

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

### **DESCRIPTION**

This work shall consist of furnishing all labor, materials, equipment and necessary supervision to remove the existing and install a complete, trouble-free control system and power distribution equipment ready for the permanent operation of the bascule bridge in accordance with the contract documents and as directed by the Engineer.

### **MATERIALS**

### **REQUIRED SUBMITTALS.**

The Contractor shall prepare the following documents and submit to the Engineer:

1. Manufacturer's warranties on equipment, materials or products purchased for the project
2. Operation and Maintenance Manual to be used by maintenance personnel, bound in hardback binders, or approved equivalent. The manual shall include, but not be limited to, the following:
  - a. General information and safety precautions
  - b. Operational and functional descriptions of the particular system, including block diagram, schematic layout of the entire system, description of the sub-system, functional relationship between subsystems and systems
  - c. Maintenance procedures and schedules of subsystems and systems
  - d. Internal and interconnecting wiring and control diagrams with data and detailed explanations of the system and equipment operation
  - e. Step-by-step control sequence of the bridge operation from Start-up to Shutdown, including pictorial illustrations of the control console, control devices, locations of control devices, and functional description of each step, and interlocking
  - f. Installation and maintenance instructions of subsystems and systems
  - g. Elementary circuit diagrams and pictorial illustrations of the equipment and the overall system
  - h. Testing methods, and performance data
  - i. Alignment procedures for adjusting the overall system for a proper operation including voltages, currents, and wave shapes
  - j. Lubrication schedule, including type, grade, temperature range, and frequency for all items requiring lubrication
  - k. Part list indicating sources of supply, recommended spare parts, name, address, and telephone numbers of servicing organization.
  - l. Names, addresses, and telephone numbers of each subcontractor, control system vendor who furnished and installed the system and equipment.
3. Operating instructions to be used by bridge operators, including overall system wiring and control diagrams, bridge control sequence, and the use of the operator's control devices and cautions. These instructions also include a concise step-by-step operational procedure for the bridge Operator and his assistants under various modes of the bridge operation including initial and final conditions, bridge condition indications and cautions.
4. Shop drawings and working drawings. The Contractor shall provide the manufacturer's shop drawings, catalog cuts, dimensional sheets, product specifications or other descriptive data. Items shall not be ordered until the shop drawings are approved. Final approval of shop drawings, details and catalog cuts will not be given by the Engineer until the Contractor affixes a statement

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

to each submittal, indicating his review of the submitted materials confirming to the specifications and compatibility of the work specified herein and shown in plans. Working drawings, diagrams and related data shall also be provided, including, but not necessarily be limited to:

- a. Elementary wiring diagrams
- b. Grounding and bonding diagrams
- c. Conduit and raceway system layout diagrams, including conductor quantity and size
- d. Electrical apparatus certified dimensional data
- e. Layout and mounting details of electrical equipment including dimensions and material of supports, brackets and hardware used for the installation.
- f. Bar-graph type tripping schedules for all limit switches. These schedules shall also be part of the control circuit shop drawings and on the record drawings.

**A. General.** Materials shall conform to the requirements described herein and as shown in plans. All equipment and components proposed for use shall be manufactured by companies which have established experience in the manufacture of such equipment and components and which, in the Engineer's opinion, have demonstrated proficiency in the manufacture of such. One-of-a-kind prototypes with an insufficient history of successful performance in industrial applications will not be accepted on this project. All equipment and components will be subject to the approval of the Engineer.

The bridge control system shall be furnished with programmable logic controller, motor control center, all necessary control relays, limit switches, control switches, indicating lights, control console panel, and all other control devices required to provide the modes and sequence of control, as shown in plans. The control of the bridge auxiliary drives shall be a discrete relay logic control system. Unless otherwise indicated in plans, the control devices shall conform to the following requirements:

1. General purpose control relays shall be multiple pole, field reversible contacts, electrically-held, rated 10 amps at 120 volts, with 120-volt AC coils. Each control relay shall be supplied with one normally open and one normally closed spare contacts in addition to those necessary for immediate use.
2. Time delay relays, when installed as discrete components, shall be adjustable, 120 volts AC operating voltage.
3. General purpose contactors shall be multiple pole, electrically held, 120 volts AC coil. Contacts shall be rated not less than the rating of the controlled devices. Auxiliary contacts shall be provided as required.
4. The Power Monitor relay shall monitor all three line-to-line voltages of the 240-volt three-phase bus. As long as correct phase sequence and phase voltage are maintained, an internal relay is energized and the output contact is closed, enabling the bridge control. Incorrect phase sequence, or over voltage or under voltage exceeding 12 percent (adjustable) shall cause drop out of relay, and resultant opening of the output contact and cutting-out the bridge control. Contact shall be rated 3 amps at 120 volts AC. Relay shall be provided with adjustable time delay of 1 to 30 seconds, preset to 5.
5. Latching relays shall have 10 amp normally open and normally closed contacts with coils operated at 120 volts AC. The relay shall be electro-magnetically operated and held by a permanent magnet which will hold all switched contacts, even after the power is removed from the coils. Activation of the latching coil will close normally open contacts and open normally

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

closed contacts. Activation of the unlatching coil will switch all contacts back to their original state.

### **B. Programmable Logic Controller (PLC).**

Bridge control system logic functions shall be performed by a programmable logic controller as indicated in plans.

1. In general, the control logic, timing, counting, and other control functions and message displaying shall be performed by the PLC. All necessary modules, interfaces and accessories shall also be included to provide the complete working system in accordance with the requirements as shown in plans, including the provisions for the remote control and status indication from the console panel via radio link across the navigable channel. The Random access memory capacity shall be at least 32K words (16-bit word).
2. Two (2) complete, functional, identical PLC's shall be installed. Only one shall be on-line and active at a time. The other PLC shall serve as the wired-in spare. A selector switch shall select which PLC performs as the active unit, and which becomes the spare. The spare unit, via the selector switch, shall be completely disconnected from all external power conductors.
3. Power for the PLC shall be via a high quality, off-line power conditioning and regulating uninterruptable power system (UPS), rated minimum 2 KVA, 120 volts AC. The UPS shall have built-in surge protector, shall be capable of powering the programmable logic controller, indicator lights, and message display on the control console for at least 20 minutes (half load rating). The UPS shall also have the following ratings:
  - Transfer time of two milli-seconds between the AC line and the inverter.
  - The common-mode noise attenuation, when the load is connected to the normal power source, shall be rated at 100 dB or more.
  - Output voltage regulation shall be +6 to -8 percent of nominal input voltage (120 volts) for variations of +20 to -20 percent.
4. PLC input/output (I/O) modules shall have LED indicating lights for each input or output on the module as follows:
  - Input - Lights when field power is applied to input terminal.
  - Output - Lights when processor issues command to energize the output terminal.
  - Blown Fuse - Lights when the individual output fuse is blown.
5. Each chassis of the PLC system shall have a self-contained power supply unit, furnished with connecting cable and quick-disconnect connectors. Each power supply shall operate at an input voltage of 120 volts AC from the UPS to provide 5 volts DC for the PLC, and shall have an input power not less than 90 VA to provide sufficient power for the connected loads on each chassis.
6. PLC programmers shall be provided, including a handheld programmer, and a portable computer. Both programmers shall be directly connectable to and fully compatible with the PLC. The handheld programmer shall be manufactured by the PLC manufacturer, and shall program in the ladder-diagram format. Special keys shall program timers, counters, data comparisons, etc. The display shall be 16-character alphanumeric. The unit shall be capable of monitoring and displaying I/O status and register values. The portable computer shall incorporate a 14-inch display screen, a full keyboard, a built-in 89 mm (3.5-inch) diskette drive, a built-in, 24X speed (minimum), read-and-write CD ROM, a 40GB hard drive and at least 128 Meg. of internal memory that allows off-line program development. The processor speed shall be 1 GHz, minimum. The computer shall have Ethernet LAN networking capability. The operating system

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

shall be Windows XP Professional. Documentation software and any other accessories shall be included which allows for hard copies of programs on a printer (not included), complete with I/O labels and comments. Comments and cross-referencing of locations of all contact and locations shall be provided as part of the required hard copy (printed) of the operating ladder-diagram program.

7. The PLC cabinet doors shall incorporate full length plexiglass windows to provide clear observation of all status indicators on all PLC's, I/O cards, and all other related peripherals.
8. All conductors connected to the PLC and I/O points shall be isolated from external circuits via "ice cube" type relays with built-in indicator lights for outputs, and shall be first landed on surge suppressor terminal blocks for inputs in the same cabinet as the respective I/O modules.
9. EMI shielding and line filtering shall be included only to the extent required to ensure compatibility and trouble-free operation of this system. Specifically, the PLC system shall not exhibit any malfunction, degradation of performance, or deviation from specified requirements when subjected to radiated electric fields or line disturbances generated by other electrical equipment supplied in this contract.
10. The PLC shall be provided with a data logging module or card with necessary software as required, designed to process and store data from the PLC registers and I/O's. The data logger shall be programmed to record in memory all significant parameters of the bridge operating sequence and automatically produce a status report in the event of equipment malfunction.

The parameters to be presented in the event of malfunction shall include, but not be limited to, the time and date of the malfunction, status of all by-pass switches, status of all motor overloads, drive motor currents, lapsed time in seconds since the raise or lower cycle was initiated, status of span overspeed, RPM from drive motors, and all alarms and warnings issued or received by the PLC. These parameters shall be the moment that the malfunction is detected, not the final stopping time or position of the bridge.

The malfunction report shall be automatically saved in a memory file for retrieval by a printer or a IBM compatible laptop or note book, as specified herein. Subsequent operation of the bridge shall not destroy or overwrite the last malfunction report, but shall rename it, then clear and/or update all parameters ready for the current report, if needed. At any given time, the data logger shall be capable of storing the last previous report and the current report if a malfunction occurs. All formatting and data manipulation shall be performed by the data logger, to the maximum extent possible, to minimize control system slowdown in the PLC.

**C. *Rotating Cam Limit Switch.***

1. Rotating cam limit switches shall be used for bridge span position indication and monitoring. The rotating cam limit switch shall consist of single-pole, double throw, snap action precision switches, each driven by an independently adjustable two-piece plastic cam. All cams shall be mounted on a common heavy-duty 19 mm (3/4-inch) shaft, mounted in sealed ball bearings. The housing shall be Nema 4X stainless steel.
2. The cams shall directly actuate the snap switch plungers with simple harmonic motion. Contact settings shall be continuously adjustable from approximately 4 degrees to 356 degrees. Adjustments shall be made without loosening bolts or screws, and without removing or relocating the switches or cams.

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

3. Each plastic cam shall consist of an assembly of two overlapping cam discs. Each of the two cam discs shall be provided with a separate reduction drive with an outer pinion band or adjusting disc. One revolution of the adjusting disc shall then result in 10 degrees of adjustment to the respective cam disc, thereby altering both the dwell and timing of the cam assembly.
4. Snap switch contacts shall be rated 120 volts, 10 amps continuous. The operating plunger shall be molded nylon with a roller follower which rides the cam. Each snap switch shall be mounted via two machine screws and be readily removable without loosening or removing other snap switches.

### ***D. Control Console Panel.***

1. The control console panel shall be constructed to exactly fit on the top of the existing console, as shown in plans, with all attachments and fasteners compatible with the fastening provisions on the existing console. The console panel shall be constructed from #10 U.S. standard gage stainless steel with a non-reflecting finish. The welded construction of the console top shall be provided with all seams continuously welded and ground smooth.
2. Indicator lights, selector switches and push buttons shall be heavy-duty, oil-tight type, of the style and size shown in plans. Indicator lights shall be push-to-test, 120 volts AC, transformer type, furnished with 6-volt incandescent lamp and colored lens, with color as shown in plans.
3. Name plates and device legend plates shall be plastic with black background and engraved white lettering. Name plates which are not part of the panel devices shall be attached with stainless steel or brass screws and nuts. Name plates which are part of the panel devices shall be installed with the devices as recommended by the manufacturer.
4. The lower interior portion of the existing console shall be illuminated by a fluorescent strip light, mounted high and provided with shield as necessary to reduce direct glare when front doors are open. The light shall be activated by interlock switch on front doors.
5. Meters shall be furnished and installed on the console panel as shown on contract drawings, consisting of voltmeters, ammeters, and wattmeter. Meters shall be of the horizontal, edgewise switchboard meter type meeting ANSI specification C-39.1. Meters shall be magnetically shielded to prevent interaction between meters, and have an accuracy of plus or minus 3 percent. The meter enclosure shall be dust-proof and splash-proof.

### ***E. Motor Control Center.***

1. The motor control center shall consist of vertical sections. Each vertical section shall be approximately 2.28m (90 inches) high, excluding lifting angles and mounting channels, 500 mm (20 inches) wide, and not less than 400 mm (15 inches) deep. Vertical sections, installed side-by-side, shall be bolted together with a common frame to form a rigid, free-standing assembly. The cabinet assemblies of the motor control center shall be NEMA-12 construction.
2. Each vertical section of the motor control center shall be of dead front construction and shall incorporate vertical buses connected to the horizontal bus when required. The vertical section shall be divided into compartments or cubicles suitable for mounting reversing and non-reversing motor starter units. Each motor starter unit shall be of the combination type with molded case circuit breaker. Wiring for each unit shall be NEMA, Class II, Type C, with master terminal board.
3. Removable structural steel lifting angles shall be provided on the tops of the sections. End vertical sections shall have end closing plates providing access to horizontal wireways and the

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

horizontal bus. The top plate shall be of removable one-piece construction. Removable blank doors shall cover all unused unit spaces and shall be provided with quick-released or one-quarter (1/4) turn pawl type latches.

4. Horizontal wireways shall be provided both top and bottom. The wireways shall be completely isolated from all buses. A full height vertical wireway shall be provided in each standard vertical section with the minimum dimensions of 102mm (4 inches) wide and 178mm (7 inches) deep, and shall be completely isolated from the horizontal and the vertical bus. A separately removable hinged door with quick-released or one-quarter (1/4) turn pawl-type latches shall cover the vertical wireway. Wire ties shall be furnished in the vertical wire trough to group and securely hold wires in place.
5. The main horizontal bus bars shall be copper electrolytically tin plated, and rated not less than 600 amperes for the 240 volt, 3 phase, 4 wire service. The bus shall be one continuous piece and extend the full-length of the assembly, except where split for shipment, in which case, the bus shall be continuous in each shipping block with a splice kit supplied as required to interconnect the buses in the field.
6. Vertical bus shall be copper electrolytically tin plated, rated 300 amps minimum for the 240 volt, 3 phase, 4 wire service.
7. Both the horizontal and vertical bus shall be supported and braced to withstand 42,000 RMS symmetrical amperes. The horizontal ground bus shall be copper, rated 300 amps, and located in the horizontal wireway, top or bottom. Ground lugs shall be provided as standard.
8. Starter unit connection shall be plug-in-type, high quality, two-point connection for each phase, designed to tighten during heavy current surge. The plug-in fingers shall be electrolytically tin plated to yield a low resistance connection, and shall be backed by spring steel clips to provide high-pressure connection points. Each plug-in unit shall be held in place by one or more latches, located at the front of the unit. Latches shall provide maximum front accessibility and installation convenience.
9. All reversing and non-reversing combination starter units of the motor control center shall include molded case circuit breaker, electrically held contactor and overload protection with auxiliary contacts as required. The primary power circuit to each motor will be via the molded case circuit breaker. Reversing starters shall consist of two contactors, one for the forward rotation and one for the reverse rotation of the motor, mechanically and electrically interlocked to prevent line shorts and energization of both contactors simultaneously; auxiliary contacts shall be included as required. The contactor rating shall not be less than the horsepower rating of the controlled motor.
10. In lieu of full-front doors, each unit shall be provided with a removable door mounted on removable pin-type hinges which will allow the door to swing open at least 110 degrees without disturbing any other doors. The unit door shall be fastened to the stationary structure, so that it can be closed to cover the unit space when the insert has been removed. The unit doors shall be held closed with quick-released or one-quarter (1/4) turn pawl-type latches, designed to resist forces during fault conditions. Each compartment or unit door enclosing the unit(s) shall be provided with external overload reset buttons which allow the reset of the overload or fault condition.
11. Track-mounted, non-pull apart terminals shall be furnished in a master terminal compartment located at the top or bottom of each section. Arrangement shall be the same for all sections.

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

12. All steel parts and accessories installed on or within the motor control center cabinets shall be painted or coated for corrosion resistance. Unpainted parts such as unit supports, horizontal wireway barriers, door hardware, unit latches, and assembly hardware shall be chrome plated or stainless steel for resistance to corrosion in a salt water environment.
13. An industrial-grade handle mechanism shall be supplied for the control of each disconnect switch or circuit breaker. This mechanism shall be engaged with the switch or circuit breaker at all times, regardless of unit door position. It shall be possible to lock this handle in both the off and on position with a shackle padlock.
14. Each unit shall have its own engraved identification nameplate indicating either a catalog number description or a serial number description, which shall be fastened to the insert near the upper right-hand corner. Each vertical section shall also be provided with an identification nameplate, indicating serial number, bus ratings and vertical section reference numbering. The nameplate shall be mounted on the vertical wireway door of each section.
15. A rectangular, plastic nameplate with 5 mm (3/16-inch) engraved lettering, bearing the name of the equipment served, shall be permanently attached to the front of each unit.

***F. Automatic Transfer Switch.***

1. Automatic transfer switch shall be as shown in plans. The complete switch assembly shall be listed under UL-1008, furnished and installed to replace of the existing transfer switch and to automatically transfer the loads between the normal (utility) power source and the alternate (generator) power source.
2. The transfer switch shall utilize double-throw, high-speed quick-make, quick-break contacts, with arc chutes designed to hasten the extinguishing of the arc. The main contacts shall be capable of being replaced without removing the power cables.
3. The switch transfer operator shall be motorized, utilizing an AC squirrel cage induction motor mounted on a worm gear reducer to drive the spring-loaded overcenter-type transfer linkage. Pivot points in the linkage shall utilize aircraft-type, self-aligning ball joints. The mechanical and electrical interlocking shall be designed so as to positively preclude both power sources from being closed at the same time. The transfer switch shall have "break before make " transfer action. The total switch transfer time shall not exceed 30 seconds.
4. A manual operating linkage shall be so designed as to provide the same contact-to-contact transfer time as the motorized operator. A two-position selector switch shall be provided inside the transfer switch cabinet to select of either automatic or manual transfer operation of the switch.
5. The transfer switch shall be enclosed in a NEMA 12 enclosure fabricated from 12 gage steel, sized to enclose all necessary accessories, components and devices. The enclosure shall be painted inside and outside with polyester powder coating over the phosphatized surfaces.
6. The control key-pad shall be a micro-processor based controller, factory-programmed to control all of the operational functions of the automatic transfer switch. LED indicators shall be furnished on the controller to show whether the switch is in the position of the normal or alternate power source. The key-pad controller shall be mounted on the door of the switch with gaskets for the Nema 12 rating of the enclosure.

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

7. Certification shall be submitted to the Engineer proving that the transfer switch conforms to, and have been subjected to, the following tests and requirements:

- a. UL-listed withstand and closing ratings of 42,000 amps at 480 volts (test voltage) without contact welding, coordinated with the circuit breakers.
- b. Overload and endurance tests conducted at 3,600 amps and 1,200 amps respectively. Tests shall be conducted with both sources energized at 480 volts, three-phase. Endurance tests shall be conducted for 3,000 to 6,000 cycles.
- c. All test reports shall include the successful completion of post-endurance temperature rise tests with values within the following limits:

Bus: 65 Degrees C  
Contacts: 65 Degrees C  
Terminals: 50 Degrees

**G. Terminal Blocks.** Terminal blocks shall be UL-listed, rated for the size of the wires to be connected, heavy-duty, 600-volt, provided with pressure-sensitive marking tape. The terminal block housing shall be flame-retardant, designed such that the contact block is protected between the molding barriers from adjacent circuits or live parts. Individual contacts shall be tubular screw type, constructed of electrical grade copper and supplied with zinc plated steel screws. Terminal blocks shall be mounted on track in cabinets or enclosures, and 20% spares shall be provided.

**H. Molded Case Circuit Breakers.**

1. Molded case circuit breakers in enclosures or panelboards shall be sized as indicated in the plans, UL-listed and shall meet NEMA Standard No. AB1, and FS No. W-C-375B/GEN, where applicable.
2. Circuit breakers shall have toggle-type operating mechanisms, with quick-make, quick-break action and positive handle indication. Circuit breaker operating handles shall assume a center position when tripped. Two-pole and three-pole breakers shall be common-trip. Each circuit breaker shall have a permanent trip unit containing individual thermal and magnetic trip elements in each pole. All breakers shall be calibrated for operation in an ambient temperature of 40 Degrees C.
3. Circuit breakers shall be suitable for mounting and operating in any position. Connections to bus shall be bolt-on. Lugs shall be copper, UL-listed for copper conductors. Circuit breakers shall be U.L. listed for installation of mechanical screw-type lugs.
4. Individually enclosed circuit breakers shall be in Nema 4 enclosures and in Nema 4X stainless steel enclosures for outdoor use, provided with operating mechanism and handle for external operation, and padlock provisions.
5. Molded case switches shall be U.L. listed per U.L. 1087, and shall be molded case circuit breakers with no overcurrent protection, provided for use as non-fused disconnect switches as indicated in plans.

**I. Panelboards.**

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

1. Circuit breaker panelboards shall be Nema 12 surface-mounted and rated for the service as shown in the plans. Panelboards shall be equipped with thermal-magnetic molded case circuit breakers, conforming to the requirements as described herein, with ratings as shown in the plans. Circuit breaker connections to the copper bus shall be bolt-on with vibration-proof hardware.
2. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type. Three-phase, four-wire bussing shall be such that only three adjacent single-pole breakers are individually connected to each of the three different phases in such a manner that two- or three-pole breakers can be installed at any location. All current-carrying parts of the buss assembly shall be copper tin-plated. Bus ratings shall be as shown on the drawings.
3. Terminals for conductors to the panelboard mains and branch circuit wiring, both breaker and neutral, shall be UL-listed as suitable for the type and size of conductor specified.
4. Panelboard circuit numbering shall be such that starting at the top, odd numbers shall be used in sequence down the left-hand side and even numbers shall be used in sequence down the right-hand side.
5. The panelboard copper bus assembly shall be enclosed in a steel cabinet. The size of the wiring gutters and gauge of steel shall be in accordance with NEMA Standards, Publication No. PB1-1977 and UL Standards No. 67 for panelboards. The box shall be fabricated from minimum number 14 gauge, galvanized steel or equivalent rust-resistant steel, conforming to UL standards, UL 50.
6. The front panel shall include a door and have flush, stainless steel, cylinder tumbler-type lock with catch and spring-loaded door pull. The flush lock shall not protrude beyond the front of the door.
7. The removable, front panel shall have adjustable, interior trim clamps, which shall be completely concealed when the door is closed. The door shall be mounted by completely concealed stainless steel hinges. The front shall not be removable with the door in the locked position.
8. A circuit directory frame of brass and a card with a clear plastic covering shall be provided on the inside of the door. The directory shall be type-written to identify the load fed by each branch circuit.
9. The front panel shall be of minimum number 12 gauge, full-finished steel, with rust-inhibiting primer and baked-enamel finish. Each panelboard, as a complete unit, shall have a short circuit current rating equal to or greater than the rating shown on the panelboard schedule or in plans. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be listed by the Underwriters Laboratories and bear the UL label.

### ***J. Disconnect Switches.***

1. In general, enclosed molded case switches or non-automatic circuit breakers shall be used as disconnect switches as shown in plans. For motors rated less than 5 horsepower at 230 volts A.C., manual starter switches rated Nema 4 with die cast zinc enclosure may be used as disconnect switches. Heavy-duty, unfused safety switches, conforming to NEMA KS-1, and UL listed, may be used in lieu of molded case switches.
2. Disconnect switches shall have a quick-make and quick-break operating handle and mechanism which shall be an integral part of the box, not the cover. Switches shall have a dual cover-

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

interlock to prevent unauthorized opening of the switch door in the on position or closing of the switch mechanism with the door open. Handle position shall indicate if switch is on or off. Padlocking provisions shall be provided for locking in the off position.

3. Unless otherwise indicated in plans, disconnect switches shall be in Nema 4X enclosure.

### ***K. Lever Arm Limit Switches.***

1. Lever arm limit switches shall be provided for use at locations as shown in plans. The lever arm limit switch shall be heavy duty, spring return type, U.L. listed, rated 600 volts A.C., gasketed, factory-prewired and sealed for liquid-tight and submersible performance. The enclosure shall be zinc die cast. Contacts shall consist of one normally-open and one normally closed, and shall be of the wiping type contact rated 10 amps continuous at 120 volts A.C.. The lever arm head shall be keyed with capability of four-direction head positioning, and field convertible for clock-wire or counter clock-wire operation with 5-degree travel and 90-degree total travel. The switch shall be provided with a 3.5 meter long, factory-prewired cable and have an operating range from -40 degrees Celsius to 105 degrees Celsius.
2. The lever arm shall be provided with appropriate arm length to accommodate with the installation of the limit switch trip plate, as shown in plans. The lever shall be furnished with meshing teeth for engagement with the meshing teeth on the switch operating shaft, and may be set in any position in a 360 degree circle in 24 steps of 15 degrees each. A steel roller shall be provided at the trip end of the lever. All fabricated trip plates, mounting supports, brackets and hardware required for the installation of the limit switch shall be included.

### ***L. Service Entry Surge Protector.***

A surge protector shall be furnished for the surge protection of the 400 amp, 240 volt, 3 phase, 4 wire service to the bridge. The surge protector shall meet the requirements of UL 1449, and shall consist of metal oxide varistor (MOV) modules, protective fuses, solid-state mother-board for control, diagnostic and monitoring purpose, control and monitoring devices, and terminal blocks. The entire surge protector unit shall be enclosed in a stainless steel Nema-4X enclosure. The MOV modules and fuses shall be replaceable and provided with spares. The surge protector shall have a maximum operating AC voltage of 115% of the rated line voltage, a response time of 1 nanosecond, nominal. The surge protector shall be a PTX400 by Eaton Electric or an equal approved by the Engineer.

### ***M. Machinery Lubrication Pump Motor.***

The pump motor shall meet Nema Standard MG1, Motors and Generators, and shall have the following ratings and features:

- Horse power: As shown on drawings
- Voltage: 230 volts A.C., 3 phase, 60 cycle
- RPM: 1725
- Service factor: 1.15
- Temperature rating: 40 degrees Celsius – ambient
- Nema design code: B
- Insulation class: F
- Full load efficiency: 81
- Enclosure: Totally-enclosed, non-ventilated (TENV) with electrostatic epoxy coating, moisture sealant on bolt heads and between frame and endplates
- Mount: Base mount
- Shaft: Stainless steel with over-sized ball bearing on locked drive end for minimum shaft movement.

**N. Spare and Renewal Parts.** Spare and renewal parts shall be furnished in compliance with AASHTO, Standard Specifications for Movable Highway Bridges, Division II, Section 10, and as specified below. It is required that recommended spares be listed in the Operation and Maintenance Manual, in three or more categories arranged in order of importance to operations, inspection, maintenance, trouble-shooting, and repair. Copies of the manufacturer's recommendations shall be included in the Operation and Maintenance Manual.

Mandatory items to be provided shall include:

- a. One (1) complete set of stationary and moving contacts for each size of each device incorporating replaceable contacts.
- b. One (1) coil for each size magnetic contactor, motor starter and relay used.
- c. One (1) set of overload devices (current monitors) and/or bimetallic element of each size and type used.
- d. Two (2) complete limit switches of each kind and size used (contact blocks only for rotary cam limit switches).
- e. Four (4) complete control relays and four complete timing relays of the type used in the control circuit.
- f. Six (6) incandescent lamps for the console indicators of each size and type used.
- g. Three (3) I/O modules of the PLC and one (1) each of all other plug-in modules which have been used.
- h. In addition to the mandatory items listed above, the Contractor shall obtain supplementary spare and renewal parts list recommendations for optional purchase from each manufacturer supplying the various items of power, control, and auxiliary equipment approved for permanent installation.

## **CONSTRUCTION DETAILS**

### **CONTRACTOR/SUBCONTRACTOR QUALIFICATIONS.**

The electrical Contractor/subcontractor performing the electrical work must be primarily and regularly engaged in the installation and servicing of industrial electrical distribution and control systems. The Contractor shall provide on-site electrical supervisory personnel who are registered electricians experienced in industrial electrical distribution and control systems, and who have been employees of the Contractor for not less than six months prior to the award of this work.

The Contractor shall engage a systems integrator as the Control System Vendor who shall have complete system responsibility for furnishing, detailing and manufacturing the total control system, and shall furnish and assist with the supervision of the installation, connection, adjustment, and testing of all electrical equipment associated with the bridge operations. Equipment required to be furnished as part of the integrated control system by the Control System Vendor shall include, but not necessarily be limited to the programmable controller, the message display, the control console, the bridge position indicator system, the motor control center with motor circuit protectors and motor starters, the flux vector motor drive system and motors, the tachometer/generator, the auxiliary drive system and motors, the rotary cam limit switches, all other limit switches, and control devices associated with the bridge control system.

The Control System Vendor shall be able to demonstrate his experience in the integration, installation, and start-up of movable bridge control systems by having successfully completed five such systems in the past ten years, three of which shall have incorporated a flux vector motor drive. Documentation

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

demonstrating that the Control System Vendor meets these requirements shall be submitted with the bid documents.

### **START-UP SERVICES.**

The Control System Vendor shall provide a factory-trained field service engineer/technician to check out the control system installation on-site, including wiring interconnections to the control system prior to the initial operation of the bridge. The field service engineer/technician shall remain or return on-site during system startup, and shall return for at least one additional site visit immediately prior to final acceptance of the control system to make final adjustments to the control system as directed by the Engineer.

In general, this work shall consist of, but not necessarily be limited to, the following principal items:

1. A complete programmable logic controller (PLC) system mounted in cabinets with associated uninterruptable power supply, peripherals, control relays, and necessary terminal blocks.
2. Free-standing motor control center cabinets including motor starters, circuit breakers, overloads, potential and current transformers, and terminal blocks.
3. A complete top panel to replace the existing panel of the control console with span control devices, including selector switches, push buttons, indicating lights, span position indicator, digital message display, and meters.
4. Span control equipment and devices such as rotating cam limit switches, lever arm limit switches, tachometer/generators, span position transmitter, and other appurtenances, including mounting brackets and fabricated supports.
5. Incoming service equipment such as metering cabinet and main disconnect.
6. Panelboards for the power distribution.
7. All field tests, adjustments, and corrective measures to properly complete all systems.
8. Complete clean-up, painting, and restoration.
9. Supervision and performance of necessary operational adjustments for a smooth operation of the span after acceptance for a period of ten regular work days.
10. Assembly and delivery of a complete file of warranties, operating instructions, operation and maintenance manual, and a complete set of construction plans revised to show the "As-Built" conditions as finally installed.
11. Complete clean-up and restoration.
12. Making arrangements and coordination with the local utility company
13. A comprehensive training program consisting of three 8-hour days shall be conducted by the control system vendor.

### **CODES AND STANDARDS.**

This work shall comply with the requirements of the following codes and standards:

1. National Fire Protection Association, National Electrical Code (NEC), latest edition
2. American Association of State Highway and Transportation Officials (AASHTO), Standard Specifications for Movable Bridges 1998, with all revisions in effect as of November 2006
3. New York State Department of Transportation, Standard Specifications, latest edition
4. National Electrical Contractors Association, NECA 1, Standard Practices for Good Workmanship in Electrical Contracting
5. Any other applicable local rules and regulations.

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

**A. General.** During construction, it will be mandatory to keep the existing bridge in operation. It will be the Contractor's responsibility to maintain service and provide necessary labor and materials for splicing, rerouting and temporarily supporting the necessary cables and conduits, as required.

Storage of materials shall conform to the requirements of the New York State Department of Transportation Standard Specifications:

Storage of Materials

106-06

Materials shall also be handled, stored and protected in accordance with the manufacturer's recommendations. Equipment, materials and components intended for indoor installation shall not be stored outdoors. Damage to material caused by the Contractor's operations shall be repaired at no expense to the State.

The Contractor shall submit a wiring diagram and list of equipment to be furnished for approval prior to starting his electrical work. Wire numbers shall be provided on the wiring diagrams. The Contractor shall submit a complete set of control circuit drawings, showing the ladder-diagram control logic with the corresponding PLC programming for the bridge control circuit and the discrete relay logic ladder diagram for the auxiliary drives. The control circuit drawings shall also illustrate, to scale, the layout of the PLC system components within the PLC cabinet, and the control console. Descriptive brochures describing the electrical characteristics of the various components shall be included.

Existing equipment, components and appurtenances required for replacement and removal shall be removed by the Contractor. With the exception of the existing automatic transfer switch to be salvaged for use as spare part for the northbound bridge, all removed materials shall become the properties of the Contractor and shall be properly disposed of away from the construction site. The Contractor shall carefully remove the existing automatic transfer switch such that it will not be damaged during the removal and shall package and include it in the spare parts as described herein.

**Basis of Acceptance**

All shop drawings submitted shall follow the general guidelines and procedures given in the New York State Steel Construction Manual. No installation or rehabilitation work may take place until the shop drawings and procedures have been approved by the Engineer.

**B. Installation.** Prior to commencing installation, the Contractor shall perform the following:

- a. Verify that all surfaces upon or in which enclosures are to be mounted, are properly prepared, and that all wire pulling required before enclosure mounting, has been completed and all wires are properly tagged. Take corrective action, if necessary.
- b. Verify that enclosure mounting provisions are suitable for intended mounting. Make corrective adjustments, if necessary.
- c. Verify that all factory-installed circuit breakers have the correct rating for the applicable circuit, as indicated. Take corrective action, if necessary.
- d. Install panelboards in accordance with the manufacturer's instructions. Complete all directory cards with the information indicated. Typewrite information on directory cards.

**ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

**C. Enclosures, Panelboards.** The Contractor shall perform the following work for the installation of enclosures and panelboards:

- a. Install at indicated or approved locations, in accordance with the manufacturer's instructions, and at convenient operating height, such that unless shown otherwise, no manually operable device will be within 760mm (2-1/2 feet) of the floor or more than 2m (6-1/2 feet) above the floor.
- b. Adjust, straight, plumb, and fasten securely in place. Align, and securely and independently fasten each section of multi-section enclosures.
- c. Install all wall-mounted enclosures and cabinets, for indoor use, on structural channel erector systems, such as Unistrut, B-Line or an approved equal. For outdoor installations, enclosures and cabinets shall be mounted on 6.4mm (1/4 inch) thick steel mounting channels, or fabricated supports.
- d. Ground, as specified in UL 67, in NEC, Articles 200 and 250. Connect the neutral wire of each circuit directly to the neutral bus in the same panel as the circuit breaker of the circuit being protected.
- e. Perform all necessary branch circuit wiring before the panelboard is energized.
- f. Neatly route, harness and support conductors in gutters, wiring spaces and compartments. Bending radii shall not be less than as recommended by the conductor manufacturer.
- g. Isolate all aluminum boxes and enclosures from dissimilar metals with neoprene shims.

**D. Lubrication Pump Motors.** The work for the machinery lubrication lump motors shall include, but not be limited to, the following:

- a. Remove existing motors.
- b. Furnish mounting as shown in plans.
- c. Install, adjust and align motors as recommended by the manufacturer.

**E. Auxiliary Drive Motors.** The work for the auxiliary drive motors shall be as shown in plans and shall include, but not be limited to, the following:

- a. Remove surface rust on the motor housing.
- b. Properly clean and prepare the motor housing for painting.
- c. Prime and paint the motor housing with corrosion-resistant paint coating.
- d. Replace the motor nameplate, when it is approaching illegible, with a stainless steel nameplate engraved with appropriate information.

**F. Testing.**

a. **Shop Testing.**

Shop testing of the Control System shall be performed on the complete assembled control system prior to shipment from the Control System Vendor's shop. The Control system Vendor shall coordinate all equipment deliveries to his shop, make connections and conduct the shop test. The complete control system, including programmable logic

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

controller, control console panel, motor control center, motor drives, rotating limit switches, and tachometers shall be assembled and temporarily interconnected for testing with all interconnected control equipment with the PLC. Various limit switches may be omitted in lieu of temporary toggle or selector switches for this test. For acceptance, the temporarily connected system shall demonstrate a proper operation through-out the opening and closing sequences in the operating modes shown in plans with indicating lights on the console panel showing their proper indication of bridge positions, the engagement and disengagement of equipment activated by limit switches and system status. Errors or deficiencies noted in this test must be rectified prior to shipment.

The shop test shall be conducted in the presence of the Engineer with written report on test results submitted to the Engineer. Accordingly, the Engineer shall be notified at least four weeks prior to the test date. The testing shall include a complete run-through of the operating sequence for Raise and for Lower. All interlocking in the control logic shall be individually confirmed during this test.

All programmable logic controller and peripheral equipment shall be subjected to a minimum 72-hour continuous burn-in at the control system manufacturer's assembly plant.

### **b. Testing After Placement.**

Prior to energizing any circuit or system, all insulated conductors shall be tested for continuity, short circuits and insulation resistance. Any damaged conductors shall be repaired or replaced by the Contractor and the test repeated. Circuit tests shall be made for each circuit and system with voltage, current, and related informational data recorded.

After being installed in place, each control item and device, including, but not be limited to, control relays, reversing and non-reversing starters, limit switches, tachometer/generators, indicating lights, and selector switches shall be connected and given an individual, in-place test run. Any discrepancies found shall be corrected, and additional test runs shall be made until the equipment operates satisfactorily in-place.

Performance tests shall be conducted on individual, group, or system of equipment, including position indicators, brakes, motors, rotating cam limit switch, flux vector motor drives and span lock to demonstrate that acceptable operation can be assured. The Contractor shall prepare a format and record thereon all results observed. Any discrepancies found shall be corrected, and additional test runs shall be made until the equipment operates satisfactorily.

When the operating machinery installation is complete and ready for testing, the Contractor shall test run the bridge. The bridge shall demonstrate a trouble-free operation with all interlocks properly functioning through the PLC. Should the tests show any deficiency, or inaccuracy, the Contractor shall make necessary corrections, adjustments, or replacements to assure a proper and reliable operation of the bridge.

The Contractor shall provide and connect to each span drive motor feeder at the motor drive cabinets, approved chart-type recording voltmeters, ammeters and wattmeters to continuously monitor and record the appropriate data variables throughout each test cycle of the machinery. The positions of the span shall be noted on each recording, along with designations of start, stop, open and close. Charts shall be run after final adjustments

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

have been made, with bridge running the full cycle. Charts shall be run for both "raise" and "lower" functions.

The Contractor shall conduct infrared scan of the motor control centers and the motor drives during bridge operation and provide to the Engineer photographs illustrating the hot spots. All lugs, terminals, and connections so identified shall be checked for tightness and proper connections. The infrared scan shall then be repeated to assure proper tightness of the connections.

The Contractor shall prepare to conduct additional miscellaneous performance tests, as requested by the Engineer, where necessary, to establish that the installed systems are trouble-free and will operate in a reliable manner.

At the conclusion of all testing, the Contractor shall turn over to the NYSDOT representative or Engineer all test results including recorded charts, voltage and current readings, and diagrams of tests set-up for records or for use in the final acceptance test.

### **c. Final Testing.**

After being placed in service, and after all significant operating adjustments have been made, the PLC shall demonstrate 72 consecutive hours of error-free on-line operation, with the PLC performing all operating functions successfully. During this period, any occurrence requiring shutdown, rebooting, or transfer of control to the second PLC shall be deemed an interruption, following which the problem shall be corrected and the test period restarted. Tests for final acceptance of the system will not be made until after the 72-hour error-free period has been achieved. This test shall be repeated for each PLC.

When the entire installation is completed with the bridge control system interlocked with the operation of all traffic signals, traffic gates, and ready for final acceptance, the bridge span shall be operated in the presence of and witnessed by the Engineer for final acceptance. Accordingly, the NYSDOT Representative shall be notified, at least, two weeks prior to the test date. The bridge shall be operated through not less than two complete cycles including raising and lowering sequences, and including the control modes shown in plans.

Should the system fail to perform as described in this specification and in plans, no further testing shall be performed until the problem is identified and the Contractor has made any necessary corrections, adjustments, or replacements. Any retesting shall be performed from the beginning of the test; no partial tests will be accepted.

For final acceptance, the bridge control system shall demonstrate a smooth and trouble-free operation through all control modes and functions as shown in plans and described herein to the satisfaction of the Engineer, including the following conditions:

- The flux vector motor drives shall demonstrate a smooth acceleration, deceleration and running of the drive motors through the raising and lowering sequences of the span from fully seated to fully opened position, and vice versa from fully opened to fully seated position with all locks engaged at span fully seated. At Jog Speed, the span shall also be satisfactorily operated at 10 percent of running speed.
- The control system shall demonstrate a trouble-free operation with all correct status indication of the span position indicators, brakes, span lock and other

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

equipment and all control modes and functions as provided on the console panel and as shown in plans.

- The results of the infrared scan of the motor control center and the flux vector motor drives shall not show any hot spots caused by loose connections or improper tightness of lugs, terminals and connections.

Should the tests show any deficiencies, or improper function, the Contractor shall make any necessary corrections, adjustments, or replacements prior to the final acceptance.

**G. Training.** Prior to the final acceptance of the bridge control system, the Contractor shall furnish the services of competent and experienced instructors to give full and in-depth instruction to State personnel in the adjustment, operation, and maintenance of the bridge control system and equipment, including pertinent safety requirements, as required. The instructor(s) shall be thoroughly familiar with all aspects of the installation and shall be trained in operating theory, as well as practical operation and maintenance work of the programmable logic controller, and all other control system components. The instruction shall be given during the first regular work week after the tests on equipment or system has been performed and prior to final acceptance of the bridge. Three 8-hour days of instruction shall be furnished within a period of five consecutive regular work days. The specific schedule will be determined by the State. The instruction shall be given at the site. The Contractor shall coordinate all other required training covered under other items to organize a complete training session to cover all systems installed for the bridge.

**H. Spare Parts.** All spare and renewal parts for both initial and future inventories shall be listed by categories with descriptions and manufacturers' catalog reference number or other designation. Each category shall be prepared in the format suitable for insertion into the Operation and Maintenance Manual with section identification and index.

All spare and renewal parts shall be carefully prepared for storage, in convenient packages of individual items or lots. Each package shall be completely identified as to its contents including quantity, bridge name, and contract number, and delivered to the selected places of storage at such time as directed by the NYSDOT Representative.

**I. Identification Nameplates.** All major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, identification nameplates shall be made of laminated plastic with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, or other approved non-adhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates.

In all instances, the nameplate shall be installed in a conspicuous location. At the option of the Contractor, and with prior approval from the Engineer, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. As a minimum, nameplates shall be provided for equipment such as panelboard, motor control center, control power transformer, motor starter, control devices, safety switch, instrument transformer. Each panel, section, or unit in motor control centers, or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, for individual compartments in the respective assembly, including nameplates for spare units.

## **ITEM 599.2106 10 M - CONTROL SYSTEM EQUIPMENT AND SWITCHGEAR – SB BRIDGE**

### **METHOD OF MEASUREMENT**

This work will be measured for payment on a lump sum basis.

### **BASIS OF PAYMENT**

The lump sum price bid shall include the costs of furnishing all material, labor and equipment to satisfactorily remove, furnish and install a complete, trouble-free control system to provide a smooth and satisfactory operation of the bridge as described herein under this item and as shown in plans. This price bid shall also include all spare parts, documentation, tests, and personnel training as described herein.

This lump sum will be paid in the following installments, with each payment subject to approval of the Engineer:

- Sixty (60) percent of the lump sum price bid will be paid to the Contractor upon satisfactory completion of the installation of the Control System Equipment and Switchgear.
- The remaining forty (40) percent of the lump sum price bid will be paid to the Contractor upon satisfactory completion of testing of the Bridge Control System and upon final acceptance by the State.