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. A manual operating handle shall be provided for maintenance purposes. The handle shall permit the operator to manually stop the contacts at

any point throughout their entire travel to inspect and service the contacts when required.

Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof which are not intended for continuous duty, repetitive switching or transfer between two active power sources are not acceptable.

Where neutral conductors must be switched, the ATS shall be provided with fully-rated neutral transfer contacts.

Where neutral conductors are to be solidly connected, a neutral terminal plate with fully-rated AL-CU pressure connectors shall be provided.

Each ATS shall be provided with a controller, which shall direct the operation of the transfer switch. The controller's sensing and logic shall be controlled by a built-in microprocessor for maximum reliability, minimum maintenance, and inherent serial communications capability. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance.

The controller shall be enclosed with a protective cover and be mounted separate from the transfer switch unit for safety and ease of maintenance. Sensing and control logic shall be provided on printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers.

Voltage and Frequency Sensing shall be provided on each ATS as follows:

1. Single-phase voltage and frequency sensing of the emergency or alternate source shall be provided.
2. The voltage of each phase of the normal source shall be monitored, with pickup adjustable to 95% of nominal and dropout adjustable from 70% to 90% of pickup setting.

Each ATS shall have time delays as follows:

1. An adjustable time delay shall be provided to override momentary normal source outages and delay all transfer and engine starting signals.
2. An adjustable time delay shall be provided on transfer to emergency, adjustable from 0 to 5 minutes for controlled timing of transfer of loads to emergency.
3. A generator stabilization time delay shall be provided after transfer to emergency.
4. An adjustable time delay and interlocking feature shall be provided on retransfer to normal. The time delay shall be adjustable from 0 to 30 minutes. Time delay shall be automatically bypassed if emergency source fails and normal source is acceptable.
5. A 5-minute cooldown time delay shall be provided on shutdown of engine generator.
6. All adjustable time delays shall be field adjustable without the use of special tools.

Each ATS shall have the following additional features:

1. A set of contacts rated 5 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.

2. A push-button type test switch located on the front of the enclosure door shall be provided to simulate a normal source failure. This function shall be able to be locked out.
3. A push-button type switch located on the enclosure door shall be provided to bypass the time delay on transfer to emergency, the engine exerciser period on the retransfer to normal time delay whichever delay is active at the time the push-button is activated. This function shall be able to be locked out.
4. Terminals shall be provided for a remote contact as follows
   a. Remote contacts which opens to signal the ATS to transfer to the emergency source.
   b. Remote contacts which open to inhibit transfer to emergency and/or retransfer to normal.
5. Auxiliary contacts shall be provided on the transfer mechanism and connected to the PLC. The auxiliary contacts shall be rated 10 amps, 250 VAC and provided two contacts, closed when the ATS is connected to the normal source and two contacts, closed, when the ATS is connected to the emergency source.
6. Indicating lights shall be provided, one to indicate when the ATS is connected to the normal sources (green) and one to indicate when the ATS is connected to the emergency sources (red).
7. Auxiliary contacts shall be provided for signal availability from the 11BG accessory module (Normal Available, Normal Failure, Generator Available and Generator Failure). The terminals from the module shall be connected to the source as shown on the plans.

The ATS shall be furnished and installed in the ATS enclosure as shown on the plans. Each Controller shall be a flush-mounted display with LED indicators for switch position and source availability mounted to the front of the enclosure door. Each Automatic Transfer Switch shall be a four-pole, 200-ampere, 480-volt switch and approved equal to Automatic Transfer Switch Co., Model 300.

Surge Suppression Device (SSD)

The Contractor shall furnish and install the Transient Voltage Surge Suppression Device (SSD) equipment having the electrical characteristics, ratings and modifications as specified herein and as shown on the contract drawings. The SSD shall be sized as a service entrance application and located on the load side of the nearest disconnect switch. To maximize performance and reliability, the AC surge protection shall be integrated into the ATS enclosure as shown on the plans. All surge suppression shall meet the latest requirements and UL standards.

Electrical Requirements for the system are as follows:

1. Unit Operating Voltage - Refer to drawings for operating voltage and unit configuration.
2. Maximum Continuous Operating Voltage (MCOV) - The MCOV shall be greater than 115% of the nominal system operating voltage.
3. The suppression system shall incorporate a hybrid designed Metal-Oxide Varistors (MOV) surge suppressor for the service entrance and other distribution level. The system shall not utilize silicon avalanche diodes, selenium cell, air gaps or other components that may crowbar the system voltage leading to system upset or create any environmental hazards.
4. Protection Modes - For a wye configured system, the device must have directly

connected suppression elements between line-neutral (L-N), line-ground (L-G), and neutral-ground (N-G). For a delta-configured system, the device must have suppression elements between line to line (L-L) and line to ground (L-G).

5. UL 1449 Suppressed Voltage Rating (SVR) - The maximum UL 1449 SVR for the device must not exceed 800V for L-N, L-G, N-G modes and 1800V for L-L mode.

SSD Design for the system shall be as follows:

1. Balanced Suppression Platform - The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating TVSS modules shall not be acceptable.
2. Electrical Noise Filter - Each unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be 50 dB at 100 kHz using the MIL-STD-220A insertion loss test method. Products not able to demonstrate noise attenuation of 50 dB @ 100 kHz shall be rejected.
3. Extended Range Filter -The Surge Protective Device shall have a High Frequency Extended Range Tracking Filter in each Line to Neutral mode with compliance to UL 1283 and NEMA LS1. The filter shall have published high frequency attenuation rating in the attenuation frequencies.
4. Internal Connections - No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be hardwired with connections utilizing low impedance conductors and compression fittings.
5. Standard Monitoring Diagnostics - Each SSD shall provide integral monitoring options:
   a. Each unit shall provide a green / red solid state indicator light shall be provided on each phase. The absence of a green light and the presence of a red light, shall indicate which phase(s) have been damaged.
   b. Remote Status Monitor - The TVSS device must include form C dry contacts (one NO and one NC) for remote annunciation of unit status. The remote alarm shall change state if any of the three phases detect a fault condition.
   c. Audible Alarm - The TVSS shall provide an audible alarm with a reset pushbutton that will be activated under any fault condition.
   d. Event Counter - The TVSS shall be equipped with an LCD display system designed to indicate to the user how many surges, sags, swells and outages have occurred at the location. The event counter triggers each time under each respective category after significant event occurs. A reset pushbutton shall also be standard allowing all counters to be zeroed.
   e. Push to Test - The TVSS shall be equipped with push-to-test feature, designed to provide users with real time testing of the suppressor's monitoring and diagnostic system. By depressing the test button, the diagnostic system initiates a self test procedure. If the system is fully operational, the self test will activate all indicator lights.
   f. Voltage Monitoring - The TVSS shall display true Root Mean Square (RMS) on three L-N voltage protection mode on Wye configuration and three L-L voltage on delta configuration.

Rotary Cam Limit Switch

Straight drive combination rotary limit switches shall be furnished and installed in the machinery

rooms as shown on the plans for Savannah Road Bridge. Each limit switch enclosure shall contain a cam-operated limit switch. Gearing furnished with the operating machinery, which shall rotate the input shaft, shall drive the combination unit. An integral reducer shall be provided with each unit, which shall provide an overall reduction as specified on the mechanical plans.

Each unit shall have the number of circuits as shown on the Plans. The rotary limit switches shall be individually micro-adjustable and have provisions for internal vernier adjustments. The limit switch shall allow for a one-quarter (¼) degree contact operation repeatability. Each contact of the limit switch shall be single-pole, double-throw, precision-type, snap-action switches. The resolver portion of the unit shall be used in conjunction with the position display and shall meet the requirements for resolvers as stated under "Resolvers".

Each unit shall be installed within a NEMA 4X stainless steel enclosure, and shall be Gemco Series 1980 or approved equal. The switch contacts shall have a minimum AC inductive continuous current carrying rating of 15A and a minimum DC resistive continuous current carrying rating of 15A.

The span limit switches shall be provided as required with a shaft extension for connection of the position resolver.

Each switch shall be preset at the factory to the settings shown on the Contract Plans. It shall be the Contractor's responsibility to determine the proper direction of rotation of each switch and to advise the manufacturer accordingly.

Manual Operation Limit Switch

Emergency operation limit switches for the span drive machinery, tail lock motors, center lock motors, span lock motors and gates motors shall be furnished and installed for the Rehoboth Avenue and Savannah Road Bridges as shown in the Plans. The switches shall trip when the mechanical clutch is activated.

Each limit switch shall meet the following requirements:

1. Track type, lever actuated, spring return, two circuit limit switch
2. 1 NC safety contact and 1 NO ancillary contact
3. Rated 600V, 10A
4. NEMA 4/6P watertight enclosure
5. Meet requirements of EN 954-1, ISO 13849-1,NFPA 79, ANSI B11.19

The length of the arm and size roller on each switch shall be to allow for the limit switch to be activated with the clutch system.

Each limit switch shall be installed in such a way to permit field adjustment of the trip point in order to optimally sense the clutch position. Manual operation limit switches shall be the Allen Bradley 802T Direct Opening Safety Limit Switch or approved equal.

Position Resolver

Each resolver shall send a signal to the PLC and touchscreens mounted on the control desk and control enclosures as specified herein to indicate absolute leaf angular position.

The position resolver shall produce an analog signal via a brushless resolver. This signal shall be converted into a 4-20 mA signal format by a ratiometric-tracking converter. The position resolver shall retain positional information, even in the event of a power failure to provide a fully absolute position resolver system. The position resolver shall be a single turn, heavy-duty, Size 40, and mounted in a NEMA-4X stainless steel enclosure. The outputs shall be furnished with short-circuit proof PNP transistors. The unit shall be furnished with a lockable, external toggle switch to allow changing of count direction without opening the housing. The unit shall be powered by a separately protected 24-volt DC source, located in the PLC cabinets. The unit shall provide a 4-20 mA output with end mount connector and multiconductor cable as provided by the manufacturer.

Each resolver shall be scaled to equate resolver shaft rotation to actual span travel in angular degrees.

	Resolver shaft rotation	Bridge Angular Position
Rehoboth Avenue	346.5°	50 Degrees
Savannah Road	270°	80 Degrees

Position resolver shall be the AMCI DC25 Absolute Single Turn Analog Rotary Shaft Encoder with integral cable or approved equal.

Speed Switch

A speed switch, associated magnet, hardware and supports shall be furnished and installed in the machinery rooms as shown on the plans. The speed switch shall send a 4-20mA signal to the PLC as specified herein to indicate span motor operating speed on the touchscreens. A separate alarm contact shall provide a failsafe alarm contact to be used to monitor the deceleration speed at each bridge. The unit shall be rated NEMA-4X and connect as shown on the plans.

The speed switch shall be a self-contained system with sensor and adjustable failsafe relay contact. The 4-20 mA signal shall be directly proportional to the rotational speed of a monitored shaft and shall have a 4 digit LCD display capable of displaying from 0.000 to 9,999 rpm or from 4 to 20 mA.

The speed switch shall be the FB420 as manufactured by Electro Sensors or approved equal.

Proximity Limit Switch

Unless otherwise shown and detailed on the plans, proximity limit switches shall be furnished and installed for the fully closed, span over travel, tail lock pulled, tail lock driven, span lock pulled and span lock driven at Rehoboth Avenue and Savannah Road bridges.

The proximity limit switches shall be inductive type, barrel type, stainless steel and rated NEMA 4X. Each limit switch shall be provided with mounting brackets, hardware and supports as shown on the plans and required for proper operation. The sensing range shall be a minimum of 40mm unless otherwise noted.

The switch shall include a conduit NPT hub and adapter for connection to 3/4" conduit. Each unit shall include a LED indicating light and shall be 120VAC and connected as a PLC input. Proximity limit

switches shall be the Turk NI40-G47SR or approved equal.

Span Drive Motors

Each span drive motor shall be AC induction type, squirrel cage, vector duty. Each motor shall be built in strict accordance with NEMA publication MG 1 and designed for use with a Variable Frequency Drive AC closed loop vector controller (Rehoboth Avenue) and AC open loop sensorless vector (Savannah Road). Each span motor shall be 3 phase 60 Hertz, NEMA Design A with moisture resistance insulation, 40° C temperature rise, and capable of instant reversing. Motor frame shall be constructed of cast aluminum. Ratings shall be as follows:

	Rehoboth Avenue	Savannah Road
Horsepower	60HP	15HP
Nominal Voltage	480 VAC, 3 Phase	480 VAC, 3 Phase
Duty	30 minute	30 minute
Speed	900 RPM	720 RPM
Frame Size	445T*	365T*
Insulation	HHH	HHH
Service Factor	1.0	1.0

* Frame size shall be coordinated with the motor and drive manufacturer for accuracy.

The motors shall be totally enclosed non ventilated (TENV) construction, with re greaseable ball bearings, moisture resistant insulation and internal space heater sized by the manufacturer. The space heater shall operate at 120 VAC. The motor shall have a special extended shaft as shown on the mechanical contract drawings to accommodate the motor coupling on one end and a rear mounted encoder on the other. The motor shafts shall be cadmium plated. A drain hole of not less than ½ inch diameter shall be provided at the bottom of the motor, fitted with a suitable drain plug.

The motor encoder shall be industrial type, marine duty, heavy mill duty, fully sealed and contain a diagnostic LED indicator. The unit shall be fabricated of stainless steel and be compatible with the motor drive system as specified under "Drive Cabinets." The encoder shall be the Avtron AV56 thin-line II or approved equal.

All windings shall be copper. The motor shall be capable of having a minimum breakdown torque of 300% of full load torque. The motor must have a speed range of 1000:1 and be capable of providing full torque at zero speed. Motor design shall be low inertia and slip design. A normally closed temperature sensor shall be embedded in the windings.

Each motor junction box mounted to the motor shall be liberally sized and located to avoid interference with the machinery. The conduit boxes shall be sized in accordance with the requirements of the NEMA MG 1 2003 PART 11. The junction box shall be provided with terminal blocks, sized by the manufacturer to terminate all cables routed to the motor. A suitable ground lug shall also be provided.

Each motor shall be provided with an output shaft as shown on the drawings.

The motors shall be designed and manufactured in the United States of America.

All motors shall be manufactured to the following standards:

1. IEEE Marine Standards No. 45.
2. American Bureau of Shipping (A.B.S.).
3. U.S. Coast Guard Inspection Service
4. NEMA MG-1

Span drive motors shall also be provided with the following features in order to meet the requirements of these Specifications.

1. All aluminum parts chemical film and zinc chromate primer.
2. Cadmium plate shaft and hardware (FED QQ P 416).
3. Double Sealed ball bearings.
4. Seal all joints and eye bolt holes.
5. Sealed leads in terminal box.
6. Shaft seals.
7. Removable drain plugs.
8. Final coat of epoxy paint.
9. Corrosion resistant coating rotor and stator laminations.
10. Stainless steel nameplate.
11. Super 'H' insulation including protection against fungus growth.

The motor frame shall be finished with a corrosion resistant paint or coating. Exposed unpainted metal surfaces shall be of a corrosion resistant material.

An in-sight disconnect switch shall be provided within view of each motor as specified under "Disconnect Switches." The 120-volt strip heater in each motor frame shall be wired to the normally open auxiliary contact in the corresponding motor disconnect switch.

Motors must be designed to operate at carrier frequencies up to 30 kHz. All motors shall be dynamically balanced. The Contractor shall ensure that the span motor is electrically and mechanically compatible with the span drive as approved by the span drive manufacturer.

Motors shall be manufactured by Reuland Electric Company or approved equal.

Lock Motors

Each motor for the span lock and tail locks shall be fabricated per NEMA publication MG 1 and designed for high-slip, high-starting torque, NEMA Design D, weatherproof, totally-enclosed, non-ventilated (TENV), ball-bearing, squirrel-cage motor, capable of withstanding instant reversal when running at full speed. It shall be rated on a basis of 30 minutes at 40 degrees Celsius ambient. Each motor shall be provided with a single-phase, 120-volt, space heater installed in the lower frame beneath the windings. The wattage of the heater shall be determined by the manufacturer. Ratings shall be as follows:

	Rehoboth Avenue	Savannah Road
Horsepower	3HP	3HP
Nominal Voltage	480 VAC, 3 Phase	480 VAC, 3 Phase
Duty	30 minute	30 minute
Speed	900 RPM	900 RPM
Frame Size	215*	215*
Insulation	HHH	HHH
Service Factor	1.0	1.0

*Frame size shall be coordinated with the motor manufacturer for accuracy.

Each lock motor junction box mounted to the motor shall be sized in accordance with the requirements of the NEMA MG 1 2003 PART 11. The junction box shall be provided with terminal blocks, sized by the manufacturer to terminate all cables routed to the motor. A suitable ground lug shall also be provided.

Each lock motor shall be provided with a motor-mounted, totally enclosed, spring-set, 480-volt, magnetically released disc brake with rated torque approximately equal to, but not less than, motor full-load torque.

Each brake shall be of dust-tight, self-adjusting, weatherproof, cast-iron construction, except modified for marine duty to comply with IEEE Standard 45, "Recommended Practice for Electrical Installations on Shipboard". The marine duty modification includes the use of brass internal parts.

Each brake shall be provided with a 120-volt, 15-watt internal strip heater and a single-voltage operating coil. Each brake shall be approved equal to the Stearns 87,000 Series brake with M-Mod for marine duty, equivalent as manufactured by Harnischfeger or Dings, or approved equal.
Each lock motor shall be controlled by magnetic reversing contactors, electrically and mechanically interlocked.

Manual operation limit switches shall be furnished and installed under this item and assembled with the lock motors. The manual operation limit switches shall meet the requirements specified under "Manual Operation Limit Switch." The manual operation limit switches shall be mounted in a similar arrangement to the existing span lock hand crank limit switches at Rehoboth Avenue and include a custom fabricated lever to cover the shaft on each motor.

The locks shall be operated from selector switches and touchscreens located on the control console. The switches shall have spring-return to center drive and pull positions, with circuitry arranged such that the lock will stop immediately when the lock rod is fully driven or pulled.

Each existing tail lock at Savannah Road Bridge shall be provided with a new rotary cam limit switch and two new individual proximity sensors. Each new center lock at Savannah Road shall be provided with new limit switches as part of the actuator assembly. Each existing span lock at Rehoboth

Avenue shall be provided two new individual proximity sensors. The limit switches shall be as specified and shall provide contacts to control the limit of travel in each direction and for indication and sequence interlocking.

New center lock motor for the actuator assembly shall be specified under the item "615503 - Bridge Mechanical System."

Adjustment of center lock crank arms, supports, strike plates and limit switches for proper operation shall be done under the item "615503 - Bridge Mechanical System."

Motors shall be manufactured by Reuland Electric Company or Engineer approved equal.

Motor Brakes and Machinery Brakes

Three (3) thrustor-type electric brakes shall be furnished and installed in each machinery room on the Savannah Road Bridge (6 total). One brake shall be located on the output shaft of the span motor and designated as a motor brake and the other two shall be located on the secondary gear frame input shafts and designated as machinery brakes.

Two (2) thrustor-type electric brakes shall be furnished and installed in the machinery room at the Rehoboth Avenue Bridge (2 total). One brake shall be located on each input shaft of the primary speed reducer and shall be designated as the north and south motor brakes.

Each brake shall be a spring set, thrustor released, shoe type, open brake and shall be provided with corrosion resisting fittings.

The Savannah Road Bridge motor brakes shall be rated on a 60-minute basis and shall be set to exert an actual retarding torque of 160 ft-lbf. Each motor brake shall be a Mondel heavy duty drum brake 10" MBT/E-ED23 or approved equal with corrosion resistant hardware and other options specified herein.

The Savannah Road Bridge machinery brakes shall be rated on a 60-minute basis and shall be set to exert an actual retarding torque of 380 ft-lbf. Each machinery brake shall be an 11" Mondel ST/E-ED50/6 heavy duty drum brake with corrosion resistant hardware and other options specified herein.

The Rehoboth Avenue Bridge motor brakes shall be rated on a 60-minute basis and shall be set to exert an actual retarding torque of 350 ft-lbf. Each motor brake shall be 11" Mondel ST/E-ED50/6 heavy duty drum brake or approved equal with corrosion resistant hardware and other options specified herein.

For both the motor and machinery brakes an approved equal manufacturer shall be considered with additional modifications as needed for proper operation and alignment. The Contractor shall be responsible for these modifications if an alternate manufacturer is selected and approved by the Engineer at no additional cost to DelDOT.

The existing brakewheels shall be reused at the Rehoboth Avenue Bridge motor brakes and the Savannah Road Bridge machinery brakes. For the Savannah Road Bridge motor brakes, the brake manufacturer shall furnish new brakewheels with the brakes. The friction surfaces of the new brakewheels shall be chrome plated. The bores shall be left undersized and the wheels shall be shipped to the motor manufacturer who shall finish bore and keyseat the wheels and fit them onto the designated

shafts.

The down stroke time delays of the thrustors shall be set in such a manner that the brakes will not be applied simultaneously should electric power fail while the span is in motion. For Savannah Road Bridge, the motor brake shall be set with a 1-second down stroke time delay, while the machinery brakes shall be set with a 4 second time delay. For the Rehoboth Avenue Bridge, one motor brake shall be set with a 1-second down-stroke time delay, while the other brake shall be set with a 4-second time delay.

The oil used in the thrustor operating chambers of the brakes shall be of a grade as recommended by the manufacturer. It shall have a free operating temperature range between -40º F and 150ºF.

The thrustors shall be actuated by 480 volt, three phase, 60 Hertz, totally enclosed, squirrel cage motors controlled by magnetic contactors. The rated stalled thrust of each thrustor shall be not less than 135 percent of the thrust actually required to release the brake with the torque adjusted to the continuous rated value.

Each bridge brake motor shall be installed with approved sizes and types of wire terminals and splice fittings for the connection of the motors to the circuit wiring. Connections between the rigid conduit system and the motors and brakes shall be made with approved flexible conduit.

The brakes shall include a 16 gauge stainless steel cover enclosing the entire brake assembly. Provide a 120-volt strip heater positioned near the brake wheel in each brake shall to prevent condensation and moisture from freezing the drum and brake pads. Wire the normally open auxiliary contact in the corresponding motor disconnect switch to disconnect the heaters when the switch is in the off position.

An in-sight disconnect switch as specified under "Disconnect Switches" shall be provided within range view of each brake motor.

Brake Limit Switches

Each brake shall be furnished with three lever type limit switches (brake set, brake released, and brake hand released) for interlock and indication of the span brakes as specified herein.

Each brake hand released limit switch shall have the number of contacts as shown on the plans and shall not change the torque setting or require removable levers or wrenches. Each hand release shall be provided with a lever type limit switch for interlocking purposes. It shall not be possible to set the hand release of the brakes without tripping these switches.

Each brake set limit switch and released limit switch shall have number of contacts as shown on the plans. Each position shall be provided with a lever type limit switch for interlocking purposes. The brake released limit switch shall trip when the brake is electrically released or hand released. The brake set limit switch shall trip when the brake is fully set.

Each limit switch shall be installed with an SOW cable of sufficient length and conductor quantity to connect the limit switch to the brake terminal boxes.

The limit switches shall be heavy duty industrial, rated for 10A, 120VAC and shall be Square D 9007C with 1NO/1NC contact.

Gate and Traffic Flashers

The four warning gates and two barrier gates at Rehoboth Avenue and the four warning gates at Savannah Road shall be modified as shown on the plans and specified herein.

The Contractor shall furnish and install a new flasher assembly inside the existing gate electrical enclosures as well as the two new west side traffic signals on Savannah Road. The flashers shall have connections for steady and alternating flashing circuits which shall be connected to the new flexible cables. The flashers shall be B&B Roadway FL-120 VAC or approved equal.

Gate Door Limit Switches

New door switches shall be furnished and installed on each access door to open the control circuit and de-energize the motor controls when the door is open. The door switches shall be lever type limit switches and shall be mounted to the existing housing. The limit switches shall be heavy duty industrial, rated for 10A, 120VAC and shall be Square D 9007C with 1NO/1NC contact.

Traffic Signals

The Contractor shall furnish and install new traffic signals as shown on the plans.

The two new traffic signals on the west side shall have a R10-6A "Stop Here on Red" signage with 12" Red flashing beacons on a steel pole and shall be furnished and installed as indicated on the plans at Savannah Road. The assembly shall include a control enclosure to house the fuses and flasher. The flasher shall be as specified herein.

12" Red/amber/green signal heads shall be furnished and installed on the new mast arm assembly on the west side of the bridge at Rehoboth Canal.

All signals and signage shall meet the requirements of MUTCD, AASHTO and DelDOT standards.

Disconnect Switches

Motor disconnect switches shall be unfused safety switches, for use as disconnects, and shall be installed in-sight to each warning gate motor, barrier gate motor, span lock motor, center lock motor, tail lock motor, brake motor, and span motors. Each unit shall be capable of being locked in the off position.

The switches shall be 3 pole, non-fusible, heavy-duty, safety switches in watertight and dust-tight NEMA 4X, stainless-steel enclosures with a rating of 30 amperes for the tail locks, span locks, center locks and brakes and 100 amperes for the Savannah Road span motors and 200 amperes for the Rehoboth Ave span motor. Each disconnect shall be furnished with two N.O. auxiliary contacts and phenolic nameplate to identify the corresponding motor. Size shall be based on the actual full load current of each motor.

New motor disconnect switches shall be furnished and installed to replace the existing units within the warning and barrier gate housings. The new units shall be 3 pole with two auxiliary contacts. Each disconnect switch shall be installed in a location that is easily seen and accessible. The disconnect switches shall be furnished in an enclosure rated NEMA 4 or 3R.

A new fused disconnect switch shall be furnished and installed for the new incoming service as shown on the plans for each bridge. The new service disconnect switch shall be a 200A, 600VAC, NEMA 4X, S.S. unit. The location, type and installation shall be coordinated with Delmarva and Lew BPW.

Wire and Cable

Except where otherwise noted, wiring in conduits shall be single conductor. All wire and cable shall conform to the requirements of NEMA Pub. No. WC70-1999. The minimum number of conductors provided in each cable shall be as shown on the Contract Plans. The cable installation in conduit, wireway and troughs shall conform to the latest edition of NEC and according to any other applicable code under local jurisdiction.

All conductors shall be soft annealed copper wire conforming to the requirements of NEMA Pub. No. WC70. All conductors shall have Class K stranding.

The insulation shall be a chemically cross linked polyethylene compound conforming to the requirements of Part 3.6 of NEMA Pub. No. WC70. The wire type for all conductors except shop wiring installed within the confines of the control cabinets or control desk shall be XHHW-2 as listed under NEC Table 310-13. "Conductor Application and Insulations". The wire type for all shop-wired conductors installed within the confines of the control cabinets and control desk shall be SIS as listed under NEC Table 310-13. "Conductor Application and Insulations".

All wire and cable shall be of a nationally recognized brand, acceptable to the Engineer, and shall have marks always used on the particular brand for identifying it. Acceptable manufacturers are as follows Houston Wire and Cable, Service Wire Company, Clifford of Vermont, Alpha Wire Company, Allied Wire and Cable, Okonite Company, General Wire and Cable, and Draka USA.

Equipment ground conductors shall be bare, stranded, coated copper conforming to the requirements of NEMA Pub. No. WC70, Part 2. When required by the National Electrical Code (NEC), equipment ground conductors shall be provided with approved insulation.

Flexible cable for specified connections shall be rubber insulated, multiple-conductor portable cords conforming to the requirements of NEMA Pub. No. WC3, Part 7.7 or NEMA Pub. No.WC8, Part 7.4 for hard service. Each cable shall be provided with a heavy-duty neoprene jacket conforming to the requirements NEMA Pub. No. WC3, Part 7.7.5.1 or NEMA Pub. No.WC8, Part 7.4.5.1. Flexible cables shall conform to the National Electrical Code, Article 400 for hard service.

The flexible control cables shall be Type SOOW -A portable cord rated 600 volts, 90-degree C. Conductors shall be flexible stranded bare annealed copper provided with ethylene propylene rubber (EPR) insulation. Cable jacket shall be chlorinated polyethylene (CPE).

New fiber optic and industrial Ethernet cables shall meet or exceed the following. The Contractor shall ensure system compatibility with all cables, equipment and systems.

Fiber optic Cables: Multi-mode, 62.5 microns core size, 125 micron cladding, less than 3.4 dB/km at 850nm and less than 1.0 dB/km at 1300 mm attenuation, greater than 200 MHz/km at 850 nm and greater than 500 MHz/km at 1300 nm bandwidth.

Industrial Ethernet Cables: Cat 6 shielded cable for use in high noise environment, 600 Volt rated

PVC jacket rated for -4°F to 176°F.

Fiber optic cables and Ethernet cables shall be installed and connected per manufactures recommendations. Splices for fiber optic cables shall be made with fiber optic splice kits inside an isolated enclosure and with necessary connectors.

Wire markings and tags shall be provided for all the conductors and shall be factory-applied heavy duty, waterproof, permanently marked, and resistant to ultraviolet light deterioration. Numbers and letters shall be black or blue on a white background. Each wire and cable shall be preprinted with labels for each wire and/or cables entire length. Each preprinted label should match the interconnection diagram shop drawing. The Contractor shall submit the proposed wire marking system and a sample of the wire markers to be installed to the Engineer for approval. The labels shall be polyolefin heat shrink tubing, approved equal to Panduit LS5 labeling system.

With the exception of the submarine cable conductors where flanged forks shall be used, when it becomes necessary to connect a cable and/or wire No. 8 AWG or smaller insulated wire ferrules shall be used. The ferrules shall be attached to the wire using the manufacturers approved tool.

Strain relief bushings shall grip the cable jacket to provide a watertight seal at the point of cable entry. Strain relief bushings shall be OZ Gedney Type SR or approved equal.

Strain relief devices shall grip the cable jacket with an entwining cable mesh to support the weight of the cable where it enters the terminal box. Strain relief devices shall be Kellem cable grips or approved equal.

Conduit System

All new conduits and fittings as shown on the plans shall be as noted herein. Where installed indoors where heat fixtures are located or where the conduit is encased in dirt or through concrete the conduit shall be rigid steel galvanized conduit. All other conduit shall be PVC coated rigid galvanized steel conduit.

In general, conduits shall not be less than ¾ inches in diameter. Sections of conduit shall be connected to each other with screw couplings made up so that the ends of both conduits will butt squarely against each other inside of the coupling.

All PVC coated galvanized steel conduit, associated fittings, and associated supporting products shall be provided by the same manufacturer to ensure that a five-year product warranty is achieved

The PVC coated galvanized rigid conduit must be UL Listed and ETL Verified. Both the PVC and Zinc coating must have been investigated by UL as providing primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to plastic coating must be UL listed. All conduit and fittings must be new, unused material.

The PVC coated galvanized rigid conduit must be ETL Verified to the Intertek ETL High Temperature H2O PVC Coating Adhesion Test Procedure for 200 hours. The PVC coated galvanized rigid conduit must bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.

A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation.

Urethane coating of nominal 2 mil thickness shall be uniformly and consistently applied to the interior of all conduit and fittings. Conduit or fittings with thin or no coating shall be unacceptable.

The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C).

All female threads on fittings and couplings shall be protected by urethane coating. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the thread.

PVC coated conduit and fittings shall be Perma-Cote Coated galvanized rigid conduit and Fittings as manufactured by Perma-Cote, Gilmer, Texas or approved equal.

Flexible conduit where required shall be liquid tight steel conduit conforming to the requirements of UL 360. Fitting and connectors used in conjunction with flexible conduit shall also be steel liquid tight fitting with hot dipped galvanized finish when used with rigid conduit and PVC coated steel when used with PVC coated steel conduit.

Unless otherwise noted the conduit supports shall consist of PVC coated U-bolts attached to PVC coated strut supports bolted to the steel members. All U-bolts and bracket hangers shall be provided with medium-series lock washers and hexagonal nuts.

In general, conduit fittings shall be of the same type and material as the associated conduit. Where used with PVC coated conduit the fittings shall be PVC coated.

Conduit expansion fittings shall be PVC coated and shall be provided with flexible bonding jumpers to maintain the electrical continuity across the joints. The fittings shall permit a total conduit movement of 4 or 8 inches as may be required.

Conduit expansion/deflection fittings shall permit a movement of ¾ inch from the normal in any direction. Flexible bonding jumpers shall be required to maintain bonding integrity whenever expansion fittings are required.

Install drain fittings in all enclosures and conduit systems. Fittings shall be fabricated of stainless steel and shall be capable of passing 25 cc of water per minute.

Conduit hubs shall be provided with a ground bushing to connect the equipment ground conductors and enclosure ground lugs. The hubs shall be PVC coated when used in conjunction with PVC coated conduit.

Conduit tags for new and existing conduit shall be 1/8" thick flexible acrylic white nametag with black lettering. Each tag shall be a minimum of 1 ¼" x 3 ¾" with space for three lines of text. Engraving shall include the conduit reference number which can be referred back to the as-built documents, conduit

size, wire size and quantity. Conduit tags shall be connected to each end of conduit with two plastic ties.

For core drill penetrations, the contractor shall core drill the required hole size and seal the conduit hole/penetration with a fireproof foam sealer intended to be used with conduit systems. The sealer shall be installed per manufacturer recommendations.

Wireway and Troughs

Wireways shall be furnished and installed in the control house as shown on the plans or as otherwise required to facilitate the installation of wiring. The Wireways shall be NEMA 12, constructed of No. 14 gauge steel, suitably reinforced with structural steel angles, and welded continuously at all seams and joints.

Wireways shall have a removable cover on one side to provide access to the interior. Stainless steel screw clamps spaced no more than 8 inches apart shall secure the cover. Intermediate steel barriers shall be provided to separate power and control wiring when possible. NEMA 12 wireways shall be approved equal to the Feed Through Type 12 Wireway as manufactured by Hoffman or approved equal.

Boxes

All junction boxes, pull boxes, terminal boxes, and cabinets shall be NEMA 4X, 14-gauge, stainless steel enclosures with hinged, 14 gauge, stainless steel doors supported by a continuous stainless steel hinge with removable pin unless otherwise noted on the plans. Seams shall be continuously welded and ground smooth. Each enclosure shall be provided with stainless steel fast operating door clamp assemblies and oil resistant gasket to insure a watertight seal. No box shall be drilled for more conduits or cables than actually enter it.

Boxes and cabinets shall be Bulletin A51S and A4S with clamp assemblies A L23SS as manufactured by Hoffman Engineering Company, equivalent manufactured by Henessey or Wiegmann or approved equal.

Terminal boxes shall be of sufficient size to provide ample room for the terminal blocks and interior wiring, and for the installation of conduit terminations and multi-conductor cable fittings. Interior mounting buttons with tapped holes shall be provided for mounting the terminal blocks.

Terminal blocks shall be feed-through type screw connection or lug type modular terminals sized for the required conductor being terminated and shall be din rail mounted. Double stack terminals are not permitted. Each terminal shall be suitably marked using factory printed terminal markers with the associated wire number. Hand written markers are not acceptable. Screw type terminals ~~Terminal~~ connections to the associated conductor shall be achieved using insulated wire ferrules. Lug type bolt on connections to the associated conductor shall be achieved using insulated flanged fork connectors. Bare wire connections are not acceptable. At least ten percent spare terminals shall be provided. Terminal blocks shall be Phoenix Contact, UT4 or approved equal.

Power distribution blocks shall be used for conductor sizes No. 6 and larger and shall be UL listed. Terminal blocks shall be suitable for use with copper wire and shall provide a withstand voltage rating of 750 volts per IEEE switchgear standards. Corrosion resistant marking strips shall be provided for conductor identification. At least ten percent spare terminals shall be provided. Terminal blocks shall be Gould Shawmut Power Distribution Blocks - Heavy Duty Series 68000 or approved equal.

The interior of all boxes shall be provided with insulated supports from which bundled cables may be supported.

Hardware and Supports.

Mounting bolts, nuts, washers and other detail parts used for fastening boxes, disconnect switches, limit switches, conduit clamps, cable/conduit supports, brackets and other electrical equipment shall be of stainless steel conforming to the requirements of ASTM A276, Type 316. Bolt heads and nuts shall be hexagonal, and shall be provided with medium series lock washers. Bolts smaller than ½ inch in diameter shall not be used except as may be necessary to fit the mounting holes in small limit switches, boxes and similar standard devices.

Unless fabricated from type 316 stainless steel, which has a minimum thickness of 5/16 inch, supports for conduits, cables, boxes, cabinets, disconnect switches, limit switches and other separately mounted items of electrical equipment shall be fabricated from structural steel not less than 3/8 inch in thickness. Channels, angles, bent plates, clip angles, other structural steel supporting members, hardware and gaskets for supporting electrical equipment shall be paid for under this item. Structural steel supporting members detailed under this item shall conform to the requirements specified elsewhere in this Contract.

Full neoprene gasket shall be furnished and installed for each box not less than 1/8-inch thick, between the equipment and the surface of the concrete.

Anchoring system for fastening equipment or brackets to concrete surfaces shall consist of stainless steel threaded rods and adhesive epoxy. All parts of the anchors shall be of Type 316 stainless steel. The Contractor is also responsible for furnishing any installation tools as required by the manufacturer to properly install the anchoring system. Threaded rods shall be HAS type 316 stainless steel threaded rods as manufactured by Hilti Corporation or approved equal, epoxy shall be HIT RE 500 Adhesive Epoxy as manufactured by Hilti Corporation or approved equal.

Receptacles:

All indoor receptacles shall be 20-ampere, 125-volt, three-wire, grounding type, polarized, duplex convenience outlets. Ground fault receptacle outlets shall be installed in locations as shown on the drawings or as required by the National Electrical Code. Each indoor receptacle shall be flush mounted in new outlet boxes and shall be provided with a Type 304 stainless steel cover plate. Outdoor receptacles shall be similar except each receptacle shall be a GFCI outlet and shall be provided with a watertight cast iron cover plate. Receptacles shall be specification grade manufactured by Hubbell, Arrow Hart, Leviton, or approved equal.

Switches:

All lights shall be controlled from tumbler switches located in a convenient, accessible location. All tumbler switches shall be specification grade, 20-ampere, 125-volt switches. Indoor switches shall be flush mounted in new outlet boxes and shall be provided with Type 304 stainless steel plates. Outdoor switches shall be mounted in waterproof, cast-iron, hot-dipped galvanized, surface mounted boxes. Switches shall be mounted 4 feet above the adjacent floor or platform. Switches shall be Specification Grade switches manufactured by Hubbell, Arrow Hart, Leviton or approved equal.

Indoor Recessed LED Light Fixture (Type A):

Indoor recessed mount light fixture shall be furnished and installed in the control room where shown on the plans. Each fixture shall be long life LED fixture with high efficiency drivers. Housing shall be recessed mounted and formed from cold rolled steel and painted after fabrication. The unit shall be 2'X2' rated for 120 VAC with 4000 lumens (35 watts) controlled from a wall switch. Fixtures shall be Lithonia Lighting Model 2ACL or approved equal.

Indoor Surface Mount LED Lighting Fixture (Type B):

Indoor surface mount light fixture shall be furnished and installed where shown on the plans. Each fixture shall be long life LED fixture with high efficiency drivers. Housing shall be surface mounted and formed from cold rolled steel and painted after fabrication. The unit shall be rated for 120 VAC with 4000 lumens (35 watts). Fixtures shall be Lithonia Lighting model 2ACLX2 (2' X 2') or 2ACL4 (2' X 4') or approved equal.

Industrial LED Lighting Fixture (Type D):

Each industrial light fixture located as shown on the plans shall be wall mounted explosion proof type, sealed marine outdoor rated NEMA 4X units designed for wet locations. Each fixture housing shall have be aluminum with electrostatically applied, baked gray epoxy clad finish. Globes shall be made of explosion proof glass, gaskets are silicone, all hardware, catch assemblies and guard shall be stainless steel. Each lamp shall be LED and equivalent to a pulse start metal halide 175W light level. The light assembly shall be Appleton Code Master LED Factory Installed Luminaire or approved equal.

Emergency lights (Type E):

Emergency Lighting units and illuminated exit signs shall consist of three 12-watt, H-lamp, halogen lamps with a solid-state dropout circuit for instantaneous load transfer on A-C failure. The emergency power source shall consist of two sealed, long-life, 10-year minimum, lead-acid batteries that shall be kept at full charge by a solid-state, pulse type battery charger. The battery shall have sufficient capacity to operate the specified lamps for a period of not less than 5 hours. All components shall be furnished in a sheet-steel housing suitable for wall mounting and provided with a permanent conduit connection. Outdoor units shall be rated NEMA 4X. Emergency lighting and exit signs shall conform to the specified requirements and manufactured by Exide Electronics, Emergi-Lite, Dual-Lite, or Engineer approved equal.

Outdoor LED Light (Type F):

Each exterior light fixture shall be wall mounted above each entrance door and outdoor rated with cast aluminum housing. Each fixture shall be gasketed with swing out door for maintenance. Each lamp shall be rated for 120VAC with 3400 lumens (33 watts). The light assembly shall be Appleton LED Wall Luminaire Model TWR1with 33 watt bulb or approved equal.

Hot Water Heater

Tankless instantaneous hot water heater where required shall be installed on the bridge below the sink in the control house. The water heater shall be on demand type with no delay when activated by a flow switch. The water heater shall be suitable for sanitary use and shall be rated at 4.1 kilowatts, 14.8

amps with a 56 degree Fahrenheit rise at 0.5 GPM. The Contractor shall supply all necessary supports, piping and fitting to properly install the unit. The water heat shall be Eemax model SP4277 or approved equal.

Air Conditioner

A wall mounted air conditioning unit shall be furnished and installed to replace the existing unit in the control room. The unit shall be rated for 208VAC and 12,000 BTU's minimum and shall be installed with a new NEMA 6-15R receptacle mounted near the unit.

Generator Diesel Fuel Lines

Diesel fuel piping shall be replaced in-kind where specified. In general, new fuel lines shall be black iron or flexible fuel hose rated for this service. No galvanized piping will be permitted. Flexible fuel lines shall be minimally rated for 300 degrees F and 100 psi.

Coupling and fitting shall be welded to the tank for connections to vent line, tank fill, low level fuel alarm, high level fuel alarm, engine fuel supply, engine fuel return, basin alarm, control sensor and fuel gauge.

The end of the suction line in the tank shall be provided with a double-poppet, brass foot valve and strainer located 3 inches clear above the bottom of the tank. Connection of both lines at the engine shall be made with bronze, flexible fuel hose with brazed-on brass couplings and threaded terminal fittings. The hose shall be approved equal to Anaconda Type S-1-H, Atlantic Metal Hose Type A-IP or Flexonics Series 300.

The connection in the fuel suction line shall be made with forged steel, plain-faced, slip-on welding flanges conforming to the requirements of ANSI B16.5-1968. The flanges shall be welded back and front to the connecting pipes. Gaskets shall be suitable for the intended use.

A fuel gauge and ultrasonic sensor shall be furnished and mounted on the storage tank to show in gallons the amount of fuel oil contained therein. The fuel sensor shall be furnished and installed in the existing fuel tank at Rehoboth Avenue. The sensor shall provide the PLC with a 4-20ma signal to indicate the level of fuel in the tank. The unit shall be rated NEMA 4X, fabricated from S.S and designed for submersible applications and capable of continuous monitoring of diesel fuel up to 30 feet. The sensor shall be manufactured by innovative components, model ULS, Ultrasonic level sensor or approved equal.

The fuel gauge shall have a weather proof, vertical direct reading, liquidometer suitable for use with diesel fuel oil. It shall have a 6 inch dial graduated every 25 gallons up to the full tank capacity of 800 gallons. The gauge shall be operated by direct mechanical linkage to a leverage float and arm, which shall be transmitted through a metal below seal assembly to isolate the gauge from the tank liquid and vapor.

Standard steel piping shall conform to the requirements of the current ASTM A53, Type S-Grade A. All piping shall be complete with all valves, fitting, supports, supports and clamps necessary for a complete installation. Drain plugs shall be provided at all low points in the fuel lines.

At the final completion of the Contract, the fuel tanks shall contain not less than 225 gallons of diesel fuel or 75% full for the propane tank.

Electric Heaters

New control house comfort heaters shall be furnished and installed on each level of the control house including the control rooms (operator's rooms), bathrooms, utility rooms, switchboard rooms and generator rooms.

Heating units shall either be baseboard type or wall mounted comfort heaters as specified in the plans or required per the room layouts. Heaters shall be located and positioned as to not interfere with new and existing equipment. The wall mounted units shall be forced air heaters as shown on the Plans and shall be rated 480/277 volt, three-phase, five-kilowatt electric heaters.

The baseboard style heaters shall be convection style heaters fabricated from heavy 18 gauge galvanized steel with heating elements constructed of rugged steel brazed fins. The length and size of baseboard heaters shall fit in the allowable space. The baseboard units shall be rated 277/120 volt, single phase, five-kilowatt electric heaters (control room) and 500 watts (for bathrooms).

Each heater shall be provided for a remote thermostat connection and contain an internal field terminal block(s) and built in contactor and transformer. Units without the internal contactor and transformer shall be provided by the contractor externally in a separate enclosure or included in the panel layout.

The Contractor shall also furnish and install new panelboards under this item as specified and shown on the plans to power the new and existing heaters. The panelboard shall be provided with a contactor to de-energize the heaters during bridge operation.

Thermostats shall be provided to control the heaters and shall have a setting range from 55 degrees to 90 degrees Fahrenheit and a differential of 3 degrees Fahrenheit and shall be provided with snap action contacts for actuation of the remote-controlled switch coils.

The thermostats shall be standalone controllers with LCD digital displays with graphical interface, internal clock scheduler, and independent relay outputs as well as an analog 4-20ma/0-10ma outputs. The relay contact outputs shall be used to control the heaters whereas the analog outputs shall be connected to the PLC for monitoring purposes. Thermostats shall be Honeywell T775M or approved equal electronic standalone controllers.

Panelboards

New panelboards shall be furnished and installed as shown on the plans for distribution of the bridge lighting, heating, and distribution circuits. The panelboards shall be of the dead-front type and shall be provided with quick-make, quick-break, thermal-trip, E-frame, both-on branch circuit breakers. Each breaker shall trip free of the operating handle, and the handle shall indicate the position of the breaker..

Each panelboard shall be provided with a circuit breaker in the mains and with a full-sized neutral bar. All branch circuits shall be numbered, and a typewritten directory shall be provided on the inside of each door. Circuit breakers shall meet the requirements of UL Standard 489. Panelboards shall be provided with number of spaces and spare breakers as indicated on the Plans.

Panelboard circuits breakers shall be rated for the connected operating voltage and have a interrupting rating of at least 35KAIC. Each circuit breaker shall be bolt on type units and shall be connected to the panelboard as shown on the plans.

Bridge lighting and distribution panelboards shall be 120/208-Volt, 3-phase, 4-wire panel. The panelboard shall be code-gauge galvanized steel with ANSI 61 light gray enamel finish unless otherwise noted.

The bridge heating panelboard shall be 480/277-Volt, 3-phase, 4-wire panel. The panelboard shall be code-gauge galvanized steel with ANSI 61 light gray enamel finish. The heating panelboard shall be provided with internal multipole lighting contactor controlled from a PLC output to de-energize the bus when the bridge is in operation.

Panelboards installed in a non-climate controlled environment shall be rated NEMA 4X Stainless Steel designed for outdoor use. Panelboards installed in a climate controlled environment shall be rated NEMA 12. Panelboards and circuit breakers shall be NQ/NF and QOH type as manufactured by Square D with ratings and number of circuits as shown on the plans.

Lighting Transformer

The lighting transformer shall be a three phase, four-wire 30-KVA, 480-volt primary, 208/120-volt secondary, epoxy resin encapsulated, non-ventilated transformer with copper windings. The Lighting Transformer shall be located as shown on the plans in a NEMA 3R enclosure.

Marine Air Horn

Air horns shall be electrically operated units and capable of providing a klaxon sound of 110dB or greater at 10 feet. Each unit shall be marine rated with a NEMA 4X or IP65 rating. The air horns shall be connected to the new lighting panelboard and operated at 120VAC. The air horn shall be provided with required mounting supports and hardware.

Navigation Lights

Fender Navigation Lights: Vandal resistant fender lights shall be mounted on the existing fender system as shown on the Plans. Each pile cluster light shall be a dual unit, 8-inch outside diameter, 180 degree, red fresnel lens and shall be mounted on a short section of 1 ½" stainless steel pipe with a flange at the bottom and bronze castings. Each pile cluster light housing shall be cast-bronze, securely bolted in position with bronze or stainless steel lag screws not less than 3/8 inch in diameter. Each pile cluster light shall be equipped with 120 volt, 100,000-hour LED lamp. New fender light shall be the PL pier light as manufactured by B&B-Roadway. No substitutions are permitted.

Red/Green Span Navigation Lights: At the outboard toe of each bascule girder, there shall be mounted a new double-unit navigation light. Each unit shall have a green light mounted above a red light. The red light shall have an 8-inch, 180-degree, red fresnel lens. The green light shall have an 8-inch, 180-degree, green fresnel lens. Each bascule span light shall be suspended by a stainless steel pipe hanger from a pivot bracket mounted on the steel work. The pivot assembly shall be provided with an anti-swing brake to prevent oscillation under windy conditions. The retriever chains shall be arranged to allow the lights to swing freely and so that the unit can be readily withdrawn for lamp replacement. The connections to the span lights shall be made with four-conductor, No. 10 AWG, flexible cable. One

conductor shall ground the span light housing. New red/green navigation lights shall be the BS bascule span light as manufactured by B&B-Roadway. No substitutions are permitted.

All bascule span navigation lights shall have gasketed doors and lenses, and each entire unit shall be completely weatherproof. Fittings shall be non-corroding, and the sockets shall be porcelain mounted on shock absorbers. The housings for all units shall be cast-bronze, and a 100-watt 120-volt, 5 year lamp with brass base shall be installed in each socket. A dual lamp and transfer relay kit shall be provided in each navigation light housing. A bronze retriever chain shall be provided for each pivoted bascule span light.

All navigation lights shall be provided in accordance with the rules and regulations of the United States Coast Guard.

Roadway Lighting

The existing LED roadway lights shall be reconnected as shown on the plans to the new incoming service with a new photocell. The photocell shall be mounted on the control house roof designed for LED lighting and shall be rated for 277 VAC and have a built in time delay. The unit shall be weatherproof, outdoor rated and shall be a turn/lock type provided with associated 15 ampere receptacle.

Fire Alarm System

A new fire alarm system shall be furnished and installed as shown on the plans and required in accordance with NFPA 502 and NFPA 72. The Contractor shall supplement the details specified and shown on the plans to meet all necessary standards and codes. All work in this section shall be approved by the fire marshal prior to installation.

The fire alarm system shall be furnished and installed in each level of the control house and machinery room(s) on each bridge. The system shall include but not be limited to: fire alarm control panel, manual pull station, rapid keyless entry box, alarms/beacons, smoke detectors, key pad, wireless hubs, primary and back-up communication, etc.

To ensure that there is one source of supply and one responsibility, the fire alarm system (fire alarm control panel, pull stations, smoke detectors, alarms, key pad, etc.) shall be built, tested, and shipped by the same manufacturer. The proposed manufacturer shall be completely responsible for furnishing, testing and placing in proper operating condition the fire alarm system. Independent vendors that buy the control panel, fire alarms, pull stations, smoke detectors, key pad and auxiliary equipment from various manufacturers and assemble the components together relying on the individual manufacturers for their supply of spare parts and engineering expertise do not meet the criteria of this Specification and will not be acceptable.

Fire Alarm Control Panel: The Fire alarm control panel shall be microprocessor based capable of providing at minimum of five hardwired zones including one wireless zone and meet the requirements of UL864/NFPA72. The unit shall support four wire smoke detectors on all five circuits and is capable of continually monitoring system status of AC, standby battery, and zone inputs. The control panel shall be capable of connecting to two phone lines as well as the DelDOT TMC network located on the bridge.

Manual Pull Station: Each Manual Fire Alarm Stations shall be non-code, with a key-operated

reset lock in order that they may be tested, and so designed that after actual Emergency Operation, they cannot be restored to normal except by use of a key. Each station shall automatically condition itself so as to be visually detected as activated. Manual stations shall be constructed of red colored LEXAN® (or polycarbonate equivalent) with clearly visible operating instructions provided on the cover. The word FIRE shall appear on the front of the stations in white letters, 1.00 inches (25.4 mm) or larger. Each station shall be suitable for surface mounting on matching back-box; or semi-flush mounting on a standard single-gang, double-gang, or 4" (10.16 cm) square electrical box, and shall be installed within the limits defined by the Americans with Disabilities Act (ADA) or per national/local requirements. Manual Stations shall be Underwriters Laboratories listed.

Smoke/CO Detector: Each smoke detector shall be a direct 4-wire ionization type unit. Detector will have a visible LED, which will blink in standby and latch on in alarm. The detector shall have a sensitivity of 1.9±0.6%/ft. as measured in the UL smoke box. The detector screen and cover should be easily removable for cleaning. It shall be possible to sensitivity and functional test on the detector need of generating smoke. The detector shall have mounting bracket that allows for mounting to a 3 1/2" or 4" octagon box or 4" square electrical box. Each detector shall be furnished and installed with Model EOL end of line power supervision relays.

Heat Detector: Each heat detector shall be a combination fixed temperature/rate-of-rise thermal sensor. The rate-of-rise element shall be activated by a rapid rise in temperature. The detector shall include a reversible mounting bracket for mounting to 3½-inch and 4-inch octagonal, single gang, and 4-inch square back boxes with a square to round plaster ring. The detector shall contain alphanumeric markings on the exterior of the housing to identify its temperature rating and activation method. The rate-of-rise element of combination fixed temperature/rate-of-rise models shall be restorable, to allow for field-testing. The detectors shall include an external collector that shall drop upon activation to identify the unit in alarm.

Alarms: Horn/Strobe alarms shall be listed to UL 1971 and UL 464 and shall be approved for fire protective service. Horn/strobe shall be wired as a primary signaling notification appliance and comply with the Americans with Disabilities Act requirements for visible signaling appliances, flashing at 1Hz over the strobe's entire operating voltage range. The strobe light shall consist of a xenon flash tube and associated lens/reflector system. The horn shall have two-tone options, two audibility options (at 24 volts) and the option to switch between a temporal 3 pattern and a non-temporal continuous pattern. Strobes shall be powered independently of the sounder with the removal of factory installed jumper wires. The horn on horn/strobe models shall operate on a coded or non-coded power supply (the strobe must be powered continuously).

Rapid Keyless Entry Box: The rapid entry keyless entry enclosure shall be located outside the control house near the keyless entry access point. The enclosure shall be outdoor rated, surface mountable and capable of holding keys a keyless access cards. The enclosure shall include a lock cover, tamper seal, shall be gasketed, and UL listed. The rapid keyless entry box shall be approved equal to the Know Box 3200 or approved equal.

Technical Manuals

Maintenance Manuals shall contain descriptive material, catalog cuts with non-pertinent data blocked out, as-built drawings, spare parts list, troubleshooting techniques and any and all information necessary for successful maintenance of the bridge functional systems and each piece of equipment furnished by the Contractor. Bridge functional systems shall be understood to include all operating

machinery, lock machinery, electrical service equipment, electrical and control systems, and all other equipment for which periodic maintenance and operation is desirable. Subsequent to acceptance of the bridge by DelDOT following successful completion of acceptance testing, errata or addenda to the manuals should address any revisions required.

Operations Manuals shall contain written descriptions of the functional systems of the movable bridge, step-by-step operating instructions for each of these systems and any and all information and directions required for their successful operation. Subsequent to the break-in period, errata or addenda to the manuals should address any revisions required.

All printed matter, data, drawings, diagrams, etc., shall be accurate, distinct and clearly and easily legible. Illustrations shall be clear; and printed matter, including dimensions and lettering on drawings, shall be legible. If reduced drawings are incorporated to manuals, the original lines and letters shall be darkened as necessary to retain their legibility after reduction. Larger drawings may be folded into manuals to page size.

Operating and maintenance manuals shall be bound in heavy-duty nickel-plated three-hole binders with three trigger positions: lock, unlock and open. Binder shall have metal hinges. Locking mechanism shall allow sheets to lie flat (i.e. channel lock). Covers shall be stiff heavy-duty plastic or other approved material.

The printed material shall be bound into each manual between rigid covers. The manuals shall be approximately 9 inches by 12 inches to contain the drawings without excessive folding so that they may be easily opened. The books shall be neatly entitled with a descriptive title, the name of the project, the location, year of installation, the name of the manufacturer, the engineering firm and the Contractor. Copies of drawings shall be in black on white background and shall be legible. The arrangements of the books, the method of binding, material to be included, and the text shall all be submitted to and approved by the Engineer.

Paper used in these manuals shall be 20-pound, punched paper, water resistant, and acid free of a quality suitable for archival use. Paper shall have 5/16-inch minimum diameter holes, reinforced with plastic or cloth at the standard three (3)-hole spacing. The paper shall be standard 8½"x11", or, in the case of larger foldout diagrams and illustrations, folded to approximately 8½"x11" size. No paper or other material shall extend beyond the manual covers.

In additional, the approved manuals shall be scanned into PDF files, which will then be placed on a CD and handed over to the Delaware Department of Transportation after final acceptance by the Engineer

Spare Parts

Spare parts shall be as specified below and include the specified quantity for each bridge and item number. For common items supplied on both bridges the spare parts shall be isolated and separately packaged and shall be not be shared. The below list of spare parts is for each bridge.

Control Cabinets and Desks (E1, E2, E19, E20)

1. One fully programmed touchscreen display for each size provided.
2. One spare PLC card and module for each type/size furnished including processors, I/O,

power and communication cards.

3. One spare PCMCIA card of each type supplied.
4. One spare Ethernet switch for each type supplied.
5. One spare power supply for each size and type installed.
6. Six fuses of each kind and size installed.
7. One circuit breaker of each type installed.
8. One complete set of contacts and one operating coil for each size and type of magnetic contactor and motor starter. For units that do not incorporate replaceable contacts, furnish one complete unit with coil.
9. One completely assembled and wired Reversing and one completely assembled Non-reversing contactor for each type installed.
10. One control relay and two extra sets of contacts for every ten installed (minimum of 1 relay and two sets of contacts).
11. One complete relay timer and time delay relay for every ten installed (minimum of 1 relay and two sets of contacts).
12. Two spare lamps for the interior lighting.
13. One door switch.
14. One selector switch and push-button for each type supplied.
15. One indicating light for each type and color supplied.
16. Three indicating light covers for each type supplied

Flux Vector Drive (E3, E21)

1. One fully programmed touchscreen display for each size provided.
2. Six fuses of each kind and size installed.
3. One circuit breaker of each type installed.
4. One complete set of contacts and one operating coil for each size and type of magnetic contactor and motor starter. For units that do not incorporate replaceable contacts, furnish one complete unit with coil.
5. One completely assembled and wired Non-reversing contactor for each type installed.
6. One control relay and two extra sets of contacts for every ten installed (minimum of 1 relay and two sets of contacts).
7. One complete relay timer and time delay relay for every ten installed (minimum of 1 relay and two sets of contacts).
8. All the internal components of one complete, calibrated FVD system for each size drive system. Power and control wiring, terminations and mounting hardware shall not be included.
9. Two spare lamps and door switches for the interior lighting.
10. One door switch.

Automatic Transfer Switch (E4, E22)

1. Six fuses of each kind and size installed.
2. One circuit breaker of each type installed.
3. Two spare lamps for the interior lighting.
4. One door switch.

Limit Switches (E5, E23)

1. Two completely assembled mechanical limit switch for each type supplied.
2. One speed switch for each type supplied.
3. Four proximity sensors for each type supplied including cord sets.
4. Four contacts for each rotary cam limit switch supplied.

Motors (E6, E24)

1. Two spare motor encoders for E23 only

Motor and Machinery Brakes (E7, E25)

1. One limit switch for each brake provided per bridge.
2. One thrustor motor for each type/size of brake supplied per bridge.

Modifications to Warning and Barrier Gates (E8, E26)

1. Two door switches for each type supplied.
2. Two flashers for each type supplied.

Miscellaneous Equipment (E15, E33)

1. Two panelboard circuit breakers for each type and size supplied
2. Six bulbs for each type of light fixture supplied.
3. One spare generator fuel sensor.

The Contractor shall arrange the spare parts in uniform size cartons of substantial construction, with typed and clearly varnished labels to indicate their contents, and store them where directed by the Engineer. Large spare parts shall be provided with moisture-proof wrapping. The Contractor shall also provide a directory of permanent type, describing the parts. The directory shall state the name of each part, the manufacturer's number thereof, and the rating of the device.

The Contractor shall be responsible for maintaining spare parts during construction and shall include charging the spare drives as directed by the manufacturer until final acceptance of the project from DelDOT.

Construction Methods:

Working Drawings, Samples and Submittals.

The Contractor shall have the ability to created and produce working installation drawings in accordance with the requirements below and herein in CAD format. The reproduction of the contract drawings will not be acceptable as part of any submitted shop drawings and will be immediately rejected and returned to the Contractor for revision. The required drawings will be submitted in as a hard copy or electronic pdf as required by the DelDOT standard specifications and shall have the Contractor border on each submitted drawing.

Within 30 days after the award of the Contract a completed schedule of electrical submissions that outline when all of the electrical submittals will be made. No more than 90 days shall pass between the award of the contract and the Contractor's first submission.

Certified dimension prints of the apparatus shall be provided and state in the certification the name of the job, the application of the apparatus, device designation, number required, right hand or left hand assembly, electrical rating, number of poles or contacts, material, finish, and any other pertinent data to show that the apparatus meets the specified requirements.

Upon completion of the work, the Contractor shall correct all electrical shop or working drawings to show the work as constructed and provide one (1) set of 11X17 pdf drawings, as well as the associated CAD files.

The Contractor shall submit for inspection and test, if directed by the Engineer, samples of any apparatus or device that he proposes to use as a part of the electrical installation.

As a minimum the Contractor shall supply the following shop drawings and submittals prior to the start of associated field work.

(a) Control System Vendor Submittals:

(1) Certified dimension prints of all limit switches, proximity sensors, motor encoders, control cabinets, PLC cabinet, drive cabinets, control desk, back panels, panelboards and other electrical apparatus external to the control desk, are required. All pertinent electrical data, ratings, drive-programmed parameters, calculations and mounting details are to be included on the prints. The vendor must schedule a site visit with Delaware Department of Transportation to perform drive analysis.

(2) A complete schematic diagram and wiring diagram, including all power, and control connections. Each electrical device and each wire between devices shall be identified by an individual designation of letters, numbers, or a combination of both; and such designations shall be used wherever the devices or wires appear on other drawings.

(3) Layout drawings and internal connection wiring diagrams of the control desk, control cabinet, back panels, PLC cabinets and flux vector drive cabinets.

(4) A schedule of electrical apparatus for each cabinet or panel which shall list each electrical device by its manufacturers designation as shown on the schematic wiring diagram and shall state for each device its rating, number of poles or contacts, function, catalog number, and location. A complete set of catalog cuts for materials furnished shall be included for each piece of apparatus.

(5) A point-to-point complete interconnection diagram(s) for all bridge control electrical apparatus and equipment used in the operation of the span. The diagram(s) shall be of the elementary type and shall show the external connections of all devices and equipment from all terminal blocks installed. Computer-generated inter-connection lists will not be acceptable in lieu of a true interconnection diagram.

(6) Shop and field testing procedures, including test forms with acceptance criteria, and schedule of testing of all equipment shall be furnished by the vendor.

(b) Contractor Installation Work Submittals: The Contractor shall be fully responsible for developing all point-to-point electrical conduits and wiring runs for the entire electrical system. Coordination with all other disciplines is required as part of the development of the drawings. The required drawings shall include, but not be limited, to:

(1) A complete schematic conduit diagram showing the interconnection of all devices and equipment, including terminal and junction boxes. The size of each

conduit, and the wire number and size of each conductor in conduit, shall be shown on the diagrams. Each conduit shall be suitably numbered or lettered, and percent wire fill shall be shown.

(2) Prior to the start of field work, a complete set of layout and installation drawings for the electrical work shall be submitted for review and approval. The drawings shall include and detail the location of equipment, installation procedures/methods, support and mounting details of equipment, electrical apparatus and equipment. These drawings shall be made to scale and shall show the exact location of all conduits, supports, cables, boxes, motors, brakes, limit switches, disconnect switches, and other electrical equipment and the method of supporting them on the structure. No work shall proceed without the approval of these drawings by the Engineer.

(3) Construction drawings of all multi conductor droop and flexible cables, including the sizes of conductors, type and thickness of insulation, jackets and other components, and giving the outer diameter of each finished cable.

(4) Detail drawings showing the construction of cabinets, brackets, and special supports required for the installation of the droop cables for circuit connections between the movable span and fixed pier including conduit installation and expansion/deflection conduit fittings.

(5) Test results from all factory and field test specified.

(6) Outline drawings, catalog cut sheets and mounting details shall be submitted for the following equipment:

i. Control Cabinets
ii. Motor Control Cabinet / Auxiliary Cabinet
iii. Back Panels
iv. Control Desk
v. Drive Cabinets
vi. Automatic Transfer Switch
vii. Wiring Devices
viii. Panelboards
ix. Circuit Breakers, Relays, Contacts, etc.
x. PLC system and equipment
xi. Transformers
xii. Safety Disconnect Switches
xiii. Grounding Equipment
xiv. Conduit
xv. Wireway
xvi. Boxes
xvii. Wire and Cable
xviii. Lugs
xix. Wire and Conduit Tags
xx. Limit Switches and Proximity Sensors
xxi. Motor Encoders
xxii. Lock Motors
xxiii. Leaf Motors
xxiv. Motor and Machinery Brakes
xxv. Traffic Gate Equipment
xxvi. Speed Switch Assemblies
xxvii. Service Lighting and Heating Fixtures

xxviii. Fire Alarm System
xxix. Marine Horn
xxx. Any new equipment required for the temporary operating system.

(7) Any other drawings, which may, in the opinion of the Engineer, be necessary to show the electrical work.

Factory Inspection and Testing of Bridge Control System. The enclosed motor control cabinet equipment, drive cabinets, control desk, back panels, and other apparatus supplied, assembled or fabricated by the vendor of the electrical control system shall be subjected to shop inspections to demonstrate compliance with all specified requirements. The complete factory inspection and testing of the bridge control system shall be as specified and paid for under the item "Testing."

Factory tests for equipment other than the bridge control system shall be as specified in the various materials sections throughout these specifications.

Field Testing. Upon completion of the electrical work for the bridge, the Contractor shall arrange for and provide all the necessary field tests, as directed and approved by the Engineer, to demonstrate that proper operation of the entire electrical system for the bridge is achieved and in accordance with the Contract Plans and Specifications. The complete acceptance testing procedure and requirements shall be as specified and paid for under the "Acceptance Testing and Functional Checkout"

Manufacturer's Field Start-up Service. In addition to furnishing the major items of electrical equipment, the system vendor shall furnish all necessary field supervisory start up material and labor to facilitate proper adjustment of all the electrical equipment so as to achieve functioning of the span to the satisfaction of the Engineer.

The systems vendor's field service engineering personnel shall be experienced in the adjustment and functioning of the particular control equipment furnished under this item. The personnel shall be capable of locating and correcting faults or defects and of obtaining from the manufacturer, without delay, new parts or replacements for apparatus that, in the opinion of the Engineer, does not perform satisfactorily.

Suggested Sequence of Construction. The Contractor shall sequence the construction and coordinate the various activities such that the contract is satisfactorily completed in accordance with the scheduling requirements of the Contract including maintaining vehicular traffic and navigation. The Contractor shall submit the proposed sequence of construction to the Engineer for approval, and construction shall not commence without the approval of the Delaware Department of Transportation.

Delivery and Storage; Protection for Shipment.

The specified electrical equipment shall be shipped from the manufacturer's facility once all test results have been approved. A portion of the equipment such as motors, drives, control cabinets, ATS, etc. shall be shipped to the drive manufacturer and control system vendor's facility for testing.

Equipment shall be stored in a humidity and temperature controlled environment. Damage to any of the equipment caused by moisture and/or weather conditions will require replacement. The Contractor will be responsible for maintaining the equipment in like-new condition. Equipment which is damaged in any way shall require replacement at the Engineers discretion at no additional cost to the Delaware Department of Transportation.

Fabrication of Control Cabinets and Back Panels

The Contractor shall follow the testing guidelines as specified herein and paid for under this item, and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the general requirements herein.

All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor. Requirements for the control system vendor shall be as specified under "Bridge Control System Vendor."

The Contractor shall install the assembled back panel and enclosures in the switchboard rooms as shown on the plans for the Flux Vector Drive Cabinets, Control Cabinets and ATS Cabinet. Adjustments to the positions and layout of the back panels and enclosures shall be made by the Contractor for proper fit at no additional cost to DelDOT.

The wiring within the control desks, drive cabinets, motor control cabinets, auxiliary cabinets and PLC cabinets shall be insulated switchboard wire conforming to the requirements hereinbefore specified for wiring in the control cabinets. The wiring shall be arranged systematically so that all circuits can be readily traced. All conductors shall be terminated on easily accessible terminal blocks mounted inside the desk at the rear. Spare terminals totaling at least 10 percent for power conductors and 20 percent for control conductors of those actually used shall be provided. Wiring shall be identified at equipment terminals by marking the adjacent area with bright yellow painted numbers to correspond to conductor designations appearing on the Contractor's wiring diagrams.

E1 Control Cabinets

The back panel for the existing drive cabinet located in the switchboard room shall be removed and replaced with a new back panel as shown on the plans. The new back panel and existing drive cabinet enclosure shall be relabeled 'Auxiliary Cabinet.'

The auxiliary cabinet shall include contactors, starters, relays, circuit breakers, etc. as shown on the plans. The layout shall be modified as required to fit within the existing cabinet and based on the routing and cables and wiring.

The existing fan blower and assembly shall be removed to the existing cabinet and repaired as required.

The PLC enclosure shall be wall mounted as shown on the plans in the switchboard room. The existing entrance door to the switchboard room shall be modified to swing outboard to accommodate the enclosure. The modifications to the entrance door shall be paid for elsewhere.

The Contractor shall coordinate locations of the equipment with existing utilities, water piping, and other existing equipment. Adjustments to the back panels, enclosures and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT.

E2 Control Desk

The existing control desk shall be removed and replaced with a new control desk as shown on the plans. Modifications shall be made to the locations of the new enclosure to accommodate the existing

conduit penetrations and routing through the floor to the end devices.

The control desk shall include PLC equipment, network switches, circuit breakers, relays, etc. as shown on the plans. The layout shall be modified as required to fit and be installed in the allowable space and based on the routing and cables and wiring.

Special attention shall be made to minimize the size of the new control desk to carry into the control room without major disassembly of the windows.

The Contractor shall coordinate locations of the equipment with existing utilities, water piping, and other existing equipment. Adjustments to the back panels, enclosures and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT.

E3 Flux Vector Drive

The back panel in the existing auxiliary cabinet located in the switchboard room shall be removed and replaced with a new back panel as shown on the plans. The new back panel and existing auxiliary cabinet enclosure shall be relabeled 'Span Drive Cabinet'.

The drive cabinet shall include VFD assemblies, touchscreen, manual controls, contactors, starters, relays, circuit breakers, etc. as shown on the plans. The layout shall be modified as required to fit within the existing cabinet and based on the routing and cables and wiring.

The existing doors on the existing auxiliary cabinet (new drive cabinet) shall be removed and modified at the control system vendor's facility. Modifications shall include installation of manual controls, drive key pad, indicators, etc. as shown on the plans.

The Contractor shall coordinate locations of the equipment with existing utilities, water piping, and other existing equipment. Adjustments to the back panels, enclosures and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT.

Each drive shall be tested at the drive manufacturer's facility with the actual bridge motor or other approved facility prior to shipping to the control system vendor for control system testing. The drives shall be full load tested in the presence of the Engineer using the actual span motors and a dynamometer up to a maximum of 150% full load torque of the span motor. The Contractor shall submit, at least two weeks prior to the test date, the anticipated schedule and location of testing as well as test forms and/or procedures to be used for the testing of each drive.

Test results shall be documented at various loads, durations and intervals and submitted to the Engineer for approval prior to shipment to the control systems vendors' facility. During testing the motor temperature shall be monitored, if the observed exceed manufacturers recommended values testing shall stop until the temperature reached a safe value at which point testing shall resume.

Certified factory start-up at the bridge site shall be provided for each drive by a factory authorized service center. In addition, a minimum of 24 hours of classroom training shall be provided for the facilities maintenance personnel.

E4 Automatic Transfer Switch (ATS)

The existing ATS and power cabinet shall be removed and replaced with a new enclosure installed in the generator room as shown on the plans. The new enclosure shall include a new ATS, circuit breakers, fuses, control transformer, etc. as specified and other equipment shown on the plans.

Special attention shall be made to minimize the size of the new enclosure to carry and fit into the generator room without major disassembly and modifications of the windows, doors or walls.

A new conduit run from the new DPL service to the ATS enclosure shall be furnished and installed as shown on the plans. The contractor shall coordinate the location of the cabinet with the new location and adjust as required.

The Contractor shall coordinate locations of the equipment with existing utilities, water piping, and other existing equipment. Adjustments to the back panels, enclosures and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT.

E19 Control Cabinets

New control enclosures shall be located in the switchboard room as shown on the plans. All work required for the control enclosures under this item shall be similar to item E1 unless otherwise noted.

E20 Control Desk

The existing control desk shall be removed and replaced with a new control desk as specified and shown on the plans. All work required for the control desk shall on this item shall be similar to item E2 unless otherwise noted.

E21 Flux Vector Drive

The existing drive cabinets located in the switchboard room shall be removed and replaced with a new enclosure as shown on the plans. All work required for the flux vector drives on this item shall be similar to item E3 unless otherwise noted.

The new doors on the drive cabinet shall modified at the control system vendor's facility. Modifications shall include installation of manual controls, drive key pad, indicators, etc. as shown on the plans.

The drive equipment for this item shall be sized to operate in sensorless vector mode and without a motor mounted encoder. All equipment and work required to operate as specified shall be provided by the Contactor at no additional cost.

E22 Automatic Transfer Switch (ATS)

An existing/new ATS shall be removed from the existing enclosure and modified to operate with the existing generator which will be reconnected for 480VAC, three phase power source. Once modified the existing ATS shall be re-installed in a new outdoor rated NEMA 4X enclosure with accessories as shown on the plans.

The existing/new ATS shall be shipped and delivered for modifications and shop assembled by the control system vendor. The completed ATS enclosure shall be made available for shop inspection and

testing as specified herein.

A new conduit run from the Lewes BPW service to the ATS enclosure shall be furnished and installed as shown on the plans. The contractor shall coordinate the location of the cabinet with the new location and adjust as required.

The Contractor shall coordinate locations of the equipment with existing utilities, water piping, and other existing equipment. Adjustments to the back panels, enclosures and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT

PLC Programing and Sequence of Operation

(a) Software Programing

(1) The control system vendor shall be fully responsible to generate a complete operating system and develop the PLC program and alarm messages using:

(i) The Software Programming, Sequence of Operation, Other PLC Functions, and Alarm sections provided in this section.

(ii) All logic and wiring shown on the plans

(iii) The testing requirements shown in Start Up and Commissioning Requirements.

(iv) Allowing for specific requirements of the Allen-Bradley PLC as supplied, the program ladder logic shall follow the above items and this Specification as closely as possible.

(2) The control system vendor shall furnish a laptop computer, interconnection cables, power supplies, software, PanelView programming, and PLC programming to accomplish the specified operation of the bridge and its auxiliaries. Software for the PLC, touchscreen, drives, and laptop computer shall be loaded and coordinated by the Contractor to achieve the correct designed operation of all software.

(3) The control system vendor shall be fully responsible for developing the PLC, and touchscreen, and desktop computer software and software programming to accomplish the specified operation of the bridge and its associated equipment. The Contractor shall assume software debugging will occur in the shop as well as in the field during start-up and subsequent testing. No additional payment shall be made for software debugging due to logic changes made in the field.

(4) The control system vendor shall be responsible for coordination with DelDOT's TMC department for testing an integration of the remote monitoring system.

(5) The PLC program shall be in accordance with the following items:

(i) The ladder logic shall be easy to understand and troubleshoot.

(ii) The ladder logic shall be fully documented, including rung comments and address comments.

(iii) The ladder logic shall be written with regards to the operational sequence of the bridge, containing separate sections for each of the major equipment areas such as gates, locks, etc.

(iv) From the Operator's standpoint, the bridge shall operate as before in terms of sequence of operation.

(v) The ladder logic shall not utilize or contain the following flaws:

(1) Latched coils: PLC logic shall be based upon real world conditions and reset when required. When the PLC loses power,

and then power is returned, the PLC will determine the position of the leaves and other electrical equipment, but not expect the bridge to be in the exact same position. If any equipment was operated manually, the PLC program will determine the new position of the equipment and operate normally.

(2) Unnecessary internal coils: PLC logic shall be as simplified as possible and not use multiple relays for a single function. The intent of this is to make the program easy to troubleshoot and understand.

(3) Improper bypass logic: When the bypass switch is utilized the bypass will bypass only the required interlocks. The intent of this item is to provide programming that will utilize the bypasses and only bypass the correct interlock, but does not remain active in the logic or bypass other interlocks in the program.

(4) Loss of alarms: PLC logic shall be written to record and store the alarms and display on the touchscreen.

(5) Switch and Push button time delays: PLC logic shall not add time delays to control desk switches and pushbuttons.

(6) Problems transferring between automatic and manual modes of operation: PLC logic shall allow simple transfer from automatic and manual modes without generating unnecessary alarms for causing failures in the program. The intent of this item is to provide programming that transfers between manual and automatic mode without problems or inaccurate alarms.

(7) Faulty timing logic: The intent of this item is to provide programming that does not have internal timers to determine when problems occur or provide inaccurate alarms.

(vi) All timer settings shown in the sequence of operation shall be clearly documented in the program. They shall be adjusted to match the selected equipment and adjusted during shop and field testing for proper operation.

(vii) Modify and add alarm messages and associated alarm ladder logic as required.

(viii) The PLC shall communicate information through the Ethernet connections with multiple pieces of equipment, such as drives and overload relays. The information shall be identified as an Ethernet input into the PLC.

(6) Contractor shall submit a fully documented and cross-referenced copy of the new PLC program for review and approval.

(7) The touchscreen alarm panel shall be programmed to timestamp, print, and store each PLC alarm. The alarms shall be stored in chronological order and the operator shall be able to scroll through the alarm screen to review alarms. The alarms shall be stored in the touchscreen and being identified by a numerical identifier. When the PLC processor transmits the numerical identifier alarm bit to the touchscreen, the touchscreen shall display the alarms, send the alarms to the printer, and store the alarms in an alarm history screen stored in chronological order.

(8) In the event of CPU failure, all outputs shall turn off.

(b) Sequence of Operation

The sequence of operation for each bridge shall be as described below. Interlocking shall be achieved in correct sequence to permit safe operation of the bridge and ancillary equipment. The normal sequence of operation shall be achieved through buttons located on the control desk touchscreen. As a back-up to the touchscreens, selector switches and push-buttons can be used should the screens fail to operate.

A selector switch on the control desk shall select the mode of operation: either through the touchscreen or the hard-wired control devices on the control desk. In touchscreen mode, the positions of the push-buttons and switches shall be ignored for the traffic signals, gates, locks and span motor. Indicators on the desk shall illuminate in either mode.

The touchscreen display located in the switchboard room shall mimic the alarm and status display of the touchscreen on the upper portion of the control desk. Parameters such as incoming service voltage, drive amperes, angle of opening, span motor speed, alarms, and status indication shall be viewable from this screen.

When the PLC is required to generate an alarm, it shall send a bit from the defined bit array to the touchscreen. When the touchscreen receives the alarm bit numeric identifier, the touchscreen will display the alarm, provide the time and date of the alarm, print the alarm, and store the alarm in an alarm history screen. A screen will be provided to allow the operator to scroll down the alarm history.

The following operation examples are for a complete bridge operation. It is the intent of the control logic that the operator can stop the operation at any time while attempting to open the bridge and 'back out' of the operation to safely allow vehicular traffic on the bridge. To 'back out' of an operation means to change the operation from opening to closing the bridge. For example, after lowering the on-coming traffic gate, the operator could 'back out' of the operation by raising the on-coming traffic gate and turning the red traffic warning signal off to release vehicular traffic.

The PLC system shall be programmed to send information to DelDOT via a remote server. As part of this work the Contractor shall coordinate the required information with DelDOT and add these features to the PLC program.

Rehoboth Avenue Bridge

(1) Fault/Reset
- (i) At any point where an alarm message is generated, the fault/reset illuminated push-button shall be turned on and remain on until the fault is cleared and the reset push-button is pressed.
- (ii) For critical faults including emergency stops, opening of specified electrical enclosure doors, and over travel, the main circuit breaker to the motor control enclosure shall be turned off through the UV circuit as shown on the plans.

(2) Control Power Selector Switch (CS-CP)
- (i) The operator shall turn the control desk Control Power (CS-CP) switch to the 'On' position.
- (ii) Control Power switch in the 'On' position is provided as an energized input 'Control Power On' to the PLC.
- (iii) The Control Power switch (CS-CP) activates bridge control relay as long as there is no power or if a fault condition exists in the service power.
- (iv) When the PLC has control power, the PLC shall verify all PLC Input card circuit

breaker check inputs are energized.

(v) If at any time during an operation, if a single or multiple PLC inputs of the above are de-energized while the 'Control Power On' PLC input is energized, the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.

(vi) The PLC input Power Fault Alarm shall be energized if there is a power fault. If there is a power fault the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC input is de-energized.

(3) Emergency Stop Push-Buttons (PB-ES1 and PB-ES2) and Safety Relays

(i) If at any time during an operation, the 'Control Power On' PLC input is energized and the 'Emergency Stop' push-buttons or safety relay inputs de-energized (the 'Emergency Stop' button is pressed), the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the Emergency Stop inputs are energized.

(ii) If any Emergency Stop push-button is depressed or safety relays are energized, or the emergency stop push-buttons are depressed during bridge operation, then the PLC input 'Emergency Stop' from PB-ES or safety relay inputs shall de-energize. The PLC shall stop all bridge operations and generate an alarm. The PLC shall not allow any other operation until all the Emergency Stop push-buttons are pulled out to the not depressed position.

(iii) If any Emergency Stop push-button is depressed, the hardwired Master Control Relays will de-energize the control output power busses and the PLC shall verify that the emergency stop inputs are de-energized.

(iv) If any of the inputs are not de-energized when the 'Emergency Stop' PLC inputs are de-energized, then the PLC shall generate an alarm.

(4) Bridge Status Indication - Upon the 'Control Power On' PLC input energizing, the PLC will scan the bridge for the status of the following items to illuminate or de-energize the touchscreen indicators as follows:

(i) Indication Lights

(1) The PLC shall verify the span, warning gate, barrier gates, span locks, alarms, and other status indications and positions and illuminate the appropriate indicators on the touchscreen.

(ii) Brake Hand Release Status and Indication

(1) The PLC shall verify that both Motor Brakes are not hand released. If either motor brake is hand released before or during span motor operation a warning message shall be displayed on the touchscreen and stored.

(2) If both brakes are hand released an alarm shall be displayed on the touchscreen and stored.

(3) If the span motor is in operation and both brakes are hand released the span drive shall decelerate the motor to an immediate stop and hold it there until at least one motor brake is no longer hand released.

(iii) Ethernet Communication on Span Motor Drives:

(1) The PLC shall verify the Ethernet inputs to determine the status of the main motor drive. If there are any alarms or fault then the PLC shall prevent span operation, send an alarm to the touchscreen, store the alarm and illuminate the fault/reset illuminated push-button.

(2) The PLC shall continuously monitor the equipment and scan for issues.

(iv) Circuit Breaker - The PLC shall monitor the inputs for each circuit breaker auxiliary contact. If any circuit breaker trips, the PLC shall prevent span operation, send an alarm to the touchscreen and store the alarm.

Bypass Operation: If there is a circuit breaker failure, the circuit breaker operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(v) Bypass Operation

(1) If an interlock does not function, the interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual bypass switch.

(2) Whenever a bypass is used, the PLC shall generate an alarm. When any bypass switch is active the PLC shall send an alarm message to the HMI display screen describing the bypass used.

(3) No more than two bypass switches shall be operated at any given time. If more than two are active an alarm message shall be displayed of the HMI display screen.

(vi) Drive Trouble Status Indication

(1) The PLC shall verify that the Span Drive does not have a Trouble alarm. If the drive does have a trouble alarm, then the PLC shall illuminate the fault/reset indicating light on the control desk, prevent drive operation with that drive, send an alarm to the touchscreen and store the alarm. (Refer to the span operation for the requirements of a Drive Trouble Alarm during an operation and the hard stop requirements).

(vii) Position Transmitter Status Indication

(1) The PLC input 'Position Resolver' shall receive an analog input from the resolver (position transmitter). The PLC located in the switchboard room shall transmit the analog signal position information to the control desk PLC and all touchscreens. The PLC shall transmit the resolver signal to the control desk touchscreen Span Position Indicator. The display shall provide the span position in degrees, from zero degrees while fully closed to 43 degrees when fully open. The PLC shall continually update the position information while control power is on.

(2) The PLC shall monitor the resolver analog input and internally monitor the span position in degrees. The PLC shall compare the resolver position to the PLC inputs for span rotary limit switch contacts. If the PLC resolver analog degree is more than 3 degrees off from the rotary limit switch contacts (as shown on the Plans) the PLC shall generate an alarm.

(3) If no analog signal is received from a position transmitter, then the PLC shall generate an alarm.

(viii) Non-Automatic Control

(1) The PLC shall verify that no equipment is being operated in non-automatic mode. The PLC shall verify that the PLC inputs from the manual-off-auto switch are in the 'auto' position. If the switches are not in the 'auto' position and are in the 'hand' or 'off' position, then the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.

(ix) Manual Operation Limit Switches

(1) When any hand crank limit switch is open, the PLC shall disable control of the associated motor and send an alarm message to the HMI display screen.

(2) When any hand crank limit switch is engaged the PLC shall disable motor operation for three (3) minutes unless bypassed on the HMI screen.

(x) Disconnect Switch Status for All Motors

(1) The PLC shall verify that no motors are disconnected.

(2) At any time, if any of the PLC disconnect switch inputs are de-energized, the PLC shall de-energize all outputs, generate an alarm identifying the specific motor that has had its disconnect operated, and shall not attempt any bridge operation until the PLC inputs are energized.

Bypass Operation:
If there is a motor disconnect switch operated, the disconnect operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(xi) Drive Ready Status Indication

(1) The PLC shall verify that all drives are ready. If the motor drive is ready and the motor is not disconnected, then the PLC shall illuminate the drive ready indicator on the touchscreen.

(2) If the drive is not ready, the PLC program shall generate an alarm.

(xii) Span Auxiliary System Operation

(1) The span can be operated with the auxiliary system. A limit switch provides indication this system has been activated. When the system is activated the PLC shall provide an alarm and prevent automatic operation of the associated equipment while manual operation is under way.

(2) When any hand crank limit switch is engaged the PLC shall disable motor operation for three (3) minutes unless bypassed on the HMI screen.

(xiii) Span Drive Ammeters and Voltmeters

(1) Span Drive Motor and voltage values for motor load shall be transmitted to the control desk touchscreen and switchboard room touchscreen through the ethernet connection. The PLC shall transmit the values to the remote rack in the control desk. The PLC shall continually update the information while control power is on

(xiv) Temperature Control

(1) The PLC shall verify and display the temperature level and heating set point from each electronic thermostat. The operator shall be able to control each thermostat from the touchscreen on the control desk or remotely from an off-site location. If the temperature in any room reaches a specified threshold an alarm message shall be generated and stored.

(xv) Stand-by Generator

(1) When low fuel, high fuel, low battery and any other generator fault is detected, the PLC shall send an alarm message to the touchscreen and

disable operation of the generator.

(2) When the generator is energized and the PLC receives a generator running status signal the PLC shall send an alarm to the touchscreen and store the alarm.

(3) When the generator is running or any generator fault is detected, the PLC shall disable bridge operation and send an alarm to the touchscreen and store the alarm.

(xvi) ATS

(1) When the ATS changes positions, the PLC shall send an alarm to the touchscreen and store the alarm.

(2) When the ATS has a fault, the PLC shall disable operation of the bridge, send an alarm to the touchscreen and store the alarm.

(xvii) Emergency Stop

(1) When any of the emergency stop push-buttons are activated or safety relays de-energized, the PLC shall prevent operation and send an alarm to the touchscreen and store the alarm.

(2) When any of the emergency stop push-buttons are activated, the PLC shall prevent operation and send an alarm to the touchscreen and store the alarm.

(3) When any of the emergency stop push-buttons are activated, the PLC shall check the associated safety relays and send an alarm message to the display screen if the contacts are not in the correct state.

(xviii) Span Drive Faults

(1) When any of the braking resistors temperature sensor detects a high temperature, the PLC shall disable operation of the associated span drive and send an alarm to the touchscreen and store the alarm.

(2) When a deceleration failure occurs in the span drives, the PLC shall immediately disable operation of the associated span drive and set all brakes. An alarm shall be sent to the touchscreen and store the alarm.

(3) When a span drive warning alarm is detected, the PLC shall send an alarm message to the HMI display screen and ramp the drive down to a stop and set all brakes.

(4) When a span drive fault alarm is detected, the PLC shall disable operation of the associated span drive, set all brakes and send an alarm to the touchscreen and store the alarm.

(5) When a span drive communication alarm is detected, the PLC shall disable operation of the associated span drive, set all brakes and send an alarm to the touchscreen and store the alarm.

(6) When an overcurrent is detected on any of the span drives, the PLC shall send an alarm to the touchscreen and store the alarm.

(7) When an encoder fault is detected, the PLC shall send an alarm message to the touchscreen and ramp the drive down to a stop and all brakes shall set. The drive, through the HMI display, shall be capable of changing to sensorless operation allowing the PLC to restart operation of the bridge through operator input.

(8) When the drive drift selector switch is set to On and the span angular position is within 10 degrees of the full open or full closed positions the PLC shall send an alarm message to the touch screen and the drive shall decelerate to a stop and set the brakes.

(xix) Phase Failure
- (1) When the phase monitor/phase failure relay has tripped, the PLC shall send an alarm to the touchscreen and store the alarm.

(xx) Limit Switch Failure
- (1) When the two fully closed limit switches do not activated within 20 seconds (to be field verified) of each other, the PLC shall send an alarm to the touchscreen and store the alarm..
- (2) When any span lock, barrier gate or warning gate limit switch does not activate within 30 seconds (to be field verified) of the opposing contact, the PLC shall send an alarm to the touchscreen and store the alarm.
- (3) When any span rotary cam limit switch contact does not change state as the correct angular setting when compared to the absolute encoder, the PLC shall send an alarm to the touchscreen and store the alarm.
- (4) When any over travel limit switches or manual operation limit switch is activated, the PLC shall send an alarm to the touchscreen and store the alarm. The over travel limit switch once activated shall not reset until the fully closed limit switch is engaged.

(xxi) Warning or Barrier Gate Door Switch
- (1) When any door switch is open, the PLC shall disable control of the associated motor and send an alarm to the touchscreen and store the alarm.

(5) Traffic Signal Selector (Switch or Touchscreen)

(i) When the selector switch for the traffic signals is in the 'Go' position the PLC shall:
- (1) Energize the touchscreen traffic signal green indicator if control power is on, all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.
- (2) De-energize the touchscreen traffic signal red indicator if all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.
- (3) De-energize the PLC outputs feeding the traffic signals and gongs.

(ii) When the selector switch for the traffic signals is placed in the 'Stop' position the PLC shall:
- (1) De-energize the touchscreen traffic signals green indicator.
- (2) Energize the touchscreen traffic signal red indicator.
- (3) Energize the PLC outputs to activate the gongs by energizing the associated relay.
- (4) The timing for the traffic signals shall be operated by control relays to ensure safe operation when the equipment is operated without PLC control.
- (5) The PLC shall monitor the inputs from CR-RSR and CR-ASR as shown on the plan to verify proper operation of the traffic signals. The PLC shall generate an alarm if the relays operate out of sequence.

(iii) Interlocks:
- (1) The only interlock to prevent the operator from activating the traffic siganls is that bridge control power is on and the timing relay is closed.

(iv) Bypass Operation:
- (1) If there is a failure with the timing relay the interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the

manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(6) On-coming Warning Gate Selector (Switch or Touchscreen)

(i) When the PLC input 'NE Warning Gate Raised' is energized, the NE gate is fully raised and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'SW Warning Gate Raised' is energized, the SW gate is fully raised and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'NE Warning Gate Lowered' is energized, the NE gate is fully lowered and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'SW Warning Gate Lowered' is energized, the SW gate is fully lowered and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'NE Warning Gate Lowered' and 'NE Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'SW Warning Gate Lowered' and 'SW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.

(viii) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NE Warning Gate Raise' and 'NE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the on-coming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output NE Warning Gate Lower

(2) De-energize the PLC output NE Warning Gate Raise

(ix) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SW Warning Gate Raise' and 'SW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the on-coming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output SW Warning Gate Lower

(2) De-energize the PLC output SW Warning Gate Raise

(x) Turn On-Coming Warning Gate Selector Switch to the Lower Position (Switch or Touchscreen)

(xi) When the selector switch or touchscreen On-Coming Warning Gate is held in the 'Lower' position, PLC inputs 'NE Warning Gate Lower' and 'SW Warning Gate Lower' shall be energized.

(xii) While PLC input 'NE Warning Gate Lower' is energized and the PLC input 'NE Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NE Warning Gate Lower'

(2) De-energize the PLC output 'NE Warning Gate Raise'

(xiii) While PLC input 'SW Warning Gate Lower' is energized and the PLC input 'SW Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SW Warning Gate Lower'

(2) De-energize the PLC output 'SW Warning Gate Raise'

(xiv) Note: If PLC input 'NE Warning Gate Lower' is energized continuously for more

than 15 seconds and the PLC input 'NE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Lower'

(xv) Note: If PLC input 'SW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Lower'

(xvi) Lower Interlocks:
- (1) The NE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.
- (2) The SW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.

(xvii) Lower Bypass Operation: There is no bypass operation for the loss of control power or traffic signals red.

(xviii) Turn On-Coming Warning Gate Selector Switch to the Raise Position (Switch or Touchscreen)

(xix) When the selector switch or touchscreen On-Coming Warning Gate is held in the 'Raise' position, PLC inputs 'NE Warning Gate Raise' and 'SW Warning Gate Raise' shall be energized.

(xx) While PLC input 'NE Warning Gate Raise' is energized and the PLC input 'NE Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'NE Warning Gate Raise'
- (2) De-energize the PLC output 'NE Warning Gate Lower'

(xxi) While PLC input 'SW Warning Gate Raise' is energized and the PLC input 'SW Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'SW Warning Gate Raise'
- (2) De-energize the PLC output 'SW Warning Gate Lower'

(xxii) Note: If PLC input 'NE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Raise'

(xxiii) Note: If PLC input 'SW Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Raise'

(xxiv) Raise Interlocks:
- (1) The NE Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, barrier gates are open, span locks are pulled, and the span is seated.
- (2) The SW Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, barrier gates are open, span locks are pulled, and the span is seated..

(xxv) Raise Bypass Operation: If there is a failure with either off-going gate, barrier gate or span seated limit switch, the on-coming gate raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(7) Off-Going Warning Gate Selector Switch (Switch or Touchscreen)

(i) When the PLC input 'NW Warning Gate Raised' is energized, the NW gate is fully raised and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'SE Warning Gate Raised' is energized, the SE gate is fully raised and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'NW Warning Gate Lowered' is energized, the NW gate is fully lowered and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'SE Warning Gate Lowered' is energized, the SE gate is fully lowered and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'NW Warning Gate Lowered' and 'NW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'SE Warning Gate Lowered' and 'SE Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.

(viii) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NW Warning Gate Raise' and 'NW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the off-going gates. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output NW Warning Gate Lower

(2) De-energize the PLC output NW Warning Gate Raise

(ix) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SE Warning Gate Raise' and 'SE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the off-going gates. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output SE Warning Gate Lower

(2) De-energize the PLC output SE Warning Gate Raise

(x) Turn Off-Going Warning Gate Selector Switch to Lower (Switch or Touchscreen)

(xi) When the selector switch or touchscreen Off-Going Warning Gate is held in the 'Lower' position, PLC inputs 'NW Warning Gate Lower' and 'SE Warning Gate Lower' shall be energized.

(xii) While PLC input 'NW Warning Gate Lower' is energized and the PLC input 'NW Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Warning Gate Lower'

(2) De-energize the PLC output 'NW Warning Gate Raise'

(xiii) While PLC input 'SE Warning Gate Lower' is energized and the PLC input 'SE Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SE Warning Gate Lower'

(2) De-energize the PLC output 'SE Warning Gate Raise'

(xiv) Note: If PLC input 'NW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW

Warning Gate Lower'

(xv) Note: If PLC input 'SE Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Lower'

(xvi) Lower Interlocks:
- (1) The NW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and both on-coming gates are lowered.
- (2) The SE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and both on-coming gates are lowered.

(xvii) Lower Bypass Operation: If there is a failure with either oncoming gate, the off-going gate lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(xviii) Turn Off-Going Warning Gate Selector Switch to the Raise Position (Switch or Touchscreen)

(xix) When the selector switch or touchscreen Off-Going Warning Gate is held in the 'Raise' position, PLC inputs 'NW Warning Gate Raise' and 'SE Warning Gate Raise' shall be energized.

(xx) While PLC input 'NW Warning Gate Raise' is energized and the PLC input 'NW Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'NW Warning Gate Raise'
- (2) De-energize the PLC output 'NW Warning Gate Lower'

(xxi) While PLC input 'SE Warning Gate Raise' is energized and the PLC input 'SE Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'SE Warning Gate Raise'
- (2) De-energize the PLC output 'SE Warning Gate Lower'

(xxii) Note: If PLC input 'NW Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Warning Gate Raise'

(xxiii) Note: If PLC input 'SE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Raise'

(xxiv) Interlocks for Raise:
- (1) The NW Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, barrier gates are open, span locks are driven, and the span is seated.
- (2) The SE Warning Gate shall be interlocked such that it cannot be raised unless there is bridge control power, the traffic signals are red, barrier gates are open, span locks are driven, and the span is seated.

(xxv) Raise Bypass Operation: If there is a failure with the span locks, barrier gates or span seated limit switch, the barrier gate raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(8) Barrier Gate Selector Switch (Switch or Touchscreen)

(i) When the PLC input 'SW Barrier Gate Raised' is energized, the SW barrier gate is fully raised and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'NW Barrier Gate Raised' is energized, the NW barrier gate is fully raised and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'SW Barrier Gate Lowered' is energized, the gate is fully lowered and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'NW Barrier Gate Lowered' is energized, the NW barrier gate is fully lowered and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'SW Barrier Gate Lowered' and 'SW Barrier Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'NW Barrier Gate Lowered' and 'NW Barrier Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.

(viii) When the touchscreen buttons are in the 'Off' position, both PLC inputs 'SW Barrier Gate Raise' and 'SW Barrier Gate Lower' shall be de-energized.

(ix) While both inputs are de-energized, the PLC shall not attempt to operate the SW barrier gate.

(1) De-energize the PLC output SW Barrier Gate Lower

(2) De-energize the PLC output SW Barrier Gate Raise

(x) While both inputs are de-energized, the PLC shall not attempt to operate the NW barrier gate.

(1) De-energize the PLC output NW Barrier Gate Lower

(2) De-energize the PLC output NW Barrier Gate Raise

(xi) Turn the Barrier Gate Selector Switch to Lower (Switch or Touchscreen)

(xii) When the selector switch SW Barrier Gate is held in the 'Lower' position, PLC inputs 'SW Barrier Gate Lower' shall be energized. While PLC input 'SW Barrier Gate Lower' is energized and the PLC input 'SW Barrier Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SW Barrier Gate Lower'

(2) De-energize the PLC output 'SW Barrier Gate Raise'

(xiii) When the selector switch NW Barrier Gate is held in the 'Lower' position, PLC inputs 'NW Barrier Gate Lower' shall be energized. While PLC input 'NW Barrier Gate Lower' is energized and the PLC input 'NW Barrier Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Barrier Gate Lower'

(2) De-energize the PLC output 'NW Barrier Gate Raise'

(xiv) Note: If PLC input 'SW Barrier Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SW Barrier Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Barrier Gate Lower'

(xv) Note: If PLC input 'NW Barrier Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NW Barrier Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Barrier Gate Lower'

(xvi) Lower Interlocks:

(1) The SW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, NW barrier gate is lowered and all warning gates are lowered.

(2) The NW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red and all warning gates are lowered.

(xvii) Lower Bypass Operation: If there is a failure with any warning gate or opposing barrier gate, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(xviii) Turn the Barrier Gate Selector Switch to Raise (Switch or Touchscreen)

(xix) When the selector switch SW Barrier Gate is held in the 'Raise' position, PLC inputs 'SW Barrier Gate Raise' shall be energized. While PLC input 'SW Barrier Gate Raise' is energized and the PLC input 'SW Barrier Gate Raise Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SW Barrier Gate Raise'

(2) De-energize the PLC output 'SW Barrier Gate Lower'

(xx) When the selector switch NW Barrier Gate is held in the 'Raise' position, PLC inputs 'NW Barrier Gate Raise' shall be energized. While PLC input 'NW Barrier Gate Raise' is energized and the PLC input 'NW Barrier Gate Raise Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Barrier Gate Raise'

(2) De-energize the PLC output 'NW Barrier Gate Lower'

(xxi) Note: If PLC input 'SW Barrier Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SW Barrier Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Barrier Gate Raise'

(xxii) Note: If PLC input 'NW Barrier Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NW Barrier Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Barrier Gate Raise'

(xxiii) Raise Interlocks:

(1) The SW Barrier Gate shall be interlocked such that it cannot be raised unless there is bridge control power, traffic signals are red and all warning gates are lowered.

(2) The NW Barrier Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, SW barrier gate is raised and all warning gates are lowered.

(xxiv) Lower Bypass Operation: If there is a failure with any barrier gate, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(9) Span Lock Selector Switch (Switch or Touchscreen)

(i) When the PLC input 'NW Span Lock Pulled' is energized, the NW span lock is fully pulled and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'NW Span Lock Driven' is energized, the NW span lock is fully driven and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'SW Span Lock Pulled' is energized, the SW span lock is fully pulled and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'SW Span Lock Driven' is energized, the SW span lock is fully driven and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'NW Span Lock Pulled and 'NW Span Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'SW Span Lock Pulled and 'SW Span Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the disconnect switch open and hand crank inputs for any span lock. If any disconnect switch is open or the hand crank activated, then the PLC shall prevent automatic span lock operation, send an alarm to the touchscreen and store the alarm.

(viii) When the touchscreen buttons are in the 'Off' position, PLC inputs 'NW Span Lock Pull', 'NW Span Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the NW Span Lock.

(1) De-energize the PLC output NW Span Lock Drive

(2) De-energize the PLC output NW Span Lock Pull

(ix) When the touchscreen buttons are in the 'Off' position, PLC inputs 'SW Span Lock Pull', 'SW Span Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the SW Span Lock or SW Span Lock.

(1) De-energize the PLC output SW Span Lock Drive

(2) De-energize the PLC output SW Span Lock Pull

(x) Turn the Span Lock Selector Switch to Pull (Switch or Touchscreen)

(xi) When the Span Lock selector switch is turned to the 'Pull' position, PLC input 'NW Span Lock Pull' shall be energized. While PLC input 'NW Span Lock Pull' is energized and the PLC input 'NW Span Lock Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Span Lock Pull'

(2) De-energize the PLC output 'NW Span Lock Drive'

(xii) Note: If PLC input 'NW Span Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'NW Span Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Span Lock Pull'

(xiii) When the Span Lock selector switch is turned to the 'Pull' position, PLC input 'SW Span Lock Pull' shall be energized. While PLC input 'SW Span Lock Pull' is energized and the PLC input 'SW Span Lock Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SW Span Lock Pull'

(2) De-energize the PLC output 'SW Span Lock Drive'

(xiv) Note: If PLC input 'SW Span Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'SW Span Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Span Lock Pull'

(xv) Pull Interlocks:

(1) The Span Locks shall be interlocked such that either span lock cannot be pulled unless there is bridge control power, traffic signals are red, all warning gates are lowered, both barrier gates are lowered, and the span is seated.

(xvi) Pull Bypass Operation: If there is a failure with any warning or barrier gate or the span seated limit switch, the span lock pull interlocks can be bypassed by using

the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(xvii) Turn the Span Lock Selector Switch to Drive (Switch or Touchscreen)

(xviii) When the Span Lock selector switch is turned to the 'Drive' position, PLC input 'NW Span Lock Pull' shall be energized. While PLC input 'NW Span Lock Drive' is energized and the PLC input 'NW Span Lock Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Span Lock Drive'

(2) De-energize the PLC output 'NW Span Lock Pull'

(xix) Note: If PLC input 'NW Span Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'NW Span Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Span Lock Drive'

(xx) When the Span Lock selector switch is turned to the 'Drive' position, PLC input 'SW Span Lock Drive' shall be energized. While PLC input 'SW Span Lock Drive' is energized and the PLC input 'SW Span Lock Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SW Span Lock Drive'

(2) De-energize the PLC output 'SW Span Lock Pull'

(xxi) Note: If PLC input 'SW Span Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'Span Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Span Lock Drive'

(xxii) Drive Interlocks:

(1) The Span Locks shall be interlocked such that either span lock cannot be driven unless there is bridge control power, traffic signals are red, all warning gates are lowered, both barrier gates are lowered, and the span is seated.

(xxiii) Drive Bypass Operation: If there is a failure with any warning, barrier gate or the span seated limit switch, the span lock pull interlocks can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(10) Drive Fault/Reset Illuminated Push Button (PB-RE)

(i) The operator may attempt to reset a drive by pressing the Drive Reset push button (PB-RE). When the operator presses Drive Reset push button (PB-RE), the PLC input 'Reset Drive' shall energize momentarily. When the PLC input 'Reset Drive' energizes momentarily, the PLC use the Ethernet connection to the drive to reset the drive (coordinate with the drive manufacturer).

(ii) When a fault of the drive is energized the PLC shall receive a signal from the Ethernet connection and the PLC output 'Drive Reset' shall energize. The PLC output for "Drive Reset" shall remain energized until the fault on the drive system is no longer active. At any time when a fault of the drive is active an alarm message shall be displayed on the touchscreen and stored.

(11) Span Control Selector Switch (Switch or Touchscreen)

(i) The PLC shall verify it is safe to operate the span and energize the load contactor and enable the drive if all the following criteria are met: The span shall not be operated if the auxiliary system is engaged, more than one motor brake is hand released, either motor brake or the span motor has its motor disconnected, the motor temperature sensor indicates a high temperature, the motor load contactor

is off, the braking resistor temperature sensor is open, the speed switch/sensor is not indicating correctly, the span lock is not pulled, the barrier gates are not closed, the warning gates are not lowered, and the traffic signals are green. (See prior steps for details.)

(ii) When the span control selector switch is in the 'Off' position, both PLC inputs 'Span Raise' and 'Span Lower' shall be de-energized. While both inputs are de-energized, the PLC shall ensure the drive is in stop, not attempt to operate the drive and use the Ethernet connection to monitor the drive status.

(iii) When the PLC input 'Fully Closed' is energized, the span is fully closed and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'Nearly Closed' is energized, the span is nearly closed and the PLC shall energize the touchscreen indicator.

(v) When the PLC input 'Nearly Open' is energized, the span is nearly open and the PLC shall energize the touchscreen indicator.

(vi) When the PLC input 'Fully Open' is energized, the span is fully open and the PLC shall energize the touchscreen indicator.

(vii) The PLC shall monitor the inputs for the disconnect switch open and hand crank inputs. If any disconnect switch is open or the hand crank activated, then the PLC shall prevent automatic span operation, send an alarm to the touchscreen and store the alarm.

(viii) Stop - If the operator presses the Stop push-button while the span is in operation, both PLC inputs 'Span Raise' and 'Span Lower' shall be de-energized. When both inputs are de-energized during a raising operation, the PLC shall continue to open the span and decelerate (ramp down) to stop in 5 seconds. Then the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 2 seconds, the PLC shall generate and store an alarm. The span operation can be restarted by following the procedure as shown above.

(ix) Drive Trouble Operation - If at any time during an operation (both opening and closing) the Drive generates a Trouble Alarm, continue to open the span and decelerate (ramp down) to stop in 5 seconds. Then the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(x) Turn the span control selector switch to Raise (Switch or Touchscreen)

(1) When Span control selector switch is in the Raise position, the PLC input 'Span Raise' will energize. The PLC shall command the drive to energize the motor and verify proof of torque feedback from the motor drive, and then the PLC will release all motor brakes by energizing the PLC outputs for 'Motor Brake 1 Release' and 'Motor Brake 2 Release.'

(2) The PLC shall verify that all the motor brakes are released, by verifying the following PLC inputs for their associated limit switches are energized. If any brake does not release within 2 seconds, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.

(3) When the PLC input 'Span Raise' is energized and all brakes are released, the PLC shall use the Ethernet connection to command the drive to raise the span, ramp in ten seconds to full operating speed. Command the drive to raise shall initiate the drive to rotate the motor in the direction that opens the span. The PLC shall verify that the drive is operating through the Ethernet communication and that the speed switch is operational and has changed states. The motor encoder shall be hardwired to the drive to provide speed control feedback. The PLC shall monitor the drive to verify proper motor control through the Ethernet communication with the drive. An analog signal input to the PLC from the speed switch shall also provide speed information throughout operation and display motor speed on the touchscreen. At any point if a fault occurs, key parameters such as speed, position, fault identifier, motor current, and motor voltage shall be stored to the touchscreen.

(4) The drive will continuous monitor the motor encoder during operation. If the motor encoder fails, the PLC shall receive a signal through the ethernet connection and shall command the span motor to decelerate to a stop and set the brakes. An alarm message will be displayed through the HMI and an option to restart operation of the bridge in sensorless mode shall be selectable through the HMI screen.

(5) Note: If PLC command to raise the span is sent continuously for more than 15 seconds and the PLC Ethernet monitoring does not indicate the drive is running or the encoder or speed switch does not provide a signal that the motor is rotating, the PLC shall generate and store an alarm on the touchscreen.

Span Position - The PLC shall continuously monitor the PLC analog input for 'Span Position' and compare the rotary cam limit switch contacts inputs for 'Raise Stop', 'Nearly Closed', 'Nearly Open', 'Fully Open', 'Raise Decel Check', 'Lower Decel Check'. If the PLC detects a variation between the limit set points and the span position angular value, then the PLC shall command the drive to decelerate (ramp down) to stop in 5 seconds and the PLC shall generate and store an alarm.

When the drive has stopped, the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(6) Open the Span to Nearly Open - The PLC shall maintain the full speed raise operation of the span until the span reaches the nearly open position. When PLC input rotary limit switch contact 'Nearly Open' is energized, then the span is nearly open.

When the span is nearly open the PLC shall command the drive to continue opening the span and reduce speed to creep speed. Once the span is at creep speed the PLC shall continue in raise creep until the full open limit switches are activated. Once the fully open limit switches

activate, the drive shall command the motor to enter reduced torque in the raise direction.

The PLC shall monitor the drive through the Ethernet connection and monitor the motor speed to verify the drive motor speed is reduced to creep speed. After the PLC input for "Nearly Open is energized, the PLC shall monitor the analog input 'Span Motor Speed' as well as the auxiliary contact "Speed Switch." If the motor speed does not begin to decelerate within 5 seconds or if the auxiliary contact does not open/close when the PLC input for Raise Decel Check' de-energizes, then the PLC shall immediately stop the span motor and set the brakes (emergency stop).

When the drive has stopped, the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(7) Open the Span to Fully Open - The PLC shall maintain creep speed until the span reaches the fully open position of 45 degrees. When PLC input for the span rotary limit switch contacts 'Fully Open' is de-energized, then the span is fully open.

When the span is fully open the PLC shall command the Drive to ramp from creep speed to zero RPM in less than one second. After one second the PLC shall de-energize the motor contactor to isolate the motor from the drive. The PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor and machinery brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(8) Span Overtravel Proximity Limit SwitchIf the span open overtravel proximity limit activates during a raise operation, the PLC shall command the Drive to ramp to a stop of zero (0) RPM in less than one second, and the PLC shall generate and store an alarm on the HMI screen. After one second the PLC shall de-energize the motor contactor to isolate the motor from the drive. The PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

Once the over travel limit switch is activated it shall stay activated and disable raise operation. An alarm shall be generated indicating the over

travel condition is present and the span must be lowered. The alarm and message shall only be reset when the full closed limit switches are activated.

(xi) Turn the span control selector switch to Lower (Switch or Touchscreen)

(1) When Span control selector switch is in the Lower position, the PLC input 'Span Lower' will energize. The PLC shall command the drive to energize the motor and verify proof of torque feedback from the motor drive, and then the PLC will release all motor brakes by energizing the PLC outputs for 'Motor Brake 1 Release' and 'Motor Brake 2 Release.'

(2) The PLC shall verify that all the motor brakes are released, by verifying the following PLC inputs for their associated limit switches are energized. If any brake does not release within 2 seconds, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.

(3) When the PLC input 'Span Lower' is energized and all brakes are released, the PLC shall use the Ethernet connection to command the drive to lower the span, ramp in ten seconds to full operating speed. Command the drive to lower shall initiate the drive to rotate the motor in the direction that closes the span. The PLC shall verify that the drive is operating through the Ethernet communication and that the speed switch is operational and has changed states. The motor encoder shall be hardwired to the drive to provide speed control feedback. The PLC shall monitor the drive to verify proper motor control through the Ethernet communication with the drive. An analog signal input to the PLC from the speed switch shall also provide speed information throughout operation and display motor speed on the touchscreen. At any point if a fault occurs, key parameters such as speed, position, fault identifier, motor current, and motor voltage shall be stored to the touchscreen.

(4) The drive will continuous monitor the motor encoder during operation. If the motor encoder fails, the PLC shall receive a signal through the ethernet connection and shall command the span motor to decelerate to a stop and set the brakes. An alarm message will be displayed through the HMI and an option to restart operation of the bridge in sensorless mode shall be selectable through the HMI screen.

(5) Note: If PLC command to lower the span is sent continuously for more than 15 seconds and the PLC Ethernet monitoring does not indicate the drive is running or the encoder or speed switch does not provide a signal that the motor is rotating, the PLC shall generate and store an alarm on the touchscreen.

Span Position - The PLC shall continuously monitor the PLC analog input for 'Span Position' and compare the rotary cam limit switch contacts inputs for 'Lower Stop', 'Nearly Closed', 'Nearly Open', 'Fully Open', 'Raise Decel Check', 'Lower Decel Check'. If the PLC detects a variation between the limit set points and the span position angular value, then the PLC shall command the drive to decelerate (ramp down) to stop in 5 seconds and the PLC shall generate and store an alarm.

When the drive has stopped, the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(6) Close the Span to Nearly Closed - The PLC shall maintain the full speed lower operation of the span until the span reaches the nearly closed position. When PLC input rotary limit switch contact 'Nearly Closed' is energized, then the span is nearly closed.

When the span is nearly closed the PLC shall command the drive to continue closing the span and reduce speed to creep speed. Once the span is at creep speed the PLC shall continue in lower creep until the full closed limit switches are activated. Once the fully closed limit switches activate, the drive shall command the motor to enter reduced torque in the lower direction.

The PLC shall monitor the drive through the Ethernet connection and monitor the motor speed to verify the drive motor speed is reduced to creep speed. After the PLC input for "Nearly Closed is energized, the PLC shall monitor the analog input 'Span Motor Speed' as well as the auxiliary contact "Speed Switch." If the motor speed does not begin to decelerate within 5 seconds or if the auxiliary contact does not open/close when the PLC input for Lower Decel Check' de-energizes, then the PLC shall immediately stop the span motor and set the brakes (emergency stop).

When the drive has stopped, the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(7) Close the Span to Fully Closed - The PLC shall maintain creep speed until the span reaches fully closed. When both PLC inputs for the fully closed position are energized, the PLC and drive shall reduce the maximum torque setting of the drive to 75% and shall monitor the speed of the motor until no movement of the motor shaft is detected. When no movement is detected the PLC shall de-energize all the brake contactors to set all brakes and continue close the span for 3 seconds (to be field adjusted). De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(8) When the span is fully closed and the 3 second delay has ended, the PLC

shall command the Drive to ramp from creep speed to zero RPM in less than one second. After one second the PLC shall de-energize the motor contactor to isolate the motor from the drive.

(xii) Interlocks:

(1) The span shall be interlocked such that the span cannot be opened unless the span locks are pulled, both barrier gates are closed, all warning gates are fully lowered, the traffic signals are red, and there is bridge control power.

(2) Bypass Operation: The PLC shall check the number of interlocks bypassed during an opening and limit the amount to a maximum of two interlocks bypassed.

If the span lock fails to pull, the span lock pulled interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

If either barrier gates fails to lower, the barrier gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

If any of the warning gates fails to lower, the warning gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

The span position failure can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(12) Hardwired Switch Only

(i) The PLC shall operate in the same manner as noted above while using the hardwired switch with exceptions noted below.

(ii) When the PLC input 'Screen Operation' is energized the PLC shall disable touchscreen operation from any location on the bridge.

(iii) Before operation of any piece of equipment using the hardwired switches and push-buttons the PLC shall check the PLC input "Control Desk Operation" prior to each component being operated.

Savannah Road Bridge

(1) Fault/Reset

(i) At any point where an alarm message is generated, the fault/reset illuminated push-button shall be turned on and remain on until the fault is cleared and the reset push-button is pressed.

(ii) For critical faults including emergency stops, opening of specified electrical enclosure doors, and over travel, the main circuit breaker to the motor control enclosure shall be turned off through the UV circuit as shown on the plans.

(2) Control Power Selector Switch (CS-CP)

(i) The operator shall turn the control desk Control Power (CS-CP) switch

to the 'On' position.

(ii) Control Power switch in the 'On' position is provided as an energized input 'Control Power On' to the PLC.

(iii) The Control Power switch (CS-CP) activates Bridge Control relay as long as there is no power fault condition in the service power.

(iv) When the PLC has control power, the PLC shall verify all PLC Input card circuit breaker check inputs are energized.

(v) If at any time during an operation, a single or multiple of the above PLC inputs are de-energized while the 'Control Power On' PLC input is energized, the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.

(vi) The PLC input Power Fault Alarm shall be energized if there is a power fault. If there is a power fault the PLC shall de-energize all outputs, generate and provide an alarm, and shall not attempt any bridge operation until the PLC input is de-energized.

(3) Emergency Stop Push-Buttons (PB-ES1 and PB-ES2) and Safety Relays

(i) If at any time during an operation, the 'Control Power On' PLC input is energized and the 'Emergency Stop' push-buttons or safety relay inputs de-energized (the 'Emergency Stop' button is pressed), the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the Emergency Stop inputs are energized.

(ii) If any Emergency Stop push-button is depressed or safety relays are energized, or the emergency stop push-buttons are depressed during bridge operation, then the PLC input 'Emergency Stop' from PB-ES or safety relay inputs shall de-energize. The PLC shall stop all bridge operations and generate an alarm. The PLC shall not allow any other operation until all the Emergency Stop push-buttons are pulled out to the not depressed position.

(iii) If any Emergency Stop push-button is depressed, the hardwired Master Control Relays will de-energize the control output power busses and the PLC shall verify that the emergency stop inputs are de-energized.

(iv) If any of the inputs are not de-energized when the 'Emergency Stop' PLC inputs are de-energized, then the PLC shall generate an alarm.

(4) Bridge Status Indication - Upon the 'Control Power On' PLC input energizing, the PLC will scan the bridge for the status of the following items to illuminate or de-energize the touchscreen indicators as follows:

(i) Indication Lights

(1) The PLC shall verify the span, warning gate, tail locks, center locks, alarms, and other status indications and positions and illuminate the appropriate indicators on the touchscreen.

(ii) Brake Hand Release Status and Indication

(1) The PLC shall verify that all motor brakes and machinery brakes are not hand released. If any brake is hand released before or during span motor operation a warning message shall be displayed on the touchscreen and stored.

(2) If any brakes are hand released an alarm shall be displayed on the touchscreen and stored.

(3) If the span motor is in operation and more than one motor (two

machinery brakes set) or one machinery brake (one motor brake and one machinery brake set) is hand released the span drive shall decelerate the motor to an immediate stop and hold it there until at least two machinery brakes are not hand released or one motor brake and one machinery brake are not hand released.

(iii) Ethernet Communication on Span Motor Drives:

(1) The PLC shall verify the Ethernet inputs to determine the status of the main motor drive. If there are any alarms or fault then the PLC shall prevent span operation, send an alarm to the touchscreen, store the alarm and illuminate the fault/reset illuminated push-button.

(2) The PLC shall continuously monitor the equipment and scan for issues.

(iv) Circuit Breaker - The PLC shall monitor the inputs for each circuit breaker auxiliary contact. If any circuit breaker trips, the PLC shall prevent span operation, send an alarm to the touchscreen and store the alarm.

Bypass Operation: If there is a circuit breaker failure, the circuit breaker operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(v) Bypass Operation

(1) If an interlock does not function, the interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual bypass switch.

(2) Whenever a bypass is used, the PLC shall generate an alarm. When any bypass switch is active the PLC shall send an alarm message to the HMI display screen describing the bypass used.

(3) No more than two bypass switches shall be operated at any given time. If more than two are active an alarm message shall be displayed of the touch screen.

(vi) Drive Trouble Status Indication

(1) The PLC shall verify that either Span Drive does not have a Trouble alarm. If the drive does have a trouble alarm, then the PLC shall illuminate the fault/reset indicating light on the control desk, prevent drive operation with that drive, send an alarm to the touchscreen and store the alarm. (Refer to the span operation for the requirements of a Drive Trouble Alarm during an operation and the hard stop requirements.)

(vii) Position Transmitter Status Indication

(1) The PLC inputs for 'Position Resolver' shall receive an analog input from the resolvers (position transmitters). The PLC located in the switchboard room shall transmit the analog signal position information to the control desk PLC and all touchscreens. The PLC shall transmit the resolver signals to the control desk touchscreen Span Position Indicator. The display shall provide the span position in degrees, from zero degrees while fully closed to 73 degrees when fully open. The PLC shall continually

update the position information while control power is on.

(2) The PLC shall monitor the resolver analog inputs and internally monitor the span position in degrees for each leaf. The PLC shall compare the resolver position to the PLC inputs for span rotary limit switch contacts. If the PLC resolver analog degree is more than 3 degrees off from the rotary limit switch contacts (as shown on the Plans) the PLC shall generate an alarm.

(3) If no analog signal is received from the position transmitters, then the PLC shall generate and print an alarm.

(viii) Non-Automatic Control

(1) The PLC shall verify that no equipment is being operated in non-automatic mode. The PLC shall verify that the PLC inputs from the manual-off-auto switch are in the 'auto' position. If the switches are not in the 'auto' position and are in the 'hand' or 'off' position, then the PLC shall de-energize all outputs, generate an alarm, and shall not attempt any bridge operation until the PLC inputs are energized.

(ix) Manual Operation Limit Switches

(1) When any hand crank limit switch is open, the PLC shall disable control of the associated motor and send an alarm message to the touchscreen.

(2) When any hand crank limit switch is engaged the PLC shall disable motor operation for three (3) minutes unless bypassed on the HMI screen.

(x) Disconnect Switch Status for All Motors

(1) The PLC shall verify that no motors are disconnected.

(2) At any time, if any of the PLC disconnect switch inputs are de-energized, the PLC shall de-energize all outputs, generate an alarm identifying the specific motor that has had its disconnect operated, and shall not attempt any bridge operation until the PLC inputs are energized.

Bypass Operation:

If there is a motor disconnect switch operated, the disconnect operated interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(xi) Drive Ready Status Indication

(1) The PLC shall verify that all drives are ready. If the motor drive is ready and the motor is not disconnected, then the PLC shall illuminate the drive ready indicator on the touchscreen.

(2) If the drive is not ready, the PLC program shall generate an alarm.

(xii) Span Auxiliary System Operation

(1) The span can be operated with the auxiliary system. A limit switch provides indication this system has been activated. When the system is activated the PLC shall provide an alarm and prevent automatic operation of the associated equipment while manual operation is under way.

(xiii) Span Drive Ammeters and Voltmeters

(1) Span Drive Motor and voltage values for motor loads shall be transmitted to the control desk touchscreen and switchboard room touchscreen through the ethernet connection. The PLC shall transmit the values to the remote rack in the control desk. The PLC shall continually update the information while control power is on.

(xiv) Temperature Control

(1) The PLC shall verify and display the temperature level and heating set point from each electronic thermostat. The operator shall be able to control each thermostat from the touchscreen on the control desk or remotely from an off-site location. If the temperature in any room reaches a specified threshold an alarm message shall be generated and stored.

(xv) Stand-by Generator

(1) When low fuel, high fuel, low battery and any other generator fault is detected, the PLC shall send an alarm message to the touchscreen and disable operation of the generator.

(2) When the generator is energized and the PLC receives a generator running status signal the PLC shall send an alarm to the touchscreen and store the alarm.

(3) When the generator is running or any generator fault is detected, the PLC shall prevent operation and send an alarm to the touchscreen and store the alarm.

(4) When the generator is running and the ATS is transferred to the emergency position, the PLC shall limit operation of the bridge to one span motor at a time. When in this condition the PLC shall provide a warning alarm and store the alarm.

(xvi) ATS

(1) When the ATS changes positions, the PLC shall send an alarm to the touchscreen and store the alarm.

(2) When the ATS has a fault, the PLC shall send an alarm to the touchscreen and store the alarm.

(xvii) Emergency Stop

(1) When any of the emergency stop push-buttons are activated or safety relays de-energized, the PLC shall prevent operation and send an alarm to the touchscreen and store the alarm.

(2) When any of the emergency stop push-buttons are activated, the PLC shall prevent operation and send an alarm to the touchscreen and store the alarm.

(3) When any of the emergency stop push-buttons are activated, the PLC shall check the associated safety relays and send an alarm message to the display screen if the contacts are not in the correct state.

(xviii) Span Drive Faults

(1) When any of the braking resistors temperature sensor detects a high temperature, the PLC shall disable operation of the associated span drive and send an alarm to the touchscreen and store the alarm.

(2) When a deceleration failure occurs in any of the span drives, the PLC shall immediately disable operation of the associated span drive and send an alarm to the touchscreen and store the alarm.

(3) When a span drive warning alarm is detected, the PLC shall send an alarm message to the touchscreen and ramp the drive down to a stop and set all brakes.

(4) When a span drive fault alarm is detected, the PLC shall disable operation of the associated span drive, set all brakes and send an alarm to the touchscreen and store the alarm.

(5) When a span drive communication alarm is detected, the PLC shall disable operation of the associated span drive, set all brakes and send an alarm to the touchscreen and store the alarm.

(6) When an overcurrent is detected on any of the span drives, the PLC shall send an alarm to the touchscreen and store the alarm.

(7) When the drive drift selector switch is set to On and the span angular position is within 10 degrees of the full open or full closed positions the PLC shall send an alarm message to the touch screen and the drive shall decelerate to a stop and set the brakes.

(xix) Phase Failure

(1) When the phase monitor/phase failure relay has tripped, the PLC shall send an alarm to the touchscreen and store the alarm.

(xx) Limit Switch Failure

(1) When the two fully closed limit switches do not activated within 20 seconds (to be field verified) of each other, the PLC shall send an alarm to the touchscreen and store the alarm.

(2) When any span lock, barrier gate or warning gate limit switch does not activate within 30 seconds (to be field verified) of the opposing contact, the PLC shall send an alarm to the touchscreen and store the alarm.

(3) When any span rotary cam limit switch contact does not change state as the correct angular setting when compared to the absolute encoder, the PLC shall send an alarm to the touchscreen and store the alarm.

(4) When any over travel limit switch or manual operation limit switch is activated, the PLC shall send an alarm to the touchscreen and store the alarm. The over travel limit switch once activated shall not reset until the fully closed limit switch is disengaged.

(xxi) Warning Gate Door Switch

(1) When any door switch is open, the PLC shall disable control of the associated motor and send an alarm to the touchscreen and store the alarm.

(5) Traffic Signal Selector (Switch or Touchscreen)

(i) When the selector switch for the traffic signals is in the 'Go' position the PLC shall:

(1) Energize the touchscreen traffic signal green indicator if control power is on, all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.

(2) De-energize the touchscreen traffic signal red indicator if all gates are raised, all barriers are open, the span locks are driven, and the span is fully closed.

(3) De-energize the PLC outputs feeding the traffic signals and gongs.

(ii) When the selector switch for the traffic signals is placed in the 'Stop' position the PLC shall:

(1) De-energize the touchscreen traffic signals green indicator.

(2) Energize the touchscreen traffic signal red indicator.

(3) Energize the PLC outputs to activate the gongs by energizing the associated relay.

(4) The timing for the traffic signals shall be operated by control relays to ensure safe operation when the equipment is operated without PLC control.

(5) The PLC shall monitor the inputs from CR-RSR and CR-ASR as shown on the plan to verify proper operation of the traffic signals. The PLC shall generate an alarm if the relays operate out of sequence.

(iii) Interlocks:

(1) The only interlock to prevent the operator from activating the traffic signals is that bridge control power is on and the timing relay is closed.

(iv) Bypass Operation:

(1) If there is a failure with the timing relay the interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(6) On-Coming Gate Selector (Switch or Touchscreen)

(i) When the PLC input 'NE Warning Gate Raised' is energized, the NE gate is fully raised and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'SW Warning Gate Raised' is energized, the SW gate is fully raised and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'NE Warning Gate Lowered' is energized, NE the gate is fully lowered and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'SW Warning Gate Lowered' is energized, the SW gate is fully lowered and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'NE Warning Gate Lowered' and 'NE Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'SW Warning Gate Lowered' and 'SW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.

(viii) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NE Warning Gate Raise' and 'NE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the oncoming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
  (1) De-energize the PLC output NE Warning Gate Lower
  (2) De-energize the PLC output NE Warning Gate Raise

(ix) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SW Warning Gate Raise' and 'SW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the oncoming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.
  (1) De-energize the PLC output SW Warning Gate Lower
  (2) De-energize the PLC output SW Warning Gate Raise

(x) Turn the On-Coming Selector Switch to the Lower Position (Switch or Touchscreen)

(xi) When the selector switch NE Warning Gate is held in the 'Lower' position, PLC inputs 'NE Warning Gate Lower' shall be energized.

(xii) While PLC input 'NE Warning Gate Lower' is energized and the PLC input 'NE Warning Gate Lower Stop' is energized, the PLC shall:
  (1) Energize the PLC output 'NE Warning Gate Lower'
  (2) De-energize the PLC output 'NE Warning Gate Raise'

(xiii) When the selector switch SW Warning Gate is held in the 'Lower' position, PLC inputs 'NE Warning Gate Lower' shall be energized.

(xiv) While PLC input 'SW Warning Gate Lower' is energized and the PLC input 'SW Warning Gate Lower Stop' is energized, the PLC shall:
  (1) Energize the PLC output 'SW Warning Gate Lower'
  (2) De-energize the PLC output 'SW Warning Gate Raise'

(xv) Note: If PLC input 'NE Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Lower'

(xvi) Note: If PLC input 'SW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Lower'

(xvii) Lower Interlocks:
  (1) The NE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.
  (2) The SW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power and the traffic signals are red.

(xviii) Lower Bypass Operation: There is no bypass operation for the loss of control power or traffic signals red.

(xix) Turn the On-Coming Selector Switch to the Raise Position (Switch or Touchscreen)

(xx) When the selector switch NE Warning Gate is held in the 'Raise' position, PLC inputs 'NE Warning Gate Raise' shall be energized.

(xxi) While PLC input 'NE Warning Gate Raise' is energized and the PLC input 'NE Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'NE Warning Gate Raise'
- (2) De-energize the PLC output 'NE Warning Gate Lower'

(xxii) When the selector switch SW Warning Gate is held in the 'Raise' position, PLC inputs 'NE Warning Gate Raise' shall be energized.

(xxiii) While PLC input 'SW Warning Gate Raise' is energized and the PLC input 'SW Warning Gate Raise Stop' is energized, the PLC shall:
- (1) Energize the PLC output 'SW Warning Gate Raise'
- (2) De-energize the PLC output 'SW Warning Gate Lower'

(xxiv) Note: If PLC input 'NE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NE Warning Gate Raise'

(xxv) Note: If PLC input 'SW Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SW Warning Gate Raise'

(xxvi) Raise Interlocks:
- (1) The NE Warning Gate shall be interlocked such that it cannot be Raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, center locks are driven and tail locks are driven.
- (2) The SW Warning Gate shall be interlocked such that it cannot be Raised unless there is bridge control power, the traffic signals are red, off-going gates are raised, center locks are driven and tail locks are driven.

(xxvii) Raise Bypass Operation: If there is a failure with either off-going gate, center lock limit switch, tail lock limit switch, span seated limit switch, the on-coming gate raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(7) Off-Going Warning Gate Selector Switch (Switch or Touchscreen)

(i) When the PLC input 'NW Warning Gate Raised' is energized, the NW gate is fully raised and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'SE Warning Gate Raised' is energized, the SE gate is fully raised and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'NW Warning Gate Lowered' is energized, the gate is fully lowered and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'SE Warning Gate Lowered' is energized, the SE gate is fully lowered and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'NW Warning Gate Lowered' and 'NW Warning Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'SE Warning Gate Lowered' and 'SE Warning

Gate Raised' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the gate door open, disconnect switch open and hand crank inputs for the gate. If any gate door is open, disconnect switch is open or the hand crank activated, then the PLC shall prevent gate operation, send an alarm to the touchscreen and store the alarm.

(viii) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'NW Warning Gate Raise' and 'NW Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the oncoming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output NW Warning Gate Lower

(2) De-energize the PLC output NW Warning Gate Raise

(ix) When the selector switch or touchscreen buttons are in the 'Off' position, both PLC inputs 'SE Warning Gate Raise' and 'SE Warning Gate Lower' shall be de-energized. While both inputs are de-energized, the PLC shall not attempt to operate the oncoming gate. The position of the hard-wired selector switch shall only be checked when the mode selector switch is not in touchscreen mode.

(1) De-energize the PLC output SE Warning Gate Lower

(2) De-energize the PLC output SE Warning Gate Raise

(x) Turn the Off-Going Warning Gate Selector Switch to Lower (Switch or Touchscreen)

(xi) When the selector switch NW Warning Gate is held in the 'Lower' position, PLC inputs 'NW Warning Gate Lower' shall be energized.

(xii) While PLC input 'NW Warning Gate Lower' is energized and the PLC input 'NW Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Warning Gate Lower'

(2) De-energize the PLC output 'NW Warning Gate Raise'

(xiii) When the selector switch SE Warning Gate is held in the 'Lower' position, PLC inputs 'SE Warning Gate Lower' shall be energized.

(xiv) While PLC input 'SE Warning Gate Lower' is energized and the PLC input 'SE Warning Gate Lower Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SE Warning Gate Lower'

(2) De-energize the PLC output 'SE Warning Gate Raise'

(xv) Note: If PLC input 'NW Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Warning Gate Lower'

(xvi) Note: If PLC input 'SE Warning Gate Lower' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Lower Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Lower'

(xvii) Lower Interlocks:

(1) The NW Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, and both on-coming gates are lowered.

(2) The SE Warning Gate shall be interlocked such that it cannot be lowered unless there is bridge control power, traffic signals are red, and both on-coming gates are lowered.

(xviii) Bypass Operation: If there is a failure with either oncoming gate, the on-coming gate lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(xix) Turn the Off-Going Warning Gate Selector Switch to Raise (Switch or Touchscreen)

(xx) When the selector switch NW Warning Gate is held in the 'Raise' position, PLC inputs 'NW Warning Gate Raise' shall be energized.

(xxi) While PLC input 'NW Warning Gate Raise' is energized and the PLC input 'NW Warning Gate Raise Stop' is energized, the PLC shall:

(1) Energize the PLC output 'NW Warning Gate Raise'

(2) De-energize the PLC output 'NW Warning Gate Lower'

(xxii) When the selector switch SE Warning Gate is held in the 'Raise' position, PLC inputs 'SE Warning Gate Raise' shall be energized.

(xxiii) While PLC input 'SE Warning Gate Raise' is energized and the PLC input 'SE Warning Gate Raise Stop' is energized, the PLC shall:

(1) Energize the PLC output 'SE Warning Gate Raise'

(2) De-energize the PLC output 'SE Warning Gate Lower'

(xxiv) Note: If PLC input 'NW WAarning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'NW Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'NW Warning Gate Raise'

(xxv) Note: If PLC input 'SE Warning Gate Raise' is energized continuously for more than 15 seconds and the PLC input 'SE Warning Gate Raise Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'SE Warning Gate Raise'

(xxvi) Raise Interlocks:

(1) The NW Warning Gate shall be interlocked such that it cannot be Raised unless there is bridge control power, traffic signals are red, tail locks are driven and center locks are driven.

(2) The SE Warning Gate shall be interlocked such that it cannot be Raised unless there is bridge control power, traffic signals are red, tail locks are driven and center locks are driven.

(xxvii) Bypass Operation: If there is a failure with the center lock limit switches, tail lock limit switches or span seated limit switches, the off-going gates raised interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(8) Center Lock Selector Switch (Switch or Touchscreen)

(i) When the PLC input 'Center Lock 1 Pulled' is energized, Center Lock 1 is fully pulled and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'Center Lock 2 Pulled' is energized, Center Lock 2 is fully pulled and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'Center Lock 1 Driven' is energized, Center Lock 1 is fully driven and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'Center Lock 2 Driven' is energized, Center Lock 2 is fully driven and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'Center Lock 1 Pulled and 'Center Lock 1 Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'Center Lock 2 Pulled and 'Center Lock 2 Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the disconnect switch open and hand crank inputs for any center lock. If any disconnect switch is open or the hand crank activated, then the PLC shall prevent automatic center lock operation, send an alarm to the touchscreen, and store the alarm.

(viii) When the touchscreen buttons are in the 'Off' position, PLC inputs 'Center Lock 1 Pull', 'Center Lock 1 Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate Center Lock 1.

(1) De-energize the PLC output Center Lock 1 Drive

(2) De-energize the PLC output Center Lock 1 Pull

(ix) When the touchscreen buttons or selector switch are in the 'Off' position, PLC inputs 'Center Lock 2 Pull', 'Center Lock 2 Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate Center Lock 2.

(1) De-energize the PLC output Center Lock 2 Drive

(2) De-energize the PLC output Center Lock 2 Pull

(x) Turn the Center Lock Selector Switch to Pull (Switch or Touchscreen)

(xi) When the Center Lock selector switch or touchscreen is turned to the 'Pull' position, PLC input 'Center Lock 1 Pull' shall be energized. While PLC input 'Center Lock 1 Pull' is energized and the PLC input 'Center Lock 1 Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'Center Lock 1 Pull'

(2) De-energize the PLC output 'Center Lock 1 Drive'

(xii) Note: If PLC input 'Center Lock 1 Pull' is energized continuously for more than 15 seconds and the PLC input 'Center Lock 1 Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'Center Lock 1 Pull'

(xiii) When the Center Lock selector switch or touchscreen is turned to the 'Pull' position, PLC input 'Center Lock 2 Pull' shall be energized. While PLC input 'Center Lock 1 Pull' is energized and the PLC input 'Center Lock 2 Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'Center Lock 2 Pull'

(2) De-energize the PLC output 'Center Lock 2 Drive'

(xiv) Note: If PLC input 'Center Lock 2 Pull' is energized continuously for more than 15 seconds and the PLC input 'Center Lock 2 Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'Center Lock 2 Pull'

(xv) Pull Interlocks:

(1) The Center Locks shall be interlocked such that either center lock cannot be pulled unless there is bridge control power, traffic signals are red, all warning gates are lowered, all tail locks are

driven and the span(s) are seated.

(xvi) Bypass Operation: If there is a failure with any warning gate, tail locks or span seated limit switches, the span lock pull interlock can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(xvii) Turn the Center Lock Selector Switch to Drive Position (Switch or Touchscreen)

(xviii) When the Center Lock selector switch or touchscreen is turned to the 'Drive' position, PLC input 'Center Lock 1 Drive' shall be energized. While PLC input 'Center Lock 1 Drive' is energized and the PLC input 'Center Lock 1 Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'Center Lock 1 Drive'

(2) De-energize the PLC output 'Center Lock 1 Pull'

(xix) Note: If PLC input 'Center Lock 1 Drive' is energized continuously for more than 15 seconds and the PLC input 'Center Lock 1 Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'Center Lock 1 Drive'

(xx) When the Center Lock selector switch or touchscreen is turned to the 'Drive' position, PLC input 'Center Lock 2 Drive' shall be energized. While PLC input 'Center Lock 1 Drive' is energized and the PLC input 'Center Lock 2 Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'Center Lock 2 Pull'

(2) De-energize the PLC output 'Center Lock 2 Drive'

(xxi) Note: If PLC input 'Center Lock 2 Drive' is energized continuously for more than 15 seconds and the PLC input 'Center Lock 2 Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'Center Lock 2 Drive'

(xxii) Drive Interlocks:

(1) The Center Locks shall be interlocked such that either center lock cannot be driven unless there is bridge control power, traffic signals are red, all warning gates are lowered, tail locks are driven and the span(s) are seated.

(xxiii) Bypass Operation: If there is a failure with any warning gate, tail locks or span seated limit switches, the span lock drive interlock can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm.

(9) Tail Lock Selector Switch (Touchscreen and Switch)

(i) When the PLC input 'West Tail Lock Pulled' is energized, the West Tail Lock is fully pulled and the PLC shall energize the touchscreen indicator.

(ii) When the PLC input 'West Tail Lock Driven' is energized, the West Tail Lock is fully driven and the PLC shall energize the touchscreen indicator.

(iii) When the PLC input 'East Tail Lock Pulled' is energized, the East Tail Lock is fully pulled and the PLC shall energize the touchscreen indicator.

(iv) When the PLC input 'East Tail Lock Driven' is energized, the East Tail Lock is fully driven and the PLC shall energize the touchscreen indicator.

(v) When both PLC inputs 'West Tail Lock Pulled and 'West Tail Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vi) When both PLC inputs 'East Tail Lock Pulled and 'East Tail Lock Driven' are de-energized, the PLC shall flash alternately the touchscreen indicators.

(vii) The PLC shall monitor the inputs for the disconnect switch open and hand crank inputs for any tail lock. If any disconnect switch is open or the hand crank activated, then the PLC shall prevent automatic tail lock operation, send an alarm to the touchscreen, and store the alarm.

(viii) When the touchscreen buttons or selector switch are in the 'Off' position, PLC inputs 'West Tail Lock Pull', 'West Tail Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the West Tail Lock.

(1) De-energize the PLC outputs West Tail Lock Drive

(2) De-energize the PLC outputs West Tail Lock Drive

(ix) When the touchscreen buttons or selector switch are in the 'Off' position, PLC inputs 'East Tail Lock Pull', 'East Tail Lock Drive' shall be de-energized. While these inputs are de-energized, the PLC shall not attempt to operate the West Tail Lock.

(1) De-energize the PLC outputs West Tail Lock Drive

(2) De-energize the PLC outputs West Tail Lock Drive

(x) Turn the Tail Lock Selector Switch to the Pull Position (Switch or Touchscreen)

(xi) When the Tail Lock selector switch or touchscreen is turned to the 'Pull' position, PLC input 'West Tail Lock Pull' shall be energized. While PLC input 'West Tail Lock Pull' is energized and the PLC input 'West Tail Lock Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'West Tail Lock Pull'

(2) De-energize the PLC output 'West Tail Lock Drive'

(xii) Note: If PLC input 'West Tail Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'West Tail Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'West Tail Lock Pull'

(xiii) When the Tail Lock selector switch is turned to the 'Pull' position, PLC input 'East Tail Lock Pull' shall be energized. While PLC input 'East Tail Lock Pull' is energized and the PLC input 'East Tail Lock Pull Stop' is energized, the PLC shall:

(1) Energize the PLC output 'East Tail Lock Pull'

(2) De-energize the PLC output 'East Tail Lock Drive'

(xiv) Note: If PLC input 'East Tail Lock Pull' is energized continuously for more than 15 seconds and the PLC input 'East Tail Lock Pull Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'East Tail Lock Pull'

(xv) Pull Interlocks:

(1) The Tail Locks shall be interlocked such that either tail lock cannot be pulled unless there is bridge control power, traffic signals are red, all warning gates are lowered, center locks are driven and the span(s) are seated

(xvi) Pull Bypass Operation: If there is a failure with any warning gate, center locks or span seated limit switches, the center locks pull interlock can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm

(xvii) Turn the Tail Lock Selector Switch to the Drive Position (Switch or Touchscreen)

(xviii) When the Tail Lock selector switch or touchscreen is turned to the 'Drive' position, PLC input 'West Tail Lock Drive' shall be energized. While PLC input 'West Tail Lock Drive' is energized and the PLC input 'West Tail Lock Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'West Tail Lock Drive'

(2) De-energize the PLC output 'West Tail Lock Pull'

(xix) Note: If PLC input 'West Tail Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'West Tail Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'West Tail Lock Drive'

(xx) When the Tail Lock selector switch is turned to the 'Drive' position, PLC input 'East Tail Lock Drive' shall be energized. While PLC input 'East Tail Lock Drive' is energized and the PLC input 'East Tail Lock Drive Stop' is energized, the PLC shall:

(1) Energize the PLC output 'East Tail Lock Drive'

(2) De-energize the PLC output 'East Tail Lock Pull'

(xxi) Note: If PLC input 'East Tail Lock Drive' is energized continuously for more than 15 seconds and the PLC input 'East Tail Lock Drive Stop' has not been de-energized, the PLC shall generate an alarm and de-energize input 'East Tail Lock Drive'

(xxii) Drive Interlocks:

(1) The Tail Locks shall be interlocked such that either tail lock cannot be driven unless there is bridge control power, traffic signals are red, all warning gates are lowered, center locks are pulled and the span(s) are seated

(xxiii) Drive Bypass Operation: If there is a failure with any warning gate, center locks or span seated limit switches, the center locks drive interlocks can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used, the PLC shall generate an alarm

(10) Drive Fault/Reset Illuminated Push Button (PB-RE)

(i) The operator may attempt to reset a drive by pressing the Drive Reset push button (PB-RE). When the operator presses Drive Reset push button (PB-RE), the PLC input 'Reset Drive' shall energize momentarily. When the PLC input 'Reset Drive' energizes momentarily, the PLC uses the Ethernet connection to the drive to reset the drive (coordinate with the drive manufacturer).

(ii) When a fault of the drive is energized the PLC shall receive a signal from the Ethernet connection and the PLC output 'Drive Reset' shall energize. The PLC output for "Drive Reset" shall remain energized until the fault on the drive system is no longer active. At any time when a fault of the drive is active an alarm message shall be displayed on the touchscreen

and stored.

(11) Span Control Selector Switches (Touchscreen and Switch)

(i) The PLC shall verify it is safe to operate the span and energize the west and east load contactors and enable the drives if all the following criteria are met: The span motors shall not be operated if either associated auxiliary system is engaged, more than one associated brake is hand released per leaf, the brake thrusters or span motors are disconnected, the motor temperature sensor indicates a high temperature, the motor load contactor is off, the braking resistor temperature sensor is open, the speed switch/sensor is not indicating correctly, the center locks are not pulled, the associated tail locks are not pulled, the warning gates are not lowered, and the traffic signals are green. (See prior steps for details.)

(ii) Under generator operation, PLC shall allow only one drive at a time to operate. When the PLC inputs "Generator Running" and "ATS in Emergency Position" are energized the PLC shall send an alarm message to the touchscreen and allow the operator to select which span motor to operate.

(iii) When the leaf control selector switch is in the 'Off' position, PLC ethernet inputs 'West Span Raise', 'West Span Lower', 'West Span Raise' and 'West Span Lower shall be de-energized. While the inputs are de-energized, the PLC shall ensure both drives are in stop, not attempt to operate the drive and use the Ethernet connection to monitor the drive status.

(iv) Turn the span control selector switch to Raise (Touchscreen Only)

(1) When Leaf control selector switch is in the Raise position, the PLC ethernet input 'West Leaf Raise' will energize for the associated leaf. The PLC shall command the drive to energize the motor and verify proof of torque feedback from the motor drive, and then the PLC will release all brakes by energizing the associated PLC outputs.

(2) The PLC shall verify that all brakes are released by verifying the PLC inputs for their associated limit switches are energized. If any brake does not release within 2 seconds, the PLC shall not continue span operation and shall generate and store an alarm on the touchscreen.

(3) When the PLC ethernet input 'West Span Raise' or 'East Span Raise' is energized for the associated leaf and all brakes are released, the PLC shall use the Ethernet connection to command the drives to raise each leaf, ramping up ten seconds to full operating speed. Commanding the drives to raise shall initiate the drives to rotate each span motor in the direction that opens the leaf. The PLC shall verify that the drives are operating through the Ethernet communication and that the speed switches are operational and has changed states. The PLC shall monitor the drives to verify proper motor control through the Ethernet communication with each drive. An analog signal input to the PLC from the speed switch shall also provide speed information for each span motor throughout operation and display motor speed on the touchscreen. At any point if a fault occurs, key

parameters such as speed, position, fault identifier, motor current, and motor voltage shall be stored to the touchscreen.

(4) Note: If the PLC command to raise either span is sent continuously for more than 15 seconds and the PLC Ethernet monitoring does not indicate the specific drive is running or the speed switch does not provide a signal that the specific motor is rotating, the PLC shall generate and store an alarm on the touchscreen.

Span Position - The PLC shall continuously monitor the PLC analog input for 'West Leaf Position' and 'East Leaf Position' and compare the rotary cam limit switch contacts inputs for 'Raise Stop', 'Nearly Closed', 'Nearly Open', 'Fully Open', 'Raise Decel Check', 'Lower Decel Check' for each leaf. If the PLC detects a variation between the limit set points and the span position angular value, then the PLC shall command the drive to decelerate (ramp down) to stop in 5 seconds and the PLC shall generate and store an alarm.

When the either drive has stopped, the PLC shall de-energize all the brake contactors to set all brakes. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(5) Stop - If the operator presses either West or East Stop push-button on the touchscreen while the span is in operation, the respective PLC ethernet inputs 'West Span Raise' and/or 'East Span Lower' shall be de-energized. When the inputs are de-energized during a raising operation, the PLC shall continue to open the respective span and decelerate (ramp down) to stop in 5 seconds. Then the PLC shall de-energize all the brake contactors to set all brakes on the respective leaf. De-energizing the brake motor contactors shall cause all the brakes to set on that leaf. The PLC shall verify that all the brakes are set by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm. The span operation can be restarted by following the procedure as shown above.

(6) Drive Trouble Operation - If at any time during an operation (both opening and closing) either Drive generates a Trouble Alarm, continue to open the respective span and decelerate (ramp down) to stop in 5 seconds. Then the PLC shall de-energize all the brake contactors to set all brakes on that specific leaf. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(7) Open the Leaf to Nearly Open - The PLC shall maintain the full speed raise operation of each leaf until it reaches the nearly open position. When PLC input rotary limit switch contact 'West Nearly Open' is energized, then the west leaf is nearly open. When PLC input rotary limit switch contact 'East Nearly Open' is energized, then the east leaf is nearly open.

When the west leaf is nearly open the PLC shall command the west drive to continue opening the west leaf and reduce speed to creep speed. Once the west leaf is at creep speed the PLC shall command the west drive to enter reduced torque in the raise direction.

When the east leaf is nearly open the PLC shall command the east drive to continue opening the east leaf and reduce speed to creep speed. Once the east leaf is at creep speed the PLC shall command the east drive to enter reduced torque in the raise direction.

The PLC shall monitor west drive through the Ethernet connection and monitor the motor speed throughout operation. After the PLC input for "West Nearly Open is energized, the PLC shall monitor the analog input 'West Leaf Motor Speed'. If the motor speed does not begin to decelerate within 5 seconds, then the PLC shall continue to open the command the west drive to decelerate (ramp down) to stop in 5 seconds.

The PLC shall monitor east drive through the Ethernet connection and monitor the motor speed throughout operation. After the PLC input for "East Nearly Open is energized, the PLC shall monitor the analog input 'East Leaf Motor Speed'. If the motor speed does not begin to decelerate within 5 seconds, then the PLC shall continue to open the command the east drive to decelerate (ramp down) to stop in 5 seconds.

If the PLC input for 'West Speed Switch' does not de-energize when the PLC input for 'West Raise Decel Check' de-energizes, then the PLC shall immediately stop the west leaf motor and set the west brakes (emergency stop).

If the PLC input for 'East Speed Switch' does not de-energize when the PLC input for 'East Raise Decel Check' de-energizes, then the PLC shall immediately stop the east leaf motor and set the east brakes (emergency stop).

When either drive has stopped, the PLC shall de-energize the brake contactors to set the brakes on the re. De-energizing the brake motor contactors shall cause all the brakes to set on that respective leaf. The PLC shall verify that all the brakes are set,

by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(8) Open the Leaf to Fully Open - The PLC shall maintain opening each leaf in creep speed until the respective span reaches the fully open position of 73 degrees. When PLC input for the leaf rotary limit switch contacts 'West Fully Open' is de-energized, then the leaf is west fully open. When PLC input for the leaf rotary limit switch contacts 'East Fully Open' is de-energized, then the leaf is east fully open.

When either leaf is fully open the PLC shall command the respective drive to ramp from creep speed to zero RPM in less than one second. After one second the PLC shall de-energize the respective motor contactor to isolate the motor from the drive. The PLC shall de-energize all the brake contactors to set all brakes on that leaf. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor and machinery brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(9) Leaf Overtravel Proximity Limit Switch

If either leaf open overtravel proximity limit activates, the PLC shall command the associated drive to ramp to a stop of zero (0) RPM in less than one second, and the PLC shall generate and store an alarm. After one second the PLC shall de-energize the motor contactor to isolate the motor from the drive. The PLC shall de-energize all the brake contactors to set all brakes on that leaf. De-energizing the brake motor contactors shall cause all the brakes to set. The PLC shall verify that all the motor and machinery brakes are set, by verifying the corresponding PLC limit switch inputs are de-energized. If any brake does not set within 5 seconds, the PLC shall generate and store an alarm.

(10) Interlocks:

The span shall be interlocked such that either span cannot be opened unless the center and tail locks are pulled, all warning gates are fully lowered, the traffic signals are red, and there is bridge control power.

(11) Bypass Operation: The PLC shall check the number of interlocks bypassed during an opening and limit the amount to a maximum of two interlocks bypassed.

If any center lock fails to pull, the center lock pulled interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

If any tail lock fails to pull, the tail lock pulled interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

If any of the warning gates fails to lower, the warning gates lowered interlock ONLY can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

The span position failure can be bypassed by using the touchscreen bypass in conjunction with the manual key operated bypass switch CS-BP. Whenever a bypass is used the PLC shall generate an alarm.

(12) Hardwired Switch Only

(i) The PLC shall operate in the same manner as noted above for the Center Locks, Tail Locks, and Span Motors while using the hardwired switch with exceptions noted below.
(ii) When the PLC input 'Screen Operation' is energized the PLC shall disable touchscreen operation from any location on the bridge.
(iii) Before operation of any piece of equipment using the hardwired switches and push-buttons the PLC shall check the PLC input "Control Desk Operation" prior to each component being operated.

Touchscreen Operation

General programing and operating requirements for each HMI touchscreen display screen is specified below. Each display screen shall consist of multiple selectable screens which are also noted below that are activated via the touchscreen. The Contractor shall adjust and add to the HMI screen program as directed by the Engineer during HMI and network testing as specified herein.

1. Operation Screen
   a. Includes general layout of selector switches, push-buttons, and indicators to mimic the layout of the hardwired switches on the control desk unless otherwise specified.
   b. Each device on the bridge shall have an individual button or switch represented pictorially which when selected shall operate the device as specified.
   c. Time and date stamp
   d. Angle of opening display
   e. Active alarm message display
   f. Selection tabs of alternate screens
   g. Time of traffic stopped display

2. Main Display Screen:
   a. Includes general imagine of the bridge including pictorial imagine of gates, locks, signals, brakes, etc. and their status (green for open to traffic, red for closed to traffic).
   b. Time and date stamp
   c. Angle of opening display
   d. Active alarm message display
   e. Selection tabs of alternate screens
   f. Time of traffic stopped display

3. Traffic and Gates Screen:
   a. Includes general imagine traffic gates and signals and their status (green for open to traffic, red for closed to traffic).
   b. Time and date stamp
   c. Angle of opening display
   d. Active alarm message display
   e. Selection tabs of alternate screens
   f. Time of traffic stopped display
   g. Operational status of each gate when selected including voltage, current and activate alarms.

4. Locks Screen:
   a. Includes general imagine center locks and tail locks and their status (green for open to traffic, red for closed to traffic).
   b. Time and date stamp
   c. Angle of opening display
   d. Active alarm message display
   e. Selection tabs of alternate screens
   f. Time of traffic stopped display
   g. Operational status of each lock when selected including voltage, current and activate alarms.

5. Span and Brakes Screen:
   a. Includes general imagine span operating machinery and their status (green for open to traffic, red for closed to traffic).
   b. Time and date stamp
   c. Angle of opening display
   d. Active alarm message display
   e. Selection tabs of alternate screens
   f. Time of traffic stopped display
   g. Operational status of each set of operating machinery when selected including voltage, current and activate alarms.
   h. Operational status of each drive when selected including speed, command, voltage, current, angle of opening, etc.

6. Alarm Screen:
   a. Includes alarm history page with last 12 alarms with date and time stamps and active or inactive status.

b. Acknowledge alarm button
c. Silence alarm button

7. Power Screen:
   a. Includes status of incoming service, generator and ATS
   b. Includes voltage and current values for each phase on the incoming service
   c. Time and date stamp
   d. Angle of opening display
   e. Active alarm message display

8. Maintenance Screen
   a. Directions screen when selected
   b. Password protected bypass operation for manual operation, warning gate door switches, deceleration failure
   c. Password protected manual operation of ATS and Generator
   d. Any other operator commended which only intended for maintenance staff.

9. Temperature
   a. Active and set temperature of each room in the control house.
   b. Status of each heating units (On or OFF).
   c. Alarms for heating system (high temperature alarm, low temperature alarm, fault)

Limit switches

Fabrication and installation for the "Limit Switches" and all associated equipment shall be paid for under items E5 and E23 "Limit Switches" unless otherwise noted. The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing," and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

All work to properly install and adjust new and existing limit switches shall be covered under this item in accordance with the plans and specified herein. All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor.

Field work for installation of the limit switches including mounting and adjustments shall be performed by the Contractor as well as fabrication of targets and mounting brackets. The alignment and fastening of the rotary cam limit switches, speed switch and resolvers shall conform to and be paid for under the requirements specified under the item 615503-Bridge Mechanical System.

Motors

Fabrication of the "Motors" and all associated equipment shall be paid for under items E6 and E25 of section. The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing", and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

All work performed for fabrication and testing as specified shall be performed by an acceptable control system vendor unless otherwise noted.

A complete set of speed torque current curves for one motor of each type and size provided shall be prepared and submitted by the manufacturer to the Engineer for approval. Curves corresponding to full load speed shall be provided. The curves shall cover the interval from breakaway torque to breakdown driving torque, referred to full load motor torque. All motors shall be subjected to a standard routine test including a full load heat run test.

All motors shall be subjected to an insulation resistance test per NEMA standard MG 1, Section Nos. 12.02 and 12.03. Insulation resistance values and test voltage shall be included on the test reports.

Tests shall be reported on the standard forms for induction motors of the National Electrical Manufacturers Association. All test reports and curve sheets shall be certified by the manufacturer, and three copies of each shall be submitted. Motors shall not be shipped from the plant of the manufacturer until the test reports have been approved by the Engineer.

Motors shall also be full load tested on a dynometer as specified under "Flux Vector Drives" with the span drive system.

Motor and Machinery Brakes

The existing motor and machinery brakes on Savannah Road Bridge and Rehoboth Avenue shall be replaced as shown on the plans including all limit switches. Fabrication, adjustment and modifications for the "Motor and Machinery Brakes" and all associated equipment shall be paid for under items E7 and E25. The alignment and fastening of the motor brakes and machinery brakes shall be as specified and paid for under section 615503. The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing", and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

Modifications to Traffic Control Equipment

The existing warning and barrier gates shall be modified as shown on the plans and specified herein. Under item E8 and E26, the barrier gates and warning gates shall be modified to include new arm light flashers, new motor disconnect switches and new door limit switches. The motor shall be reconnected as 480VAC, 3 phase and other modifications as noted.

The same items, shall also include installation of new traffic stop lines in accordance with MUTCD, installation of traffic signal heads, and flashing red warning beacons with "Stop Here On Red" sign on Savannah Road as part of item E26.

The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing," and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

Disconnect Switches

New motor and service disconnect switches shall be furnished and installed as shown on the plans and specified herein. Under item E9, the contractor shall furnish and install new disconnect switches for the span motor, brakes and span locks motors. Under item E27, the contractor shall furnish and install new disconnect switches for the span motors, brakes, center lock motors and tail locks motors.
Under items E12 and E30, the contractor furnish and install new service disconnects witch for the new incoming service.

The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing," and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

Wire and Cable

Under the items E10 and E28, the size of all conductors shall be as indicated on the Contract Plans. If no size is indicated or the conductor size and number as shown on the approved electrical schematics vary from that shown on the Contract Plans, conductors of sufficient size and number shall be provided to accommodate the circuits to be installed. These conductors shall be sized in conformance with the National Electrical Code and any other applicable codes. The Contractor shall provide wiring and cables of sufficient ampacity and number as may be required for the installation in accordance with the wiring diagrams on his approved working drawings and these specifications without extra cost to Delaware Department of Transportation.

In each conduit and multi-conductor cable, at least two spare conductors shall be provided for every ten conductors of control wire and at least one conductor shall be provided for every ten conductors of power (or fraction thereof) actually used.

Internal shop wiring for control cabinets and the control stations shall not be smaller than No. 14 AWG. External control wiring shall not be smaller than No. 12 AWG.

Wiring shall not be installed in any conduit before all joints are made up tightly and the conduits rigidly secured in place. The drawing of conductors into conduits shall be done without injury to the wire, insulation or jacket.

For all conductors No. 8 AWG or smaller, approved wire ferrules terminal lugs shall be installed on each end of said conductors in all locations except for the submarine cable terminal cabinets, where flanged fork terminals shall be used. Where connections to pilot devices are required, either flanged forks or wire ferrules shall be used at the Contractor's discretion.

Terminal lugs shall be installed per lug manufacturer recommendations using the proper tools approved by the manufacturer. The terminal lugs for all outgoing wires (No. 8 AWG or smaller) in terminal boxes, control cabinets, control stations and other enclosures shall be connected to terminal blocks herein after specified. Each terminal of all terminal blocks shall be permanently marked to show the same number or designation as appears on the wire connected thereto. Under no circumstance will splicing of wires be permitted without the use of a terminal block. Wherever it becomes necessary to join or branch conductors, terminal blocks shall be used and wires shall be clearly tagged.

The existing submarine cables routed across the channel shall be connected as shown on the plans and specified herein. The existing ring tongue terminals and terminal blocks shall be reused. New wire and terminal block tags shall be furnished installed with the numbers noted on the as-built schematic wiring diagrams.

Fiber optic cables and Ethernet cables shall be installed and connected per manufactures recommendations. Splices for fiber optic cables shall be made with fiber optic splice kits inside an isolated enclosure.

Sufficient slack shall be left in all cables to permit proper connections in boxes, cabinets and

enclosures. Conductors inside terminal boxes, control cabinets, control stations and other enclosures shall be neatly formed into cables and laced with approved cable ties with the individual conductors leaving the bundled cable at their respective termination points. Each conductor shall be looped to allow not less than three (3) inches of free conductor when disconnected from its respective terminal. The bundled cables shall be held securely away from the terminals and from contact with the enclosure by means of approved insulating supports and ties.

Equipment ground conductors shall be installed in all conduits and multi-conductor cables per the National Electrical Code latest edition, and all other applicable local codes.

Both ends of every single length of conductor shall be permanently and clearly tagged in accordance with the same numbers or designations appearing on the approved wiring diagrams.

All wiring shall be carefully tested after installation. The Contractor shall administer continuity tests, insulation resistance tests and any other required test for any conductor run as directed by the Engineer at no additional cost to the Delaware Department of Transportation.

All droop cables shall be provided with sealing bushings where they enter terminal cabinets or junction boxes.

Fabrication and installation for the "Electrical Cable Wire and Connectors" and all associated equipment shall be paid for under this Section. The Contractor shall follow the testing guidelines as specified and paid for under the item "Testing", and all applicable paragraphs under this Section. For general material and installation requirements the Contractor is directed to the requirements as listed herein.

Conduit Systems

Under items E11 and E28, all conduits to be installed in outdoor locations and/or corrosive environments such as the machinery rooms, access platforms, outside the control house and other said locations shall be plastic coated as hereinafter specified. Conduit fittings, including couplings, unions, elbows, expansion and deflection fittings, and other items, shall also be plastic coated.

Unions to connect sections of conduit that cannot be joined to each other or to boxes in the regular manner shall be the same type as the installed conduit systems.

The interior surfaces shall have a smooth finish and be free of burrs or projections, which might cause injury to the cables. All conduits shall be free from blisters, cracks, or injurious defects and shall be reamed at each end after being threaded. Conduits shall be installed to be continuous and watertight between boxes or equipment. Conduits shall be protected at all times from the entrance of water or other foreign matter by being well-plugged overnight or when the work is temporarily suspended.

All bends shall be made with factory-bent, standard or large radius conduit elbows. When approved by the Engineer, bends and offsets can be made with a hydraulic or power pipe bender, provided with standard shoes for conduit as required. Field bends shall be made without kinking or damaging the exterior surface or smooth bore of the conduit. The radius of curvature of pipe bends made in the field shall not be less than eight times the inside diameter of conduit. All bends shall be long sweep, free from kinks, and of such easy curvatures as to permit the drawing of conductors without injury. The use of a pipe tee or vise for bending conduit will not be permitted. Conduit that has been crushed,

deformed or damaged shall be discarded. Conduit runs shall be made with as few couplings as standard lengths will permit, and the total angle of all bends between any two boxes or cabinets shall not exceed 270 degrees, unless otherwise approved by the Engineer. Long running threads will not be permitted. Pull boxes shall be used whenever necessary to facilitate the installation of the wire.

Installation of the Perma-Cote Conduit System or approved equal shall be performed in accordance with the Perma-Cote or approved equal Installation Manual. To assure correct installation, the installer shall be certified by Perma-Cote or approved equal manufacturer prior to installing coated conduit. The Contractor shall submit certification two weeks prior to any start of conduit work. In no case shall the Contractor use a chain vise or other equipment without protection means on the PVC coated conduit. Any damage to the PVC coating on the conduit is subject to removal of the damaged section and re-installation of a new section at no additional cost to DelDOT.

The use of condulets or conduit bodies for pulling conductors, for making turns in conduit runs, or for branching conductors shall only be permitted for lighting and heating conduit.

All conduits in the control house, wherever practicable, shall be concealed. Where conduits pass through the floors or walls of the control house, they shall be cast-in-place, or they shall be provided with galvanized pipe sleeves for free passage of the conduits. After the conduits are installed, the openings shall be caulked with an elastic compound and escutcheon plates provided on the interior walls, ceilings, and floors. Conduits shall be securely clamped and supported at intervals not exceeding 5 feet in length.

Conduit runs exposed on the steel structure shall be securely clamped to the steelwork. Supports shall be arranged so that conduits rest on top of the support and conduit U-bolts rest on top of the conduits. The use of J-bolts to fasten structural supports or to clamp conduits will not be permitted.

Where conduits are to be mounted exposed on non-steel surfaces, they shall be securely clamped to the surface using bent plate pipe supports with back spacers held by not less than two bolts.

Exposed conduits shall be installed parallel to, or at right angles to ceilings, walls and partitions. Where changes in direction of exposed conduit cannot be made with neat and orderly bends, pull boxes shall be used. Exposed conduits shall be securely clamped and supported at intervals not exceeding five (5) feet in length. All boxes and fixtures shall be provided with structural supports independent of associated conduit. No boxes nor fixtures shall be cantilevered from nor supported by conduit. The conduit supports shall be as specified elsewhere under this item.

At any point where a conduit crosses an expansion joint longitudinally or where movement between adjacent sections of conduit can be expected, conduit expansion fittings shall be installed. The fittings shall be bronze expansion fittings and shall be provided with flexible bonding jumpers to maintain the electrical continuity across the joints. The fittings shall permit a total conduit movement of 8 inches.

At any point where a conduit crosses a joint laterally or where an offsetting type movement between adjacent sections of conduit can be expected, expansion and deflection fittings shall be installed. The fittings shall permit a movement of ¾ inch from the normal in any direction. Flexible bonding jumpers shall be required to maintain bonding integrity whenever expansion fittings are required.

Flexible conduits for the connections between the rigid conduit system and all limit switches, motors, and other equipment subject to vibration shall be made with sections of approved flexible conduit. Approved liquid-tight connectors shall be provided for connections between rigid and flexible

conduit. Each flexible, liquid-tight conduit section shall not exceed eighteen (18) inches in length without prior approval of the Engineer.

All conduit embedded in concrete, insofar as possible, shall be completely encased by concrete of not less than 3 inches, measured in any direction, and shall be securely held in place during pouring and construction operations. A group of conduits terminating together shall be held in place by a template.

All cutting and threading of conduit shall be performed as recommended by the conduit manufacturer. After being threaded, conduits shall be reamed at each end. All threads shall be degreased and then liberally coated with a zinc-rich sealer/de-oxidizer before connection. The sealer/de-oxidizer shall not damage the specified conductor insulation. All field cut threads shall be National Pipe Taper. Running threads will not be permitted.

Conduit lengths shall be connected to each other with approved screw couplings assembled hand-tight and then, using strap wrenches, tightened two more turns. Wrench marks or chuck marks shall be touched up with the appropriate touch up compound. Conduit runs shall be made with as few couplings as standard lengths will permit. No conduit runs with a total angle of bends between any two boxes shall exceed (270) two hundred and seventy degrees, unless otherwise approved by the Engineer.

Ends of conduits left empty including stubs shall be capped during construction, and care shall be taken to ensure that no moisture or other matter is in or enters the conduits.

All conduits shall be pitched where feasible to allow for water drainage. Where conduits cannot be drained to pull boxes, a drain "T" with drain fitting shall be installed at the low point and drained. Drain fittings shall be of stainless steel and shall be capable of passing 25 cc of water per minute.

Conduit hubs shall be provided at the ends of all conduits entering boxes and enclosures furnished with slip holes.

The ends of all conduits projecting into boxes and equipment enclosures shall be provided with insulated grounding bushings or hubs. All bushings or hubs in any box or enclosure shall be bonded together to the ground lugs in each box with No. 8 AWG bare copper wire.

All conduit, enclosures, and fittings shall be mechanically joined and electrically bonded together to form a continuous electrical conductor to provide effective electrical continuity. An equipment ground conductor shall be provided in every conduit and enclosure throughout the raceway. Conduits shall be installed so as to be continuous and watertight between boxes or equipment. All conduits shall be pitched not less than one (1) inch in ten feet (except by special permission) and drained to pull boxes where feasible. Conduits shall be protected at all times from the entrance of water or other foreign matter by being well plugged overnight or when the work is temporarily suspended. End of abandon conduits, spare conduits, and empty conduits and stubs shall be capped during and after construction, and care shall be taken to ensure that no moisture or other matter is in or enters the conduit.

Both ends of each conduit run shall be provided with conduit tags as specified.

All conduits and fittings shall be carefully examined and cleaned both before and after installation. Upon completion of the conduit and box installation, the Contractor shall clear each conduit by snaking with a nonabrasive mandrel of a diameter not less than 85 % of the nominal inside diameter of the conduit, and shall then draw in the cables. All conduits shall be free from blisters, cracks,

deformations and defects. Conduits with any damage or injurious defects as judged by the Engineer shall be removed from the site and replaced by the Contractor at no extra cost to DelDOT.

The minimum size of conduits shall be as indicated on the Contract Plans. If no size is indicated or conduit fill varies from that shown on the Plans, conduit shall be sized to accommodate the conductors to be installed therein in conformance with the National Electrical Code. No conduit smaller than ¾ inch shall be installed.

Conduit shall be installed in accordance with the manufacturer's installation manual. The manufacturer's installation manual shall be kept on the job site and made available to the Engineer at all times.

As required under Working Drawings and Samples, layout and installation drawings for the electrical work, which includes the conduit system, shall be submitted prior to pertinent structural and mechanical shop drawings so that the conduit installation details may be incorporated by the structural and mechanical fabricators and erectors. A drawing showing the assembly and complete construction details of the conduit system shall be prepared and submitted for approval prior to fabrication. The Contractor shall follow the assembly and details of the system as shown on the plans.

The Contractor shall be fully responsible for coordination of the raceway installation with all other trades as part of this Contract.

Boxes.

Under items E11 and E29, boxes shall be furnished and installed where required and shown on the plans.

Pull boxes shall be used whenever necessary to facilitate the installation of the wire. Conduit bodies shall not be used for pulling conductors, for making turns in conduit runs, nor for branching conductors, for lighting and heating conduit runs only.

Surface mounted interior and exterior boxes shall be provided with external mounting lugs. No box shall be drilled for more conduits or cables than actually enter it. Exterior boxes shall be provided with ½ inch combination drain and breather fittings.

Terminal blocks shall be provided in each terminal box for the connection of all conductors including spare conductors entering the box plus at least twenty percent spare terminals for any control conductors and ten percent for any power conductors. All terminal blocks and boards shall be mounted on suitable straps or structural steel brackets in such a manner as to permit routing the conductors behind the terminal blocks. Terminal blocks shall be one-piece blocks suitable for use in highly corrosive atmospheres and shall conform to the requirements hereinbefore specified.

Each power distribution block shall be constructed of one-piece molded phenolic compound and shall conform to the requirements hereinbefore specified. A cover of insulating material shall be provided for each block.

Brake junction boxes shall be mounted in the machinery room and conform to the requirements as listed herein to route the flexible conduit or cables carrying control conductors to the brake limit switches. Each brake junction box shall have a PVC coated steel galvanized conduit from the switchboard

room entering the box and three individual flexible conduits or cables leaving the box routed to the brake limit switches.

All manholes, junction boxes, pull boxes, and terminal boxes shall be inspected for proper duct entries, terminators, bell ends, pulling-in-irons, concrete seal around ducts, caps or plugs, pull lines, ladders, grout seals between the frame and chimney.

Hardware and Supports.

The Contractor is responsible for developing all conduit details consistent with applicable codes and these specifications. Structural steel brackets, boxes and other equipment mounted on concrete surfaces shall be provided with a full neoprene gasket as specified.

The anchoring system shall be used to fasten all electrical equipment to concrete as specified. The Contractor is required to use all accessories for installing the anchoring system as recommended by the manufacturer including but not limited to wire brush, air nozzle with air compressor and epoxy dispenser.

Motors, brakes, and limit switches shall be fastened to structural steel supports with approved shim packs and fasteners as specified under the machinery specifications.

The Contractor shall prepare and submit details of all electrical equipment supports to the Engineer for approval.

Each electrical device and enclosure shall be provided with a rigid structural steel support. No enclosure or device shall be permitted to cantilever from conduit unless specifically permitted in writing by the Engineer.

All Enclosures shall be mounted to concrete floor using stainless steel bolts as required.

If the Contractor elects to field drill certain electrical supports, the Engineer prior to any installation actually taken place must approve all details and locations.

Pull Wire.

After Installation, all conduit which will be left empty shall have a pull wire or cord installed. Pull wire or cord shall be made of corrosion resistant material with a minimum tensile strength of 400lb.

Incoming Electrical Service

Under items E12 and E30, the Contractor shall furnish and install the new incoming service at each bridge as shown on the plans. All work shall be coordinated with Delmarva and Lewes BPW.

As part of this work Delmarva and Lewes BPW will furnish and install the primary conduit, wire, transformer and transformer pad. The Contractor shall furnish and install the secondary conduit and wire, support stand and disconnect switch. The Contractor will be responsible for any coordination related to the incoming service between the Contractor, DelDOT and Delmarva/Lewes BPW. All fees related to the incoming service shall be paid for directly by DelDOT.

The new service shall not be connected and energized by the Contractor until all equipment on

the bridge is compatible with the new operating voltage. Any work required to be performed to use either incoming service for bridge operation and construction activities shall be paid for by the Contractor under this item. Adjustment to the incoming service equipment as previous defined shall also be performed under this item.

It shall be the responsibility of the contractor to notify the City of Lewes, Board of Public Works, or Delmarva twenty four (24) hours in advance of performing any work so that the city inspector may be present to witness the work.

Modifications to Stand-By Generator

Under items E12 and E30, the two existing stand-by generators shall remain and shall be reconnected and adjusted by the Contractor to operate at 3 phase, 480/277 Volts. Control and ancillary equipment shall be modified to operate with the available voltages. Adjustments shall include but not be limited to reconnection of the generator windings, connection of all wiring and circuits shown on the plans, adjustment of all settings and parameters, adjustment of louvers and actuators, replacement of block/jacket heaters, battery chargers and all other generator accessories. Coordination with the generator manufacturers shall be paid for under this item.

Also included in item E12, the Contractor shall furnish and install a new fuel sensor to indicate the level of fuel in the existing fuel tank. Installation of the sensor and all modifications to the existing tank to accommodate the new fuel sensor shall be paid for under this item.

The nameplate information for the two existing generators are as follows:

(1) Savannah Road Bridge:
- (i) Cummins Power Generation, Model GGHG-1522753
- (ii) Serial No. I150871812, Spec N
- (iii) 85 KW/106.2 KVA Stand-by, 0.8 Power factor

(2) Rehoboth Avenue Bridge
- (i) Taylor Power Systems, Model DS150M3
- (ii) Serial No. 21581U006848P
- (iii) 145 KW/181 KVA Stand-by, 0.8 Power factor

Fuel Supply System (for Rehoboth Avenue only)

Diesel oil for operation of the engine shall be stored in the existing stand-alone tank outside the generator room. As part of this item, the contractor shall furnish and install fuel lines between the fuel tank, overflow tank and diesel engine as shown on the plans to match the existing. The fuel lines, installation, layout, etc. shall be of the type recommended by the manufacturer.

Field Measuring

Under items E13 and E31, the Contractor shall provide a field survey and field verifications of the existing equipment, bridge structure, layouts, and all other measurements required for the new electrical system as specified. The required field measurements shall be used as a way to avoid errors in fabrication and installation of the new equipment which could result in errors in the shop plans and working drawings, delays in the approval process, impacts to the project schedule, and problems with the assembly and operation of the systems. The work required to obtain measurements of some of the existing

components may require temporary disassembly of those components or systems. The Contractor shall submit a Measure and Survey Plan that shall include but not be limited to the following:

(1) The overall sequence and schedule of the systems and components to be measured.
(2) A description and plan of how the Contractor will access all areas where measurements will be taken. Propose temporary platforms/access in accordance with Section Field Measuring.
(3) A description of the methods, procedures and equipment that will be used where it may be necessary to disassemble and reassemble components or systems in order to perform the measurements.
(4) A description of the methods and equipment used to perform the measurements. Identify control points, datum's and plumb lines.
(5) A narrative of the potential impacts to the systems and operation of the bridge. The Contractor shall comply with the Coast Guard requirements that may limit the durations that the bridge can be taken out of service.
(6) Identify the individuals doing the field measuring and provide resumes that show that they are competent and experienced.
(7) A complete list of personnel who will be performing surveys or taking measurements to be used in the preparation of shop/working drawings or for coordinating and verifying the relationship of machined parts.

All measurements affecting elements to be included in the shop plans and working drawings shall be performed by or under the direct supervision of the Contractor who is responsible for preparing the shop plans or working drawings.

The Contractor shall not begin field measuring until the Measurement and Survey Plan for that work item is approved.

Manual Operation/Temporary Operating System

Under items E14, the Contractor shall utilize the air motor system during construction to operate the bridge once the main span motor become inoperable. The contractor shall furnish a portable air compressor and power source for the air motor system. Temporary operation shall occur with at least one motor brake installed and manually operable.

Under items E32, the Contractor shall utilize hand crank system during construction to operate the bridge once the main span motor become inoperable. The contractor may at his cost furnish a portable air compressor, power source, and air motor system to connect to the hand crank manual system. During the motor or machinery brake replacement, temporary operation shall be permitted when steady wind speeds are 25 mph or less with either both machinery brakes manually operable or the motor brake manually operable.

The warning gates, barrier gates, span locks and brakes shall be manually operated once electrical controls and power are removed. When the warning and barrier gates become manually inoperable a separate traffic barricade shall be used.

Bridge Operator

During the construction period, from the time the Contract is awarded until acceptance of the bridge by DelDOT, the Contractor shall provide and train personnel to operate the bridge, during

scheduled bridge openings.

Each Bridge Operator shall be familiar with the bridge layout as well as be trained in the operation and maintenance of the bridge. Included in the Contractor's training program shall be subjects such as troubleshooting, repair of electronic motor controls, drive circuit logic, maintenance and adjustment of all new, existing, and temporary electrical equipment and hardware, and other items required for full bridge operation and maintenance.

Upon completion of training, each of the Operators will be required to demonstrate safe operation of the Bascule spans, in the presence of the Engineer, prior to being assigned to duty as a Bridge Operator.

Bridge Opening Delay

Upon a call from a vessel to open the bridge, the Contractor must open the bridge within 20 minutes. This includes the time to stop traffic, stop conflicting construction activities, and operate bridge equipment. The Contractor may need to operate the bridge utilizing temporary controls and drives or manual devices such as hand cranks, etc. while equipment is being removed and installed.

Historical Bridge Opening Logs.

The Contractor is provided the following information showing the frequency of bridge openings for marine vessels.

BR 3-153 in REHOBOTH							
	APR	MAY	JUN	JUL	AUG	SEP	OCT
2006	0	4	11	15	14	9	3
2007	0	7	11	15	19	3	1
2008	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2009	2	2	2	3	7	4	6
2010	0	0	0	4	8	4	1
2011	0	2	5	2	11	1	0
2012	0	0	0	6	1	8	0
2013	0	0	0	5	0	0	0
2014	0	2	3	1	2	0	2
2015	0	2	3	1	2	0	2
2016	0	2	3	N/A	N/A	N/A	N/A

BR 3-154 in LEWES							
	APR	MAY	JUN	JUL	AUG	SEP	OCT
2006	0	3	13	10	14	8	10
2007	0	2	5	5	8	5	1
2008	0	4	22	14	4	0	0
2009	2	1	7	7	8	6	6
2010	0	0	0	6	7	6	1
2011	0	1	4	2	10	1	0
2012	0	0	2	4	1	5	2
2013	0	0	0	3	0	0	0
2014	0	3	1	7	0	0	0
2015	0	0	0	6	1	0	2
2016	2	1	1	N/A	N/A	N/A	N/A

Demonstration of Temporary Bridge Operating System

The Contractor shall perform a demonstration of the Temporary Bridge Operating System in the presence of the Engineer in which interlocking and operating procedure will be verified.

The Contractor shall prepare a procedure for demonstration, which shall be submitted at a minimum of 14 days prior to the test date for review and approval. The procedure shall list in numbered steps each device to be demonstrated, the action required by the operator and the expected results.

Bridge Maintenance

The Contractor shall maintain all operating equipment on the bridge throughout the duration of construction. This shall include but not be limited to; inspection, lubrication, general maintenance and servicing of all newly installed equipment as well as existing equipment. Maintenance of equipment shall be performed in accordance with manufacturer's recommendations, and bridge maintenance manuals.

Technical Manuals

The following are suggested tables of contents for each of the manuals. They are not intended to be complete tables of contents and the Contractor shall include all information which may be helpful in maintaining the bridge functional systems, in the case of the Maintenance Manual, or in operating the bridge functional systems, in the case of the Operating Manual. The tables of contents are given here are in general terms and include information and material on items provided under mechanical and electrical pay items. This is done intentionally to call attention to the need for coordination between the Contractor and all mechanical and electrical sub-contractors in the preparation of these manuals.

Maintenance Manual - Suggested Table of Contents:

(1) Description of all bridge functional systems and sub-systems.
(2) Layout of all bridge functional systems and sub-systems.
(3) Listing of any warnings, cautions, or safety issues or procedures that must be followed as a part of any maintenance work, either specific or general.
(4) Listings of all parts suppliers' local representatives, including suppliers' and representatives' names, addresses, telephone and fax numbers, and websites, if any. The names, addresses, telephone and fax numbers, and websites of the Contractor, all subcontractors installing any of the bridge functional systems or subsystems, and the Engineer shall also be provided.
(5) Listing of all spare parts and components provided by the Contractor.
(6) Preventative maintenance procedures, including the frequency at which the various procedures should be done.
(7) Lubrication schedule charts and diagrams.
(8) Maintenance testing and procedure equipment lists.
(9) Troubleshooting procedures and checklists.
(10) Repair procedures and repair procedure equipment lists, including suggested procedures for installation and removal of machinery, electrical and control items.
(11) Description of the proper theoretical approach to installing and aligning machinery and installing and testing electrical and control systems.
(12) As-Built Drawings
(13) Conduit and electrical equipment layout and installation drawings, including mounting details.
(14) Control desk, motor control panels and drive panel layouts and wiring diagrams.
(15) Schematic-wiring diagrams
(16) Certified Drawings
(17) Manufacturers' brochures, literature and composite schedule of apparatus, including any suggested installation, alignment, maintenance, troubleshooting and repair procedures.
(18) Any and all other material or information which in the opinion of the Engineer may be desirable to include in order to assist in maintaining the bridge functional systems and sub-system.

Operating Manual - Suggested Table of Contents:

(1) Description of all bridge functional systems and sub-systems.
(2) Description of functional relationships between bridge functional systems and sub-systems.
(3) Listing of any warnings, cautions, or safety issues or procedures that must be followed as a part of any bridge functional system or sub-system operation, either specific or general.
(4) Theory of operation, detailed operating instructions, which shall cover in full the step-by-step sequence of normal operation of the movable bridge functional systems, all precautions required for the correct and safe operation of all bridge functional systems, adjustment instructions, and operational limits and restrictions.
(5) A similar description for the use of the bypass switches, noting all precautions for their correct and safe operation.
(6) Description of control, which shall describe in full the functions of all protective devices, limit switches, contactors, relays, and all other equipment used in all bridge functional systems, in connection with each step in the operating sequence. Wire and apparatus numbers appearing on the wiring diagrams shall be used in this description for identifying the various devices and circuits.

(7) Block diagrams illustrating the sequencing and operation of and functional relationships between all bridge functional systems and sub-systems.
(8) Any and all other material or information which in the opinion of the Engineer may be desirable to include in order to assist in the operation the bridge functional systems and sub-systems.

A preliminary submittal of the technical manuals shall include, two copies of sample formats and outlines of contents in draft form 90 days prior to final inspection, acceptance tests, or return of span operation to the Department, showing proposed methods of binding, methods of printing and reproduction.

A draft submittal of the technical manuals shall include two copies of completed manuals in final form 30 days prior to the final inspection, acceptance tests or return of span operation to the Department. At the Engineers discretion, additional submittals of the draft technical manuals may be required as a result of inaccurate information or omitted information.

A final submittal of seven (7) copies of approved manuals and (1) electronic copy in pdf format ten days after final inspection and acceptance tests. One of the seven copies shall become the property of the Engineer; the remaining copies shall become the property of the Department. The final submittal of technical manuals shall only be made once the draft version as noted about has been review and approved.

Training

After submission of copies of the manuals in their final form and prior to the return of span operation to DelDOT, the Contractor shall provide instruction and training for DelDOT Maintenance Personnel for a period of 15 days.

The instructors shall be skilled persons competent to operate the bridge and be completely familiar with the operating equipment of the bridge. They shall be able to make any adjustments required to the electrical and mechanical equipment.

During the 15-day training period specified above, the instructor(s) shall be in attendance at the bridge during bridge opening and maintenance procedures.

Included in the 15-day training and instruction period, there shall be an on-site training of DelDOT electricians, maintenance workers, and other personnel as indicated by the Department on subjects such as troubleshooting, repair of electronic motor controls, drive circuit logic, maintenance and adjustment of all electrical equipment and hardware, and other items required for full bridge operation and maintenance. Three 8-hour sessions shall be devoted to hardware and maintenance related topics. In addition, two 8-hour sessions shall be devoted to software requirements.

Instruction pertaining to hardware and maintenance shall be offered on two separate occasions to allow bridge personnel to coordinate the course with their normal activities. The Contractor shall furnish all necessary instruction sheets, student training aids, books, paper, and booklets to supplement training. The Contractor shall submit to DelDOT, a minimum of 2 weeks prior to training session, an outline of topics to be covered and training material for review. It shall also be the Contractor's responsibility to coordinate with DelDOT the location where training sessions will be held. Supplying of visual aid equipment and other miscellaneous items required for training shall be the responsibility of the

Contractor.

Lighting and Heating Systems

Under items E15 and E33, the Contractor shall furnish and install floor or wall mounted lighting and distribution transformers, panelboards, hot water heater, light fixtures, receptacles, etc. as shown on the plans.

The existing hot water heaters at both Rehoboth Avenue and Savannah Road Bridge shall be replaced with a new instantaneous unit as specified. The new units shall be installed below the sinks at both locations. The existing unit at Savannah Road Bridge shall be delivered to DelDOT under this item.

New lighting and heating panelboards shall be furnished and installed as shown on the plans. The new panelboards shall be connected to new and existing fixtures as specified. The heaters shall be de-energized by the self-contained contactors in the heaters.

New lighting and heating fixtures shall be furnished and installed in the control house on each floor and room. The lighting shall be located based on the final location of the new equipment. Where no new equipment is installed the light fixture shall be located in the same location.

The existing roadway lights shall be connected to operate with the new 480/277 VAC incoming service. The Contractor shall make all necessary adjustments and changes to the existing fixture under this item.

The Contractor shall coordinate locations of the specified equipment with existing utilities, water piping, and other existing equipment Adjustments to the final locations and equipment shall be made by the contractor for proper fit and installation at no additional cost to DelDOT.

General Testing Requirements ~~Field Testing by Contractor~~

The Contractor shall arrange for and provide all the necessary field tests, as directed by the Engineer and specified herin, to demonstrate that the entire electrical system is in proper working order and in accordance with the Plans and Specifications. The tests shall include, but not be limited to continuity and insulation resistance testing of wire and cables, duct test for all conduit, operational and interlock testing of the bascule leafs, span locks, center locks, tail locks, brakes, navigation lights and signals, warning gates, barrier gates traffic signals, standby generator and the automatic transfer switch.

The Contractor shall also be responsible for coordination of the bride PLC system with the TMC center's network and all associated testing to confirm proper operation.

Should the tests show that any piece of equipment or cable or wiring connection, in the judgment of the Engineer, is defective or functions improperly, such adjustments and/or replacements shall be made by the Contractor as to make the installation satisfactory to the Engineer and at no extra cost.

The bridge field tests are intended to confirm each major sub-component acceptance factory tests, and that the subsystem is operational prior to conditional acceptance functional checkout. Confirmation of correct operation of sub-components will be demonstrated through successful operation of the particular component. However, the Contractor is still responsible for the factory acceptance tests as required per contract specifications. Examples of subsystems are the span drive systems, control and power wiring,

limit switches, starters, relay systems, etc.

Upon completion of the installation of the entire control system, the Contractor shall perform motor operating tests for each main span motor and drive under each mode of operation to demonstrate that the motors function properly and provides the specific operating characteristics as specified in the contract documents. The data, which is to be recorded using data logging equipment, shall include but not be limited to motor speed (RPM), motor KW, Motor Current, time of operation, and angular position of the span. The data shall be submitted in table and graph form and shall show acceleration, deceleration, full speed, reduced speed and creep speed. Test data shall be included in the "Technical Manuals".

Stage 1 - Contractors Field Testing

The Contractor shall adjust, calibrate and test all equipment, place the integrated system in service, and test the integrated system. The Contractor shall provide verification that all inputs and outputs and all signals have been properly installed and tested.

The Contractor shall demonstrate that the completed system functions properly by performing at least 10 consecutive complete bridge operations for each location (Savannah Road and Rehoboth Avenue) including both PLC A and B control, each without failure or any adjustments to the satisfaction of the Engineer. (A complete bridge operation shall be defined as starting from turning control power on, operating all equipment up to completely opening the span, operating all equipment up to completely closing the span, and ending by turning control power off.) The Contractor shall demonstrate the operation of all bypass functions. The Contractor shall demonstrate the operation of the ATS and generator and provide at least 3 complete operations under generator power. The Contractor shall deliver a report describing results of the contractor's field tests, diagnostics, and calibrations including written certification to the Contracting Agency that the installed complete system has been calibrated, tested, and is ready to begin Stage 2 - Conditional Acceptance Functional Checkout. The report shall also include a copy of the approved Stage 1 - Contractor's Field Testing procedure.

Stage 2 - Acceptance Testing Functional Checkout

During this stage, the contractor shall perform a step-by-step demonstration of the bridge operating systems as specified. The demonstration shall not be performed until all construction (including all trades) is completed and the "Technical Manuals" and other documents are submitted and approved by the Engineer.

The Contractor shall prepare a test procedure, which shall be submitted at a minimum of 30 days prior to the test date for review and approval. The test procedure shall list in numbered steps each device to be demonstrated, the action required by the operator and the expected results. The bridge operation shall be performed using the main utility source and the stand-by generator in conjunction with any back-up systems and the main control system. Operation of all interlocks and bypass switches shall be demonstrated. Each step shall be provided with a pass/fail blank.

The conditional acceptance functional checkout test, as specified, shall not commence until receipt by the Contractor of written permission from the Contracting Agency and approved by DelDOT, based on the Contractor's Stage 1 written report. This shall include certification of successful completion of Stage 1- Contractor's Field Testing, as specified above. The Contracting Agency may terminate this portion of the testing at any time when the system fails to perform as specified.

Upon a failure resulting in termination of testing by the Contracting Agency or by the Contractor, the Contractor shall commence an assessment period. The Contractor shall identify all failures, determine the cause of all failures, repair all failures, and deliver a written report to the Contracting Agency. The report shall explain in detail the nature of each failure, corrective action taken, results of tests performed, and shall recommend the point at which the testing should be resumed. After delivering the written report, the Contractor shall convene a test review meeting at the job site to present the results and recommendations to the Contracting Agency. As part of this test review meeting, the Contractor shall demonstrate that all failures have been corrected by performing the appropriate portions of the conditional acceptance functional checkout test. Based on the Contractor's report and test review meeting, the Contracting Agency will determine the retest date.

Upon successful completion of the conditional functional checkout testing, the Contractor shall deliver test reports and other documentation specified to the Contracting Agency for approval prior to commencing the endurance test.

Stage 3 - Endurance Period

After successful completion of the field testing and acceptance testing (Stages 1 and 2) including correction of all deficiencies, the Contractor submit a request to DelDOT to start the endurance period. The letter shall include dates of final acceptance testing as well as a signed field test procedure. The start of the endurance period shall not occur until the approval of the record as-built drawings and O&M manuals.

Approval of the letter by DelDOT will start the endurance period in which the Contractor shall witness a minimum of 30 bridge openings per bridge within a two-week period by DelDOT bridge operators for each bridge. At any point during the endurance period should a fault occur the Contractor shall notify DelDOT of the fault and cause as well as actions to be taken to repair or further troubleshoot.

After documentation of the fault is submitted to DelDOT the contractor will enter a conditional testing period not to exceed two weeks. During this period the Contractor will be required to perform additional testing to prove the fault has been repaired. Once conditional testing is accepted by DelDOT the endurance period can continue at which point the Contractor will witness the remaining bridge openings or 12 additional bridge opening whichever is greater.

Following successful completion of the endurance period the Contractor shall submit a letter with the endurance period results. Acceptance of this letter by DelDOT will start the warranty period.

Factory Inspection and Testing of the Bridge Control System

The enclosed motor control cabinets, drive cabinets, back panels, control desk, ATS and other apparatus supplied, assembled or fabricated by the vendor of the electrical control system shall be subjected to shop inspections to demonstrate compliance with all specified requirements. The inspection is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor of responsibility for imperfect material or workmanship.

The control cabinets, drive cabinets, PLC cabinets, back panels and control desk shall be completely assembled at the factory, and shall be subjected to the manufacturer's standard inspections and testing. The manufacturer's standard testing for the equipment may comprise at least the following:

(1) Wire continuity tests, either visual or verified with continuity tester.
(2) Operational check of circuits to determine proper interlocking of circuits and operator's devices.
(3) Simulated operational testing to verify proper operation in accordance with the plans and specifications using all modes of operation.
(4) Polarity of connections to instruments and other polarity-sensitive devices.
(5) Inspection of materials, fit of parts, finishes, adjustments, and conformance with catalog cuts.

The enclosed control cabinets, back panels, drives cabinets and control desk shall be completely interconnected and shall be subjected to electrical and operational testing to ensure accuracy of connections and to demonstrate proper functioning of equipment. Limit switch contacts shall be simulated using the actual limit switches if available or by using toggle or knife switches.

The entire PLC system shall be interconnected as part of these tests including touchscreens. The PLC I/O shall be monitored from a separate laptop computer with the associated programing and monitoring software for the PLC system. As the touchscreen, pilot devices, limit switches, sensors, etc. are activated the associated PLC I/O will be monitored. Alarms and indicators will be tested and monitored during simulated operation. All back-up systems will also be tested.

The factory testing shall also include a complete sequenced, simulated operation of the bridge auxiliaries and span drive, and shall include complete adjustment, verification and testing of the control logic, control relays PLC, and contactors to demonstrate operation in accordance with specified requirements. Testing of the various interlocks as specified herein and shall also be included during the factory tests.

The Engineer or his authorized representative shall witness the factory inspection and special testing required herein, and no equipment shall be shipped from the factory until it has been released for shipment by the Engineer. The Contractor shall provide thirty (30) days notification in advance of the date of tests so that arrangements can be made for DelDOT and the Engineer to be present at the tests. The Contractor shall submit to the Engineer for review, thirty (30) days prior to the testing date, a copy of all standard and all special tests to be performed, as well as actual test forms to be approved by the Engineer.

During the witnessed inspections, nameplate legends, conductor identifications, instrument scales, escutcheon plate engraving and all other details of construction shall be checked for conformity with specified requirements and approved shop drawings.

Factory tests for equipment other than the bridge control system shall be as specified in the various materials sections throughout these specifications.

HMI Display Screen and Network Testing

The complete network including HMI, PLC's and Drives shall be connected and tested with the HMI screen for proper operation. The testing shall include emergency stop testing and local operation testing of the drive systems.

The test date for HMI and network testing shall be 30 days or more from the date of the factory testing of the completed control system. During the testing an opportunity shall be provided to review the

HMI screen layout with the control system vendor and make adjustments to design of each screen and the overall layout. As part these tests the on-going fabrication of the control system will be visual inspected by the Engineer.

Drive Testing

Under the items E3 and 21, the drives shall be shop assembled and tested by a qualified control system vendor. The Contractor shall follow the testing guidelines as specified and paid for under the item E16 and E34, and all applicable paragraphs under this Section.

Each drive shall be tested at the drive manufacturer's faculty prior to shipping to the control system vendor for control system testing. The drives and motors shall be load tested at 25, 50, 75, 100 and 150% and varying motor speeds in the presence of the Engineer using the actual span motors and a dynamometer. Test results shall be submitted to the Engineer for approval prior to shipment to the control systems vendors' facility.

Field Acceptance Test Data

All test results, parameters; data specified herein to be recorded shall reference the appropriate paragraph number and shall be presented in legible, tabular format, listing associated parameters and conditions. For example, motor current shall reference speed (rpm), span leaf angle (degrees), raise or lower mode, drive control selector position number, etc.

The results of the drive, ancillary and emergency systems tests shall be presented in a matrix form on an Inspection Report Data Sheet. The proposed format of these sheets shall be submitted to the Engineer for acceptance prior to the actual testing. Any parameter value, which falls beyond the recommended range, would require the re-adjustment or replacement of the defective device.

The table of the test results shall have references to the specific sections of the testing procedure. The precision of the results will depend on the accuracy of recording equipment, the observer and weather conditions. For each stage of testing of the bridge control equipment, the name of the person who will perform the test, instruments used with calibration data if required, the exact date, time and weather conditions shall be recorded.

Some devices such as the transfer switch, lamps, console indicator lights, brake function indicator lights, console controlled lighting, horn, can be easily tested without performing any bridge opening operation.

The bridge main parameters shall also be observed on the drive keypad and a laptop screen, and visually compared to the control console touchscreen and indicators. Any discrepancy between results should be recorded. A discrepancy between critical measurements like span angle indication shall be resolved prior to continuing the tests.

The testing shall be accomplished sequentially, following the bridge operation instructions for normal operation and emergency operation. The major bridge systems shall be monitored while the bridge operates. All safety interlocking shall be verified such that each components can only be operated in the correct sequence. All bypass switch operations shall be verified.

The printout originals of all tests shall be kept for future reference, and a printout copy shall be

attached to the Technical Manuals for reference. Another printout copy shall be provided to the Engineer.

~~**Acceptance Testing Functional Checkout**~~

~~The contractor shall perform a step-by-step demonstration of the bridge operating systems as specified. The demonstration shall not be performed until all construction is completed and the "Technical Manuals" and other documents are submitted and approved by the Engineer.~~

~~The Contractor shall prepare a test procedure, which shall be submitted at a minimum of 30 days prior to the test date for review and approval. The test procedure shall list in numbered steps each device to be demonstrated, the action required by the operator and the expected results. The bridge operation shall be performed using the main utility source and the stand-by generator in conjunction with any back-up systems and the main control system. Operation of all interlocks and bypass switches shall be demonstrated. Each step shall be provided with a pass/fail blank.~~

Arc Flash Study and Labeling

Once construction of the electrical system is complete but prior to final acceptance, the Contractor shall provide adhesive vinyl arc flash labeling on all new and existing equipment in accordance with applicable codes and requirements. Equipment requiring labels include components that are likely to be opened for maintenance including motor control equipment, drive enclosures, panel boards, disconnect switches, etc. Labeling shall include the arc flash hazard at the location clearly indicating the appropriate level of protection required.

In order to prepare and affix the arc flash labels, the Contractor shall retain the services of a professional engineer registered in the state of Delaware to perform a survey of the existing and newly installed electrical equipment and perform an analysis of the arc flash hazards using industry standard software. Prior to procuring and installing the arc flash labels, submit the results of the arc flash analysis, including calculations and label schedules, and submit for review.

Removal of Existing Equipment

The removal work at the existing equipment under this subsection shall be done in conformance with all requirements governing the sequencing and scheduling of construction. Removal of electrical equipment shall not commence until all new equipment and parts to be installed are delivered to the site or an approved storage facility unless otherwise approved by the Engineer.

The electrical equipment to be removed in stages at each bridge shall include, but not be limited to, the following

(1) Main Control Desk
(2) Control and Drive Cabinets (Savannah Road Only)
(3) Existing Back Panels from Existing Cabinets (Rehoboth Avenue Only)
(4) Panelboards
(5) Motor Resistors
(6) Span Motors
(7) Overspeed Switches and Tachometers
(8) Motor and Machinery brakes
(9) Limit switches which are designated to be replaced
(10) Conduit and wire which are designated to be replaced

(11) Terminal and pull boxes which are designated to be replaced
(12) Span lock motors
(13) Tail Lock Motors
(14) Center Lock Motor
(15) Lighting and Heating Fixtures which are designated to be replaced
(16) Disconnect switches which are designated to be replaced
(17) Remote Control switches for Heating Systems
(18) Panelboards
(19) Any equipment listed herein which requires that the equipment be preserved for future use shall be salvaged as specified.

The Contractor shall protect any piece of equipment associated with the stand-by generator operation which is required to remain in place as specified in the Contract Documents.

Any existing conduit encased in concrete, which are to be abandoned, shall be cut back to the concrete surface, threaded and capped with steel pipe caps.

In general, all apparatus to be removed shall be disconnected by removing existing bolts, nuts and screws. The work shall include removal of all brackets, hangers, clamps, fittings and other hardware no longer needed.

All existing holes in concrete created from the removal of existing equipment including conduit, supports, boxes, water lines, etc. shall be sealed.

All existing facilities, apparatus, cables, wiring and other equipment which are to remain in place on the bridge, shall be protected at all times from damage or defacement caused by the Contractor's operations. Any such damage or defacement shall be promptly repaired or cleaned to the satisfaction of the Engineer at no extra cost. If, in the opinion of the Engineer, the Contactor's operations require the temporary removal of existing equipment for proper protection, such removal and remounting shall be done at no extra cost.

Prior to the actual removal of the electrical equipment the Contractor shall submit to the Engineer a removal plan which states each piece of electrical equipment to be removed during each stage of Construction stage. No piece of electrical equipment shall be removed from the existing operating system until the removal plan has been approved.

Upon completion of the work, the Contractor shall repair all damaged or defaced areas exposed by the removal of equipment, or caused by his operations, in a workmanlike manner satisfactory to the engineer. Small bolt holes in concrete surfaces shall be filled with epoxy mortar. Holes in the walls ceilings or floors of the houses shall be filled with grout and finished to match the existing surfaces. Any damage to windows, window framing, sash, sills, frames or any other architectural trim shall be repaired, and painted surfaces shall be repainted after being repaired. Any holes in the ground shall be filled with earth top soil and suitably landscaped to match the surrounding areas.

All existing materials and equipment removed under this item shall become the property of the Contractor unless otherwise specified, and shall be removed from the site and disposed of properly.

Painting of Electrical Equipment

All new and existing electrical equipment (unless otherwise noted), such as brake frames, conduits, non-stainless boxes/enclosures, device enclosures, supporting clips and brackets, and other devices, shall be given two coats of paint as specified under the requirements for painting structural steel. Before applying the two coats, all surfaces shall be cleaned free of all grease, oil, dirt, and foreign material. Galvanized surfaced shall be etched with copper sulfate solution, after which two coats of paint shall be applied. In lieu of etching, the Contractor may use galvanizing primer as a first coat for galvanized surfaces followed by two coats of paint. The final coat of paint on equipment mounted on the steel work shall be of a color and type of paint to match the structural steel. The final coat of paint on equipment shall be of a color and type of paint to match the bridge.

Stainless steel enclosures, PVC coated conduit, liquid tight conduit, and fittings and die cast zinc limit switch enclosures shall not be field painted. These devices shall be adequately protected from all field-painting operations. Equipment not to be painted shall be carefully masked with polyethylene to prevent accidental paint coverage. If any coating material is applied to the surfaces indicated, as not to be painted, the paint shall be completely removed.

Method of Measurement:

Item 615504, BRIDGE ELECTRICAL SYSTEM, will not be measured.

Basis of Payment:

The work will be paid for at the contract bid price for lump sum for Item 615504, BRIDGE ELECTRICAL SYSTEM. This price shall include all labor, tools, equipment, material and incidentals necessary to satisfactorily complete the work in accordance with the Contract Plans and Special Provisions.

The lump sum bid for Item 615504 shall be the sum of the cost associated with the work performed at each bridge listed. The breakout sheet provided in the Bid Proposal shall be completed and attached to the Contractor's bid. Failure to submit the breakout sheet with the Bid Proposal will result in the Bid Proposal being declared non-responsive and rejected.

4/12/2018