12-17.1617 SEISMIC CONTROLS FOR ELECTRICAL WORK

PART 1 – GENERAL

Seismic controls for electrical work shall conform to the provisions in these special provisions, and include mounting and seismic restraints and other damage-reduction measures for electrical components.

DEFINITIONS

CBC: California Building Code.

Seismic restraint: A fixed device (a seismic brace, an anchor bolt or stud, or a fastening assembly) used to prevent vertical or horizontal movement, or both vertical and horizontal movement, of an electrical system component during an earthquake.

Mobile structural element: A part of the building structure such as a slab, floor structure, roof structure, or wall that may move independent of other mobile structural elements during an earthquake.

SUBMITTALS

The Contractor shall submit the following:

Product Data:

1. Submit scaled dimensioned drawings of strut and accessories including clamps, brackets, hanger rods, and fittings.
2. Submit manufacturer's product data on strut channels including, but not limited to, types, materials, finishes, gauge thickness, and hole patterns. For each different strut cross section, submit cross sectional properties including section modulus (Sx) and moment of inertia (Ix).
3. Anchor bolts and studs: Tabulate types and sizes, complete with report numbers and rated strength in tension and shear as evaluated by International Conference of Building Officials (ICBO) Evaluation Service.

Working drawings: For anchorage and bracing. Indicate materials, and show designs and calculations signed and sealed by a Professional Structural Engineer in the State of California.

1. Design analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
2. Details: Detail fabrication and arrangement of all typical tunnel luminaire and raceway systems. Detail luminaire, raceway and box mounting and attachment with code compliant raceway support member spacing and clamps. Detail attachment of restraints to both structural and restrained items. Show attachment locations, methods, and spacing, identifying components and listing their strengths. Indicate direction and value forces transmitted to structure during seismic events.
3. Pre-approval and evaluation documentation: By California Office of Statewide Health Planning and Development (OSHPD), showing maximum ratings of restraints and the basis for approval (tests or calculations).

Coordination drawings: Plans and sections of equipment drawn to scale and coordinating supports and seismic bracing for electrical components with other systems and equipment, including other seismic restraints, in the vicinity.

Qualification data: For firms and persons specified in "Quality Assurance" of this special provision section.

QUALITY ASSURANCE

Comply with seismic restraint requirements in California Building Code/Code of Regulations of OSHPD, unless requirements in the Section are more stringent.

Professional engineer qualifications: A professional engineer who is experienced in providing seismic engineering services, including the design of seismic restraints, that are similar to those indicated for this Project.

Testing agency qualifications: An independent testing agency with the experience and capability to conduct the testing indicated.

PROJECT CONDITIONS

Project Seismic Zone and Zone Factor as defined in CBC: Zone 4, Zone Factor 0.40.

Occupancy Category as defined in CBC: IV.

Acceleration Factor: 1.0G.

COORDINATION

Coordinate layout and installation of seismic bracing with tunnel and Substation Building structural systems architectural features, and with mechanical, fire-protection, electrical, and other building features in the vicinity.

Coordinate concrete bases with Substation Building structural system.

PART 2 – PRODUCTS

Use the following materials for mounting and restraints:

Indoor dry locations: Steel, zinc plated.

Outdoors and damp locations: Galvanized steel.

Roadway tunnel locations: AISI Type 316 stainless steel.

ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

Strength: Defined in reports by ICBO Evaluation. Structural safety factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

Concrete and Masonry Anchor Bolts and Studs:

Dry locations: Zinc plated steel-expansion wedge type.

Tunnel anchor bolts: Anchor bolts supporting strut and conduit supports shall be AISI Type 304 stainless steel mechanical anchor type or epoxy anchor bolts. Both types shall be rated for dynamic loading.

1. Mechanical anchor bolts shall be stainless steel hexagon head finished bolt with a longitudinally tapered treaded end and a spring loaded multi-part conforming threaded zinc expander nut. Anchor shall meet Federal Spec FF-S-325, Group II, Type 4 Class I, be heat treated to SAE Grade 5 and zinc plated in accordance with ASTM B633-78, Type III, Class Fe/Zn 5, SC-1. Anchors shall be Taper Bolt.
2. Epoxy anchor bolts shall be stainless steel all-thread, encapsulated epoxy type with embedment length and drilled hole diameter per the manufacturer's recommendations. Polyester and vinyl resin is not acceptable.

Other connection components:

Through bolts shall be structural type, hex head, high strength. Compliance with ASTM A 325.

Toggle bolts shall be all-steel springhead type.

Beam clamps for steel beams and joists shall be double-sided. Single-sided type is not acceptable.

Pipe sleeves: Shall be ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

Raceway and cable supports shall be manufactured clevis hangers, riser clamps, straps, threaded C-clamps with retainers, ceiling trapeze hangers, and wall brackets.

MOUNTING AND SEISMIC BRACING COMPONENTS

Steel channel (not in roadway tunnel) shall be 41 mm by 41 mm cross section, formed from 12 gauge steel, if over 610 mm long:

Materials for channel shall comply with ASTM A 570, GR 33.

Materials for fittings and accessories shall comply with ASTM A 575, ASTM A 576, or ASTM A 36.

Fittings and accessories shall be the products of the same manufacturer as channels and designed for use with that product.

Use electro-plated zinc for interior use and hot-dip galvanized after fabrication for exterior use.

TUNNEL STRUT SUPPORT SYSTEM

The bolted stainless steel strut and attachments shall be installed as shown on the plans, and as may be additionally required by the seismic analysis, and design required by this section. The trapeze supports, drop rods, strut side rails, and splice plates, shall be capable of supporting the light fixtures, conduit, conductors, and junction boxes. Strut, fastening and attachment systems shall be off-the-shelf type.

The strut shall AISI Type 316 stainless steel. All nuts, bolts, screws, clamps, brackets and miscellaneous hardware shall be stainless steel. If a particular part is not available in stainless steel, then the part shall be galvanized steel. The Contractor shall identify which components are non-stainless steel in submittals. Non-stainless steel parts shall not be used on the project without prior Engineer's approval.

Conform to ASTM 167, MFMA and AISI for material properties requirements:

ASTM A167-Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.

MFMA-Metal Framing Standards Publication, MFMA-1

AISI-American Iron and Steel Institute

MATERIAL REQUIREMENTS

All materials shall be of standard off-the-shelf type, new and brought to the site in manufacturers original package. Underwriter's Laboratories shall list all equipment whenever UL has published a standard for that item of equipment.

Bolted framing channels and fittings shall have the manufacturer's name, part number, and material heat code identification number stamped in the part itself for identification.

A material designator shall be stamped into the bolted framing parts to identify the material to maintain tractability of the product. Material certification sheets and test reports must be made available by the manufacturer upon request.

Strut shall be 41 mm wide in varying heights and welded combinations as required to meet load capacities and designs indicated on the plans. Use clamps and fittings designed for use with the strut system.

Strut channels shall be 12 gauge material thickness as required to meet the strength requirements of the application. Factory punched slotted holes, 14 mm x 22 mm on 51 mm centers, designed for use with 13 mm diameter hardware to provide adjustment and eliminate drilling.

Fabricated pieces shall be in accordance with the plans. Drilling, punching and cutting shall be carefully and accurately performed to prevent any possibility of irregularities occurring which might introduce difficulty in the erection of the raceway or result in straining or distortion of the parts thereof. All material shall be clean and straight. No straightening or flattening shall be allowed. All members shall be free from kinks, twists, or bends.

Firms regularly engaged in the manufacture of bolted metal framing of the types required, whose products have been in satisfactory use in similar service for not less than 5 years.

Channel-type bracing assemblies shall be slotted steel channel, with 14 mm by 22 mm slots at a maximum of 51 mm on center spacing in webs, and flange edges turned toward web and with adjustable hinged steel brackets and bolts.

PART 3 – EXECUTION

Install mounting materials and seismic restraints according to manufacturer's recommended practices, applicable codes and regulations and as approved by authorities having jurisdiction, unless more stringent are indicated. The plans provide typical installation details that may require adaptation to actual field conditions, and in all cases, require qualification by certified calculation.

STRUCTURAL ATTACHMENTS

Use bolted connections with steel brackets, slotted channel, and slotted-channel fittings to spread structural loads and reduce stresses.

Attachments to concrete shall use expansion anchors, unless otherwise indicated.

Holes for expansion anchors in concrete shall be drilled at locations and to depths that avoid reinforcing bars.

Attachments to solid concrete masonry unit walls shall use expansion anchors.

Attachment to hollow walls: Bolt to slotted steel channels fastened to wall with expansion anchors.

Attachments to wood structural members: Install bolts through members.

Attachments to steel: Bolt to clamps on flanges of beams or on upper truss chords of bar joists.

ELECTRICAL EQUIPMENT ANCHORAGE

Anchor rigidly to a single mobile structural element or to a concrete base that is structurally tied to a single mobile structural element.

Anchor any free-standing equipment, panelboards, medium voltage switchgear, secondary unit substation, medium voltage motor controllers, emergency standby generators, automatic transfer switch, auxiliary transformer, battery racks, battery charger.

Size concrete bases so expansion anchors will be a minimum of 10 bolt diameters from the edge of the concrete base.

Torque bolts and nuts on studs to values recommended by equipment manufacturer.

MOUNTING STRUT AND SEISMIC BRACING INSTALLATION

Install mounting supports bracing according to spacing and strengths indicated by plans and approved analysis.

Expansion and contraction: Install to allow for thermal movement of braced components.

Cable braces shall be installed with maximum cable slack recommended by manufacturer.

Attachment to structure: If specific attachment is not indicated, anchor bracing to the structure at flanges of beams, upper truss chords of bar joists, or at concrete members.

Tunnel strut system:

Locate the strut to position the luminaries as indicated in the plans.
All nuts and bolts shall be tightened to the following values:

Bolt Size	Torque Nm
6.35 mm	8
7.94 mm	15
9.52 mm	26
19 mm	68

ACCOMMODATION OF DIFFERENTIAL MOTION

Make flexible connections in raceways, and cables, where they cross expansion and seismic control joints, where adjacent sections or branches are supported by different structural elements, and where they terminate at electrical equipment anchored to a different mobile structural element from the one supporting them.

FIELD QUALITY CONTROL

Testing agency: The Contractor shall engage a qualified testing agency to perform the following field quality-control testing.

Test pull-out resistance of seismic anchorage devices: The Contractor shall:

Provide test equipment required for reliable testing.

Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

Schedule test with Department, through Engineer, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days advance notice.

Obtain Engineer's approval before transmitting test loads to the structure. Provide temporary load-spreading members.

Test at least four of each type and size of installed anchors and fasteners selected by Engineer.

Test to 90 percent of rated proof load of device.

If a device fails the test, modify all installations of same type and retest until satisfactory results are achieved.

Record test results.

PART 4 – MEASUREMENT AND PAYMENT

Full compensation for seismic controls for electrical work shall be considered as included in the contract lump sum prices paid for various tunnel electrical items of work involved and no additional compensation will be allowed therefor.

12-17.1618 SYSTEM STUDIES AND FIELD TESTING

PART 1 – GENERAL

Scope: The following systems studies and field testing work will be performed by independent firms hired and paid by Caltrans. The Contractor shall cooperate with these independent firms as required to accomplish the work. The work will include furnishing labor and material to perform the following tasks:

Engineering services for the electrical systems studies including short-circuit analysis and protective device coordination;

Independent field protective device setting and testing services for all electrical equipment and systems; and

Commissioning assistance for final coordinated systems.

SHORT-CIRCUIT AND PROTECTIVE DEVICE COORDINATION STUDIES

Short-circuit and protective device coordination will include the following:

Complete single-line diagram of system studied with all buses identified to report data;

Utility company maximum expected three-phase fault with X/R ratio and utility company maximum expected single-line to ground fault currents with X/R ratio at 12 kV incoming supply location indicated shall be used in short circuit studies.

Short-circuit study including three phase and line to ground short-circuit currents at major buses extended down to system buses. Relay settings and protection device coordination studies shall include:

1. Coordinated composite time-current characteristic curves including recommended ratings and settings of all protective devices in tabulated form; and associated calculations to demonstrate that the power system protection will be selectively coordinated by the use of devices or equipment submitted.
2. Situations where system coordination is not achievable due to device limitations along with inadequate interrupting ratings will be noted.
3. The studies will consider operation during normal conditions, alternate operations, and during emergency power conditions, and will include ground fault protective device settings.
4. A registered Electrical Engineer in the State of California shall perform these studies.
5. Settings of main 12 kV breaker relays on both incoming supply feeders from PG&E shall be coordinated and approved by PG&E.

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

The power systems study will be required within 30 days after the electrical equipment submittals by the Contractor have been received for review by the Engineer. The electrical submittals will be reviewed but will not be approved until the power systems studies have been received and reviewed.

Engineer's Qualifications: The power systems studies shall be performed by a registered Professional Engineer with at least five years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to his contract.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

FIELD TESTING

Field testing will be performed by an independent firm which is a recognized electrical testing firm. The field testing firm will furnish all test instruments, materials and labor necessary to perform the following tests. All tests will be performed in the presence of the Engineer. All instruments will have been calibrated within a period of two years preceding testing. Calibrations will be traceable to applicable industry recognized standards. Testing will conform to the following:

All protective devices with field adjustable settings will be set and tested in the field after installation. This work will be performed as part of the testing requirements specified in the individual specification sections, and will be conducted by the approved independent testing agency.

All testing requirements specified in the individual specification sections will be performed in accordance with an approved Test Plan. The Test Plan will consist of complete field test procedures including inspections and tests to be performed, test equipment required, and tolerance limits, including complete testing and verification of protective device settings, ground fault and motor protection equipment.

Performance test reports: Test Reports will be in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report will indicate the final positions of controls and a summary of the test results.

Suitability of test equipment, test instrument calibration, and test reports will comply, as a minimum, with NETA ATS, Section 5, latest edition.

Certificates: Certificates will be provided certifying that all devices and equipment meet the requirements of the contract documents.

TESTING AGENCY QUALIFICATIONS

Testing agency will be a member company of the International Electrical Testing Association and acceptable to authorities having jurisdiction.

Testing agency's field supervisor will be a person currently certified by the International Electrical Testing Association or National Institute for Certification in Engineering Technologies to supervise on-site testing specified in these special provisions.

SYSTEMS COMMISSIONING ASSISTANCE

Upon completion of all equipment field testing and protective device setting, the independent testing agency will supply qualified manpower to assist in the complete mechanical and electrical system commissioning conducted by the Contractor. The independent testing agency will also assist the Contractor with commissioning problems which may occur.

QUALITY ASSURANCE

The study will be performed in accordance with applicable ANSI and IEEE Standards. Field testing will be performed per NETA ATS specifications, manufacturer's recommendations, and these special provisions.

The independent testing agency will examine utilization equipment nameplates and installation instructions; install fuses of sizes and with characteristics appropriate for each piece of equipment, and evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings. Proceed with field testing only after unsatisfactory conditions have been corrected. The independent testing agency will perform field testing as specified in these special provisions.

PART 4 – MEASUREMENT AND PAYMENT

Full compensation for system studies and field testing shall be considered as included in the contract lump sum prices paid for various electrical items of work involved and no additional compensation will be allowed therefor.

12-17.1619 TUNNEL LIGHTING

PART 1 – GENERAL

The tunnel lighting system shall consist of furnishing, installing, and testing of tunnel luminaires, including all wire, cable and mounting in conformance with the provisions in these special provisions. The tunnel lighting system shall also include the installation of conduit and raceway in conformance with "Basic Materials and Methods (Tunnel)" of these special provisions.

Tunnel lighting includes miscellaneous lighting including lighting fixtures, lamps, ballasts, exit fixtures, and accessories for installation in the cross passages, portal Substation Building and special fixtures in the roadway tunnels.

SUMMARY

Scope: The tunnel luminaires shall be installed in the tunnel as shown on the plans to provide good visibility for the drivers during day and night.

RELATED WORK

The Contractor's attention is directed to "Tunnel SCADA/PLC Control and Monitoring System" of these special provisions for lighting control system. Testing agency qualifications shall conform to "Systems Studies and Testing" of these special provisions.

DEFINITIONS

Lighting unit: A luminaire or an assembly of luminaires complete with support accessories.

SUBMITTALS

The Contractor shall make submittals in conformance with the requirements specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions and the requirements specified herein.

Product data: The submittals shall include complete details, information, and drawings of each type of lighting unit arranged in order of lighting unit designation as shown on the plans. The submittals shall also include the data on features, accessories, finishes, and the following:

Materials and dimensions of luminaires.

Certified results of laboratory tests for fixtures and lamps for photometric performance.

High-intensity-discharge luminaire ballasts.

Product certificates signed by manufacturers of lighting units certifying that products comply with requirements. A certificate of compliance for each lighting unit shall be furnished to the Engineer in conformance with the following.

1. Certificate of Compliance shall be furnished prior to the use of any materials for which these specifications or the special provisions require that a certificate be furnished. In addition, when so authorized in these specifications or in the special provisions, the Engineer may permit the use of certain materials or assemblies prior to sampling and testing if accompanied by a Certificate of Compliance. The certificate shall be signed by the manufacturer of the material or the manufacturer of assembled materials and shall state that the materials involved comply in all respects with the requirements of the specifications. A Certificate of Compliance shall be furnished with each lot of material delivered to the work and the lot so certified shall be clearly identified in the certificate.

2. Materials used on the basis of a Certificate of Compliance may be sampled and tested at any time. The fact that material is used on the basis of a Certificate of Compliance shall not relieve the Contractor of responsibility for incorporating material in the work which conforms to the requirements of the plans and specifications, and any material not conforming to the requirements will be subject to rejection whether in place or not.
3. The Department reserves the right to refuse to permit the use of material on the basis of a Certificate of Compliance.
4 The form of the Certificate of Compliance and its disposition shall be as directed by the Engineer.

Miscellaneous lighting fixtures: Submit the following:

1. Dimensions of lighting fixtures
2. Data sheets for fluorescent and high intensity-discharge ballast.
3. Operation and Maintenance data for miscellaneous lighting fixtures.

Field test reports that indicate and interpret test results for compliance with performance requirements.

Installation procedures, sequences, schedule, and tolerances.

Maintenance manuals for lighting units.

Warranty for lighting units or components.

1. Specification of light fixture and related components such as housing, latches, fuses, terminal block, lamp housing, ballast, gasket, identification label and anchor plate, if necessary.
2. Product drawings with top, side, and bottom views, and the necessary details, including required clearance.
3. Photometric file in Illuminating Engineering Society (IES) formatting and lighting calculations.

QUALITY ASSURANCE

Luminaires and accessories shall be listed and labeled in conformance with NFPA 70, Article 100, for their intended use, location, and installation conditions.

REFERENCE STANDARDS

Luminaires and accessories shall conform to the following:

ANSI C2.
ANSI/IESNA RP-22-96.
AASHTO 1944, "Information Guide for Roadway Lighting"
FHWA 1994, "Tunnel Lighting Design and Procedures",
ANSI/IES RP-8-00

PART 2 – PRODUCTS

MATERIALS

Lighting unit type tunnel luminaires: All manufacturers shall meet the intended product quality, serviceability, space restraints, and illumination standards as specified in these special provisions. Lamp and ballast technology shall conform to the requirements specified in these special provisions.

Warranty: Manufacturer shall warrant that the factory-installed electrical system (consisting of a coil ballast, starting aid, capacitor, terminal board and wiring) shall be free from defects in material and workmanship for 5 years from the date that the fixtures are shipped from manufacturer's factory.

Description: The Contractor shall furnish lighting fixtures complete with lamps, ballasts, fuses, terminal blocks, capacitors, reflector, gaskets, latches, lenses, hinges, lamp holders, wiring, starters, and all accessories necessary to perform tunnel lighting as a coordinated assembly.

All luminaire components shall meet the requirements of the latest version of UL 1572 40°C High Intensity Discharge Lighting Fixture (wet label) specifications.

The luminaires shall be for use in exterior environments between -18 and +38°C, and zero to 100 percent humidity.

The luminaires shall be rated for the environment encountered in marine and vehicular covered roadways. The following conditions shall be taken into account:

1. Air containing a large percentage of lint and dust particles.
2. Exposure to chemically corrosive solutions from auto emissions, pavement deicing salts, and pavement traction minerals.
3. Concrete leaching onto mounting plates and luminaires.
4. Covered roadway cleaning involving high pressure detergent wash downs.
5. Vibration from large tractor trailer trucks traveling within 620 mm of the luminaires.
6. Fog.

The luminaires shall have the following features to facilitate maintenance:

1. Quick and easy luminaire removal with gloves on for the purpose of repair in shop.
2. Luminaire cleaning using high pressure water and detergent.
3. Luminaire relamping.
4. Quick and easy replacement of modular interior components, including ballasts tray and lens with luminaire housing in fixed, overhead mounting position.

All internal fixture components and wiring shall be capable of operating at the internal temperatures found inside the fixture without affecting component life by accelerating deterioration.

Lamp holders shall be mogul, heavy-duty type, composed of glazed porcelain rated for 4,000 volts pulse voltage. The mogul socket shall be UL listed for 600 volt, 1,500 watt operation.

Each luminaire shall be provided with a grounding terminal rated for a single conductor as shown on the plans with stranded copper wire connection.

Lamps: High-pressure sodium lamps shall conform to ANSI C78-42 series for each type of lamp. The type and wattage of lamps shall conform to the details as shown on the plans. Lamps shall be non-cycling, reduced lead and mercury, high pressure sodium lamps. Lamps shall be constructed with a lead-free welded base in conformance with Federal TCLP requirements.

Mounting: The mounting arrangements for the tunnel luminaires shall conform to the detailed shown on the plans. The mounting assembly shall be supplied by the manufacturer of luminaires in conformance with the mounting method and wiring as shown on the plans.

Housing: Housing shall conform to the following requirements:

The housing shall be formed of cast aluminum alloy using the permanent mold process. The casting shall have a minimum 3 mm wall thickness and shall be designed to provide the luminaire body with adequate rigidity by incorporating ribs in the structure. No welding will be permitted in constructing the luminaire housing.

Stainless steel screws or bolts used for attachment of the mounting or hinging components to the luminaire housing shall be provided with nonmetallic coating to prevent corrosive interaction between the stainless steel fastener and the luminaire aluminum alloy. The coating shall withstand the standard 5 percent salt spray corrosion test by more than 1000 hours.

All luminaire assemblies shall be designed for removal
In order to prevent entry of moisture into the luminaire housing, the Contractor shall provide a NEMA ICS 6, Type 4 enclosure. All electrical components mounted in the luminaire enclosure shall be compatible with the conditions encountered within a totally enclosed NEMA 4 housing and shall meet UL requirements.

The luminaires shall consist of standardized sizes and shapes (not including mounting plate). The housing of all luminaires shall not be greater than 600 mm long by 750 mm wide x 200 mm deep. Luminaires shall be secured by latches to a luminaire mounting plate.

The junction between the lens frame and the luminaire housing shall be sealed with a gasket of high strength hollow core silicone rubber. The gasket seal shall be weatherproof, moisture proof, and dust proof. The gasket shall be securely attached to the luminaire housing or lens frame and shall not depend solely on adhesive to hold it in place. Latches shall evenly compress the gasket against the housing.

Doors, frames, and other internal access shall be smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, frames, lenses, diffusers, and other pieces shall be arranged to prevent accidental falling during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lens. When door opens, ballast shall be disconnected.

All external luminaire housing auxiliary components shall be manufactured of ANSI 316 stainless steel. These include latches, screws, bolts, nuts, and washers used in constructing the luminaire housing. Hinging components shall be fabricated from ANSI 300 Series stainless steel alloy.

A luminaire mounting plate with nominal dimensions of 600 mm wide x 750 mm long shall be supplied for each luminaire. The mounting plate, constructed of 3.3 mm (10 gauge) ANSI 316 stainless steel, shall be furnished with six slotted holes (12.7 mm wide by 25.4 mm long) for bolting plate to the channel and strut light fixture support angles. All exposed metal parts of the luminaire (inside and outside) shall be protected against corrosive environments.

The aluminum surfaces inside and outside of the luminaire shall undergo an alkaline cleaning and a pretreatment process of electro-deposited epoxidized acrylic paint. Minimum file thickness of this primer coat shall be 0.02 mm after curing. The paint used for the luminaire protection against the corrosive elements shall be heavy duty, zinc enriched, epoxy powder paint with a minimum total dry file thickness of 0.05 mm. The paint shall be applied on both the inside and the outside of the luminaire housing. Color shall be light gray, ANSI 70. All stainless steel hardware, hinges, and latches shall be installed after the luminaire fixture has been painted.

Each luminaire housing shall be permanently marked with the manufacturer's name, the luminaire type, the wattage, and with an arrow indicating direction of traffic flow. The marking shall be visible from below with the lens assembly removed. Also, on the shoulder side of the exterior of the housing, this information shall be shown on with 75 mm high by 40 mm wide black characters on a 90 mm high yellow background made of premium outdoor 0.127 mm grade vinyl with permanent adhesive.

LENS

The lens shall be manufactured of flat 6.35 mm minimum thickness tempered glass plate. The lens shall be heat resistant, non-discoloring, mechanical and thermal impact resistant, capable of withstanding sound vibrations, liquid pressure, and mechanical impacts. The lens shall conform to the current Glass Tempering Association Specification No. E61.05 for appliance glass. The lens shall withstand a wash down with cold water 4°C five minutes after the luminaire has been turned off.

The lens shall be gasket-sealed into a die-cast aluminum frame which, in turn, shall be gasket-sealed to the housing. The lens frame shall be secured to the housing by use of hinged and spring-loaded, quick-closing latches that create a compressive pressure between the lens frame and housing permitting rapid and efficient opening and replacement of the lens assembly. The frame shall be designed to permit opening and closing the access to the luminaire without distortion or change of water-tightness requirements. Since the lens assembly will be used as the means of entering into the luminaire interior, its frame shall be so designed that it will contain sufficient rigidity to permit opening and closing the access to the luminaire without distortion or change of water-tightness requirement. The lens frame shall make an allowance for mechanical forces originating from glass expansion and contraction due to temperature changes.

REFLECTOR

The reflector system shall achieve the photometric performance in conformance with the lighting performance criteria specified in these special provisions.

The reflector shall be treated to provide the necessary light reflectance compatible with the optical design requirements.

A fabricated reflector assembly shall consist of a segmented optical system of homogeneous sheet aluminum, electro-chemically brightened, anodized and sealed. The segmented reflector shall be set in a faceted arc image duplicator pattern to achieve the proper distribution. The reflector assembly shall be secured to the luminaire housing to ensure its geometric position with respect to intended light distribution and control requirements. All edges shall be smooth and rounded. The reflector assembly shall not deform when subjected to normal wiping and cleaning.

The screw mechanism holding the lamp shall be provided with an anti-rotating device and reinforced to retain the lamp in the socket under normal operating conditions. In addition to the socket engaging the lamp base, the glass envelope of the lamp shall be provided with support for the purpose of reducing the vibration stresses on the lamp base.

BALLAST

Ballasts shall be furnished and installed for all lighting fixtures in conformance with ANSI C82.4. Ballasts shall be designed to meet the latest UL 1029 specification and to operate the lamps as specified in these special provisions. The ballast shall be a three-coil isolated winding magnetic regulator.

Each ballast shall be installed on its own mounting plate within the housing. A spring loaded latch or quarter turn, quick release, captive screw fastener shall be used to secure the mounting plate to the housing. The mounting plate and all internal brackets shall be fabricated from 300 Series stainless steel.

Ballasts shall be NEMA Class 220 (formerly Class H) type 180°C and shall be designed for operation on a 480/277 volt grounded system, and shall be connected to 480 volts, phase to phase. The terminal block and all connections shall be rated 600 volts, with a total insulation level of 10.0 kV. Ballast operating temperature shall not exceed 150°C for full ballast life.

The ballast shall supply an open circuit voltage as recommended by the lamp manufacturer and shall be guaranteed to start at least 90 percent of seasoned lamps at -30°C.

The lamp current crest factor shall not exceed 1.8 for a plus or minus 10 percent line voltage variation from nominal throughout lamp life.

Ballast shall be capable of withstanding momentary dips in voltage up to 30 percent without extinguishing the lamp.

Ballast primary current during starting shall not exceed normal operation current

The ballast, including starting aid, shall protect itself against normal lamp failure modes. The ballast shall be capable of operating the lamp in open or short circuit conditions for a period of six months without significant loss of ballast life.

The power factor of the lamp ballast system shall not drop below 90 percent for a +10 percent line voltage variation at any lamp voltage, from nominal through life.

The starter supplied with the ballast shall be of plug-in type to allow its removal without special tools. Each ballast, starter, and capacitor shall be provided with nameplates indicating manufacturer's product name, model number, rating, and similar essential data.

Ballast cores shall be made from laminations of high-grade silicon steel, die-cut to assure tight mechanical tolerances and precision assembled assuring consistent performance from unit to unit. Ballast coils shall be made of high temperature insulated magnetic wire wound into a frame. Precision would coils shall be used to provide adequate heat dissipation and avoid hot spots. Complete core and coil assembly shall be impregnated with compounds in conformance with NEMA Class 220 (formerly Class H) insulation requirements.

The capacitors shall be constructed according to the latest ANSI specification for the luminaire operating temperature (minimum rating 90°C) and shall be of close tolerance to assure consistency of lamps. They shall be non-PCB type and provided with pressure sensitive interrupter.

Ballasts shall have an average life in pulsing mode of 10,000 hours at an igniter and starter case temperature of 90°C.

Noise shall be uniformly quiet operation, with a noise rating of Class B or better.

INTERIOR WIRING

Each luminaire shall be provided with two 8.0 ampere Type KTK fuses fitted to a fusible disconnect type terminal block, rated 600 volts. The fusible disconnect type terminal block shall allow a maintenance person to open the disconnect, which will automatically remove the fuses and shut-off power to the fixture. The fuse element shall apply to all luminaires.

Wiring between the ballast and the lamp socket shall be made using SF-2 insulated wire, having the rating of 600 volt, 200°C. Wiring between the ballast and its auxiliary components shall be made using XFF cross-linked polyolefin insulated wire rated 150°C. All wiring shall be color coded and arranged in a neat manner.

All wiring to or from the ballast shall be made with plug-in connectors to permit removal of the ballast tray in the field without the use of tools.

The wiring diagram shall be attached to the luminaire interior wall and shall be legible under field maintenance conditions and throughout the life expectancy of the fixture.

Exterior attachment to luminaire: All luminaires shall be provided with 12.7 mm threaded hub for liquid-tight flexible conduit connection. The conductors shall be terminated in the fixture at fused disconnect terminal blocks.

PHOTOMETRIC REQUIREMENTS

Counterbeam type luminaire: The photometric distribution shall be designed for counterbeam tunnel luminance applications. The fixture shall provide a cutoff, asymmetric distribution of light, with the majority of lamp lumens being directed towards oncoming traffic.

IES Type IV luminaire: The luminaire shall be designed to house a 150 watt, clear high-pressure sodium lamp, and its optical system shall produce an IES Type IV, medium distribution cut-off pattern. This luminaire is designated for nighttime illumination of the tunnel and shall be designed for asymmetrical tunnel luminance applications. The fixture shall provide a cutoff, asymmetric distribution of light, with the majority of light directed toward the opposite wall of the tunnel. Minimum downward efficiency shall be 70 percent of rated lamp lumens.

Lighting performance criteria: The luminaires shown on the plans are positioned to provide a minimum level of photometric performance. The luminaire manufacturer shall submit computer calculations demonstrating that manufacturer's luminaires are in conformance with the following requirements:

West Bound-Daylight Operation Except As Noted				
Tunnel Roadway Area	Average Luminance (cd/square meters)	Average to Minimum Luminance	Maximum to Minimum Luminance	Max to Min Wall Illuminance (up to 3 m high)
Threshold Zone	175	2.0:1	3.5:1	3.5:1
Transition 1	44	2.0:1	3.5:1	3.5:1
Transition 2	14	2.0:1	3.5:1	3.5:1
Interior Level	5	2.0:1	3.5:1	3.5:1
Night Time Interior Level	2.5	3.0:1	5:1	5:1

The Contractor shall submit hard copies and compact discs (CDs) in an Illuminating Engineering Society of North America (IESNA) formatting, of candlepower distribution data for each type of luminaire. A hard copy of photometric candlepower data shall be submitted on 2.5 degree intervals within 10 degrees of the maximum candlepower.

In addition, the Contractor shall submit the following:

Vertical candlepower curves for the maximum candlepower plane at the 0/180-degree plane and 90/270-degree plane.

With the tunnel light fixture at a 4.5 m mounting height from the pavement to the bottom of luminaire:

1. Isocandela plot with a minimum of 7 contours.
2. Lux readings on a 300 mm grid.

Computer calculations shall be done in accordance with IESNA standards, except the point samples for spacing along and across the roadway shall be at 600 mm centers. Spacings across roadway shall begin at the left edge of roadway. The roadway is defined as two 3.66 m travel lane, and does not include the shoulder and sidewalk. A maintenance factor of 0.65 shall be used and a maintained wall reflectance shall be 35 percent. Reflectance shall be designed for pavement type R1 in conformance with ANSI/IES RP-8.

MANUFACTURER'S CERTIFICATION AND TESTING

The Contractor shall submit manufacturer certification that the furnished luminaires meet the requirements of these special provisions including a detailed description of each variance for the Engineer's approval.

The Contractor shall submit to the Engineer with a list of all the electrical components contained in the luminaires.

Before installation, twenty 400 W counterbeam luminaires and eight 150W IES Type IV luminaire will be selected at random by the Engineer from the project luminaires at the job site or at the Contractor's storage facility for independent laboratory testing provided by the State.

If any unit fails, the Engineer will require up to five additional tests to estimate the extent of nonconformance.

The test results shall substantiate that the selected luminaires fulfill the specified photometric requirements prior to beginning installation of tunnel luminaires. If test fails to meet any specified requirement, further testing will be required to validate a manufacturer's claim of compliance with these special provisions.

The Contractor shall furnish to the Engineer test results from the independent testing laboratory demonstrating conformance with the following requirement for each type of light fixture.

Data: Complete photometric data for each fixture type including, coefficient of utilization table, horizontal and vertical candle-power tabulation in 5 degree increments, graph of candle-power in maximum plane and maximum cone. The photometric data shall conform to the photometric specification to within 10 percent. The photometric data will then be used to demonstrate conformance with the performance criteria.

Lamp: For a simulated installation, in a 35°C outdoor ambient temperature, demonstrate lamp voltage and temperature conformance with ANSI standards C78.388, C78.1350 and C78.1355 for maximum stabilized fixture temperature. Test shall be run with lamps aged 100 hours. Fixture mounted lamp voltage and temperature shall be compared against performance of a similar but non-enclosed lamp. Test shall be repeated for each type of lamp.

Miscellaneous lighting fixtures shall comply with the following:

Fluorescent fixtures shall conform to UL 1598. Fluorescent lamp ballast shall conform to following requirements:

Designed for type and quantity of lamps at full light output.

Total harmonic distortion rating: Less than 10 percent.

Rapid start, thermally protected, automatic resetting.

UL listed Class P, high power factor (95 minimum).

Instant start ballast.

Sound rating: A

Electronic ballasts for linear lamps shall conform to the following requirements:

Certified ballast manufacturer certification: Indicated by label.

Encapsulation: Without voids in potting compound.

Parallel lamp circuits: Multiple lamp ballasts connected to maintain full light output on surviving lamps if one or more lamps fail.

Temperatures 4°C and above starting temperature.

Full replacement warranty of two years from the date of placing system in service.

Ballasts for compact fluorescent lamps shall be programmed start.

Reflecting surfaces of fluorescent fixtures shall have minimum reflectance as follows:

White surfaces: 85 percent.

Specular surfaces: Not less than 83 percent.

Diffusing specular surfaces: 75 percent.

Laminated silver metallized film: 90 percent.

Lenses, diffusers, covers, and globes shall be 100 percent annealed crystal glass or virgin acrylic plastic with high resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation. The minimum thickness of lens shall be 3 mm.

Exit signs shall conform to UL 924. The lamps of internally lighted signs for AC operation shall be light-emitting diodes, 70,000 hours minimum rated lamp life.

The fluorescent color temperature index of lamps shall be 4100 K for cool white lamps. Fluorescent lamp life shall be rated average of 20,000 hours at 3 hours per start when used on rapid-start circuits.

Fixture support components including steel strut channel system and fittings for mounting lights shall be galvanized. Beam clamps, wall mount brackets, and channel shall be manufactured by the same manufacturer.

Finishes of fixtures shall conform to the manufacturer's standard. Paint finish shall be applied over corrosion-resistant treatment or primer, free of defects. Metallic finish shall be corrosion resistant.

The interior lighting fixtures shall conform the following:

Fixture Type E1, Exit:

1. Severe duty type, NEMA Type 4X, UL50, UL924.
2. Cast aluminum or polycarbonate housing.
3. Voltage: 120 V (ac).
4. Mounting: End mount.
5. Number of faces: Double-face.
6. Nominal dimensions: 330 mm X 75 mm X 200 mm.
7. Lamps: Low wattage, Green LED, 25 year lamp life.
8. External finish: Aluminum/gray.

Fixture Type E2, Exit:

1. Severe duty type, NEMA Type 4X, UL50, UL924
2. Cast aluminum or polycarbonate housing.
3. Voltage: 120 V (ac).
4. Mounting: End mount.
5. Number of faces: Single-face.
6. Nominal dimensions: 330 mm x 75 mm X 200 mm.
7. Lamps: Low wattage, Green LED, 25 year lamp life.
8. External finish: Aluminum/gray.

Fixture Type E3, Exit:

1. Severe duty type, NEMA Type 4X, UL50, UL924.
2. Cast aluminum or polycarbonate housing.
3. Voltage: 120 V (ac).
4. Mounting: Ceiling mount.
5. Number of faces: Double-face.
6. Nominal dimensions: 330 mm X 75 mm X 200 mm.
7. Lamps: Low wattage, Green LED, 25 year lamp life.
8. External finish: Aluminum/gray.

Fixture Type E4, Exit:

1. Severe duty type, NEMA Type 4X, UL50, UL924.
2. Cast aluminum or polycarbonate housing.
3. Voltage: 120 V (ac).
4. Mounting: Back mount.
5. Number of faces: Single-face.
6. Nominal dimensions: 330 mm X 75 mm X 200 mm.
7. Lamps: Low wattage, Green LED, 25 year lamp life.
8. External finish: Aluminum/gray.

Fixture Type F1, enclosed industrial fluorescent.

1. Gasketed, enclosed, damp label.
2. Voltage: 120 V (ac).
3. Mounting: Ceiling or strut mounted.
4. Nominal dimensions: 1220 mm X 305 mm.
5. Lamps: Two 32W, T8.
6. Ballast types and features: Electronic.
7. Housing: Heavy-duty steel with shatter-resistant acrylic diffuser.

Fixture Type F2, heavy-duty Turret industrial fluorescent;

1. Voltage: 120 V (ac).
2. Mounting: Strut or pendant mounted.
3. Nominal dimensions: 1220 mm X 305 mm.
4. Lamps: Two 32W, T8.
5. Ballast types and features: Electronic.
6. Up-light: 10 to 15 percent.
7. Housing: Heavy steel with die embossed reflector.
8. External finish: High gloss baked white enamel over rust inhibitor.

PART 3 – EXECUTION

INSTALLATION

Installation shall conform to the following requirements:

Luminaire attachment shall be installed to the details as shown on the plans.

Low smoke, flexible conduit connection shall be provided from embedded conduit stub-up and conductors, per schedules shown on the plans, shall be installed to embedded terminal boxes.

Electrical connectors and terminals shall be tightened in accordance with manufacturer's recommendations.

Luminaires shall be installed in accordance with to manufacturer's written instructions. Malfunctioning lamps shall be replaced.

FIELD QUALITY CONTROL

The Contractor shall inspect each installed lighting unit for damage. Damaged lighting units and components shall be replaced by the Contractor at the Contractor's expense.

The testing agency shall provide a minimum of two working days advance notice to the Engineer for the dates and times of the field tests. The testing agency shall provide instruments to record test results.

Normal operation of the lighting units shall be verified after installing luminaires and energizing circuits with normal power source. The following field tests shall be performed:

Light intensities shall be measured at night at each lighting zone to test illumination performance. Luminance meter shall be used with calibration referenced to NIST standards for the photometric measurements. The photometric measurement shall comply with IESNA LM-71-96.

Intensity and uniformity of illumination shall be checked.

Any noticeable noisy ballasts shall be checked and replaced.

Luminaires and components that failed any test shall be repaired or replaced, and then retested.

Within two working days after tests are completed, the testing agency shall submit to the Engineer a written test report, including test procedure, inspections, observations, verifications, test results, repairs made, test date and signature of test person.

Prior to final acceptance of the installation, all luminaires shall be cleaned with methods and materials recommended by manufacturer.

Miscellaneous Lighting Fixtures: The Contractor shall inspect each installed fixture for damage. Damaged fixtures and components shall be replaced by the Contractor. The Contractor shall provide advance notice a minimum of two working days to the Engineer for the dates and times of field tests. The Contractor shall provide instruments to make and record test results.

The testing agency shall conduct following tests:

Verify normal operation of each fixture after installation.

Verify normal transfer to battery source and retransfer to normal.

Report results in writing.

Fixtures and components that failed tests shall be repaired or replaced, and then retested.

The testing agency shall submit to the Engineer a written test report including test procedure, test results, repairs made, test date and signature of test person within 5 working days after tests are completed.

PART 4 – MEASUREMENT AND PAYMENT

The contract lump sum price paid for tunnel lighting shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in testing and integrating the tunnel lighting as a single system, complete in place, as shown on the plans, as specified in these special provisions, and as directed by the Engineer.

12-17.1620 RELOCATE EQUIPMENT FROM EXISTING TO NEW OMC BUILDING

PART 1 – GENERAL

Scope: This work shall consist of relocating existing materials and equipment, installation of new raceway and conduit, cables, termination and field testing in accordance with the details on the plans and these special provisions.

SUMMARY

Equipment and systems identified for relocation and rewiring to the new OMC Communication Room are as follows:

Six radio communication racks, power supply batteries and charger, and main distribution frame for communication wiring cross connection in the existing Bore No. 3 west portal communication room. Contractor shall coordinate this work with Department of General Services (DGS) who will be responsible for the transfer of all state radio equipment, fire white voter shelf equipment and reconnection of interconnecting cables and external field wiring.

Telephone and communication equipment in the existing Bore No. 3 west portal building telephone room consisting of telephone main distribution frame and existing PBX switch panel.

Equipment and systems identified for relocation and rewiring to the new OMC Control Room are as follows:

Three sets of main dispatch monitors and servers.

Security control panel.

Reroute or extend cables from these existing systems to the new OMC communication room:

Trango System repeater antenna for CCTV camera monitoring west bound traffic.

Tower Microwave antenna. (Tower will be relocated to a new location to avoid Bore 4 construction).

Miscellaneous items:

New conduit and cable from new OMC communication room to existing Bores 1 and 2 west portal building and maintenance building electrical room.

New conduit and cable from new OMC communication room to existing OMC telephone room.

The Contractor shall be responsible for verifying and tracing wiring circuits, review of existing facilities drawings for the systems to be relocated and required termination, field and functional testing and coordination with Caltrans Tunnel Operations.

The Contractor shall be responsible for coordinating electrical, telephone and data circuit outages with Caltrans and DGS Telecommunications to minimize disruption to day-to-day tunnel operations and radio communications.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION

RELOCATION

Materials or equipment to be relocated shall be removed carefully to avoid damage to the materials or equipment or to the materials or equipment which are to remain. Assemblies to be relocated which require dismantling for removal shall be matchmarked before dismantling.

The Contractor shall notify the Engineer prior to the relocation work in order that the materials or equipment may be inspected for existing damage.

Materials or equipment which are damaged by the Contractor's operations shall be replaced or restored to match the condition of the materials or equipment prior to the beginning of the Contractor's operations. Replacement or restoration of damaged materials or equipment shall be at the Contractor's expense.

Connections, anchorages and fasteners for relocated materials and equipment shall match existing and shall be furnished and installed by the Contractor. Assemblies which have been dismantled shall be reassembled to match the existing installation. Relocated materials and shipment shall be installed as required for new work.

Modifications to wiring to accommodate relocated items shall be as shown on the plans. Ends of conduits to be abandoned shall be capped.

Surfaces that are exposed to view upon removal or relocation of materials or equipment shall be patched. Bumps shall be removed and depressions filled, and the surface finished to match the existing surfaces.

DISPOSAL

Material from existing facilities to be reused in the work, in the opinion of the Engineer, is unsuitable for use shall become the property of the Contractor and disposed of away from the premises.

PART 4 – MEASUREMENT AND PAYMENT

The contract lump sum price paid to relocate equipment from existing to new OMC Building shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work to relocate equipment from existing to new OMC Building, as shown on the plans, as specified in these special provisions, and as directed by the Engineer..

12-17.1621 TUNNEL SCADA/PLC CONTROL AND MONITORING SYSTEM

PART 1 – GENERAL

Scope: The tunnel control and monitoring system include a programmable logic controller (PLC)-based supervisory control and data acquisition (SCADA) system for tunnel systems and components, including control components for units that are not supplied with factory-wired controls. Equipment includes control equipment and associated software programming, communications and data transmission equipment and associated software programming, electrical controls devices. The tunnel control and monitoring system shall provide the functionality specified herein and shall operate according to the sequences of operation for tunnel ventilation fans, tunnel lighting, and electrical and ancillary system monitoring.

SUMMARY

The existing tunnel control system equipment at Caldecott uses a Modicon based PLC system, with Wonderware based supervisory computer software program.

The Caltrans proposed upgrade to the existing PLC/SCADA system for the tunnels include:

Change to Ethernet communication protocol – to increase data throughput

Add new SCADA servers with terminal services, Database servers and associated peripherals

Replace existing PLC CPU and Power Supply modules and add an Ethernet module at existing PLC's for Bore No. 1 through Bore No. 3 as indicated on plans.

Add new Workstations with Window-based SCADA software (Wonderware) at new OMC Building.

Replace the serial communication link between Caldecott Tunnel and the Webster and Posey Tube by replacing the Data Service Unit/Channel Service Unit (DSU/CSU) module with an Ethernet Router.

Programming, testing, and screen developments for the new SCADA system, including operator interface functions and graphic screens for the Bore No. 4 expansion and reprogramming required to integrate screens for existing Bore No. 1, Bore No. 2 and Bore No. 3.

SYSTEM DESCRIPTION

The fiber optic link that ties the four existing PLCs will be reconnected to include the new PLCs required for Bore No. 4 and the client server devices and workstations in the new OMC Building.

Control equipment and related software programming shall be provided at each location shown on the plans. Equipment shall be distributed, as equivalently functioning control nodes, at each equipment area, and as equivalently functioning remote I/O nodes within each cross-passage. The configuration and programming of the equipment shall provide control nodes and remote I/O nodes that will continue to function in the last commanded state or operating status, in the event of a system communication failure.

Fiber optic communication equipment and transmission media, as well as required communication programming, shall be provided at each location as shown on the plans. Network communications among the individual control nodes and the remotely located operator interface equipment shall be via dedicated fiber optic cabling routed within the tunnel duct system and onward to the new OMC Building. The communication network shall be tolerant of a transmission media break between control nodes or operator interface units such that full communications shall be maintained between all nodes not physically isolated from the network as a result of the break.

Operator Interface Unit (OIU) equipment, software, and functional programming shall be provided as shown on the plans. Each OIU shall allow Operator access to all tunnel systems via the same log-in screen and shall utilize the same programming and control commands, control software programming languages, and graphical representations. Dynamic control and monitoring displays, representing tunnel systems and equipment, shall be developed in close coordination with the Department operations and engineering staff. Operator access to the tunnel control system, for the purpose of system manipulation, shall not be allowed from any device other than the dedicated OIU.

Enclosures, sensors, control devices, raceways, and other components shall be provided as shown on the plans and as required for complete and fully operational control and monitoring systems. The Contractor shall include installation and calibration, supervision, adjustments, and fine-tuning necessary for complete and fully operational system.

The Contractor shall have the following additional responsibilities under the scope of this contract:

Provide submittal and record documentation.

Provide operator and maintenance training for minimum of ten (10) Department personnel.

Perform all system startup and commissioning procedures as required and described by the specification.

Correct any system deficiencies discovered during installation, testing and commissioning work under this section without any additional compensation.

SUBMITTALS

The Contractor shall make submittals in conformance with the requirements specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions and the requirements specified herein.

The submittals shall include complete details, information, and drawings for the tunnel control systems as shown on the plans and as specified in these special provisions. The submittals shall also include the following:

SCADA/PLC System Integrators Qualifications. Submit a printed certified qualification resume of the contractor or systems integrator performing the fabrication, configuration, and programming of the tunnel control system components.

Manufacturer's technical data for each type of product specified. Include manufacturer's technical data for each control system component furnished, indicating dimensions, capacities, performance characteristics, control/communication characteristics, finishes of materials, installation instructions, and startup instructions.

Shop Drawings from manufacturer detailing equipment assemblies or components and indicating dimensions, weights, loadings, required clearances, method of field assembly, and location and characteristics of each field connection.

Shop Drawings containing the following information for each PLC and field interface panel:

1. Schematic flow diagram showing fans, lighting contactors CO/NO, pull station, linear heat detectors and other control and monitoring devices served.
2. Each control device labeled with setting or adjustable range of control.
3. Diagrams for all required electrical wiring. Clearly differentiate between factory-installed and field-installed wiring.
4. Each conductor labeled utilizing identifying labels shown on the plans.
5. Details of panel faces, including controls, instruments, and labeling.
6. Written description of sequence of operation.
7. Listing of connected data points, including connected control unit and input device.
8. Each data point labeled utilizing identifying labels shown on the plans.
9. Associated Operator Interface Unit system graphics indicating monitored systems and devices, data (connected and calculated) point addresses, and operator notations.
10. System configuration showing I/O and peripheral devices, power supplies, diagrams, and interconnections.
11. Software description and sequence of operation.
12. Control Program Listing, fully annotated to describe the function of each programming element and each functional segment.

Wiring diagrams detailing wiring for power, signal, and control systems and differentiating clearly between manufacturer-installed and field-installed wiring.

Commissioning Plan: Procedures and certification of control system functionality. Submit for approval at least 90 days prior to commencement of formal testing.

Closeout Submittals

1. Project Record Documents: Record actual locations of control components, including all field control components and sensors. Revise Shop Drawings to reflect actual installation and operating sequences. Include all data specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions in the final "Record Documents" form.
2. Maintenance data for control systems equipment to include in the operation and maintenance manuals as specified in these special provisions. Include the following:

   a. Maintenance instructions and replaceable parts list for each type of control component or device.
   b. Interconnection wiring diagrams with identified and numbered conductors and system components and devices.
   c. Keyboard illustrations and step-by-step procedures indexed for each operator function.

d. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
e. Calibration records and list of set points or calibrated ranges.
f. Training materials for tunnel control and monitoring system operation and maintenance training sessions as specified in these special provisions.
g. Final Commissioning report and test manual.

REPLACEABLE PARTS

The following materials shall be provided as new additional parts, in original unopened packaging, to enable the replacement of the following components in the event of a failure during commissioning:

Six (6) of each type of fuse used within the control system panels.

Two (2) of each type and rating of relays and contactors used.

Three (3) of each type of relay/contactor/module socket base used.

Two (2) of each type and rating of channel mounted circuit breakers used.

Two (2) of each type of PLC processor, local and remote I/O module, communications module, and power supply module used.

TRAINING

The Contractor shall be responsible for training coordination and scheduling and for ensuring that training is completed on all equipment in accordance with these special provisions. Department operating and maintenance staff shall receive orientation and training, in accordance with these special provisions, on all modes, functions, operations and maintenance of all features, systems, and equipment as a provided by this project and as defined and outlined herein.

QUALITY ASSURANCE

Installer Qualifications: The Contractor shall engage an experienced installer specializing in control system installations with minimum three years documented experience approved by the SCADA/PLC system manufacturer.

Manufacturer Qualifications: The Contractor shall engage a firm experienced in manufacturing control systems similar to those indicated for this Project and that have a five year documented record of successful in-service performance. Manufacturer shall maintain a field service office within 250 km of project site. This field office shall have a minimum of five years experience engineering and installing the control systems proposed for this project. At Engineer's request, provide a listing of at least five projects of similar magnitude, complexity and facility use type completed within the past five years.

System Integrator Qualifications: The contractor or integrator shall have a minimum of 5 years experience related to design, fabrication, programming, installation, start-up, and testing of similar SCADA/PLC systems. If more than one contractor or systems integrator is employed, a certified resume for each one shall be provided indicating their specific specialty and item of work.

Commissioning/Startup Personnel Qualifications: Where necessary, The Contractor shall engage specially trained personnel in direct employ of manufacturer of SCADA/PLC system components.

PART 2 – PRODUCTS

OPERATOR INTERFACE UNIT (OIU)

The Operator Interface Unit (OIU) shall be a microcomputer station with printer, including the following:

Workstation: IBM-compatible microcomputer with minimum configuration as follows:

1. Processor: Intel Pentium 4, 3.0 GHz.
2. Random-Access Memory: 512 MB.
3. Cache Memory: 256 KB.
4. Graphics: Super Extended Graphics (SXGA) color graphic adapter.
5. Monitor: Touch-screen capable 533 mm, non-interlaced, color, with maximum 0.26 mm dot pitch.
6. Keyboard: QWERTY.
7. Floppy Disk Drives: 1.44 MB.
8. Hard Disk Drive: 200.0 GB.
9. Mouse: 3-button.
10. Modem: Auto-dial, internal, minimum 56 KBaud.
11. Network Adapter: Ethernet 10/100
12. Tape Back-Up: Internal, 250 MB.
13. Operating System: Microsoft Windows XP, Professional Edition.

Printer: Dot-matrix type as follows:

1. Print Head: 24 pin.
2. Carriage: Wide, 132 characters per line of paper.
3. Paper Handling: Fan-fold paper, with 2 cartons containing minimum 2500 sheets each.
4. Print Speed: Minimum 120 characters per second.

Application software shall include the following:

1. Input/output capability from operator station.
2. Operator system access levels via software password.
3. Database creation and support.
4. Dynamic color graphic displays.
5. Alarm processing.
6. Event processing.
7. Automatic restart of field equipment on restoration of power.
8. Data collection, storage, and historical trending.
9. Graphic development on workstation.
10. Maintenance management.
11. Print reports.

SCADA/PLC

PLC units (PLC-9 and PLC-10) shall be modular, comprising microprocessor-based central processor unit modules with programmable, nonvolatile, random-access memory, power supply modules, remote I/O communication network modules, input/output interface processing modules, and system communications modules (Ethernet TCP/IP Module), and include the following features:

Units monitor each input and control each output; process information; execute commands from other control units, devices, and operator stations; and download data from or upload data to operator station.

Stand-alone node control functions operate regardless of network status. Functions include the following:

1. Global communications.
2. Discrete/digital, analog, pulse input/output and latched outputs.
3. Monitoring, controlling, or addressing data points.
4. Testing and developing control algorithms without disrupting field hardware and controlled environment.

Global Communications: Broadcast point and status data onto system communication network, making that information available for use by other PLC units and utilizing data from other PLC units. Transmit and receive any or all input/output point data via remote I/O network.

Each PLC shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all subsidiary equipment. Information concerning detected diagnostic faults shall be broadcast network-wide.

All necessary software to form a complete operating system as described in this specification shall be provided. The software programs shall be provided as an integral part of the SCADA/PLC panel and shall not be dependent upon any higher-level computer for execution.

Each stand-alone PLC shall be provided with an RS 232C serial data communication port for operator I/O devices such as industry standard portable operator's terminals or portable lap-top computers.

Cabinet lights, folding table, print pockets, circuit breakers and fuse blocks for internal 120 V AC power distribution, neutral terminal blocks, marshaling terminal blocks, and ground bus shall be provided and mounted inside and, in general, near the bottom of each enclosure.

All PLC hardware components requiring 120 V AC power source shall be wired to power distribution circuit breakers mounted inside the enclosure.

A removable terminal block shall be mounted on each I/O module. All I/O modules shall be prewired from the removable terminal blocks to marshaling terminal blocks mounted inside the enclosure. Marshaling terminal blocks for analog I/O wiring shall be mounted separately from those for digital I/O wiring. The removable terminal block permits replacing a module without affecting the prewiring.

The removable terminal block and the marshaling terminal block shall be capable of accommodating at least 2 No. 14 AWG stranded copper wires for digital I/O and 2 No. 16 AWG stranded copper wires for analog I/O per terminal.

Wire ducts shall be used and arranged to allow convenient installation of all internal wiring and incoming cables from top and bottom entries. Wire duct filing shall not exceed 30 percent.

All I/O module removable terminal blocks and marshaling terminal blocks shall be equipped with screw terminals providing a compression connection. At least 20 percent spare marshaling terminal blocks shall be spaced equally along the terminal strips, and 5 percent additional marshaling terminal blocks shall be located together for each voltage level in each enclosure for future use.

Provide Uninterruptible Power of adequate rating to each standalone tunnel field interface panel (FIP) 24 DC Power Supply.

Sensor and Control Wiring Surge Protection: Controllers and FIP remote I/O modules shall have sensor and control wiring surge protection with optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

COMMUNICATIONS NETWORKS (LANS)

Communications Networks (LANs) shall include the following:

System Support: Capacity for a minimum of 10 workstations connected to multi-user, multitasking environment with concurrent capability to access SCADA/PLC network or control units.

PLC manufacturer's standard communications protocol at minimum transmission rate of 19.2 kBaud.

Communication via multi-mode fiber optic cables.

Fiber optic communication modules that provide fault-tolerant, self-healing communication path via redundant fiber media. Fault locating and reporting with on-line error checking and interactive diagnostics accessible network-wide.

SCADA/PLC SYSTEM UPGRADE EQUIPMENT

The upgrade of existing SCADA/PLC Equipment includes:

SCADA Servers: Provide two (2) Servers with upgraded version of the Windows based SCADA software (Wonderware). The servers shall be configured as a redundant pair to operate the PLCs and at all 4 Bores at Caldecott Tunnel and the Posey and Webster Tubes. Caltrans to provide information on Posey and Webster Tubes data and control requirement to successful bidder.

Database Server: Provide an SQL Server that will host a database system to support logging of alarm and events.

Replace CPU and Power Supply modules with upgrade units (Existing PLC 1, 2, 3, and 4)

Replace existing fiber optic repeaters with industrial Ethernet Switch with seven 10/100 Base TX ports and two fiber ports to match existing Sixnet EtherTRAK.

Add new Ethernet TCP/IP Module to existing PLC 1, 2, 3, and 4.

Replace existing Data Service Unit/Channel Service Unit (DSU/CSU) with an Ethernet router.

SOFTWARE AND PROGRAMMING

Software shall be updated to latest versions of software at project completion. Software shall be developed to provide the control units with the functionality specified herein and on the plans:

Automatic response of ventilation system to fire alarm system event signaling.

Automatic response of the tunnel lighting system in response to measured portal luminance by use of existing sensors.

Manual (operator initiated) selection and control of individual ventilation and lighting system components.

Manual (operator initiated) selection and control of switchgear breakers for transfer control and starting of emergency generators. Generators to start automatically upon sensing no voltage at the 12 kV switchgear bus S1 and S2.

Monitoring and controlling of indicated field equipment and devices.

The scope of configuration and programming shall include:

Download or transfer the existing data and screen files (Bore No. 1, Bore No. 2, and Bore No. 3) to the new servers from existing computers.

New Graphic Screens for lighting control to include Bore No. 1, Bore No. 2, Bore No. 3, and Bore No. 4 (previous screen information for Bore No. 1, Bore No. 2, and Bore No. 3 are available in existing PLC program and can be used as reference).

New Graphic Screens to incorporate changes in the power supply system.

New Graphic Screens for the call box system (Bore No. 1, Bore No. 2, Bore No. 3, and Bore No. 4)

Control algorithms for control of fans, pumps and tunnel lighting and associated monitoring and alarm points.

Communication firmware and programming for communication links to other sub systems as required.

Configuration of all control, measuring and alarm loops based upon control descriptions, elementary and interconnection diagrams and control logic diagrams.

Display configuration based on charts, tabulations, sketches and other information furnished by Caltrans.

Software shall be developed to provide the Operator Interface Units (OIU) with the functionality specified herein and on the plans:

1. Touch screen operation.
2. Input/Output Capability from Operator Station:

    a. Request display of current values or status in tabular or graphic format.
    b. Command selected equipment to specified state.
    c. Initiate logs and reports.
    d. Change analog limits. Change set analog values to digital outputs for trip or Alarm functions.
    e. Add, delete, or change points within each control unit or application routine.
    f. Change point input/output descriptors, status, alarm descriptors, and engineering unit descriptors.
    g. Add new control units to existing and upgraded system.
    h. Modify and set up maintenance scheduling parameters.
    i. Develop, modify, delete or display full range of color graphic displays.
    j. Automatically archive select data even when running third party software.
    k. Provide capability to sort and extract data from archived files and to generate custom reports.
    l. Support two printer operations.
    m. Alarm printer: Print alarms, operator acknowledgments, action messages, system alarms, operator sign on and sign off.
    n. Data printer: Print reports, page prints, and data base prints.
    o. Operator selectable output of screen graphical images, data trend logs, and alarm summary information to printer.
    p. Automatic time and date stamped output of all system alarms and automatic or manual control system actions to printer.
    q. Select daily, weekly or monthly as scheduled frequency to synchronize time and date in digital control units. Accommodate daylight savings time adjustments.
    r. Print selected control unit database.

3. Dynamic Color Graphic Displays:

    a. Utilizes custom symbols or system supported library of symbols.
    b. Sixteen (16) colors.
    c. Sixty (60) outputs of real-time live dynamic data per graphic.
    d. Dynamic graphic data.
    e. Up to 1,000 separate graphic pages.
    f. Modify graphic screen refresh rate between 1 and 60 seconds.

4. Graphic screens to be developed in conjunction with the Caltrans Department staff include but are not limited to:

    a. Overview of entire tunnel system, providing means to quickly select specific segment, system, or overview graphics and indicating critical system-wide operating parameters and alarms.
    b. Overviews of each tunnel system, providing means to quickly select specific related graphics and indicating associated operating parameters and alarms.
    c. Graphical representation of tunnel equipment configuration at each specific equipment chamber and cross-passage location, indicating status of each system component.
    d. For each tunnel control and monitoring system or element, provide screens showing user-configurable historical data trend logging of equipment status and monitored signal values.
    e. System-wide alarm summary screen indicating date, time, and nature of alarm event and providing the means to quickly select the graphical representation screen pertaining to the affected equipment or system.
    f. Communications network overview screen indicating status and diagnostic information generated by the system communications network sub-system and the remote I/O communications subsystem.
    g. Operator System Access: Via software password with minimum 10 access levels at OIU.

5. Data Base Creation and Support: Changes shall utilize standard procedures. Control unit shall automatically check workstation data base files upon connection and verify data base match. Minimum capability shall include:

    a. Add and delete points.
    b. Modify any point parameter.
    c. Change, add, or delete English language descriptors.
    d. Add, modify, or delete alarm limits.
    e. Add, modify, or delete points in start/stop programs and trend logs.
    f. Create custom relationship between points.
    g. Create or modify PLC loops and parameters.
    h. Create or modify override parameters.
    i. Add, modify, and delete any applications program.
    j. Add, delete, develop, or modify dynamic color graphic displays.

6. Alarm Processing.

    a. Off normal condition: Cause alarm and appropriate message, including time, system, point descriptor, and alarm condition.
    b. Critical alarm or change of state: Display message, stored on disk for review and sort, or print.
    c. Print on line changeable message, up to 40 characters in length, for each alarm point specified.
    d. Display alarm reports on video. Display multiple alarms in order of occurrence.
    e. Define time delay for equipment start up or shutdown.
    f. Allow unique routing of specific alarms.
    g. Operator specifies if alarm requires acknowledgment.
    h. Continue to indicate unacknowledged alarms after return to normal.
    i.. Alarm notification: print automatically and display indicating alarm condition, with selectable audible alarm indication.

Control Panels

1. SCADA/PLC Control Panels: Free-standing, single door, enclosures rated ICS 6, NEMA Type 12 shall be provided. Enclosures shall, as a minimum, be constructed of 16 gauge steel with all seams continuously welded and smoothly finished, and shall possess integral, rolled lip framing around the door to prevent dirt, water, and other debris from falling into the cabinet when the door is opened. Enclosure door shall be fully gasketed with glued-in-place oil resistant gaskets and shall be equipped with a screwed-down door clamp mechanism and padlockable hasp assembly. Exterior finish shall be cabinet manufacturer's standard corrosion inhibiting, baked-on enamel finish over phosphatized surfaces. The enclosure interior surfaces and back panels shall be finished with the cabinet manufacturer's standard corrosion-inhibiting, white high-gloss baked-on enamel finish.
2. Field Interface Panel (FIP) - Remote I/O Monitoring Panels and SCADA/PLC – TOS Interface Remote I/O Panel: Wall-mounted, continuous hinge, single door, enclosures rated ICS 6, NEMA Type 12 shall be provided. Enclosures shall, as a minimum, be constructed of 16-gauge steel with all seams continuously welded and smoothly finished. Enclosure door shall be fully gasketed with glued-in-place oil resistant gaskets and shall be equipped with a screwed-down door clamp mechanism and padlockable hasp assembly. Enclosure exterior and interior finishes shall be cabinet manufacturer's standard corrosion inhibiting, baked-on enamel finish over phosphatized surfaces.
3. Control Panel Components

    a. Fiber Optic Patch Panels: Provide surface mount telecommunications outlet housings of a high-density, low-profile, design with four (4) field-configurable ports, snap-lock cover, and cable knockouts on back. Base shall include tie-wrap anchor points at all cable entrances. Housings shall be mountable with screws and have mounting holes that are compatible with standard NEMA wall boxes. Constructed of high-impact self-extinguishing plastic. UL listed.
    b. Terminal Blocks: Provide channel mounted, impact and combustion resistant, self-extinguishing type terminal blocks. Terminal blocks shall be rated 10A minimum, for continuous at 600 V AC. Terminals shall be of the tubular screw clamp type and shall be capable of accommodating two (2) 2.08 square millimeters or one (1) 3.31 square millimeters conductors of the type specified herein. Furnish all required end plates, channel clamps, separators and other components required for installation in accordance with the manufacturer's recommendations. Terminal blocks shall each be equipped with an appropriate label which is large enough to legibly accommodate identifying numbers as shown on the plans.

c. Channel Mounted Circuit Breakers: Units equipped with "tripped" indication shall be provided, rated as specified in the plans. Channel mounted breakers and fuses shall mount on the same size and type of mounting channel as the terminal blocks specified herein and shall possess terminals each capable of accommodating one (1) 2.08 square millimeters wire of the type specified herein. Each breaker and fuse shall be equipped with an appropriate label and labeling space large enough to legibly accommodate a three-digit identifying number. Thermal-magnetic type circuit breakers with a "normal blow" tripping characteristic curve shall be provided.

d. Wireway: Provide slotted type plastic wireways, with covers, of the size specified in the plans and as required for neat installation of interconnecting conductors. Wireways shall be restricted slot type to prevent accidental removal of wires and shall be constructed of rigid, non-flammable polyvinyl chloride (PVC). Wireway shall be UL recognized for continuous operation at 49°C.

e. Selector Switches. Provide industrial duty, 30 mm body, selector switch units with stackable, replaceable contact blocks. Units shall possess the number and type of contacts indicated on the plans and shall be rated NEMA Type 13, oil tight. Operator units shall be maintained with the number of positions as indicated in the plans. Where indicated in the plans, keylocked selector switch units shall posses identical cylinder locks employing the same master key, and shall hold the key captive in the positions indicated as 'Local' control positions. All selector switch unit contacts shall be rated for continuous operation at 10 A at 120 V (ac).

f. Pushbuttons: Provide industrial duty, 30 mm body, round button, momentary operator pushbutton units with stackable, replaceable contact blocks. Units shall possess the number and type of contacts indicated on the contract drawings and shall be rated NEMA Type 13, oil tight. All pushbutton unit contacts shall be rated for continuous operation at 10 A at 120 V (ac).

g. Control Relays: Provide control relays utilizing DIN rail mounted 8-pin round socket bases. Relays shall be equipped with double pole double-throw (DPDT) contacts, neon internal pilot lights to indicate coil energization, and shall be rated for operation over the temperature range of -34°C to +43°C. Control relays shall have 120 V (ac) or 24 V DC coils as indicated on plans and shall be equipped with contacts rated for continuous operation at 10 A at 120 V (ac), with a resistive load. Surge suppression modules shall be supplied on all control relay coils.

h. 24 V DC Power Supplies: Provide regulated 24 V DC power supplies of adequate rating for the control system as shown on the plans.

i. Control Cable: Electronic cable for control wiring and optical-fiber cable for signal transmission shall be in accordance with these special provisions.

SEQUENCE OF OPERATION

Jet Fans:

PLC will be programmed based upon fan operating logic indicated in jet fans operation mode tables to provide run/stop toggle output contacts shown in control schematics. The number of operating fans will be limited so that the air velocity does not exceed 10 m/s as sensed by pitot tube air velocity sensors located inside the tunnel. Under normal operation "Manual-Off-Auto" selector switch will be in Auto mode. During fire-emergency or excessive CO concentration PLC will generate run/stop command to start or stop the fan. Such run/stop command can also be initiated by the operator at OMC at PLC/SCADA work station.

Air Quality Operation

In normal operation all jet fans are off, the SCADA/PLC system polls the tunnel gas detectors for levels of concentration. If a carbon monoxide (CO) gas concentration in excess of 10* ppm (* - programmable setpoint) is detected in the vicinity of any group of two jet fans, one fan in the group is started in the forward direction. If a CO gas concentration in excess of 15* ppm or higher is detected, both fans in the group are started in the forward direction. Fan operation shall continue until the concentration has again fallen to below 5* ppm.

In order to prevent a conflict with a potential fire, the fan start is held for 5* seconds. If the rate of rise in CO over this period of time is greater or equal to 10* ppm per second, the fans start is halted and a fire emergency situation is assumed. See discussion below for fire emergency operation.

During the fan hold period, the operator can confirm the tunnel situation via the CCTV camera images, controlled by TOS. If there is no fire in the tunnel, the operator can override the air quality fan start at the SCADA/PLC workstation, or wait until the fan start hold period expires and the normal air quality fan start sequence is initiated.

Nitric Oxide (NO) concentration is reported to the OMC operator via SCADA/PLC system in order to obtain the NO concentration history during normal and congested operations. The SCADA/PLC system shall have the capability for storage and archiving of CO/NO concentration history for the life of the tunnel.

Fire Emergency Operation

If the SCADA/PLC detects a CO concentration exceeding 100* ppm or a rate of rise in CO that is equal to or exceeds 10* ppm per second a fire situation is assumed. In both these cases, an alarm is passed to the TOS server indicating the possible fire situation. The TOS will initiate the fire response strategy as described in "Traffic Operations System Software" of these special provisions. At the same time, the SCADA/PLC system prepares to initiate the fire emergency start sequence as shown on the plans and as described below.

The presence of fire in Bore 4 is detected by linear heat detector (LHD) cable and the linear heat detector control panel (LDP). The sensor cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape and sheath. Alarm on each detection zone is individually reported to the FACP. Alarm contacts from the FACP will be wired to input modules in SCADA/PLC system which will process the information to determine the zone/s of the fire origin. The alarm is also passed to the TOS server via the TOS/SCADA interface to indicate the presence of fire. At the same time the SCADA/PLC system prepares to initiate the fire emergency fan start sequence as shown on the plans and as described below. LHD was not used in the existing Bore 3. Fire detection will be by CO and by TOS as described below. Bore 3 Exhauster fans will be activated through the SCADA/PLC according to the fire emergency start sequence and evacuation procedure.

A fire alarm indication could also be derived from the TOS; the function of the TOS in identifying and verifying a fire situation is described below. The SCADA/PLC system response to a TOS-identified fire is identical to the SCADA/PLC-derived fire alarm.

SCADA/PLC Fan Operation

Upon receipt of a fire alarm, the SCADA/PLC monitor indicates to the operator that a fire emergency fan start is scheduled to begin in 10* seconds, unless the operator intervenes. The operator can select a CANCEL button on the SCADA/PLC monitor that cancels the emergency fan start if there is no fire in the tunnel.

If motorists need to be evacuated from the tunnel prior to starting the ventilation system, the operator can select a DELAY button on the SCADA/PLC monitor that pauses the fan start sequence for 120* seconds to allow motorists to evacuate the tunnel. After the delay period has expired, the fan start sequence is initiated.

If the fire condition is confirmed and no evacuation is necessary, the operator can select a START button on the SCADA/PLC monitor that immediately initiates the fan start sequence.

Note that the operator does not need to intervene in the fan operation but is provided an opportunity to delay or cancel the fire emergency response, depending on the circumstances in the tunnel.

During automatic fire/event operations, all fans remain on regardless of fan or motor status until the system is reset by the control system operations personnel at the direction of the designated incident commander.

Fan direction during automatic fire/event operations can be reversed at the scene by operation of a door-mounted selector switch located at the fan starter. The control system shall enforce a 10* second time delay prior to energizing a reversing direction contactor.

TOS Operation

The TOS includes the operation of the vehicle incident detection (VID) system may also lead to the automated detection of a fire situation in the tunnel. As noted in the Emergency Response Plan described in "Traffic Operations System Software" of these special provisions, the VID system detects stopped vehicles.

Upon detecting an incident in the tunnel the TOS alerts the operator and provides video images of the incident location on the operator's TOS monitor. The operator examines the situation and either verifies or cancels the alarm.

If the operator identifies the presence of a fire, the operator selects the fire response option at the TOS workstation. Doing so causes the TOS to initiate the fire response strategy, which includes among other things the passing of a fire notification to the SCADA/PLC system. The information passed to the SCADA/PLC system includes the presence and location of the fire. The response of the SCADA/PLC to the notification is described under the SCADA/PLC fan operation above.

In a similar manner, the CO alarm, LHD alarm, and Call-box off-hook alarm trigger a sequence of response strategies for the operator selection. An optional response to each of these alarms is to select the fire emergency option. Doing so triggers the same sequence of events described above.

If there is a false alarm the operator ascertains that there is no fire situation, the operator can clear the alarm at the TOS workstation. Note that clearing the alarm at the TOS workstation does not clear or interrupt a pending fan start on the SCADA/PLC system. The SCADA/PLC alarm and/or pending fan start would be cancelled at the SCADA/PLC workstation.

Alarm Exchange

As noted, the SCADA/PLC and TOS system pass messages back and forth as part of the fire response strategy. Following are the specific alarms passed:

1. SCADA/PLC Alarms passed to TOS

    a. CO fire threshold value alarm for each CO sensor
    b. CO rate of rise alarm for each CO sensor
    c. LHD temperature alarm for each fire zone (Fire Zone 1 through 4) Bore 4 only
    d. Call box handset off-hook for each call box location
    e. Strong motion sensor alarm

2. TOS Alarms passed to SCADA/PLC

    a. Fire emergency confirmed for each fire zone (Fire Zone 1 through 4)

SCADA/PLC and TOS Interface

1. SCADA/PLC Remote I/O modules will be hardwired to a TOS PLC, connected to the TOS LAN, in the OMC server room. The following discrete output points, namely Bore 3 and Bore 4 call box activation, CO high level, CO rate of rise high, fire alarm activation through FACP and VID (Zone 1 through Zone 4) shall be programmed according to the device status and set points for proper integration to the TOS. Coordinate with the Engineer, Caltrans and the TOS controls commissioning Agent.
2. The ventilation control system creates a time and date stamped log of all jet fan operations indicating individual fan status including all fan and motor related run states and alarms.

Tunnel Lighting: The lighting level controls for Bore 4 shall duplicate the lighting controls developed by PLC Multipoint, Inc. for Bore 1, 2 and 3. Existing luminance sensors signals will be utilized for Bore 4. Refer to the Caldecott Tunnel Lighting Control manual for detailed sequence of operations. Basically the lighting level controls permit the light levels inside the tunnel to be adjusted for varying exterior light levels. Controls shall be programmed to pre-determined values for the lights to come on and stay on until the outside light level reduces to below another pre-determined value, and then turns the lights off. To account for intermittent cloud cover and other short-term transient ambient conditions, the turn on and off process shall incorporate programmable time delays at each transition.

Lighting Control – Bore 4:

1. Modes of Operation

   The Caldecott tunnel has four bores, each with distinct mode of operation. Bores 1, 2 will be eastbound; Bores 3 and 4 will be westbound. The lighting controls for Bores 1, 2 and 3 will remain the same. Bore 4 will match the lighting control of Bore 3. The daytime lighting for Bore 4 will have threshold, transition, interior, and exit. Nighttime and emergency lighting will be provided also.

2. Daytime

   The daytime mode provides 6 levels of daytime contrast for the threshold zone, as well as a high level of interior lighting using a dimmer feature. The daytime contrast lighting level control has several stages of operation. Each lighting level has its own parameter group. The operating sequence starts when the luminance sensor passes above a turn-on setpoint, initiating an input time delay. After the delay expires, the output switches on and starts a hold on timer – to prevent short cycling of fixtures. Later, as the high level decreases past the turn-off setpoint, another time delay is initiated. After the time delay expires, the output switches off. A hold off timer allows fixtures to cool down before restriking.

3. Nighttime

   The night mode provides dimmed output of fixtures inside the tunnel. Dimming is accomplished by turning on only selected lighting fixtures that will provide the required lighting level.

4. Emergency

   Since one circuit is always energized through the UPS, backup power is always enabled and in use. The UPS is rotated daily between each of the three phases. Normal lighting contactors are locked out of the emergency circuit so that normal and emergency power cannot simultaneously feed a circuit's fixtures. In the event of emergency power failure, the circuit reverts back to circuits being controlled by normal power.

5. Maintenance

   Maintenance override is accomplished through several levels. The highest priority is the Hand/Off/Auto selector switch on the main contactor panel. Next priority will be from the Operator Workstation in the OMC Building.

Cross Passage Ventilation: When a contact closure input is received from the SCADA/PLC system indicating a fire/event in one of the tunnel bores, the control system shall close the damper serving the incident tunnel and open the damper on the non-incident tunnel. The complete sequence of operation for the cross passage ventilation fan shall be as indicated in the mechanical plans. Cross-passage fan and associated dampers and their position indications by PLC is shown in control schematics.

Substation Ventilation: Each substation ventilation fan control and PLC interface shall be provided as shown in control schematics.

CONDUIT AND RACEWAYS

Conduit and raceway shall conform to "Basic Materials and Methods (Tunnel)" in Section 12-16, "Electrical," of these special provisions.

WIRING AND OPTICAL FIBER

Wire, cable, and optical fiber shall conform to "Basic Materials and Methods (Tunnel)" in Section 12-16, "Electrical," of these special provisions.

EQUIPMENT RACKS

Equipment racks in the OMC Communications and Server rooms shall be steel 483-millimeters EIA racks with enclosed steel sides, 2500 millimeters tall and 915 millimeters deep. Racks shall be braced in accordance with the requirements in "Seismic Controls for Electrical Work" of these special provisions.

PART 3 - EXECUTION

Pre-Installation Meeting: A pre-installation meeting shall be convened a minimum of one week prior to commencing work.

Field Measurements: The Contractor shall verify field measurements and clearances prior to fabrication and installation of control system components

Maintenance Service: During the warranty period the Contractor shall provide a 24-hour emergency service number where a qualified automation service engineer familiar with the installed system may be reached.

Power Line Surge Protection: Equipment connected to ac circuits shall be protected from power-line surges. Equipment protection shall meet the requirements of IEEE C62.41.1. Fuses shall not be used for surge protection.

Delivery, Storage, and Handling: Equipment and materials shall be stored inside and protected from weather.

The Contractor shall verify that conditioned supply power is available to control units and operator workstation, and verify that field end devices and wiring are correctly and securely installed before proceeding with installation.

Equipment shall be installed as indicated to comply with manufacturer's written instructions.

Software shall be installed in control units and operator workstation, implementing all features of programs to specified requirements and appropriate to sequence of operation.

The Contractor shall connect and configure equipment and software to achieve the sequence of operation specified.

The Contractor shall verify location of exposed control sensors with plans and structural details before installation, and install labels and nameplates to identify control components.

ELECTRICAL WIRING AND CONNECTIONS

Signal and communication cable installation shall include the following:

Install all cables and conductors in raceway.

Conceal raceway, except in mechanical rooms and areas where other conduit and piping are exposed.

Bundle and harness multi-conductor instrument cable in place of single cables where a number of cables follow a common path.

Fasten flexible conductors, bridging cabinets and doors, neatly along hinge side; protect against abrasion. Tie and support conductors neatly.

Label all control conductors, utilizing identifying labels shown on the plans, for future identification and servicing of control system.

Electrical components shall be connected to wiring systems and to ground as indicated and instructed by manufacturer. Connectors and terminals, including screws and bolts, shall be tightened according to equipment manufacturer's published torque-tightening values for equipment connectors. Label all terminals and cables at termination locations. Where manufacturer's torquing requirements are not indicated, connectors and terminals shall be tightened according to tightening requirements specified in UL 486A.

FIELD QUALITY CONTROL

Checks shall be implemented as part of the pre-commissioning checklist to verify signal integrity and interconnections between the control system and the field instruments and devices. All signal interconnections shall be individually physically verified for proper terminations and noted on the pre-commissioning checklist. The completed checklist shall be submitted as part of the final test report.

COMMISSIONING

The Contractor shall develop, in concert with the project Commissioning Agent, a commissioning plan that details the implementation of the commissioning process for the ventilation control system and includes the following elements:

Tunnel lighting control, call boxes, cross-passage ventilation fans, substation ventilation fans, interface with tunnel fire alarm panel, PA system interface, SCADA/PLC interface with TOS system.

Detailed definition of responsibilities, accountabilities, and deliverables by each party within the commissioning process.

System and equipment commissioning scope of work list.

Pre-Commissioning Checklist: Procedure and certification to provide individual verification of all installed system components. Verify that submittal information and installed components match. Review complete system installation, cleaning, and initial settings and verify that system is ready for operations.

Pre-Operation Checklist: Procedure and certification to provide verification, by system or equipment, of system setpoints, operating strategies, and required pre-operational component adjustments and testing such as correct fan rotation and component operation.

Functional Performance Test Plan: Test plans shall include a test calendar, a detailed sequence and schedule, and a step-by-step procedural description of all required tests which clearly indicates planned actions and the anticipated corresponding equipment response or sequence of responses. Test plans shall include a comprehensive tunnel system component and equipment list that provides a test verification signoff field for each item. Performance tests shall verify that all components, sub-systems, and systems comprising the tunnel control system function in accordance with the contract documents.

Acceptable System Performance Standards: Definition of test durations, test criteria, and acceptable operational functionality and performance criteria for each of the planned functional tests.

Training Plan: Plans for both operator's training and maintenance personnel training as specified in these special provisions. Training plans shall include proposed training schedules along with detailed descriptions of all course contents and training materials. Training plans shall clearly indicate training objectives and shall outline anticipated means of achieving stated objectives. The Controls Commissioning Agent develops training objectives and a format for the training plan and agenda after meeting with the appropriate Department Operations and Maintenance staff to determine needs and areas of emphasis for this project. The Contractor shall provide the services of a factory-authorized manufacturer's field service representative to assist in commissioning and training of control systems. The Contractor shall provide a designated qualified individual as a Controls Commissioning Agent to work in concert with the project Commissioning Agent, to develop the ventilation control system commissioning plan, as well as all other tunnel sub-systems manage and coordinate all control system commissioning activities, and to provide the required submittals. The Contractor shall replace, at no cost to the Caltrans, all controls and equipment found to be damaged, malfunctioning, or that do not meet acceptable system performance standards. The Controls Commissioning Agent shall submit a corrective action plan for all noted deficiencies identified during the commissioning process. The Contractor shall provide a ventilation control system and other tunnel sub-systems connected to SCADA/PLC system, final commissioning report and test manual in accordance with "Systems Commissioning" of these special provisions.

Provide as-built record drawings of the SCADA/PLC and controls system.

PART 4 – MEASUREMENT AND PAYMENT

The contract lump sum price paid for tunnel SCADA/PLC control and monitoring system shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in testing and integrating the tunnel SCADA/PLC control and monitoring system as a single system, complete in place, as shown on the plans, as specified in these special provisions, and as directed by the Engineer.

12-17.1622 PUBLIC ADDRESS SYSTEM

PART 1 – GENERAL

Scope: The public address (PA) system shall be furnished, installed, and tested in conformance to the details shown on the plans and the requirements specified in these special provisions. The PA system shall include amplifier cabinet, termination blocks and wire and cable. Conduit and raceway, and ductbank shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

SUMMARY

PA system shall be installed at intervals through the tunnel and at cross passages as shown on the plans.

SUBMITTALS

The Contractor shall make submittals in conformance with the requirements specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions and the requirements specified herein.

Complete functional diagram of the PA system;

Speaker circuit impedance calculations and expected individual speaker output variation as a function of impedance. Include verification of wiring for supervision in trouble and alarm conditions;

Equipment power consumption calculations for Bore No. 3 and Bore No. 4 tunnels, including speakers for Bore No. 1 and Bore No. 2 in the future. Calculations shall be performed for 3 Sound Pressure Levels (SPL): 0 dBA SPL at 1.2 meters from speaker centerline; 80 dBA SPL at 1.2 meters from speaker centerline; and 94 dBA SPL at 1.2 meters from speaker centerline;

SPL coverage calculation, acoustical modeling and performance test results. Coverage shall be at 1.5 meters above tunnel floor level. Calculations shall include speaker outputs at 80 dBA SPL at 1.2 meters from speaker centerline;

Cabling, grounding, and shielding scheme in equipment cabinets; and

Description of the purpose and function of proposed test and diagnostic equipment, and procedures for programming the voice and tone synthesizer for pre-recorded messages.

QUALITY ASSURANCE

Contractor shall furnish, install and test all wiring, equipment, and devices for PA system. The PA system shall conform to the following:

Referenced Standards

Acoustical Society of America (ASA)

1. S1 Standards on Acoustics
2. S2 Standards on Mechanical Vibration and Shock
3. S12 Standards on Noise

American National Standards Institute (ANSI)

1.	ANSI S1.1	Acoustical Terminology
2.	ANSI S1.8	Preferred Reference Quantities for Acoustical Levels
3.	ANSI S1.14	Methods for the Measurement of Sound Pressure Level
4.	ANSI S3.2	Method for Measuring the Intelligibility of Speech over Communication Systems

Electronic Industries Association (EIA)

1.	RS-160	Sound Systems
2.	RS-174	Audio Transformers for Electronic Equipment
3.	RS-276	Acceptance Testing of Dynamic Loudspeakers
4.	RS-278	Mounting Dimensions for Loudspeakers
5.	RS-299	Loudspeakers, Dynamic, Magnetic Structures and Impedance
6.	RS-426	Loudspeakers Power Rating, Full Range
7.	RS-438	Test Measuring Stiffness of Loudspeaker Spiders
8.	RS-446	Detail Specification – Illuminated and Non-Illuminated Pushbutton Switches
9.	RS-490	Standard Test Methods of Measurement for Audio Amplifiers
10.	SE-101	Amplifiers for Sound Equipment
11.	SE-103	Speakers for Sound Equipment
12.	SE-104	Engineering Specifications for Amplifiers for Sound Equipment
13.	SE-105	Microphones for Sound Equipment

National Fire Protection Agency (NFPA)

1. NFPA 72A Standard for the Installation, Maintenance and use of Protective Signaling Systems

California Occupational Safety and Health Standards (CAL/OSHA)

DESIGN WORK

The Contractor shall design the PA system and determine the number and location of speakers that will provide coverage in the Bore No. 4 tunnel areas and cross passages in accordance with the acoustical requirements specified herein. In addition, the Contractor shall be responsible for reconnecting the existing Bore No. 3 speakers system to the new PA system, including investigation and refurbishing of existing speaker wiring and to check compatibility to the new PA system.

The PA system design shall include acoustical modeling and test measurements to verify conformance with ANSI S3.2 for intelligibility of speech and voice announcement requirements for minimum articulation Index of 0.80.

An average of 80 dBA plus or minus 3dB shall be achieved at 1.2 meters above tunnel floor level in accordance with ANSI S1.8 and S1.14. The background ambient noise level of 60 dBA shall be used to calculate the nominal sound pressure level in accordance with ANSI S1.14.

The harmonic distortion when measured at the speaker output shall be a maximum of 5 percent over the frequency range of 250 Hz to 5000 Hz.

The PA system shall be designed in accordance with the requirements of ASA Standards S1, S2, and S12.

The PA system shall be designed such that all speaker circuits are supervised.

The methods used for the measurement of sound pressure levels and intelligibility of speech and sound shall conform to the requirements of ANSI S1.14, and S3.2.

A cutout switch shall be provided in the Operator Control Room to allow connection or disconnection of pre-recorded messages and announcement from Operation and Maintenance Center (OMC). This interface shall conform to "Traffic Operations System" of these special provisions.

PART 2 – PRODUCTS

FUNCTIONAL REQUIREMENTS

The Public Address System shall provide manual voice and automatic announcements at Bores No. 3 and Bore No. 4 tunnel areas.

Manual voice announcements shall originate from the Operation and Maintenance Center (OMC).

Automatic announcements shall originate from the following locations or subsystem:

1. Upon activation of the Fire Alarm manual pull box, located as shown on the plans, shall initiate a one-time automatic announcement on the PA system.

Announcement shall be prioritized in using the PA system in the order listed below. Any announcement shall be pre-empted by an announcement of higher priority. Pre-empted automatic announcements that are still called for shall resume after a higher priority announcement is completed.

1. Fire Alarm
2. Code Calls

    a. Srong Motion Detector
    b. PBX System
    c. Traffic Operations System
    d. Operation and Maintenance Center

PERFORMANCE REQUIREMENTS

The PA equipment shall be of solid state design and shall be the latest manufacturer's model that satisfies the design criteria. The equipment shall be rack-mountable with balanced outputs and powered from 120 VAC, single phase, 60 Hz.

The PA system shall perform in accordance with EIA SE-104 and meet the following requirements:

Frequency Response: Plus or minus 3 dB over the frequency range of 30 Hz to 20 kHz, and plus or minus 1 dB or better over the frequency range of 250 Hz to 5000 Hz as measured from OMC handset to the output of any speaker.

Harmonic Distortion: Less than 1 percent over the frequency range of 30 Hz to 20 kHz measured at the output of any speaker.

Nominal Sound Pressure Level (SPL): Average of 80 dBA ± 3 dB at 1.5 meters above tunnel floor level.

Operating Performance: Operation between 0°C to 40°C. Relative humidity 5 percent to 95 percent.

Headroom: ± 20 dB above nominal SPL, without increase in hum, noise, total harmonic distortion, or decrease in frequency response.

Hum and Noise: 80 dB below Nominal SPL.

The power amplifier shall be provided with a nameplate indicating power rating to satisfy design coverage, SPL requirements, and reserve capacity requirements. Power amplifiers shall conform to EIA SE-101 and to the following criteria:

Frequency response: 80 Hz to 20 kHz flat plus or minus 1 dB;

Output: Constant 70.7 volts nominal, transformer isolated. Vendors may propose a different audio distribution voltage if required to satisfy functional requirement of the PA system.

Overload Protection: Current limited, thermal overload;

Front Panel Controls: ON/OFF switch, volume control, fuse or circuit breaker (maintainable from front of unit);

Front Panel Indications: LED ON/OFF indicator lamp;

Listed for Protective Signaling Service; and

Supervised in accordance with NFPA 72.

Compressors shall be provided to compensate for the varying audio levels of sources utilizing the system.

Mixer/preamplifiers shall be provided as needed that conform with the following requirements:

Inputs: Minimum of two spare inputs;
Front Panel Controls: ON/OFF switch, level controls, line or mic; and
Front Panel Indications: LED ON/OFF indicator lamp.

An Automatic Level Control Unit (ALCU) shall be provided for automatic adjustment of announcement levels to the speakers located throughout the tunnel. Sensing of the ambient noise on the tunnel and cross passages shall be via separate microphones.

A voice and tone synthesizer shall be provided to conform with the following requirements:

Messages: Minimum of 30 voice messages with a 30 second maximum time limit per message;

Tones: Multi-frequency, constant or periodic;

Supervision: Provision for supervision or fault detection in accordance with NFPA 72;

Quality: Messages generated shall be from recording and storage of human voices; and

Message Storage: Messages shall be stored in solid-state memory devices.

Loudspeakers, Audio Transformers, Enclosures, and Baffles:

Loudspeakers shall conform to EIA SE-103, RS-299, and RS-426, and shall meet but not be limited to the following requirements:

1. Power: Minimum 10 watts continuous;
2. Weatherproof, corrosion and fire resistant;
3. Listed for Protective Signaling Service;

Audio transformers shall be provided to conform with EIA RS-174 and with the following requirements;

1. Insertion loss: 0.5 dB maximum;
2. Distribution: Primary for nominal, tapped required to meet SPL;
3. Power rating: 15 watts continuous; and
4. Listed for Protective Signaling Service.

Speaker enclosures shall be designed and constructed to suppress any resonances in the audio band of 80 Hz to 20 kHz.

DC power supplies shall conform to the following requirements:

Regulation +/- 0.5 percent:
Ripple: Less the 1 percent;
Front Panel Controls: ON/OFF switch, circuit breaker;
Front Panel Indicators: ON/OFF lamp; and
120 VAC Input: Operate at 105 VAC to 130 VAC, 60 Hz +/- 5 Hz.

The supervisory equipment shall include but not be limited to the following requirements:

Output: Relay contact, one contact for any power amplifier, synthesizer or DC power supply fault.

Front panel: Latched LED for each power amplifier, synthesizer or DC power supply fault. Reset pushbutton to clear latched LEDs.

Loudspeaker cables shall be twisted single pair, foil-shielded. Cable size shall be determined by system design. Minimum cable size runs under 300 meters shall be 16 gauge; and for cable runs over 300 meters, shall be 14 gauge.

PART 3 – EXECUTION

TESTING

Factory and acceptance testing shall be performed to the PA equipment in accordance with EIA RS-276 and RS-490, and as specified in these special provisions.

In addition, the following tests shall be performed on the PA systems:

Test on coverage and intelligibility of voice announcements shall be performed by the Contractor, within Bore No. 3 and Bore No. 4 tunnel and cross passage areas.

System frequency response from handset to loudspeaker output and pre-amp to loudspeaker output at nominal SPL.

Dispersion of loudspeakers between 80 Hz to 20 kHz.

PART 4 - MEASUREMENT AND PAYMENT

Full compensation for public address system shall be considered as included in the contract lump sum prices paid for various electrical items of work involved and no additional compensation will be allowed therefor.

12-17.1623 TELEPHONE SYSTEM

PART 1 – GENERAL

Scope: The telephone system shall consist of relocation of existing main distribution frame in the Bore No. 3 West Portal Building telephone room, including ancillary equipment and rerouting of data and video signals from the existing Bore No. 1 and Bore No. 2 West Portal Building maintenance and electrical room. The telephone system shall be furnished, installed, and tested in conformance to the details shown on the plans and these special provisions. The tunnel emergency system shall include termination blocks, jacks, wire and cable, and telephones. Conduit and raceway shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions. Ductbank shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

The new OMC system shall include main distribution frame backboards, termination blocks, jacks, wire and cable, relay racks, standby battery(s), auxiliary systems, cable management items, and associated hardware in conformance with the requirements of FCC Part 68 rules and the current issue of CFR 47, Part 68.

SUMMARY

Emergency fire telephone jacks shall be installed at Bore No. 4 tunnel entrances. One emergency telephone shall be installed on Portal No. 1 Substation Building and Portal No. 2 Substation Building as shown on the plans. Telephone cables shall be installed in the ductbank between the OMC, Portal No. 1 and Portal No. 2 Substation Buildings, and the tunnel and shall terminate on the backboard in the new OMC MDF.

SUBMITTALS

The Contractor shall make submittals in conformance with the requirements specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions and the requirements specified herein.

Product data: The submittals shall include complete details, information, and drawings for the telephone system as shown on the plans and as specified in these special provisions. The submittals shall also include the following:

Manufacturer's technical data for each type of product in the telephone system.

Interconnection diagram showing all instruments and wiring.

Operation and Maintenance data to include in maintenance manuals.

QUALITY ASSURANCE

Electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, Article 100. The system and components shall comply with NFPA 502. All system components shall be UL Listed.

DEFINITIONS

Distribution Circuit: A circuit from the network interface device to a telecommunications outlet.

Main Distribution Frame (MDF): Backboard and terminal blocks for distribution and station circuits.

PART 2 – PRODUCTS

SYSTEM COMPONENTS

Jacks for emergency fire telephones shall be RJ-11. Wall plates shall be designed for telephone service and shall match those indicated for power receptacle outlets in same spaces for materials and finish. Wall plates for wall telephone units shall include provision for support of unit.

Backboards shall be 20 mm, fire-proofed interior grade plywood. Backboards shall be the size as indicated on plans. Backboards shall be painted black.

Wall mount and desk telephones shall be standard, single-line beige telephones and shall be installed in all jack locations as shown on the plans. Telephones shall be compatible with the existing PBX system.

Standard punch-down blocks shall be used for termination blocks for the main distribution frame. Termination blocks for incoming distribution cable and cable routed through the tunnel shall include isolation and surge suppression.

PART 3 – EXECUTION

Wire and cable shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

COORDINATION

The Contractor shall coordinate the ordering and installation of telephone company circuits through DGS.

TELEPHONES

Telephones shall be secured with anti-tamper screws. The telephones shall be programmed as follows:

Telephones in the OMC control room shall be capable of picking up the West Portal and East Portal Substation Buildings and tunnel emergency fire phones.

Loss of AC power to the existing PBX shall initiate power failure transfer of calls to the OMC Control room.

IDENTIFICATION

All system components, wiring, cabling, and terminals shall be identified with permanent labeling in conformance with "Basic Materials and Methods (Tunnel)" of these special provisions. The telephone system backboard shall be identified with the legend "Telephone". Identification labels shall be provided to indicate location of telephones served from each termination block.

GROUNDING

Cable shields and equipment shall be grounded according to system manufacturer's written instructions to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

FIELD QUALITY CONTROL

Testing: Test results shall be documented in writing and submitted to the Engineer prior to final acceptance of the telephone systems. The following field quality control testing shall be performed:

Test continuity of each circuit pair loops.

Test operation of each phone.

Test operation of existing PBX.

1. Verify operation of all telephones including Portal No. 1 and Portal No. 2 Substation Buildings and tunnel emergency fire phones.
2. Confirm programming operation as specified.
3. Verify PBX functions.
4. Confirm transfer of incoming line on loss of power.
5. Verify operation of existing Audio Recorder.

DEMONSTRATION AND TRAINING

The factory-authorized service representative shall perform the demonstration and train Department's maintenance personnel to adjust, operate, and maintain telephone equipment including the following:

Procedures and schedules for troubleshooting, servicing, and maintaining equipment.

Review data in maintenance manuals.

Training shall be scheduled with the Engineer with at least seven days advance notice.

PART 4 – MEASUREMENT AND PAYMENT

Full compensation for telephone system shall be considered as included in the contract lump sum price paid for relocate equipment from existing to new OMC Building and no additional compensation will be allowed therefor.

12-17.1624 TUNNEL CALL BOX

PART 1 – GENERAL

SUMMARY

Scope: This work shall consist of Tunnel Call Box in accordance with the details shown on the plans and these special provisions. Tunnel call box shall also include the installations of conduit and raceway in conformance with "Basic Materials and Methods (Tunnel)" of these special provisions.

DESCRIPTION OF WORK

Furnish and install a complete system for the Tunnel Call Box system and other equipment as shown on the plans and as further defined herein:

Existing call box for Bores 1, 2 and 3 will be upgraded to SCADA/PLC by providing control through hardwired I/O and software logic and interlock through the SCADA/PLC system. New Call Boxes for Bore 4 shall be implemented in the same manner.

The system shall include, but may not be limited by the following list:

1. Call Box, caution and sign assembly which include cellular antenna, power supply transformer, battery charger, flasher, fluorescent and LED lighting, ballast, relays and any contact closure output device, raceways and electrical boxes and fittings required for the installation of the equipment and wiring.
2. Existing Call Box conversion to SCADA work includes field checkout of existing relay control in the existing console number 1 located in Bore 3 West Portal building control room and removal of relays and rewire of the control interface points to the existing PLC panel No. 1 located in the same room. At the Bore 3 East Portal the control interface points shall be to the existing PLC panel No. 2.

SUBMITTALS

Shop Drawings: Submit dimensioned drawings of Call Box caution and sign assembly and accessories.

Control Schematic Diagram: Submit a diagram of the system configuration proposed indicating the type, size and number of conductors between each component if it differs from that illustrated in the diagram shown on the plans.

Bill of Materials: Submit a complete bill of materials with part numbers and voltage specifications.

PART 2 – PRODUCTS

MATERIALS

Call Box: Seventeen new Call Boxes for Bore 4 will be state-furnished to match existing Call Box manufactured by Comarco Wireless Technologies.

Caution and Call Box Signs: Dimensions, assembly, bill of materials, mounting, finish, to match existing system and as shown on the plans and these special provisions.

PART 3 – EXECUTION

INSTALLATION

Furnish labor and related materials, appliances, tools and equipment necessary for and incident to performing all operations in connection with furnishing, delivery, installation, training and operation of Tunnel Call Box in accordance with manufacturer's written instructions, NEMA standards, NEC requirements.

Locations and Layout: Bore 4 Call Boxes will be installed inside the fire telephone cabinets (FTC) in the tunnel niches on both sides of the tunnel.

FIELD QUALITY CONTROL

Inspect installation and equipment for physical damage, proper alignment, anchorage, grounding and completeness.

Check continuity of all circuits

Check tightness of all bolted connections

Check nameplates and identification.

The commissioning of the Tunnel Call Box shall be in conjunction with the "Tunnel SCADA/PLC Control and Monitoring System" of these special provisions.

A trained electrician shall functionally test each component in the system after installation to verify proper operation and confirm that the Call Box, Call Box caution and signs conform to the wiring documentation.

PART 4 – MEASUREMENT AND PAYMENT

The contract lump sum price paid for tunnel call box shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in testing and integrating the tunnel call box as a single system, complete in place, as shown on the plans, as specified in these special provisions, and as directed by the Engineer.

12-17.1625 ACCESS CONTROL AND INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

SUMMARY

Scope: The Access Control and Intrusion Detection (ACID) system includes cross-passage door sensors, intrusion detection control panel, cross-passage emergency signs (CPES), intercom units, facility entrance gate controller modification, and the OMC ACID software.

Security data and control options from the ACID subsystems will be available to operators at the traffic operations system (TOS) workstations in the OMC Building control room. Operators will also use intercoms and motorized gate controls at each operator console to control access at the facility gates. Operators will have the ability to communicate with intercom units located at cross passages in Bore No. 3 and Bore No. 4, and at the west portal area gates.

SUBMITTALS

The Contractor shall submit shop drawing, consisting of equipment list and drawings in conformance with the provisions in Section 86-1.04, "Equipment List and Drawings," of the Standard Specifications. The Contractor shall submit complete shop drawings for all proposed products to the Engineer for approval a minimum of 30 days before ordering or fabrication of equipment.

Manufacturer's technical data for each type of product in the system, including data on features, ratings, and performance shall be submitted for approval.

Shop drawings for equipment, including plans, elevations, sections, details, and attachments to other work, plan views of device locations and routing of raceway connections, and wiring diagrams showing power, signal, and control wiring, differentiating between manufacturer-installed and field-installed wiring shall be submitted for approval.

Operation and Maintenance data included in the maintenance manuals shall be in conformance with the provisions in "Basic Materials and Methods (Tunnel)" of these special provisions.

The Contractor shall provide the Engineer a Certificate of Compliance from the manufacturer for each product shipment in conformance with the provisions of Section 6-1.07, "Certificates of Compliance," of the Standard Specifications.

Warranty:

All equipment in the ACID system shall be warranted by the manufacturer against defects in materials and workmanship for 5 years beyond system acceptance. Product manufacturer warranties shall be transferred to the State by the Contractor.

Warranties for all products shall be submitted to the Engineer for approval 2 weeks prior to installation of equipment.

QUALITY ASSURANCE

Each device type in the system shall have been tested by an independent testing laboratory to meet or exceed the requirements listed below. Each shipment of ACID devices shall be listed and labeled by the independent testing laboratory.

PART 2 - PRODUCTS

CROSS PASSAGE DOOR SENSOR

Sensors shall be overhead mount door switches. Door sensors shall sense door openings and closings by closing and opening contacts. The cross-passage door sensor indicates to the TOS server the current status of the cross-passage doors.

Door sensors on doors in the cross-passages shall indicate door open or door closed by sending a signal to intrusion detection control panel. Switches shall be designed to work with steel doors.

Status indication shall be displayed on TOS workstations in the new OMC Building no more than 2.0 seconds after a change in door status. Attention is directed to Section "Traffic Operations System Software" of these special provisions for response time requirements.

Sensors shall meet the following requirements:

Environmental Limitations:

1. Temperature: 0°C to 66°C
2. Relative Humidity: 0 to 100 percent, condensing (hermetically sealed)

Door Open Accuracy: minimum 99.9 percent

Door Closed Accuracy: minimum 99.9 percent

Active Gap Distance: minimum 50 mm

Mass: maximum 500 g per switch/magnet combination

Dimensions:

1. Height: maximum 50 mm
2. Width: maximum 50 mm
3. Depth: maximum 26 mm

Electrical (per sensor):

1. Switch Configuration: SPDT
2. Power Switching Capability: maximum 30V (dc) at maximum 0.25A
3. Maximum Power Dissipated: maximum 3.0 VA
4. Transient Protection: NEMA TS-2 Section 2.1.6

UL rating

INTRUSION DETECTION CONTROL PANEL

The intrusion detection control panel senses the door switch change-of-state, time stamps each switch status change, and sends the event data to the TOS via the fiber optic Ethernet switch (FOES). OMC Building control room software shall respond to the messages and shall update the TOS database.

The intrusion detection control panel shall provide power to operate the door switch. The intrusion detection control panel shall translate contact closures to changes in door switch status.

The intrusion detection control panel shall provide contact closure outputs as follows:

One contact closure output shall be connected to a tunnel pan/tilt/zoom (PTZ) CCTV camera associated with the cross-passage door. When the cross-passage door opens, the contact closure output shall be asserted, which will automatically initiate a move to a preset position for the tunnel PTZ camera. Attention is directed to Section "Closed Circuit Television System" of these special provisions for requirements regarding CCTV.

One contact closure output shall be connected to the cross-passage emergency signs (CPES) on the either side of the cross-passage. The contact closure output shall provide the ability to operate the CPES in the following modes:

Remote: TOS operators at the OMC Building will be able to select software functions accessed via the graphical user interface on TOS workstations. Software functions that activate and deactivate the CPES include those associated with ACID control and emergency response plan (ERP). Attention is directed to Section "Traffic Operations System Software" of these special provisions for ACID and ERP functional requirements.

Local: When either cross-passage door opens, the contact closure output shall be asserted, which shall automatically activate the CPES over each door at both ends of the cross-passage.

At each west portal gate, 2 contact closure outputs shall be connected to the entrance gate motor controller. The contact closure outputs shall provide the ability to communicate open gate and close gate commands to the existing tunnel facility entrance gate motor controllers. The gate controller circuitry for opening and closing the gates shall be activated by keypad at each gate, or remotely from the control room in the OMC Building.

The cross-passage intrusion detection control panel shall be mountable in the cross-passage TOS cabinet.

Intrusion detection control panels shall meet the following requirements:

Ethernet Interface: 10/100Base-T Ethernet

Contact Closure Digital Input Interface: screw terminals, one pair per input

Contact Closure Digital Output Interface: screw terminals, one pair per output

Power to Screw Terminals: minimum 0.20A at 24V (dc)

Environmental Specification:

1. Temperature: 0°C to 74°C
2. Relative Humidity: 5 to 95 percent, non-condensing

Mass: maximum1000 g

Dimensions:

1. Height: maximum 203 mm
2. Width: maximum 152 mm
3. Depth: maximum 26 mm

Electrical (per sensor):

1. Switch Configuration: SPDT
2. Power Switching Capability: maximum 30V (dc) at maximum 0.25A
3. Power Requirements: maximum 24V (dc)
4. Power Consumption: maximum 10W
5. Transient Protection: NEMA TS-2 Section 2.1.6
6. Network Interfaces: minimum one 10/100Base-T Ethernet
7. Network Connectors: minimum 2 EIA-568
8. Contact Closure Inputs: minimum 2
9. Contact Closure Outputs: minimum 2

CROSS PASSAGE EMERGENCY SIGN

The cross-passage emergency sign (CPES) shall be activated or deactivated under automatic TOS or manual operator control.

The CPES inside the doors of the cross-passages shall inform pedestrians of live traffic in the adjacent bore by flashing the amber 2-line message "LIVE TRAFFIC AHEAD" and "USE CAUTION" flashing on and off at one second intervals.

Each CPES shall have a single-face consisting of black acrylic background and white acrylic stencil characters with LED backlight.

The CPES shall be controlled via a contact closure output from the intrusion detection control panel as specified herein.

The CPES shall have 2 control states, either activated or deactivated. When activated, the CPES message shall flash on and off. When deactivated, the CPES message shall be dark

The CPES at each end of a cross-passage shall automatically be activated by a contact closure output in the intrusion detection control panels whenever either door of the cross-passage is open.

The Contractor shall provide the ability for the TOS operator at the OMC Building to select a CPES from the graphical user interface associated with ACID functions, and issue an "ON" or "OFF" command. The command shall be sent to the intrusion detection control panel associated with the selected CPES, which shall activate or deactivate the CPES. The CPES shall be activated by TOS software functions associated with the emergency response plan (ERP) described in Section "Traffic Operations System Software" of these special provisions.

The LED backlight and flasher shall be capable of a minimum of 100,000 hours of continuous operation.

CPES shall be a single, locking, self-contained device, not requiring on-site assembly for installation. The CPES enclosure shall open from the front and shall comply with NEMA 3R requirements. Mounting and locking hardware shall be stainless steel.

CPES shall have a minimum 3 mm thick acrylic face and a door and gasket between the face and the aluminum cabinet. The font panel shall be contained within an extruded aluminum frame. All exterior mounting hardware shall be of stainless steel or cadmium plated materials.

Assembly and manufacturing processes for CPES shall be designed to assure all internal components will be adequately supported to withstand mechanical shock and vibration.

CPES shall meet the following requirements:

Environmental Specification:

1. Temperature: 0°C to 74°C
2. Relative Humidity: 5 to 96 percent, non-condensing

Mass: maximum 25 kg

Dimensions:

1. Height: maximum 255 mm
2. Width: maximum 660 mm
3. Depth: maximum 77 mm

Electrical:

1. Power Consumption: maximum 50W at 120V (ac)
2. Power Requirements: 120V (ac), of 60 Hz ± 3 Hz
3. Transient Protection: NEMA TS-2 Section 2.1.6

The power supply and flasher module for each CPES shall be mounted inside the CPES enclosure.

OMC ACCESS CONTROL AND INTRUSION DETECTION SOFTWARE

The interface between operators and the OMC Building access control and intrusion detection subsystem shall be the TOS operator workstation, reading, inserting and updating the ACID database.

All OMC Building and cross-passage doors shall send event data by IP to the TOS traffic management servers. This data shall update the ACID database maintained within the TOS database servers. Data shall be made visible for monitoring and control and alarms shall be made visible to operators through a security application running on the TOS workstations as specified in "Traffic Operations System Software" of these special provisions.

All event messages shall be visible in the security database.

INTERCOM SUBSYSTEM

The intercom subsystem shall allow 2-way voice communications between the TOS operators and personnel requesting entry to the OMC facility at the main building door entrance and at each of facility access road entrances. The intercom subsystem shall allow 2-way voice communications between the TOS operators and emergency personnel at cross-passages in Bores No. 3 and No. 4. The intercom subsystem shall utilize a voice over IP (VoIP) transport technology and shall be accessed and integrated through the TOS operator workstation.

Intercom units intended for installation at outdoor and tunnel locations shall be weatherproof and of vandal-resistant construction, consisting of a user push-to-call button and combination microphone/speaker assembly. The unit shall be capable of stand-alone pedestal, pole, or wall mounting using a suitably sized NEMA 4X rated enclosure, or be capable of flush mounting at building and tunnel locations as shown on the plans.

The intercom units shall meet the following requirements:

Environmental Specification:

1. Temperature: -20°C to 80°C;
2. Relative Humidity: 5 to 95 percent, non condensing;

Electrical Specification:

1. Power: 9-24VDC stand-alone or power-over-Ethernet (POE) in accordance with IEEE 802.3af, 6 watts maximum
2. Ethernet: Network Interface: 10/100Base-T via copper (EIA-568) or fiber
3. Ethernet: Network Protocols: TCP, UDP, IP, Ethernet MAC, SNTP
4. Internet Engineering Task Force (IETF) Protocols:
5. Session Initiating Protocol (SIP) - RFC 3261
6. Internet Group Management Protocol (IGMP) v3 - RFC 3376
7. Real-time Transport Protocol (RTP) - RFC 1889.IP Address Assignment: Static or Automatic via DCHP
8. Audio Sample Rate: 8 kHz
9. Audio Coding: PCM 16-bit
10. Audio Latency: less than 0.5 seconds
11. Bandwidth: less than or equal to 350 kbps during active conversation

Functional Specifications: The intercom units shall be SIP or multicast softphone addressable. The intercom units call button shall perform the following functions when pushed:

1. The intercom unit shall light an LED indicator.
2. The intercom unit shall play a confirmation tone or optional recorded message.
3. The intercom unit shall initiate a call to one or more SIP addresses associated with the TOS operator workstations.

SIP Proxy Servers (IP-PBX):

The Contractor shall provide a rack-mounted SIP proxy server or IP-PBX (Internet Protocol - Private Branch Exchange) in the OMC Building server room.

The SIP proxy server shall provide call setup and signaling in order to create 2-party and multiparty calls between VoIP intercom units and the TOS operator workstations.

The SIP proxy server shall be used to provide IP registration, authentication, and authorization for IP services, implement real-time call routing, and provide telephone type features.

The Contractor shall setup and configure the SIP proxy server for all intercom units and TOS workstations (i.e. clients) as specified herein and shown on the plans. The Contractor shall provide the ability for remote user administrative and configuration of the SIP proxy server via the network.

The SIP proxy server shall meet the following requirements:

Environmental Specification:

1. Temperature: 0°C to 60°C
2. Relative Humidity: 5 to 95 percent, non-condensing

Electrical Specification:

1. Power: 90 - 240 VAC; 2 A maximum;
2. Ethernet: Network Interface: Two 10/100/1000Base-T, EIA-568 connector
3. Ethernet: Network Protocols: TCP, UDP, IP, Ethernet MAC, SNTP, SNMP
4. Internet Engineering Task Force (IETF) Protocols:

5. Session Initiating Protocol (SIP) - RFC 3261
6. SIP Info Method - RFC 2976
7. Reliability of Provisional Responses in SIP - RFC 3262
8. Extension to SIP for Symmetric Response Routing - RFC 3581
9. SIP Specific Event Notification - RFC 3265
10. Session Description Protocol (SDP) - RFC 2327
11. An Offer/Answer Model with SDP - RFC 3264
12. Message Digest 5 (MD5) authentication for SIP

Processor and Storage:

1. Dual-Core processer 3.0GHz (minimum)
2. 1024 MB RAM (minimum)
3. Embedded Windows XP or Linux operating system

Capacity:

1. Minimum number of extensions (e.g. intercom units, TOS workstations): 25
2. Minimum number of concurrent calls: 10

Telephone Functions:

1. Call Transfer, Call Waiting, Call Hold
2. Unconditional, no answer, busy, and unavailable call forwarding

Software applications required for the operation and configuration of the intercom subsystem, including software applications for the SIP proxy servers and TOS operator workstations, shall be provided by the Contractor in accordance with "Traffic Operations System Software" of these special provisions.

CONDUIT, RACEWAYS, AND WIRING

Conduit and raceway shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

Wire and cable shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

PART 3 - EXECUTION

Identification: All system components, wiring, cabling, and terminals shall be identified with permanent labeling in accordance with "Basic Materials and Methods (Tunnel)" of these special provisions.

Grounding: Cable shields and equipment shall be grounded according to system manufacturer's written instructions to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

Cleaning: Paint splatters and other spots, dirt, and debris shall be removed. Scratches and marred finishes shall be touched up to match original finish. Units shall be cleaned thoroughly using methods and materials recommended by the manufacturers.

TESTING

Pretesting: After aligning and adjusting the system in accordance with manufacturers' recommendations, components, wiring, and functions shall be pretested to verify that they comply with specified requirements. Malfunctioning or damaged items shall be replaced, and the system shall be retested. The equipment shall be prepared for acceptance and operational testing.

Testing Prerequisites:

The conduit system for electrical power and communications to all ACID system devices shall be complete before performing ACID system testing and integration. Electrical power shall be available at all ACID device cabinets and in the control, server and communications rooms. The telephone system shall be operational.

The CCTV system shall be tested and integrated before performing the ACID system testing and integration. Testing and integration of the ACID system shall be performed as specified in "System Commissioning" of these special provisions.

Factory test and certification tags shall have been previously submitted to and accepted by the Engineer for all subsystem components prior to testing.

Testing: The Contractor shall schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. The Contractor shall notify the Engineer at least 10 days prior to testing. Testing and integration shall conform to "System Commissioning" of these special provisions.

PART 4 - MEASUREMENT AND PAYMENT

The contract lump sum price paid for access control and intrusion detection system shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and installing the access control and intrusion detection system, complete in place, including wiring and testing, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

12-17.1626 ENVIRONMENTAL MONITORING SYSTEM

All equipment to be furnished and installed shall be compatible with the equipment specified in "Tunnel SCADA/PLC Control and Monitoring System" of these special provisions. The installation shall comply with NFPA 70, "National Electrical Code."

PART 1 – GENERAL

The environmental monitoring system for detection of carbon monoxide (CO) and nitrous oxide (NO) including monitors, mounting, wire and cable, testing and training shall conform to these special provisions. Conduit and raceway shall conform to "Basic Materials and Methods (Tunnel)" of these special provisions.

SUMMARY

Scope: CO and NO detectors shall be installed inside the Fire Telephone Cabinet (FTC) in the tunnel as shown on the plans to detect hazardous levels of the gases. Monitors shall read the level of CO and the level of NO in the tunnel at regular intervals and provide that data to the SCADA/PLC system. Each monitoring location shall consist of one CO monitor and one NO monitor.

REFERENCES

Underwriters Laboratories, Inc., UL 2075, UL Standard for Safety Gas and Vapor Detectors and Sensors

Underwriters Laboratories, Inc., UL 2034, Single and Multiple Station Carbon Monoxide Alarms

SUBMITTALS

The Contractor shall make submittals in conformance with the requirements specified in "Submittals" in section "Basic Materials and Methods (Tunnel)" of these special provisions and the requirements specified herein.

Product Data: The submittals shall include complete detailed information and drawings for the environmental monitoring system as shown on the plans and as specified in these special provisions. The submittals shall include the following:

Manufacturer's technical data for each type of product in the environmental monitoring system.

Shop wiring diagrams showing detail wiring and differentiating between manufacturer-installed and field-installed wiring. Diagrams for equipment and for the system shall be included with all terminals and interconnections identified. Device locations and routings of raceway connections shall be indicated.

System operation description including detailed description of method of operation.

Maintenance data to include in the maintenance manuals.

PART 2 – PRODUCTS

SYSTEM COMPONENTS

Gas Monitors: Gas Monitors shall be housed in an aluminum, epoxy-coated enclosure. Sensors shall be mounted external to the monitor for easy replacement. Monitors shall be rated for an installation in an outdoor environmental and shall be designed for the detection of either CO or NO gas. The monitors shall operate in the diffusion mode. A sampling tube will not be required. The monitors shall be calibrated in the factory prior to shipping. The monitors shall have the following features:

Field – replaceable plug-in sensors.

Internal relay contacts for FAULT, WARNING and ALARM.

4-20 mA output, RS-485 with Modbus.

Logging of minimum, maximum and average gas concentrations over field programmable time intervals.

Selectable lock-out of output signals during calibration.

Local display of the gas concentration, analog output of gas concentration, alarm indications and optional relay outputs.

Built-in temperature compensation.

Measuring Range: 0-100 ppm; Accuracy 2 ppm or less.

CSA and UL approved: Class 1, Div. 1, Groups B, C, & D.

PART 3 – EXECUTION

INSTALLATION

Grounding: Cable shields and equipment shall be grounded according to system manufacturer's written instructions to eliminate shock hazard and to minimize ground loops, common mode returns, noise pickup, cross talk, and other impairments.

FIELD QUALITY CONTROL

Manufacturer's Field Service: A factory-authorized service representative shall inspect field-assembled components and connections and supervise pretesting, testing, and adjustment of the system.