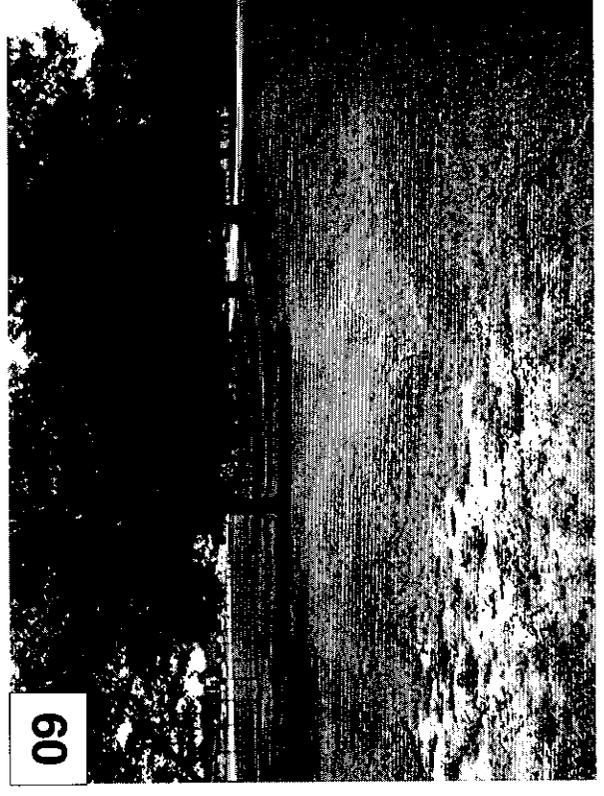
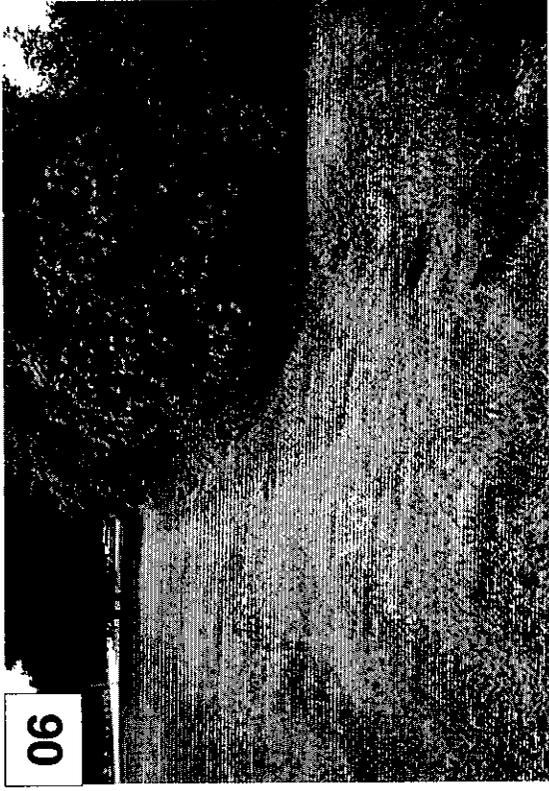


# APPENDIX J

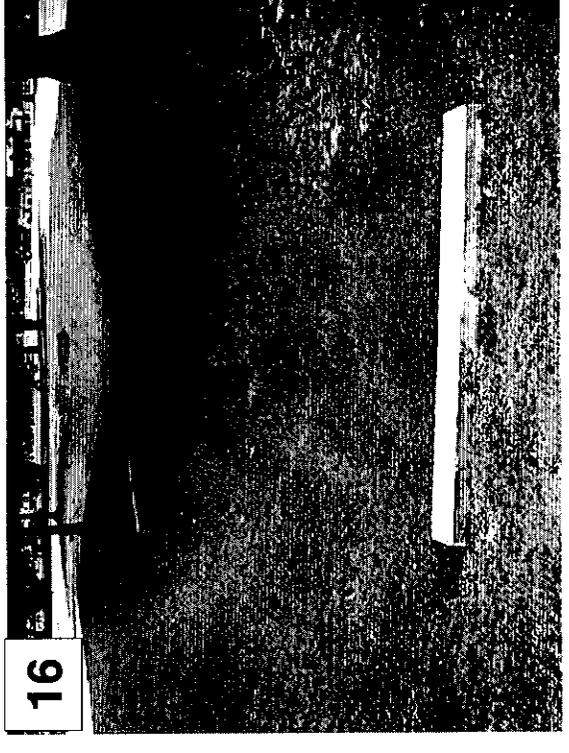
## SITE PICTURES REFERENCED FROM DRAWINGS

APPENDIX J INCLUDES PICTURES OF THE PROJECT SITE. THESE PICTURES CORRESPOND TO THE  SYMBOL ON DRAWINGS C-101 THROUGH C-107. THE NUMBER IN FRONT OF THE CAMERA CORRESPONDS TO THE NUMBER IN THE UPPER RIGHT HAND CORNER OF THE PICTURES.





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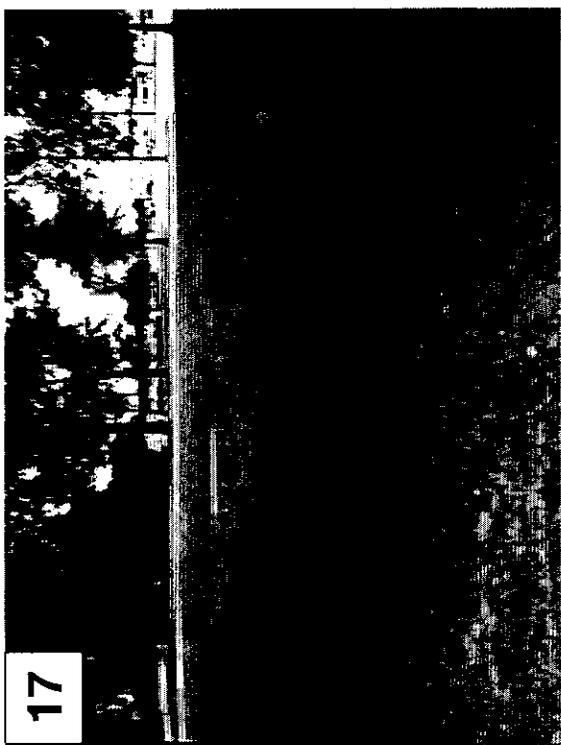
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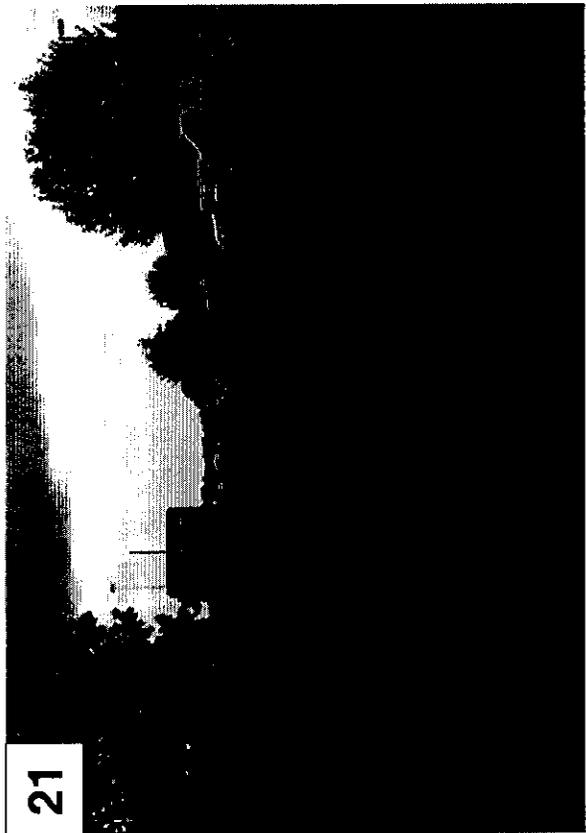




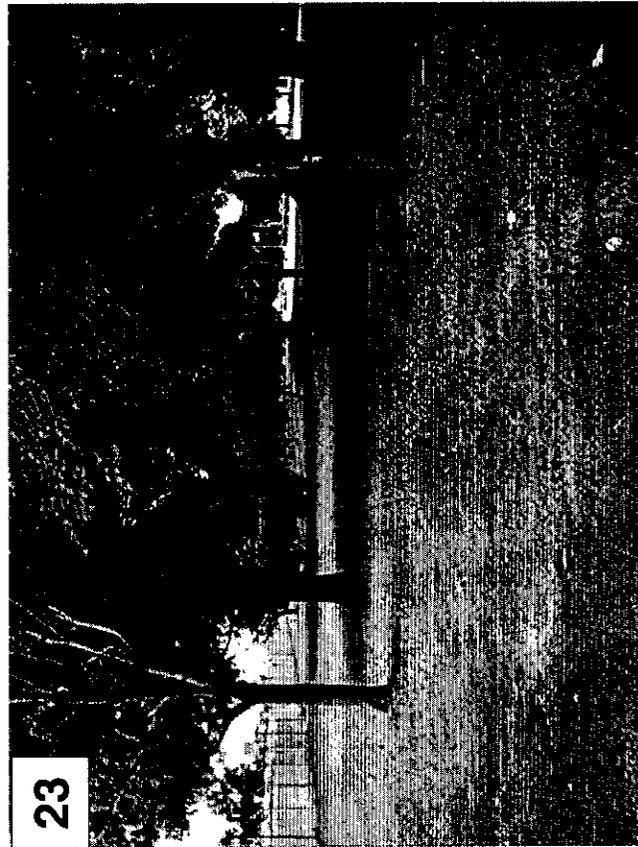
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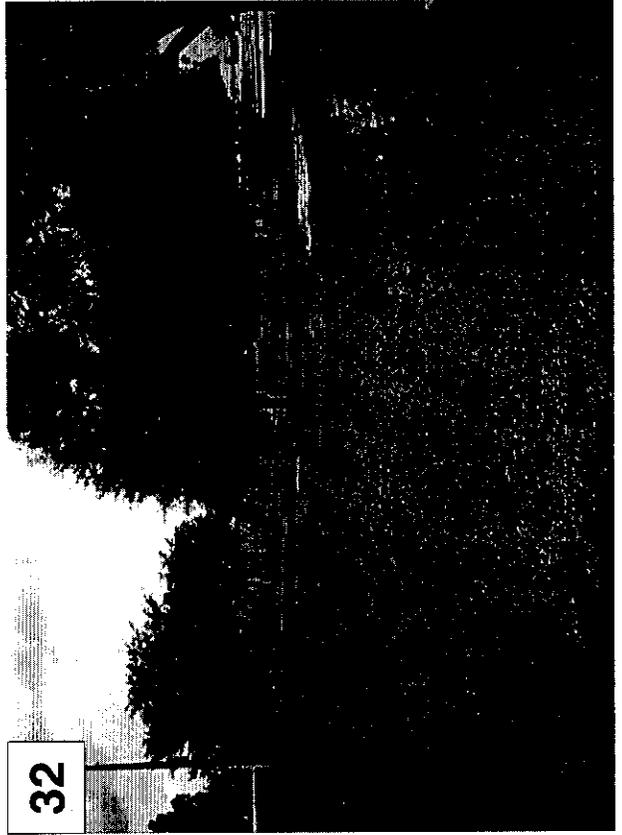
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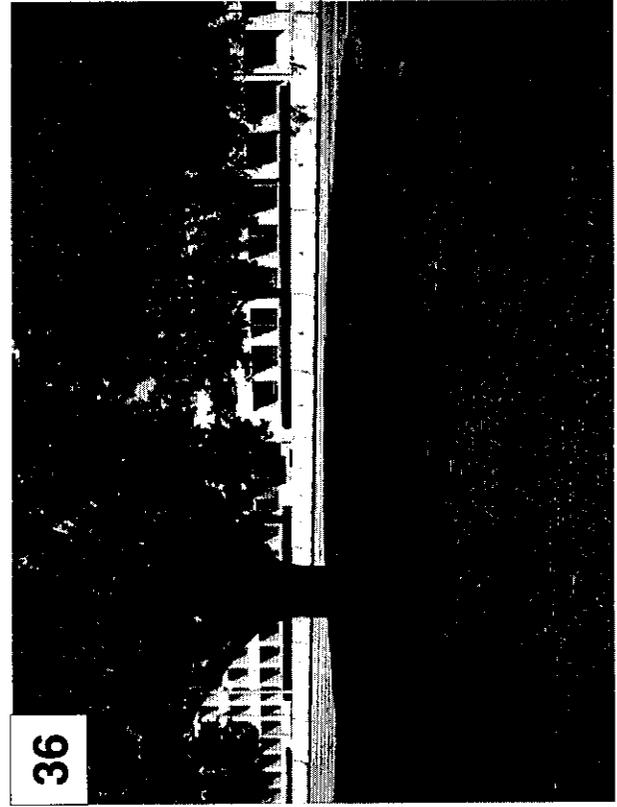
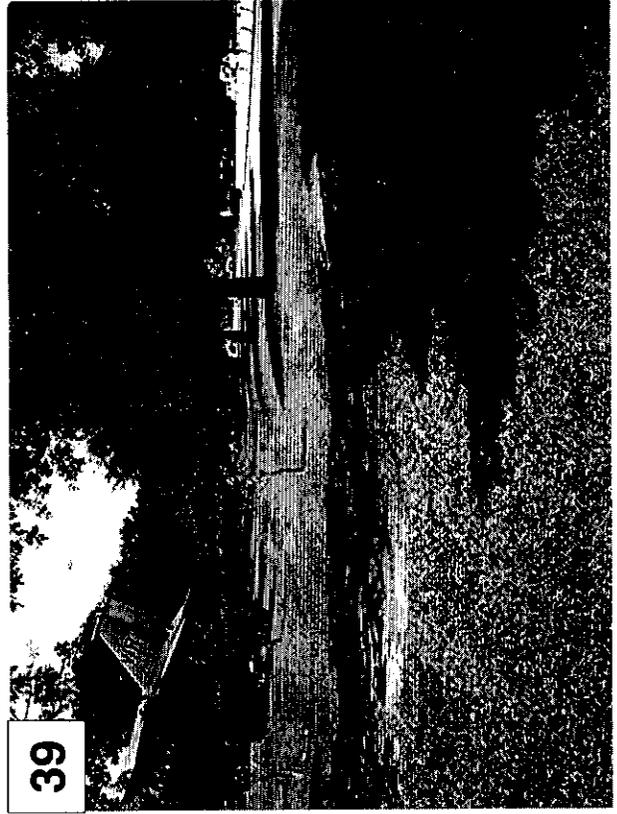
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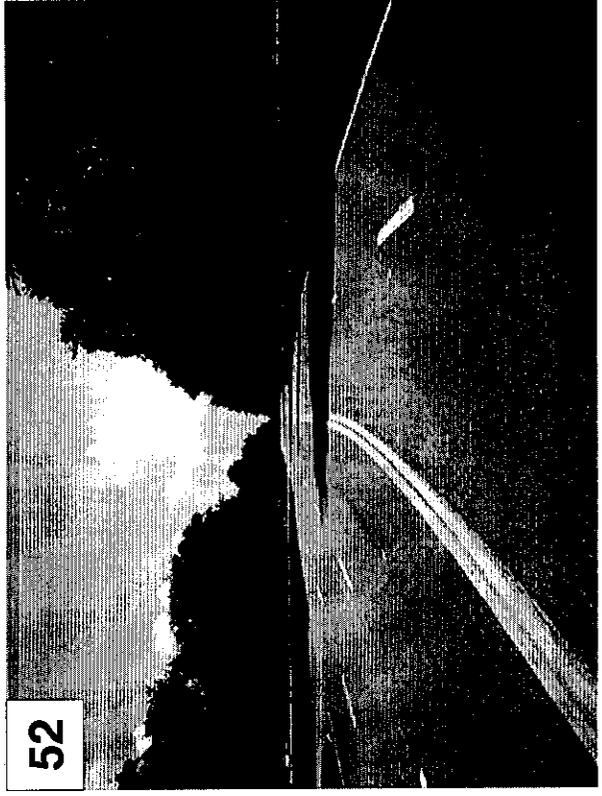
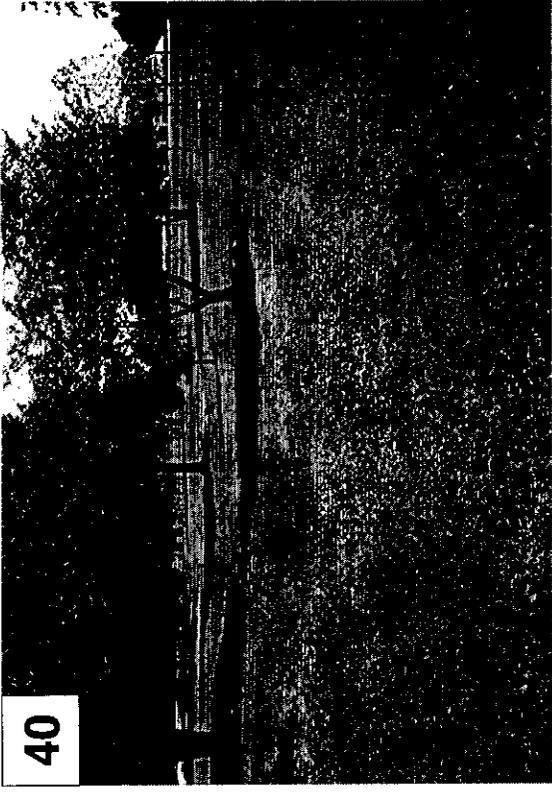


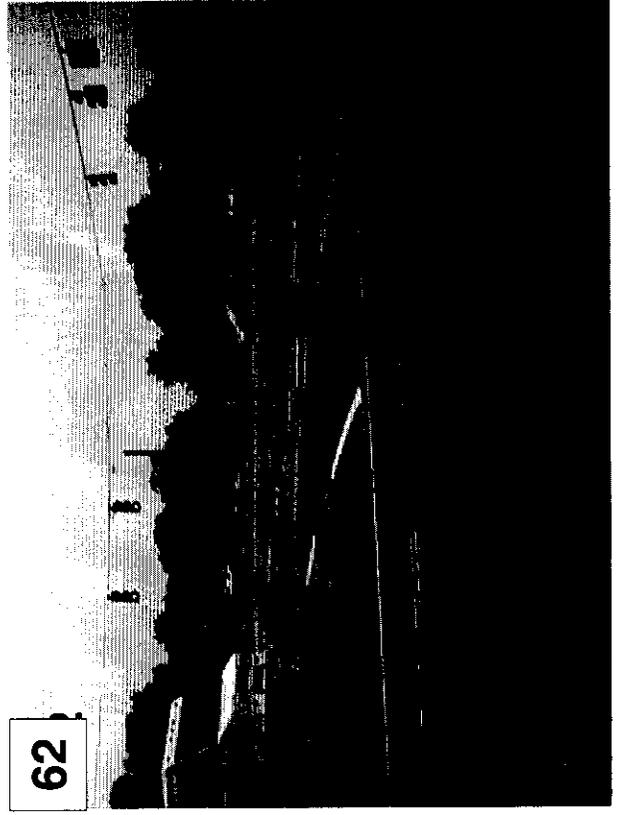
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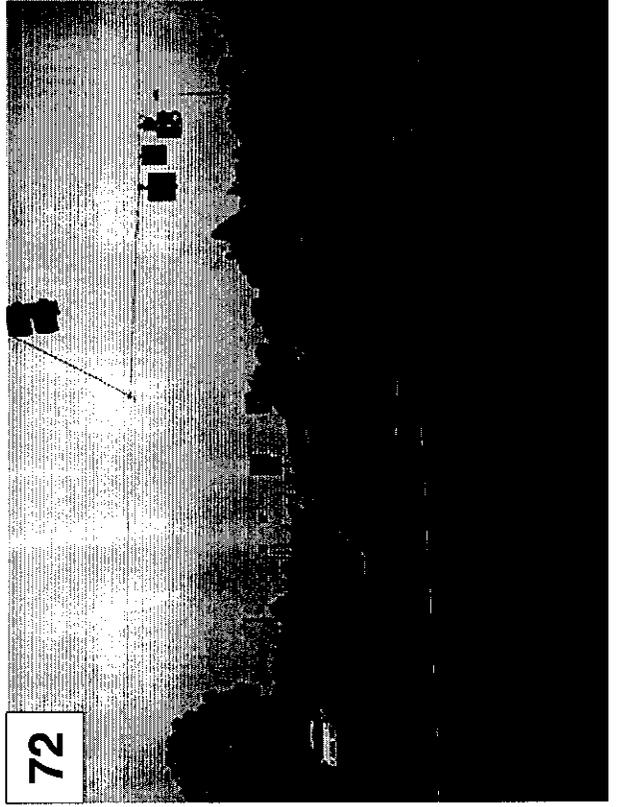
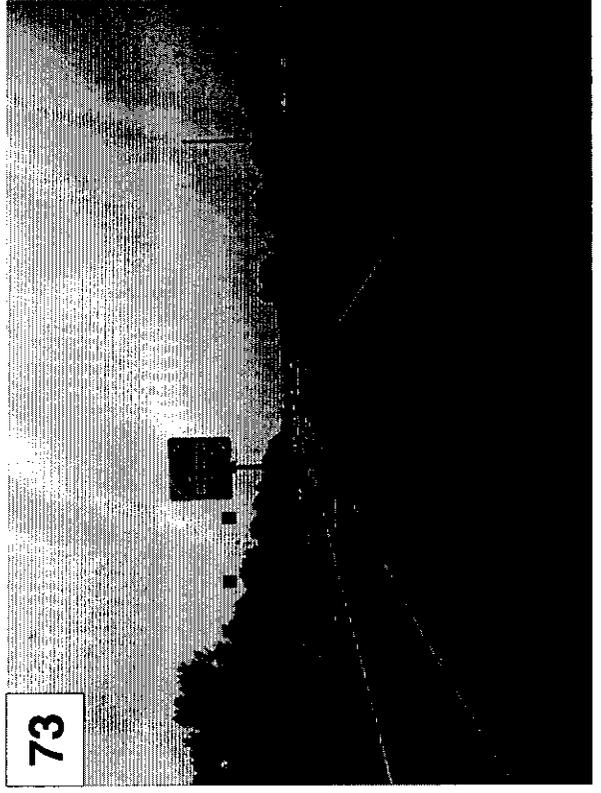
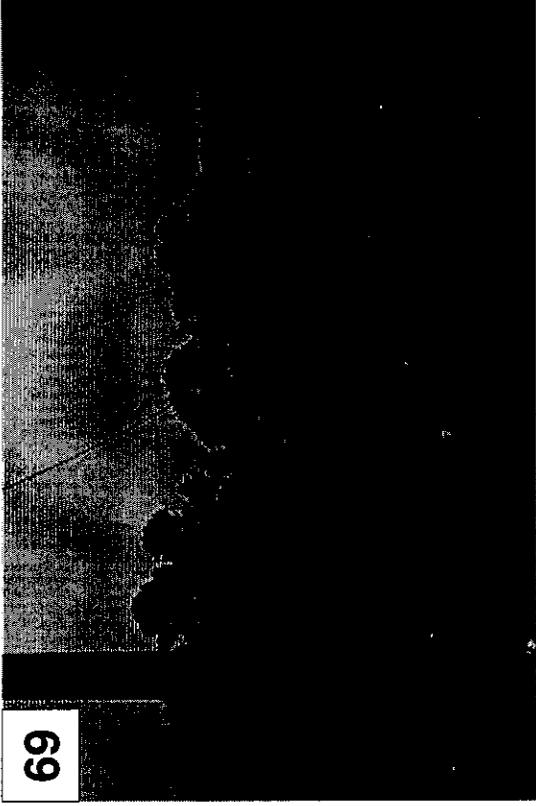


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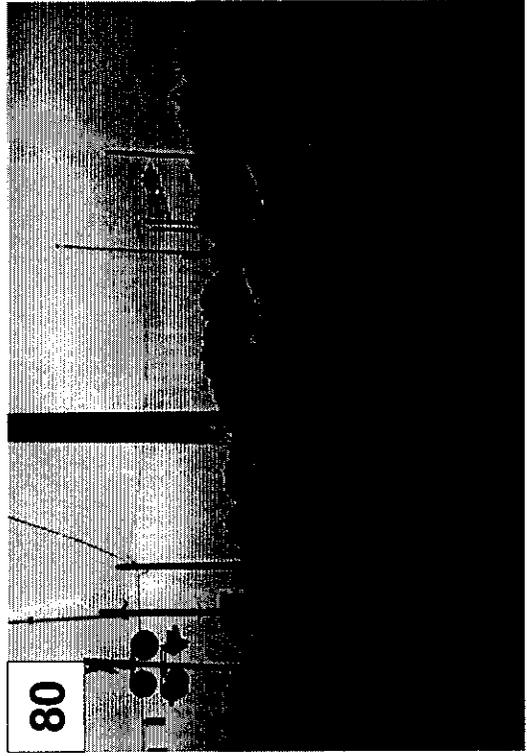
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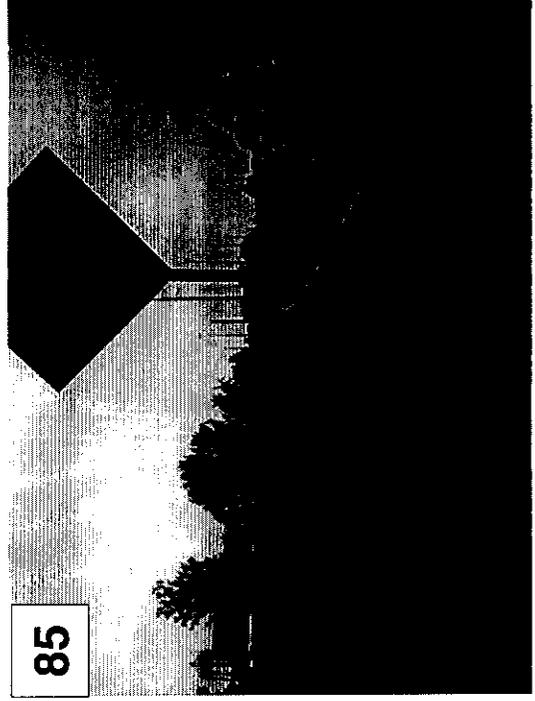
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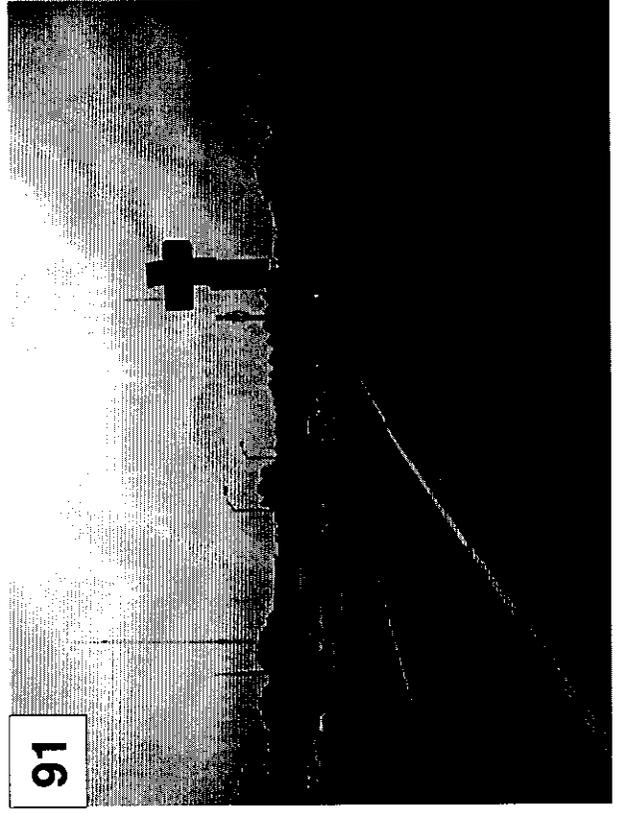


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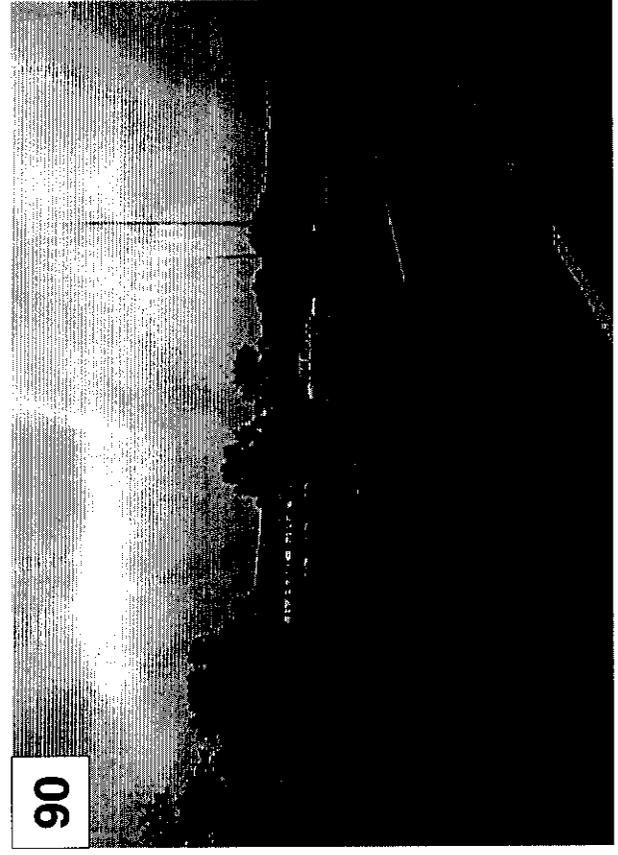
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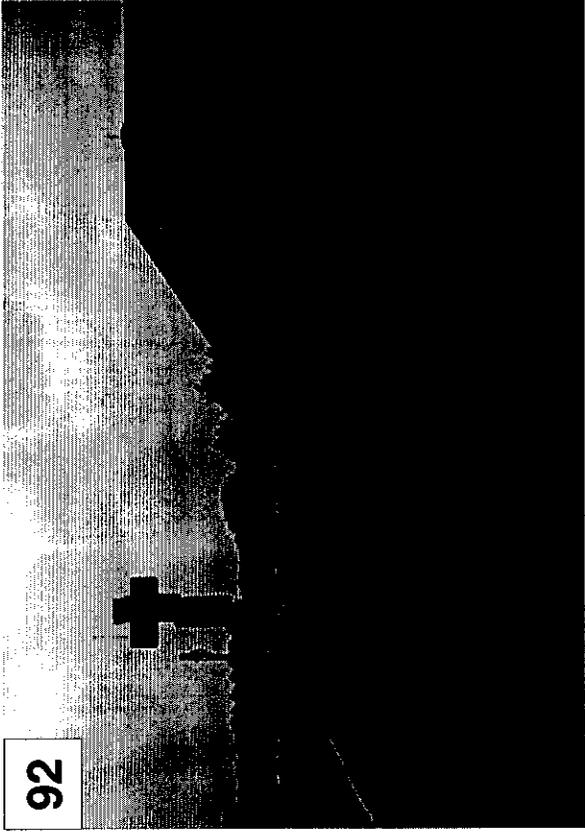
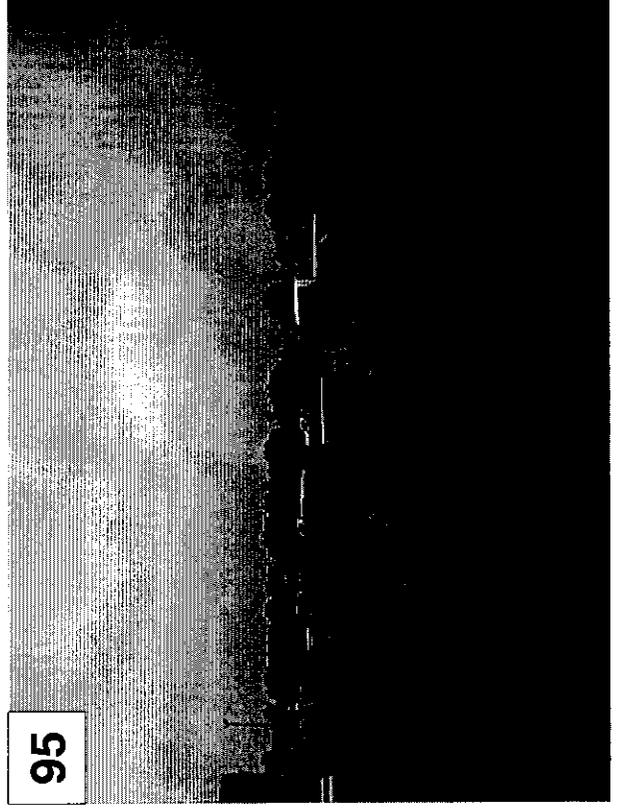
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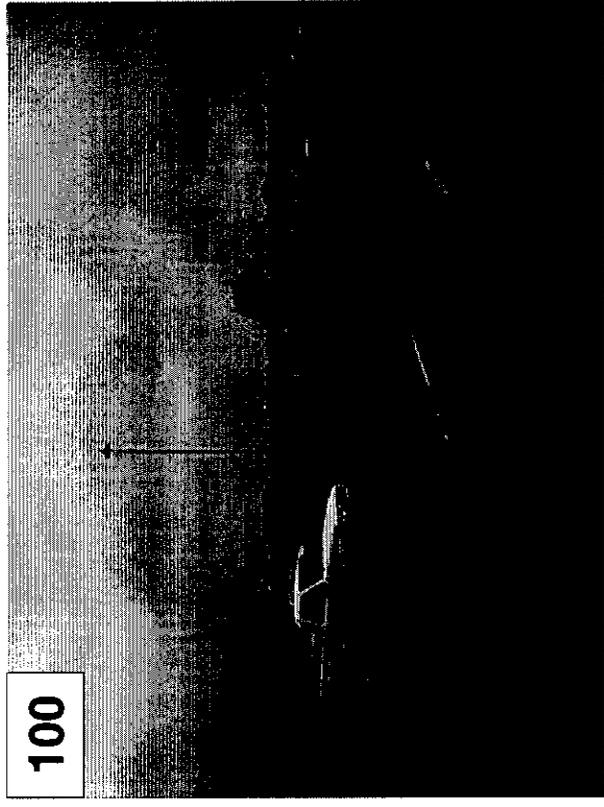


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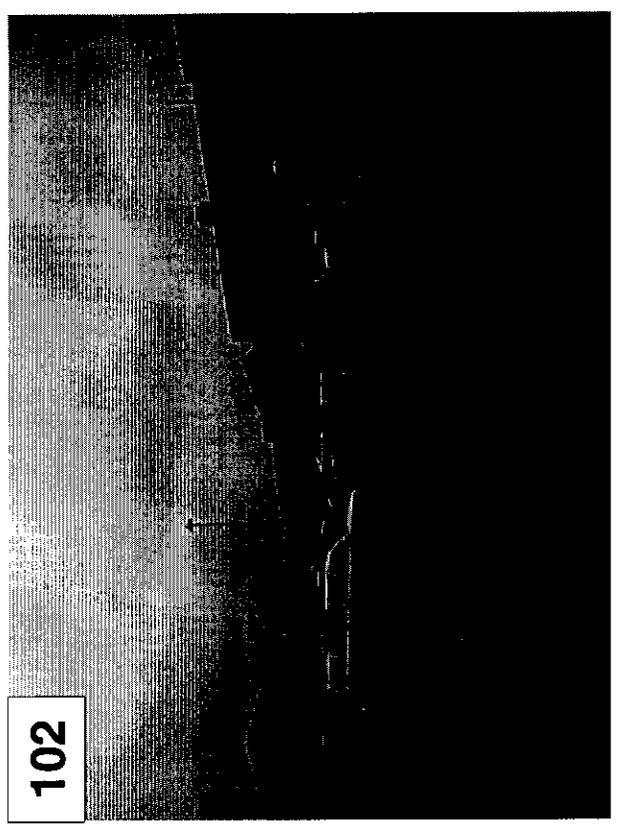


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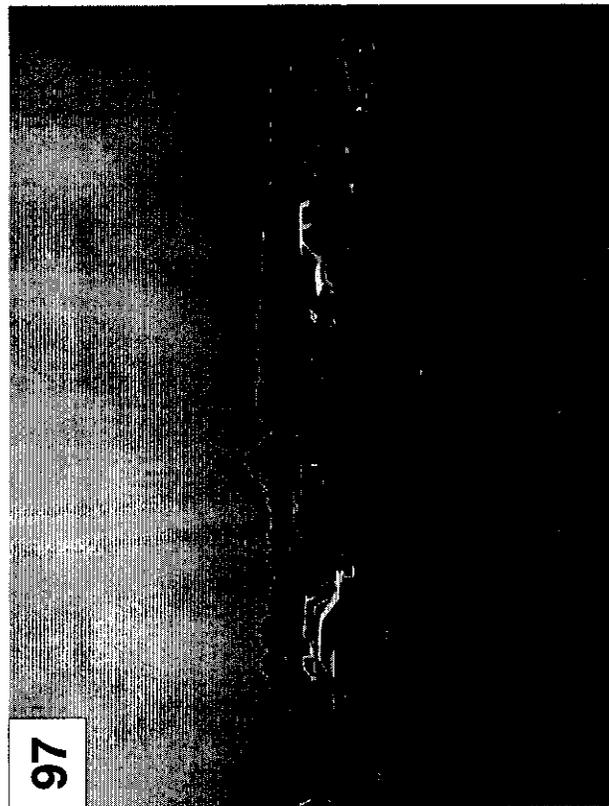




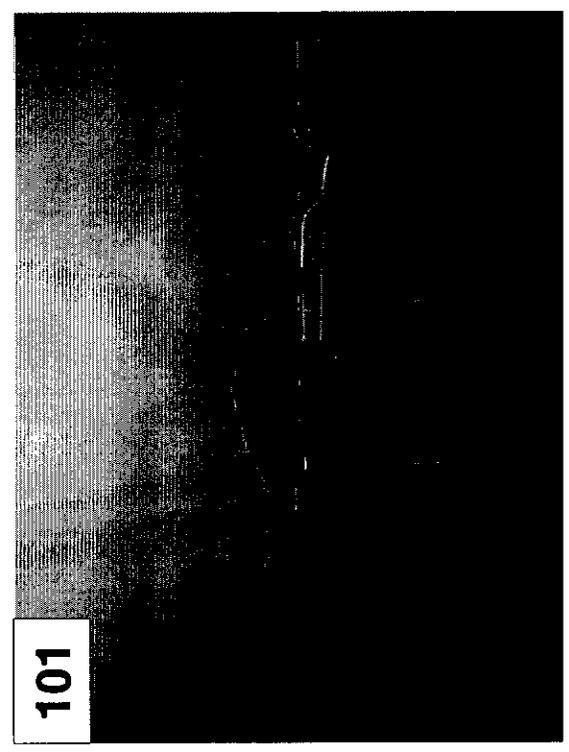
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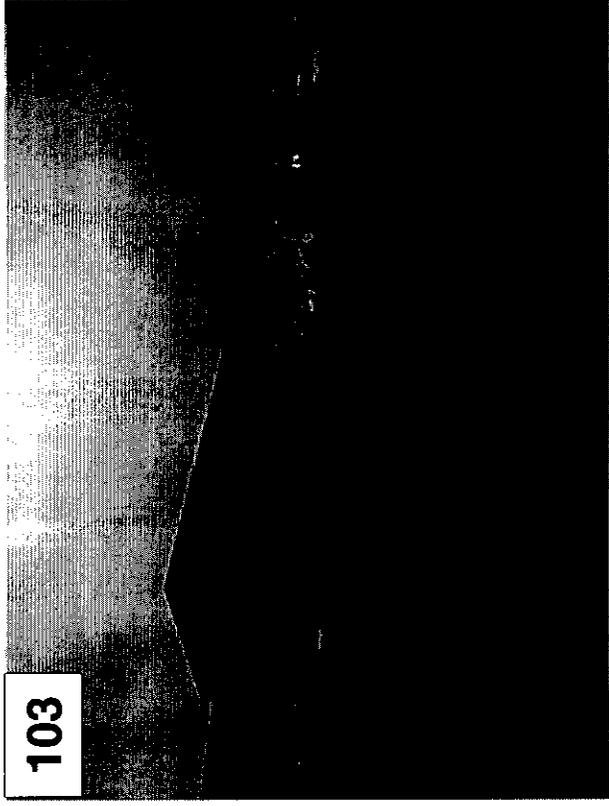
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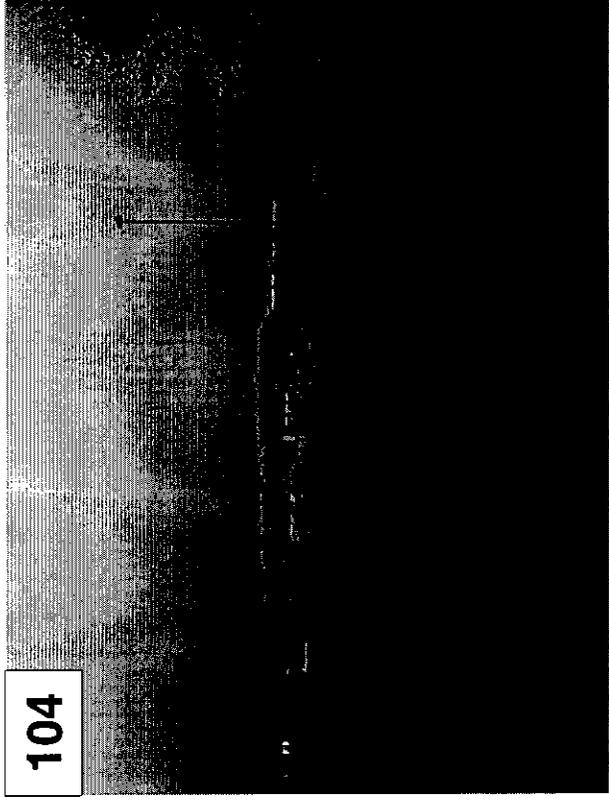
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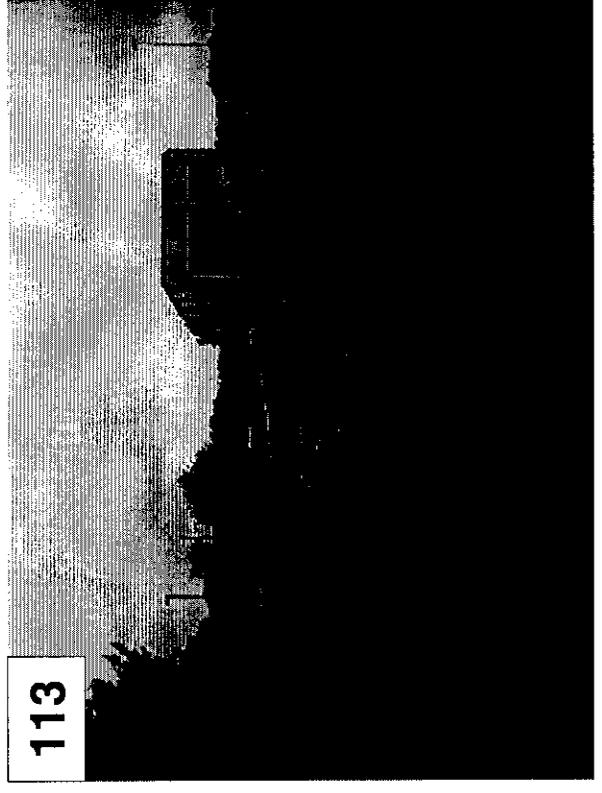
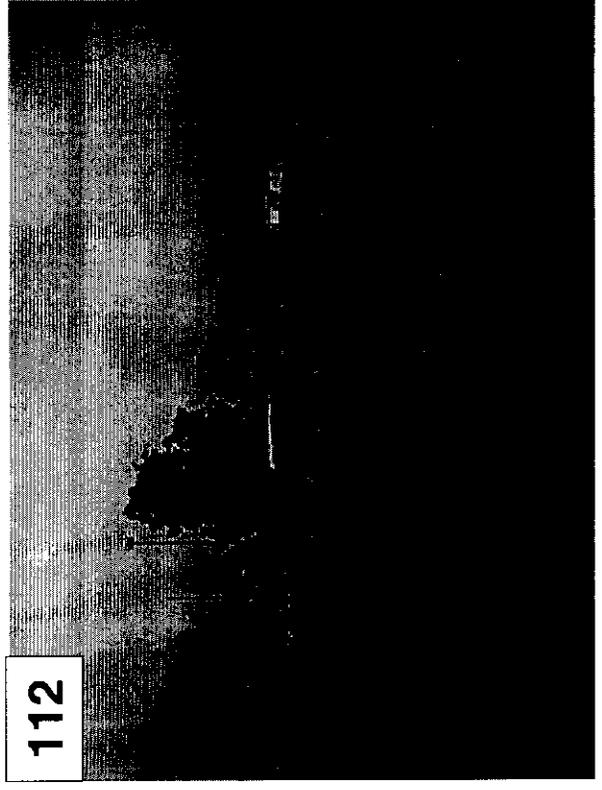
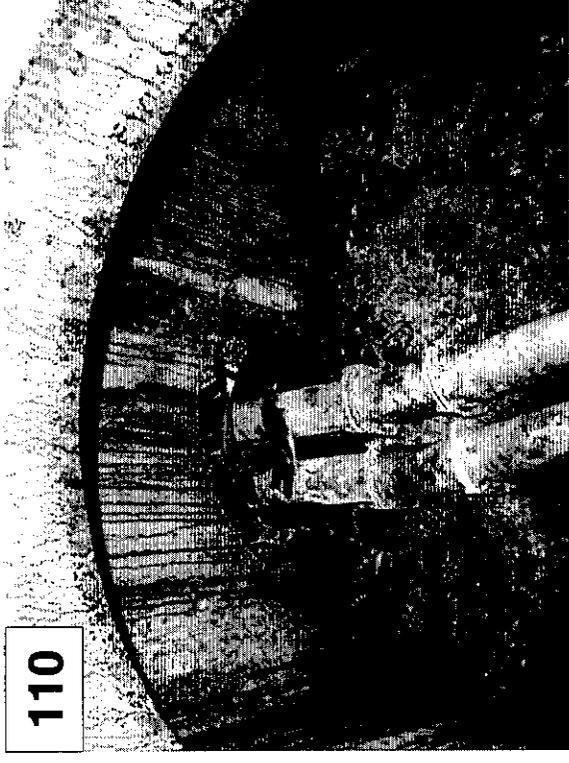
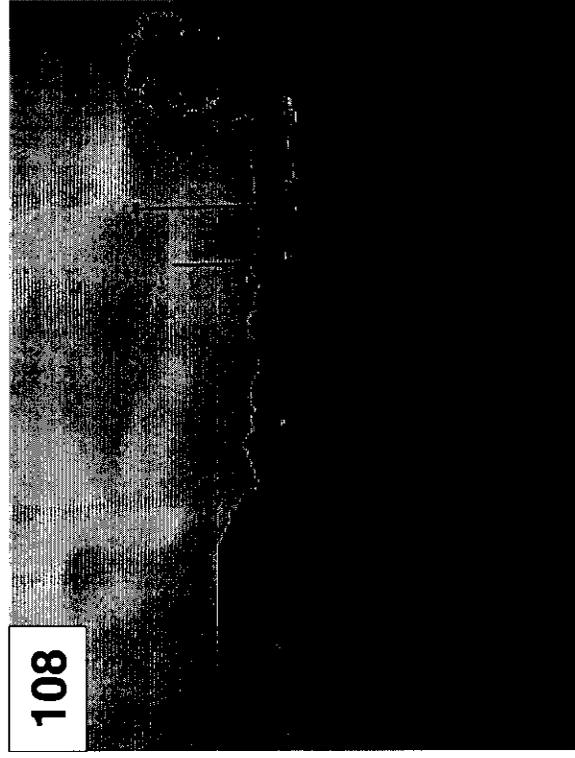
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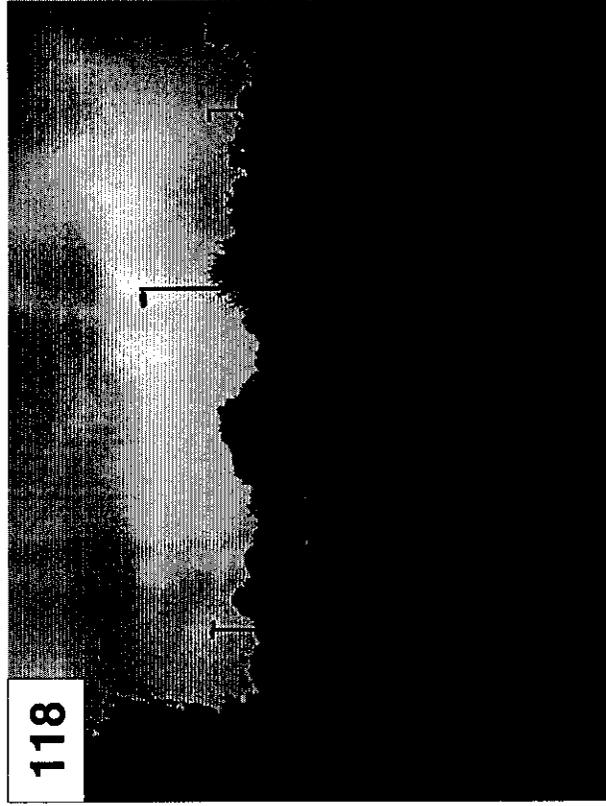
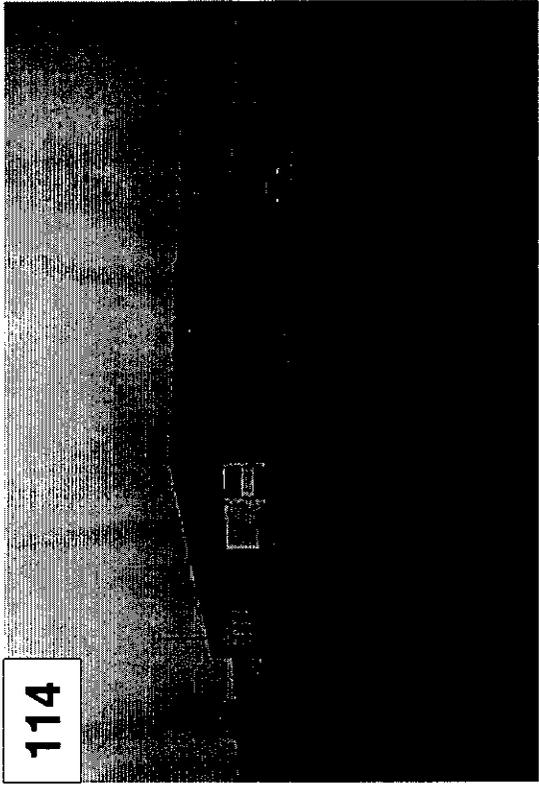
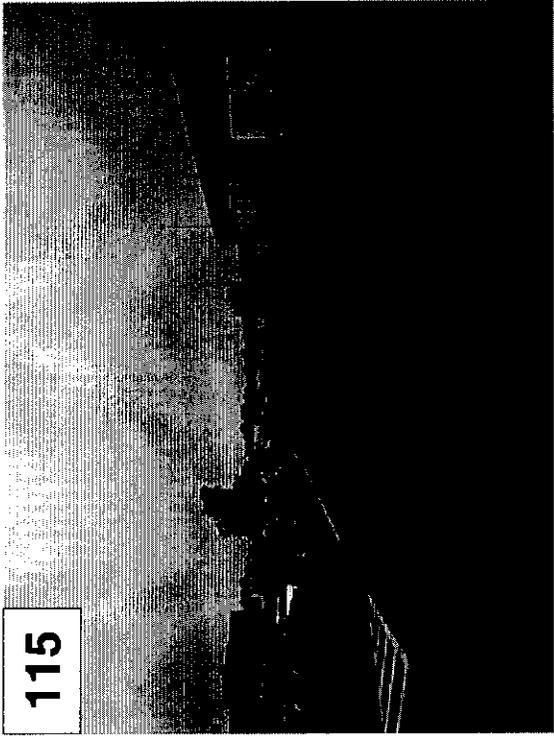


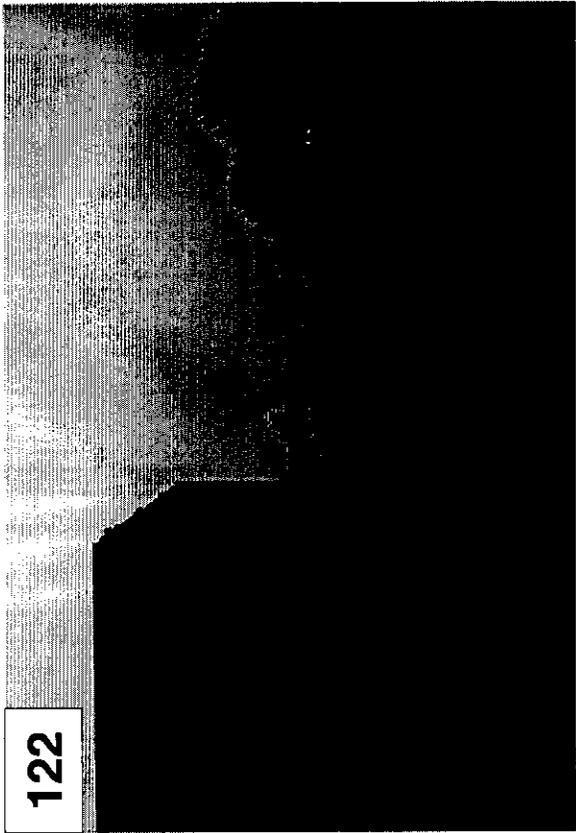
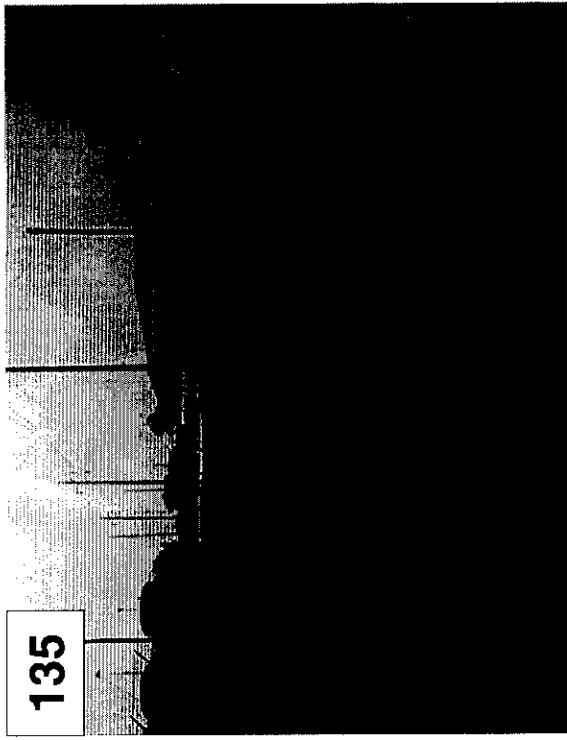
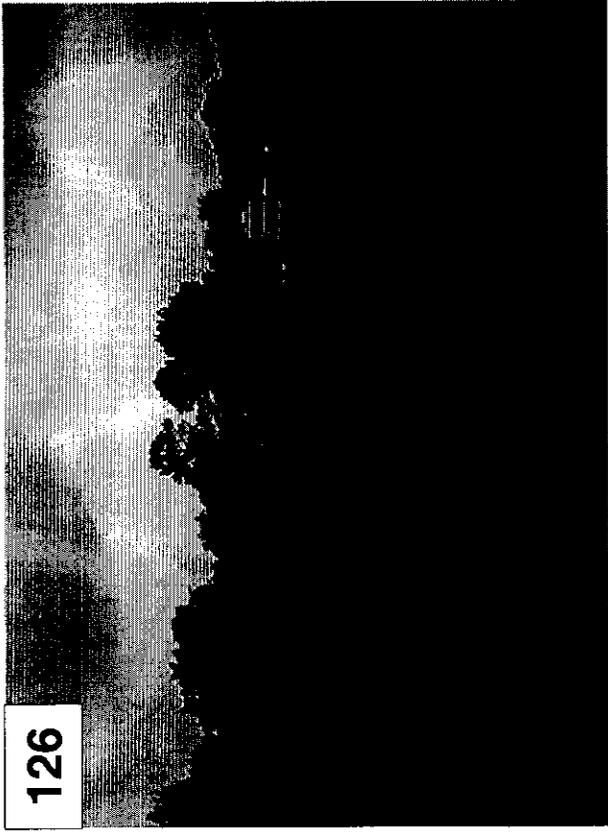
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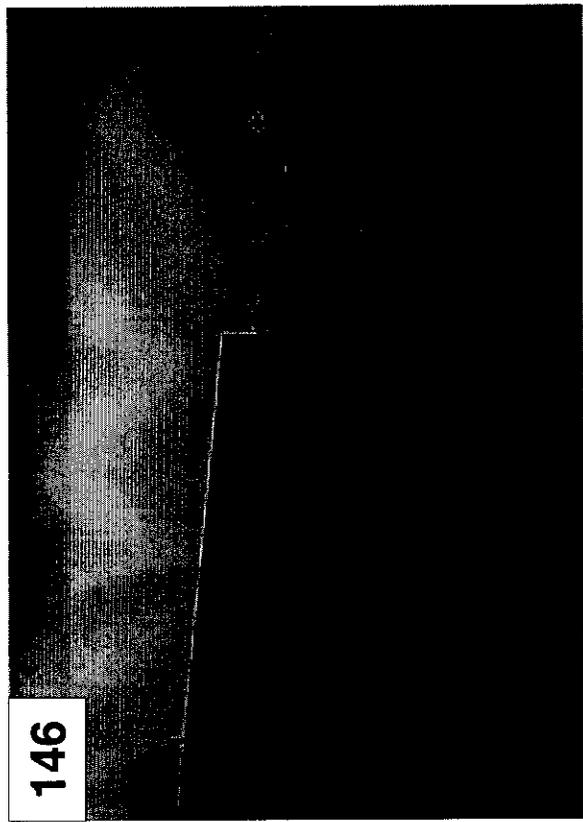
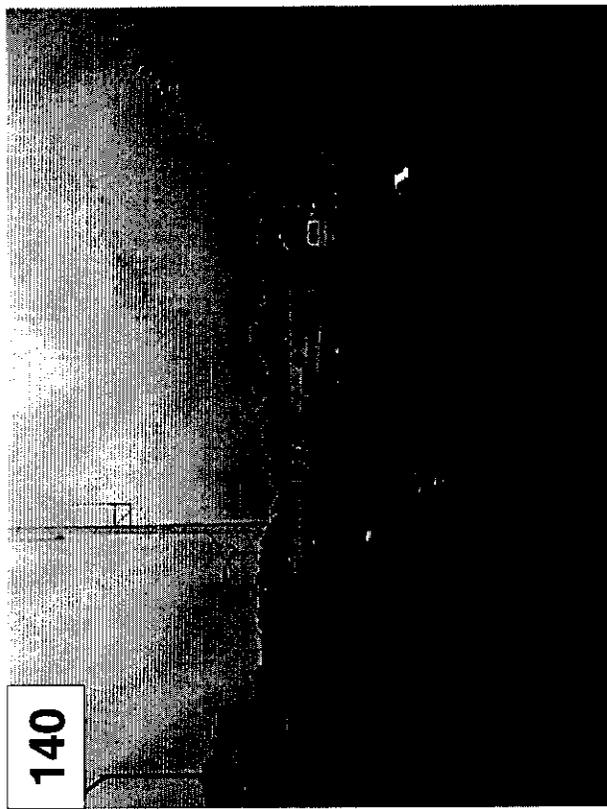
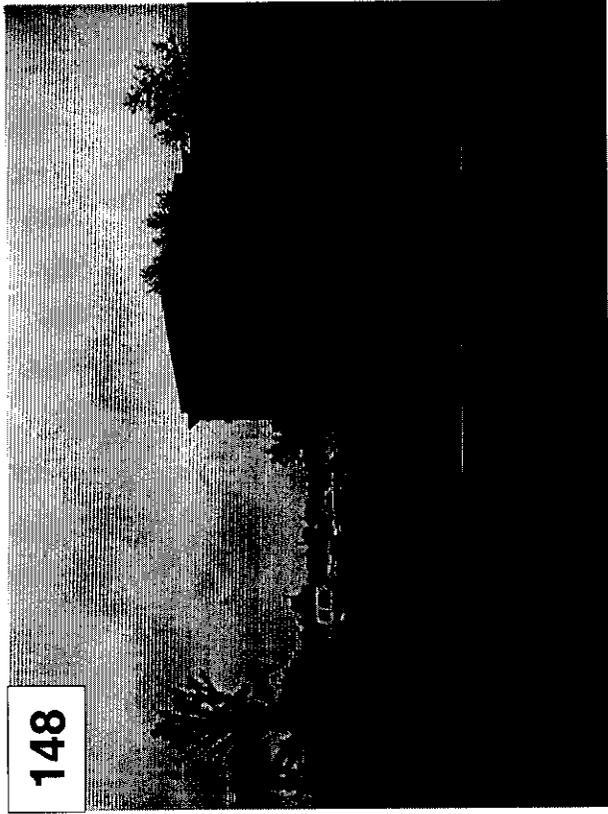
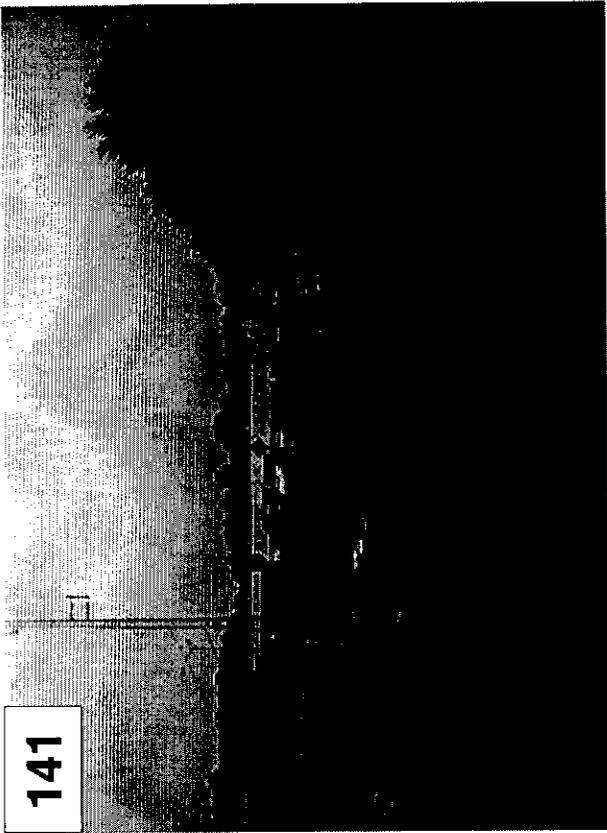


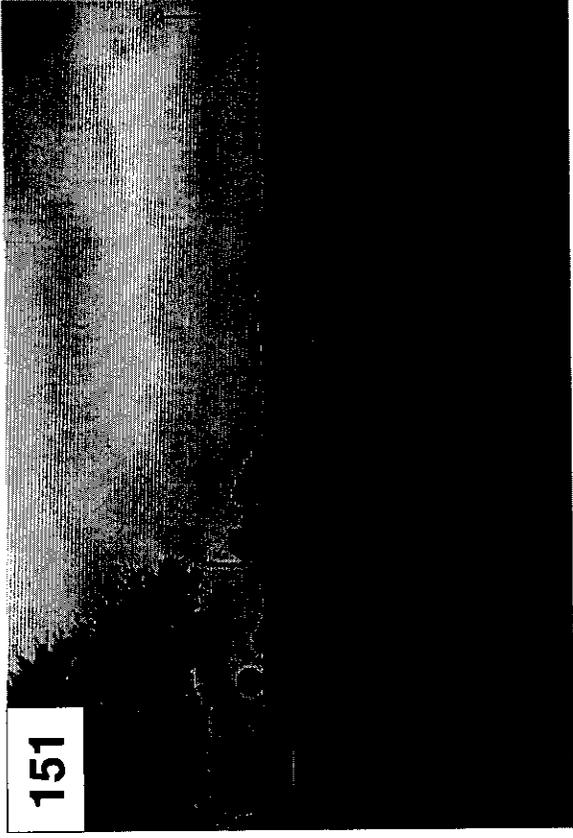
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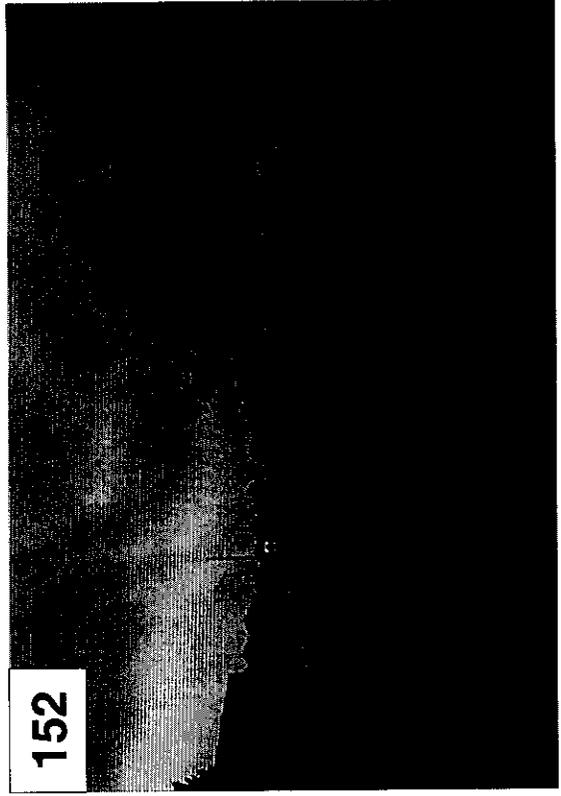




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# APPENDIX K

## ROBINS AFB SPECIFICATIONS

## SECTION 07416

## STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM

## PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

Regulatory, Reference Requirements and Standards; the most recent edition of each regulation, standard, code and requirement shall apply upon award of contract. "Where there is a conflict between the RFP and building codes, the most stringent shall apply. When codes are in conflict, the most stringent shall apply. This list is not intended to be a complete list. All work shall be designed and constructed to meet all state and federal codes, standards and laws."

## ALUMINUM ASSOCIATION (AA)

AA-02 Aluminum Design Manual Specifications and Guidelines for Aluminum Structures

## AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC-04 Specification for Structural Steel Buildings - Allowable Stress Design, Plastic Design

## AMERICAN IRON AND STEEL INSTITUTE (AISI)

AISI-01 Cold-Formed Steel Design Manual

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 463 Steel Sheet, Aluminum-Coated, by the Hot-Dip process

ASTM A 653 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Gal annealed) by the Hot-Dip Process

ASTM A 792 Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process

ASTM B 117 Operating Salt Spray (Fog) Testing Apparatus

ASTM C 518 Steady-State Heat Flux Measurements and Thermal Transmission Properties By Means of the Heat Flow Meter Apparatus

ASTM C 991 Flexible Glass Fiber Insulation for Pre-Engineered Metal Buildings

ASTM C 1289 Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board

ASTM D 522 Mandrel Bend Test of Attached Organic Coatings

ASTM D 523 Specular Gloss

ASTM D 714 Evaluating Degree of Blistering of Paints

ASTM D 968 Abrasion Resistance of Organic Coatings by Falling Abrasive

|  |  |
|--|--|
| ASTM D 1308                                | Effect of Household Chemicals on Clear and Pigmented Organic Finishes  |
| ASTM D 1654                                | Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments  |
| ASTM D 2244                                | Calculation of Color Differences from Instrumentally Measured Color Coordinates  |
| ASTM D 2247                                | Testing Water Resistance of Coatings in 100% Relative Humidity   |
| ASTM D 2794                                | Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)  |
| ASTM D 3359                                | Measuring Adhesion by Tape Test  |
| ASTM D 4214                                | Evaluating the Degree of Chalking of Exterior Paint Films  |
| ASTM D 4397                                | Polyethylene Sheeting for Construction, Industrial, and Agricultural Applications  |
| ASTM D 4587                                | Conducting Tests on Paint and Related Coatings and Materials Using a Fluorescent UV-Condensation Light- and Water-Exposure Apparatus |
| ASTM E 84                                  | Surface Burning Characteristics of Building Materials  |
| ASTM E 96                                  | Water Vapor Transmission of Materials  |
| ASTM E 1592                                | Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference                              |
| AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE) |  |
| ASCE 7                                     | Minimum Design Loads for Buildings and Other Structures  |

## 1.2 GENERAL REQUIREMENTS

The Contractor shall furnish a manufacturer's standard product which satisfies all requirements contained herein and has been verified by load testing and independent design analyses to meet the specified design requirements.

### 1.2.1 Manufacturer

The SSSMR system shall be the product of a manufacturer who has been in the practice of manufacturing SSSMR systems for a period of not less than 3 years and has been involved in at least five projects similar in size and complexity to this project.

### 1.2.2 Installer

The installer shall be certified by the SSSMR system manufacturer to have experience in installing at least three projects that are of comparable size, scope and complexity as this project for the particular roof system furnished. The installer may be either employed by the manufacturer or be an independent installer.

## 1.3 DESIGN REQUIREMENTS

The design of the SSSMR system shall be provided by the Contractor as a complete system. Members and connections not indicated on the drawings shall be designed by the Contractor. Roof panels, components, transitions, accessories, and assemblies shall be supplied by the same manufacturer.

#### 1.3.1 Design Criteria

Design criteria shall be in accordance with ASCE 7 unless otherwise specified.

#### 1.3.2 Dead Loads

The dead load shall be the weight of the SSSMR system. Collateral loads such as sprinklers, mechanical and electrical systems, and ceilings shall not be attached to the panels.

#### 1.3.3 Live Loads

##### 1.3.3.1 Concentrated Loads

The panels and anchor clips shall be capable of supporting a 1335 N concentrated load. The concentrated load shall be applied at the panel midspan and will be resisted by a single standing seam metal roof panel assumed to be acting as a beam. The undeformed shape of the panel shall be used to determine the section properties.

##### 1.3.3.2 Uniform Loads

The panels and concealed anchor clips shall be capable of supporting a minimum uniform live load of 960 Pa (20 psf).

#### 1.3.4 Roof Snow Loads

The design roof snow loads shall be as shown on the contract drawings.

#### 1.3.5 Wind Loads

The design wind uplift pressure for the roof system shall be as shown on the contract drawings. The design uplift force for each connection assembly shall be that pressure given for the area under consideration, multiplied by the tributary load area of the connection assembly. The safety factor listed below shall be applied to the design force and compared against the ultimate capacity. Prying shall be considered when figuring fastener design loads.

- a. Single fastener in each connection.....3.0
- b. Two or more fasteners in each connection...2.25

#### 1.3.6 Thermal Loads

Roof panels shall be free to move in response to the expansion and contraction forces resulting from a total temperature range of 110 degrees C (220 degrees F) during the life of the structure.

#### 1.3.7 Framing Members Supporting the SSSMR System

Any additions/revisions to framing members supporting the SSSMR system to accommodate the manufacturer/fabricator's design shall be the Contractor's responsibility and shall be submitted for review and approval. New or revised framing members and their connections shall be designed in accordance with AISC-04. Maximum deflection under applied live load, snow, or wind load shall not exceed 1/180 of the span length.

#### 1.3.8 Roof Panels Design

Steel panels shall be designed in accordance with AISI-01. Aluminum panels shall be designed in accordance with AA-02. The structural section properties used in the design of the panels shall be determined using the unloaded shape of the roof panels. The calculated panel deflection from concentrated loads shall not exceed 1/180 of the span length. The calculated panel deflection under applied live load, snow, or wind load shall not exceed 1/180 times the span length. Deflections shall be based on panels being continuous across three or more supports. Deflection shall be calculated and measured along the major ribs of the panels.

#### 1.3.9 Accessories and Their Fasteners

Accessories and their fasteners shall be capable of resisting the specified design wind uplift forces and shall allow for thermal movement of the roof panel system. Exposed fasteners shall not restrict free movement of the roof panel system resulting from thermal forces. There shall be a minimum of two fasteners per clip. Single fasteners with a minimum diameter of 9 mm (3/8 inch) will be allowed when the supporting structural members are prepunched or predrilled.

#### 1.4 PERFORMANCE REQUIREMENTS

The SSSMR shall be tested for wind uplift resistance in accordance with ASTM E 1592; SSSMR systems previously tested and approved by the Corps of Engineers' STANDARD TEST METHOD FOR STRUCTURAL PERFORMANCE OF SSMRS BY UNIFORM STATIC AIR PRESSURE DIFFERENCE may be acceptable. Two tests shall be performed. Test 1 shall simulate the edge condition with one end having crosswise restraint and other end free of crosswise restraint. The maximum span length for the edge condition shall be 750 mm (30 inches). Test 2 shall simulate the interior condition with both ends free of crosswise restraint. The maximum span length for the interior condition shall be 1.5 m (5.0 feet). External reinforcement, such as clamps on the ribs, shall not be installed to improve uplift resistance. Bolts through seams shall not be installed.

#### 1.5 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

##### SD-01 Data

Design Analysis; GA.

Design analysis signed by a Registered Professional Engineer employed by the SSSMR manufacturer. The design analysis shall include a list of the design loads, and complete calculations for the support system (when provided by the Contractor), roofing system and its components; valley designs, gutter/downspout calculations, screw pullout test results, and shall indicate how expected thermal movements are accommodated.

##### SD-04 Drawings

Structural Standing Seam Metal Roof System; GA.

Metal roofing drawings and specifications and erection drawings; shop coating and finishing specifications; and other data as necessary to clearly describe design, materials, sizes, layouts, standing seam configuration, construction details, provisions for thermal movement, line of panel fixity, fastener sizes and spacings, sealants and erection procedures. Drawings shall reflect the intent of the architectural detailing using the manufacturer's proprietary products and fabricated items as required. The SSSMR system shop drawings shall be provided by the metal roofing manufacturer.

SD-08 Statements

Qualifications; FIO.

Qualifications of the manufacturer and installer.

SD-09 Reports

Test Report for Uplift Resistance of the SSSMR; GA.

The report shall include the following information:

- a. Details of the SSSMR system showing the roof panel cross-section with dimensions and thickness.
- b. Details of the anchor clip, dimensions, and thickness.
- c. Type of fasteners, size, and the number required for each connection.
- d. Purlins/subpurlins size and spacing used in the test.
- e. Description of the seaming operation including equipment used.
- f. Maximum allowable uplift pressures. These pressures are determined from the ultimate load divided by a factor of safety equal to 1.65.
- g. Any additional information required to identify the SSSMR system tested.
- h. Signature and seal of an independent registered engineer who witnessed the test.

SD-13 Certificates

Structural Standing Seam Metal Roof System; GA.

- a. Certification that the actual thickness of uncoated sheets used in SSSMRS components including roofing panels, subpurlins, and concealed anchor clips complies with specified requirements.
- b. Certification that materials used in the installation are mill certified.
- c. Previous certification of SSSMR system tested under the Corps of Engineers' Standard Test Method in lieu of ASTM E 1592 testing.
- d. Certification that the sheets to be furnished are produced under a continuing quality control program and that a representative sample consisting of not less than three pieces has been tested and has met the quality standards specified for factory color finish.
- e. Certification of installer.
- f. Warranty certificate. At the completion of the project the Contractor shall furnish signed copies of the 20-year Warranty for Structural Standing Seam Metal Roof (SSSMR) System, a sample copy of which is attached to this section, and the 20-year Manufacturer's Material Warranty.

Insulation; FIO.

Certificate attesting that the polyurethane or polyisocyanurate insulation furnished for the project contains recovered material, and showing an estimated percent of such recovered material.

SD-14 Samples

Accessories; FIO.

One sample of each type of flashing, trim, closure, thermal spacer block, cap and similar items. Size shall be sufficient to show construction and configuration.

Roof Panels; GA.

One piece of each type to be used, 225 mm (9 inches) long, full width.

Factory Color Finish; FIO.

Three 75 by 125 mm (3 by 5 inches) samples of each type and color.

Fasteners; FIO.

Two samples of each type to be used, with statement regarding intended use. If so requested, random samples of bolts, nuts, and washers as delivered to the job site shall be taken in the presence of the Contracting Officer and provided to the Contracting Officer for testing to establish compliance with specified requirements.

Insulation; FIO.

One piece, 300 by 300 mm (12 by 12 inches), of each type and thickness to be used, with a label indicating the rated permeance (if faced) and R-values. The flame spread, and smoke developed rating shall be shown on the label or provided in a letter of certification.

Gaskets and Insulating Compounds; GA.

Two samples of each type to be used and descriptive data.

Sealant; GA.

One sample, approximately 0.5 kg (1 pound), and descriptive data.

Concealed Anchor Clips; GA.

Two samples of each type used.

Subpurlins; GA.

One piece, 225 mm (9 inches) long.

EPDM Rubber Boots; GA.

One piece of each type.

#### 1.6 DELIVERY AND STORAGE

Materials shall be delivered to the site in a dry and undamaged condition and stored out of contact with the ground. Materials shall be covered with weathertight coverings and kept dry. Storage conditions shall provide good air circulation and protection from surface staining.

#### 1.7 WARRANTIES

The SSSMR system shall be warranted as outlined below. Any emergency temporary repairs conducted by the Government shall not negate the warranties.

##### 1.7.1 Manufacturer's Weathertightness Warranty

The SSSMR system shall be warranted by the Manufacturer on a no penal sum basis for a period of twenty years against material and workmanship deficiencies; system deterioration caused by ordinary exposure to the elements and service design loads, water leaks, and wind uplift damage. The SSSMR system covered under this warranty shall include the entire roofing system including, but not limited to, the following: panel seams and joints, all accessories, components and trim; penetrations such as vents and curbs; interior or exterior gutters and downspouts; eaves, ridge, hip, valley, rake, gable, wall, or other roof system flashings installed to provide a weathertight roof system; and items specified in other sections of these

specifications that become part of the structural standing seam metal roof system. All material and workmanship deficiencies, system deterioration caused by ordinary exposure to the elements and service design loads, water leaks and wind uplift damage shall be repaired as approved by the Contracting Officer. This warranty shall warrant and cover the entire cost of repair or replacement, including all material, labor, and related markups. The Manufacturer may supplement this warranty with written warranties from the installer, which shall be submitted along with Manufacturer's warranty; however, the Manufacturer shall be ultimately responsible for this warranty. The Manufacturer's written warranty shall be as outlined in attached example WARRANTY FOR STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM, and shall start upon final acceptance of the facility or the date the Government takes possession, whichever is earlier.

#### 1.7.2 Manufacturer's Material Warranties.

The Contractor shall furnish, in writing, the following manufacturer's material warranties which cover all SSSMR system components such as roof panels, anchor clips and fasteners, flashing, accessories, and trim, fabricated from coil material:

- a. A manufacturer's 20 year material warranty warranting that the aluminum, zinc-coated steel, aluminum-zinc alloy coated steel or aluminum-coated steel as specified herein will not rupture, structurally fail, fracture, deteriorate, or become perforated under normal design atmospheric conditions and service design loads. Liability under this warranty shall be limited exclusively to the cost of either repairing or replacing nonconforming, ruptured, perforated, or structurally failed coil material.
- b. A manufacturer's 20 year exterior material finish warranty on the factory colored finish warranting that the finish, under normal atmospheric conditions at the site, will not crack, peel, or delaminate; chalk in excess of a numerical rating of eight, as determined by ASTM D 4214 test procedures; or change color in excess of five CIE or Hunter Lab color difference (delta E) units in accordance with ASTM D 2244. Liability under this warranty is exclusively limited to refinishing with an air-drying version of the specified finish or replacing the defective coated material.

## PART 2 PRODUCTS

### 2.1 ROOF PANELS

Panels shall be steel and shall have a factory color finish. Length of sheets shall be sufficient to cover the entire length of any unbroken roof slope for slope lengths that do not exceed 9 m (30 feet). When length of run exceeds 9 m (30 feet) and panel laps are provided, each sheet in the run shall extend over three or more supports. Sheets longer than 30 m (100 feet) may be furnished if approved by the Contracting Officer. Width of sheets shall provide not more than 600 mm (24 inches) of coverage in place. SSSMR system with roofing panels greater than 300 mm (12 inches) in width shall have standing seams rolled during installation by an electrically driven seaming machine. Height of standing seams shall be not less than 38mm (2 inches).

#### 2.1.1 Steel Panels

Steel panels shall be zinc-coated steel conforming to ASTM A 653; aluminum-zinc alloy coated steel conforming to ASTM A 792, AZ 55 coating; or aluminum-coated steel conforming to ASTM A 463, Type 2, coating designation T2 65. Uncoated panels shall be 0.6 mm (0.0239 inch) thick minimum. Panels shall be within 95 percent of tested thickness.

### 2.2 CONCEALED ANCHOR CLIPS

Concealed anchor clips shall be the same as the tested roofing system. Clip bases shall have factory punched or drilled holes for attachment. Clips shall be made from multiple pieces with the allowance for the total thermal movement required to take place within the clip. Single piece clips may be acceptable when the manufacturer can substantiate that the system can accommodate the thermal cyclic movement under sustained live or snow loads.

### 2.3 ACCESSORIES

Flashing, trim, metal closure strips, caps and similar metal accessories shall be the manufacturer's standard products. Exposed metal accessories shall be finished to match the panels furnished. Die cast metal closures shall be installed with double bead tape sealant and fasteners that stitch the panel to a 2 mm (16 gage) preformed backer plate to ensure a positive compression of the tape sealant. The use of a continuous angle butted to the panel ends to form a closure will not be allowed.

### 2.4 FASTENERS

Fasteners for steel roof panels shall be zinc-coated steel, aluminum, corrosion resisting steel, or nylon capped steel, type and size specified below or as otherwise approved for the applicable requirements. Fasteners for aluminum roof panels shall be aluminum or corrosion resisting steel. Fasteners for structural connections shall provide both tensile and shear ultimate strengths of not less than 3340 N (750 pounds) per fastener. Fasteners for accessories shall be the manufacturer's standard. Exposed roof fasteners shall be sealed or have sealed washers on the exterior side of the roof to waterproof the fastener penetration. Washer material shall be compatible with the roofing; have a minimum diameter of 10 mm (3/8 inch) for structural connections; and gasketed portion of fasteners or washers shall be neoprene or other equally durable elastomeric material approximately 3 mm (1/8 inch) thick. Exposed fasteners for factory color finished panels shall be factory finished to match the color of the panels.

#### 2.4.1 Screws

Screws for attaching anchor devices shall be not less than No. 14. Actual screw pull out test results shall be performed for the actual material gage and yield strength of the structural purlins or subpurlins to which the clip is to be anchored/attached. Other screws shall be as recommended by the manufacturer to meet the strength design requirements of the panels.

#### 2.4.2 Bolts

Bolts shall be not less than 6 mm (1/4 inch) diameter, shouldered or plain shank as required, with locking washers and nuts.

#### 2.4.3 Structural Blind Fasteners

Blind screw-type expandable fasteners shall be not less than 6 mm (1/4 inch) diameter. Blind (pop) rivets shall be not less than 7 mm (9/32 inch) minimum diameter.

### 2.5 SUBPURLINS

Cold formed supporting structural members/subpurlins shall have a minimum thickness of 1.5 mm (0.059 inches) and a minimum tensile yield strength of 345 MPa (50000 psi). Hot rolled structural members shall have a minimum thickness of 6 mm (0.25 inches) and a minimum tensile yield strength of 248 MPa (36000 psi). Subpurlins shall be galvanized or given one coat of shop paint.

### 2.6 FACTORY COLOR FINISH

Panels shall have a factory applied polyvinylidene fluoride finish on the exposed side. The exterior finish shall consist of a baked-on topcoat with an appropriate prime coat. Color shall match in accordance with the Architectural Compatibility Guide for Robins Air Force Base. The exterior coating shall be a nominal 0.025 mm (2 mil) thickness consisting of a topcoat of not less than 0.018 mm (0.7 mil) dry film thickness and the paint manufacturer's recommended primer of not less than 0.005 mm (0.2mil) thickness. The interior color finish shall consist of a backer coat with a dry film thickness of 0.013 mm (0.5 mil). The exterior color finish shall meet the test requirements specified below.

#### 2.6.1 Formability Test

When subjected to testing in accordance with ASTM D 522 Method B, 3 mm diameter mandrel, the coating film shall show no evidence of cracking to the naked eye.

#### 2.6.2 Accelerated Weathering, Chalking Resistance and Color Change

A sample of the sheets shall be tested in accordance with ASTM D 4587, test condition B for 1,000 total hours. The coating shall withstand the weathering test without cracking, peeling, blistering, loss of adhesion of the protective coating, or corrosion of the base metal. Protective coating that can be readily removed from the base metal with tape in accordance with ASTM D 3359, Test Method B, shall be considered as an area indicating loss of adhesion. Following the accelerated weathering test, the coating shall have a chalk rating not less than No. 8 in accordance with ASTM D 4214 test procedures, and the color change shall not exceed 5 CIE or Hunter Lab color difference (delta E) units in accordance with ASTM D 2244. For sheets required to have a low gloss finish, the chalk rating shall be not less than No. 6 and the color difference shall be not greater than 7 units.

#### 2.6.3 Humidity Test

When subjected to a humidity cabinet test in accordance with ASTM D 2247 for 1000 hours, a scored panel shall show no signs of blistering, cracking, creepage or corrosion.

#### 2.6.4 Impact Resistance

Factory-painted sheet shall withstand direct and reverse impact in accordance with ASTM D 2794 13 mm (0.500 inch) diameter hemispherical head indenter, equal to 6.7 times the metal thickness in mm, expressed in Newton-meters, (1.5 times the metal thickness in mils), expressed in inch-pounds, with no loss of adhesion.

#### 2.6.5 Abrasion Resistance Test

When subjected to the falling sand test in accordance with ASTM D 968, Method A, the coating system shall withstand a minimum of 50 liters of sand before the appearance of the base metal. The term "appearance of base metal" refers to the metallic coating on steel or the aluminum base metal.

#### 2.6.6 Specular Gloss

Finished roof surfaces shall have a specular gloss value of 10 or less at an angle of 85 degrees when measured in accordance with ASTM D 523.

#### 2.6.7 Pollution Resistance

Coating shall show no visual effects when covered spot tested in a 10 percent hydrochloric acid solution for 24 hours in accordance with ASTM D 1308.

### 2.7 INSULATION

Thermal resistance of insulation shall be not less than the R-values shown on the contract drawings. R-values shall be determined at a mean temperature of 24 degrees C (75 degrees F) in accordance with ASTM C 518. Insulation shall be a standard product with the insulation manufacturer, factory marked or identified with insulation manufacturer's name or trademark and R-value. Identification shall be on individual pieces or individual packages. Insulation, including facings, shall have a flame spread not in excess of 75 and a smoke developed rating not in excess of 150 when tested in accordance with ASTM E 84. The stated R-value of the insulation shall be certified by an independent Registered Professional Engineer if tests are conducted in the insulation manufacturer's laboratory.

#### 2.7.1 Polyisocyanurate Rigid Board Insulation for Use Above a Roof Deck

Polyisocyanurate insulation shall conform to ASTM C 1289, Type II, Class 1 (having a minimum recovered material content of 9 percent by weight of core material in the polyisocyanurate portion). For polyisocyanurate the maximum design R-value per 25 mm (1 inch) of insulation used shall be 1.27. Facings shall be non-asphaltic, glass fiber reinforced.

#### 2.8 INSULATION RETAINERS

Insulation retainers shall be type, size, and design necessary to adequately hold the insulation and to provide a neat appearance. Metallic retaining members shall be nonferrous or have a nonferrous coating. Nonmetallic retaining members, including adhesives used in conjunction with mechanical retainers or at insulation seams, shall have a fire resistance classification not less than that permitted for the insulation.

#### 2.9 SEALANT

Sealants shall be elastomeric type containing no oil or asphalt. Exposed sealant shall be colored to match the applicable building color and shall cure to a rubberlike consistency. Sealant placed in the roof panel standing seam ribs shall be provided in accordance with the manufacturer's recommendations.

#### 2.10 GASKETS AND INSULATING COMPOUNDS

Gaskets and insulating compounds shall be nonabsorptive and suitable for insulating contact points of incompatible materials. Insulating compounds shall be nonrunning after drying.

#### 2.11 VAPOR RETARDER

##### 2.11.1 Vapor Retarders Separate from Insulation

Vapor retarder material shall be polyethylene sheeting conforming to ASTM D 4397. A single ply of 0.25 mm (10 mil) polyethylene sheet; or, at the Contractor's option, a double ply of 0.15 mm (6 mil) polyethylene sheet shall be used. A fully compatible polyethylene tape which has equal or better water vapor control characteristics than the vapor retarder material shall be provided. A cloth industrial duct tape in a utility grade shall also be provided to use as needed to protect the vapor retarder from puncturing.

##### 2.11.2 Slip Sheet for Use With Vapor Retarder

Slip sheet for use with vapor retarder shall be a 0.24 kg per square meter (5 lb. per 100 square feet) rosin-sized, unsaturated building paper.

#### 2.12 EPDM RUBBER BOOTS

Flashing devices around pipe penetrations shall be flexible, one-piece devices molded from weather-resistant EPDM rubber. Rubber boot material shall be as

recommended by the manufacturer. The boots shall have base rings made of aluminum or corrosion resisting steel that conform to the contours of the roof panel to form a weather-tight seal.

## PART 3 EXECUTION

### 3.1 INSTALLATION

Installation shall be in accordance with the manufacturer's erection instructions and drawings. Dissimilar materials which are not compatible when contacting each other shall be insulated by means of gaskets or insulating compounds. Molded closure strips shall be installed wherever roofing sheets terminate in open-end configurations, exclusive of flashings. The closure strip installation shall be weather-tight and sealed. Screws shall be installed with a clutching screw gun, to assure screws are not stripped. Field test shall be conducted on each gun prior to starting installation and periodically thereafter to assure it is adjusted properly to install particular type and size of screw as recommended by manufacturer's literature. Improper or mislocated drill holes shall be plugged with an oversize screw fastener and gasketed washer; however, sheets with an excess of such holes or with such holes in critical locations shall not be used. Exposed surfaces and edges shall be kept clean and free from sealant, metal cuttings, hazardous burrs, and other foreign material. Stained, discolored, or damaged sheets shall be removed from the site.

#### 3.1.1 Field Forming of Panels

When roofing panels are formed from factory-color-finished steel coils at the project site, the same care and quality control measures that are taken in shop forming of roofing panels shall be observed. Rollformer shall be operated by the metal roofing manufacturer's representative. In cold weather conditions, preheating of the steel coils to be field formed shall be performed as necessary just prior to the rolling operations.

#### 3.1.2 Subpurlins

Unless otherwise shown, subpurlins shall be anchored to the purlins or other structural framing members with bolts or screws. Attachment to the substrate (when provided) or to the panels is not permitted. The subpurlin spacing shall not exceed 750 mm (30 inches) on centers at the corner, edge and ridge zones, and 1500 mm (5 foot) maximum on centers for the remainder of the roof. Corner, edge, and ridge zones are as defined in ASCE 7.

#### 3.1.3 Roof Panel Installation

Roof panels shall be installed with the standing seams in the direction of the roof slope. The side seam connections for installed panels shall be completed at the end of each day's work. Method of applying joint sealant shall conform to the manufacturer's recommendation to achieve a complete weather-tight installation. End laps of panels shall be provided in accordance with the manufacturer's instructions. Closures, flashings, EPDM rubber boots, and related accessories shall be installed according to the manufacturer's drawings. Fasteners shall not puncture roofing sheets except as provided for in the manufacturer's instructions for erection and installation. Expansion joints for the standing seam roof system shall be installed at locations indicated on the contract drawings and other locations indicated on the manufacturer's drawings.

#### 3.1.4 Concealed Anchor Clips

Concealed anchor clips shall be fastened directly to the structural framing members. Attachment to the substrate (when provided) or to the panels is not permitted. The maximum distance, parallel to the seams, between clips shall be

750 mm (30 inches) on center at the corner, edge, and ridge zones, and 1500 mm (5 feet) maximum on centers for the remainder of the roof.

### 3.2 INSULATION INSTALLATION

Insulation shall be continuous over entire roof surface. Where expansion joints, terminations, and other connections are made, the cavity shall be filled with batt insulation with vapor retarder providing equivalent R-value and perm rating as remaining insulation. Insulation shall be installed as indicated and in accordance with manufacturer's instructions.

#### 3.2.1 Board Insulation with Blanket Insulation

Rigid board insulation shall be laid in close contact. Board shall be attached to the metal roof deck with bearing plates and fasteners, as recommended by the insulation manufacturer, so that the insulation joints are held tight against each other, and shall have a minimum of 1 fastener per 0.37 square meters (4 fasteners per square feet). Layout and joint pattern of insulation and fasteners shall be indicated on the shop drawings. If more than one layer of insulation is required, joints in the second layer shall be offset from joints in the first layer. A layer of blanket insulation shall be placed over the rigid board insulation to be compressed against the underside of the metal roofing to reduce thermal bridging, dampen noise, and prevent roofing flutter. This layer of blanket insulation shall be compressed a minimum of 50 percent.

### 3.3 PROTECTION OF VAPOR RETARDER FROM ROOF DECK

A cloth industrial duct tape shall be applied over the seams of metal roof decks, at penetration edges, and at surface areas exhibiting sharp burrs or similar protrusions. For other types of roof decks, cloth industrial duct tape shall be applied over irregularities which could potentially puncture polyethylene membrane.

### 3.4 VAPOR RETARDER INSTALLATION

#### 3.4.1 Polyethylene Vapor Retarder

The polyethylene vapor retarder membrane shall be installed over the entire surface. A fully compatible polyethylene tape shall be used to seal the edges of the sheets to provide a vapor tight membrane. Sheet edges shall be lapped not less than 150 mm (6 inches). Sufficient material shall be provided to avoid inducing stresses in the sheets due to stretching or binding. All tears or punctures that are visible in the finished surface at any time during the construction process shall be sealed with polyethylene tape.

### 3.5 SLIP SHEET INSTALLATION

A slip sheet shall be laid over the blanket insulation facing to prevent the vinyl facing from adhering to the metal roofing.

### 3.6 CLEANING AND TOUCH-UP

Exposed SSSMR systems shall be cleaned at completion of installation. Debris that could cause discoloration and harm to the panels, flashings, closures and other accessories shall be removed. Grease and oil films, excess sealants, and handling marks shall be removed and the work shall be scrubbed clean. Exposed metal surfaces shall be free of dents, creases, waves, scratch marks, and solder or weld marks. Immediately upon detection, abraded or corroded spots on shop-painted surfaces shall be wire brushed and touched up with the same material used for the shop coat. Factory color finished surfaces shall be touched up with the manufacturer's recommended touch up paint.

MANUFACTURER'S TWENTY (20) YEAR NO PENAL SUM WARRANTY  
FOR  
STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM

PROJECT DESCRIPTION AND LOCATION (Include Bldg. No.): \_\_\_\_\_  
CORPS OF ENGINEERS CONTRACT NUMBER: \_\_\_\_\_  
SPECIFICATION SECTION NUMBER & DESCRIPTION:

07416 STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM

MANUFACTURER: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
POINT OF CONTACT: \_\_\_\_\_  
TELEPHONE NUMBER: \_\_\_\_\_  
CONTRACTOR: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
POINT OF CONTACT: \_\_\_\_\_  
TELEPHONE NUMBER: \_\_\_\_\_  
OWNER: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
POINT OF CONTACT: \_\_\_\_\_  
TELEPHONE NUMBER: \_\_\_\_\_  
CONSTRUCTION AGENT: \_\_\_\_\_  
ADDRESS: \_\_\_\_\_  
POINT OF CONTACT: \_\_\_\_\_  
TELEPHONE NUMBER: \_\_\_\_\_

THE SSSMR SYSTEM INSTALLED ON THE ABOVE NAMED BUILDING IS WARRANTED BY \_\_\_\_\_ FOR A PERIOD OF TWENTY (20) YEARS AGAINST WORKMANSHIP AND MATERIAL DEFICIENCIES, WIND DAMAGE, STRUCTURAL FAILURE AND LEAKAGE. THE SSSMR SYSTEM COVERED UNDER THIS WARRANTY SHALL INCLUDE THE ENTIRE ROOFING SYSTEM, INCLUDING THE STANDING SEAM METAL ROOF PANELS, PANEL FINISHES, ROOFING SECUREMENT COMPONENTS, ALL ACCESSORIES, COMPONENTS, AND TRIM; INCLUDING PENETRATIONS SUCH VENTS, CURBS, SKYLIGHTS; INTERIOR OR EXTERIOR GUTTERS AND DOWNSPOUTS; EAVES, RIDGE, HIP, VALLEY, RAKE, GABLE, WALL, OR OTHER ROOF SYSTEM FLASHINGS INSTALLED TO PROVIDE A WEATHERTIGHT ROOF SYSTEM; AND ITEMS SPECIFIED IN OTHER SECTIONS OF THE SPECIFICATIONS THAT ARE PART OF THE SSSMR SYSTEM. ALL LEAKS SHALL BE REPAIRED AS APPROVED BY THE CONTRACTING OFFICER. THIS WARRANTY SHALL COVER THE ENTIRE COST OF REPAIR OR REPLACEMENT, INCLUDING ALL MATERIAL, LABOR, AND RELATED MARKUPS. THE ABOVE REFERENCED WARRANTY COMMENCED ON THE DATE OF FINAL ACCEPTANCE ON \_\_\_\_\_ AND WILL REMAIN IN EFFECT FOR STATED DURATION FROM THIS DATE.

SIGNED, DATED, AND NOTARIZED (BY COMPANY PRESIDENT)

\_\_\_\_\_  
(Company President) (Date)

(SEE REVERSE SIDE FOR SUPPLEMENTAL PROVISIONS AND EXCLUSIONS)

MANUFACTURER'S TWENTY (20) YEAR NO PENAL SUM WARRANTY  
FOR  
STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM  
(continued)

THE MANUFACTURER MAY SUPPLEMENT THIS WARRANTY WITH WRITTEN WARRANTIES FROM THE INSTALLER OF THE SSSMR SYSTEM, WHICH SHALL BE SUBMITTED ALONG WITH THE MANUFACTURER'S WARRANTY. HOWEVER, THE MANUFACTURER WILL BE ULTIMATELY RESPONSIBLE FOR THE WARRANTY AS OUTLINED IN THE SPECIFICATIONS AND AS INDICATED IN THIS WARRANTY EXAMPLE.

EXCLUSIONS FROM COVERAGE

1. NATURAL DISASTERS, ACTS OF GOD (LIGHTING, FIRE, EXPLOSIONS, SUSTAINED WIND FORCES IN EXCESS OF THE DESIGN CRITERIA, EARTHQUAKES, AND HAIL).
2. ACTS OF NEGLIGENCE OR ABUSE OR MISUSE BY GOVERNMENT OR OTHER PERSONNEL, INCLUDING ACCIDENTS, VANDALISM, CIVIL DISOBEDIENCE, WAR, OR DAMAGE CAUSED BY FALLING OBJECTS.
3. DAMAGE BY STRUCTURAL FAILURE, SETTLEMENT, MOVEMENT, DISTORTION, WARPAGE, OR DISPLACEMENT OF THE BUILDING STRUCTURE OR ALTERATIONS MADE TO THE BUILDING.
4. CORROSION CAUSED BY EXPOSURE TO CORROSIVE CHEMICALS, ASH OR FUMES GENERATED OR RELEASED INSIDE OR OUTSIDE THE BUILDING FROM CHEMICAL PLANTS, FOUNDRIES, PLATING WORKS, KILNS, FERTILIZER FACTORIES, PAPER PLANTS, AND THE LIKE.
5. FAILURE OF ANY PART OF THE SSSMR SYSTEM DUE TO ACTIONS BY THE OWNER TO INHIBIT FREE DRAINAGE FROM THE ROOF AND ALLOW PONDING WATER. MANUFACTURER'S DESIGN SHALL INSURE FREE DRAINAGE FROM THE ROOF AND NOT ALLOW PONDING WATER.
6. THIS WARRANTY APPLIES TO THE STRUCTURAL STANDING SEAM METAL ROOF (SSSMR) SYSTEM. IT DOES NOT INCLUDE ANY CONSEQUENTIAL DAMAGE TO THE BUILDING INTERIOR OR CONTENTS WHICH IS COVERED BY THE WARRANTY OF CONSTRUCTION CLAUSE INCLUDED IN THIS CONTRACT.
7. THIS WARRANTY CANNOT BE TRANSFERRED TO ANOTHER OWNER WITHOUT WRITTEN CONSENT OF THE MANUFACTURER AND THIS WARRANTY AND THE CONTRACT PROVISIONS WILL TAKE PRECEDENCE OVER ANY CONFLICTS WITH STATE STATUTES, UNLESS OTHERWISE APPROVED IN WRITING BY THE CONTRACTING OFFICER.

LEAKS SHALL BE RESPONDED TO WITHIN 48 HOURS OF RECEIPT OF NOTICE BY TELEPHONE OR IN WRITING FROM EITHER THE OWNER, OR CONTRACTING OFFICER. EMERGENCY REPAIRS, TO PREVENT FURTHER ROOF LEAKS, SHALL BE INITIATED IMMEDIATELY; A WRITTEN PLAN SHALL BE SUBMITTED FOR APPROVAL TO REPAIR OR REPLACE THIS SSSMR SYSTEM WITHIN SEVEN CALENDAR DAYS. ACTUAL WORK FOR PERMANENT REPAIRS OR REPLACEMENT SHALL BE STARTED WITHIN 30 DAYS AFTER RECEIPT OF NOTICE, AND COMPLETED WITHIN A REASONABLE TIME FRAME. IF THE MANUFACTURER FAILS TO ADEQUATELY RESPOND TO THE WARRANTY PROVISIONS, AS STATED IN THE CONTRACT AND AS CONTAINED HEREIN, THE CONTRACTING OFFICER MAY HAVE THE SSSMR SYSTEM REPAIRED OR REPAIRED BY OTHERS AND CHARGE THE COST TO THE MANUFACTURER.

A FRAMED COPY OF THIS WARRANTY SHALL BE POSTED IN THE MECHANICAL ROOM OR OTHER APPROVED LOCATION DURING THE ENTIRE WARRANTY PERIOD.

-- End of Section --

SECTION 16375

Robins AFB/COE SPEC, Dated 12/04/98

ELECTRICAL DISTRIBUTION SYSTEM, UNDERGROUND

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PART 1 GENERAL

## 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

## AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

|                |   |
|----------------|---|
| ANSI C2        | (1999) National Electrical Safety Code  |
| ANSI C29.1     | (1988) Electrical Power Insulators -<br>Test Methods  |
| ANSI C57.12.26 | (1987) Transformers - Pad-Mounted<br>Compartmental- Type, Self- Cooled, Three<br>Phase Distribution Transformers for Use<br>with Separable Insulated High Voltage<br>Connectors |
| ANSI C80.1     | (1990) Rigid Steel Conduit - Zinc Coated  |
| ANSI C135.30   | (1988) Zinc-Coated Ferrous Ground Rods<br>for Overhead or Underground Line<br>Construction  |

## AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

|             |   |
|-------------|---|
| ASTM A 48   | (1983; R 1990) Gray Iron Castings   |
| ASTM A 123  | (1989a) Zinc (Hot-Dip Galvanized)<br>Coatings on Iron and Steel Products                            |
| ASTM A 153  | (1982; R 1987) Zinc Coating (Hot-Dip) on<br>Iron and Steel Hardware                                 |
| ASTM B 8    | (1990) Concentric-Lay-Stranded Copper<br>Conductors, Hard, Medium-Hard, or Soft                     |
| ASTM B 117  | (1990) Salt Spray (Fog) Testing   |
| ASTM C 478  | (1990b) Precast Reinforced Concrete<br>Manhole Sections   |
| ASTM D 923  | (1991) Sampling Electrical Insulating<br>Liquids  |
| ASTM D 1654 | (1979a; R 1984) Evaluation of Painted or<br>Coated Specimens Subjected to Corrosive<br>Environments |

ASTM D 4059 (1991) Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography

ASTM F 883 (1990) Padlocks

ASSOCIATION OF EDISON ILLUMINATING COMPANIES (AEIC)

AEIC CS5 (1987) Thermoplastic and Cross-linked Polyethylene Insulated Shielded Power Cables Rated 5 Through 35 kV

AEIC CS6 (1987; Rev Mar 1989) Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV

FACTORY MUTUAL ENGINEERING AND RESEARCH CORPORATION (FM)

FM P7825 (1992; Supple I, II, and III) Approval Guide FEDERAL SPECIFICATIONS (FS)

FS HH-I-595 (Rev C) Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

RR-F-621 (Rev E) Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole

FS W-F-1814/GEN (Rev A; Supple 1, Notice 1) Fuses, Cartridge, High-Interrupting Capacity

FS W-S-610 (Rev E) Splice Connectors

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE)

IEEE C37.41 (1988; 37.41c) Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches, and Accessories

IEEE C37.90.1 (1989; R 1991) Surge Withstand capability (SWC) Tests for Protective Relays and Relay Systems

IEEE C57.12.00 (1987) Liquid-Immersed Distribution, Power, and Regulating Transformers

IEEE C57.13 (1978; R 1986) Instrument Transformers

IEEE C57.98 (1986) Guide for Transformer Impulse Tests -Appendix to C57.12.90

- IEEE C62.1 (1989) Standard for Gapped Silicon-Carbide Surge Arresters for AC Power Circuits
- IEEE C62.2 (1987) Guide for the Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems
- IEEE C62.11 (1987) Metal-Oxide Surge Arresters for AC Power Circuits
- IEEE Std 48 (1990) Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations
- IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- IEEE Std 100 (1988) IEEE Standard Dictionary of Electrical and Electronics Terms
- IEEE Std 386 (1985; R 1991) Separable Insulated Connector Systems for Power Distribution Systems Above 600V
- IEEE Std 404 (1986) Cable Joints for Use with Extruded Dielectric Cable Rated 5000 V through 46 000 V and Cable Joints for Use with Laminated Dielectric Cable Rated 2500 V Through 500 000 V
- IEEE Std 590 (1977; R 1991) Cable Plowing Guide
- IEEE Std 592 (1990) Exposed Semiconducting Shields on High Voltage Joints and Separable Insulated Connectors

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA AB 1 (1986; Rev 1) Molded Case Circuit Breakers and Molded Case Switches
- NEMA FB 1 (1988) Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies
- NEMA LA 1 (1986) Surge Arresters

NEMA PB 1 (1990; PB 1.1) Panelboards

NEMA SG 5 (1990) Power Switchgear Assemblies

NEMA TC 6 (1990) PVC and ABS Plastic Utilities  
Duct for Underground Installation

NEMA WC 7 (1988) Cross-Linked-Thermosetting  
-Polyethylene-Insulated Wire and Cable  
for the Transmission and Distribution of  
Electrical Energy

NEMA WC 8 (1988)  
Ethylene-Propylene-Rubber-Insulated Wire  
and Cable for the Transmission and  
Distribution of Electrical Energy

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL)

UL 6 (1981; Rev thru Dec 1992) Rigid Metal  
Conduit

UL 198E (1988; Rev Jul 1988) Class R Fuses

UL 467 (1984; Rev thru Nov 1986) Grounding and  
Bonding Equipment

UL 486A (1991; Rev Oct 1991) Wire Connectors and  
Soldering Lugs for Use with Copper  
Conductors

UL 489 (1991; Rev thru May 1992) Molded-Case  
Circuit Breakers and Circuit-Breaker  
Enclosures

UL 514A (1991) Metallic Outlet Boxes

UL 651 (1989; Rev thru Dec 1989) Schedule 40  
and 80 Rigid PVC Conduit

UL 854 (1991; Rev Dec 1992) Service-Entrance  
Cables

UL 857 (1990; Errata Apr 1990) Busways and  
Associated Fittings

UL 1242

(1983; Rev thru Jan 1993) Intermediate  
Metal Conduit

## 1.2 GENERAL REQUIREMENTS

### 1.2.1 Terminology

Terminology used in this specification is as defined in IEEE Std 100.

### 1.2.2 Service Conditions

Items provided under this section shall be specifically suitable for the following service conditions:

- a. Altitude 1000 feet.
- b. Ambient Temperature 120 degrees F.
- c. Frequency 60HZ.

## 1.3 SUBMITTALS

The following shall be submitted:

SD-01 Data

Manufacturer's Catalog Data; GA

Catalog cuts, brochures, circulars, specifications, product data, and printed information in sufficient detail and scope to verify compliance with the requirements of the contract documents. Original copies obtained from the manufacturer shall be provided in 3 ring hard cover binders. Photo-copies and/or fax copies will not be reviewed. If a Protective Coordination Study is specified in Section 16415, then the pad mount transformer shall be submitted with the study.

Material, Equipment, and Fixture Lists; FIO

A complete itemized listing of equipment and materials proposed for incorporation into the work. Each entry shall include an item number, the quantity of items proposed, and the name of the manufacturer of each such item.

Installation Procedures; FIO

As a minimum, installation procedures for transformers, substations, switchgear, and medium-voltage cable terminations and splices.

Procedures shall include cable pulling plans, diagrams, instructions, and precautions required to install, adjust, calibrate, and test the devices and equipment.

SD-04 Drawings

Electrical Distribution System; GA.

Detail drawings consisting of equipment drawings, illustrations, schedules, instructions, diagrams manufacturers standard installation drawings and other information necessary to define the installation and enable the Government to check conformity with the requirements of the contract drawings.

If departures from the contract drawings are deemed necessary by the Contractor, complete details of such departures shall be included with the detail drawings. Approved departures shall be made at no additional cost to the Government.

Detail drawings shall show how components are assembled, function together and how they will be installed on the project. Data and drawings for component parts of an item or system shall be coordinated and submitted as a unit. Data and drawings shall be coordinated and included in a single submission. Multiple submissions for the same equipment or system are not acceptable except where prior approval has been obtained from the Contracting Officer. In such cases, a list of data to be submitted later shall be included with the first submission. Detail drawings shall consist of the following:

Detail drawings showing physical arrangement, construction details, connections, finishes, materials used in fabrication, provisions for conduit or busway entrance, access requirements for installation and maintenance, physical size, electrical characteristics, foundation and support details, and equipment weight. Drawings shall be drawn to scale and/or dimensioned. All optional items shall be clearly identified as included or excluded.

Internal wiring diagrams of equipment showing wiring as actually provided for this project. External wiring connections shall be clearly identified.

The following items shall be submitted as minimum:

- a. Medium-voltage cables and accessories including cable installation plan.
- b. Pad mount transformers (including fusing), transformer pad construction (showing grade level, grounding etc).
- c. Surge arresters, terminations, splices.

- d. Exterior pole mounted light fixtures.
- e. Conduit and cables
- f. Nametags
- g. Padlocks
- h. Manholes

As-Built Drawings; GA.

The as-built drawings shall be a record of the construction as installed. The drawings shall include all the information shown on the contract drawings as well as all deviations, modifications, and changes from the contract drawings, however minor. Provide a complete set of original drawings with as-built mark-ups on a disc in autocad or microstation format. Also, provide a full sized set of prints and two half size marked to reflect all deviations, modifications, and changes. The as-built drawings shall be complete and show the location, size, dimensions, part identification, and other information. Additional sheets may be added. The as-built drawings shall be jointly inspected for accuracy and completeness by the Contractor's quality control representative and by the Contracting Officer prior to the submission of each monthly pay estimate. Upon completion of the work, the Contractor shall submit three full sized sets of the marked prints to the Contracting Officer for approval. If upon review, the as-built drawings are found to contain errors and/or omissions, they will be returned to the Contractor for correction. The Contractor shall correct and return the as-built drawings to the Contracting Officer for approval within 10 calendar days from the time the drawings are returned to the Contractor.

As built drawings shall be provided to the Government with other trades at the completion of the project. In addition, complete set of all electrical drawing sheets reflecting actual installed shall be included within the Operating and Maintenance Manuals.

SD-09 Reports

Factory Test; FIO.

Certified factory test reports shall be submitted when the manufacturer performs routine factory tests, including tests required by standards listed in paragraph REFERENCES. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted within 7 days following successful completion of the tests specified in applicable publications or in

these specifications. The manufacturer's pass-fail criteria for tests specified in paragraph FIELD TESTING shall be included.

Field Testing; FIO.

A proposed field test plan, 30 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

Test Reports; FIO.

Six copies of the information described below in 8-1/2 by 11-inch binders having a minimum of three rings from which material may readily be moved and replaced, including a separate section for each test. Sections shall be separated by heavy plastic dividers with tabs.

- a. A list of all equipment used, with calibration certifications.
- b. A copy of all measurements taken.
- c. The dates of testing.
- d. The equipment and values to be verified.
- e. The condition specified for the test.
- f. The test results, signed and dated.
- g. A description of all adjustments made.

SD-13 Certificates

Materials and Equipment; FIO.

Where materials or equipment are specified to conform to the standards of the Underwriters Laboratories (UL) or to be constructed or tested, or both, in accordance with the standards of the American National Standards Institute (ANSI), the Institute of Electrical and Electronics Engineers (IEEE), or the National Electrical Manufacturers Association (NEMA), the Contractor shall submit proof that the items provided under this section of the specifications conform to such requirements. The label of, or listing by, UL will be acceptable as evidence that the items conform. Either a certification or a published catalog specification data statement, to the effect that the item is in accordance with the referenced ANSI or IEEE standard, will be acceptable as evidence that the item conforms. A similar certification or published catalog specification data statement to the

effect that the item is in accordance with the referenced NEMA standard, by a company listed as a member company of NEMA, will be acceptable as evidence that the item conforms. In lieu of such certification or published data, the Contractor may submit a certificate from a recognized testing agency equipped and competent to perform such services, stating that the items have been tested and that they conform to the requirements listed, including methods of testing of the specified agencies. Compliance with above-named requirements does not relieve the Contractor from compliance with any other requirements of the specifications.

#### Cable Splicer Qualifications; GA.

Any company or individual which performs medium voltage splices and terminations shall not be employed by the Electrical Contractor. The individual may be a subcontractor of the Electrical Contractor. The individual and company shall be a separate medium voltage company and in no way owned or operated by the Electrical Contractor. The company and the individual shall be regularly engaged in the splicing, termination, and maintenance of medium voltage lines. This shall include overhead and underground medium voltage distribution between 1000 volts and 100,000 volts.

Provide a certification that contains the names and the qualifications of people recommended to perform the splicing and termination of medium-voltage cables approved for installation under this contract. The certification shall indicate that any person recommended to perform actual splicing and terminations has been adequately trained in the proper techniques and have had at least 5 recent years of experience in splicing and terminating the same or similar types of cables approved for installation.

In addition, any person recommended by the Contractor shall be required to perform sample splices and terminations, in the presence of the Contracting Officer, before being approved as a qualified installer of medium-voltage cables. A sample air switch termination for each size cable and loadbreak elbow being terminated shall be performed in front of the Government representative. The samples shall be done in the same manner as intended to be installed on the primary cables. Each sample shall be performed on a five foot section of 15 KV cable. The samples may not be used on the primary cables being installed on this project. After witnessing the sample splices, the Government representative may reject any individual which does show adequate experience or does not demonstrate proper installation techniques. All splices and terminations shall be installed in accordance with the detailed installation instructions as recommended by the manufacturer. The samples shall be performed prior to any terminating of 15 KV cables on this project.

#### Cable Installer Qualifications; GA.

The Contractor shall provide at least one onsite person in a supervisory position with a documentable level of competency and experience to supervise all cable pulling operations.

A resume shall be provided showing the cable installers' experience in the last 5 years, including a list of references complete with points of contact, addresses and telephone numbers.

SD-19 Operation and Maintenance Manuals

Electrical Distribution System; GA.

Six copies of Operation and Maintenance manuals which includes installation, operation and maintenance instructions, spare parts data which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked, and all test reports.

Manuals shall also include data outlining detailed procedures for system startup and operation, and a troubleshooting guide which lists possible operational problems and corrective action to be taken. A brief description of all equipment, basic operating features, and routine maintenance requirements shall also be included. Documents shall be bound in a binder marked or identified on the spine and front cover. A table of contents page shall be included and marked with pertinent contract information and contents of the manual. Tabs shall be provided to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the quantity of documents included under separate tabs or dividers.

Manuals shall be submitted with Section 16415, but separate from other sections included within this specification. Manual shall consist only of original manufacturers' literature and catalogs. Copies will not be accepted.

Manuals shall include a complete set of electrical sheets reflecting as-built conditions.

#### 1.4 DELIVERY, STORAGE, AND HANDLING

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Oil filled transformers and switches shall be stored in accordance with the manufacturer's requirements. Light poles shall be handled and stored in accordance with the manufacturer's instructions.

## PART 2 PRODUCTS

## 2.1 STANDARD PRODUCT

Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 5 years' prior to bid opening.

## 2.2 NAMEPLATES

### 2.2.1 General

Each major component of this specification shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a nameplate securely attached to the equipment. Nameplates shall be made of noncorrosive metal. Equipment containing liquid dielectrics shall have the type of dielectric on the nameplate. Air switch nameplates match existing at Robins AFB. As a minimum, nameplates shall be provided for transformers and air switch section.

### 2.2.2 Liquid-Filled Transformer Nameplates

Nameplates shall indicate percent impedance, voltage, kVA, frequency, number of phases, cooling class, insulation class, temperature rise, the number of gallons and composition of liquid-dielectric, and shall be permanently marked with a statement that the dielectric supplied is nonpolychlorinated biphenyl. If transformer nameplate is not so marked, the Contractor shall furnish manufacturer's certification for each transformer that the dielectric is non-PCB classified, with less than 50 ppm PCB content in accordance with paragraph LIQUID DIELECTRICS. Certifications shall be related to serial numbers on transformer nameplates. Transformer dielectric exceeding the 50 ppm PCB content or transformers without certification will be considered as PCB insulated and will not be accepted.

## 2.3 CORROSION PROTECTION

### 2.3.2 Ferrous Metal Materials

#### 2.3.2.1 Hardware

Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A 153 and ASTM A 123.

#### 2.3.2.2 Equipment

Equipment and component items, including but not limited to transformer stations and ferrous metal luminaires not hot-dip galvanized or porcelain enamel finished, shall be provided with

corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B 117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The scribed test mark and test evaluation shall be in accordance with ASTM D 1654 with a rating of not less than 7 in accordance with TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

## 2.4 CABLES

All medium voltage and low voltage cables shall be single copper conductor type. Multiconductor cables are not acceptable.

### 2.4.1 Medium-Voltage Cables

Conductors shall be rated for a voltage of 15,000 volts, phase to phase. All cables shall be single copper conductors. Cables shall conform to the requirements of NEMA WC-7.

#### 2.4.1.1 Conductor

Stranded annealed copper and extruded semi-conductive conductor shield

#### 2.4.1.2 Insulation

100 percent insulation level, cross-link polyethylene (XLP) or EPR and a semiconducting layer with black polyvinylchloride jacket.

#### 2.4.1.3 Shield:

Tape shielded cable

#### 2.4.1.4 Neutrals

Neutral conductors installed with 15 KV conductors shall be a separate single 600 volt copper conductor and of the same insulation material, cross-linked polyethylene (XLP).

### 2.4.2 Low-Voltage Cables

Cables shall be rated 600 volts and shall conform to the requirements of NFPA 70. Cables shall utilize THHN/THWN insulation.

## 2.5 CABLE JOINTS, TERMINATIONS, AND CONNECTORS

### 2.5.1 Air Switch Terminations

Two types are acceptable:

Type 1: 3M 5633K for #2 cable and 3M 5635K for #500 MCM cable.

Type 2: Raychem HVT-151-SJ for #2 cable and Raychem HVT-153-SJ for 500MCM. Complete kits shall be purchased from the manufacturer. The following installation equipment shall be used in the installation of the cable termination: cable preparation tools, Raychem P63 cable preparation kit, clean lint free cloths, nonconductive abrasive cloth (120 grit or finer), electricians tape, connectors and installation tools, and Raychem recommended torch. The torch shall include the Raychem FH-2629 for refillable cylinders and FH-2616A1 for disposable cylinder.

2.5.1.1 All lugs shall be copper compression terminal long barrel, UL Listed to 35 KV, closed-end barrel transition to protect the conductor from moisture, two hole, 1/2 inch bolt hole.

Install ground braid around spring clamp per manufacturers' installation instructions. Connect all three ground braids together in a copper #6 one hole lug with 1/2 inch stud, and connect with the neutral on the ground bus of the air switch. Neutral conductor and ground braids shall be connected to the same bolt on the ground bus. Air Switch terminations shall be installed in strict conformance with the latest manufacturers' installation instructions.

2.5.1.2 A sample air switch termination for each size cable being terminated shall be performed in front of the Government representative. This sample shall be done in the same manner as intended to be installed on the primary cables. The sample termination shall be performed on a five foot section of 15 KV cable. The sample may not be used on the primary cables being installed on this project. After witnessing the sample splice, the Government representative may reject any individual which does show adequate experience or does not demonstrate proper installation techniques. The terminations shall be installed in accordance with the detailed installation instructions as recommended by the manufacturer. The sample shall be performed prior to any terminating of 15 KV cables on this project.

## 2.5.2 Medium-Voltage Separable Insulated Connectors

Pad-mount transformer terminations shall be 200 amp, 15 KV class three-phase rated (8.2/14.4 KV). Loadbreak elbow connectors shall meet the full requirements of ANSI/IEEE Standard 386 - Separable, Insulated, Connector Systems. Elbow connectors shall be fully shielded and separable connection for loadbreak operation. Elbows shall be made of molded high quality Peroxide Cured EPDM insulation and have a semiconducting shield. Elbow shall contain a coppertop friction welded compression connector, tin plated copper probe, and an abative arc

follower tip. Termination shall contain a built-in stress relief to control voltage gradients, and a test point for determination of circuit condition.

A sample loadbreak elbow termination shall be performed in front of the Government representative. This sample shall be done in the same manner as intended to be installed on the primary cables. The sample termination shall be performed on a five foot section of 15 KV cable. The sample may not be used on the primary cables being installed on this project. After witnessing the sample splice, the Government representative may reject any individual which does show adequate experience or does not demonstrate proper installation techniques. The terminations shall be installed in accordance with the detailed installation instructions as recommended by the manufacturer. The sample shall be performed prior to any terminating of 15 KV cables on this project.

Grounding of elbows shall be in accordance with the instructions from the Government representative. Contractor shall request an on-site meeting prior to start of any work.

### 2.5.3 In-Line Splices

### 2.5.3 In-Line Splices

Two types are acceptable:

Type 1: 3M 5717 for #2 cable, and 3M 5719 for 500 MCM cable. Use latest version for installation instructions from the manufacturer.

Type 2: Raychem HVS-1511S-J for #2 cable, Raychem HVS-1513S-J for 500 MCM.

Complete kits shall be purchased from the manufacturer. The following installation equipment shall be used in the installation of the cable splice: cable preparation tools, Raychem P42 cable preparation kit, clean lint free cloths, nonconducting abrasive cloth (120 grit or finer), electricians tape, connectors and installation tools, and Raychem recommended torch. The torch shall include the Raychem FH-2609, FH-2629 for refillable propane cylinders and FH-2616A1 for disposable cylinder. In-line splice terminations shall be installed in strict conformance with the manufacturers' installation instructions.

Use latest version for installation instructions from the manufacturer. Use latest version for installation instructions from the manufacturer.

### 2.5.3.1 Sample In-line Splice

A sample in-line splice shall be performed in front of the Government representative. This sample shall be done in the same manner as intended to be installed on the primary cables. The sample termination shall be performed on a five foot section of 15 KV cable. The sample may not be used on the primary cables being installed on this project. After witnessing the sample splice, the Government representative may reject any individual which does show adequate experience or does not demonstrate proper installation techniques. The terminations shall be installed in accordance with the detailed installation instructions as recommended by the manufacturer. The sample shall be performed prior to any terminating of 15 KV cables on this project.

## 2.6 CONDUIT AND DUCTS

All medium voltage lines shall be concrete encased. All secondary lines from the transformer to the service entrance shall be concrete-encased. All other lines installed below grade shall be direct buried schedule 40 or DB. Conduit installed in concrete encased ductbanks shall be schedule 40 or DB. All elbows installed to transformer or an air switch shall be schedule 80 with long sweeping bends.

Pull wires shall be installed in each empty duct. Pull wire shall be nylon, Greenlee #430 or equal with a tensile strength of 210.

### 2.6.1 Metallic Conduit

Intermediate metal conduit shall comply with UL 1242. Rigid galvanized steel conduit shall comply with UL 6 and ANSI C80.1. Metallic conduit fittings and outlets shall comply with UL 514A and NEMA FB 1.

### 2.6.2 Nonmetallic Ducts

#### 2.6.2.2 Concrete Encased Ducts

Types Permitted: UL 651 Schedule 40 or Type DB.

#### 2.6.2.3 Direct Burial

Ducts specified to be concrete encased elsewhere in this specification shall be concrete encased. Only ducts not specified elsewhere as concrete encased shall be direct burial.

Types Permitted: UL 651 Schedule 40 or Type DB.

### 2.6.3 Conduit Sealing Compound

Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials.

## 2.7 MANHOLES ---

Manholes shall have the following dimensions: 8 ft X 8 ft X 7 ft high. Minimum cover opening shall be 32 inches. All manholes shall have sumps. Primary manholes shall have four 5-inch cast in terminators with end bells on each side of the manhole. Precast-concrete manholes shall have the required strength established by ASTM C 478. Frames and covers shall be made of gray cast iron and a machine-finished seat shall be provided to ensure a matching joint between frame and cover. All frames and covers shall be rated for H20 wheel loading. Cast iron shall comply with ASTM A 48, Class 30B, minimum.

## 2.8 Handholes

Handholes shall be provided where shown or specified. A handhole may not be used in lieu of a manhole if a manhole is specified.

Handholes shall be 4 ft X 4 ft X 4 ft. All sides and bottom shall be concrete. Handhole covers shall have a minimum clear circular opening of 32 inches, and H20 wheel loading. All new handholes shall be manufactured with two four inch cast in terminators. All connections to any existing handhole shall be core-drilled.

## 2.9 Pad-Mounted Transformers

Transformer stations shall be of the loop feed type with one set of high voltage bushings used for cable feed and the other set of high voltage bushings used for M.O.V.E. deadfront arrestors. Pad-mounted transformers shall comply with ANSI C57.12.26. Pad-mounted transformer stations shall be assembled and coordinated by one manufacturer and each transformer station shall be shipped as a complete unit so that field installation requirements are limited to mounting each unit on a concrete pad and connecting it to primary and secondary lines. Stainless steel pins and hinges shall be provided. Barriers shall be provided between high- and low-voltage compartments. High-voltage compartment doors shall be interlocked with low-voltage compartment doors to prevent access to any high-voltage section unless its

associated low-voltage section door has first been opened. Compartments shall be sized to meet the specific dimensional requirements of ANSI C57.12.26.

2.9.1 High-Voltage Compartments

High-voltage compartments shall be dead-front construction.

For transformers 1500 kVA and less, fuses shall be externally replaceable bayonet oil-immersed, expulsion fuses in series with oil-immersed current limiting fuses. For transformers exceeding 1500 KVA, fuses shall be full range current limiting tandem mounted fuse assembly.

Transformer shall contain loadbreak switching, medium-voltage separable connectors, and surge arresters. Switches shall be of the group-operated type. Switches may be mounted inside transformer tanks with switch operating handles located in high-voltage compartments and equipped with metal loops for hook stick operation. Adjacent to switches, nameplates shall identify switch operating handles and "ON" and "OFF" positions. Only two position switch (On and Off) shall be provided.

2.9.2 Transformer Tank Sections

Transformers shall be less-flammable, liquid-insulated type with high molecular-weight hydrocarbon. Transformers shall be suitable for outdoor use and shall have two separate windings per phase. Standard NEMA primary taps shall be provided. Primary taps shall have four, 2-1/2 percent rated KVA high-voltage taps shall be provided two above and two below rated primary voltage. Operating handles for primary tap changers for de-energized operation shall be located within high-voltage compartments, externally to transformer tanks. Adjacent to the tap changer operating handle, a nameplate or equivalent stenciled inscription shall be provided and inscribed "DO NOT OPERATE UNDER LOAD." Transformer ratings at 60 Hz shall be as follows:

|                                       |   |         |   |             |
|---------------------------------------|---|---------|---|-------------|
| Three-phase capacity.....             | [ |         | ] | KVA         |
| Impedance.....                        |   | 5.75    |   |             |
| Temperature rise.....                 |   | 55/65   |   | degrees C   |
| High-voltage winding.....             |   | 12470   |   | volts       |
| High-voltage winding connections..... |   | Delta   |   |             |
| Low-voltage winding.....              | [ | 480/277 | ] | [ 208/120 ] |
| Low-voltage winding connections.....  |   | WYE     |   |             |

2.9.3 Low-Voltage Cable Compartments

Neutrals shall be provided with fully-insulated bushings. Spade type cable terminations, suitable for copper conductors entering from

below, shall be provided as necessary. Bonding jumper between the neutral and cabinet shall be sized and installed by the transformer manufacturer at the factory. All low voltage cable terminations shall be of the compression type only.

#### 2.9.4 Accessories

High-voltage warning signs shall be permanently attached to each side of transformer stations. Voltage warning signs shall comply with ANSI C2. Copper-faced steel or stainless steel ground connection pads shall be provided in both the high- and low-voltage compartments. Dial-type thermometer, liquid-level gauge, and drain valve with built-in sampling device shall be provided for each transformer station. Transformer shall have a steel sleeve pocket welded onto the inside of the high voltage door for manual and 3 spare fuses. Three (3) spare bayonet fuses shall be provided by the transformer manufacturer and placed in the steel door pocket. Insert parking stands shall be provided and installed for each bushing well.

#### 2.9.5 Surge Arrestors

Surge arrestors shall be of dead-front MOV type. Arrestor shall be rated with a 9 KV duty cycle and 7.65 KV MCOV rating, 15 KV class. The arrestor shall combine metal (zinc) oxide varistor technology in a premolded rubber elbow.

The arrestor elbow shall provide protection in an insulated, fully shielded, submersible, deadfront device. The arrestor housing shall conform to ANSI/IEEE Standard 386 - Separable Insulated Connector Systems. The housing shall be made of molded EPDM insulating rubber. Connector shall be designed for use with 200 amp loadbreak bushings.

#### 2.9.6 Spare Fuses

3 spare bayonet fuse elements shall be supplied with each pad mount transformer. Fuses shall have the same characteristics, ratings, and manufacturer as the fuses shipped in the transformer.

#### 2.9.7 Color

Color shall be Sherwin Williams brown #48 or equal matching color.

#### 2.9.8 Padlocks

Padlocks shall be provided for pad-mounted equipment. Best #21B720L-R with core 8A59, short shack with two uncut keys.

Padlock shall be provided with the core number prior to any power application.

2.10 Omitted

2.11 Omitted

## 2.12 GROUNDING AND BONDING

### 2.12.1 Driven Ground Rods

Ground rods shall be copper-clad steel conforming to UL 467 not less than 5/8 inch in diameter by 10 feet in length. Sectional type rods may be used.

### 2.12.2 Grounding Conductors

Grounding conductors shall be bare, except where installed in conduit with associated phase conductors. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Bare conductors shall be ASTM B 8 soft-drawn unless otherwise indicated. Aluminum is not acceptable.

## 2.13 CONCRETE IN DUCTBANK

Concrete shall be a minimum of 3000 psi at 28 days.

2.14 OMITTED

2.15 OMITTED

## 2.16 LIQUID DIELECTRICS

Liquid dielectrics for transformers shall be nonpolychlorinated biphenyl (PCB) less-flammable liquid. Nonflammable fluids shall not be used. Tetrachloroethylene (perchloroethylene) and 1, 2, 4 trichlorobenzene fluids shall not be used. Liquid dielectrics in retrofitted equipment shall be certified by the manufacturer as having less than 50 parts per million (ppm) PCB content. In lieu of the manufacturer's certification, the Contractor may submit a test sample of the dielectric in accordance with ASTM D 923 and have tests performed per ASTM D 4059 at a testing facility approved by the Contracting Officer. Equipment with test results indicating PCB level exceeding 50 ppm shall be replaced.

## 2.17 PAD MOUNT TRANSFORMER FACTORY TESTS

Factory tests shall be performed, as follows, in accordance with the applicable publications and with other requirements of these specifications. The Contracting Officer shall be notified at least 30 days before the equipment is ready for testing. The Contracting Officer reserves the right to witness the tests.

a. Transformers: Manufacturer's standard tests in accordance with IEEE C57.12.00.

### 3.1 GENERAL INSTALLATION REQUIREMENTS

Equipment and devices shall be installed and energized in accordance with the manufacturer's published instructions. Steel conduits installed underground shall be installed and protected from corrosion in conformance with the requirements of Section 16415 ELECTRICAL WORK, INTERIOR.

#### 3.1.1 Conformance to Codes

The installation shall comply with the requirements and recommendations of NFPA 70 and ANSI C2 as applicable.

#### 3.1.2 Verification of Dimensions

The Contractor shall become familiar with details of the work, shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing any work.

### 3.2 Medium Voltage Cable Installation

All medium voltage cables shall be installed by a company with 5 years specialized experience in medium voltage work (1,000V to 100,000V). All submittals shall be prepared by the medium voltage installer. The Contractor shall obtain from the manufacturer an installation manual or set of instructions which addresses such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, etc. The Contractor shall then prepare a checklist of significant requirements and perform pulling calculations to prepare a pulling plan which shall be submitted along with the manufacturers instructions in accordance with SUBMITTALS.

#### 3.2.1 Marking of Medium Voltage Cables

Each circuit shall be identified by means of a laminated plastic, size 4 inches by 2 inches, with black background and white 1/4 inch high letters. Tags shall be attached around the three phases and neutral with two tie wraps, (one at each corner of the tag) at three evenly spaced locations in the manhole.

Tags shall be marked as designated by the Government.

#### 3.2.2 Duct Cleaning

Duct shall be cleaned with an assembly that consists of a flexible mandrel manufacturers standard product in lengths recommended for the specific size and type of duct that is 1/4 inch less than inside

diameter of duct, two wire brushes, and a rag. The cleaning assembly shall be pulled through conduit a minimum of two times or until less than a volume of 131 cubic centimeters (8 cubic inches) of debris is expelled from the duct.

### 3.2.3 Duct Lubrication

The cable lubricant shall be compatible with the cable jacket for cable that is being installed. Application of lubricant shall be in accordance with lubricant manufacturer's recommendations.

### 3.2.4 Cable Installation For Medium Voltage Cables

The Contractor shall provide a cable feeding truck and a cable pulling winch. The Contractor shall provide a pulling grip or pulling eye in accordance with cable manufacturer's recommendations. The pulling grip or pulling eye apparatus shall be attached to polypropylene or manilla rope followed by lubricant front end packs and then by power cables. A dynamometer shall be used to monitor pulling tension. Pulling tension shall not exceed cable manufacturer's recommendations.

The Contractor shall not allow cables to cross over while cables are being fed into duct. For cable installation in cold weather, cables shall be kept at 10 degrees C (50 degrees F) temperature for at least 24 hours before installation.

### 3.2.5 Cables in Manholes/ Handholes

Primary cables shall be routed around the interior walls and securely supported from walls on cables racks. Cable routing shall minimize cable crossover, provide access space for maintenance and installation of additional cables, and maintain cable separation in accordance with ANSI C2.

All cables shall be routed and supported by the medium voltage installer. New racks shall be provided as needed to support new cables in existing manholes.

### 3.2.5 Duct Line

Cables shall be installed in duct lines where indicated. Cable splices for medium-voltage cables shall be made in manholes only. Neutral and grounding conductors shall be installed in the same duct with their associated phase conductors.

### 3.2.6 Cable Splices and Terminations

All air switch, pad mount transformer, and cable splices shall be performed by the medium voltage installer. Qualifications of cable splicers shall be submitted in accordance with paragraph SUBMITTALS.

### 3.3 Cable Markers

0.127 mm (5-mil), brightly colored plastic tape not less than 75 mm (3 inches) in width and suitably inscribed at not more than 3 m (10 feet) on centers, or other approved dig-in warning indication, shall be placed approximately 12 inches below finished grade levels of all electrical duct lines. Inscription shall read "Electrical".

### 3.4 Omitted

### 3.5 DUCT LINES

#### 3.5.1 Requirements

Numbers and sizes of ducts shall be as indicated. Duct lines shall be laid with a minimum slope of 4 inches per 100 feet. Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Long sweeping schedule 40 manufactured 90-degree duct bends shall be used at air switch and pad mount transformer risers. In ducts, the minimum manufactured bend radius shall be 18 inches for ducts of less than 3-inch diameter, and 36 inches for ducts 3 inches or greater in diameter. Otherwise, long sweep bends having a minimum radius of 25 feet shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in manholes or handholes.

#### 3.5.2 Treatment

Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

#### 3.5.3 Concrete Encasement

Each single duct requiring concrete encasement shall be completely encased in concrete with a minimum of 3 inches of concrete around each duct, except that only 2 inches of concrete are required between adjacent electric power or adjacent communication ducts, and 6 inches of concrete shall be provided between adjacent electric power and

communication ducts. Duct line encasements shall be monolithic construction. Where a connection is made to a previously poured encasement, the new encasement shall be well bonded or doweled to the existing encasement. Stepped concrete connected together without rebar will not be acceptable means to achieve the monolithic construction. The Contractor shall submit proposed bonding method for approval in accordance with the detail drawing portion of paragraph SUBMITTALS. Tops of concrete encasements shall be not less than 3 feet. Contractor shall coordinate exact depth requirements with other trades and existing utilities.

Separators shall be made of plastic placed not farther apart than 6 feet on centers. Ducts shall be securely anchored to prevent movement during the placement of concrete by tying the ducts to the ground at every 6 feet. Install metallic backed warning tape above all duct banks.

#### 3.5.4 Nonencased Direct-Burial

Outside the building perimeter, the top of duct lines shall be 3 feet below finished grade. Conduits installed below the building slab shall be installed 1 (one) foot below the building capillary water barrier. All conduits shall be installed with a minimum of 3 inches of earth around individual ducts, or 2 inches between adjacent ducts. Between adjacent electric power and communication ducts, 12 inches of earth is required. Bottoms of trenches shall be graded toward manholes or handholes and shall be smooth and free of stones, soft spots, and sharp objects. Where bottoms of trenches comprise uneven materials, or materials which may damage the ducts, a 3-inch layer of sand shall be laid first and compacted to approximate densities of surrounding firm soil before installing ducts.

The excavation shall be backfilled and compacted in to 6-inch layers. Install metallic backed warning tape above all duct banks.

#### 3.5.5 Installation of Couplings

Joints in each type of duct shall be made up in accordance with the manufacturer's recommendations for the particular type of duct and coupling selected and as approved.

##### 3.5.5.2 Plastic Duct

Duct joints shall be made by brushing a plastic solvent cement on insides of plastic coupling fittings and on outsides of duct ends. Each duct and fitting shall then be slipped together with a quick 1/4 turn twist to set the joint tightly.

#### 3.5.6 Duct Line Markers

Duct line markers shall be a 5-mil brightly colored plastic tape, not less than 3 inches in width and suitably inscribed at not more than 10 feet on centers, with a continuous metallic backing and a corrosion-resistant 1 mil metallic foil core. This shall permit easy location of the duct line and be placed approximately 12 inches below finished grade levels of such lines.

### 3.6 Installation --- MANHOLES, HANDHOLES

The exact location shall be determined after careful consideration has been given to the location of other utilities, grading, and paving. The location shall be approved by the Contracting Officer before installation is started. In unpaved areas, the top of covers shall be approximately 15 mm (1/2 inch) above the finished grade. Where existing grades are lower than the new finished grade, concrete bricks with mortar or manufactured concrete rings designed for the purpose shall be installed to elevate the cover to the new finished grade. A cast metal grille-type sump frame and cover shall be installed over the sump.

Racks shall be grounded by extending a #1/0 bare ground around the walls and connected to a ground rod.

Cables shall be securely supported from walls by metal cable racks and equipped with adjustable hooks and insulators. Two cable racks shall be installed in each manhole wall and not less than two spare hooks shall be installed on each cable rack. Porcelain insulators shall be installed on the cable racks with cables. Insulators will not be required on spare hooks.

Existing manholes and handholes shall be core-drilled for duct penetrations. Install endbells on duct connections to manholes and handholes.

All ducts shall be installed perpendicular to the walls.

#### 3.6.1 Ground Rods

A ground rod shall be installed in the manholes and handholes. Precast concrete shall have the top of the ground rod above the bottom of the manhole with a watertight sleeve in the floor or wall.

### 3.7 PAD-MOUNTED EQUIPMENT INSTALLATION

Units shall be carefully installed so as not to damage equipment or scratch painted or coated surfaces. After installation, surfaces shall be inspected and scratches touched up with a paint or coating provided by the manufacturer especially for this purpose. Three-phase transformer installations shall be installed with ABC phase sequence.

### 3.7.1 Concrete Pads

Pads shall extend 6 inches beyond all sides. Concrete pads for pad-mounted electrical equipment shall be poured-in-place. Prefabricated pads will not be acceptable.

Pads shall have dimensions needed for the actual equipment to be installed. Tops of concrete pads shall be level and shall project 8 inches above finished grade and sloped to drain. Edges of concrete pads shall have 3/4 inch chamfer. Conduits for primary, secondary, and grounding conductors shall be set in place prior to placement of concrete pads. Where grounding electrode conductors are installed through concrete pads, PVC conduit sleeves shall be installed through the concrete to provide physical protection. Concrete pad shall have concrete poured around ducts.

Pad shall be placed concrete on the jobsite with 3000 PSI concrete. Concrete shall placed around ducts with no window. Pad shall be minimum 14 inches thick, with 8 inches above grade. Install #5 rebar 12 inches on center each way.

#### 3.7.1.3 Sealing

When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.

### 3.8 OMITTED

### 3.9 OMITTED

### 3.10 GROUNDING

#### 3.10.1 Transformer Grounding

Grounding counterpoise consisting of #4/0 bare copper shall be installed around each pad-mount transformer. Install a 3/4 inch ground rod at each corner and extend minimum two #4/0 grounding conductors into the pad mount sections, one conductor in the secondary and one conductor in the primary. All below grade connections shall be the exothermic type. All connections to the transformer shall be of the compression type. Split bolts shall not be acceptable. Install PVC sleeve through the pad. Connect the #4/0 conductors to the transformer enclosure with compression connectors; one in the primary and one in the secondary. Connect the secondary ground directly to the enclosure, not the neutral bus. Transformer shall have a copper bonding jumper from the neutral to the enclosure installed at the transformer factory.

Loadbreak bushing inserts shall be grounded at the ground tab by a bare copper #12 stranded wire, through the metal eye located on the insert well, then to the grounding system. Loop all three ground tabs and metal eyes together on the left side separate from the three ground tabs and metal eyes on the right side. The end of the #12 stranded wire shall be brazed together to keep the conductor strands from separating.

Drain leads from the loadbreak elbows shall be connected to the 4/0 ground in the primary with H-tap compression. Grounded neutral shall be connected to the 4/0 ground in the primary with compression H-tap. #12 stranded ground looped from the ground tabs on the left side and #12 stranded ground looped from the tabs on the right side shall be connected to the 4/0 ground with H-tap compression. Note: Three H-tap compression connectors shall be used for the above.

### 3.10.2 Surge Arrester Grounding

Surge arresters shall be bonded directly to the grounding electrode system.

### 3.10.5 Manhole, Handhole, or Concrete Pullbox Grounding

Ground rods installed in electrical-distribution-system manholes, handholes, or concrete pullboxes shall be connected to cable racks with a #4/0 bare copper conductor. Connect all cable shielding, and metallic sheath with a No. 6 tinned copper. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Grounding electrode conductors shall be neatly and firmly attached to manhole or handhole walls and the amount of exposed bare wire shall be held to a minimum.

## 3.11 FIELD TESTING

### 3.11.1 General

Field testing shall be performed in the presence of the Contracting Officer. The Contractor shall notify the Contracting Officer 14 days prior to conducting tests. The Contractor shall furnish all materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform all tests and inspections recommended by the manufacturer unless specifically waived by the Contracting Officer. The Contractor shall maintain a written record of all tests which includes date, test performed, personnel involved, devices tested,

serial number and name of test equipment, and test results. All field test reports shall be signed and dated by the Contractor. All field testing shall be completed and test results submitted to the Corps of Engineers Robins Area Office prior to requesting for power to facility.

### 3.11.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

### 3.11.3 Ground-Resistance Tests

The resistance of each grounding electrode system shall be measured using the fall-of-potential method defined in IEEE Std 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

### 3.11.5 Medium-Voltage Cable Test

After installation and terminations, all medium voltage cables shall be given a high potential test.

If new cables are in-line spliced to existing cables, then the new cables, splices and existing cables shall be given a high potential test together. Test shall be performed at a voltage as recommended for the existing cable.

Direct-current voltage shall be applied on each phase conductor of the system by connecting conductors as one terminal and connecting grounds or metallic shieldings or sheaths of the cable as the other terminal for each test. Prior to making the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The test shall be conducted with all splices, connectors, and terminations in place. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 7 or NEMA WC 8 for the particular type of cable installed, except that 28 kV and 35 kV insulation test voltages shall be in accordance with either AEIC CS5 or AEIC CS6 as applicable, and shall not exceed the recommendations of IEEE Std 404 for cable joints and IEEE Std 48 for cable terminations unless the cable and

accessory manufacturers indicate higher voltages are acceptable for testing.

Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs and replace cables. Repaired or replaced cables shall be retested.

### 3.11.6 Low-Voltage Cable Test

Cables shall be tested for phase to phase, phase to ground connections, and correct phase sequence. Low-voltage cable, complete with splices, shall be tested for insulation resistance after the cables are installed, in their final configuration, ready for connection to the equipment, and prior to energization. The test voltage shall be 1000 volts dc, applied for 1 minute between each conductor and ground and between all possible combinations of conductors in the same trench, duct, or cable, with all other conductors in the same trench, duct, or cable grounded. The minimum value of insulation shall be:

$R$  in megohms = (rated voltage in kV + 1) x 1,000 length of cable in meters (feet)

Each cable failing this test shall be repaired or replaced. The repaired cable system shall be retested until failures have been eliminated.

### 3.11.7 Liquid-Filled Transformer Tests

The following field tests shall be performed on the liquid-filled pad mount transformer(s).

- a. Clockwise rotation of phases
- b. Correct operation of tap changer.

## 3.12 Pre-Energization of Service

### 3.12.1 Padlocks

Padlocks for air switches and pad mount transformers shall be required to be provided to the Government prior to energization of the system. The padlocks specified in this specification shall be the type locks provided prior to initial energization.

### 3.12.2 Energization/ Inspection Schedule With The Government

The Contractor shall notify the Government in writing that the electrical system is ready for inspection. The Government shall be given three working days to inspect the installation. After the inspection with the Government, all deficiencies noted shall be corrected. After the Contractor notifies the Government that all deficiencies have been corrected, three working days shall be given to the Government to inspect correction of all prior noted deficiencies. The Contractor shall then give the Government written notice that the facility is ready for application of power. The Government shall then be given not less than three working days ( Mon - Fri ) for the application of power to the primary system and the main switchboard.

**-- End of Section --**

**THIS SPECIFICATION IS PREPARED FOR USE AT ROBINS AFB.**

**ONLY ITEMS LISTED WITH BOLD BRACKETS MAY BE EDITED FOR THE PARTICULAR PROJECT. NO OTHER ITEMS OR SPECIFICATIONS MAY BE EDITED OR DELETED WITHOUT WRITTEN PERMISSION FROM ROBINS AFB AT THE CIVIL ENGINEERING SECTION, 78 CEG/CECE.**

**SELECTION OF TYPE SWITCHBOARD, DOUBLE ENDED OR SINGLE, OR PANELBOARD CONSTRUCTION IS BASED STRICTLY ON THE AMPACITY OF THE BUS. THE BASE FACILITY STANDARD AND DESIGN-BUILD RFP (MILCON PROJECTS) PROVIDES DIRECTION ON THE TYPE REQUIRED.**

ROBINS AFB/ COE SPEC  
Dated 12/20/01

SECTION 16415

ELECTRICAL WORK, INTERIOR

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

- ANSI C12.1 (1988) Code for Electricity Metering
- ANSI C12.16 (1991) Electricity Metering Solid State Electricity Meters
- ANSI C57.12.50 (1981; R 1989) Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase, and 15 to 500 kVA, Three-Phase, with High-Voltage 601 to 34 500 Volts, Low-Voltage 120 to 600 Volts
- ANSI C57.12.70 (1978; R 1987) Terminal Markings and Connections for Distribution and Power Transformers
- ANSI C80.5 (1990) Rigid Aluminum Conduit\
- ANSI C82.4 (1985; C82.4a) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
- ANSI C135.30 (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction

CODE OF FEDERAL REGULATIONS (CFR)

- CFR 47 Part 18 Rules and Regulations: Industrial, Scientific and Medical Equipment

FEDERAL SPECIFICATIONS (FS)

- FS L-C-530 (Rev C) Coating, Pipe, Thermoplastic Resin
- FS L-P-387 (Rev A; Am 1, Int Am 2) Plastic Sheet, Laminated, Thermosetting (for Designation Plates)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

- IEEE C37.13 (1990) Low-Voltage AC Power Circuit Breakers Used in Enclosures

- IEEE C37.20.1 (1987) Metal-Enclosed Low-Voltage Power Circuit-Breaker Switchgear
- IEEE C57.12.00 (1987) Liquid-Immersed Distribution, Power, and Regulating Transformers
- IEEE C57.12.01 (1989) Dry-Type Distribution and Power Transformers Including Those With Solid Cast and/or Resin - Encapsulated Windings
- IEEE C57.12.80 (1978; R 1986) Terminology for Power and Distribution Transformers
- IEEE C57.12.90 (1987; Appendix C57.98) Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
- IEEE C57.12.91 (1979) Test Code for Dry Type Distribution and Power Transformers
- IEEE C57.13 (1978; R 1986) Instrument Transformers
- IEEE C57.94 (1982; R 1987) Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
- IEEE C57.98 (1986) Guide for Transformer Impulse Tests - Appendix to C57.12.90
- IEEE C57.100 (1986) Test Procedure for Thermal Evaluation of Oil-Immersed Distribution Transformers
- IEEE C57.105 (1978; R 1987) Transformers Connections in Three Phase Distribution Systems
- IEEE C62.41 (1991) Surge Voltages in Low-Voltage AC Power Circuits
- IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

INSULATED CABLE ENGINEERS ASSOCIATION (ICEA)

- ICEA S-80-576 (1988) Communications Wire and Cable for Wiring of Premises

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

- NEMA 250 (1991) Enclosures for Electrical Equipment (1000 Volts Maximum)

NEMA AB 1 (1986; Rev 1) Molded Case Circuit Breakers and Molded Case Switches

NEMA BU 1 (1988; BU 1.1-1986) Busways

NEMA FU 1 (1986) Low Voltage Cartridge Fuses

NEMA ICS 1 (1988; Rev 1, 2 & 3) Industrial Controls and Systems

NEMA ICS 2 (1988; Rev 1) Industrial Control Devices, Controllers and Assemblies

NEMA ICS 3 (1988; Rev 1) Industrial Systems

NEMA ICS 6 (1988; Rev 1) Enclosures for Industrial Control and Systems

NEMA LE 4 (1987) Recessed Luminaires, Ceiling Compatibility

NEMA MG 1 (1987; Rev 1 and 2) Motors and Generators

NEMA MG 10 (1983; R 1988) Energy Management Guide for Selection and Use of Polyphase Motors

NEMA OS 1 (1989) Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports

NEMA PB 1 (1990; PB 1.1) Panelboards

NEMA PB 2 (1989; PB 2.1) Deadfront Distribution Switchboards

NEMA PE 5 (1985; R 1991) Utility Type Battery Chargers

NEMA PE 7 (1985; R 1991) Communication Type Battery Chargers

NEMA RN 1 (1989) Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit

NEMA ST 20 (1992) Dry-Type Transformers for General Applications

EMA WD 1 (1983; R 1989) General Requirements for Wiring Devices

NEMA WD 6 (1988) Wiring Devices - Dimensional Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

- NFPA 70 (1999) National Electrical Code
- NFPA 101 (1991) Safety to Life from Fire in Buildings and Structures

RURAL ELECTRIFICATION ADMINISTRATION (REA)

- REA TE&CM 823 (1980) Electrical Protection by Use of Gas Tube Arresters

UNDERWRITERS LABORATORIES (UL)

- UL-03 (1992; Supple) Electrical Construction Materials Directory
- UL 1 (1985; Rev thru Nov 1992) Flexible Metal Conduit
- UL 5 (1985; Rev thru Sep 1990) Surface Metal Raceways and Fittings
- UL 6 (1981; Rev thru Dec 1992) Rigid Metal Conduit
- UL 20 (1986; Rev thru Jul 1991) General-Use Snap Switches
- UL 44 (1991; Rev thru Jan 1993) Rubber-Insulated Wires and Cables
- UL 50 (1992) Enclosures for Electrical Equipment
- UL 67 (1988; Rev thru Feb 1993) Panelboards
- UL 83 (1991; Rev thru Jul 1992) Thermoplastic-Insulated Wires and Cables
- UL 94 (1991; Rev Aug 1992) Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
- UL 98 (1987; Rev thru Apr 1990) Enclosed and Dead-Front Switches
- UL 198B (1988; Rev Jan 1988) Class H Fuses
- UL 198C (1986; Rev thru Oct 1992) High-Interrupting-Capacity Fuses, Current-Limiting Types
- UL 198D (1988; Rev Jul 1988) Capacity Class K Fuses

UL 198E (1988; Rev Jul 1988) Class R Fuses

UL 198F (1988) Plug Fuses

UL 198G (1988; Rev May 1988) Fuses for  
Supplementary Overcurrent Protection

UL 198H (1988; Rev Jun 1990) Class T Fuses

UL 198L (1988; Rev Mar 1988) D-C Fuses for  
Industrial Use

UL 360 (1986; Rev thru Jan 1993)  
Liquid-Tight Flexible Steel Conduit

UL 467 (1984; Rev thru Nov 1986) Grounding and  
Bonding Equipment

UL 486A (1991; Rev Oct 1991) Wire Connectors  
and Soldering Lugs for Use with Copper  
Conductors

UL 486C (1991; Rev thru Sep 1992) Splicing  
Wire Connectors

UL 489 (1991; Rev thru May 1992) Molded-Case  
Circuit Breakers and Circuit-Breaker  
Enclosures

UL 497 (1991; Rev Sep 1992) Protectors for  
Paired Conductor Communication Circuits

UL 498 (1991; Rev thru Aug 1992) Attachment  
Plugs and Receptacles

UL 506 (1989; Errata Jan 1990) Specialty  
Transformers

UL 508 (1993) Industrial Control Equipment

UL 510 (1986; Rev Oct 1986) Insulating Tape

UL 512 (1987) Fuseholders

UL 514A (1991) Metallic Outlet Boxes

UL 514B (1992; Rev thru Mar 1993) Fittings  
for Conduit and Outlet Boxes

UL 514C (1988; Rev thru Jun 1989) Nonmetallic  
Outlet Boxes, Flush-Device Boxes, and Covers

UL 542 (1985; Rev thru Dec 1992)  
Lampholders, Starters, and Starter Holders

for Fluorescent Lamps

UL 651 (1989; Rev thru Dec 1989) Schedule 40 and 80 Rigid PVC Conduit

UL 651A (1989; Rev thru Dec 1989) Type EB and A Rigid PVC Conduit and HDPE Conduit

UL 674 (1989) Electric Motors and Generators for Use in Hazardous (Classified) Locations

UL 698 (1991; Rev Nov 1991) Industrial Control Equipment for Use in Hazardous (Classified) Locations

UL 719 (1985; Rev thru May 1992) Nonmetallic-Sheathed Cables

UL 797 (1983; Rev thru Jul 1991) Electrical Metallic Tubing

UL 817 (1986; Rev thru May 1991) Cord Sets and Power-Supply Cords

UL 844 (1990; Rev Nov 1990) Electric Lighting Fixtures for Use in Hazardous (Classified) Locations

UL 845 (1988; Rev thru Aug 1989) Motor Control Centers

UL 857 (1990; Errata Apr 1990) Busways and Associated Fittings

UL 869A (1987; Rev thru Sep 1992) Reference Standard for Service Equipment

UL 877 (1985; Rev thru Mar 1987) Circuit Breakers and Circuit-Breaker Enclosures for Use in Hazardous (Classified) Locations

UL 886 (1985; Rev Apr 1992) Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations

UL 891 (1984; Rev thru Jun 1991) Dead-Front Switchboards

UL 924 (1990; Rev thru Dec 1991) Emergency Lighting and Power Equipment

UL 935 (1993; Rev Feb 1993) Fluorescent-Lamp Ballasts

UL 943 (1985; Rev thru Mar 1993)

Ground-Fault Circuit Interrupters

- UL 1004 (1989; Rev thru Mar 1993) Electric Motors
- UL 1010 (1991; Rev thru Aug 1991) Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations
- UL 1022 (1979; Rev thru Jun 1984, Errata Nov 1985) Line Isolation Monitors
- UL 1029 (1986; Rev thru Nov 1991) High-Intensity-Discharge Lamp Ballasts
- UL 1047 (1990; Errata May 1991) Isolated Power Systems Equipment
- UL 1236 (1992) Battery Chargers for Charging Engine-Starter Batteries
- UL 1242 (1983; Rev thru Jan 1993) Intermediate Metal Conduit
- UL 1561 (1986; Rev thru Jul 1992) Dry-Type General Purpose and Power Transformers
- UL 1564 (1982; Rev thru Nov 1991) Industrial Battery Chargers
- UL 1570 (1988; Rev thru Feb 1993) Fluorescent Lighting Fixtures
- UL 1571 (1991; Rev thru Aug 1992) Incandescent Lighting Fixtures
- UL 1572 (1991; Rev thru Aug 1992) High Intensity Discharge Lighting Fixtures
- UL 1660 (1987) Liquid-Tight Flexible Nonmetallic Conduit

1.2 GENERAL

1.2.1 Rules

The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Lighting

fixtures, outlets, and other equipment and materials shall be located to avoid interference with mechanical or structural features; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change. The Contractor is responsible for coordinating all wire sizes shown on the drawings with the electrical manufacturer. In the event a problem exists with wire sizes and the lugs, the Contractor shall request a clarification from the Government prior to submission of the electrical equipment.

1.2.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.2.5 Identification Nameplates

Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Designation of motors shall coincide with their designation in the motor control center or panel. Unless otherwise specified, all identification nameplates shall be made of laminated plastic in accordance with FS L-P-387 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws, except motors, or approved nonadhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates.

In all instances, the nameplate shall be installed in a conspicuous location.

At the option of the Contractor, the equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The front of each panelboard, motor control center, switchgear, and switchboard shall have a nameplate to indicate the phase letter, corresponding color and arrangement of the phase conductors. The following equipment, as a minimum, shall be provided with identification nameplates:

| Minimum 1/4 inch<br>High Letters | Minimum 1/8 inch<br>High Letters |
|----------------------------------|----------------------------------|
| _____                            | _____                            |
| Panelboards                      | Control Power Transformers       |
| Starters                         | Control Devices                  |
| Safety Switches                  | Instrument Transformers          |
| Motor Control Centers            |                                  |
| Transformers                     |                                  |
| Equipment Enclosures             |                                  |
| Switchgear                       |                                  |
| Switchboards                     |                                  |
| Motors                           |                                  |

Each panel, section, or unit in motor control centers, switchgear or similar assemblies shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

#### 1.2.6 As-Built Drawings

Following the project completion or turnover, within 30 days, the Contractor shall furnish three sets of as-built drawings to the Contracting Officer.

#### 1.2.7 Y2K Compliant

All equipment in this specification shall be Y2K compliant.

### 1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01300 SUBMITTAL DESCRIPTIONS:

#### 1.3.1 Material For Submission; GA.

Submit all material in 3 ring hard cover binders.

Contractor shall submit drawings to scale on a CAD software which demonstrates the actual equipment layout meets NEC 110-26 and Article 384. Drawing shall demonstrate coordination with other trades in the same room with the equipment, such as structural steel or beams, sprinkler lines, HVAC duct, mechanical equipment, etc. This drawing shall be approved by the Government prior to any installation of conduit or material. Any installation without the approved CAD drawing shall be subject to demolition and reinstallation at the expense of the Contractor.

All material submitted for equipment shall be the manufacturers' original data sheets. No copies or faxes will be acknowledged. Conduit, conduit supports, switches, and receptacles will not require original manufacturers' data. However, all other equipment shall be the original manufacturers' data.

All material for the light fixtures, circuit breakers, dry type transformers, panelboard schedules, panelboard manufacturers' data, switchboards, pad mount transformers, and motor control centers shall be submitted together. Operation and Maintenance Manuals for the items above shall be included in the submittal. Submit these items in a single 3 ring hard cover binder. All electrical equipment shall be separated by tabs. Within each tab shall include the submittal data for the equipment and the Operation and Maintenance Manuals and/or catalog for the equipment. Only manufacturers' original data and catalogs shall be provided. No copies or faxes will be acknowledged.

All other material shall be provided in a separate 3 ring hard cover binder. All material shall be submitted together in one single submission. Different material shall be separated by tabs with Operation and Maintenance Manuals.

Catalog data for all materials and equipment to be incorporated in this project shall be submitted. This drawings shall consist of a complete list of

equipment and materials, including manufacturer's descriptive and technical data; catalog cuts; and any special installation instructions that may be required.

Complete wiring diagrams shall be provided for all electrical equipment. The wiring diagrams shall be computer generated and prepared by the electrical manufacturer.

This shall include complete dimensions of the equipment, wiring schematics, diagrams of bus structure for switchboards/motor control centers, panelboard schedules, and lug sizes for all cable connections.

1.3.2 Coordinated Power System Protection --- OMITTED

1.3.3 Reports

Materials and Equipment; GA.

All material for use in this project shall have a label or listing of the Underwriters Laboratories, Inc.. In lieu of this label or listing, a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with UL procedures and that the materials and equipment comply with all contract requirements will be accepted. Materials and equipment shall be approved based on the manufacturer's published data.

For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with the applicable Federal Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable.

1.3.4 Electrical Contractor Qualifications; GA

Evidence that the jobsite superintendant at the project during all installation contains an Electricians Master License, Unrestricted.

1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

PART 2 PRODUCTS

2.0 MATERIALS AND EQUIPMENT

Materials and equipment shall conform to the respective publications and other requirements specified below. Materials and equipment not listed below shall be as specified elsewhere in this section.

2.1 Cables and Wires

All conductors shall be single, rated 600 volt copper type with THHN/THWN insulation. Cables and wires shall conform to UL 44 for rubber-insulated type; UL 83 for the thermoplastic-insulated type. Wiring for lights and receptacle

circuits shall be stranded conductors. Light switches and receptacles shall be connected to the stranded wire by a vinyl insulated brazed fork terminal.

#### 2.1.1 Grounding Cables

Grounding cables shall be insulated when in conduit with conductors and shall be bare when below grade installed in direct contact with earth. Insulated conductors shall have a green insulation in conduit and in the interior of electrical equipment.

#### 2.2 Omitted

#### 2.3 Circuit Breakers

Circuit breakers shall have voltage, current and interrupting ratings as indicated. Fully rated circuit breakers shall be provided to obtain the specified interrupting rating. Series rating of circuit breakers will not be acceptable. Circuit breakers, switchboards, meters, and panelboard enclosures shall be the same manufacturer.

All circuit Breakers shall be UL Listed.

Molded-Case Circuit Breakers: Standard thermal magnetic breakers shall be used. Provide adjustable magnetic trip on all breaker frames where available.

Ground Fault Circuit Interrupters:

UL 943. Breakers less than 20 amps equipped with ground fault interrupters shall have ground fault class, interrupting capacity, and voltage and current ratings as indicated.

#### 2.4 OMITTED

#### 2.5 Panelboards

2.5.1 Panelboards shall meet requirements listed below:

2.5.1.1 Deadfront construction, NEMA PB 1, Federal Specification W-P-115a. Panelboards, UL 67; UL 50 cabinets and boxes

2.5.1.2 All phase, neutral, and ground bus shall be copper. AIC rating shall be fully rated. Series rating of circuit breakers to achieve short circuit rating is unacceptable.

2.5.1.3 Directory shall be typed to reflect installed as-built conditions. Directory shall indicate item and room number served, such as "Receptacles, Room Number ; Lighting, Corridor Room Number ;etc ."  
Install a laminated nameplate on the panel front to designate bus fed from, such " Fed From Main Switchboard ".

2.5.1.4 Breakers shall be located in the designated pole locations as shown on the contract drawings. Power panelboards shall be provided in lieu of lighting panelboards at no additional cost if needed to comply.

2.5.1.5 On any panelboard bus equal 800 amperes, construction shall be power distribution. Lighting panelboards will not be acceptable for 800 amperes. Boxes shall be minimum 9 1/2 inches deep.

2.5.1.6 Breakers shall be arranged in the panel interior as shown on the contract drawings. Power distribution panelboards shall be provided, if needed, to place the breakers in the designated locations regardless of bus ampacity specified. Manufacturer may not rearrange the breaker locations in order to utilize lighting panelboard construction.

## 2.5.2 Service Entrance Rated Equipment

2.5.2.1 Panelboards shall meet all requirements listed in para.2.5.1.

2.5.2.2 Main panel shall be rated "service entrance" and contain a neutral bonding jumper constructed of a copper bus installed by the manufacturer at the factory. The "service entrance" rated panel shall contain a UL service entrance label.  
Panel shall contain a copper neutral and copper ground bus.

2.5.2.3 A transient voltage surge suppressor (TVSS) shall be installed downstream from the main breaker.

2.6 OMITTED

2.7 OMITTED

2.8 OMITTED

## 2.9 Dry - Type Transformers

### 2.9.1 General Purpose Dry Type Transformers

#### 2.9.1.1 Standards

Transformers shall be U.L. Listed under the requirements of Standard 506 and 1561. In addition, each transformer shall meet the requirements of NEMA ST-20, 1992, and applicable ANSI and IEEE standards.

2.9.1.2 Construction Specifications of General Purpose Dry Type Transformers Only single- and three-phase transformers having two windings per phase will be approved. Three-phase transformers shall be connected only in a delta-wye, [except isolation transformers having a one-to-one turns ratio]. The insulation on transformer windings shall be 150 degree celsius winding rise with 220 degree celsius temperature class. The insulation system shall be suitable for 40 degree celsius ambient as defined by ANSI and NEMA standards.

Transformers to be located within the building shall be provided in the manufacturer's standard, ventilated indoor enclosure. Transformers shall contain six 2 1/2 percent universal taps, two above and four below rated primary.

#### 2.9.1.3 Sound Levels of Dry Type Transformers

The average sound level in decibels (dB) of transformers shall not exceed the following dB level based on ANSI C89.2-1986.

| kVA RANGE | dB SOUND LEVEL |
|-----------|----------------|
| 1-9       | 40             |
| 10-50     | 45             |
| 51-150    | 50             |
| 151-300   | 55             |
| 301-500   | 60             |

2.10 Omitted

2.11 Omitted

2.12 Omitted

2.13 Omitted

2.14 Omitted

2.15 Omitted

2.16 Conduit and Tubing

See para. 3.2.1.1 for conduit types permitted

2.16.1 Electrical, Zinc-Coated Steel Metallic Tubing (EMT) UL 797. See para 3.2.2 for description of couplings permitted with EMT.

2.16.2 Flexible Conduit, Steel and Plastic

General-purpose type, UL 1; liquidtight, UL 360 and UL 1660.

2.16.3 Intermediate Metal Conduit

UL 1242.

2.16.4 PVC Coated Rigid Steel Conduit --- NEMA RN 1.

2.16.5 Rigid Aluminum Conduit --- ANSI C80.5 and UL 6.

2.16.6 Rigid Metal Conduit --- UL 6.

2.16.7 Rigid Plastic --- UL 651A.

2.16.8 Surface Metal Electrical Raceways and Fittings --- UL 5.

2.16.9 Omitted

2.17 Omitted

2.18 Omitted

2.19 Omitted

2.20 Boxes, Metallic Outlet --- NEMA OS 1 and UL 514A.

2.21 Omitted

2.22 Combination Starters shall meet the following:

a) Heavy Duty Type

b) Enclosure shall be Nema type 1 indoors and Nema Type 3R outdoor.

c) Combination starters shall contain an integral starter, disconnect, and control transformer with fusing all built in the same enclosure and by the same manufacturer. Combination starter shall be UL Listed. Secondary voltage shall be [ 120 ] [ 24 ] volts. Each starter shall have a combination HOA switch, red pilot lamp for "on" and a green pilot lamp for "off".

2.23 Boxes, Switch (Enclosed), Surface-Mounted --- UL 98.

2.24 Fittings for Conduit and Outlet Boxes --- UL 514B.

2.25 Omitted

2.26 Fittings, PVC, for Use with Rigid PVC Conduit and Tubing ---- UL 514B.

2.27 Conduit Coatings Plastic Resin System --- FS L-C-530 or NEMA RN 1,  
Type A-40.

2.28 Connectors, Wire Pressure

2.29 Copper Conductors --- UL 486A.

2.30 Electrical Grounding and Bonding Equipment --- UL 467.

2.30.1 Ground Rods

Ground rods shall be of copper-clad steel conforming to UL 467, 3/4 inch 3/4 inch in diameter by 10 feet in length of the sectional type driven full length into the earth.

2.31 Enclosures

NEMA ICS 6 or NEMA 250 [or UL 698 for use in hazardous classified locations], unless otherwise specified.

2.32 Cabinets and Boxes --- UL 50.

2.33 Fixtures, Lighting and Fixture Accessories/Components

Refer to RFP and Base Facility Standards

Fixtures, accessories and components, including ballasts, lampholders, lamps, starters and starter holders, shall conform to industry standards.

2.33.1 Exit Signs

All exit signs shall contain an integral sealed, maintenance free nickel cadmium battery or connected to an emergency source which delivers 90 minutes capacity to lamps.

Exit signs shall be LED type, with a uniform illumination. Exit signs which show visible LEDs will not be accepted. Housing shall be constructed of die cast aluminum. Finish shall be brushed aluminum. Panel letter color shall be red. Fixtures shall operate in the normal and emergency mode.

Exit signs installed on a balcony, under a canopy or exterior walkway shall be listed for "damp locations."

Exit signs in explosion proof areas shall be two 13 watt, quad type fluorescent lamps for emergency use only. Batteries in explosion proof fixtures, unless connected to a central IPS system, shall be nickel-cadmium, maintenance-free. Fixtures shall operate in the normal and emergency mode.

2.33.2 OMITTED

2.33.3 OMITTED

2.33.4 Fluorescent

Electronic Ballast: All fluorescent fixtures shall have electronic rapid start ballasts.

Low Harmonic Distortion: less than 10 percent THD  
Lamp Current Crest Factor: less than 1.7  
Transient Protection: Meets IEEE 587A (ANSI C62.1)  
EMI: MEET FCC Part 18C, Class A  
UL Listed: Class P, Type 1  
Power Factor: Greater Than .97  
Input Frequency: 60 HZ  
Starting Temperature: 50 degree minimum  
Voltage Range: +/- 10 % of rated input  
Sound Rating: Quieter than Class A

2.34 Omitted

2.35 Omitted

2.36 Omitted

2.37 Fuses and Fuseholders

2.37.1 Fuses, Low Voltage Cartridge Type --- NEMA FU 1.

2.37.2 Fuses, High-Interrupting-Capacity, Current-Limiting Type  
UL 198C.

2.37.3 Fuses, Class K, High-Interrupting-Capacity Type --- UL 198D.

2.37.4 Fuses, Class H --- UL 198B.

- 2.37.5 Fuses, Class R --- UL 198E.
- 2.37.6 Fuses, Class T --- UL 198H.
- 2.37.8 Fuses for Supplementary Overcurrent Protection  
UL 198G.
- 2.37.9 Fuses, D-C for Industrial Use --- UL 198L.
- 2.37.10 Fuseholders --- UL 512.

2.38 Motors, ac, Fractional and Integral Kilowatt (Horsepower)

Motors, ac, fractional and integral kilowatt, (horsepower,) 373.0 kW (500 hp) and smaller shall conform to NEMA MG 1 and UL 1004 for motors; NEMA MG 10 for energy management selection of polyphase motors.

2.38.1 Kilowatt (Horsepower) Rating

The kilowatt (horsepower) rating of motors should be limited to no more than 125 percent of the maximum load being served unless a NEMA standard size does not fall within this range. In this case, the next larger NEMA standard motor size should be used.

2.38.2 Motor Controls

NEMA ICS 1, NEMA ICS 2, NEMA ICS 3 and NEMA ICS 6, and UL 508 and UL 845.

2.39 Receptacles

2.39.1 Federal Specification/ Commercial Grade

Single and duplex receptacles shall be NEMA 5-20R, rated 20 amperes, 125 volts, two-pole, three-wire, grounding type with polarized parallel slots. Bodies shall be ivory. Receptacles shall be heavy duty with high grade brass alloy triple wipe contacts, indestructible nylon face, and rigid glass reinforced nylon back body. Receptacles shall be supported by mounting strap having plaster ears.

Receptacle shall be side- or back-wired with two screws per terminal. The third grounding pole shall be connected to the metal mounting yoke.

2.39.2 Receptacles, 15-Ampere, 250-Volt -- NEMA 6-15R

Receptacles, 15-ampere, 250-volt, shall be duplex two-pole, three-wire, grounding type with bodies of ivory phenolic compound supported by mounting yoke having plaster ears. The third grounding pole shall be connected to the metal yoke. Each receptacle shall be provided with a mating cord-grip cap.

2.39.3 Receptacles, 20-Ampere, 250-Volt -- NEMA 6-20R

Receptacles, single, 20-ampere, 250-volt, shall be molded plastic, two-pole, three-wire or three-pole, four-wire, grounding type complete with appropriate mating cord-grip plug.

\*\*\*\*\*

**Designer should show detail of any special receptacle on the drawings. Provide on the drawings a MIL-STD number (if available or applicable), manufacturer design basis, NEMA number, etc. Detail on the drawing should clearly show pin configuration, voltage, number phases, and amp rating.**

\*\*\*\*\*

2.39.4 Special-Purpose or Heavy-Duty Receptacles

Special-purpose or heavy-duty receptacles shall be of the type and of ratings and number of poles required for the anticipated purpose. One matching plug shall be furnished with each receptacle. Locking of receptacles, indicated to be the locking type shall be accomplished by the rotation of the plug.

2.40 Wall Switches

2.40.1 AC Switches

Switches shall be rated 20-ampere, [ 120 ] [ 277 ] volt for use on alternating current only. Switches shall be of the specification grade. Wall switches shall be of the totally enclosed tumbler type. The wall switch handle shall be ivory. Wiring terminals shall be of the screw type. Dimming switches shall be solid-state flush mounted, sized for the loads. All switches shall have a grounding screw.

2.41 Wall Plates

All device plates shall be Type 302, .035 inch thick, brushed finish, U.L Listed stainless steel.

2.42 Ground Fault Interrupters UL 943, Class A or B.

2.43 Service Equipment --- UL 869A.

2.44 Splice, Conductor ---- UL 486C.

2.45 Omitted

2.46 Omitted

2.47 Snap Switches --- UL 20.

2.48 Tapes

2.48.1 Plastic Tape --- UL 510.

2.48.2 Rubber Tape --- UL 510.

PART 3 EXECUTION

3.0 Electrical Contractor Qualifications

Electrical Contractor shall have on-site during all installation an Electrician with a Master Electricians License.

### 3.1 Grounding

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

#### 3.1.1 Service Entrance Grounding

Resistance to ground shall be measured using the fall-of-potential method described in IEEE Std 81. The maximum resistance of a the system ground shall not exceed 25 ohms under normally dry conditions. On all service entrance equipment, a triangular ground shall be installed 10 feet from the facility which consists of three 3/4 inch ground rods spaced 20 ft apart with #4/0 connecting the rods, with a #4/0 wire extended to the service entrance ground bus. All below grade connections shall be exothermic. Extend one #4/0 from the service entrance ground bus to the steel structure and a #4/0 to the building lightning protection counterpoise. All metallic water piping shall be bonded to the service entrance ground bus. All connections to steel structure shall be exothermic type. In addition, on facilities with new construction, extend a #4/0 to the building rebar footing from the service entrance ground bus.

#### 3.1.3 Grounding Conductors

A green ground wire shall be furnished regardless of the type of conduit or load. All equipment grounding conductors, including metallic raceway systems used as such, shall be bonded or joined together in each wiring box or equipment enclosure. Metallic raceways and grounding conductors shall be checked to assure that they are wired or bonded into a common junction. Metallic boxes and enclosures, if used, shall also be bonded to these grounding conductors by an approved means per NFPA 70. When boxes for receptacles, switches, or other utilization devices are installed, any designated grounding terminal on these devices shall also be bonded to the equipment grounding conductor junction with a short jumper. All switches shall contain a ground screw for ground connections; in addition, switches shall be bonded to the box through a short bonding jumper. All equipment grounding conductors installed in conduit with phase conductors shall have the same insulation as the phase conductors. All equipment grounding conductors in the panelboards shall have insulation the entire length except at terminations.

### 3.2 WIRING METHODS

#### 3.2.1 Conduit Types Permitted

Conduits installed exposed in the shop areas shall be rigid steel or threaded intermediate metallic conduit.

In all other areas, wiring shall consist of insulated conductors installed in rigid zinc-coated steel conduit, rigid plastic conduit (schedule 40 in the earth only), electrical metallic tubing, or intermediate metal conduit. Flexible nonmetallic conduit or tubing will not be accepted as a raceway.

Short sections less than 4 ft of sealtite conduit shall be used for connections to motors or equipment which may need flexible connection. Light fixtures shall have a 4" X 4", 1 1/2 inch depth junction box installed within 6 ft of the light fixture. Connect the light fixture to the junction

box with metallic flexible conduit. Manufacturers' approved flexible connections (3/8 inch or larger metallic flexible conduit less than 6 ft with internal separate ground conductor) shall be acceptable for light fixtures only. Maximum length of flexible conduit in any application shall not exceed 6 feet, regardless of size.

### 3.2.2 Conduit Homerun Symbols

Conduit homeruns shall be installed as shown on the contract drawings. At each homerun symbol, a separate conduit shall be installed from the homerun symbol to the feeder panelboard. Contractor shall not mix or revise the homerun symbols from that shown on the contract drawings.

### 3.2.3 Conduits at Switchboards, Panelboards and Motor Control Centers

#### Panelboards:

If a panelboard is top fed, then the wiring shall enter the top of the panelboard enclosure. Likewise, on bottom fed panels, wiring shall enter only the bottom of the panel enclosure. Installing the conduit on the bottom and running the conductors in the side gutter space to reach top fed panels will be considered unacceptable workmanship. Likewise, installing conduit on the top of the panel enclosure and running the conductors through the side gutter space to reach bottom fed panels will be considered unacceptable workmanship. The Contractor shall coordinate with the manufacturer and plan the conduit runs appropriately.

3.2.4 Conductors shall not be spliced inside a switchboard or panelboard. All wiring shall terminate on lugs or terminal strips within the unit.

### 3.2.5 Conduit and Tubing Systems

All fittings for electrical metallic conduit shall be of the steel compression type. Connectors for flexible metal conduit shall be malleable iron/ zinc plated and of the 2 screw clamp type with insulated throats conforming to UL 514B and NEMA FB-1. Minimum size of raceways shall be 1/2 inch. Electrical metallic tubing may be installed in concrete and grout in dry locations. Electrical metallic tubing installed in concrete or grout shall be provided with concrete tight fittings. EMT will not be installed in damp or wet locations. Insulating fittings shall be installed on the ends of all conduit, including all sizes of electrical metallic tubing. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Aluminum conduit may be used only where installed exposed in dry locations. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped to maintain the fire rating of the rated wall. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas as permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 6 inches away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints shall be provided with expansion fittings to compensate for the building expansion and contraction and to provide for continuity of grounding. Covers to junction boxes shall be labeled with a permanent marker; labeling shall include panel designation and circuit number.

### 3.2.6 Below Slab-on-Grade or in the Ground

All electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit below the slab shall be installed in the earth and (1) one foot below the capillary water barrier. Conduit passing vertically through slabs-on-grade shall be rigid steel or IMC. Conversion to rigid steel or IMC shall be accomplished by a rigid steel elbow. Conduits installed below slab-on-grade or in the earth shall be field wrapped with 0.010 inch thick pipe-wrapping plastic tape applied with a 50 percent overlay.

### 3.2.7 Installing in Slabs Including Slabs on Grade

No conduits shall be installed within a horizontal run of a slab.

### 3.2.8 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations.

### 3.2.9 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be taken to prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment during the course of construction. Clogged raceways shall be entirely freed of obstructions or shall be replaced.

### 3.2.10 Supports

Metallic conduits and tubing shall be securely and rigidly fastened in place at intervals of not more than 10 feet and within 3 feet of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, or ceiling trapeze. Conduit may not be used for a ceiling trapeze, only approved factory manufactured unistrut may be used to build conduit supports. C-clamps or beam clamps shall have strap or rod-type retainers. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structures, but no load shall be applied to joist bridging.

Each conduit support shall be extended to the building structural steel or bar joists. Attaching a unistrut to a box with over-hang on each side to support conduit will not be permitted. Conduit supported between threaded rods attached to the structure may not be used as a support for conduit raceways. Unistrut (and associated hardware such as channel nuts, spring nuts, conduit strut clamps, washers, threaded rods, and rod couplings) shall be used to support all conduit from the structure. Conduit pressure caddy clips which clamp onto structural steel may only be used for maximum 3/4 inch conduit size.

Supports shall be fastened to wood with wood screws; with bolts and metal expansion shields on gypsum, concrete or brick and concrete filled CMU cells; with toggle bolts on hollow masonry units; and with machine screws on steel work. Expansion metal anchors shall be permitted in lieu of toggle bolts on hollow masonry units for 3/4 inch conduit size or less only. Only toggle bolts shall be used on all equipment enclosures and boxes on hollow masonry units. Nail-type nylon anchors are not acceptable. Raceways or pipe straps shall not be welded to steel structures. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joists shall avoid cutting the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet-metal screws shall be used. Conduit shall not be supported using wire or nylon ties. Raceways shall be installed as a complete system and be independently supported from the structure.

Upper raceways shall not be the support of lower raceways. No conduit shall be supported from cable tray supports. Supporting means will not be shared between electrical raceways and mechanical piping or ducts and shall not be fastened to hung ceiling supports. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts, one locknut on each side. Insulating bushings shall be installed on all conduit, including all sizes of electrical metallic conduit. A pull wire shall be inserted in each empty raceway in which wiring is to be installed by others if the raceway is more than 15 meters 50 feet in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 150 feet in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 200 psi tensile strength. Not less than 10 inches of slack shall be left at each end of the pull wire. Electrical metallic conduit shall be supported in the interior of stud walls within 3 feet of boxes and every 10 feet.

#### 3.2.11 OMITTED

#### 3.2.12 General Installation Of Conduits Concealed Verses Exposed

Rooms with finished walls shall have the conduits installed concealed in walls, ceilings, or below the slab; except surface mounting is acceptable in mechanical and electrical rooms.

#### 3.2.13 Cables and Conductors

All conductors shall be single conductor, copper, and with Type THHN/THWN insulation. Wiring for lights and receptacle circuits shall be stranded conductors.

Light switches and receptacles shall be connected to the stranded wire by a vinyl insulated brazed fork terminal.

Wire connectors of insulating material or solderless pressure connectors properly taped shall be utilized for all splices. Feeder conductors to panelboards shall not be spliced; all ends of conductors shall be installed at breaker terminations. Any conductors installed with the outer insulation damaged as a result of pulling conductors in electrical equipment shall be replaced with new material at the expense of the Contractor. Taping of damaged conductors will not be acceptable.

### 3.2.14 Sizes

All sizes are based on copper conductors. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 100 feet long and of 277 volts more than 230 feet long shall be no smaller than No. 10 AWG.

### 3.2.15 Power Conductor Identification

Phase conductors shall be identified by color coding. The color of the insulation on phases A, B, and C respectively (for three phase) or phases A and B respectively (for single phase) of different voltage systems shall be as follows:

120/208 volt, 3-phase: Black, red, and blue. White on neutral.

277/480 volt, 3-phase: Brown, orange, and yellow. Grey on neutral.

120/240 volt, single/phase: Black and red.

Conductor phase and voltage identification shall be made by color-coded insulation for all conductors No. 10 and smaller. For conductors No. 8 AWG and larger, identification shall be made by color-coded insulation, or conductors with black insulation may be furnished and identified by the use of half-lapped bands of colored electrical tape wrapped around the insulation for a minimum of 3 inches of length near the termination. Conductor identification shall be provided within each enclosure where a tap, splice, or termination is made. In panelboards at branch circuits, install a label sticker with marking to identify branch circuit number. Install sticker to allow the circuit to be identified with the interior panel cover installed.

### 3.2.16 Control Conductor Identification

Control circuit conductor identification shall be made by color-coded insulated conductors, plastic-coated self-sticking printed markers, permanently attached stamped metal foil markers, or equivalent means as approved. Control circuit terminals of equipment shall be properly identified. Terminal and conductor identification shall match that shown on approved detail drawings. Hand lettering or marking is not acceptable.

### 3.2.17 Switch Leg Identification

Switch leg identification for lighting circuits shall be the same color insulation as the phase conductor. Both conductors (to/from) the switch shall be the same color as the phase conductor.

## 3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways, 4-inch by 4-inch nominal size, shall be of the weatherproof type when located in normally wet locations, when flush and surface mounted on outside of exterior surfaces. In partitions of light steel construction, boxes shall be supported in walls with the studs installed between adjacent studs for back support. Another acceptable method to support

boxes in walls is a pre-manufactured box mounting bracket, which shall provide support for boxes or plaster rings between studs. The premanufactured mounting bracket shall have the same height as the boxes, extend from stud to stud, and be of 16 gauge thickness.

The edges of plaster rings for electrical devices shall be not more than 1/4 inch back from the finished surfaces in gypsum and CMU finished walls. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. Plaster ring extensions which decrease the box interior dimensions are not acceptable and shall not be used to extend the box to the finished surface. Boxes for mounting lighting fixtures shall be not less than 4 inches square except smaller boxes may be installed as required by fixture configuration, as approved. The bottom of boxes installed in masonry-block walls for concealed wiring shall be flush with the top or bottom of a block to minimize cutting of blocks. Unless otherwise indicated, boxes for wall switches shall be mounted 48 inches above finished floors. Cast-metal boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws on steel work. Expansion metal anchors shall be permitted in lieu of toggle bolts on hollow masonry units for 3/4 inch conduit size or less only. Toggle bolts shall be used on all equipment enclosures and boxes on hollow masonry units. In open overhead spaces, cast-metal boxes threaded to raceways shall be separately supported where used for fixture support; sheet metal boxes having threadless connectors supported directly from the building structure by 1/4 inch "all-thread". Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 24 inches from the box.

Penetration of more than 1-1/2 inches into reinforced-concrete beams or more than 3/4 inch into reinforced-concrete joists shall avoid cutting any main reinforcing steel.

The Electrical Contractor shall have a representative present at the jobsite during the wall construction to ensure boxes are maintained flush with the finished surface.

### 3.3.1 Boxes for Use with Raceway Systems

3.3.1.1 Large size boxes shall be NEMA type 1 indoors and Nema 4X when located outdoors. Aluminum boxes shall be used with aluminum conduit. All junction boxes with devices shall have a plaster ring.

3.3.1.2 Sheetmetal junction boxes for all devices, except communication outlets, shall be not less than 4 inches square and 1 1/2 inch deep.

### 3.3.3 Pull Boxes

Pull boxes of not less than the minimum size required by NFPA 70 shall be constructed of [aluminum or] galvanized sheet steel. Boxes shall be furnished with screw-fastened covers. Where several feeders pass through a common pull

box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation.

#### 3.3.4 Clock Outlet

Clock outlet, for use in other than a wired clock system, shall consist of an outlet box, a plaster cover where required, and a single receptacle with clock-outlet plate. The receptacle shall be recessed sufficiently within the box to allow the complete insertion of a standard cap, flush with the plate. A suitable clip or support for hanging the clock shall be secured to the top of the plate. Material and finish of the plate shall be as specified in paragraph Wall Plates.

#### 3.3.6 Omitted

### 3.4 Wall Plates

Wall Plates shall be specified in section under Materials.

Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

### 3.5 RECEPTACLES

Contractor is responsible to coordinate receptacle types as needed.

#### 3.5.1 Single and Duplex

All conductors shall be installed with a pigtail connection to the receptacle. Pigtail connection shall be installed on the neutral, phase and ground. Pigtail connections shall be installed in the same outlet box as the receptacle.

Receptacles with ground fault circuit interrupters shall have the current rating as indicated, and shall be UL Class A type unless otherwise shown. Ground fault circuit protection shall be provided as required by NFPA 70 and as indicated on the drawings.

#### 3.5.2 Weatherproof

Weatherproof receptacles shown shall be mounted in a box with a gasketed, weatherproof, cast-metal cover plate and gasketed cap over each receptacle opening. The cap shall be provided with a spring-hinged flap and completely cover the plug when inserted.

### 3.6 Wall Switches

Not more than one switch shall be installed in a single-gang position.. Separate equipment ground conductor shall be connected to the switch grounding screw.

3.7 - 3.8 Omitted

3.9 Panelboards

Door locks shall be keyed alike. Directories shall be typed to indicate loads served by each circuit, room number circuit feeds, such as "RECEPT- RM 102" "LIGHTS- RM 103", etc. and mounted in a holder behind a clear protective covering. All manufacturers' bolts shall be re-torqued at the jobsite in the field. Coordinate with manufacturer on the required torque for all connections. Interior of all components shall be cleaned thoroughly of all dirt and debris prior to requesting for power.

3.10 Omitted

3.11 FUSES

Equipment provided under this contract shall be provided with a complete set of properly rated fuses when the equipment manufacturer utilize fuses in the manufacture of the equipment. Fuses shall have a voltage rating of not less than the phase-to-phase circuit voltage.

3.11.1 Cartridge Fuses; Current-Limiting Type

Cartridge fuses, current-limiting type, Class RK1, RK5 shall have tested interrupting capacity not less than 100,000 amperes. Fuse holders shall be the type that will reject all Class H fuses.

3.12 OMITTED

3.13 MOTORS

3.13.1 Each motor shall conform to the kW (hp) and voltage ratings indicated, and shall have a service factor and other characteristics that are essential to the proper application and performance of the motors under conditions shown or specified. Three-phase motors for use on 3-phase 208-volt systems shall have a nameplate rating of 200 volts, application on 3 phase 480 volt systems shall have a nameplate of 460 volts. Unless otherwise specified, all 3 phase motors shall have a totally enclosed, fan cooled frame, and continuous-duty classification based on a 40 degree C ambient temperature reference. Polyphase motors shall be squirrel-cage type, having normal-starting-torque and low-starting-current characteristics, unless other characteristics are specified in other sections of these specifications or shown on contract drawings. The Contractor shall be responsible for selecting the actual kilowatt (horsepower) ratings and other motor requirements necessary for the applications indicated. When electrically driven equipment furnished under other sections of these specifications materially differs from the design, the Contractor shall make the necessary adjustments to the wiring, disconnect devices and branch-circuit protection to accommodate the equipment actually installed.

3.14 MOTOR CONTROL

Each motor or group of motors requiring a single control shall be provided under other sections of these specifications with a suitable controller and devices that will perform the functions as specified for the respective motors. Each motor of 1/8 hp or larger shall be provided with thermal-overload protection. Polyphase motors shall have overload protection in each ungrounded conductor. The overload-protection device shall be provided either integral with the motor or controller, or shall be mounted in a separate enclosure. Unless otherwise specified, the protective device shall be of the manually reset type. Single or double pole tumbler switches specifically designed for alternating-current operation only may be used as manual controllers for single-phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as thermostats, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate kilowatt (horsepower) rating. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the HAND position; all safety control devices, such as low- or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the Manual and the Automatic positions of the selector switch.

### 3.15 MOTOR-DISCONNECT MEANS

All equipment which contains a motor shall have a wall-mounted disconnect next to the equipment. Disconnect switches shall be rated "heavy duty" and fused per manufacturers' recommendations.

Each motor shall be provided with a disconnect switch rated for the horsepower even though not indicated on the drawings. Circuit breaker will not be an acceptable means for a disconnect. For single-phase motors, a single or double pole toggle switch, rated only for alternating current, will be acceptable for capacities less than 30 amperes, provided the ampere rating of the switch is at least 125 percent of the motor rating. Switches shall disconnect all ungrounded conductors.

### 3.16 Transformers

Dry type transformers shall be installed on a 4 inch high concrete housekeeping pad with rubber isolation pads. Connect all conduits to the transformer enclosure with flexible conduit less than five feet; however, convert flexible conduit back to EMT prior to connection to a nearby panelboard or switchboard enclosure.

All conductor terminations shall be compression type only. Transformers shall be grounded in accordance with NFPA 70, Article 250.

### 3.17 LAMPS AND LIGHTING FIXTURES

Ballasted fixtures shall have ballasts which are compatible with the specific type and rating of lamps indicated and shall comply with the applicable provisions of the publications referenced.

#### 3.17.1 Lamps

Lamps of the type, wattage, and voltage rating indicated shall be delivered to the project in the original cartons. The lamps shall not be installed in the fixtures until four weeks prior to final acceptance of the facility.

3.17.1.1 Omitted

3.17.1.2 Omitted

3.17.2 Exit Signs

Exit signs shall be installed not higher than 9 feet to the center.

3.17.2 Fixtures

3.17.2.1 Accessories

Accessories such as straps, mounting plates, nipples, or brackets shall be provided for proper installation.

3.17.2.2 Suspended Fixtures

Suspended fixtures shall be provided with swivel hangers in order to ensure a plumb installation. Pendants, rods, or chains 4 feet or longer excluding fixture, shall be braced to limit swinging. Bracing shall be three directional, 120 degrees apart. Single unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple unit or continuous-row fluorescent units shall have a tubing or stem for wiring at one point, and a tubing or rod suspension provided for each length of chassis including one at each end. Maximum distance between adjacent tubing or stems shall be 10 feet. Rods shall be of not less than 3/16 inch diameter. Flexible raceway shall be installed to each fixture from an overhead junction box. Fixture to fixture wiring installation is allowed only when fixtures are installed end to end in a continuous run.

3.17.2.3 Ceiling Fixtures

Ceiling fixtures shall be coordinated with and suitable for installation in, on, or from the suspended ceiling. Recessed fixtures shall have a hangar wire within 6 inches attached to the grid at opposite corners and the structure ceiling above. Recessed fixtures shall have adjustable fittings to permit alignment with ceiling panels.

3.20 EQUIPMENT CONNECTIONS

All wiring not furnished and installed under other sections of the specifications for the connection of electrical equipment as indicated on the drawings shall be furnished and installed under this section of the specifications. Connections shall comply with the applicable requirements of paragraph WIRING METHODS. Flexible conduits 6 feet or less in length shall be provided to all electrical equipment subject to periodic removal, vibration, or movement and for all motors. All motors shall be provided with separate grounding conductors. Liquid-tight conduits shall be used in damp or wet locations.

3.21 OMITTED

3.22 OMITTED

3.23 PAINTING AND FINISHING

All conduit and boxes on finished walls shall be painted the same color to match the wall surface. Galvanized electrical conduit and boxes shall first be given a primer washcoat to prepare the galvanized surface for painting. The surfaces shall then be painted in accordance with the finished schedules on the contract drawings or the paint specification.

3.24 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Government.

3.25 FIELD TESTS

Field tests shall be performed at the jobsite in the presence of the Government.

3.25.1 Insulation Tests

All conductors and electrical equipment shall be given an insulation test. Each component in the power system shall be tested separately with no other apparatus or equipment connected. Provide all proposed test procedures with manufacturers' recommendations not later than 30 days prior to performing tests.

All test results shall be given to the Government not less than two weeks after performing tests. Tests results shall be submitted in 3 ring hard cover binders. Tests results shall be submitted prior to energizing power to any component.

Insulation resistance for each phase, neutral, and ground wire shall be shown. Any component which fails the test and/or indicate damaged insulation shall be removed, new material reinstalled and tested at the no additional cost to the Government.

3.25.2 Facility Ground Testing

The service entrance shall be given a resistance testing of that system's ground rods and submission of test results to the Contracting Officer. Test reports shall indicate the location of the rod and the resistance and the soil conditions at the time the test was performed.

3.26 ONE-LINE DIAGRAM

A one-line diagram with main transformer, building disconnect means, and feeder breakers/switches to building panels located at the building disconnect shall be provided. Diagram shall be plastic laminated. The breaker/switch

identification on the diagram shall match nameplate on the installed equipment. One line diagram shall include all data as stated in IEEE std. 141, chapter 2.3.28.

### 3.27 Energization of Electrical System

No part of the electrical distribution system shall be energized prior to inspection from the Government.

#### 3.27.1 Energization/ Inspection Schedule With The Government

The Contractor shall notify the Government in writing that the electrical system is ready for inspection. The Government shall be given three working days to inspect the installation. After the inspection with the Government, all deficiencies noted shall be corrected. A followup inspection shall be performed by the Government to ensure all known deficiencies have been corrected. The Government shall then be given not less than three working days ( Mon - Fri ) for the application of power to the primary system and the main switchboard.

### 3.28 Training

Training shall consist of the following:

3.28.1 The Contractor shall conduct a training course for the operating staff. The training period shall consist of (8) eight hours classroom instruction on the operation and Maintenance Manuals and (8) eight hours hands-on field training. Training shall be provided after permanent power has been placed on the facility.

3.28.2 Training shall start after the system is functionally completed but prior to final acceptance tests. Training shall start not less than (30) days prior to receipt of approved Operating and Maintenance Manuals and Test Reports.

### 3.29 Spare Parts and Stock

At the completion of the project, the Contractor shall provide the following spare parts:

- 1) At least one of each type of fixture for spare stock
- 2) At least 10 percent of each type of lamp for spare stock

-- End of Section --

**THIS SPECIFICATION IS PREPARED FOR USE AT ROBINS AFB.**

**ONLY ITEMS LISTED WITH BOLD BRACKETS MAY BE EDITED FOR THE PARTICULAR PROJECT.**

ROBINS AFB/ COE SPEC  
Dated 12/04/98

SECTION 16500

COMMUNICATIONS SYSTEM

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70

(1999) National Electrical Code

1.2 GENERAL

The communications systems cables and connecting hardware shall meet the standards established by the American National Standards Institute (ANSI), the Electronic Industry Association (EIA) and the Telecommunications Industry (TIA) Standards.

1.2.1 Rules

1.2.2 Coordination

The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment shall be properly located and readily accessible. Raceways shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and reasons for departures shall be submitted and approved prior to implementing any change.

1.2.4 Standard Products

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

1.3.1 Material For Submission; FIO.

Submit all material in 3 ring hard cover binders.

Contractor shall submit drawings to scale on a CADD software which demonstrates the actual equipment layout. Drawing shall demonstrate coordination with other trades in the same room with the equipment, such as structural steel or beams, sprinkler lines, HVAC duct, mechanical equipment, etc. This drawing shall be approved by the Government prior to any installation of conduit or material. Any installation without the approved CAD drawing shall be subject to demolition and reinstallation at the expense of the Contractor.

All material submitted for equipment shall be the manufacturers' original data sheets. No copies or faxes will be acknowledged.

Catalog data for all materials and equipment to be incorporated in this project shall be submitted. This drawings shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical data; catalog cuts; and any special installation instructions that may be required.

Drawing shall show all backboard terminations, communications room layout of blocks/ equipment/jacks/hub rack, etc. Provide layout of facility on CADD which shows facility with rooms, doors, jack locations and labeling method. A file format compatible with an Intergraph system shall be used. Provide grid map as described in Part 3, execution section of the specifications. Submittal shall include complete installation instructions for all wall jacks and terminations in the communication backboard(s). Installation instructions shall be obtained from the manufacturer.

### 1.3.3 Reports

Materials and Equipment; FIO.

All material for use in this project shall have a label or listing of the EIA/TIA standard and Underwriters Laboratories, Inc..

### 1.3.4 Certificates

Telephone Installer and Company; FIO.

Qualifications of the telephone installers in the field and the company.

## 1.4 WORKMANSHIP

Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as specified herein.

## PART 2 PRODUCTS

### 2.0 MATERIALS AND EQUIPMENT

Materials and equipment shall conform to the respective publications and other requirements specified below.

#### 2.1 Modular Outlet

Voice shall be single Category 5, 8 pin RJ-45 modular connector, ivory color. Data shall be duplex Category 5, 8 pin RJ-45 modular connector. orange color.

Voice and data jacks shall be T568B wiring pattern.

#### 2.2 Communication Wiring

##### 2.2.1 Voice:

Category 5e, 4 pair (UTP) unshielded twisted pair, 24 AWG copper conductors.

##### 2.2.2 Data:

Category 5e, 4 pair (UTP) unshielded twisted pair, 24 AWG copper conductors.

#### 2.3 Communication Backboard Terminations

2.3.1 Voice: 6600 type punch down blocks rated for category 5 mounted on stand off block. Provide number required plus 50 percent spare. Two separate sets of 6600 blocks shall be provided in the main communication room and each telecommunication closet: one set for the voice station jacks and another set for the voice riser tie cable. Separation between the two sets of blocks shall be 24 inches.

2.3.2 Data: Terminations shall be modular jack panel. Jacks shall be T568B wiring pattern.

The modular jack panel shall have on the front an 8 pin RJ-45 connector. The rear of the modular panel shall contain 110 connecting blocks mounted on a printed wiring board. The 110 connecting blocks shall be made continuous to the 8 pin modular jack on the front of the panel through printed wiring board interconnections. The panel shall be 19 inches wide.

Modular jacks shall be mounted on 6-inch depth hinged wall brackets for 19-inch panels.

The modular jack panels shall meet or exceed the electrical requirements of EIA/TIA TSB-40 for category 5 cable when tested in accordance with the methods described in EIA/TIA-568. Provide number required plus 50 percent spare.

#### 2.4 Telephone Backboards

Install 3/4 inch plywood on the walls.

#### 2.5 Hub Rack ---- Visitors Center Only

A hub rack shall be installed in the main communication room and each telecommunication closet that contains category 5 modular backboard terminations.

Hub rack shall be contain the following features:

Constructed of 14 and 12 gauge steel;  
Eight inch deep, welded "U" member and triangular bracket hold uprights to 12 gauge base;  
Panel mounting rails tapped 10-32 on EIA universal spacing;  
Chassis type base, 20 3/8 inch X 28 inch, drilled for RC-7754 casters;  
Rack bolted together in "add- a rack" fashion;  
Finish-Metallic Grey;  
Size shall be 7 inches X 19 inches, height 80 3/8 inch, width 20 3/8 inch , weight 80 LBS.

Hub equipment to be installed within the rack will be provided by others, but the hub rack shall be provided and installed by the Contractor.

#### 2.6 Omitted

#### 2.7 Device Plates

All device plates on finished walls shall be Type 302, .035 inch thick, brushed finish, U.L Listed stainless steel.

#### 2.8 OMITTED

#### 2.9 Conduit

See "Execution", for description of types of conduit permitted at certain locations.

##### 2.9.1 Intermediate Metal Conduit

UL 1242.

##### 2.9.2 Rigid Metal Conduit --- UL 6.

##### 2.9.3 Rigid Plastic --- UL 651A.

##### 2.9.4 Electrical Metallic Conduit

UL 797. See para 3.2.2 for description of couplings permitted with EMT

### PART 3 EXECUTION

#### 3.0 Electrical Contractor Qualifications

Electrical Contractor shall have on-site during all installation an Electrician with a 16 hour course on category 5 wiring and terminations. Provide copy of course certificate to the Government.

#### 3.1 Grounding

Grounding shall be in conformance with NFPA 70, the contract drawings, and the following specifications.

##### 3.1.1 Ground Bus In Each Communication Room

Install a 1 1/2 wide x four feet long copper bus in each communication room. Install the ground bus on insulators. Connect the ground bus to the service entrance ground bus with #1/0 insulated copper. Use compression connectors on both sides.

#### 3.2 WIRING METHODS

##### 3.2.1 Communication Raceways

All voice and data wiring in office areas shall be installed in a conduit system. Each outlet shall have a separate 3/4 inch conduit from the outlet to the communications backboard.

Where conduit material is specified for use above, conduits shall be of the following types: rigid plastic conduit (schedule 40 in the earth only, electrical metallic tubing (inside facility only), or threaded intermediate metal conduit. Flexible nonmetallic conduit or tubing will not be accepted as a raceway, except as six feet or less connection to modular office systems furniture. Conduit in hazardous areas shall be threaded rigid or intermediate metallic conduit only.

##### 3.2.2 Conduit and Tubing Systems

All fittings for electrical metallic conduit shall be of the steel compression type. Connectors for flexible metal conduit shall be malleable iron/ zinc plated and of the 2 screw clamp type with insulated throats conforming to UL 514B and NEMA FB-1. Minimum size of raceways shall be 3/4 inch. Electrical metallic tubing may be installed in concrete and grout in dry locations. Electrical metallic tubing installed in concrete or grout shall be provided with concrete tight fittings. EMT will not be installed in damp or wet locations. Insulating fittings shall be installed on the ends of all conduit, including all sizes of electrical metallic tubing. Only UL listed adapters shall be used to connect EMT to rigid metal conduit, cast boxes, and conduit bodies. Aluminum conduit may be used only where installed exposed in dry locations. Penetrations of above grade floor slabs, time-rated partitions and fire walls shall be firestopped to maintain the fire rating of the rated wall. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas as permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 6 inches away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise

shown. Raceways crossing structural expansion joints shall be provided with expansion fittings to compensate for the building expansion and contraction and to provide for continuity of grounding. Covers to junction boxes shall be labeled with a permanent marker; labeling shall include panel designation and circuit number.

### 3.2.3 Below Slab-on-Grade or in the Ground

All electrical wiring below slab-on-grade shall be protected by a conduit system. Conduit below the slab shall be installed in the earth and (1) one foot below the capillary water barrier. Conduit passing vertically through slabs-on-grade shall be rigid steel or IMC. Conversion to rigid steel or IMC shall be accomplished by a rigid steel elbow. Metallic conduits installed below slab-on-grade, passing vertically through the slab shall be field wrapped with 0.010 inch thick pipe-wrapping plastic tape applied with a 50 percent overlay.

### 3.2.4 Installing in Slabs Including Slabs on Grade

No conduits shall be installed within a horizontal run of a slab.

### 3.2.5 Exposed Raceways

Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings. Raceways under raised floors and above accessible ceilings shall be considered as exposed installations.

### 3.2.6 Changes in Direction of Runs

Changes in direction of runs shall be made with symmetrical bends or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be taken to prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment during the course of construction. Clogged raceways shall be entirely freed of obstructions or shall be replaced.

### 3.2.7 Supports

Metallic conduits and tubing shall be securely and rigidly fastened in place at intervals of not more than 10 feet and within 3 feet of boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps, or ceiling trapeze. Conduit may not be used for a ceiling trapeze, only approved factory manufactured unistrut may be used to build conduit supports. C-clamps or beam clamps shall have strap or rod-type retainers. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structures, but no load shall be applied to joist bridging.

Supports shall be fastened to wood with wood screws; with bolts and metal expansion shields on gypsum, concrete or brick and concrete filled CMU cells; with toggle bolts on hollow masonry units; and with machine screws on steel work. Expansion metal anchors shall be permitted in lieu of toggle bolts on hollow masonry units for 3/4 inch conduit size or less only. Only toggle bolts shall be used on all equipment enclosures and boxes on hollow masonry units. Nail-type nylon anchors are not acceptable. Raceways or pipe straps shall not be welded to steel structures. Holes cut to a depth of more than 1-1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joists shall avoid cutting the main reinforcing bars. Holes not

used shall be filled. In partitions of light steel construction, sheet-metal screws shall be used. Conduit shall not be supported using wire or nylon ties. Conduit supported between threaded rods attached to the structure may not be used as a support for conduit raceways. Unistrut (and associated hardware such as channel nuts, spring nuts, conduit strut clamps, washers, threaded rods, and rod couplings) shall be used to support all conduit from the structure. Conduit pressure caddy clips which clamp onto structural steel may only be used for maximum 3/4 inch conduit size. Raceways shall be installed as a complete system and be independently supported from the structure. Upper raceways shall not be the support of lower raceways. No conduit shall be supported from cable tray supports. Supporting means will not be shared between electrical raceways and mechanical piping or ducts and shall not be fastened to hung ceiling supports. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts, one locknut on each side. Insulating bushings shall be installed on all conduit, including all sizes of electrical metallic conduit. A pull wire shall be inserted in each empty raceway in which wiring is to be installed by others if the raceway is more than 15 meters 50 feet in length and contains more than the equivalent of two 90-degree bends, or where the raceway is more than 150 feet in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 200 psi tensile strength. Not less than 10 inches of slack shall be left at each end of the pull wire. Electrical metallic conduit shall be supported in the interior of stud walls within 3 feet of boxes and every 10 feet.

### 3.2.8 Junction Boxes For Tie Cables

Tie cable shall be installed with junction boxes if the run exceeds 75 feet, and shall not contain more than two 90-degree bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated.

### 3.2.9 General Installation Of Conduits Concealed Verses Exposed

Rooms with finished walls, either sheetrock or concrete masonry units, shall have the raceways installed concealed in walls, ceilings, or below the slab; except surface mounting is acceptable in mechanical and electrical rooms. Explosion proof areas shall have the conduits installed on the surface of the walls.

## 3.3 BOXES AND SUPPORTS

Boxes shall be provided in the wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be of the weatherproof type when located in normally wet locations, when flush and surface mounted on outside of exterior surfaces. In partitions of light steel construction, boxes shall be supported in walls with the studs installed between adjacent studs for back support. Another acceptable method to support boxes in walls is a pre-manufactured box mounting bracket, which shall provide support for boxes or plaster rings between studs. This bracket shall be 16 gauge, of the same height as the box or boxes being mounted, and extend from stud to stud. The edges of plaster rings for electrical devices shall be not more than 1/4 inch back from the finished surfaces in gypsum and CMU finished walls. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. Plaster ring extensions which decrease the box interior dimensions are not acceptable and shall not be used to extend the box to the finished surface. Boxes for mounting lighting fixtures shall be not less than 4 inches square except smaller boxes may be installed as required by fixture configuration, as approved. The bottom of boxes installed in masonry-block

walls for concealed wiring shall be flush with the top or bottom of a block to minimize cutting of blocks. Unless otherwise indicated, boxes for wall switches shall be mounted 48 inches above finished floors. Cast-metal boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided.

Boxes and supports shall be fastened to wood with wood screws or screw-type nails of equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws on steel work. Expansion metal anchors shall be permitted in lieu of toggle bolts on hollow masonry units for 3/4 inch conduit size or less only. Toggle bolts shall be used on all equipment enclosures and boxes on hollow masonry units. In open overhead spaces, cast-metal boxes threaded to raceways shall be separately supported where used for fixture support; sheet metal boxes having threadless connectors supported directly from the building structure by 1/4 inch "all-thread". Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 24 inches from the box.

Penetration of more than 1-1/2 inches into reinforced-concrete beams or more than 3/4 inch into reinforced-concrete joists shall avoid cutting any main reinforcing steel.

The Electrical Contractor shall have a representative present at the jobsite during the wall construction to ensure boxes are maintained flush with the finished surface.

### 3.3.1 Boxes for Use with Raceway Systems

#### 3.3.1.1 Communication Junction Boxes

Boxes for voice and data outlets shall be 4-11/16 inch square and 2-1/8 inch deep.

#### 3.3.3 Pull Boxes

Common pull boxes shall not be used with communication raceways.

### 3.4 Wall Plates

Wall Plates shall be specified in section under Part 2, Materials.

Screws shall be of metal with countersunk heads, in a color to match the finish of the plate. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

### 3.5 Cables

3.5.1 Cables For Voice and Data Station Jacks: A separate four-pair cable shall be installed from each jack to the backboard termination. Splicing of individual cables shall not be permitted.

### 3.6 Outlets

Each outlet in the room and at the backboard shall be numbered for easy identification of type and location. The contractor shall coordinate with the

Government for the desired labeling scheme. The telephone outlet shall consist of an outlet box, modular outlet and device cover.

### 3.7 Termination Blocks

3.7.1 Modular jacks shall be T568B wiring pattern.

3.7.2 The installer shall submit to the Government the proposed layout of the connecting blocks prior to installation. Layout shall be drawn on a computer CADD system.

3.7.3 At the backboard, terminate the voice cables on 6600 blocks rated for category 5. Each cable at the jack and the backboard termination shall be labeled as designated by the Government. Install a label sticker on the cables from a label machine designed for this purpose. Punch down 6600 type connecting blocks rated for category 5 shall be provided to terminate all voice and riser tie cables. Terminate riser tie cable on separate blocks from the station blocks

3.7.4 Modular RJ-45 jack panel rated for category 5 shall be used to terminate all category 5 data cables.

### 3.8 Labeling Method For Cabling, Voice Blocks, and Data Modular Cross-connect Blocks

1) The Contractor shall provide a CAD drawing which shows all outlets in the facility. The CAD drawing shall be provided in the submittal stage prior to any installation. The drawing shall be drawn to scale with outlet locations, walls, doors, system furniture identification numbers (if project includes) and room numbers. Sheet size shall be 36 inches by 24 inches. Drawing shall identify each outlet location with a distinct number.

2) At completion of the project, the CAD drawing shall reflect As-Built conditions. Grid shall be placed in each communication room and telecommunication closet. The grid shall contain the actual length based on test results from a cable testing instrument.

### 3.9 Backboards

Telephone backboards shall be installed at each communication room. The backboards shall be 3/4 inch plywood having a two-coat paint finish.

Provide D rings along the sides for running conductors up the plywood backboard.

### 3.10 Ground Bus At Each Backboard

3.10.1 Install copper ground busses in the communication rooms as follows:

Main communications room:  
2 feet length, 4 inch high, 1/4 inch thick.

Telecommunications closets:  
1 feet length, 4 inch high, 1/4 inch thick.

Install on two standoff brackets with two insulators. For gypsum board, copper ground bar shall be supported to the wall with a wood backing behind the gypsum board. For filled CMU, install copper bar to the wall with metal expansion anchors. For hollow masonry units, install copper bus to the wall with toggle bolts.

3.10.2 Grounding Conductors Between Copper Ground Busses:

3.10.2.1 Main Communications Room:

At the main communications room, connect one insulated #500 MCM copper conductor to the copper ground bus from the service entrance ground bus.

3.10.2.3 All connections to the copper ground busses shall be compression type lugs. Install ground conductor in IMC conduit above grade and PVC below a slab.

3.11 Hub Rack

Install hub rack within 12 inches of category 5 modular terminations in each communication closet or communication room. Bolt hub rack to floor with metal expansion shields. Hub equipment to be installed within the rack will be provided by others, but the rack shall be provided by the Contractor. Install cable tray from the backboard to the hub rack.

3.12 Auxiliary Devices

All auxiliary devices such as tie bars, cable rings, etc. which are not shown but are required for a high grade installation shall be provided.

3.13 Qualifications of Installer

The system shall be installed by an experienced installer regularly engaged in the installation of a category 5 wiring system. Installer in the field shall have a minimum of 2 years experience or satisfactory classroom training on category 5 installation. The Contracting Officer may reject any proposed installer who can not show evidence of such qualifications. Sufficient qualifications of any installer in the field shall be provided. No installer will be permitted on the jobsite unless evidence of qualifications has been provided to the Government. These qualifications will be required for any individual which installs any category 5 wiring on the jobsite. This shall include pulling wire, terminating wire, and testing.

3.14 Omitted

3.15 Communication Testing

3.15.1 Unshielded Twisted Pair Tests

All cable pairs shall be tested for proper identification and continuity. All opens, shorts, crosses, grounds, and reversals shall be corrected. Correct color coding and termination of each pair shall be verified in the communications closet and at the outlet.

3.15.2 Category 5 Circuits:

All category 5 circuits shall be tested using a test set. Cables which contain failed circuits shall be replaced and retested to verify the standard is met.

Telephone installer shall test each data wiring to the backboard connecting block for transmission characteristics of the category 5 wiring. Test shall be provided with a communication cable testing instrument designed for testing category 5 wiring. This test shall be in addition to a continuity test. Test results shall be provided for each jack installed in this project. Provide

hardcopy of all test results in 3 ring binders with O & M manuals. Test all voice wiring for continuity and correct wiring pattern. All terminations shall be complete prior to any testing.

### 3.16 Final Documentation (O & M Manuals)

At completion of the project, provide the following in a 3 ring hardcover binder:

- 1) Drawing which shows the location of all outlets. Each jack location shall show the label placed on the cable and the termination block.
- 2) Grid Map updated which reflects as-builts, include actual lengths from pentascanner and furniture ID (if applicable).
- 3) Tests results from each jack using a pentascanner.

### 3.17 Training

Training shall consist of the following:

The Contractor shall conduct a training course for the operating staff. The training period shall consist of (2) three hours classroom instruction on the operation and Maintenance Manuals and (2) three hours hands-on field training. O & M Manuals shall be accepted by the Government prior to scheduling the training. Training shall be provided after installation and testing is complete.

A separate classroom instruction and field training shall be given for each major piece of electrical equipment.

Training shall be given by a "Telephone Installer".

### 3.18 PAINTING AND FINISHING

All conduit and boxes on finished walls shall be painted the same color to match the wall surface. Galvanized electrical conduit and boxes shall first be given a primer washcoat to prepare the galvanized surface for painting. The surfaces shall then be painted in accordance with the finished schedules on the contract drawings or the paint specification.

### 3.19 REPAIR OF EXISTING WORK

The work shall be carefully laid out in advance, and where cutting, channeling, chasing, or drilling of floors, walls, partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved, at no additional cost to the Government.

-- End of Section --

07/24/99

NONADDRESSABLE FIRE ALARM SYSTEM

SECTION 16721

FIRE DETECTION AND ALARM SYSTEM

INDEX

ROBINS AFB/ COE SPEC

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PART 1 GENERAL

|     |            |
|-----|------------|
| 1.1 | SUMMARY    |
| 1.2 | REFERENCES |

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

|             |  |
|-------------|--|
| IEEE C62.41 | (1980) Surge Voltages in Low-Voltage AC Power Circuits |
|-------------|--|

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

|          |  |
|----------|--|
| NFPA 70  | (1999) National Electrical Code  |
| NFPA 72  | (1999) Installation, Maintenance<br>and Use of Protective Signaling<br>Systems |
| NFPA 90A | (1996) Installation of Air Conditioning and<br>Ventilating Systems             |

UNDERWRITERS LABORATORIES (UL)

|       |   |
|-------|---|
| UL 6  | (1997; Rigid Metal Conduit              |
| UL 38 | (1994); Rev Nov 1994) Manually Actuated |

Signaling Boxes for Use with Fire-Protective Signaling Systems

- UL 228 (1997; Door Closers-Holders, with or without Integral Smoke Detectors
- UL 268 (1996) Smoke Detectors for Fire Protective Signaling Systems
- UL 464 (1996; Rev May 1997) Audible Signal Appliances
- UL 521 (1993; Rev Oct 1994) Heat Detectors for Fire Protective Signaling Systems
- UL 797 (1993; Rev thru Mar 1997) Electrical Metallic Tubing
- UL 864 (1996) Control Units for Fire-Protective Signaling Systems
- UL 1242 (1996; Rev Mar 1998) Intermediate Metal Conduit

1.3 GENERAL REQUIREMENTS

1.3.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall be items that have been in satisfactory use for at least 3 years prior to bid opening. Equipment shall be supported by a service organization that can provide service within 24 hours.

1.3.2 Nameplates

Major components of equipment shall have the manufacturer's name, address, type or style, voltage and current rating, and catalog number on a noncorrosive and nonheat-sensitive plate which is securely attached to the equipment.

1.3.3 Keys and Locks

Locks shall be keyed alike.

1.3.4 Tags

Tags with stamped identification number shall be furnished for keys and locks.

1.3.5 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

1.3.6 Compliance

The fire detection and internal alarm system and the central reporting system shall be configured in accordance with NFPA 72. The equipment furnished shall

be compatible and be UL listed or FM approved or approved or listed by a nationally recognized testing laboratory in accordance with the applicable NFPA standards.

#### 1.3.7 Qualifications

##### Technician:

National Institute For Certification in Engineering Technologies (NICET) qualifications as an engineering technician in fire alarm systems program with verification of experience and current NICET certificate.

##### Installer:

The installing Contractor shall provide the following:

A NICET level 3 or level 4 Fire Alarm Technician shall supervise the installation of the fire alarm system. "Supervise" means provide technical on-site assistance and guidance of NFPA codes, ensuring system is being installed in a manner to meet the Style NFPA wiring specified, ensuring the system is being installed in accordance with manufacturers' requirements, etc. NICET Level 3 technician shall be on-site for the following: 1) prior to any installation (at preparatory meeting) 2) final check-out of the system wiring and terminations

#### 1.4 SYSTEM DESIGN

##### 1.4.1 Operation

The fire alarm and detection system shall be a complete, supervised fire alarm system. The system shall be activated into the alarm mode by actuation of any alarm initiating device. The system shall remain in the alarm mode until initiating device is reset and the fire alarm control panel is reset and restored to normal. Alarm initiating devices shall be connected to initiating device circuits (IDC), Style D in accordance with NFPA 72. Indicating appliance circuits (IAC), such as bells, horns, and strobes, shall be connected to Style Z in accordance with NFPA 72.

All textual, audible, and visual appliances and systems shall comply with NFPA 72 and NFPA 72G.

##### 1.4.2 Operational Features

The system shall have the following operating features:

a. Electrical supervision of alarm IDC and IAC. Smoke detectors shall have combined alarm initiating and power circuits.

b. Electrical supervision of the primary power (ac) supply, battery voltage, placement of alarm zone module (card, PC board) within the control panel, and transmitter tripping circuit integrity.

c. Trouble buzzer and trouble lamp (light emitting diode or neon light) to activate upon a single break, open, or ground fault condition which prevents the required normal operation of the system. The trouble signal shall also operate upon loss of primary power (ac) supply, low battery voltage, removal of alarm zone module (card, PC board), and disconnection of the circuit used for transmitting alarm signals off-premises. A trouble alarm

silence switch shall be provided which will silence the trouble buzzer, but will not extinguish the trouble indicator lamp. After the system returns to normal operating conditions, the trouble buzzer shall again sound until the silencing switch returns to normal position, unless automatic trouble reset is provided.

d. Transmitter disconnect switch to allow testing and maintenance of the system without activating the transmitter but shall provide a trouble signal when disconnected and a restoration signal when reconnected.

e. Evacuation alarm silencing switch or switches which, when activated, will silence alarm devices, but will not affect the zone indicating lamp nor the operation of the transmitter. This switch shall be over-ridden upon activation of a subsequent alarm from an unalarmed zone and the alarm devices will be activated.

f. Electrical supervision of circuits used for supervisory signal services. Supervision shall detect any open, short, or ground.

g. Zones for alarm IDS shall be arranged as indicated on the contract drawings.

#### 1.4.3 Alarm Functions

An alarm condition on a circuit shall automatically initiate the following functions:

- a. Transmission of alarm and trouble signal over the radio fire reporting system.
- b. Visual indications of the alarmed zones on the fire alarm control panel annunciator.
- c. Continuous sounding of alarm notification appliances throughout the building.
- d. Deactivation of the air handling units throughout the building.
- e. Deactivation of the exhaust fans throughout the facility.

#### 1.4.4 Primary Power

Operating power shall be provided as required by paragraph Power Supply for the System. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and not cause transmission of a false alarm. Loss of ac power shall not prevent transmission of a signal via the fire reporting system upon operation of any initiating circuit.

#### 1.4.5 Battery Backup Power

Battery backup power shall be through use of rechargeable, sealed-type storage batteries and battery charger.

### 1.5 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FI0" designation are for information only. The

following shall be submitted in accordance with Section 01300 SUBMITTAL DESCRIPTIONS:

1.5.1 Battery; GA.

Substantiating battery calculations for supervisory and alarm power requirements. Ampere-hour requirements for each system component and each panel component, and the battery recharging period shall be included.

1.5.2 Spare Parts; FIO

Spare parts data for each different item of material and equipment specified, not later than 1 month prior to the date of beneficial occupancy. Data shall include a complete list of parts and supplies with the current unit prices and source of supply and a list of the parts recommended by the manufacturer to be replaced after 1 year[s] of service.

1.5.3 Drawings; GA.

Detail drawings shall be prepared and signed by a NICET Level 4 fire alarm Technician.

A. Detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

All drawings shall be shown on a computer generated CADD system.

On a separate sheet of white full size drawing (minimum sheet size - 36 inches by 24 inches), show the following external panel wiring:

- 1) Layout of the entire facility drawn to scale which shows all device locations;
- 2) Fire alarm panel mounting and location which demonstrates proper clearance and coordination with other trades;
- 3) All conduit and wiring runs external to the fire alarm panel. Conduit runs shall be drawn parallel and perpendicular to the facility at the same locations to be installed;
- 4) Detail drawings shall show all connections between the FACP and all devices, appliances, supervised devices, and any equipment controlled by the FACP;
- 5) The drawing shall be specific for this particular project. Standard drawings obtained from a manufacturer shall not be accepted.

B. Provide hardcopy of program in 3 ring inch binder and electronic copy of program on 3 1/2 inch floppy.

C. Only original manufactures' literature shall be included in submittal. Photo-copies will not be acknowledged. Submittals shall be provided in 3 ring hard cover binders.

1.5.4 Instructions

Fire Alarm Reporting System; GA.

Six copies of operating instructions outlining step-by-step procedures required for system startup, operation, and shutdown. The instructions shall

include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Six copies of maintenance instructions listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guide. The instructions shall include conduit layout, equipment layout and simplified wiring, and control diagrams of the system as installed. Instructions shall be approved prior to training. All information included in para. "SD-04, Drawings" shall be included in the O & M Manuals reflecting as-built conditions. Only original manufacturers' literature shall be included in the O & M Manuals. Manuals shall be provided in 3 ring hard cover binders. The manuals in Section 16721 shall be in separate binders from other O & M Manuals in this contract.

#### 1.5.5 Training, GA

Lesson plans and training data, in manual format, for the training courses.

#### 1.5.6 Statements

Test Procedures; GA.

Detailed test procedures for the fire detection and alarm system 30 days prior to performing system tests. Test procedures shall be specific for this project and system installed.

#### 1.5.7 Reports

Testing; GA.

Test reports in booklet form showing all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall document all readings, test results and indicate the final position of controls.

#### 1.5.8 Certificates

Equipment; GA.

Certified copies of current approvals or listings issued by UL, FM or other nationally recognized testing laboratory, showing compliance with specified NFPA standards.

#### 1.5.9 Qualifications

Submit certifications of the NICET level training as specified in this specification.

### 1.6 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variation, dirt and dust, and any other contaminants.

## PART 2 PRODUCTS

### 2.1 CONTROL PANEL

Control panel shall comply with all the applicable requirements of UL 864. Panel shall be modular, installed in a surface mounted steel cabinet with hinged door and cylinder lock. Control panel shall be a clean, uncluttered, and orderly assembled panel containing all components and equipment required to provide the specified operating and supervisory functions of the system. The panel shall have prominent rigid plastic, phenolic or metal identification plates for all lamps, zones, controls, meters, fuses, and switches. Nameplates for fuses shall also include ampere rating. Separate alarm and trouble lamp shall be provided for each zone alarm located on exterior of cabinet door or be visible through the cabinet door. Control panel switches shall be within the locked cabinet. A suitable means shall be provided for testing the control panel visual indicating devices (meters or lamps). Meters and lamps shall be plainly visible when the cabinet door is closed. Signals shall be provided to indicate by zone any alarm, supervisory or trouble condition on the system. Each IDC initiating circuit shall be powered and supervised so that a signal on one zone does not prevent the receipt of signals from other zones. Loss of power, including any or all batteries, shall not require the reloading of a program. Upon restoration of power, startup shall be automatic, and shall not require any manual operation. The loss of primary power or the sequence of applying primary or emergency power shall not affect the transmission of alarm, supervisory or trouble signals.

Visual annunciators shall be provided for each active zone and spare zone. Four spare zones shall be provided. Each lamp shall provide specific identification of the zone by means of a permanently attached rigid plastic, phenolic or metal sign with either raised or engraved letters. Zone identification shall consist of word description of the zone.

Cabinets shall be provided with ample gutter space to allow proper clearance between the cabinet and live parts of the panel equipment. If more than one modular unit is required to form a control panel, the units shall be installed in a single cabinet large enough to accommodate all units. All devices and control panels shall be painted red.

#### 2.1.2 Circuit Connections

Circuit conductors entering or leaving the panel shall be connected to screw-type terminals with each terminal marked for identification.

#### 2.2 STORAGE BATTERIES

Storage batteries shall be provided and shall be the sealed, lead-calcium type requiring no additional water. The batteries shall have ample capacity, with primary power disconnected, to operate the fire alarm system for a period of 48 hours. Following this period of operation via batteries, the batteries shall have ample capacity to operate all components of the system, including all alarm signaling devices in the total alarm mode for a minimum period of 15 minutes. Batteries shall be sized per NFPA requirements. Battery cabinet shall be a separate compartment within the control panel or a separate cabinet.

#### 2.3 BATTERY CHARGER

Battery charger shall be completely automatic, and capable of restoring the batteries from full discharge to full charge as recommended by the manufacturer. Charger shall be located in control panel or battery cabinet.

#### 2.4 MANUAL FIRE ALARM STATIONS

Manual fire alarm stations shall conform to the applicable requirements of UL 38. Manual stations shall be connected into alarm-initiating circuits. Stations shall be installed on semiflush-mounted outlet boxes. Stations shall be single action type. Stations shall be finished in red, with raised letter operating instructions of contrasting color. Stations requiring the breaking of glass or plastic panels for operation are not acceptable. Stations employing glass rods are not acceptable. The use of a key or wrench shall be required to reset the station. Gravity or mercury switches are not acceptable. Switches and contacts shall be rated for the voltage and current upon which they operate. Stations shall have a separate screw terminal for each conductor. Surface-mounted boxes shall be painted the same color as the fire alarm manual stations.

## 2.5 FIRE DETECTING DEVICES

Fire detecting devices shall comply with the applicable requirements of NFPA 72, and UL 521. The detectors shall be provided as indicated. Detector base shall have screw terminals for making connections. No solder connections will be allowed. Detectors shall be connected into alarm initiating circuits. Detectors located in concealed locations (above ceiling, etc.) shall have a remote visible indicator lamp. Installed devices shall conform to the classification of the area.

### 2.5.2 Smoke Detectors

Detectors shall be designed for detection of abnormal smoke densities. Smoke detectors shall be photoelectric type. Detectors shall contain a visible indicator lamp that shows when the unit is in alarm condition. Detectors shall not be adversely affected by vibration or pressure. Detectors shall be the plug-in type in which the detector base contains terminals for making all wiring connections. Detectors that are in concealed above false ceilings shall have a remote visible indicator lamp.

#### 2.5.2.2 Photoelectric Detectors

Detectors shall operate on a light scattering concept using an LED light source. Failure of the LED shall not cause an alarm condition. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268.

#### 2.5.2.4 Duct Detectors

Duct detectors shall be provided and installed under this section of the specifications. The duct detector shall be UL Listed for compatibility with the fire alarm control panel and shall obtain power from the alarm initiating circuit. Detectors shall be photoelectric type and operate on the light-scattering, photodiode principle. To minimize nuisance alarms, detectors shall have an insect screen and be designed to ignore invisible airborne particles or smoke densities that are below the factory-set alarm point. No radioactive materials shall be used. Removal of the detector head shall interrupt the supervisory circuit and activate a trouble signal at the control panel.

## 2.6 NOTIFICATION APPLIANCES

Audible appliances shall be heavy duty and conform to the applicable requirements of UL 464. Devices shall be connected into alarm indicating circuits. All devices shall have a separate screw terminal for each conductor. All shall be painted red.

#### 2.6.5 Combination Audible/Visual Notification Appliances

Combination audible/visual notification appliances shall provide the same requirements as individual units except they shall mount as a unit in standard backboxes. All units shall be factory assembled. Any other audible indicating appliance employed in the fire alarm systems shall be approved by the authority having jurisdiction.

### 2.8 FIRE DETECTION AND ALARM SYSTEM PERIPHERAL EQUIPMENT

#### 2.8.3 Conduit

Conduit and fittings shall comply with UL 6, UL 1242 and UL 797. In nonhazardous areas, wiring shall be installed in electrical metallic conduit above grade and schedule 40 conduit below grade. In hazardous areas, wiring shall be installed in conduit which complies with NEC article 500.

#### 2.8.4 Conductors

Wiring for 120V ac power shall be No. 12 AWG minimum. Wiring for low voltage dc circuits shall be No. 14 AWG stranded minimum. Power wiring and control wiring shall be isolated. All wiring shall conform to NFPA 70. System field wiring shall be stranded copper. All conductors shall be color coded. Conductors used for the same functions shall be similarly color coded. Wiring code color shall remain uniform throughout the circuit.

#### 2.8.5 Special Tools and Spare Parts

- 1) Two of each type of detector
- 2) Two spare fuses of each type
- 3) Five spare lamps and LED's of each type.

Fuses and lamps shall be mounted in the fire alarm panel.

### 2.9 Radio Transmitter and Antenna

BT2-7 Radio transmitter, antenna, surge suppressor, coax, and mounting brackets shall be provided and installed under this contract. Radio transmitter shall have a frequency of 165.1375 MHZ and shall be compatible with the base-wide MONACO D-700 system. Backup battery shall be capable of standby for 60 hours.

Radio transmitter shall have 4 zones. Antenna shall be omni-directional type. Installation of antenna and grounding shall be as recommended by the manufacturer.

## PART 3 EXECUTION

### 3.1 INSTALLATION

All work shall be installed as shown and in accordance with the manufacturer's diagrams and recommendations, unless otherwise specified. Smoke detectors shall not be installed until the building has been thoroughly cleaned.

### 3.1.1 Power Supply for the System

A single dedicated branch-circuit connection for supplying power to each building fire alarm system shall be provided.

### 3.1.2 Wiring

Wiring for systems shall be installed in 3/4 inch minimum diameter conduit.

Wiring shall be installed in electrical metallic conduit above grade and schedule 40 conduit below grade. In hazardous areas, wiring shall be installed in conduit which complies with NEC article 500.

Wiring for the fire alarm system shall not be installed in conduits, junction boxes, or outlet boxes with conductors of lighting and power systems. No more than one conductor shall be installed under any screw terminal.

All conductors shall be installed from device to device with no splices in-between devices. Terminal strips installed between devices in junction boxes will not be accepted. Connections and splices shall be made only at the FACP terminals or at the device terminals. The use of wire nut type connectors are prohibited in the system.

A two-loop conduit system shall be provided. Junction boxes shall not be shared in the two-loop conduit system, in other words, all supply and return wiring shall be installed in separate junction boxes, as well as separate conduit.

Not more than three initiating device circuits may be installed with a signal circuit in the same conduit. If signal circuits are in separate conduit, then not more than four initiating circuits may be combined in the same conduit.

Pigtail or T-tap connections to alarm initiating, supervisory circuits, and alarm indicating circuits are prohibited.

### 3.1.3 Control Panel

The control panel and its assorted components shall be mounted so that no part of the enclosing cabinet is less than 12 inches nor more than 78 inches above the finished floor. All manually operable controls shall be between 36 inches to 42 inches above the finished floor. Panel shall be installed to comply with the requirements of UL 864.

### 3.1.4 Detectors

Detectors shall be installed in accordance with NFPA 72. Detectors shall be at least 12 inches from any part of any lighting fixture. Detectors shall be located at least 3 feet from diffusers of air handling systems. Each detector shall be provided with appropriate mounting hardware as required by its mounting location. Detectors which mount in free space shall be mounted directly to the end of the stubbed down rigid conduit drop. Conduit drops shall be firmly secured to minimize detector sway. Where length of conduit drop from ceiling or wall surface exceeds 3 feet, sway bracing shall be provided.

### 3.1.5 Notification Appliances

Notification appliances shall be mounted a minimum of 8 feet above the finished floor unless limited by ceiling height or otherwise indicated.

### 3.1.6 Annunciator Equipment

Annunciator equipment provided shall be mounted where indicated.

### 3.2 OVERVOLTAGE AND SURGE PROTECTION

All equipment connected to alternating current circuits shall be protected from surges per IEEE C62.41 and NFPA 70. All cables and conductors which serve as communications links, except fiber optics, shall have surge protection circuits installed at each end. Fuses shall not be used for surge protection.

### 3.3 GROUNDING

Grounding shall be provided from an equipment grounding conductor supplied from the panel which supplies power to the FACP.

### 3.4 TESTING

All preliminary and acceptance testing listed below shall be performed by the fire alarm installing company. The Contractor shall notify the Contracting Officer by writing 14 days before the acceptance tests are to be conducted. The Contractor shall provide written notice of all deficiencies found in the preliminary testing have been corrected prior to written notice of acceptance test to be scheduled. The tests shall be performed in accordance with the approved test procedures in the presence of the Contracting Officer. The fire alarm system installing company shall be present to supervise all tests. The Contractor shall furnish all instruments and personnel required for the tests.

#### 3.4.1 Preliminary Tests

Upon completion of the installation, the system shall be subjected to functional and operational performance tests including random testing of installed initiating and notification appliances. Tests shall include the meggering of all system conductors to determine that the system is free from grounded, shorted, or open circuits. The megger test shall be conducted prior to the installation of fire alarm equipment. If deficiencies are found, corrections shall be made and the system shall be retested to assure that it is functional.

#### 3.4.2 Acceptance Test

Acceptance tests shall not be performed until two weeks after written notice of all deficiencies completed in the preliminary testing. Testing shall be in accordance with NFPA 72. The test shall include the following:

- a. Test of each function of the control panel.
- b. Test of each circuit in both trouble and normal modes.
- c. Tests of alarm initiating devices in both normal and trouble conditions.
- d. Tests of each control circuit and device.
- e. Tests of each alarm notification appliance.

- f. Tests of the battery charger and batteries.
- g. Complete operational tests under emergency power supply.
- h. Visual inspection of all wiring connections.
- i. Opening the circuit at each alarm initiating device and notification appliance to test the wiring supervisory feature.
- j. Ground fault
- k. Short circuit faults
- l. Stray voltage
- m. Loop resistance

3.5 TRAINING

Training course shall be provided for the operations and maintenance staff. The training period shall consist of 1 training day (8 hours) and shall start after the system is functionally completed but prior to final acceptance tests. The instructions shall cover all of the items contained in the operating and maintenance instructions. The training shall continue at the jobsite to discuss the panel interior, operation, and wiring diagrams. All training shall be conducted by the fire alarm manufacturers' service representative. Training shall be conducted (14) fourteen days prior to testing. The Contractor shall notify the Government of the training time in writing not less than 14 days prior to the scheduled training.

| <u>Training</u>    | <u>Length</u>   | <u>Location</u>         |
|--------------------|-----------------|-------------------------|
| Classroom Training | (3 hours) ----- | Conference Room on-site |
| Field Training     | (2 hours) ----- | Project Site            |

3.6 CONDUIT LABELING

Conduit shall be labeled every 10 ft with a 3 inch wide red tape band. Junction box covers shall be painted red.

**END OF  
SECTION 1020  
APPENDICES**

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