

Section 16486

MECHANICAL EQUIPMENT MANUFACTURER (MEM) PROVIDED
CONTROL PANELS

PART 1 GENERAL

1.01 SUMMARY

This Section includes the furnishing and installation of functional MEM control panels to manually or automatically operate control systems as specified in the detailed requirements of this Section and as described in the Process Equipment Division Specifications.

1.02 MEASUREMENT AND PAYMENT

No separate payment for work performed under this Section. Include cost of same in Contract price bid for work of which this is a component part.

1.03 REFERENCES

This specification references the following publications in their current editions. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

- A. NEMA ICS 2: Industrial Control and Systems Controllers, Contactors, and Overload Relays Rated 600 Volts
- B. NFPA 70: National Electrical Code (NEC)
- C. NFPA 70E: Standard for Electrical Safety in the Workplace
- D. NFPA 79: Electrical Standard for Industrial Machinery
- E. UL 489: UL Standard for Safety Molded-Case Circuit Breakers. Molded Case Switches and Circuit Breaker Enclosures
- F. UL 508: UL Standard for Safety Industrial Control Equipment
- G. UL 508A: UL Standard for Safety Industrial Control Panels
- H. ANSI/ISA 60079-0: Explosive Atmospheres - Part 0: Equipment - General Requirements
- I. All equipment components and completed assemblies specified in this Section of the Specifications shall bear the appropriate label of Underwriters Laboratories

1.04 SUBMITTALS

Submit the following in accordance with Section 01330 – “Submittal Procedures.”

- A. All submittals for, process equipment panels specified under this Section, shall be submitted as a part of the Process Equipment Manufacturer’s submittal under the Process Equipment Division submittals.
- B. Submittals shall be made in accordance with the requirements of Division 01, Process Equipment Division and as specified herein.
- C. Provide systems engineering to produce coordination curves, showing coordination between existing and proposed breakers and/or fuses submitted, such that protective device coordination is accomplished. Such curves and settings shall be included as a part of these submittals.
- D. Submittals shall also contain information on related equipment to be furnished under this Section but described in the related Sections listed in the RELATED REQUIREMENTS paragraph below. Incomplete submittals not containing the required information on the related equipment will also be returned unreviewed.
- E. The mechanical equipment Manufacturer shall create all equipment shop drawings, including all wiring diagrams, in the Manufacturer’s Engineering department. All equipment shop drawings shall bear the mechanical equipment Manufacturer’s logo, drawing file numbers, and shall be maintained on file in the mechanical equipment Manufacturer’s archive file system.
- F. Submit shop drawings and product data for the following:
 - 1. The MEM shall use their control systems engineering department to produce custom unit elementary drawings. Plans shall be on the MEM’s drawing sheets, and shall include all schematics for control logic as described in the Process Equipment Specifications, and any associated control schematics shown on the Plans for this project. Show interwiring and interlocking between components and to remotely mounted devices. Include and identify all connecting equipment and remote devices on the schematics. The notation “Remote Device” will not be acceptable. Show wire and terminal numbers. Indicate special identifications for devices as required by the MEM or as may be shown on the Plans.
 - 2. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and anchor bolt pattern. Indicate all options, special features, ratings and deviations from this Section.

3. Power and control schematics including external connections. Show wire and terminal numbers and color-coding.
 4. Instruction and replacement parts books, including Manufacturer's part numbers and selections of component ratings, and CT and PT ratios.
 5. As-built final drawings
 6. Documentation that the panel assembly facility is a UL 508A certified facility
 7. Facsimile of the UL label that is to be applied to the completed panel
 8. Furnish complete Bill of Materials indicating Manufacturer's name and part numbers
 9. Manufacturer's cut sheets for every component used in the panel assembly adequately marked to show the items being included. The Manufacturer's name shall be clearly visible on the each cut sheet submitted.
 10. Assembly ratings including:
 - a. Short-circuit rating
 - b. Voltage
 - c. Continuous current
 11. Major component ratings including:
 - a. Voltage
 - b. Continuous current
 - c. Interrupting ratings
 12. Cable terminal sizes
 13. Instruction and renewal parts books
- G. Factory Tests: Submittals shall be made for factory tests specified herein
- H. Field Test Reports: Submittals shall be made for field tests specified herein

I. Operation and Maintenance (O&M) Manuals:

Operation and Maintenance Manuals shall include the following information as per Section 01782 - "Operations and Maintenance Data:"

1. Manufacturer's contact address and telephone number for parts and service
2. Instruction books and/or leaflets
3. Recommended renewal parts list
4. Record Documents for the information required by the Submittals paragraph above.

J. The Manufacturer shall submit for approval, a training agenda for all training specified herein. Training agenda shall not be submitted until final approval of the Operation and Maintenance Manual.

1.05 RELATED REQUIREMENTS

- A. Plans and Specification Sections show and/or specify those features required to describe and illustrate functional requirements for providing, testing, and installing pressure gauge, pressure level transmitters and appurtenances.
- B. All materials, supplies, labor, and supervision to be provided as required for a complete and workable system in coordination with available pressures and in accordance with Manufacturer's recommendations.
- C. Section 01330 - "Submittal Procedures"
- D. Section 01782 - "Operations and Maintenance Data"
- E. Section 16195 - "Electrical Identification"
- F. Section 16196 - "Low Voltage AC Surge Protective Devices (SPDs)"

1.06 QUALITY ASSURANCE

- A. The Manufacturer of the control panels shall have produced similar equipment for a minimum period of five (5) years. When requested by Project Manager, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. The control panels shall be assembled in a UL 508 certified facility. A submittal of documentation certifying that the panel fabrication facility is a UL 508 certified facility is required. A UL label shall be affixed to the inside of the external door by the panel fabrication assembly. Submit a facsimile of the UL label in the submittal

information.

- C. All components and material shall be new and of the latest field proven design and in current production. Obsolete components or components scheduled for immediate discontinuation shall not be used.
- D. Control panels submitted shall fit within the space shown on the Plans. Equipment which does not fit within the space is not acceptable.
- E. For the equipment specified herein, the Manufacturer shall be ISO 9001 2000 certified

1.07 SYSTEM DESCRIPTION (NOT USED)

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Prior to jobsite delivery, the Contractor shall have successfully completed all submittal requirements, and present to the Project Manager upon delivery of the equipment, an approved copy of all such submittals. Delivery of incomplete constructed equipment, onsite factory work, or failed factory tests will not be permitted.
- B. Equipment shall be handled and stored in accordance with Manufacturer's instructions. Two (2) copies of these instructions shall be included with the equipment at time of shipment, and shall be made available to the Contractor and Project Manager.
- C. Shipping groups shall be designed to be shipped by truck, rail, or ship. Indoor groups shall be bolted to skids. Breakers and accessories shall be packaged and shipped separately.
- D. Equipment shall be installed in its permanent finished location shown on the Plans within seven (7) calendar days of arriving onsite. If the equipment cannot be installed within seven (7) calendar days, the equipment shall not be delivered to the site, but stored offsite, at the Contractor's expense, until such time that the site is ready for permanent installation of the equipment.
- E. Where space heaters are provided in equipment, provide temporary electrical power and operate space heaters during storage, and after equipment is installed in permanent location, until equipment is placed in service

1.09 WARRANTY

The Manufacturer shall warrant the equipment to be free from defects in material and workmanship for the same length of time as the associated mechanical equipment, but not less than 1 year from date of final acceptance of the equipment. Within such period of warranty the Manufacturer shall promptly furnish all material and labor necessary to return the equipment to new operating condition. Any warranty work, requiring shipping or transporting of the equipment, shall be performed by the Manufacturer, at no expense to the Owner.

PART 2 PRODUCTS

2.01 MANUFACTURER(S)

- A. Subject to compliance with the Contract Documents, the following material Manufacturers are acceptable:
 - 1. General Electric
 - 2. Eaton / Cutler Hammer
 - 3. Square D
 - 4. Allen Bradley
- B. The MEM shall be responsible for providing all required controls and apparatus as specified utilizing the specified components herein.

2.02 MATERIALS AND/OR EQUIPMENT

- A. Ratings
 - 1. The service voltage shall be as specified and as shown on the Plans. The overall short circuit withstand and interrupting rating of the equipment and devices shall be equal to or greater than the overall short circuit withstand and interrupting rating of the feeder device immediately upstream of the Control Panel, but not less than 22,000 amperes RMS symmetrical at 480/277 Volts. This includes all circuit breakers and combination motor starters. Systems of motor controllers employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL 508A labeled for the specified short circuit duty in combination with the motor branch circuit protective device.
 - 2. There shall be selective device coordination between the Main Breaker, Feeder Breakers and control circuit protective devices. When using a circuit breaker or fuses as a main protective device, the instantaneous trip levels of the main protective device shall be higher than the available fault current to the control panel. If fuses are utilized in the control panel design, the protective devices for 3 phase loads shall contain single phase protection of such equipment. If a fault occurs in the circuit of one load of a design with a backup load, the feeder protective device shall not remove both loads from the control system.
 - 3. Use ground fault sensing on grounded wye systems.
 - 4. The complete control panel assembly shall be UL certified and carry a UL listing for "Industrial Control Panels".

5. The control panel shall meet all applicable requirements of the National Electrical Code.
6. The control panel enclosure shall be NEMA rated as specified herein.
7. Motor controllers, including associated devices, shall be designed for continuous operation at rated current in a 40 degree C ambient temperature.
8. For additional ratings and construction notes, refer to the mechanical equipment specifications and the Plans.
9. The Manufacturer shall produce and install on each panel, an Arc Flash Warning Label listing the various Flash Hazard Protection Boundaries, calculated from NFPA 70E, Annexes, as listed below:
 - a. Flash Hazard Protection Boundary
 - b. Limited Approach Boundary
 - c. Restricted Boundary
 - d. Prohibited Boundary
 - e. Incident Energy Level
 - f. Required Personal Protective Equipment Class
 - g. Type of Fire Rated Clothing
10. Provide an Arc Flash Warning Label, printed in color and affixed to the front of each panel provided.
11. Shown below is a typical label. Size of each label shall be not less than 8 inches wide and 6 inches tall.



B. Service Entrance Device

Where the Control Panel is rated and used as a service entrance panel, the Manufacturer shall furnish factory installed in the Control Panel, a dedicated (SPD) (Type 2), permanently connected, Surge Protective Device on the load side of the service entrance device, as specified in Section 16196 - "Low Voltage AC Surge Protective Devices (SPDs)."

C. Main Circuit Protective Device

1. Unless otherwise shown on the Plans, the main circuit protective device shall be a molded case (MCCB), 3 Pole, 600 Volt, fixed type, manually operated with a stored energy closing mechanism. Trip device shall be a solid stat with adjustable long time pickup, and delay; adjustable short time pickup and delay; short time i^2t switch; adjustable ground fault pickup and delay, and ground fault delay and pickup trips for selective tripping.
2. Provide a flange mounted main power disconnect operating handle with mechanical interlock having a bypass that shall allow the panel door to open only when the switch is in the "OFF" position. Where panels are shown or specified with inner and outer doors, disconnecting handles and controls shall be located on the inner door.

D. Motor Controllers

1. Manufacturers
 - a. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
 - 1) General Electric
 - 2) Eaton / Cutler Hammer

- 3) Square D
- 4) Allen Bradley

2. General

- a. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the Manufacturer's heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.
- b. Furnish lugs for incoming wiring. Allow adequate clearance for bending and terminating of cable size and type specified.
- c. A NEMA rated magnetic motor starter shall be furnished for each motor. Each motor starter shall be provided with a motor circuit protector, or circuit breaker, and equipped to provide undervoltage release and overload protection on all three phases. The short circuit protective device shall have an adjustable magnetic trip range up to 1400 percent of rated continuous current and a trip test feature. MCPs shall be labeled in accordance with UL 489. NEMA starter sizes and breaker trip ratings shall be as required for the horsepower indicated, but shall be in no case less than NEMA Size 1. If the Manufacturer of the equipment utilizing the motor, supplies a motor horsepower larger than that shown on the Plans, the Contractor shall supply a motor starter sufficient in size to control the motor supplied.
- d. A mechanical disconnect mechanism, with bypass, shall be installed on each motor circuit protector, capable of being locked in the "OFF" position to provide a means of disconnecting power to each motor. Disconnects mechanisms shall be located inside the enclosure such that the main circuit breaker handle is the only device interlocked with the panel door.
- e. Each motor starter shall have a 120 volt operating coil unless otherwise noted.
- f. Overload relays shall be standard Class 20, ambient compensated, manually reset by pushbutton located on front of the starter door. A normally closed contact shall be directly used in the start circuit and a normally open contact shall be wired to a terminal board for overload alarm.

- g. All interfaces between control panel and remote devices shall be isolated via an interposing relay. Interposing relays shall have contacts rated for 250 VAC and 10 Amps continuous. Relays shall be Control Relays as specified herein.
- 3. Magnetic Motor Starters
 - a. Motor starters shall be 2 or 3 pole, single or 3 phase as required, 60 Hertz, 600 volt, magnetically operated, full voltage nonreversing. NEMA sizes shall be as required for the horsepower shown on the Plans.
 - b. Each motor starter shall have a 120 volt operating coil, and control power transformer. Starters shall have motor overload protection in each phase. Auxiliary contacts shall be provided as shown on the Plans. A minimum of one "NORMALLY OPEN" and one "NORMALLY CLOSED" auxiliary contacts shall be provided in addition to the contacts required.
 - c. Overload relays shall be adjustable, ambient compensated and manually reset.
 - d. Built in control stations and indicating lights shall be furnished where shown on the Plans.
 - e. All wires shall be terminated on terminal blocks and shall be tagged.
 - f. Provide as built wiring diagram and post it in a protective cover inside the cell.
- 4. Contactors
 - a. Contactors shall be a circuit breaker and contactor, 600 Volt, 3 Pole, 60 Hz, magnetically operated. NEMA size shall be as required for the kilowatt ratings required for the equipment provided, but shall be not less than NEMA size 1.
 - b. Contactors shall have a 120 Volt operating coil and control power transformer. Furnish the control power transformer with extra capacity for the unit heater fan.
 - c. Where an elapsed time meter is specified or shown on the Plans, a six digit, non-resettable elapsed time meter shall be installed on the face of each motor starter. Meter shall be as specified in Section 16195 – "Electrical Identification."
- 5. Control Relays

Control relays shall be 300 volt, industrial rated, plug-in socket type, housed in a transparent polycarbonate dust cover, designed in accordance with UL 508 for motor controller duty. Continuous contact rating shall be 10 amperes resistive, ¼ HP at 120 VAC, operating temperature minus 10 to plus 55 degrees C. Provide spare "NORMALLY OPEN" and "NORMALLY CLOSED" contacts. Relays shall be Potter & Brumfield KRP Series or equal with neon coil indicator light. Timing relays shall be 300 Volt, solid state type, with rotary switch to select the timing range

E. Logic Devices

1. Programmable Logic Controller

- a. Where the control panel contains a programmable logic controller (PLC) for programming of the control logic, the Manufacturer shall provide the address list, and an Ethernet interface to connect to the Owner's plant monitoring system for monitoring of the PLC's operation.
- b. Provide a scripted program file for each PLC.

2. Operation Interface Terminal

- a. Where the control panel contains an Operation Interface Terminal for interfacing to the control logic, the Manufacturer shall provide the address list, and an Ethernet and serial interface to connect to the related PLC for monitoring and control of the PLCs operation.
- b. Provide a scripted application and fully documented setup for each OIT.

F. Instrumentation Devices

1. Flow Devices

Where Flow Devices are specified herein or shown on the Plans, refer to applicable flow meter specifications for requirements.

2. Programmable Logic Controllers (PLCs)

Where PLCs are specified herein or shown on the Plans, refer to the Specification Sections covering PLCs for the required devices.

3. Operator Interface Terminals (OITs)

Where OITs are specified herein or shown on the Plans, refer to the Instrumentation Divisions for the required devices.

G. Remote Monitoring and Control Interface

1. General:

All control and interconnection points from the equipment to the plant control and monitoring system shall be brought to a separate connection box. No field connections shall be made directly to the equipment control devices. Functions to be brought out shall be as specified in the Instrumentation Divisions.

2. Discrete control or status functions shall be form C relays with contacts rated at 120 volts AC. Analog signals shall be isolated from each other.

3. Equipment functions to be directly interfaced to the Plant Control and Monitoring System, shall be designed for operation with an Ethernet Connection.

4. The equipment Manufacturer shall factory enter the proper IP Address for such connection. Upon request by the Contractor, the Project Manager will provide the proper Internet Protocol Address (IP Address), to be configured by the equipment Manufacturer

5. Refer to the Instrumentation Divisions for monitored parameters.

6. Communication:

a. For remote monitoring, one of the following communication capabilities shall be provided:

- 1) One (1) integral 10/100 BaseT Ethernet port supporting Modbus TCP, Ethernet IP and SNMP protocols.
- 2) One (1) media protocol converter, interfacing the provided equipment to a 10/100 BaseT Ethernet port supporting Modbus TCP, Ethernet IP and SNMP.

b. The protocol interface shall implement the following:

- 1) All data shall be available and/or mirrored within the Modbus 4x or "Holding Register" memory area.
- 2) Register 4x00001 shall exist and be readable to allow simple, predictable "comm tests."

c. The media protocol converter shall meet the following criteria:

- 1) The converter shall support 10/100Base-T Ethernet. The serial port speed (baud rate) shall support 230kbps. The protocol shall

support Modbus TCP, Ethernet IP, DF1, and Modbus RTU/ASCII. Protocol shall be Web Browser configurable.

- 2) Operating limits shall be 0-60 degrees C, with humidity range minimum of 5-90 percent. Shock capability on the serial port shall be ESD +15 kV air GAP meeting IEC 1000-4-2. Power requirements shall be 9-30VDC at 0.5A minimum.
- 3) The converter shall have LED status for serial, signals, power, and Ethernet.
- 4) The converter housing shall be ANSI/ISA 60079-0, Class 1 Div 2, DIN Rail mountable. The converter shall have DB-9M port connection, with screw terminals, to the input.
- 5) Converter shall be Digi One IAP, or approved equal

H. Spare Parts

1. Provide the following spare parts for each control panel in the quantities specified:
 - a. One-half dozen replacement fuses, of all types and sizes
 - b. One replacement lamp, of each color, for pilot lights
 - c. One of each color replacement lens caps for pilot lights
 - d. One starter coil for each NEMA size furnished
 - e. One, 3-ple set of replacement overload heaters of each size range used
 - f. One, 3-pole set of starter contacts of each NEMA size used
 - g. One can of aerosol touch-up paint
2. Spare parts shall be boxed or packaged for long term storage. Identify each item with Manufacturer's name, description and part number on the exterior of the package.

2.03 FABRICATION

A. General

1. Refer to Plans for: actual layout and location of equipment and components; current ratings of devices, bus bars, components; protective relays, voltage ratings of devices, components and assemblies; and other required details.

2. Control units shall be arranged as shown on the Plans.
3. Except for Variable Frequency Drive (VFD) components, where the equipment contains a programmable logic controller (PLC) or a uninterruptible power supply (UPS), the equipment Manufacturer shall furnish factory installed, a dedicated Point of Utilization Device (SPD), as specified in Section 16196 - "Low Voltage AC Surge Protective Devices (SPDs)," Individual Control Panel and Related Equipment Protection (Type 3).
4. Where Kirk-Key arrangements are used, the Kirk keyed interlocks shall be Kirk HD Series (Heavy Duty) 316 Series of 316 stainless steel, or approved equal.
5. Nameplates
 - a. External
 - 1) Nameplates shall be engraved, laminated impact acrylic, matte finish, not less than 1/16-in thick by 3/4-in by 2-1/2-in, Rowmark 322402. Nameplates shall be 316 SS screw mounted to all enclosures except for NEMA 4 and 4X. Nameplates for NEMA 4 and 4X enclosures shall be attached with double faced adhesive strips, TESA TUFF TAPE 4970, .009 X 1/2", or equal. Prior to installing the adhesive nameplates, the metal surface shall be thoroughly cleaned with 70% alcohol until all residue has been removed. Epoxy adhesive or foam tape is not acceptable.
 - 2) There shall be a master nameplate that indicates supply voltage equipment ratings, short circuit current rating, Manufacturer's name, shop order number and general information. Cubicle nameplates shall be mounted on the front face, on the rear panel and inside the assembly, visible when the rear panel is removed.
 - 3) Provide permanent warning signs as follows:
 - a) "Danger- High Voltage- Keep Out" on all doors.
 - b) "Warning- Hazard of Electric Shock - Disconnect Power Before Opening or Working On This Unit" on main power disconnect or disconnects.
 - b. Internal
 - 1) Provide the panel with a UL 508A label.

- 2) Control components mounted within the assembly, such as fuse blocks, relays, pushbuttons, switches, etc., shall be suitably marked for identification, corresponding to appropriate designations on Manufacturer's wiring diagrams.
- c. Special

Identification nameplates shall be white with black letters, caution nameplates shall be yellow with black letters, and warning nameplates shall be red with white letters.
6. Control Devices and Indicators
 - a. All operating control devices, indicators, and instruments shall be securely mounted on the panel door. All controls and indicators shall be 30mm, corrosion resistant, NEMA 4X/13, anodized aluminum or reinforced plastic. Booted control devices are not acceptable. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by the detailed mechanical and electrical equipment requirements.
 - b. Indicator lamps shall be LED type. For all control applications, indicator lamps shall incorporate a push-to-test feature. Lens colors shall be as follows:
 - 1) Red for "ON," Valve "OPEN," and Breaker "CLOSED."
 - 2) Green for "OFF," Valve "CLOSED" and Breaker "OPEN."
 - 3) Amber for "FAIL"
 - 4) Blue for "READY"
 - 5) White for "POWER ON"
 - c. Mode selector switches ("HAND-OFF-AUTO," "LOCAL-OFF-REMOTE," etc.) shall have the number of positions and contact arrangements, as required. Each switch shall have an extra dry contact for remote monitoring.
 - d. Pushbuttons shall be as follows:
 - 1) Red for "STOP," Valve "OPEN," Breaker "CLOSE" and mushroom Red for "EMERGENCY STOP"
 - 2) Green for "START," Valve "CLOSE" and Breaker "OPEN"

- 3) Black for "RESET"
- e. Furnish nameplates for each device. All nameplates shall be laminated plastic, black lettering on a white background, attached with stainless steel screws. Device mounted nameplates are not acceptable.
- f. The Manufacturer shall not remove, reuse, alter, or replace original equipment nameplates or equipment tags associated with equipment or components supplied by the Manufacturer's suppliers and sub-suppliers.
- g. Control and Instrument Power Transformers
 - 1) Control power transformers shall be provided. Transformer shall be sized for the entire load, including space heaters, plus 25% spare capacity, and shall be not less than 100VA.
 - 2) Control power transformers shall be 120 volt grounded secondary. Primary side of the transformer shall be fused in both legs. One leg of the transformer secondary shall be solidly grounded while the other leg shall be fused.
7. A failure alarm with horn and beacon light shall be provided when required or specified. Silence and Reset buttons shall be furnished. Alarm horn and beacon shall be by Federal Signal; Crouse-Hinds, or equal, NEMA 4X for all areas except for NEMA 7 areas, which shall be NEMA 7/4X cast aluminum.
8. Where specified or shown on the Plans, provide a six digit, non-resettable elapsed time meter shall be installed on the face of each motor starter. Meter shall be as specified in Section 16196 - "Low Voltage AC Surge Protective Devices (SPDs)."

B. Enclosure Types

1. NEMA 7/4X, cast aluminum enclosures for indoor/outdoor use in hazardous (classified as Class 1, Division 1, Groups B, C and D), as defined in NFPA 70.

Enclosures constructed for either indoor or outdoor use in hazardous (classified as Class 1, Division 1, Groups A, B, C, or as defined in NFPA 70. Boxes shall be copper-free aluminum, with stainless steel hinged cover, watertight neoprene cover gasket with stainless steel bolts. All penetrations shall be factory drilled and tapped. Enclosures shall be Type EJB Style C as manufactured by the Crouse-Hinds Co.; Appleton Electric Co. or approved equal. See "ATTACHMENT" for additional information on size, location, manufacturer and model.
2. NEMA 4X Aluminum Enclosures where specifically shown on the Plans.

Enclosures shall be NEMA Type 4X of aluminum with mounting lugs or brackets made on the enclosure suitable for wall mounting. Enclosures shall not have holes or knockouts. Enclosures shall not be less than .080 in. thick, gauge metal. All enclosures shall have continuous hinged, foam-in-place gasketed doors with handle latch, 3- point above 20" x 20". All enclosures shall have bonding provisions on door. Enclosures shall be ECL Series with Window Kit, where shown on the Plans, and as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, manufacturer and model.

3. NEMA 4X Non-metallic enclosures, of PVC or fiberglass reinforced polyester, for Chlorine, Caustic and other Chemical Rooms. Fiberglass enclosures shall not be used in the presence of sodium hypochlorite.

Enclosures shall be NEMA 4X, non-metallic construction. Nonmetallic boxes shall have UV inhibitors, but not mounted in direct sunlight. Where clamp type latches are required, provide quick- release luggage type latches. All enclosures shall have foam-in-place gasketed doors with handle latch, 3-point above 20" x 20". All enclosures shall have bonding provisions on door. Enclosures shall be with Window Kit, where shown on the Plans, and as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, type of window kit, manufacturer and model.

4. NEMA 4X 316 Stainless Steel enclosures for all other areas, unless specifically stated otherwise, or shown on the Plans.

- a. Wall Mounted

Enclosures shall be NEMA Type 4X of 316 stainless steel with mounting lugs or brackets made on the enclosure suitable for wall mounting. Enclosures shall not have holes or knockouts. Enclosures shall not be less than .080 in. thick, gauge metal. All enclosures shall have continuous hinged, foam-in-place gasketed doors with handle latch, 3-point above 20" x 20". All enclosures shall have bonding provisions on door. Enclosures shall be a LHC-SS6 Series with Hoffman APWK-NFSS Window Kit, where shown on the Plans, as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, series of enclosure, type of window kit, manufacturer and model.

- b. Free Standing

Enclosures shall be NEMA Type 4X of 316 stainless steel, with lifting eyes, without knockouts or holes. Enclosures shall not be less than 12 gauge metal. All enclosures shall have continuous hinged, foam-in-

place gasketed doors with handle latch, 3-point. All enclosures shall have bonding provisions on door. Enclosures shall be a A-FSSS6 Series with Hoffman APWK-NFSS Window Kit, where shown on the Plans, as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, series of enclosure, type of window kit, manufacturer and model.

5. NEMA 12 enclosures where specifically shown on the Plans.
 - a. Wall Mounted

Enclosures shall be of factory gray painted aluminum, with mounting lugs suitable for wall mounting. Enclosures shall not have holes or knockouts. Enclosures shall not be less than .080 in. thick, gauge metal. All enclosures shall have continuous hinged, foam-in-place gasketed doors with handle latch, 3-point above 20" x 20". All enclosures shall have bonding provisions on door. Enclosures shall be a Com line Series with Hoffman APWK-NFSS Window Kit, where shown on the Plans, as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, series of enclosure, type of window kit, manufacturer and model.
 - b. Free Standing

Enclosures shall be of factory gray painted steel, with lifting eyes, without knockouts or holes. Enclosures shall not be less than 12 gauge metal. All enclosures shall have continuous hinged, foam-in-place gasketed doors with handle latch, 3-point. All enclosures shall have bonding provisions on door. Enclosures shall be an A-FS Series with Hoffman APWK-NFSS Window Kit, where shown on the Plans, as manufactured by Hoffman Engineering Co. or equal. See "ATTACHMENT" for additional information on size, series of enclosure, type of window kit, manufacturer and model.
6. NEMA Types 1 or 1A enclosures will not be permitted, unless specifically stated in the Specification for the equipment, or shown on the Plans.
7. All panels installed outdoors shall have a factory applied, suitable primer and final coat of weather-proof white paint.
8. Each enclosure shall incorporate a removable back panel, and side panels, on which control components shall be mounted. Back panel shall be secured to the enclosure with collar studs for wall mounted enclosures, and 316 SS hardware for free standing enclosures. The enclosure door shall be interlocked with the main circuit breaker by a door mounted operating mechanism. Back panel shall

be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any components.

9. All enclosures shall be padlockable.
10. The enclosure outer door shall have a rear mounted pocket, containing laminated copies of the Control schematics.
11. Overload tables shall be laminated and adhered to the inside of the door.

C. Environmental Conditioning

1. Condensation Control

- a. A self-contained enclosure condensation heater with thermostat and fan shall be mounted inside the control panel, if panel is mounted outdoors or in a non-air-conditioned space.
 - 1) Enclosure heaters shall be energized from 120 volt, single-phase power supply and sized to prevent condensation within the enclosure.
 - 2) Locate enclosure heaters to avoid overheating electronic hardware or producing large temperature fluctuations on the hardware.
 - 3) Enclosure heaters shall have an internal fan for heat distribution and shall be controlled with adjustable thermostats. The thermostat shall have an adjustment range of 40 degrees Fahrenheit to 90 degrees Fahrenheit. Provide a circuit breaker or fused disconnect switch within the enclosure.
 - 4) Enclosure heaters shall be Hoffman type DAH or equal.
- b. Strip heaters may be provided if they are 240 volt rated, powered at 120 volts AC and do not have a surface temperature higher than 60°C. Strip heaters and thermostats shall be as manufactured by Chromalox or equal.
 - 1) Strip heaters shall be Chromalox, Type OT, 1.5-in wide, 240 Volts, single phase, 150 watts, energized at 120 volts, with rust resisting iron sheath, Catalog No. OT-715, Product Code No. 129314, or equal. Provide sufficient wattage in heaters to prevent condensation should the interior temperature of the enclosure drop below the dew point.

- 2) A control thermostat mounted inside the control Panel shall be Chromalox, Type WR, single stage, Catalog No. WR-80, Product Code No.263177, or equal.
 - 3) The strip heater terminals shall be guarded by a protective terminal cover.
 - 4) High temperature connecting lead wire shall be used between the thermostat and the heater terminals. Wire shall be No. 12 AWG stranded, nickel-plated copper with Teflon glass insulation and shall be the product of Chromalox, Catalog No. 6-CFI-12, Product Code No. 263783, or equal.
- c. Each panel shall have a ½” stainless steel condensate drain, installed on a stainless steel conduit hub, HGTZ Series, T&B or equal, in the bottom of the enclosure. Drain shall be O-Z Gedney DBB-50SS, or equal.

2. Panel Interior Ambient Control

- a. The Manufacturer shall provide ambient temperature control within the panel to maintain internal temperatures below the maximum operating temperatures of the panel components. Ambient temperature range of -20° C to 40°C.
- b. The Manufacturer shall provide panel internal heat rise calculations to show that the panel internal temperatures will be maintained below the maximum operating temperatures of the panel components.
- c. The calculation shall show all the internal and external heat gain loads, the expected internal temperature rise in degrees C above the specified ambient, If the specified temperature range cannot be met, an air conditioning system shall be provided with sufficient capacity to maintain the temperature within the specified limits. Panels, for which the calculated heat rise exceeds 40° C., shall have an air conditioning system, sized as required to reduce the heat rise to 40° C. or less, without violating the NEMA rating of the enclosure.
- d. The air conditioner shall have the following features:
 - 1) Use CFC-free R134a refrigerant.
 - 2) Have fully gasketed flanges on all four mounting edges for a watertight seal that maintains NEMA 4X rating of the panel.
 - 3) Thermostatic low temperature control to provide energy efficient operation and prevents over-cooling.

- 4) EMI/RFI suppressor to minimize transient spikes during compressor on/off cycling
 - 5) Separated blower-driven evaporator and condenser air systems for closed loop cooling
 - 6) UL listed
 - 7) Stainless steel enclosure
 - 8) Internal corrosion resistant coating
 - 9) Low ambient kit
 - 10) Short cycle protector
 - 11) The air conditioning unit shall be Hoffman, Thermo Electric or approved equal
3. Enclosure Fans
- a. Fans shall be furnished for soft start starters and VFDs, as required by the Manufacturer, to provide air circulation and cooling. Fans shall be controlled by a temperature switch. The fan shall operate only when the drive is “ON” and for a cool-down period after the drive has stopped. Otherwise the fan shall not run when the drive is “OFF”. Louvers, if provided, shall have externally removable filters. The filter shall be metallic and washable.
 - b. Fan motors shall be protected by an input circuit breaker. Metal squirrel cage ball bearing, three phase fan motors with 10-year design life shall be used in the drive design. Plastic muffin fans are not acceptable. Fan power shall be obtained from a tap on the main control power transformer.
 - c. A “loss of cooling” fault shall be furnished. In the event of clogged filters or fan failure, the drive shall produce an alarm and then, in a predetermined time, be shut down safely without electronic component failure by the temperature switch.
 - d. Redundant fans shall be provided in the drive design as backup in the event of fan failure.

D. Internal Wiring

1. Power and control wiring shall be tinned stranded copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type MTW

- thermoplastic insulation. Line side power wiring shall be sized for the full rating or frame size of the connected device.
2. Analog signal wires shall be 600 Volt Class, insulated stranded tinned copper, twisted shielded #16 AWG pair.
 3. All interconnecting wires between panel mounted equipment and external equipment shall be terminated at numbered terminal blocks. Field wiring shall not be terminated directly on any panel-mounted device.
 4. All wiring shall be tagged and coded with an identification number as shown on the Plans. Coding shall be typed on a heat shrinkable tube applied to each end showing origination and destination of each wire. The marking shall be permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal.
 5. All wiring shall be enclosed in PVC wire trough with slotted side openings and removable cover. Plan wire routing such that no low twisted shielded pair cable conducting analog 4-20 mA signals or low voltage analog signals are routed in the same wire trough as conductors carrying discrete signals or power.
 6. All control panel wiring shall use the following color code.
 - a. Black: AC power at line voltage
 - b. Red: switched AC power
 - c. Orange: May be energized while the main disconnect is in the off position
 - d. White: AC neutral
 - e. Orange/white stripe or white/orange stripe: separate derived neutral
 - f. Red/white stripe or white/red stripe: switched neutral
 - g. Green or green w/ yellow tracer: ground/earth ground
 - h. Blue: Ungrounded DC power
 - i. Blue/white stripe or white/blue stripe: DC grounded common
 - j. Brown: 480V AC 3 phase - phase A
 - k. Orange: 480V AC 3 phase - phase B

- l. Yellow: 480V AC 3 Phase - phase C
 - m. Purple: common for analog signal wiring
 - n. Brown: positive leg of an analog signal
- E. Field Installed Internal Wiring
1. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed. In addition, low signal wiring (millivolt and milliamp) shall be bundle separately from the rest of the control wiring.
 2. All field wiring shall be tagged and coded with an identification number. Coding shall be typed on a heat shrinkable tube applied to each end of the wire. The marking shall be a permanent, non-smearing, solvent-resistant type similar to Raychem TMS-SCE, or equal
 3. In general, all conduit entering or leaving equipment shall be stubbed up into the bottom of the enclosure directly below the area in which the conductors are to be terminated. Conduits shall not enter the side unless approved in writing by the Project Manager and/or Engineer.
- F. Terminal Blocks
1. Terminal blocks shall be DIN-rail-mounted one-piece molded plastic blocks with tubular-clamp-screw type and end barriers. Terminal blocks shall be rated for 600 volts except for control and instrumentation circuits, or 4-20 mA analog signal conductors.
 2. Provide 600 volt rated terminal blocks for any conductor carrying any voltage over 120 volts to ground.
 3. Provide 600 volt rated strap screw terminal blocks for any power conductors carrying over 20 amps, at any voltage. Terminals shall be double sided and supplied with removable covers to prevent accidental contact with live circuits.
 4. Power conductors carrying over 20 amps, at any voltage shall be terminated to strap-screw type terminal blocks with crimp type, pre-insulated, ring-tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated. Do not terminate more than one conductor in any lug, and do not land more than two conductors under any strap-screw terminal point.
 5. Terminals shall have permanent, legible identification, clearly visible with the protective cover removed. Each terminal block shall have 20 percent spare terminals, but not less than two spare terminals.

6. Use the Manufacturer's provided bridge connectors to interconnect terminal blocks terminating common or ground conductors.
7. Twisted shielded pair or triad cables shall have each individual conductor and shield drain wire landed on individual terminal blocks. Use the Manufacturer's provided bridge connectors to interconnect terminal blocks terminating the shield drain wire conductors.
8. Control circuits, 120 volts and below, and 4-20 mA analog signal conductors shall be terminated with Manufacturer's recommended insulated connectors.
9. Provide an AC ground bar bonded to the panel enclosure (if metal) with 20 percent spare terminals.
10. Provide ground terminal blocks for each twisted-shielded pair drain wire

2.04 SOURCE QUALITY CONTROL (NOT USED)

PART 3 EXECUTION

3.01-3.02 (NOT USED)

3.03 ERECTION/INSTALLATION/APPLICATION AND/OR CONSTRUCTION

A. Installation

1. The Contractor shall install all equipment per the Manufacturer's recommendations and Plans.
2. Conduit hubs for use on raceway system pull and junction boxes shall be watertight, threaded aluminum, insulated throat, stainless steel grounding screw, as manufacturer by T&B H150GRA Series, or equal.
3. Conduits entering a Control Panel shall not enter the enclosure through the top.
4. Install required safety labels

B. Raceway Sealing

1. Where raceways enter junction boxes or control panels containing electrical or instrumentation equipment, entrances shall be sealed with 3M 1000NS Watertight Sealant, or approved equal.
2. This requirement shall be strictly adhered to for all raceways in the conduit system.

3.04 REPAIR/RESTORATION

Touch-up and restore damaged surfaces to factory finish, as approved by the Manufacturer. If the damaged surface cannot be returned to factory specification, the surface shall be replaced.

3.05 FIELD QUALITY CONTROL

- A. Inspect installed equipment for anchoring, alignment, grounding, and physical damage.
- B. Check tightness of all accessible electrical connections. Minimum acceptable values are specified in Manufacturer's instructions.
- C. Provide one set of as-built panel drawings laminated, in each panel pocket.
- D. Installer's Qualifications

Installer shall be specialized in installing this type of equipment, with minimum 5 year documented experience. Experience documentation shall be submitted for approval prior to beginning work on this project.

3.06 ADJUSTING

Adjust all circuit breakers, switches, access doors, operating handles for free mechanical and electrical operation as described in Manufacturer's instructions.

- 3.07 The Power Monitoring and Protective Relays shall be set in the field by a qualified representative of the Manufacturer, retained by the Contractor, in accordance with settings designated in a coordinated study of the system. All such settings, including the application of arc flash labels, shall have been made and submitted to the Project Manager for approval by the Engineer, prior to energizing of the equipment.

3.08 CLEANING

Remove all rubbish and debris from inside and around the motor controllers. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags. Do not use compressed air.

3.09 DEMONSTRATION / TESTING AND INSPECTION

- A. Factory Testing
 - 1. The entire control panel shall be completely assembled, wired, and adjusted at the factory and shall be given the Manufacturer's routine shop tests and any other additional operational test to insure the workability and reliable operation of the equipment.

2. Factory test equipment and test methods shall conform to the latest applicable requirements of ANSI, IEEE, UL and NEMA standards, and shall be subject to the Project Manager approval.
3. The operational test shall include the proper connection of supply and control voltage and, as far as practical, a mockup of simulated control signals and control devices shall be fed into the boards to check for proper operation.

B. Witness Testing

1. The Owner and Engineer will witness the factory tests for each of the equipment units identified in the "ATTACHMENT."
2. The number of Owner and Engineer persons witnessing the tests is identified in the "ATTACHMENT."
3. Under no circumstances, will the equipment be approved for shipment, nor will the equipment be accepted by the Owner, if witness testing is specified, and the equipment is shipped without the testing being witnessed.
4. If a test must be re-run due to failure in meeting the specified requirements, the witness expenses for the re-test shall be borne by the Manufacturer or Vendor. Retesting on the same trip shall be only at the option of the Project Manager and Engineer.
5. The Project Manager and Engineer, who is witnessing the testing, shall approve all travel arrangements, including the airline selected, flight times, hotel selected, testing agenda, etc.
6. An interpreter/guide shall be provided if English is not widely spoken, or in areas where English is not the native language.
7. The Project Manager shall have direct communications with the person who is responsible for local arrangements and has the authority to pay for those expenses prior to leaving the Project location, or other designated location.
8. The Contractor shall submit the testing agenda for approval at least 30 days prior to the test date, or the test date shall be rescheduled, with no change in the Contract price or time. The agenda shall include a detailed list of all tests to be done.
9. Where travel is over night, testing shall not start on the arrival day.
10. Travel Documents:
 - a. The Contractor shall be responsible to obtain Letters of Invitation and other documentation required to obtain a VISA into the host country.

The Contractor shall obtain the VISA itself and directly pay for the cost of a VISA service and the fee that the host country charges for the VISA.

- b. The Contractor shall use a VISA service located in the area designated in the "ATTACHMENT" to handle the Owner and Engineer's passport(s) who is/are traveling to witness the test, and to pay all expenses for the VISA service company and the cost of the VISA required by the host country.

11. Travel Expenses

- a. Owner and Engineer shall not have to provide for any out of pocket expenses related to the trip, transportation, meals or incidentals that would require later reimbursement.
- b. The Contractor shall provide, and pay for, all air travel fare, including ground shuttle or taxi, to and from the Owner and Engineer's office or residence. Air fare inside the continental United States shall be nonstop if available, Coach Class or better. Air fare outside the Continental United States shall be nonstop if available, Business Class or better.
- c. Ground transportation at any destination shall be provided by the host Original Equipment Manufacturer (OEM). The Owner and Engineer shall not be required to drive in a foreign country under any circumstances.
- d. The Contractor shall provide for hotel, meals, travel and incidentals to be paid for by the host OEM at the testing location, whose equipment is being tested. The host OEM shall have the authority to resolve any expense problems. If the Hotel offers restaurants, those charges shall be covered in the Hotel expenses. If meals are not offered at the Hotel, transportation to restaurants and the cost of those meals shall be provided by the host OEM.
- e. Access to an international cell phone shall be provided while out of the Continental United States.
- f. Access to the internet shall be provided while out of the Continental United States.

C. Examination

- 1. Examine installation area to assure there is enough clearance to install the equipment.

2. Housekeeping pads shall be included for the floor mounted motor controllers as detailed on the Plans with the exception of motor controllers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.
 3. Check concrete pads and base plates for uniformity and level surface.
 4. Verify that the equipment is ready to install.
 5. Verify field measurements are as instructed by Manufacturer.
- D. Field Testing
1. Perform all electrical field tests recommended by the Manufacturer. Disconnect all connections to solid-state equipment prior to testing.
 2. Megger and record phase to phase and phase to ground insulation resistance. Megger for 1 minute at minimum voltage of 1,000 VDC. Measured insulation resistance shall be at least 100 mega ohms. In no case shall the Manufacturer's maximum test voltages be exceeded.
 3. Test each key interlock system for proper functioning.
 4. Test all control logic before energizing the motor or equipment.
- E. Manufacturer's Certification
1. A qualified factory-trained Manufacturer's representative shall certify in writing that the equipment has been installed, adjusted, including all settings designated in the Power System Study, and tested in accordance with the Manufacturer's recommendations.
 2. The Contractor shall provide three (3) copies of the Manufacturer's representative's certification.
- F. Training
1. Provide Manufacturer's services for training of plant personnel in operation and maintenance of the soft start starters furnished under this Section.
 2. The training for each type of equipment shall be for a period of not less than one (1) eight hour day.
 3. The cost of training program to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

4. Provide detailed O&M manuals to supplement the training course. The manuals shall include specific details of equipment supplied and operations specific to the project.
5. The training session shall be conducted by a Manufacturer's qualified representative. Training program shall include instructions on the assembly, motor starters, protective devices, metering, and other major components.
6. The Owner reserves the right to videotape the training sessions for the Owner's use.

3.09-3.10 (NOT USED)

ATTACHMENT

[Design Engineer is to complete blanks per site requirements. If additional types of enclosures are needed, add additional sections]

A. Enclosure Types

1. NEMA 7/4X cast aluminum enclosures (see Paragraph 2.03.B.1)

- a. Equipment Unit I.D. *: _____
- b. Type of Location: Indoor/Outdoor
- c. Type: EJB Style C
- d. Size: _____
- e. Manufacturer: _____
- f. Model No.: _____

2. NEMA 4X Aluminum Enclosures (see Paragraph 2.03.B.2)

- a. Equipment Unit I.D. *: _____
- b. Type: NEMA Type 4X
- c. Size: _____
- d. Type of Enclosure: ECL Series with Window Kit
- e. Manufacturer: Hoffman Engineering Company
- f. Model No.: _____

3. NEMA 4X Non-metallic enclosures (see Paragraph 2.03.B.3)

- a. Equipment Unit I.D. *: _____
- b. Type: NEMA 4X
- c. Size: _____
- d. Type of Enclosure: _____
- e. Manufacturer: Hoffman Engineering Company
- f. Model No.: _____

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4. NEMA 4X 316 Stainless Steel enclosures - Wall Mounted (see Paragraph 2.03.B.4.a)
- a. Equipment Unit I.D. *: _____
 - b. Type: NEMA 4X
 - c. Size: _____
 - d. Type of Enclosure: LHC [XXXXXXXX]SS6 Series *
 - e. Window Kit: Hoffman APWK [XXXXXXXX] NFSS *
 - f. Manufacturer: Hoffman Engineering Company
 - g. Model No.: _____
5. NEMA 4X 316 Stainless Steel enclosures - Free Standing (see Paragraph 2.03.B.4.b)
- a. Equipment Unit I.D. *: _____
 - b. Type: NEMA 4X
 - c. Size: _____
 - d. Type of Enclosure: A [XXXXXXXX]FSSS6 Series *
 - e. Window Kit: Hoffman APWK [XXXXXXXX] NFSS *
 - f. Manufacturer: Hoffman Engineering Company
 - g. Model No.: _____
6. NEMA 12 enclosures - Wall Mounted (see Paragraph 2.03.B.5.a)
- a. Equipment Unit I.D. *: _____
 - b. Size: _____
 - c. Type of Enclosure: Com line Series *
 - d. Window Kit: Hoffman APWK [XXXXXXXX] NFSS *
 - e. Manufacturer: Hoffman Engineering Company
 - f. Model No.: _____

7. NEMA 12 enclosures - Free Standing (see Paragraph 2.03.B.5.b)
- a. Equipment Unit I.D. *: _____
 - b. Type: NEMA 4X
 - c. Size: _____
 - d. Type of Enclosure: A /XXXXXX/FS Series *
 - e. Window Kit: Hoffman APWK /XXXXXX/ NFSS *
 - f. Manufacturer: Hoffman Engineering Company
 - g. Model No.: _____

B. Witness Testing

- 1. Equipment Units identified for Witness Testing of Factory Tests (see Paragraph 3.09.B.1): for each of the equipment units identified in the "ATTACHMENT."
 - a. Equipment Unit I.D. _____
 - b. Equipment Unit I.D. _____
 - c. Equipment Unit I.D. _____
 - d. Equipment Unit I.D. _____
 - e. Equipment Unit I.D. _____
- 2. Number of Owner and Engineers witnessing the Tests (see Paragraph 3.09.B.2): _____
- 3. Travel Documents - VISA service location (see Paragraph 3.09.B.10): _____

END OF SECTION