

SECTION 02055

SOILS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Subsoil materials.
 - 2. Topsoil materials.
- B. Related Sections:
 - 1. Document CS17888-125: Geotechnical report; bore hole locations and findings of subsurface materials.
 - 2. Section 02311 - Rough Grading.
 - 3. Section 02740 – Flexible Pavement: binder and finish asphalt courses.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
 - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 2. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 3. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

1.3 SUBMITTALS

- A. Section 01330 - Submittal Procedures: Requirements for submittals.
- B. Samples: Submit, in air-tight containers, 1 - 40 lb / 18.1 kg sample of each type of fill to testing laboratory.
- C. Materials Source: Submit name of imported materials source.

1.4 QUALITY ASSURANCE

- A. Furnish each sample of subsoil or topsoil material from single source throughout the Work.

- B. Perform Work in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- C. Maintain one copy of each set of specifications on site.

PART 2 PRODUCTS

2.1 SUBSOIL MATERIALS

- A. Subsoil: Conforming to Colorado Department of Transportation standards.

2.2 TOPSOIL MATERIALS

- A. Topsoil: Conforming to Colorado Department of Transportation standards.

2.3 SOURCE QUALITY CONTROL

- A. Section 01400 - Quality Requirements: Testing and Inspection Services Testing and analysis of soil material.
- B. Testing and Analysis of Subsoil Material: Perform in accordance with ASTM D698, ASTM D1557, and AASHTO T180.
- C. Testing and Analysis of Topsoil Material: Perform in accordance with ASTM D698, ASTM D1557, and AASHTO T180.
- D. When tests indicate materials do not meet specified requirements, change material and retest.
- E. Furnish each sample of subsoil or topsoil material from single source throughout the Work.

PART 3 EXECUTION

3.1 EXCAVATION

- A. Excavate subsoil and topsoil from designated areas. Strip topsoil to full depth of topsoil in designated areas.
- B. Stockpile excavated material meeting requirements for subsoil materials and topsoil materials.
- C. Remove excess excavated materials subsoil and topsoil not intended for reuse, from site.
- D. Remove excavated materials not meeting requirements for subsoil materials and topsoil materials from site.

3.2 STOCKPILING

- A. Stockpile materials on site at locations indicated by site supervisor.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Separate differing materials with dividers or stockpile apart to prevent mixing.
- D. Prevent intermixing of soil types or contamination.
- E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.3 STOCKPILE CLEANUP

- A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 02060

AGGREGATE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Coarse aggregate materials.
 - 2. Fine aggregate materials.
- B. Related Sections:
 - 1. Document CS17888-125: Geotechnical report; bore hole locations and findings of subsurface materials.
 - 2. Section 02055 - Soils: Fill and grading materials.
 - 3. Section 02311 - Rough Grading.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M147 - Standard Specification for Materials for Aggregate and Soil Aggregate Subbase, Base and Surface Courses.
 - 2. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
 - 1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
 - 2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 4. ASTM D2487 - Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 5. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

1.3 SUBMITTALS

- A. Section 01330 - Submittal Procedures: Requirements for submittals.
- B. Samples: Submit, in air-tight containers, 1 - 40 lb / 18.1 kg sample of each type of fill to testing laboratory.
- C. Materials Source: Submit name of imported materials suppliers.

1.4 QUALITY ASSURANCE

- A. Furnish each sample of aggregate material from single source throughout the Work.
- B. Perform Work in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- C. Maintain one copy of each set of specifications on site.

PART 2 PRODUCTS

2.1 COARSE AGGREGATE MATERIALS

- A. Coarse Aggregate: Conforming to Colorado Department of Transportation standards.

2.2 FINE AGGREGATE MATERIALS

- A. Fine Aggregate: Conforming to Colorado Department of Transportation standards.

2.3 SOURCE QUALITY CONTROL

- A. Section 01400 - Quality Requirements: Testing and inspection services.
- B. Coarse Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, ASTM D1557, AASHTO T180, ASTM D4318, and ASTM C136.
- C. Fine Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, ASTM D1557, AASHTO T180, ASTM D4318, and ASTM C136.
- D. When tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.1 EXCAVATION

- A. Excavate aggregate materials from on-site locations indicated on plans as specified in Section 02311 and 02315.
- B. Stockpile excavated material meeting requirements for coarse aggregate materials and fine aggregate materials.
- C. Remove excess excavated materials coarse aggregate materials and fine aggregate materials not intended for reuse, from site.

- D. Remove excavated materials not meeting requirements for coarse aggregate materials and fine aggregate materials from site.

3.2 STOCKPILING

- A. Stockpile materials on site at locations indicated by site supervisor.
- B. Stockpile in sufficient quantities to meet Project schedule and requirements.
- C. Separate different aggregate materials with dividers or stockpile individually to prevent mixing.
- D. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.3 STOCKPILE CLEANUP

- A. Remove stockpile, leave area in clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 02311

ROUGH GRADING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating topsoil.
2. Excavating subsoil.
3. Cutting, grading, filling, and compacting.

B. Related Sections:

1. Section 02055 - Soils.
2. Section 02060 - Aggregate.

1.2 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
3. ASTM D1556 - Standard Test Method for Density of Soil in Place by the SandCone Method.
4. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft³ (2,700 kN-m/m³)).
5. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
6. ASTM D2419 - Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
7. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head).
8. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
9. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 QUALITY ASSURANCE

- A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.
- B. Perform Work in accordance with the Colorado Department of Transportation Specifications.

PART 2 EXECUTION

2.1 EXAMINATION

- A. Verify survey bench mark and intended elevations for the Work are as indicated on Drawings.

2.2 PREPARATION

- A. Call Local Utility Line Information service not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum.
- C. Protect utilities indicated to remain from damage.
- D. Protect plant life, lawns, [rock outcropping] and other features remaining as portion of final landscaping.
- E. Protect bench marks, [survey control point,] [existing structures,] [fences,] sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

2.3 TOPSOIL EXCAVATION

- A. Excavate topsoil from areas to be further excavated, or regraded, and marked areas without mixing with foreign materials for use in finish grading. B. Do not excavate wet topsoil.
- C. Do not remove topsoil from site.

2.4 SUBSOIL EXCAVATION

- A. Excavate subsoil areas to be further excavated, or regraded, and marked areas.
- B. Do not excavate wet subsoil.
- C. When excavating through roots, perform Work by hand and cut roots with sharp axe.

- D. Remove excess subsoil not intended for reuse, from site.
- E. Stability: Replace damaged or displaced subsoil as specified for fill.

2.5 FILLING

- A. Fill areas to contours and elevations with unfrozen materials.
- B. Place fill material in continuous layers and compact.
- C. Maintain optimum moisture content of fill materials to attain required compaction density.
- D. Slope grade away from building minimum **2 inches in 10 ft**, unless noted otherwise.
- E. Make grade changes gradual. Blend slope into level areas.
- F. Repair or replace items indicated to remain damaged by excavation or filling.

2.6 TOLERANCES

- A. Section 01400 - Quality Requirements: Tolerances.
- B. Top Surface of Subgrade: Plus or minus **1/10 foot** from required elevation.

2.7 FIELD QUALITY CONTROL

- A. Perform in place compaction tests in accordance with the following:
 - 1. Density Tests:[ASTM D1556.
 - 2. Moisture Tests: ASTM D3017.
- B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

END OF SECTION

SECTION 02315

EXCAVATION AND FILL

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Soil densification.
 - 2. Excavating for building foundations.
 - 3. Excavating for [paving,] [roads,] [and] [parking areas].
 - 4. Excavating for slabs-on-grade.
 - 5. Excavating for site structures.
 - 6. Excavating for landscaping.
- B. Related Sections:
 - 1. Document CS17888-125: Geotechnical report; bore hole locations and findings of subsurface materials.
 - 2. Section 02311 - Rough Grading: Topsoil and subsoil removal from site surface.

1.2 REFERENCES

- A. ASTM International:
 - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the SandCone Method.
 - 3. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 4. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- B. Local utility standards when working within 24 inches of utility lines.

1.3 SUBMITTALS

- A. Section 01330 - Submittal Procedures: Requirements for submittals.
- B. Excavation Protection Plan: Describe sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property; include structural calculations to support plan.
- C. Shop Drawings: Indicate soil densification grid for each size and configuration footing requiring soils densification.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards. B. Maintain one copy of each document on site.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 PREPARATION

- A. Call Local Utility Line Information service not less than three working days before performing Work.
 - 1. Request underground utilities to be located and marked within and surrounding construction areas.
- B. Identify required lines, levels, contours, and datum.
- C. Protect utilities indicated to remain from damage.
- D. Protect plant life, lawns, rock outcroppings and other features remaining as portion of final landscaping.
- E. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.2 SOIL DENSIFICATION - VIBRO-COMPACTION

- A. Densify existing subsoils in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.

3.3 EXCAVATION

- A. Underpin adjacent structures which may be damaged by excavation work.
- B. Excavate subsoil to accommodate building foundations, slabs-on-grade paving and site structures, and construction operations in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.

- C. Notify Architect/Engineer of unexpected subsurface conditions.
- D. Remove excess and unsuitable material from site.
- E. Repair or replace items indicated to remain damaged by excavation.

3.4 FIELD QUALITY CONTROL

- A. Section 01400 - Quality Requirements: Testing and Inspection Services 01700 - Execution Requirements: Testing, adjusting, and balancing.

3.5 PROTECTION

- A. Prevent displacement or loose soil from falling into excavation; maintain soil stability.
- B. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- C. Protect structures, utilities and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth operations.

END OF SECTION

SECTION 02610

PIPE CULVERTS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Corrugated steel pipe culvert.
 - 2. Concrete pipe culvert.
 - 3. Joints and accessories.
 - 4. Bedding.
 - 5. Slope protection at pipe end.
- B. Related Sections
 - 1. Section 02060 - Aggregate.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M294 - Specification for Corrugated Polyethylene Pipe, 305- to 915mm (12- to 36-In.) Diameter
 - 2. AASHTO T99 - Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 lb) Rammer and a 305 mm (12 in.) Drop.
 - 3. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
 - 1. ASTM A929/A929M - Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe.
 - 2. ASTM C14 - Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
 - 3. ASTM C76 - Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
 - 4. ASTM C443 - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.
 - 5. ASTM C506 - Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe.
 - 6. ASTM C507 - Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
 - 7. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 8. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft³ (2,700 kN-m/m³)).

9. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
10. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

- A. Product Data: Submit data on pipe, fittings and accessories.
- B. Manufacturer's Installation Instructions: Submit special procedures required to install Products specified.

1.4 CLOSEOUT SUBMITTALS

- A. Project Record Documents:
 1. Accurately record actual locations of pipe runs, connections, and invert elevations.

PART 2 PRODUCTS

2.1 CONCRETE CULVERT PIPE

- A. Concrete Pipe: **ASTM C14**, Class 3:
 1. Bell and spigot end joints.
 2. Shape: Circular
- B. Reinforced Concrete Pipe Joint Device: **ASTM C443** (**ASTM C443M**), rubber compression gasket joint.

2.2 PLASTIC CULVERT PIPE

- A. Furnish materials in accordance the Colorado Department of Transportation Specifications.
- B. Polyethylene Culvert Pipe: AASHTO M294, smooth interior.
 1. Joints: AASHTO M294, corrugated to match pipe.
 2. Joints: Polyethylene sleeve with gasket.

PART 3 EXECUTION

3.1 PREPARATION

- A. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.

3.2 EXCAVATION AND BEDDING

- A. Excavate culvert trench to **12 inches** below pipe invert for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.
- B. Place bedding material at trench bottom, level fill materials in one continuous layer not exceeding **8 inches** compacted depth, compact to 95 percent.
- C. Maintain optimum moisture content of bedding material to attain required compaction density.
- D. Place filter fabric over compacted bedding.

3.3 INSTALLATION - PIPE

- A. Lift or roll pipe into position. Do not drop or drag pipe over prepared bedding.
- B. Shore pipe to required position; retain in place until after compaction of adjacent fills. Ensure pipe remains in correct position and to required slope.

3.4 ERECTION TOLERANCES

- A. Lay pipe to alignment and slope gradients noted on Drawings; with maximum variation from indicated slope of **1/8 inch** in **10 feet**.
- B. Maximum Variation From Intended Elevation of Culvert Invert: **1/2 inch**.
- C. Maximum Offset of Pipe From Indicated Alignment: **1 inch**.
- D. Maximum Variation in Profile of Structure From Intended Position: 1 percent.

3.5 FIELD QUALITY CONTROL

- A. Compaction Testing: In accordance with ASTM D1557.
- B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.6 PROTECTION OF INSTALLED CONSTRUCTION

- A. Protect pipe and bedding from damage or displacement until backfilling operation is in progress.

END OF SECTION

SECTION 02721

AGGREGATE BASE COURSE

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Aggregate base course.
- B. Related Sections:
 - 1. Section 02060 - Aggregate Materials.
 - 2. Section 02311 - Rough Grading: Preparation of site for base course.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.
- B. ASTM International:
 - 1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³)).
 - 2. ASTM D1556 - Standard Test Method for Density of Soil in Place by the SandCone Method.
 - 3. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 4. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
 - 5. ASTM D2922 - Standard Test Method for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
 - 6. ASTM D3017 - Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

- A. Section 01330 - Submittal Procedures: Requirements for submittals.
- B. Samples: Submit, in air-tight containers, 1 - 40 lb / 18.1 kg sample of each type of fill to testing laboratory.
- C. Materials Source: Submit name of imported materials suppliers.

1.4 QUALITY ASSURANCE

- A. Furnish each aggregate material from single source throughout the Work.
- B. Perform Work in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- C. Maintain one copy of each document on site.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Coarse Aggregate Fill: Conforming to Colorado Department of Transportation standards.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Section 01300 - Administrative Requirements: Verification of existing conditions before starting work.
- B. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

3.2 PREPARATION

- A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and recompacting.
- B. Do not place fill on soft, muddy, or frozen surfaces.

3.3 AGGREGATE PLACEMENT

- A. Spread aggregate over prepared substrate to Colorado Department of Transportation standards.
- B. Level and contour surfaces to elevations and gradients indicated.
- C. Add small quantities of fine aggregate to coarse aggregate as appropriate to assist compaction.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 FIELD QUALITY CONTROL

- A. Compaction testing will be performed in accordance with ASTM D1556, ASTM D1557, ASTM D698, AASHTO T180, ASTM D2167, ASTM D2922, and ASTM D3017.
- B. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

END OF SECTION

SECTION 02740

FLEXIBLE PAVEMENT

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Asphaltic concrete paving, wearing, binder and base course.
 - 2. Surface sealer.
 - 3. Aggregate subbase course.
- B. Related Sections:
 - 1. Section 02311 - Rough Grading: Preparation of site for paving [and base].
 - 2. Section 02721 - Aggregate Base Course: Compacted subbase for paving.
 - 3. Section 09900 - Paints and Coatings: Pavement markings.

1.2 REFERENCES

- A. Asphalt Institute:
 - 1. AI MS-2 - Mix Design Methods for Asphalt Concrete and Other Hot- Mix Types.
 - 2. AI MS-19 - Basic Asphalt Emulsion Manual.
- B. ASTM International:
 - 1. ASTM D946 - Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction.
 - 2. ASTM D3381 - Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction.

1.3 SUBMITTALS

- A. Product Data: Submit product information and mix design.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards. B. Mixing Plant: Conform to Colorado Department of Transportation standards.
- C. Obtain materials from same source throughout.
- D. Maintain one copy of each document on site.

1.5 ENVIRONMENTAL REQUIREMENTS

- A. Do not place asphalt when ambient air or base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Asphalt Cement: ASTM D946, ASTM D3381, In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- B. Aggregate for Base Course Mix: In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- C. Aggregate for Binder Course Mix: In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- D. Aggregate for Wearing Course Mix: In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- E. Fine Aggregate: In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.
- F. Mineral Filler: Finely ground particles of limestone, hydrated lime or other mineral dust, free of foreign matter.
- G. Reclaimed Asphalt Pavement (RAP): Processed material obtained by milling or full depth removal of existing asphalt concrete pavements.
- H. Oil: In accordance with the UCCS Campus Construction Standards, Pikes Peak Regional Pavement Specifications, or Colorado Department of Transportation standards.

2.2 ASPHALT PAVING MIX

- A. Use dry material to avoid foaming. Mix uniformly.
- B. Base Course: In accordance with Colorado Department of Transportation standards.
- C. Binder Course: In accordance with Colorado Department of Transportation standards
- D. Wearing Course: In accordance with Colorado Department of Transportation standards

E. Reclaimed Asphalt Content: In accordance with Colorado Department of Transportation standards.

F. Mix Temperature: In accordance with Colorado Department of Transportation standards.

2.3 SOURCE QUALITY CONTROL AND TESTS

A. Submit proposed mix design of each class of mix for review prior to beginning of Work.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify gradients and elevations of base are correct.

3.2 SUBBASE

A. Prepare subbase in accordance with Colorado Department of Transportation standards

3.3 PROTECTION OF FINISHED WORK

A. Immediately after placement, protect pavement from mechanical injury in accordance with the UCCS Construction Standards.

END OF SECTION

SECTION 02763

PAINTED PAVEMENT MARKINGS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Traffic lines and markings.
 - 2. Paint.
- B. Related Sections:
 - 1. Section 02740 Flexible Pavement.
 - 2. Section 02750 Rigid Pavement.

1.2 REFERENCES

- A. American Association of State Highway and Transportation Officials:
 - 1. AASHTO M247 - Standard Specification for Glass Beads Used in Traffic Paint.
- B. ASTM International:
 - 1. ASTM D34 - Standard Guide for Chemical Analysis of White Pigments.
 - 2. ASTM D126 - Standard Test Methods for Analysis of Yellow, Orange, and Green Pigments Containing Lead Chromate and Chromium Oxide Green.
 - 3. ASTM D562 - Standard Test Method for Consistency of Paints Using the Stormer Viscometer.
 - 4. ASTM D711 - Standard Test Method for No-Pick-Up Time of Traffic Paint.
 - 5. ASTM D713 - Standard Practice for Conducting Road Service Tests on Fluid Traffic Marking Materials.
 - 6. ASTM D969 - Standard Test Method for Laboratory Determination of Degree of Bleeding of Traffic Paint.
 - 7. ASTM D1301 - Standard Test Methods for Chemical Analysis of White Lead Pigments.
 - 8. ASTM D1394 - Standard Test Methods for Chemical Analysis of White Titanium Pigments.
 - 9. ASTM D1475 - Standard test Method for Density of Liquid Coatings, Inks, and Related Products.
 - 10. ASTM D1640 - Standard Test Methods for Drying, Curing, or Film Formation of Organic Coatings at Room Temperature.
 - 11. ASTM D2202 - Standard Test Method for Slump of Sealants.
 - 12. ASTM D2371 - Standard Test Method for Pigment Content of Solvent-Reducible Paints.
 - 13. ASTM D2621 - Standard Test Method for Infrared Identification of Vehicle Solids From Solvent-Reducible Paints.

14. ASTM D2743 - Standard Practices for Uniformity of Traffic Paint Vehicle Solids by Spectroscopy and Gas Chromatography.

1.3 PERFORMANCE REQUIREMENTS

- A. Paint Adhesion: Adhere to road surface forming smooth continuous film one minute after application.
- B. Paint Drying: Tack free by touch so as not to require coning or other traffic control devices to prevent transfer by vehicle tires within two minutes after application.

1.4 SUBMITTALS

- A. Product Data: Submit paint formulation for each type of paint.
- B. Test Reports: Submit source and acceptance test results in accordance with AASHTO M247.
- C. Manufacturer's Installation Instructions: Submit instructions for application temperatures, eradication requirements, application rate, line thickness, type of glass beads, bead embedment and bead application rate, and any other data on proper installation.
- D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with the Colorado Department of Transportation Specifications.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Invert containers several days prior to use when paint has been stored more than 2 months. Minimize exposure to air when transferring paint. Seal drums and tanks when not in use.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Do not apply materials when surface and ambient temperatures are outside temperature ranges required by paint product manufacturer.
- B. Do not apply exterior coatings during rain or snow when relative humidity is outside humidity ranges, or moisture content of surfaces exceed those required by paint product manufacturer.
- C. Do not apply paint when temperatures are expected to fall below 50 degrees F for 24 hours after application.
- D. Volatile Organic Content (VOC). Do not exceed State or Environmental Protection Agency maximum VOC on traffic paint.

PART 2 PRODUCTS

2.1 PAINTED PAVEMENT MARKINGS

- A. Furnish materials in accordance with the Colorado Department of Transportation Specifications.

2.2 EQUIPMENT

- A. Continuous Longitudinal Line Application Machine: Use application equipment with following capabilities.
 - 1. Dual nozzle paint gun to simultaneously apply parallel lines of indicated width in solid or broken patterns or various combinations of those patterns.
 - 2. Pressurized bead-gun to automatically dispense glass beads onto painted surface, at required application rate.
 - 3. Measuring device to automatically and continuously measure length of each line placed, to nearest **foot**.
- B. Other Equipment:
 - 1. For application of crosswalks, intersections, stop lines, legends and other miscellaneous items by walk behind stripers, hand spray or stencil trucks, apply with equipment meeting requirements of this section. Do not use hand brushes or rollers.

2.3 SOURCE QUALITY CONTROL

- A. Test and analyze traffic paints in accordance with [ASTM D34] [ASTM D126] [ASTM D562] [ASTM D711] [ASTM D713] [ASTM D969] [ASTM D1301] [ASTM D1394] [ASTM D1475] [ASTM D2202] [ASTM D2371] [ASTM D2621] [ASTM D2743].

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not apply paint to concrete surfaces until concrete has cured for 28 days.

3.2 PREPARATION

- A. Maintenance and Protection of Traffic:
 - 1. Provide short term traffic control in accordance with Section 01500.
 - 2. Prevent interference with marking operations and to prevent traffic on newly applied markings before markings dry.
- B. Surface Preparation.
 - 1. Clean and dry paved surface prior to painting.
 - 2. Blow or sweep surface free of dirt, debris, oil, grease or gasoline.

3.3 APPLICATION

- A. Agitate paint for 1-15 minutes prior to application to ensure even distribution of paint pigment.
- B. Apply markings to indicated dimensions at indicated locations.
- C. Prevent splattering and over spray when applying markings.
- D. Unless material is track free at end of paint application convoy, use traffic cones to protect markings from traffic until track free. When vehicle crosses a marking and tracks it or when splattering or over spray occurs, eradicate affected marking and resultant tracking and apply new markings.
- E. Install Work in accordance with the Colorado Department of Transportation Specifications.

3.4 APPLICATION TOLERANCES

- A. Section 01400 - Quality Requirements: Tolerances.
- B. Maximum Variation from Wet Film Thickness: 1 mil.
- C. Maximum Variation from Wet Paint Line Width: Plus or minus **1/8 inch**.

3.5 FIELD QUALITY CONTROL

- A. Inspect for incorrect location, insufficient thickness, line width, coverage, retention, uncured or discolored material, and insufficient bonding.
- B. Repair lines and markings, which after application and curing do not meet following criteria:
 - 1. Incorrect Location: Remove and replace incorrectly placed patterns.
 - 2. Insufficient Thickness, Line Width, Paint Coverage, or Retention: Prepare defective material by acceptably grinding or blast cleaning to remove substantial amount of beads and to roughen marking surface. Remove loose particles and debris. Apply new markings on cleaned surface in accordance with this Section.
 - 3. Uncured or Discolored Material, Insufficient Bonding: Remove defective markings in accordance with this Section and clean pavement surface **one foot** beyond affected area. Apply new markings on cleaned surface in accordance with this Section.
- C. Replace failed or defective markings in entire section of defective markings within 30 days after notification when any of the following exists during warranty period:
 - 1. Average retroreflectivity within any **528 foot** section is less than 1225 mcd/m²/1x for white pavement markings and 100 mcd/m²/1x for yellow pavement markings.
 - 2. Marking is discolored or exhibits pigment loss, and is determined to be unacceptable by three member team based on visual comparison with beaded color plates.

- D. Maintain daily log showing work completed, results of above inspections or tests, pavement and air temperatures, relative humidity, presence of any moisture on pavement, and any material or equipment problems. Make legible entries in log in ink, sign and submit by end of each work day. Enter environmental data into log prior to starting work each day and at two additional times during day.

3.6 PROTECTION OF FINISHED WORK

- A. Protect painted pavement markings from vehicular and pedestrian traffic until paint is dry and track free. Follow manufacturer's recommendations or use minimum of 30 minutes. Consider barrier cones as satisfactory protection for materials requiring more than 2 minutes dry time.

END OF SECTION

**UCCS ARENA PARKING LOT
ELECTRICAL SPECIFICATIONS
TABLE OF CONTENTS
DIVISION 16**

<u>DIVISION 16</u>	<u>DESCRIPTION</u>
SECTION 16010	ELECTRICAL REQUIREMENTS
SECTION 16050	IDENTIFICATION
SECTION 16100	BASIC MATERIAL AND METHODS
SECTION 16110	RACEWAY AND BOXES
SECTION 16120	ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 16140	WIRING DEVICES
SECTION 16210	PANELBOARDS
SECTION 16265	ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS
SECTION 16350	GROUNDING AND BONDING
SECTION 16450	LIGHTING FIXTURES
SECTION 16470	POLES AND STANDARDS
SECTION 16781	CODE BLUE RADIO

Page 1 of 1
SECTION 16010

ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Section supplements Division 1, General Requirements.
- B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. Owner shall decide which is most stringent.
- C. Provisions of Divisions 15 and 16 shall also apply to the work of this section as if fully repeated here.

1.2 REGULATORY REQUIREMENTS

- A. All materials shall conform with the current applicable industry standards. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of the Engineer and at no additional cost to the Owner.
- B. The latest editions of the following standards are minimum requirements.
 - 1. Underwriters' Laboratories, Inc. (UL)
 - 2. National Electrical Manufacturer's Assoc. (NEMA)
 - 3. American National Standards Institute (ANSI)
 - 4. Institute of Electrical and Electronic Engineers (IEEE)
 - 5. International Electrical Testing Association (NETA)
 - 6. Insulated Cable Engineer's Association (ICEA)

- C. All work and materials shall comply with latest rules, codes and regulations including, but not limited to the following:
 - 1. OSHA.
 - 2. National Fire Codes of National Fire Protection Assoc. (NFPA)
 - 3. National Electrical Safety Code (NESC, ANSI C2)
 - 4. National Electrical Code (2011 Edition).
 - 5. International Building Code Building Code (2009 Edition).
 - 6. Americans With Disabilities Act (ADA).
 - 7. All applicable Federal, state and local laws, code amendments and regulations.
- D. Code compliance is mandatory. Nothing in these drawings and specifications permits work not conforming to these codes.
- E. No work shall be concealed until after inspection and approval by proper authorities. If work is concealed without inspection and approval, Contractor shall be responsible for all work required to open and restore the concealed area including all required modifications.
- F. Contradictions: Where Codes are contradictory, follow the most stringent. Engineer(s) shall determine which is most stringent.

1.3 CONTRACT DOCUMENTS

- A. Drawings indicate general arrangement of circuits and locations of outlets, conduit, and other work. Information shown on drawings is as accurate as planning can determine, but not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is directed. Review all contract drawings, and adjust all work to conform to all conditions shown therein. Civil drawings shall take precedence over all other drawings. Discrepancies between different drawings or between drawings and specifications or regulations and codes governing installation shall be brought to attention of the Civil Engineer.
- B. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Engineer(s) in writing during the Bidding Period of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
- C. Follow Drawings and Specifications where they are superior to Code requirements. The more stringent of plans and drawing shall apply.

1.4 COORDINATION DRAWINGS

- A. Prepare coordination drawings in accordance with Division 1 "Submittals" to a scale of $\frac{1}{4}" = 1'-0"$ or larger; detailing major elements, components, and systems of electrical equipment (i.e., all transformers and electrical enclosures) and materials in relationship with other systems, installations, and building components. Where equipment is located

outdoors, prepare shop drawings indicating electrical equipment locations and exterior elements in the equipment areas. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to the efficient flow of the work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, and materials.
Include the following:
 - a. Support details.
 - b. Sizes and location of required concrete pads and bases.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Underground conduit and duct bank routing.

1.5 RECORD DRAWINGS

- A. Refer to Division 1 for additional requirements.
- B. Maintain a blue-line set of Electrical Contract Drawings in clean, undamaged condition, for mark-up of installations which vary from the Contract Drawings. These drawings shall be a separate set of drawings, not used for construction purposes, and shall be kept up to date as the job progresses. This set shall be made available for inspection by the Engineer(s) at all times. Upon completion of the contract a set of computerized "as built" capable of interfacing with AutoCAD software, shall be delivered to the Owner.
- C. Prepare record documents in accordance with the requirements in Division 1 Section "Project Closeout." In addition to the requirements specified in Division 1, indicate installed conditions for:
 1. Major raceway systems, size and location, locations of handholes and conduit stub-up locations.
 2. Panelboard circuit directories reflecting all field changes.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 4. Results of all testing performed as specified in the specification.
 5. Certification of inspection from Authorities Having Jurisdiction.
- D. Record the locations and invert elevations of underground installations.

1.6 OPERATING AND MAINTENANCE MANUALS

- A. Refer to Division 1 for additional requirements.
- B. Submission:
 1. Submit three typed and bound copies of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner.
 2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings.
 - a. Mark the back spine of each binder with system identification and volume number.

C. Requirement Contents:

1. Manuals shall have index with tab dividers for each submittal section identifying all equipment and materials installed on the project including a local supplier for replacing a specific piece of equipment.
2. Provide certificates for such items of equipment which have warranties in excess of one year.
3. Provide test results for each specification section identified herein.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Protection of Equipment:

1. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, rain, sleet, or dust. Large diameter cables may be stored on reels outside; however, all cable ends shall be waterproofed and the reels covered with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened, and made impervious to the elements.
2. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers, or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.
3. Equipment damaged as a result of the above conditions shall be properly repaired at the contractor's expense or shall be replaced at the contractor's expense, if in the opinion of the Engineer, the equipment has been damaged to such an extent that it cannot operate properly after repairs are made.
4. All electrical enclosures exposed to construction damaged such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs, and pipe covering compound splashes, shall be completely covered and protected against damage.
5. In the event leakage into the building of any foreign material or fluid occurs or may occur, the contractor shall take all steps as described above to protect any and all equipment.
6. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape, and insulation removed in order to make the connection.

1.8 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This

requirement will apply continuously and not be limited to normal working hours. See also General Conditions.

- B. No act, service, drawings review or construction review by the Engineer(s), is intended to include review of the adequacy of the Contractor's safety measures in, on, or near the construction site.

1.9 WARRANTIES

- A. The warranty period is generally one year after Date of Acceptance.
 - 1. During this period, provide labor and materials as required to repair or replace defects in the electrical systems at no cost to the Owner. Provide certificate with O & M manual submittal which guarantees same day service response to the Owner's call for such warranty service.
 - 2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies of O & M manual. Such equipment shall include:
 - a. Major electrical switchgear and switchboard
 - b. Lighting fixtures
 - 3. Provide extended manufacturers warranties to cover one full year from Date of Acceptance if standard manufacturers' warranty ends any time prior to that date.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. All equipment and materials installed shall be new, unless otherwise specified.
- B. All major equipment components shall have manufacturers' name, address, model number and serial number permanently attached in a conspicuous location.
- C. All equipment shall be UL listed and bear the UL label.

2.2 GENERAL SUBMITTAL REQUIREMENTS

- A. Coordination and Sequencing:
 - 1. After receipt of notice to proceed, the Contractor shall submit to the Engineer a typed list of submittals and the scheduled date of submission. List shall include submittal number, section number and scheduled date of submission. Submittals shall be grouped and submitted in no more than ten complete packages.
 - 2. The contractor shall not submit any shop drawings or product data that does not comply with the contract documents. Prior to submitting shop drawings, review submittal for compliance with Contract Documents and place a stamp or other confirmation thereon which states that submittals have been reviewed. Submittals without such verification will be returned disapproved without review.
 - 3. Submittal is for information and record, unless otherwise indicated, and is not a change order request.

B. Preparation of Submittals:

1. Refer to Division 1 requirements.
2. The Contractor shall submit for approval by the Engineer data of materials and equipment to be incorporated in the work. Submittals shall be supported by descriptive material, catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Provide complete electrical characteristics for all equipment. Submit product submittals on items as outlined in sections hereinafter.
3. Product submittals shall be made by specification section. All items of a section, requiring submission, shall be submitted together at one time in a tabbed binder. If two or more sections require inter-coordination (e.g., emergency generator and transfer switch; short circuit study, electrical room layouts and electrical switchboards, fire alarm and fire command center layout), they shall be submitted at the same time.
4. Each individual submittal item shall be organized electronically and noted to show specific section number(s) pertaining to the item.
5. Provide the following within each electronic file: Project name, Contractor, Subcontractor, submittal name, date of submission, specification section, and information to distinguish it from other submittals.
6. Submittals not presented in a neat and legible fashion will be returned "Without Action."
7. Submittals shall show Contractor's executed review and approval marking. Submittals which are received from sources other than through Contractor's office will be returned "Without Action."
8. Provide space for Engineer's "Action" marking.

C. Substitutions

1. Refer to the General Conditions, which governs "Substitution" of specified equipment or materials.
2. Indicate any portions of work which deviate from the Contract Documents.
 - a. Explain the reasons for the deviations.
 - b. Show how such deviations coordinate with interfacing portions of other work.
3. Where substitution of materials alters space requirements indicated on the drawings, submit shop drawings indicating proposed layout of space, all equipment to be installed therein and clearances between equipment (i.e., electrical rooms). All clearances required by the National Electrical Code and applicable state and local regulations must be maintained.

D. Review Process

1. The Engineer reserves the right to require a sample of any equipment to be submitted for approval and to retain its possession.
Refer to the individual sections for identified equipment and material for which submittals are required. In addition, provide shop drawings and product data on the following equipment:

Electrical Power Conductors and Cables

Raceway and Boxes
Cable Trays
Underground Duct, Raceway & Manholes
Panelboards
Lighting Fixtures
Poles and Standards
Enclosed Switches and Circuit Breakers

Do not submit on equipment or materials not requested in the specifications.

2. Review of shop drawings and product data by the Engineer(s), including any review annotations or stamp notations, does not relieve the contractor from the required compliance with the contract documents.
3. The shop drawing and product data review stamp notation requirements are defined as follows:
 - a. “NO EXCEPTION TAKEN:” The reviewer did not observe any items which were not in compliance with the contract documents. All dimensions, details, and coordination with other trades is the responsibility of the contractor.
 - b. “MAKE CORRECTIONS NOTED:” The reviewer indicated items observed that were not in compliance with the contract documents. The contractor shall not resubmit, but shall make corrections and provide corrected documents with the “Record Drawings.”
 - c. “REJECTED, REVISE AND RESUBMIT:” The reviewer indicated items observed which were not in compliance with the contract documents. The contractor shall resubmit showing corrections of all noted items. Delays for resubmittal does not relieve the contractor from meeting project schedules.
 - d. “REJECTED:” The submission does not comply with the contract requirements. The entire submittal must be corrected and submitted for review. Delays for resubmittal does not relieve the contractor from meeting project schedules.
4. If shop drawings are submitted and returned as “NO EXCEPTION TAKEN” or “MAKE CORRECTIONS NOTED” and meet contract requirements, the contractor shall not resubmit any other shop drawings for these items.
5. If resubmittals are necessary, they shall be made as specified above for submittals. Resubmittals shall highlight all revisions made and cover shall include the phrase “RESUBMITTAL NO. _____.”

Resubmittal requirements do not entitle the Contractor to additional time and are not a cause for delay of the project.

PART 3 – EXECUTION

3.1 CONDITIONS AT SITE

- A. Visit to site is required of all bidders prior to submission of bid. All bidders will be held to have familiarized themselves with all discernible conditions, and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.
- B. Lines of other services and/or equipment that are damaged as a result of this work shall promptly be repaired at no expense to the Owner.

3.2 LICENSES, FEES AND PERMITS

- A. Arrange for required inspections and pay all license, permit and inspection fees. Furnish a certificate of final inspections and approvals from local authority having jurisdiction over electrical installation.

3.3 WORKMANSHIP AND CONTRACTOR'S QUALIFICATIONS

- A. Only professional quality workmanship will be accepted. Haphazard or poor installation practice will be cause for rejection of work.
- B. Provide foreman in charge of this work at all times. Foremen for this work shall have had experience in installing not less than 5 such electrical systems of equal or greater complexity.
- C. Where specifications call for an installation to be made in accordance with manufacturers' recommendations, a copy of such recommendations shall at all times be kept in job superintendent's office.

3.4 RELATION WITH OTHER TRADES

- A. Contractor shall coordinate work of this Division with other trades to avoid conflict and to provide rough-ins and other connections for equipment furnished under other divisions that require electrical connections. Inform other trades of required clearances of accesses for or around electrical equipment to maintain serviceability and code compliance.
- B. Verify equipment dimensions and rough-in requirements for Divisions 2 through 16 with provisions specified under this Section of work, and report discrepancies to the Engineer in ample time to prevent delays or unwarranted changes of work.

3.5 TESTING

- A. Provide all labor, materials, and equipment necessary to make required tests. Tests shall be complete and results approved before final inspection is begun.

3.6 PROGRESS OF WORK

- A. Order progress of electrical work so as to conform to progress of work of other trades, and complete entire installation as soon as condition of building will permit. Assume any cost resulting from defective or ill-timed work performed under this Division.

3.7 EXCAVATION, TRENCHING, AND BACKFILLING

- A. Perform all excavation to install conduit and duct banks indicated on the drawings or specified herein. During excavation, pile material for backfilling back from the banks of the trench to avoid overloading and to prevent slides and cave-ins. Remove and dispose of all excavated materials not to be used for backfill. Grade to prevent surface water from flowing into trenches and excavation. Remove any water accumulating therein by pumping. Do all excavation by open cut. No tunneling shall be done unless indicated on the drawings or unless written permission is received from the Engineer.
- B. Grade the bottom of trenches to provide uniform bearing and support for conduits or duct bank on undisturbed soil at every point along its entire length. Tamp over depths with loose, granular, moist earth. Remove unstable soil that is not capable of supporting equipment or installation and replace with specified material for a minimum of 12" below invert of equipment or installation.
- C. Backfill the trenches with excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel or soft shale. These materials should be free from large clods of earth and stones, deposited in 6" layers and rammed until the installation has cover of not less than the adjacent ground but not greater than 2" above existing ground. Backfilling shall be carried on simultaneously on both sides of the trench so that injurious pressures do not occur. Compaction of the filled trench shall be at least equal to that of the surrounding undisturbed material. Do not settle backfill with water. Reopen any trenches not meeting compaction requirements or where settlement occurs, refill, compact, and restore surface to grade and compaction indicated on the drawings, mounded over and smoothed off.
- D. In addition, all excavation and backfilling shall comply with Division 2. The most stringent requirement shall apply.

3.8 CLEANUP

- A. Remove all materials, scrap, etc., relative to electrical installations and leave premises in a clean, orderly condition. Any costs to the Owner for cleanup of site will be charged to the Contractor. At completion, all equipment, raceways, etc., shall be thoroughly cleaned and all residue removed from the inside and outside surfaces. Defaced finish shall be refinished.

3.9 MINOR CHANGES

- A. The Owner reserves the right to make minor changes in the locations of outlets and equipment up to the time of electrical rough-in without any cost to the Owner.

3.10 ELECTRICAL SYSTEMS OPERATIONAL TESTS, CERTIFICATION, AND DESIGN AUTHORITY ASSISTANCE

- A. Testing

1. Refer to the individual specification sections for test requirements.
 2. Prior to the final inspection, the systems or equipment shall be tested and reported as herein specified. Six (1) electronic typewritten copy of the tests shall be submitted to the Engineer(s) for approval.
 3. All electrical systems shall be tested for compliance with the specifications.
- B. Manufacturers' Certifications
1. The electrical systems specified herein shall be reviewed for compliance with these specifications, installation in accordance with the manufacturers' recommendations and system operation by a representative of the manufacturer. The manufacturer shall submit certification that the system has been installed in accordance with the manufacturers' recommendations and is operating as specified in the contract documents.
- C. Design Authority Assistance
1. The Contractor shall provide personnel to assist the Engineer(s) or his representative during all construction review visits. The Contractor shall provide all necessary tools and equipment to demonstrate the system operation and provide access to equipment, including screwdrivers, wrenches, ladders, flashlights, circuit testing devices, meters, keys, etc.
 2. Remove equipment covers (i.e., panelboard trims, panelboards, and junction box covers) as directed for inspection of internal wiring. Reinstall all covers after inspection.
 3. Energize and de-energize circuits and equipment as directed. Demonstrate operation of equipment as directed by Engineer(s).
 4. The Contractor shall provide authorized representatives of the manufacturers to demonstrate to the Engineer(s) compliance with the specifications of their respective system during or prior to the final inspection at a time designated by the Engineer. Refer to the appropriate specification section for additional testing requirements. Representatives of the emergency generator/automatic transfer switch and fire alarm systems are required for demonstrations.

END OF SECTION

SECTION 16050

IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this Section:
 - 1. "Electrical Requirements."

1.2 SUMMARY

- A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
 - 1. Buried electrical line warnings.
 - 2. Identification labeling for raceways, cables, and conductors.
 - 3. Operational instruction signs.
 - 4. Warning and caution signs.
 - 5. Equipment labels and signs.
- B. Related Sections: The following Sections contain requirements that relate to this Section;
 - 1. Division 16 Section "Wires and Cables" for requirements for color coding of conductors for phase identification.
- C. Refer to other Division 16 Sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product Data for each type of product specified.
- C. Schedule of identification nomenclature to be used for identification signs and labels.
- D. Samples of engraved, plastic laminate to be used on switchgear, switchboards, disconnect switches and panelboards.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

- A. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mil thick by 1 inch to 2 inches in width.
- B. Underground Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic tape with magnetic tracer strip not less than 6 inches wide by 4 mil thick. Printed legend indicative of general type of underground line below.
- C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wrap around, cable/conductor markers with preprinted numbers and letters.
- D. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for sign up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in black letters on white face for normal power and red letters on white face for emergency and standby power. Plastic laminate shall be punched for mechanical fasteners.
- E. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide ¼-inch grommets in corners for mounting.
- F. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.
- G. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

- H. Electronic Labels: Self-adhesive, 3/16 inch industrial label, black on clear for normal circuits and red on clear for emergency/standby circuits. Acceptable manufacturers include the following:
 - 1. Kroy
 - 2. Brother

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.
- B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.
- C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

3.2 CONDUIT IDENTIFICATION

- A. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use pressure-sensitive plastic labels at exposed locations and similar labels at concealed boxes.
- B. Underground Electrical Line Identification: During trench backfilling, for underground power, signal, and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches; install a single line marker.
- C. Install line marker for underground wiring, both direct-buried and in raceway.
- D. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- E. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

<u>240/120 Volts</u>	<u>Phase</u>
Black	A
Red B White	Neutral
Green	Ground

- F. Use conductors with color factory-applied the entire length of the conductors except as follows:
1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG:
 - a. Apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
 - b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.
 2. All grounded conductors No. 6 AWG and smaller shall be a factory applied color across the entire length of conductors.
- G. Power Circuit Identification:
1. Securely fasten wrap-around marker bands to cables, feeders, and power circuits in pull boxes and junction boxes.
- H. Apply warning, caution, and instruction signs and stencils as follows:
1. Install warning, caution, or instruction signs where required by NEC where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
 2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
- I. Install equipment/system circuit/device identification as follows:
1. Apply equipment identification labels of engraved plastic-laminate on each major unit for electrical equipment. This includes communication/signal/alarm system, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 3/8-inch-high lettering on 1 1/2-inch-high label (2-inch-high where two lines are required), black lettering in white field for normal power and red lettering on white field for emergency and standby power. Text shall match terminology and numbering of the Contract

Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment:

- a. Panelboards, electrical cabinets, and enclosures.
2. Apply electronic label on the inside of all receptacle and switch plates. The labels shall identify circuit and panelboard.

END OF SECTION

SECTION 16100

BASIC MATERIAL AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Section supplements Division 1, General Requirements.

1.2 DESCRIPTION OF WORK

- A. Work included in this section consists of conduits, wires and other miscellaneous materials not specifically mentioned in other sections of Division 16 but necessary or required for equipment or system operation or function, and the labor to install them.

1.3 SUBMITTALS

- A. Materials list with manufacturer, style, series or model identified.
- B. Manufacturer's descriptive literature and/or sample if requested by the Engineer(s).

PART 2 - PRODUCTS

2.1 CONDUIT RACEWAYS: Refer to Section 16110.

2.2 ELECTRICAL POWER CONDUCTORS AND CABLES: Refer to Section 16120.

2.3 WIRING DEVICES: Refer to Section 16140.

2.4 OUTLET BOXES, JUNCTION AND PULL BOXES

- A. Outlet Boxes: Hot-dipped galvanized or sherardized of required size, 4" square minimum, for flush mounted devices and lighting fixtures. Cast-type FD with gasketed covers for surface-mounted devices.
- B. Junction and Pull Boxes: Use outlet boxes as junction boxes wherever possible. Larger junction and pull boxes shall be fabricated from sheet steel, sized according to code, with screw-on covers, galvanized where required for outdoor exposure.
- C. All exterior boxes shall be cast, gasketed, weatherproof type with cast covers.

- D. Refer to Section 16110 for additional requirements.

2.5 WIRE CONNECTORS

- A. For wires that are #8 AWG and smaller: Insulated pressure type with live spring, rated 105°C, 600 volt, for building wiring and 1000 volt in signs or fixtures.
- B. For wires that are #6 AWG and larger: Compression type with 3M #33 or equal tape insulation.

2.6 FUSES: Refer to Section 16265.

2.7 EQUIPMENT MOUNTING AND SUPPORT HARDWARE

- A. Steel channels, bolts and washers, used for mounting or support of electrical equipment shall be galvanized typed. Where installed in corrosive atmosphere, stainless steel type hardware shall be used.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide complete raceway systems for all conductors including control wiring and low voltage wiring unless otherwise noted.
- B. Electrical system layouts indicated on drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served.
- C. All home runs to panelboards are indicated as starting from the outlet nearest to the panel and continuing in the general direction of that panel. Continue such circuits to panel as though routes were completely indicated.
- D. Furnish and install all necessary hardware, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

3.2 RACEWAYS: Refer to Section 16110.

3.3 OUTLETS

- A. Verify final location of all outlets, panels, equipment, etc., with the Engineer(s).

- B. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4" octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8" no-bolt fixture studs.
- C. Surface-mounted devices are to be mounted in cast type boxes with gasketed covers: (Crouse-Hinds condulets or equal).
- D. Confirm final location and heights of all outlets, with Engineer(s) prior to installation.
- E. Refer to Section 16110 for additional requirements.

3.4 JUNCTION PULL BOXES

- A. Construct junction or pull boxes not over 150 cubic inches in size shall be standard outlet boxes, and those over 150 cubic inches shall be constructed the same as "Cabinets," with screw covers of same gauge metal. Removal covers must be accessible at all times.

END OF SECTION

SECTION 16110

RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.
- B. Requirements of the following Division 16 Sections apply to this Section:
 - 1. "Electrical Requirements."
 - 2. "Basic Material and Methods"

1.2 SUMMARY

- A. Drawings are diagrammatic. All bends, boxes, fittings, couplings are not necessarily shown. Supply as necessary to comply with the National Electric Code.
- B. This Section includes raceways for electrical wiring. Types of raceways, boxes and fittings in this section include the following:
 - 1. Electrical metallic tubing (EMT).
 - 2. Flexible metal conduit.
 - 3. Intermediate metal conduit (IMC).
 - 4. Liquid-tight flexible conduit.
 - 5. Rigid metallic conduit (RMC).
 - 6. Metal clad cable (MC).
 - 7. Surface raceways.
 - 8. Rigid non-metallic conduit.
 - 9. Electrical non-metallic tubing (ENT) 10. Wireway.
 - 11. Outlet boxes.
 - 12. Junction boxes.
 - 13. Pull boxes.
 - 14. Bushings.
 - 15. Locknuts.
 - 16. Knockout closures.
- C. Related Sections: The following section contains requirements that relate to this section:
 - 1. Division 16 Section "Raceway and Boxes" for conduit connectors, fittings, and couplings.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.
- B. Product Data for the following products:
 - 1. Raceways and fittings.
 - 2. Wireways and fittings.
 - 3. Boxes and fittings.
- C. Installation Instructions: Manufacturer's written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.
- C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.
- D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.
- E. Installer's Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.
- F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.
- G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.
- H. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.'s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.
- I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, "Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps."

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1
- B. Intermediate Steel Conduit: UL 1242.
- C. Electrical Metallic Tubing and Fittings: ANSI C80.3.
- D. Flexible Metal Conduit: UL 1, zinc-coated steel.
- E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360.

2.2 METAL CLAD CABLE, TYPE MC

- A. The multi-conductor metal clad cable shall comply with UL 1569 “Metal Clad, Type MC,” UL 83 “Thermoplastic Insulated Wires and Cables” Federal Specification J-C-30B “Wire and Cable,” Local and National Electrical Codes.
- B. The metal clad cable shall be THHN insulation, copper conductors in sizes #12 through #8 AWG only for continuous operation at a maximum conductor temperature of 90 degree C dry.
- C. These cables shall bear appropriate Underwriters Laboratories labels for metal clad cable and be suitable for use as branch circuits in both exposed and concealed work in accordance with applicable sections of the National Electrical Code.
- D. An insulated grounding conductor sized in accordance with Table 5.3 Underwriter’s Standard UL 1569 shall be cabled with the circuit conductors and shall be identified in compliance with Section 29 of UL 1569. The grounding conductor shall not be smaller than size indicated in NEC Article Table 250.122.
- E. A galvanized steel or aluminum armor shall be applied over the inner cable assembly with a positive interlock in compliance with Section 10 of UL 1569. A PVC jacket shall completely cover the steel or aluminum armor when installed in the slab.

2.3 NONMETALLIC CONDUIT AND DUCTS

- A. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 and UL 651, Schedule 40 or 80 PVC.
- B. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

- C. Conduit, Tubing and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information. Mate and match accessories with raceway.
- D. Electrical non-metallic tubing (ENT): NEMA TC13 and UL1653.

2.4 CONDUIT BODIES AND FITTINGS

- A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.
- B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.
- C. EMT Conduit Bodies 1 Inch and Smaller: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.
- D. EMT Conduit Bodies 1 Inch and Larger: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.
- E. Nonmetallic Conduit and Tubing: Use nonmetallic conduit bodies conforming to UL514B.
- F. Liquid-Tight Flexible Conduit Fittings: With threaded grounding cone, a steel, nylon or equal plastic compression ring, and a gland for tightening. Either steel or malleable iron only with insulated throats and male thread and locknut or male bushing with or without O-ring seal. Each connector shall provide a low resistance ground connection between the flexible conduit and the outlet box, conduit or other equipment to which it is connected.
- G. Bushings: Insulated type, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, for rigid steel conduit, IMC and EMT, larger than $\frac{3}{4}$ " size.
- H. Expansion Fittings: Each conduit that is buried in or secured to the buildings construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subject to excessive stresses shall be provided with an expansion fitting. Expansion fittings for rigid steel conduit shall be hot-dipped galvanized malleable iron with factory installed packing and a grounding ring. Expansion fittings for rigid nonmetallic conduit shall be of the short type in runs 25' or less, and the long type in runs 26' to 80'. The long type shall be a two piece barrel and piston joint, providing 6" of the total movement range in $\frac{3}{4}$ " through 6" conduit sizes. The short type shall be a one piece, coupling with O-ring, providing 2" of total movement range in $\frac{3}{4}$ " to 2" conduit sizes.

- I. Seal Off Fittings: Threaded, zinc or cadmium coated, cast or malleable iron type for steel conduits. Fittings used to prevent passage of water vapor shall be of the continuous drain type.

2.5 WIREWAYS

- A. General: Electrical wireways shall be of types, sizes, and number of channels as indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for complete system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.
- B. Wireway covers shall be hinged type.

2.6 SURFACE RACEWAYS

- A. General: Sizes and channels as indicated on drawings. Provide fittings that match and mate with raceway. Provide internal barriers for areas with power and communications sections.
- B. Surface Metal Raceway: Construct of two piece galvanized steel with snap-on covers, with 9/32-inch mounting screw knockouts in base approximately 8 inches o.c. Finish with manufacturer's standard prime coating suitable for painting. Provide raceways of types suitable for each application required. Sizes 1-3/4" H x 4-3/4" W.
- C. Accessories:
 - 1. Couplings for joining raceway sections.
 - 2. Wire clips for conductors.
 - 3. Blank end fittings.
 - 4. Circuit breaker housings for single pole breakers.
 - 5. Device brackets for single or two gang devices.
 - 6. Combination receptacle and telephone outlet covers.
 - 7. Outlet boxes with hubs for conduit connectors.

2.7 FABRICATED MATERIALS - BOXES

- A. Outlet Boxes: Provide galvanized flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 1/2 inch deep), including box depths as required, suitable for installation at respective locations. Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding.
 - 1. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet

boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

- B. Device Boxes: Provide galvanized coated flat rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 ½ inches deep), including box depths as indicated, suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with conduit-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide conduit connectors and corrosion-resistant screws for equipment type grounding.
 - 1. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster ears, and plasterboard expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.
- C. Raintight Outlet Boxes: Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners.
- D. Junction and Pull Boxes: Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers. Pull boxes installed in finished spaces must be flush mounted cabinets provided with trim, hinged door and flush latch and lock to match flush mounted panelboard trim.
- E. Exterior junction or pull boxes, flush with grade:
 - 1. Junction or pull box to be mounted flush with grade shall be polymer composite raintight with screw cover lids. Box dimensions shall be 30"W x 48"L x 36"D. Covers shall be polymer composite suitable for pedestrian traffic secured to box with stainless steel screws. Box to be furnished with continuous neoprene gasket to seal cover. Conduit entry shall be on side of box with bell ends.
- F. Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.

PART 3 - EXECUTION

3.1 WIRING METHOD

- A. Outdoors: Use the following wiring methods:
 - 1. Exposed: Intermediate metal conduit, rigid steel conduit.
 - 2. Concealed: Intermediate metal conduit, rigid steel conduit.
 - 3. Underground, Single Run: Rigid non-metallic conduit. PVC coated GRC 90° elbows.
 - 4. Underground, Grouped: Rigid non-metallic conduit. PVC coated GRC 90° elbows.
 - 5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.
- B. Indoors: Use the following wiring methods:
 - 1. Exposed (below 10 ft. to floor): Intermediate metal conduit, rigid steel conduit.
 - 2. Exposed (above 10ft. or in electrical room): Electrical metallic tubing.
 - 3. Concealed: Electrical metallic tubing.
 - 4. Concealed: Metal clad cable will be allowed as final branch wiring of receptacles and light fixtures (maximum total length of 25' from homerun J-box or hard piped J-box to outlet). MC is not allowed for homeruns to panels, connections to mechanical equipment. Maximum conductor size is in MC cable #8 AWG.
 - 5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Flexible metal conduit.
 - 6. Connection to Vibrating Equipment in Moist/Humid or Corrosive Atmosphere including pneumatic or electric solenoid, and motor-operated equipment: Liquidtight flexible metal conduit.
 - 7. Within concrete slabs: electrical non-metallic tubing, PVC coated MC cable, or rigid non-metallic conduit. PVC coated MC cable is not allowed for homeruns. Homeruns shall be in conduit. Maximum sizes and locations as approved by the Structural Engineer.
 - 8. Raceway mounted to underside of metal-corrugated sheet roof decking shall be Rigid Metal Conduit or intermediate Metal Conduit.

3.2 INSTALLATION OF RACEWAYS

- A. General: Install electrical raceways in accordance with manufacturers' written installation instructions, applicable requirements of NEC, and as follows.
- B. Complete installation of electrical raceways before starting installation of conductors within raceways.
- C. Provide supports for raceways as specified elsewhere in Division 16 and in accordance with NEC and local authorities seismic requirements.
- D. Prevent foreign matter from entering raceways by using temporary closure protection.

- E. Protect stub-ups from damage where conduits rise from below grade. Arrange so curved portion of bends is not visible above grade.
- F. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
- G. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.
- H. Run underground raceways with a minimum of bends in the shortest practical distance considering the routing and obstructions except as otherwise indicated.
- I. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.
- J. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel.
- K. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Use expansion fittings at building expansion joints.
- L. Tighten set screws of threadless fittings with suitable tool.
- M. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside of the box. All conduit connections to junction boxes shall have insulated bushings.
- N. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- O. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave no less than 12 inches of slack at each end of the pull wire.

- P. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
 - 1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces, air-conditioned spaces and walk-in coolers.
 - 2. Where required by the NEC.
- Q. Stub-up Connections: Extend conduits above grade for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs. Extend conductors to equipment with galvanize rigid conduit. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs flush with floor.
- R. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.
- S. All underground conduits shall be installed a minimum of 30 inches below finish grade. All other conduits shall be installed in accordance with the NEC and coordinated depth with other trades.
- T. Grounding: Install a separate green equipment grounding conductor in all raceways from the panelboard/junction box supplying the raceway to the receptacle or equipment ground terminals. Conduits will not be permitted as a ground conductor.

3.3 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

- A. General: Install electrical boxes and fittings in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.
- C. Provide raintight "in use" outlets for interior and exterior locations exposed to weather or moisture.
- D. Provide knockout closures to cap unused knockout holes where blanks have been removed.
- E. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

- F. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.
- G. Fasten electrical boxes firmly and rigidly to surfaces to which attached.
- H. Provide electrical connections for installed boxes.
- I. Exterior junction or pull boxes shall be mounted flush with grade, unless noted otherwise or indicated to be above ground on the drawings. Boxes shall be surrounded on all sides with 6 inches minimum of concrete. Top of concrete shall flush with grade. Seal all conduit entries into box with duct seal to prevent entrance of moisture, after conductors are installed.
- J. Tap and splices, where permitted by these specifications within exterior junction boxes, shall be performed with an encapsulating watertight splice or tap kit which insulates and moisture seals the connection. Kit shall consist of the appropriate size and type mold, encapsulating resin and end sealing tape.
- K. Subsequent to installation of boxes, protect boxes from construction debris and damage.

3.4 GROUNDING

- A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.5 ADJUSTING AND CLEANING

- A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

END OF SECTION

SECTION 16120

ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirement of the following Division 16 Sections apply to this section:
 - 1. Electrical Requirements

1.2 SUMMARY

- A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.
- B. Related Sections: The following Sections contain requirements that relate to this section:
 - 1. Division 2 Section "Earthwork" for trenching and backfilling.
 - 2. Division 16 Section "Electrical Boxes and Fittings" for connectors for terminating cables in boxes and other electrical enclosures.

1.3 SUBMITTALS

- A. Product Data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the following code:
- B. NFPA 70 "National Electrical Code."
 - 1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.
- C. UL Compliance: Provide components, which are listed and labeled by UL under the following standards.
 - 1. UL Std. 44 Rubber Insulated Wires and Cables
 - 2. UL Std. 83 Thermoplastic-Insulated Wires and Cables
 - 3. UL Std. 486A Wire Connectors and Soldering Lugs for
Use with Copper Conductors
 - 4. UL Std. 854 Service Entrance Cable

- D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
 - 1. WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 2. WC-7: Cross Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- E. IEEE Compliance: Provide components, which comply with the following standard.
 - 1. Std. 82: Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 WIRES AND CABLES (600 VOLT COPPER CONDUCTORS – BASE DESIGN)

- A. General: Provide suitable wire and cable for the temperature, conditions and location where installed. All wires and cables shall be new and delivered to the site in unbroken packages and reels.
- B. All wires and cables shall be of the same manufacturer throughout the entire project.
- C. Conductors: Provide solid conductors for power and lighting circuits #10 AWG and smaller. Provide stranded conductors for #8 AWG and larger.
- D. Conductor Material: All wires and cables shall be copper, single conductor rated at 600 volts, which conform to or exceed ICEA specifications and the following:
 - 1. In sizes 1/0 AWG to 4/0: Cross-linked polyethylene insulation type XHHW-2 (75 - 90°C) or THWN.
 - 2. In sizes 250 KCMIL and larger: Type XHHW-2 (75°C) or THWN.
 - 3. In sizes 1 AWG and smaller: All conductors shall have heat/moisture resistant thermoplastic insulation type THWN (75°C) except as follows:
 - a. Where conduit temperature will exceed 100°F, use type THHN (90°C).
 - b. In 120 volt incandescent fixtures, type SF-2 or SFF-2 (150 - 200°C).
 - c. In wireway of fluorescent lighting fixtures type THHN (90°C).
- E. Grounding conductors: Shall be of the same type as its associated phase conductors.
- F. All conductors shall be label with wire size, insulation rating, etc using an engraved process, computer scan on labels are not permitted.
- G. Color Coding for phase identification in accordance with Table 1 in Part 3 herein.
- H. Connectors for Conductors:
 - 1. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use connectors with temperature ratings equal to or greater than those of the wires upon which used.

I. Splices and Taps:

1. No. 10 AWG and smaller - Connectors for solid conductors shall be solderless, screw-on, spring pressure cable type, 600 volt, 105°C with integral insulation and UL approved for aluminum and copper conductors. Connectors for stranded conductors shall be crimp-on type with integral insulating cover.
2. No. 8 AWG and larger - Hydraulically applied crimping sleeve or tap connector sized for the conductors. Insulate the hydraulically applied connector with 90-degree, 600-volt insulating cover provided by the connector manufacturer. Insulator materials and installation shall be approved for the specific application, location, voltage, and temperature and shall not have an insulation value less than the conductors being joined.

PART 3 - EXECUTION

3.1 WIRING METHOD

- A. Use the following wiring methods as indicated:
1. Install all wire in raceway. Power and control wiring shall be installed in separate raceways.

3.2 INSTALLATION OF WIRES AND CABLES

- A. General: Install electrical cables, wires, and connectors in compliance with NEC.
- B. Coordinate cable and wire installation with other Work.
- C. Do not install more conductors in a raceway than indicated on the drawings. A maximum of three branch circuits are to be installed in any one conduit on a 3-phase, 4-wire system, unless specifically noted otherwise on the drawings. When more than three branch circuits are installed in a raceway, the conductor size shall be increase per code for derating. No two branch circuits of the same phase are to be installed in the same conduit, unless specifically noted otherwise on the drawings.
- D. Where multiple circuits share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously.
- E. Minimum wire size shall be a No.12 AWG except for control or signal circuits, which may be No. 14 AWG.
- F. Unless otherwise indicated on drawings, all wiring for branch circuits shall be a minimum No. 12 AWG in ¾" conduit, protected by 20 amperes circuit breakers. If distance from panel to first outlet is 75 feet or greater for 120 volt circuits, and 125 feet or greater for 244 volt circuits, No. 10 AWG shall be installed throughout the circuit, unless noted otherwise on the drawings.
- G. Size of current carrying conductors, unless noted otherwise on drawings, shall be determined from Table 310-16 of the latest National Electric Code for the load served.

- H. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- I. Use pulling means including: fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.
- J. Size of conduits, unless specifically shown, shall be determined from Appendix C of the latest National Electrical Code.
- K. Keep conductor splice to minimum. All splices shall be made within junction boxes, wiring troughs and other enclosures as permitted by the National Electrical Code. Do not splice conductors in panelboards, safety switches, switchboards, motor control centers or motor control enclosures. Splices in conductors installed below grade will not be permitted, unless approved in writing by the Engineer.
- L. Install splice and tap connectors, which possess equivalent or better mechanical strength and insulation rather than conductors being spliced.
- M. Use splice and tap connectors which are compatible with conductor material.
- N. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- O. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturers' published torque tightening values. Where manufacturers' torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque values specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.
- B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.
- C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.
- D. Prior to completion of project, an infrared scan of switchgear and panelboard feeder equipment connection shall be performed when all loads are energized.

3.4 FEEDER TESTING

- A. Products

1. Material: Contractor shall provide all necessary testing equipment and devices required to perform the test described in this section.

B. Execution

1. Visual and Mechanical Inspection
 - a. Inspect cables for physical damage and proper connection in accordance with one-line diagrams.
 - b. Test cable mechanical connections to manufacturer's recommended values using a calibrated torque wrench.
 - c. Check cable color coding with specification section 16050 and National Electrical Code standards.
2. Electrical Tests
 - a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
 - b. Perform continuity test to insure proper cable connection.
3. Test Values
 - a. Evaluate results by comparison with cables of same length and type. Investigate any insulation-resistance values less than 50 megohms.
 - b. Submit results to Engineer for approval in accordance with Section 16020.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles
 - 2. Ground Fault Circuit Interrupter Receptacles
 - 3. Plugs
 - 4. Plug Connectors

1.3 SUBMITTALS

- A. Product data for each type of product specified.
- B. Occupancy Sensors
 - 1. Submit a lighting plan clearly marked by manufacturer identifying product type, locations, orientation and coverage for each sensor.
 - 2. Submit any interconnection diagrams per major subsystems showing proper wiring.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the following codes.
 - 1. NFPA 70 "National Electrical Code."
- B. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL, Federal Specification and comply with applicable UL and NEMA standards.

1.5 SEQUENCE AND SCHEDULING

- A. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

- A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards.
- B. Color of Devices: Color of all devices unless noted otherwise shall be black.
- C. Receptacles: As scheduled in Table 1 in Part 3 indicated herein. Comply with UL 498 and NEMA WD 1 and WD 6.
- D. Ground-Fault Interrupter (GFI) Receptacles: As scheduled in Table 1 in Part 3 indicated herein: Provide "terminal" or feed-through type ground-fault circuit interrupter, as indicated on drawings, with integral heavy-duty NEMA 5-20R duplex receptacles. Provide unit designed for installation in a 2-3/4-inch deep outlet box without adapter, grounding type, Class A, Group 1 per UL Standard 943.
- E. All exterior weatherproof receptacles shall be GFI type or GFI protected and have cast metallic "in use" covers.
- F. All devices shall be premium specification grade.

2.2 WIRING DEVICE ACCESSORIES

- A. For all devices installed which are exposed to the weather, moisture or where indicated on the drawings, device plates shall be weatherproof. Device plates shall be cast metallic type with gasketing to prevent entrance of moisture when closed.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES

- A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other work.

- C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torque requirements are not indicated, tighten connectors and terminal to comply with tightening torque requirements specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

3.2 PROTECTION

- A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

- A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for shortcircuits. Ensure proper polarity of connections is maintained. Subsequent to energizing test wiring devices and demonstrating compliance with requirements, operate each operable device at least six times.
- B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. TABLE 1

RECEPTACLES

Designation ⁽¹⁾	Current Rating Amps	Voltage Rating	Single/ Duplex	NEMA Config.	Hubbell Catalog #	Notes
WP/GFI	20	125	Duplex	5-20R	GFR5362	Integral GFI ⁽²⁾ In Use Weather- proof

NOTES

1. Letter designations are used where symbols alone do not clearly designate on plans locations where specific receptacle types are used.
2. Protecting downstream receptacles on same circuit is not acceptable.

END OF SECTION

SECTION 16210

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division 16 Basic Electrical Material and Methods sections apply to work specified in this section.

1.2 SUMMARY

- A. Provide all panelboards and enclosure work, including cabinets and cutout boxes, as indicated by drawings and schedules, and as specified herein.
- B. Types of panelboards, and enclosures required for the project include the following:
 - 1. Power-distribution panelboards.
 - 2. Lighting and appliance panelboards.
- C. All panelboards, disconnect switches, etc., shall be fabricated by the same manufacturer throughout the entire project.
- D. Wires/cables, bus-way, electrical boxes and fittings, and raceways required in conjunction with the installation of panelboards, and enclosures are specified in other Division 16 sections.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on panelboards, and enclosures.
- B. Wiring Diagrams: Submit wiring diagrams for panelboards showing connections to electrical power feeders and distribution branches.
- C. Submit plan view drawings at 1/4" scale showing all equipment, panelboards, disconnects and ratings, buss work, conduit areas, dimensions and mounting of equipment supplied.
- D. Submittals shall be in accordance with specification section 16010.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: The manufacturer of this equipment shall be regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required and have produced similar electrical equipment, for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. Codes and Standards
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Article 384 as applicable to installation, and construction of electrical panelboards and enclosures.
 - 2. UL Compliance: Comply with applicable requirements of UL 67, "Electric Panelboards", and UL's 50, 869, 486A, 486B, 891, and 1053 pertaining to panelboards, accessories and enclosures. Provide panelboard units which are UL-listed and labeled.
 - 3. Special-Use Markings: Provide panelboards, constructed for special-use, with appropriate UL markings which indicated that they are suitable for special type of use/application.
 - 4. NEMA Compliance: Comply with NEMA Stds Pub/No. 250, "Enclosure for Electrical Equipment (1000 Volts Maximum)", Pub/No. PB 1, "Panelboards", and Pub/No. PB 1.1, "Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less".

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store panelboards in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic; where necessary to store outdoors, store electrical components above grade and enclose with watertight wrapping.
- B. Handle panelboards carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged components; replace and return damaged units to equipment manufacturer.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate installation of panelboards and enclosures with installation of wires/cables, electrical boxes and fittings, and raceway work.

PART 2 - PRODUCTS

2.1 PANELBOARDS (800 AMPS OR LESS)

- A. General: Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated on drawings, which comply with manufacturer's standard materials; with the design and construction in accordance with

published product information; equip with proper numbers of unit panelboard devices as required for complete installation.

- B. Lighting and Appliance Panelboards: Provide dead-front safety type lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown. Equipped with anti-turn solderless pressure type lug connectors approved for use with copper conductors; construct unit for connecting feeders at top of panel; equip with copper buss bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breakers, with toggle handles that indicate when tripped. Provide suitable lugs on neutral buss for each outgoing feeder required; and provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards. Employ breakers that are fully rated for the available short-circuit condition but not less than 10,000 sym AIC at 120/240 volts; and 14,000 sym AIC at 277/480 volts. Where multiple single pole breakers share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously.
- C. Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges with door in door swings as indicated. Equip with interior circuit directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for surface mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.
- D. Molded-Case Circuit Breakers: Provide factory-assembled, molded-case circuit breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated. Select breakers with permanent thermal and instantaneous magnetic trip, and ampere ratings as indicated on the drawings. Construct with overcenter, tripfree, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position, and operating in ambient temperature of 40°C. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated. The breakers for 277/480V panelboards shall be industrial grade; breakers that allow or direct particles of combustion resulting from fault conditions out of the breaker are not acceptable, they shall be contained within its casing. For example; GE AE series panelboards with TEY circuit breakers are not acceptable, TED breakers are acceptable.

PART 3 - EXECUTION

2.1 EXAMINATION

- A. Examine area and conditions under which panelboards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

2.2 INSTALLATION

- A. Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC standards and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque tightening requirements specified in UL Std 486A and B.
- C. Fasten enclosures firmly to surfaces, ensuring that they are permanently and mechanically anchored.
- D. Provide properly wired electrical connections for panelboards within the enclosures.
- E. Provide engraved, plastic laminate labels for all panelboards indicating name, voltage, phase, wire and short circuit rating. Refer to Section 16050 for more information.
- F. Provide typed panelboards circuit directory card upon completion of installation work to match as-built conditions and nomenclature indicated on engineering drawings and submit directories to the Engineer for review prior to mounting in panelboard.

2.3 GROUNDING

- A. Provide equipment grounding connections as indicated herein. Tighten connection to comply with torque tightening requirements specified in UL 486A to assure permanent and effective grounds.
- B. Refer to Section 16350 for additional grounding requirements.

2.4 FIELD QUALITY CONTROL

Tests shall conform to International Electrical Testing Association (INETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment".

- A. Panelboards:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect for physical damage and code violations.
 - b. Inspect for proper alignment, anchorage and grounding.

- c. Inspect for proper identification of protective devices and switches.
 - d. Check tightness of accessible bolted buss joints.
 - e. Physically test all electrical or mechanical interlocks to assure proper function.
 - f. Clean interior and insulator surfaces once a month prior to job completion.
 - g. Inspect for proper operation of space heaters and thermostat settings (if they exist).
2. Electrical Tests:
- a. Measure insulation resistance of each buss section phase-to-phase and phase-to-ground.
 - b. Check panelboards for electrical continuity of circuits and for short circuits.

2.5 ADJUSTING AND CLEANING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Touch-up scratched or marred surfaces to match original finishes.

2.6 DEMONSTRATION

- A. Subsequent to wire and cable hook-ups, energize and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION

SECTION 16265

ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. Division 16 Basic Electrical Materials and Methods sections, apply to work of this section.

1.2 SUMMARY

- A. Provide all circuit and motor disconnect switch work including fusing, electrical connections to motors, appliance and mechanical equipment as indicated on the drawings and schedules.
- B. Types of circuit and motor disconnect switches in this section include the following:
 - 1. Equipment disconnects.
 - 2. Appliance disconnects.
- C. Applications of electrical power connections specified in this section include the following:
 - 1. To lighting fixtures.
 - 2. To grounds including earthing connections.
 - 3. To panelboards, contactors, time clocks and similar equipment.
- D. All panelboards, transformers, disconnect switches, etc., shall be fabricated by same manufacturer throughout the entire project.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on circuit and motor disconnect switches, and equipment connectors.
- B. Fuse Product Data: For each type of fuse indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

- a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
- b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 QUALITY ASSURANCE

- A. All equipment shall be in compliance with codes and standards referenced in Section 26 05 02 titled "Electrical Requirements".
- B. UL Compliance: Comply with requirements of UL 98, "Enclosed and Dead-Front Switches." Provide circuit and motor disconnect switches which have been UL listed and labeled.
- C. Comply with UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," including, but not limited to, tightening of electrical connectors to torque values indicated.
- D. NEMA Compliance: Comply with applicable requirements for NEMA Stds Pub/No. KS 1, "Enclosed Switches," and No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."
- E. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, "Low-Voltage Cartridge Fuses 600 Volts or Less."
- F. NEMA Compliance: Comply with NEMA FU1 for cartridge fuses.

1.5 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 CIRCUIT AND MOTOR DISCONNECT SWITCHES

- A. Furnish and install safety switches as required for motor outlets or other equipment. Switches shall be of size, number of poles, and fused or non-fused, as required for job conditions and the National Electrical Code.
- B. Switches shall be equipped with fuse contacts and jaws which ensure positive fuse and jaw contact by means of reinforcing spring clips or other approved means. All current carrying parts shall be silver-plated. Hinges shall be non-current carrying. Switches shall be so designed that they can be locked in either open or closed position.
- C. All safety switches shall be NEMA 1 enclosed Type "HD" (heavy duty) quick-make, quick-break, and have interlocking cover with handle that may either be front or side operating with padlocking provisions. Provide NEMA 3R weather proof enclosures where indicated on the drawings or exposed to exterior or damp locations. Incorporate rejection clips where used with Class "R" fuses.
- D. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated on drawings. See Section "2.3" for Fuse specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.
- E. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated on drawings.
- F. Double-Throw Switches: Heavy duty switches of classes and current rating as indicated on drawings.
- G. Bolted Pressure Switches: Bolted pressure switches conforming to and listed under UL Standard 977; single or double-throw arrangement as indicated. For fusible units provide fuses as indicated on drawings.
- H. Accessories:
 - 1. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated on drawings or specified elsewhere in specifications.
 - 2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated on drawings to be NEMA 4X: a. Stainless Steel Type 316.
b. Heavy case aluminum.
 - 3. Captive Fuse Pullers: Provide built-in pullers arranged to facilitate fuse removal.

2.2 CONNECTIONS FOR EQUIPMENT

- A. General: For each electrical connection indicated provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties, solderless wirenuts. All other items and accessories as needed to complete splices and terminations of types indicated.

- B. Metal Conduit, Tubing and Fittings:
 - 1. General: Provide metal conduit, tubing and fitting of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Where types and grades are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with NEC requirements for raceways. Provide products complying with Section 16100 titled "Basic Materials and Methods" and Section 16110 titled "Raceways and Boxes" and in accordance with the following listing of metal conduit, tubing and fittings: a.
 - Rigid steel conduit.
 - b. Rigid metal conduit fittings.
 - c. Liquid-tight flexible metal conduit.
 - d. Liquid tight flexible metal conduit fittings.
- C. Wires, Cables, and Connectors:
 - 1. General: Provide wires, cables and connectors complying with Division 16100 titled "Basic Materials and Methods" and "Section 16120" titled "Electrical Power Conductors and Cables."
 - 2. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes and rating, of wires/cables which are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
 - 3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended for use by equipment manufacturer for intended applications.
 - 4. Electrical Connection Accessories: Provide electrical insulating tape, heat shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

2.3 FUSES

- A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.
- B. Class RK1 dual element time-delay fuses: Provide UL Class RK1 current limiting timedelay fuses rated 600-volts, (250 volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors and panelboards.
- C. Class RK5 dual element time-delay fuses: Provide UL Class RK5 current limiting timedelay fuses rated 600 volts, (250 volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors, and transformers.

- D. Class L time-delay fuses: Provide UL Class L time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECT SWITCHES

- A. Install circuit and motor disconnect switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation," and in accordance with recognized industry practices.
- B. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.
- C. Install disconnect switches for use with motor-driven appliances, and motors and controllers within sight of controller position unless otherwise indicated.

3.2 INSTALLATION OF EQUIPMENT CONNECTIONS

- A. Install electrical connections in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of installation" to ensure that products fulfill requirements.
- B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.
- C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.
- D. Cover splices with electrical insulating material equivalent to, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.
- E. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "nicking" copper conductors while skinning wire.
- F. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torque tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torque requirements are not available, tighten connectors and terminals to comply with torque values contained in UL 486A.
- H. Provide PVC-coated conduit and fittings for highly-corrosive atmospheres.
- I. Provide flexible conduit for motor connections, and other electrical equipment connections, where subject to movement and vibration.
- J. Provide liquid-tight flexible conduit for connection of motors and other electrical equipment where subject to movement and vibration, and also where connections are subjected to one or more of the following conditions:
 - 1. Exterior location.
 - 2. Moist or humid atmosphere where condensation can be expected to accumulate.
 - 3. Water spray.
 - 4. Dripping oil, grease, or water.
- K. Fasten identification markers to each electrical power supply wire/cable conductor which indicates their voltage, phase and feeder number in accordance with Division 26 section titled "Electrical Identification." Affix markers on each terminal conductor, as close as possible to the point of connection.
- L. Provide flexible metal conduit or Type "S" rubber cords, pigtails, caps, etc., as required to constitute an operating system. All flexible cords shall have a grounding conductor. Ground all equipment. See Section 16350 titled "Grounding and Bonding" for additional requirements.
- M. Prior to roughing-in, refer to all equipment manufacturer's shop drawings for details of equipment connections. Provide receptacles as required to match the cord caps on the equipment furnished. Provide either direct wiring or receptacles for final connection to equipment as required for the particular equipment furnished regardless of the type of outlet shown on the plans.

3.3 INSTALLATION OF FUSES

- A. Install fuses as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC, and NEMA standards for installation of fuses.
- B. Coordinate work including electrical wiring, as necessary, to interface installation of fuses with other trades.
- C. Install fuses in fused switches.

- D. Provide spare fuse cabinet located in each main switchgear room. Provide spare fuse of size and type for every five (5) fuses installed. A minimum of three (3) spare fuses shall be provided for each size installed.

3.4 GROUNDING

- A. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground for electrical disconnect switches.

3.5 FIELD QUALITY CONTROL

- A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION

SECTION 16350

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division-16 Basic Materials and Methods sections apply to work of this section.
- C. Requirements of this section apply to electrical grounding and bonding work specified elsewhere in these specifications.

1.2 SUMMARY

- A. Extent of electrical grounding and bonding work is indicated by drawings and schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.
- B. Type of electrical grounding and bonding work specified in this section includes the following:
 - 1. Solidly grounded.
- C. Applications of electrical grounding and bonding work in this section includes the following:
 - 1. Underground metal piping.
 - 2. Electrical power systems.
 - 3. Grounding electrodes.
 - 4. Separately derived systems.
 - 5. Raceways.
 - 6. Lighting Standards.
- D. Refer to other Division-16 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work; not work of this section.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on grounding and bonding products and associated accessories.

- B. Wiring Diagrams: Submit wiring diagrams for electrical grounding and bonding work which indicates layout of ground rods, location of system grounding electrode connections, routing of grounding electrode conductors, also include diagrams for circuits and equipment grounding connections.
- C. Submit ground riser diagram for entire project. Show bus bars with transformer ground electrode conductors, etc.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience on projects with electrical grounding work similar to that required for project.
- C. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.
 - 2. UL Compliance: Comply with applicable requirements of UL Standards No.'s 467, "Electrical Grounding and Bonding Equipment", and 869 "Electrical Service Equipment", pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are UL-listed and labeled for their intended usage.
 - 3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141 and 142 pertaining to grounding and bonding of systems, circuits and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials and Components:
 - 1. Provide electrical grounding and bonding system; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is installer's option. Where materials or components are not indicated provide products which

comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductors, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductors.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper 1/4 by 3 by 12 inches (6 by 76 by 300 mm) in cross section, unless otherwise indicated; with insulators.

2.3 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by Cadweld (or approved equal) manufacturer for materials being joined and installation conditions.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 – EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No.10 AWG and smaller, and stranded conductors for No.8 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned copper conductor, No.3/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements
- B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No.3/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits. The conduit shall not be acceptable as an equipment ground.

- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
- C. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 EXAMINATION

- A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.5 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS

- A. General: Install electrical grounding and bonding systems in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.
- B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.
- C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- E. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

- F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
 - 1. Install tinned-copper conductor not less than No.4/0 AWG for ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 24 inches (600 mm) from building foundation.
- I. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- J. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.
- K. Install all connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

3.6 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION

SECTION 16450

LIGHTING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including general and supplementary conditions and Division-1 Specification sections, apply to work of this section.
- B. Division-16 Basic Electrical Materials and Methods sections apply to work specified in this section.
- C. Refer to Appendix "A" for Light Fixture Cutsheets

1.2 SUMMARY

- A. Extent, Relative location, and details of lighting fixture work are indicated on drawings and in schedules. Refer to Civil Plans for precise fixture locations.
- B. Types of lighting fixtures in this section include the following:
 - 1. High-intensity-discharge (HID). Metal halide.
 - 2. Fluorescent.
 - 3. Incandescent and quartz.
 - 4. Light Emitting Diode, LED
 - 5. Other lamps as noted on fixture schedule.
- C. Fixture: A complete lighting unit Includes lamps, wiring, controls and parts required to securely support fixture.
- D. Installation details shall be verified and coordinated with fixture type and mounting prior to ordering.
 - 1. All materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this Specification shall be furnished by the Contractor.
 - 2. Fixtures shall be manufactured in strict conformance with the Contract Drawings and Specifications.
 - 3. Specifications and scale drawings are intended to convey the salient features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary of the work.

4. Minor details, not usually indicated on the drawings nor specified, but that are necessary for the proper execution and completion of the fixtures, shall be included, the same as if they were herein specified or indicated on the drawings.
 5. The Owner shall not be held responsible for the omission or absence of any detail, construction feature, etc., which may be required in the production of the fixtures. The responsibility of accurately fabricating the fixtures to the fulfillment of this specification rests with the Contractor.
- E. Where a catalog number and a narrative or pictorial description is provided, the written description shall take precedence and prevail.
- F. General Contractor shall provide electrical subcontractor with entire lighting specification (including fixture cut sheets, illustrations and sketches); electrical subcontractor shall provide each specified manufacturer with complete information about the fixtures they will supply.
- G. Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:
1. Cost to the Owner is reduced or equal.
 2. Fixture performance is equal or improved.
 3. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
 4. Modifications have been reviewed by the Architect and have been approved by the Architect in writing.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

1. Exterior Luminaire:
 - a. Basis of Measurement: Each.
 - b. Basis of Payment: Includes wood pole installation and base compaction, luminaire pole, luminaire with lamps and accessories and connection to power source.

1.4 SUBMITTALS

Submit shop drawings, samples, and prototypes as specifically instructed below.

- A. Shop drawings shall include but not be limited to:
1. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer which clearly show all elements to be supplied and all corresponding product data (including lamping; ballast manufacturer and model number; voltage; accessories or options and any miscellaneous items

- detailed in the written description of the specification). If cut sheet shows more than one (1) fixture type, all non-applicable information shall be crossed out.
2. For lamps, submit catalog cut sheets prepared by the manufacturer which clearly shows manufacturer, CRI, CT, wattage, base type, lumen output, lamp life, and any other pertinent information.
 3. The Architect/Engineer shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the fixture cut is insufficient.
 4. Maintenance Data: Submit maintenance data and parts list for each lighting fixture, accessory and also include "trouble-shooting" maintenance guide. In addition to the product data and shop drawings, a maintenance manual in accordance with general requirements of Division 1 shall be provided.
- B. Shop drawings and samples requested shall be submitted for approval before fabrication. Any material produced prior to the approval of shop drawings or samples, and not in conformance with the Contract Documents, shall be disapproved with the Contractor bearing full responsibility and cost.
- C. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on the drawings submitted for approval.
- D. Substitutions: Manufacturers or light fixtures not listed on fixture schedule must be prequalified prior to bid. For approval of all manufacturer/fixture substitutions, the bidders shall comply to specifications herein and as outlined below for submitting alternate fixtures:
1. Request for approval shall be accompanied by working fixture samples (with an appropriate lamp, complete photometric, mechanical and electrical data, list of materials and finishes and unit cost to the Owner) of both the specified brand and the proposed substitutes as required to make complete comparison and evaluation. These samples shall be in addition to those required by Lighting Fixture Specification. The above data shall be delivered separately to the Architect and the Engineer. The fixture samples shall be furnished and installed at the bidder's expense, at a location selected by the Architect. In addition, the bidder shall furnish the Architect and the Engineer with the name and location of at least one completed project where each proposed substitute has been in operation for a period of at least six (6) months, as well as the names and addresses of the Owner, the Architect and the Engineer.
 2. Point by point lighting calculations of areas affected by proposed substitution will be done by the bidder for review.

3. The Architect and Engineer shall determine whether the prototype sample complies with the specifications and shall reserve the right to disqualify any bidders.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience on projects with lighting fixture work similar to that required for this project.
- C. Codes and Standards:
 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 220, 225, 250, 410, and 500 as applicable to installation and construction of building lighting fixtures.
 2. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No's LE 1 and LE 2 pertaining to lighting equipment.
 3. IES Compliance: Comply with IES RP-1 pertaining to office lighting practices and RP-15, regarding selection of illuminance values for interior office lighting. Comply with IES RP-8, 19, 20, and PB-15 pertaining to exterior, parking, and roadway lighting practices and fixtures.
 4. UL Compliance: Comply with UL standards, including UL 486A and 486B, pertaining to lighting fixtures. Provide lighting fixtures and components which are UL-listed or ETL listed and labeled.
 5. CBM Labels: Provide fluorescent lamp ballasts which comply with Certified Ballast Manufacturer's Association standards and carry the CBM label.
- D. Special Listing and Labeling: Provide fixture for damp locations, wet locations, recessed in rated ceilings and walls, hazardous that are UL listed and labeled for specific use.
- E. Materials and Equipment:
 1. Materials, equipment, and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standards, and as specified and as indicated on drawings. Fixture parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the fixtures.
 2. All fixtures shall be manufactured to a consistent level of quality. Size, color, and component parts shall be identical for all fixtures of the same type.

1.6 DELIVERY, STORAGE, HANDLING, AND WARRANTY

- A. Deliver lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from damage.
- B. Store lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperature, humidity, laid flat and blocking off ground.
- C. Handle lighting fixtures carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.
- D. Provide a 5-year warranty of failure in materials, workmanship, ballast, etc., in addition to and not limited to other rights the Owner may have under the contract documents. A full warranty shall apply for the first year, and a prorated warranty for the last four years.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways to properly interface installation of lighting fixtures.
- B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The Contractor shall base bid for lighting fixtures on the manufacturers listed on the fixture schedule only.
- B. Alternate manufacturer's identification by means of manufacturer's names is to establish basic features and performance standards. Alternate manufacturer's or substitutions must meet or exceed the standards of the primary manufacturer listed.
- C. Qualifications: The contractor is allowed 60 days after the contract has been awarded to submit independent photometric tests and samples for all approved alternate fixtures. If these fixtures fail to comply with the specification requirements at that time, the Contractor will furnish acceptable fixtures at no additional cost to the Owner and with no delay to the project.

- D. Any submittals for cost reduction alternates or value engineering shall include unit prices for the specified manufacturer, the specified equal manufacturer, and the proposed alternates. Refer to Part 1.3 for approval process.

2.2 MATERIALS AND FABRICATION

- A. Provide thickness of metal required or as specified so that all fixture are rigid, stable and will resist deflection, twisting, warping or bending under normal installation procedures, loading, relamping, etc.
- B. Provide neoprene or silicone gasketing, stops, and barriers where required to prevent light leak or water and water vapor (penetration).
- C. Provide finished product with ground metal edges, tight fitting connections, hinges and closures; clean, neat edges, trims, and frames; continuous welds, ground smooth with sharp corners; all exposed screws countersunk flush.
- D. Provide positive, durable means of connection at all joints as required.
- E. All cast parts, including die-cast members, shall be of uniform quality, free from blow holes, pores, hard spots, shrinkage defects, cracks or other imperfections that affect strength and appearance or are indicative of inferior metals or alloys.
- F. Provide sufficient ventilation for lamps, ballasts and transformers including vent holes where required. Outdoor fixtures shall have corrosion resistant wire mesh screens in the vent holes.
- G. All adjustable fixtures shall be provided with reliable locking device to secure aiming angles of the fixture housing or lamp yoke as well as lamp and lens orientation devices to secure oval beam pattern lamps and/or spread lenses.

2.3 FINISHES

- A. Fixture finishes shall be applied in a manner that will assure a durable, wear resistant surface.
 - 1. Prior to finishing, all surfaces shall be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
 - 2. Where necessary, surfaces shall be hot cleaned by accepted chemical means and shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
 - 3. Provide all ferrous metal surfaces with a protective finish having rust-inhibiting properties. Painted finishes shall be a minimum of 1.5 mils thick and shall have a

balance between hardness and bending properties suitable for application. White finishes shall have 87 percent minimum reflectance. Application and cleaning shall be performed so as to prevent any loss of reflectance capability.

2.4 WIRING

- A. All wiring shall comply with the following:
 - 1. All wiring devices within lighting fixtures or from the fixture to the splice with the project branch circuit wiring shall be as specified below.
 - 2. Wiring shall be protected with tape or tubing at all points where abrasion may occur.
 - 3. Wiring shall be concealed within the fixture construction except where design or mounting dictates otherwise.
 - 4. Connections of wires to terminals of lampholders and other accessories shall be made in a neat and workmanlike manner and electrically and mechanically secure with no protruding or loose strands. The number of wires extending to or from the terminals of a lampholder or other accessory shall not exceed the number which the accessory is designed to accommodate.
 - 5. Joints in wiring within lighting fixtures and connections of the fixture wiring to the wiring of the building shall be specified in Division 16.
 - 6. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout, and all points or edges over which conductors must pass and may be subject to injury or wear shall be rounded and bushed.
 - 7. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.
 - 8. Junction boxes attached to lighting fixtures shall be manufactured in accordance with the National Electrical Code and approved for the number of conductors indicated on the drawings. Supplementary junction boxes shall be installed where required to comply with Code.

2.5 MARKING OF FIXTURES

- A. Fixtures designed for voltages other than 110-125 volts shall be marked with operating voltage.
- B. Fixtures equipped for operation of rapid start lamps shall be clearly marked "USE RAPID START LAMPS ONLY."
- C. Fixtures designed for operation of lamps below the rated enclosure maximum shall be clearly marked "Lamp Watts Not to Exceed _____" to maintain the design energy load.

2.6 LAMPS

- A. Provide lamps as shown in the fixture schedule or as modified in reviewed shop drawings.
- B. Lamps as specified for the individual luminaries or lighting equipment shall be delivered and installed in fixtures and lighting equipment leaving these completely lamped and in normal operating condition.
- C. High intensity discharge lamps, unless noted otherwise, shall be color corrected, phosphor coated, mogul base metal halide lamps. The mogul base color rendering index (CRI) shall not be less than 80 and a color shift not exceeding $\pm 400^\circ\text{K}$, unless otherwise specified. All medium base metal halide lamps to have a CRI of not less than 80 and color shift not exceeding $\pm 200^\circ\text{K}$. Refer to light fixture schedule for details.
- D. Lamps shall be by the same manufacturer and produced by the following acceptable manufacturers:
 - 1. General Electric Lighting
 - 2. Osram Sylvania, Inc.
 - 3. North American Philips Lighting
 - 4. Venture Lighting International, Inc.
 - 5. Others only where specified.

2.7 LAMPHOLDERS

- A. Lamp sockets shall be rigidly attached to fixture enclosure or housing.
- B. Incandescent and high intensity discharge lamp sockets shall be made of heavy duty heatresistant porcelain.
- C. Provide nickel plated brass or nickel and silver plated contacts in all lampholders for tungsten halogen lamps, lamps in outdoor fixtures, and mogul base incandescent, metal halide or mercury vapor lamps.
- D. All lamp sockets shall be suitable for the indicated lamps and shall be set so that lamps are positioned in optically correct relation to all lighting fixture components. All adjustable sockets shall be preset at the factory for lamp specified.

2.8 HIGH INTENSITY DISCHARGE LAMP BALLASTS

- A. All high intensity discharge lamp ballasts shall conform to the following:
 - 1. All ballasts for a particular lamp type shall be of the same manufacturer and where possible all ballasts on the projects be of the same manufacturer.

2. All ballasts shall be "Class P" indicating approved integral ballast protection. Fuses in the primary leads shall be provided in addition to the "Class P" ballast.
 3. All HID magnetic ballasts to be encapsulated and have maximum crest factor 1.6.
 4. All HID ballasts shall meet U.L. standards for "Class H" operations (180°C).
 5. U.L. and ANSI specifications with labels and/or symbols of approval by the U.L. and of certification by the Certified Ballast Manufacturers (C.B.M.) as tested by the E.T.L.
 6. The component parts shall be designed, fabricated, and assembled in accordance with the latest requirements of the N.E.C.
 7. Ballasts shall provide safe and reliable operation of the specified lamps.
 8. Approved Lamp/Ballast combinations should be used to allow for maximum energy efficiency, unless otherwise specified,
 9. Identical ballasts shall be installed within each fixture type.
 10. For HID fixtures specified with remote ballasts, the contractor shall verify and coordinate the maximum distance from lamp to ballast allowed.
 11. Fixture design, fabrication, and assembly shall be such as to prevent overheating or cycling of lamps and ballasts under normal operating temperature variations.
 12. Provide the lowest sound rating available for the lamps specified and clearly show their respective sound ratings. Ballasts found by the Architect or Engineer to be unduly noisy shall be replaced without charge prior to acceptance of the work.
 13. Ballasts intended for outdoor use shall have a minimum lamp starting temperature of 0°F, except as noted otherwise.
 14. Where ballasts are remote from fixture housing, provide suitable enclosure for installation with the conduit and wire from the ballast to the lamp socket clearly marked "Caution," "High Voltage." All remote ballasts to be installed within the recommended distance from the lamp socket as per the manufacturer with access plates for maintenance and on neoprene pads for sound absorption.
 15. Provide internal disconnecting means for ballast maintenance. Disconnecting means shall disconnect all conductors, including grounded conductor.
 16. Contractor to coordinate ballast line side voltage with branch circuit voltage as shown on Contract Drawings.
 17. Provide multitap ballasts (Mvolt) whenever offered by manufacturer.
- B. Ballasts manufactured by the following are acceptable:
1. Motorola/GE
 2. Advance
 3. Universal
 4. Osram Sylvania
 5. Approved Equal

2.9 REFLECTORS

- A. Reflectors and reflecting cones or baffles shall be as follows:
 - 1. Absolutely free of any tooling marks including spinning lines, indentations caused by riveting or other assembly techniques.
 - 2. No rivets, springs, or other hardware visible after installation.
 - 3. First quality polished, buffed and anodized finish, "Alzak" or approved equal.
 - 4. Specular finish color as selected by the Architect or as specified in the fixture schedule.
- B. Other aluminum reflectors shall be as follows:
 - 1. Formed and finished as noted on the Drawings and elsewhere in the Specification.
 - 2. Reflectors free from blemishes, scratches, or indentations which would distort their reflective function.
 - 3. Finished by means of the "Alzak" process or approved equal unless otherwise noted.

2.10 LENSES

- A. All lenses secured by positive means with neoprene or silicone gasketing or washers as required to hold the lens tight within a frame or attach to housing.
- B. All glass lenses shall be heat treated (tempered) or sealed with a clear acrylic laminate layer to provide a "safety glass" rating. All lenses which require removal for relamping or normal maintenance shall be attached to the fixture housing by a minimal length of safety chain to prohibit the lens from falling and striking surrounding surfaces.
- C. Acrylic lenses shall be 100 percent virgin acrylic polymer and colorless. For lenses with pattern of pyramids or cones, specified minimum thickness refers to distance from flat surface to base of pyramids (cones), or thickness of undisturbed material. All lenses shall be a minimum .156" thick.
- D. The quality of the raw acrylic material must exceed IES, SPI, and NEMA Specifications by at least 100 percent which, as a minimum standard, shall not exceed yellowness factor of 3 after 2,000 hours of exposure in the Fade-o-meter or as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years.

2.11 LIGHTING FIXTURE TYPES AND CATALOG NUMBERS

- A. General: Various fixtures types required are indicated on Lighting drawing Fixture Schedule. Fixtures must comply with minimum requirements as stated herein.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which lighting fixtures are to be installed. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF LIGHTING FIXTURES

- A. Contractor to coordinate exact quantities and critical dimension with field conditions.
- B. Contractor to verify and coordinate that appropriate framing, support structures, mounting brackets, and other required structural connections are provided by the General Contractor or other trades to insure a timely, correct and neat installation of all luminaries.
- C. Contractor to coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the luminaries. Provide each light fixture with complete installation instructions. All light fixtures to be installed in strict conformance with manufacturer's recommendations and instructions.
- D. Install lighting fixtures in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation," NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
- E. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on UL Stds. 486A and 486B and the National Electrical Code.
- F. Fasten electrical lighting fixtures and brackets securely to indicate structural supports, including poles/standards, and ensure that installed fixtures are plum and level.

3.3 FIELD QUALITY CONTROL

- A. Replace defective and burned out lamps for 3 months following the Date of Substantial Completion.
- B. At Date of Substantial Completion, replace lamps in lighting fixtures which have been operational over 400 hours and have a lamp life of less than 4,000 hours.
 - 1. Refer to Division-1 sections for the replacement/restoration of lamps in lighting fixtures, where used for temporary lighting prior to Date of Substantial Completion.
- C. Furnish stock or replacement lamps amounting to 5%, but not less than 4 lamps in each case, of each type and size lamp used in each type fixture. Deliver replacement stock as directed to Owner's storage space.

3.4 CLEANUP

- A. Clean lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses. Two weeks prior to substantial completion, re-clean all fixtures for dust, fingerprints, and smudges from all visible parts of the fixture.
- B. Protect installed fixtures from damage during remainder of construction period.
- C. At the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturers, all broken parts shall have been replaced, and all lamps shall be operative.

3.5 GROUNDING

- A. Provide equipment grounding connections for lighting fixtures as indicating. Tighten connections to comply with tightening torques specified in UL STD 486A to assure permanent and effective grounds.

3.6 DEMONSTRATION

- A. Upon completion of installation of lighting fixtures, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION

SECTION 16470

POLES AND STANDARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division – 16 Basic Electrical Materials and Methods sections apply to work specified in this section.

1.2 SUMMARY

- A. The section includes not limited erecting, trenching and installation of poles and standards.
- B. Applications of lighting poles and standards specified in this section include the following:
 - 1. Automobile parking lots.
 - 2. Pedestrian walkways.
- C. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 2 Section, “Earthwork” for excavation and backfilling of poles, standards, and foundations are specified in Division 2.
 - 2. Division 3 Section, “Concrete” for embedding poles, and for pole foundations.
 - 3. Wires/cables, raceways, and electrical boxes and fittings which are required in connection with electrical poles and standards are specified in Division-16.
 - 4. Exterior lighting fixtures (luminaries) and brackets which are required in connection with electrical poles and standards are specified in another Division-16 section, “Lighting Fixtures”.

1.3 SUBMITTALS

Submit shop drawings, samples, and prototypes as specifically instructed herein and as follows:

- A. Shop drawings shall include but not be limited to:
 - 1. Submit fixture shop drawings in booklet form with a separate sheet for each fixture, assembled in “luminaire type” alphabetical or numerical order, with proposed fixture and accessories clearly indicated on each sheet.
 - 2. Manufacturer’s dimensioned scale drawings showing in complete detail, the fabrication of all electrical pole standards, arms, and hardware including overall

and detail dimensions, finishes, metal thickness, type, fabrication methods, support method, ballasts, hinges, gaskets, wind loading, wire/cable connections, and all other information to show compliance with the Contract Documents.

- B. Wiring Diagrams: Submit wiring diagrams for electrical poles and standards showing connections to electrical power panel feeders, switches, and controllers. Differentiate between portions of electrical wiring which are manufacturer-installed and portions which are field-installed.
- C. Shop drawings and samples requested shall be submitted for approval before fabrication. Any material produced prior to the approval of shop drawings or samples, and not in conformance with the Contract Documents, shall be disapproved with the Contractor bearing full responsibility and cost.
- D. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on the drawings submitted for approval.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electrical poles and standards of types and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience with projects utilizing electrical pole and standard work similar to that required for this project.
- C. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirement of the authority having jurisdiction and NEC Articles 220, 225, 250, 410, and 501 as applicable to installation, and construction of electrical poles and standards.
 - 2. UL Compliance: Comply with UL standards, including UL 486A and 486B, pertaining to electrical poles and standards. Provide lighting components and fittings which are UL-listed and labeled.
 - 3. ANSI/ASTM Compliance: Comply with applicable requirements of ANSI C 2, "National Electrical Safety Code", pertaining to construction and installation of lighting poles and standards.
 - 4. ASHTO Compliance: Comply with applicable requirements of American Association of State Highway and Transportation Officials Standard LTS-1; "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals".
 - 5. NEMA Compliance: Comply with NEMA Stds Pub/No's. LE 2 and TT 1 pertaining to electrical pole and standard units, materials, and installation.

6. IES Compliance: Comply with applicable requirements of IES RP-8, “Roadway Lighting”, and RP-20, “Parking Facilities Lighting”.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver electrical pole and standard products, and fittings in factory-fabricated containers or wrapping, which properly protect products from damage.
- B. Store electrical pole and standard products and fittings in original cartons in wellventilated space protected from moisture, construction traffic and debris.
- C. Handle electrical pole and standard products carefully to prevent breakage, denting and scoring finish. Do not install damaged units or components; replace with new.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of electrical pole and standard work with other work.
- B. Sequence electrical pole and standard installation work with other work to minimize possibility of damage and soiling during remainder of construction period.

PART 2 – PRODUCTS

2.1 ELECTRICAL POLE STANDARDS

- A. Metal Lighting Standards: Provide metal, raceway-type, lighting poles and standards, of sizes and types shown on schedules, comprised of shafts and tenon joints. Equip with grounding connections readily accessible from handhole or transformer base access doors; and constructed of the following materials and additional construction features:
 1. Material: Cast aluminum - pedestrian lighting – unless otherwise shown.
 2. Configuration: Anchor base type with hand hole and cover where indicated.
 3. Configuration: Transformer base type with access door and cover.
 4. Metal Lighting Standard Accessories: Provide accessories for metal lighting standards, including anchor bolts, anchor bolt cover, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- B. Pole base shall be designed by a professional structural engineer licensed in the state of Colorado who is hired by the manufacturer to ensure pole base meets AASHTO requirements (i.e. 100 mph with a 1.3 gust factor).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which pole standard, equipment and components are to be installed, and substrate which will support equipment. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PARKING AREA LIGHTING

- A. Install pole and standard units and products in accordance with manufacturer's written instructions, applicable requirements of NEC, NESC and NEMA standards, and with recognized industry practices to ensure that roadway and parking area lighting equipment fulfill requirements.
- B. Utilize belt slings or rope (not chain or cable) to protect finishes when raising and setting finished poles and standards.
- C. Set poles and standards plumb. Support adequately during backfilling, or when anchoring them to the foundations.
- D. Provide sufficient space encompassing hand access and cable entrance holes for installation of underground cabling and conduit.
- E. Fasten electrical lighting fixtures and brackets securely to structural supports, including poles/standards; and ensure that installed fixtures are plum and level.
- F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B, and the National Electrical Code.

3.3 GROUNDING

- A. Provide equipment grounding connections for poles and standards. Provide a $\frac{3}{4}$ " x 10' copper rod at each pedestrian, parking lot and street lighting pole. Connect to a #6 bare copper ground wire. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounding.

END OF SECTION

SECTION 16781

CODE BLUE RADIO

PART 1 – GENERAL

1.1 RESPONSIBLE PARTY

- A. Communication Solutions & Associates Inc. is the preferred RF Integrator for the University of Colorado Colorado Springs. All questions or correspondence regarding the scope of work described within this document shall be directed to:

Communication Solutions & Associates
384 E. Garden of the Gods Road
Unit 140
Colorado Springs, CO 80907
719 578 8435
Doug@comsolwireless.net

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including general and supplementary conditions and Division-1 Specification sections, apply to work of this section.
- B. Requirements of the following Division 16 Sections apply to this Section:
1. “Electrical Requirements.”
 2. “Basic Material and Methods”
 3. “Raceway and Boxes”
 4. “Poles and Standards”

1.2 SUMMARY

- A. Extent, Relative location, and details of the code blue radio call box and work are indicated on drawings and in schedules. Refer to Civil Plans for precise fixture locations.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Exterior RF Radio Call Box:
1. Basis of Measurement: Each.
 2. Basis of Payment: Includes enclosure, RF Radio and any associated antenna, installation to wood lighting pole (pole not in scope), accessories and connection to power source, inclusive of power transformers at the unit.

1.4 SUBMITTALS

Contractor shall coordinate shop drawings with the RF Integrator as required for a complete installation.

- A. Shop drawings shall include but not be limited to:
 - 1. The Architect/Engineer shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the fixture cut is insufficient.
 - 2. Maintenance Data: Submit maintenance data and parts list for each call box, accessories and also include "trouble-shooting" maintenance guide. In addition to the product data and shop drawings, a maintenance manual in accordance with general requirements of Division 1 shall be provided.

1.5 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles.
- B. Materials and Equipment:
 - 1. Materials, equipment, and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standards, and as specified and as indicated on drawings. Parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the fixtures.

1.6 DELIVERY, STORAGE, HANDLING, AND WARRANTY

- A. Deliver products in factory-fabricated containers or wrappings, which properly protect product from damage.
- B. Store components in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperature, humidity, laid flat and blocking off ground.
- C. Provide a 5-year warranty of failure in materials, workmanship, etc., in addition to and not limited to other rights the Owner may have under the contract documents. A full warranty shall apply for the first year, and a prorated warranty for the last four years.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with other work including poles, wires/cables, electrical boxes and fittings, and raceways to properly interface installation of call box.

- B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

PART 2 - PRODUCTS

2.1 PRODUCT DESCRIPTION

- A. Product: Motorola AC/DC Powered ACB Call Box, **RRDN4368A**. – or approved equal.
- B. The unit shall be an easily identifiable, vandal resistant communications device that is Americans with Disabilities Act (ADA) compliant, multi-functional, wall or pole mounted and weather resistant for use in outdoor applications.

2.2 CONSTRUCTION

- A. The housing shall be fabricated of powder-coated aluminum. The unit shall be 14" W x 20" H x 7.5" deep. The faceplate shall be clear Lexan for direct access to call buttons. The bottom shall have a 3/4" diameter opening for power raceway connections. The back shall have four holes for the accommodation of mounting hardware.

2.3 MOUNTING

- A. The Integrator shall supply all necessary mounting hardware (straps, anchors, etc) to attach the unit to wood lighting poles (provided elsewhere in the contract documents).

2.4 ELECTRICAL

- A. All electrical components shall have a modular plug for easy service and replacement. All electrical wiring shall be concealed within the unit and shall not be visible from the outside of the unit.
- B. All electrical components in the unit shall be equipped with a fuse for protection from transient voltage conditions.
- C. The unit will be provided with 120V AC power and the integrator shall supply and install any required power transformers as necessary.

2.5 LIGHTS - ?? Does the client desire a Light?

- A. **Faceplate Light:** A LED Faceplate Light shall be mounted within the unit above the recessed opening which houses the communications device. This fixture will direct light onto the communications device and shall be vandal resistant.

2.6 COMMUNICATIONS

- A. The unit shall have a high quality vandal resistant and ADA compliant speakerphone communication device.
 - 1. RF interface with UCCS Campus Motorola Two-Way Radio system.

2.7 GRAPHICS

- A. The graphics shall be a durable reflective vinyl for high visibility and legibility.
- B. Standard 11" length graphics text offering shall be:
 - EMERGENCY
 - ASSISTANCE
 - SECURITY
 - COURTESY
 - POLICE
- C. Standard graphics color offering shall be:
 - Reflective Blue
 - Reflective Black
 - Reflective Green
 - Reflective Red
 - Reflective Yellow
- D. Custom graphics text, length and color shall be available by the manufacturer.

2.8 GENERAL OPTIONS

- A. The following optional equipment shall be available for the unit by the manufacturer. Please refer to the associated Architect and Engineering Specification:
 - Remote Mount Beacon/Strobe Kit
 - Pole Mount Kit

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which lighting fixtures are to be installed. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF LIGHTING FIXTURES

- A. Contractor to coordinate exact quantities and critical dimension with field conditions.

- B. Contractor to verify and coordinate that appropriate framing, support structures, mounting brackets, and other required structural connections are provided by the General Contractor or other trades to insure a timely, correct and neat installation of all luminaries.
- C. Contractor to coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the call box. Provide each call box with complete installation instructions.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on UL Std. 486A and 486B and the National Electrical Code.
- E. Fasten call box and brackets securely to indicate structural supports, including poles/standards, and ensure that installed fixtures are plum and level.

3.3 CLEANUP

- A. Clean call box of dirt and construction debris upon completion of installation.

3.4 DEMONSTRATION

- A. Upon completion of installation of call box, and after circuitry has been energized, demonstrate capability and compliance with existing Two-Way Radio system. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION

**UCCS ARENA PARKING LOT
ELECTRICAL SPECIFICATIONS
TABLE OF CONTENTS
DIVISION 16**

<u>DIVISION 16</u>	<u>DESCRIPTION</u>
SECTION 16010	ELECTRICAL REQUIREMENTS
SECTION 16050	IDENTIFICATION
SECTION 16100	BASIC MATERIAL AND METHODS
SECTION 16110	RACEWAY AND BOXES
SECTION 16120	ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 16140	WIRING DEVICES
SECTION 16210	PANELBOARDS
SECTION 16265	ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS
SECTION 16350	GROUNDING AND BONDING
SECTION 16450	LIGHTING FIXTURES
SECTION 16470	POLES AND STANDARDS
SECTION 16781	CODE BLUE RADIO

Page 1 of 1
SECTION 16010

ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Section supplements Division 1, General Requirements.
- B. Where contradictions occur between this Section and Division 1, the more stringent of the two shall apply. Owner shall decide which is most stringent.
- C. Provisions of Divisions 15 and 16 shall also apply to the work of this section as if fully repeated here.

1.2 REGULATORY REQUIREMENTS

- A. All materials shall conform with the current applicable industry standards. Workmanship and neat appearance shall be as important as electrical and mechanical operation. Defective or damaged materials shall be replaced or repaired prior to final acceptance in a manner meeting approval of the Engineer and at no additional cost to the Owner.
- B. The latest editions of the following standards are minimum requirements.
 - 1. Underwriters' Laboratories, Inc. (UL)
 - 2. National Electrical Manufacturer's Assoc. (NEMA)
 - 3. American National Standards Institute (ANSI)
 - 4. Institute of Electrical and Electronic Engineers (IEEE)
 - 5. International Electrical Testing Association (NETA)

6. Insulated Cable Engineer's Association (ICEA)
- C. All work and materials shall comply with latest rules, codes and regulations including, but not limited to the following:
 1. OSHA.
 2. National Fire Codes of National Fire Protection Assoc. (NFPA) 3.
National Electrical Safety Code (NESC, ANSI C2)
 4. National Electrical Code (2011 Edition).
 5. International Building Code Building Code (2009 Edition).
 6. Americans With Disabilities Act (ADA).
 7. All applicable Federal, state and local laws, code amendments and regulations.
- D. Code compliance is mandatory. Nothing in these drawings and specifications permits work not conforming to these codes.
- E. No work shall be concealed until after inspection and approval by proper authorities. If work is concealed without inspection and approval, Contractor shall be responsible for all work required to open and restore the concealed area including all required modifications.
- F. Contradictions: Where Codes are contradictory, follow the most stringent. Engineer(s) shall determine which is most stringent.

1.3 CONTRACT DOCUMENTS

- A. Drawings indicate general arrangement of circuits and locations of outlets, conduit, and other work. Information shown on drawings is as accurate as planning can determine, but not guaranteed and field verification of all dimensions, locations, levels, etc., to suit field conditions is directed. Review all contract drawings, and adjust all work to conform to all conditions shown therein. Civil drawings shall take precedence over all other drawings. Discrepancies between different drawings or between drawings and specifications or regulations and codes governing installation shall be brought to attention of the Civil Engineer.
- B. Where the Drawings and Specifications do not comply with the minimum requirements of the Codes, either notify the Engineer(s) in writing during the Bidding Period of the revisions required to meet Code requirements, or provide an installation which complies with the Code requirements. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.
- C. Follow Drawings and Specifications where they are superior to Code requirements. The more stringent of plans and drawing shall apply.

1.4 COORDINATION DRAWINGS

- A. Prepare coordination drawings in accordance with Division 1 "Submittals" to a scale of $\frac{1}{4}" = 1'-0"$ or larger; detailing major elements, components, and systems of electrical

equipment (i.e., all transformers and electrical enclosures) and materials in relationship with other systems, installations, and building components. Where equipment is located outdoors, prepare shop drawings indicating electrical equipment locations and exterior elements in the equipment areas. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are important to the efficient flow of the work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, and materials.
Include the following:
 - a. Support details.
 - b. Sizes and location of required concrete pads and bases.
2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
3. Underground conduit and duct bank routing.

1.5 RECORD DRAWINGS

- A. Refer to Division 1 for additional requirements.
- B. Maintain a blue-line set of Electrical Contract Drawings in clean, undamaged condition, for mark-up of installations which vary from the Contract Drawings. These drawings shall be a separate set of drawings, not used for construction purposes, and shall be kept up to date as the job progresses. This set shall be made available for inspection by the Engineer(s) at all times. Upon completion of the contract a set of computerized "as built" capable of interfacing with AutoCAD software, shall be delivered to the Owner.
- C. Prepare record documents in accordance with the requirements in Division 1 Section "Project Closeout." In addition to the requirements specified in Division 1, indicate installed conditions for:
 1. Major raceway systems, size and location, locations of handholes and conduit stub-up locations.
 2. Panelboard circuit directories reflecting all field changes.
 3. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 4. Results of all testing performed as specified in the specification.
 5. Certification of inspection from Authorities Having Jurisdiction.
- D. Record the locations and invert elevations of underground installations.

1.6 OPERATING AND MAINTENANCE MANUALS

- A. Refer to Division 1 for additional requirements.
- B. Submission:
 1. Submit three typed and bound copies of Operating and Maintenance Manuals prior to scheduling systems demonstration for the Owner.
 2. Bind each Maintenance Manual in one or more vinyl covered, 3-ring binders, with pockets for folded drawings.

- a. Mark the back spine of each binder with system identification and volume number.
- C. Requirement Contents:
 - 1. Manuals shall have index with tab dividers for each submittal section identifying all equipment and materials installed on the project including a local supplier for replacing a specific piece of equipment.
 - 2. Provide certificates for such items of equipment which have warranties in excess of one year.
 - 3. Provide test results for each specification section identified herein.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- B. Protection of Equipment:
 - 1. All electrical equipment to be used in the construction shall be properly stored and protected against the elements. All equipment shall be stored under cover, and shall not be stored at the construction site on the ground, in mud, water, rain, sleet, or dust. Large diameter cables may be stored on reels outside; however, all cable ends shall be waterproofed and the reels covered with weatherproof materials. Such weatherproof materials shall be heavy-duty, securely fastened, and made impervious to the elements.
 - 2. Conventional electrical construction materials such as building wire, outlet and junction boxes, wiring devices, conduit, lighting fixtures, fittings, etc., shall be stored in construction buildings, covered trailers, or portable covered warehouses. Any equipment subject to damage or corrosion from excessive moisture shall be stored in dry, heated areas. Any equipment containing plastic or material subject to damage caused by excessive heat or sunlight shall be stored to prevent such damage. This includes plastic ducts and lenses.
 - 3. Equipment damaged as a result of the above conditions shall be properly repaired at the contractor's expense or shall be replaced at the contractor's expense, if in the opinion of the Engineer, the equipment has been damaged to such an extent that it cannot operate properly after repairs are made.
 - 4. All electrical enclosures exposed to construction damaged such as paint spots, spackling or plaster spatter, grout splashes, waterproofing compound, tar spots or runs, and pipe covering compound splashes, shall be completely covered and protected against damage.
 - 5. In the event leakage into the building of any foreign material or fluid occurs or may occur, the contractor shall take all steps as described above to protect any and all equipment.
 - 6. After connections to electrical equipment are complete and the equipment is ready for operation, all construction debris shall be removed from all enclosures. Such debris includes dust, dirt, wire clippings, tape, and insulation removed in order to make the connection.

1.8 SAFETY AND INDEMNITY

- A. The Contractor shall be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. See also General Conditions.
- B. No act, service, drawings review or construction review by the Engineer(s), is intended to include review of the adequacy of the Contractor's safety measures in, on, or near the construction site.

1.9 WARRANTIES

- A. The warranty period is generally one year after Date of Acceptance.
 - 1. During this period, provide labor and materials as required to repair or replace defects in the electrical systems at no cost to the Owner. Provide certificate with O & M manual submittal which guarantees same day service response to the Owner's call for such warranty service.
 - 2. Provide certificates for such items of equipment which have warranties in excess of one year. Insert copies of O & M manual. Such equipment shall include:
 - a. Major electrical switchgear and switchboard
 - b. Lighting fixtures
 - 3. Provide extended manufacturers warranties to cover one full year from Date of Acceptance if standard manufacturers' warranty ends any time prior to that date.

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. All equipment and materials installed shall be new, unless otherwise specified.
- B. All major equipment components shall have manufacturers' name, address, model number and serial number permanently attached in a conspicuous location.
- C. All equipment shall be UL listed and bear the UL label.

2.2 GENERAL SUBMITTAL REQUIREMENTS

- A. Coordination and Sequencing:
 - 1. After receipt of notice to proceed, the Contractor shall submit to the Engineer a typed list of submittals and the scheduled date of submission. List shall include submittal number, section number and scheduled date of submission. Submittals shall be grouped and submitted in no more than ten complete packages.
 - 2. The contractor shall not submit any shop drawings or product data that does not comply with the contract documents. Prior to submitting shop drawings, review submittal for compliance with Contract Documents and place a stamp or other confirmation thereon which states that submittals have been reviewed.

Submittals without such verification will be returned disapproved without review.

3. Submittal is for information and record, unless otherwise indicated, and is not a change order request.

B. Preparation of Submittals:

1. Refer to Division 1 requirements.
2. The Contractor shall submit for approval by the Engineer data of materials and equipment to be incorporated in the work. Submittals shall be supported by descriptive material, catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Provide complete electrical characteristics for all equipment. Submit product submittals on items as outlined in sections hereinafter.
3. Product submittals shall be made by specification section. All items of a section, requiring submission, shall be submitted together at one time in a tabbed binder. If two or more sections require inter-coordination (e.g., emergency generator and transfer switch; short circuit study, electrical room layouts and electrical switchboards, fire alarm and fire command center layout), they shall be submitted at the same time.
4. Each individual submittal item shall be organized electronically and noted to show specific section number(s) pertaining to the item.
5. Provide the following within each electronic file: Project name, Contractor, Subcontractor, submittal name, date of submission, specification section, and information to distinguish it from other submittals.
6. Submittals not presented in a neat and legible fashion will returned "Without Action."
7. Submittals shall show Contractor's executed review and approval marking. Submittals which are received from sources other than through Contractor's office will be returned "Without Action."
8. Provide space for Engineer's "Action" marking.

C. Substitutions

1. Refer to the General Conditions, which governs "Substitution" of specified equipment or materials.
2. Indicate any portions of work which deviate from the Contract Documents.
 - a. Explain the reasons for the deviations.
 - b. Show how such deviations coordinate with interfacing portions of other work.
3. Where substitution of materials alters space requirements indicated on the drawings, submit shop drawings indicating proposed layout of space, all equipment to be installed therein and clearances between equipment (i.e., electrical rooms). All clearances required by the National Electrical Code and applicable state and local regulations must be maintained.

D. Review Process

1. The Engineer reserves the right to require a sample of any equipment to be submitted for approval and to retain its possession.

Refer to the individual sections for identified equipment and material for which submittals are required. In addition, provide shop drawings and product data on the following equipment:

Electrical Power Conductors and Cables
Raceway and Boxes
Cable Trays
Underground Duct, Raceway & Manholes
Panelboards
Lighting Fixtures
Poles and Standards
Enclosed Switches and Circuit Breakers

Do not submit on equipment or materials not requested in the specifications.

2. Review of shop drawings and product data by the Engineer(s), including any review annotations or stamp notations, does not relieve the contractor from the required compliance with the contract documents.
3. The shop drawing and product data review stamp notation requirements are defined as follows:
 - a. “NO EXCEPTION TAKEN:” The reviewer did not observe any items which were not in compliance with the contract documents. All dimensions, details, and coordination with other trades is the responsibility of the contractor.
 - b. “MAKE CORRECTIONS NOTED:” The reviewer indicated items observed that were not in compliance with the contract documents. The contractor shall not resubmit, but shall make corrections and provide corrected documents with the “Record Drawings.”
 - c. “REJECTED, REVISE AND RESUBMIT:” The reviewer indicated items observed which were not in compliance with the contract documents. The contractor shall resubmit showing corrections of all noted items. Delays for resubmittal does not relieve the contractor from meeting project schedules.
 - d. “REJECTED:” The submission does not comply with the contract requirements. The entire submittal must be corrected and submitted for review. Delays for resubmittal does not relieve the contractor from meeting project schedules.
4. If shop drawings are submitted and returned as “NO EXCEPTION TAKEN” or “MAKE CORRECTIONS NOTED” and meet contract requirements, the contractor shall not resubmit any other shop drawings for these items.
5. If resubmittals are necessary, they shall be made as specified above for submittals. Resubmittals shall highlight all revisions made and cover shall include the phrase “RESUBMITTAL NO. _____.”

Resubmittal requirements do not entitle the Contractor to additional time and are not a cause for delay of the project.

PART 3 – EXECUTION

3.1 CONDITIONS AT SITE

- A. Visit to site is required of all bidders prior to submission of bid. All bidders will be held to have familiarized themselves with all discernible conditions, and no extra payment will be allowed for work required because of these conditions, whether specifically mentioned or not.
- B. Lines of other services and/or equipment that are damaged as a result of this work shall promptly be repaired at no expense to the Owner.

3.2 LICENSES, FEES AND PERMITS

- A. Arrange for required inspections and pay all license, permit and inspection fees. Furnish a certificate of final inspections and approvals from local authority having jurisdiction over electrical installation.

3.3 WORKMANSHIP AND CONTRACTOR'S QUALIFICATIONS

- A. Only professional quality workmanship will be accepted. Haphazard or poor installation practice will be cause for rejection of work.
- B. Provide foreman in charge of this work at all times. Foremen for this work shall have had experience in installing not less than 5 such electrical systems of equal or greater complexity.
- C. Where specifications call for an installation to be made in accordance with manufacturers' recommendations, a copy of such recommendations shall at all times be kept in job superintendent's office.

3.4 RELATION WITH OTHER TRADES

- A. Contractor shall coordinate work of this Division with other trades to avoid conflict and to provide rough-ins and other connections for equipment furnished under other divisions that require electrical connections. Inform other trades of required clearances of accesses for or around electrical equipment to maintain serviceability and code compliance.
- B. Verify equipment dimensions and rough-in requirements for Divisions 2 through 16 with provisions specified under this Section of work, and report discrepancies to the Engineer in ample time to prevent delays or unwarranted changes of work.

3.5 TESTING

- A. Provide all labor, materials, and equipment necessary to make required tests. Tests shall be complete and results approved before final inspection is begun.

3.6 PROGRESS OF WORK

- A. Order progress of electrical work so as to conform to progress of work of other trades, and complete entire installation as soon as condition of building will permit. Assume any cost resulting from defective or ill-timed work performed under this Division.

3.7 EXCAVATION, TRENCHING, AND BACKFILLING

- A. Perform all excavation to install conduit and duct banks indicated on the drawings or specified herein. During excavation, pile material for backfilling back from the banks of the trench to avoid overloading and to prevent slides and cave-ins. Remove and dispose of all excavated materials not to be used for backfill. Grade to prevent surface water from flowing into trenches and excavation. Remove any water accumulating therein by pumping. Do all excavation by open cut. No tunneling shall be done unless indicated on the drawings or unless written permission is received from the Engineer.
- B. Grade the bottom of trenches to provide uniform bearing and support for conduits or duct bank on undisturbed soil at every point along its entire length. Tamp over depths with loose, granular, moist earth. Remove unstable soil that is not capable of supporting equipment or installation and replace with specified material for a minimum of 12" below invert of equipment or installation.
- C. Backfill the trenches with excavated materials approved for backfilling, consisting of earth, loam, sandy clay, sand and gravel or soft shale. These materials should be free from large clods of earth and stones, deposited in 6" layers and rammed until the installation has cover of not less than the adjacent ground but not greater than 2" above existing ground. Backfilling shall be carried on simultaneously on both sides of the trench so that injurious pressures do not occur. Compaction of the filled trench shall be at least equal to that of the surrounding undisturbed material. Do not settle backfill with water. Reopen any trenches not meeting compaction requirements or where settlement occurs, refill, compact, and restore surface to grade and compaction indicated on the drawings, mounded over and smoothed off.
- D. In addition, all excavation and backfilling shall comply with Division 2. The most stringent requirement shall apply.

3.8 CLEANUP

- A. Remove all materials, scrap, etc., relative to electrical installations and leave premises in a clean, orderly condition. Any costs to the Owner for cleanup of site will be charged to the Contractor. At completion, all equipment, raceways, etc., shall be thoroughly cleaned and all residue removed from the inside and outside surfaces. Defaced finish shall be refinished.

3.9 MINOR CHANGES

- A. The Owner reserves the right to make minor changes in the locations of outlets and equipment up to the time of electrical rough-in without any cost to the Owner.

3.10 ELECTRICAL SYSTEMS OPERATIONAL TESTS, CERTIFICATION, AND DESIGN
AUTHORITY ASSISTANCE

- A. Testing
 - 1. Refer to the individual specification sections for test requirements.
 - 2. Prior to the final inspection, the systems or equipment shall be tested and reported as herein specified. Six (1) electronic typewritten copy of the tests shall be submitted to the Engineer(s) for approval.
 - 3. All electrical systems shall be tested for compliance with the specifications.
- B. Manufacturers' Certifications
 - 1. The electrical systems specified herein shall be reviewed for compliance with these specifications, installation in accordance with the manufacturers' recommendations and system operation by a representative of the manufacturer. The manufacturer shall submit certification that the system has been installed in accordance with the manufacturers' recommendations and is operating as specified in the contract documents.
- C. Design Authority Assistance
 - 1. The Contractor shall provide personnel to assist the Engineer(s) or his representative during all construction review visits. The Contractor shall provide all necessary tools and equipment to demonstrate the system operation and provide access to equipment, including screwdrivers, wrenches, ladders, flashlights, circuit testing devices, meters, keys, etc.
 - 2. Remove equipment covers (i.e., panelboard trims, panelboards, and junction box covers) as directed for inspection of internal wiring. Reinstall all covers after inspection.
 - 3. Energize and de-energize circuits and equipment as directed. Demonstrate operation of equipment as directed by Engineer(s).
 - 4. The Contractor shall provide authorized representatives of the manufacturers to demonstrate to the Engineer(s) compliance with the specifications of their respective system during or prior to the final inspection at a time designated by the Engineer. Refer to the appropriate specification section for additional testing requirements. Representatives of the emergency generator/automatic transfer switch and fire alarm systems are required for demonstrations.

END OF SECTION

SECTION 16050 IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this Section:
 - 1. "Electrical Requirements."

1.2 SUMMARY

- A. This Section includes identification of electrical materials, equipment, and installations. It includes requirements for electrical identification components including but not limited to the following:
 - 1. Buried electrical line warnings.
 - 2. Identification labeling for raceways, cables, and conductors.
 - 3. Operational instruction signs.
 - 4. Warning and caution signs.
 - 5. Equipment labels and signs.
- B. Related Sections: The following Sections contain requirements that relate to this Section;
 - 1. Division 16 Section "Wires and Cables" for requirements for color coding of conductors for phase identification.
- C. Refer to other Division 16 Sections for additional specific electrical identification associated with specific items.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product Data for each type of product specified.
- C. Schedule of identification nomenclature to be used for identification signs and labels.
- D. Samples of engraved, plastic laminate to be used on switchgear, switchboards, disconnect switches and panelboards.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. ANSI Compliance: Comply with requirements of ANSI Standard A13.1, "Scheme for the identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

PART 2 - PRODUCTS

2.1 ELECTRICAL IDENTIFICATION PRODUCTS

- A. Colored Adhesive Marking Tape for Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mil thick by 1 inch to 2 inches in width.
- B. Underground Line Marking Tape: Permanent, bright-colored, continuous-printed, plastic tape with magnetic tracer strip not less than 6 inches wide by 4 mil thick. Printed legend indicative of general type of underground line below.
- C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wrap around, cable/conductor markers with preprinted numbers and letters.
- D. Engraved, Plastic-Laminated Labels, Signs, and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for sign up to 20 square inches, or 8 inches in length; 1/8-inch thick for larger sizes. Engraved legend in black letters on white face for normal power and red letters on white face for emergency and standby power. Plastic laminate shall be punched for mechanical fasteners.
- E. Exterior Metal-Backed Butyrate Warning and Caution Signs: Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gage, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide 1/4-inch grommets in corners for mounting.
- F. Fasteners for Plastic-Laminated and Metal Signs: Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.
- G. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from minus 50°F to 350°F. Provide ties in specified colors when used for color coding.

- H. Electronic Labels: Self-adhesive, 3/16 inch industrial label, black on clear for normal circuits and red on clear for emergency/standby circuits. Acceptable manufacturers include the following:
 - 1. Kroy
 - 2. Brother

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.
- B. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC.
- C. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

3.2 CONDUIT IDENTIFICATION

- A. Identify Junction, Pull, and Connection Boxes: Code-required caution sign for boxes shall be pressure-sensitive, self-adhesive label indicating system voltage in black, preprinted on orange background. Install on outside of box cover. Also label box covers with identity of contained circuits. Use pressure-sensitive plastic labels at exposed locations and similar labels at concealed boxes.
- B. Underground Electrical Line Identification: During trench backfilling, for underground power, signal, and communications lines, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines installed in a common trench or concrete envelope do not exceed an overall width of 16 inches; install a single line marker.
- C. Install line marker for underground wiring, both direct-buried and in raceway.
- D. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
- E. Conductor Color Coding: Provide color coding for secondary service, feeder, and branch circuit conductors throughout the project secondary electrical system as follows:

240/120 Volts

Phase

Black		A
Red	B White	Neutral
Green		Ground

- F. Use conductors with color factory-applied the entire length of the conductors except as follows:
1. The following field-applied color-coding methods may be used in lieu of factory-coded wire for sizes larger than No. 10 AWG:
 - a. Apply colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Use 1-inch-wide tape in colors as specified. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.
 - b. In lieu of pressure-sensitive tape, colored cable ties may be used for color identification. Apply three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten for snug fit, and cut off excess length.
 2. All grounded conductors No. 6 AWG and smaller shall be a factory applied color across the entire length of conductors.
- G. Power Circuit Identification:
1. Securely fasten wrap-around marker bands to cables, feeders, and power circuits in pull boxes and junction boxes.
- H. Apply warning, caution, and instruction signs and stencils as follows:
1. Install warning, caution, or instruction signs where required by NEC where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
 2. Emergency Operating Signs: Install engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
- I. Install equipment/system circuit/device identification as follows:
1. Apply equipment identification labels of engraved plastic-laminate on each major unit for electrical equipment. This includes communication/signal/alarm system, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 3/8-inch-high lettering on 1 1/2-inch-high label (2-inch-high where two lines are required), black lettering in white field for normal power and red lettering on white field for emergency and standby power. Text shall match terminology and numbering of the Contract

Documents and shop drawings. Apply labels for each unit of the following categories of electrical equipment:

- a. Panelboards, electrical cabinets, and enclosures.
2. Apply electronic label on the inside of all receptacle and switch plates. The labels shall identify circuit and panelboard.

END OF SECTION

SECTION 16100

BASIC MATERIAL AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. This Section supplements Division 1, General Requirements.

1.2 DESCRIPTION OF WORK

- A. Work included in this section consists of conduits, wires and other miscellaneous materials not specifically mentioned in other sections of Division 16 but necessary or required for equipment or system operation or function, and the labor to install them.

1.3 SUBMITTALS

- A. Materials list with manufacturer, style, series or model identified.
- B. Manufacturer's descriptive literature and/or sample if requested by the Engineer(s).

PART 2 - PRODUCTS

2.1 CONDUIT RACEWAYS: Refer to Section 16110.

2.2 ELECTRICAL POWER CONDUCTORS AND CABLES: Refer to Section 16120.

2.3 WIRING DEVICES: Refer to Section 16140.

2.4 OUTLET BOXES, JUNCTION AND PULL BOXES

- A. Outlet Boxes: Hot-dipped galvanized or sherardized of required size, 4" square minimum, for flush mounted devices and lighting fixtures. Cast-type FD with gasketed covers for surface-mounted devices.
- B. Junction and Pull Boxes: Use outlet boxes as junction boxes wherever possible. Larger junction and pull boxes shall be fabricated from sheet steel, sized according to code, with screw-on covers, galvanized where required for outdoor exposure.
- C. All exterior boxes shall be cast, gasketed, weatherproof type with cast covers.

- D. Refer to Section 16110 for additional requirements.

2.5 WIRE CONNECTORS

- A. For wires that are #8 AWG and smaller: Insulated pressure type with live spring, rated 105°C, 600 volt, for building wiring and 1000 volt in signs or fixtures.
- B. For wires that are #6 AWG and larger: Compression type with 3M #33 or equal tape insulation.

2.6 FUSES: Refer to Section 16265.

2.7 EQUIPMENT MOUNTING AND SUPPORT HARDWARE

- A. Steel channels, bolts and washers, used for mounting or support of electrical equipment shall be galvanized typed. Where installed in corrosive atmosphere, stainless steel type hardware shall be used.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide complete raceway systems for all conductors including control wiring and low voltage wiring unless otherwise noted.
- B. Electrical system layouts indicated on drawings are generally diagrammatic, but shall be followed as closely as actual construction and work of other trades will permit. Govern exact routing of raceways and locations of outlets by structure and equipment served.
- C. All home runs to panelboards are indicated as starting from the outlet nearest to the panel and continuing in the general direction of that panel. Continue such circuits to panel as though routes were completely indicated.
- D. Furnish and install all necessary hardware, blocking, brackets, bracing, runners, etc., required for equipment specified under this Section.

3.2 RACEWAYS: Refer to Section 16110.

3.3 OUTLETS

- A. Verify final location of all outlets, panels, equipment, etc., with the Engineer(s).
- B. Provide zinc-coated or cadmium-plated sheet steel outlet boxes not less than 4" octagonal or square, unless otherwise noted. Equip fixture outlet boxes with 3/8" no-bolt fixture studs.

- C. Surface-mounted devices are to be mounted in cast type boxes with gasketed covers: (Crouse-Hinds condulets or equal).
- D. Confirm final location and heights of all outlets, with Engineer(s) prior to installation.
- E. Refer to Section 16110 for additional requirements.

3.4 JUNCTION PULL BOXES

- A. Construct junction or pull boxes not over 150 cubic inches in size shall be standard outlet boxes, and those over 150 cubic inches shall be constructed the same as "Cabinets," with screw covers of same gauge metal. Removal covers must be accessible at all times.

END OF SECTION

SECTION 16110

RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.
- B. Requirements of the following Division 16 Sections apply to this Section:
 - 1. "Electrical Requirements."
 - 2. "Basic Material and Methods"

1.2 SUMMARY

- A. Drawings are diagrammatic. All bends, boxes, fittings, couplings are not necessarily shown. Supply as necessary to comply with the National Electric Code.
- B. This Section includes raceways for electrical wiring. Types of raceways, boxes and fittings in this section include the following:
 - 1. Electrical metallic tubing (EMT).
 - 2. Flexible metal conduit.
 - 3. Intermediate metal conduit (IMC).
 - 4. Liquid-tight flexible conduit.
 - 5. Rigid metallic conduit (RMC).
 - 6. Metal clad cable (MC).
 - 7. Surface raceways.
 - 8. Rigid non-metallic conduit.
 - 9. Electrical non-metallic tubing (ENT) 10. Wireway.
 - 11. Outlet boxes.
 - 12. Junction boxes.
 - 13. Pull boxes.
 - 14. Bushings.
 - 15. Locknuts.
 - 16. Knockout closures.
- C. Related Sections: The following section contains requirements that relate to this section:
 - 1. Division 16 Section "Raceway and Boxes" for conduit connectors, fittings, and couplings.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of contract and Division 1 Specification Section.
- B. Product Data for the following products:
 - 1. Raceways and fittings.
 - 2. Wireways and fittings.
 - 3. Boxes and fittings.
- C. Installation Instructions: Manufacturer's written installation instructions for wireway, surface raceway, and nonmetallic raceway products.

1.4 QUALITY ASSURANCE

- A. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- B. NEMA Compliance: Comply with applicable requirements of NEMA standards pertaining to raceways.
- C. UL Compliance and Labeling: Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL.
- D. Manufacturers: Firms regularly engaged in manufacture of electrical boxes and fittings, of types, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than five years.
- E. Installer's Qualifications: Firms with at least five years of successful installation experience on projects utilizing electrical boxes and fittings similar to those required for this project.
- F. NEC Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.
- G. UL Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.
- H. NEMA Compliance: Comply with applicable requirements of NEMA Stds/Pub No.'s OS1, OS2 and PUB 250 pertaining to outlet and device boxes, covers and box supports.
- I. Federal Specification Compliance: Comply with applicable requirements of FS W-C 586, "Electrical Cast Metal Conduit Outlet Boxes, Bodies, and Entrance Caps."

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Rigid Steel Conduit: ANSI C80.1
- B. Intermediate Steel Conduit: UL 1242.
- C. Electrical Metallic Tubing and Fittings: ANSI C80.3.
- D. Flexible Metal Conduit: UL 1, zinc-coated steel.
- E. Liquid-tight Flexible Metal Conduit and Fittings: UL 360.

2.2 METAL CLAD CABLE, TYPE MC

- A. The multi-conductor metal clad cable shall comply with UL 1569 "Metal Clad, Type MC," UL 83 "Thermoplastic Insulated Wires and Cables" Federal Specification J-C-30B "Wire and Cable," Local and National Electrical Codes.
- B. The metal clad cable shall be THHN insulation, copper conductors in sizes #12 through #8 AWG only for continuous operation at a maximum conductor temperature of 90 degree C dry.
- C. These cables shall bear appropriate Underwriters Laboratories labels for metal clad cable and be suitable for use as branch circuits in both exposed and concealed work in accordance with applicable sections of the National Electrical Code.
- D. An insulated grounding conductor sized in accordance with Table 5.3 Underwriter's Standard UL 1569 shall be cabled with the circuit conductors and shall be identified in compliance with Section 29 of UL 1569. The grounding conductor shall not be smaller than size indicated in NEC Article Table 250.122.
- E. A galvanized steel or aluminum armor shall be applied over the inner cable assembly with a positive interlock in compliance with Section 10 of UL 1569. A PVC jacket shall completely cover the steel or aluminum armor when installed in the slab.

2.3 NONMETALLIC CONDUIT AND DUCTS

- A. Rigid Nonmetallic Conduit (RNC): NEMA TC 2 and UL 651, Schedule 40 or 80 PVC.
- B. PVC Conduit and Tubing Fittings: NEMA TC 3; match to conduit or conduit/tubing type and material.

- C. Conduit, Tubing and Duct Accessories: Types, sizes and materials complying with manufacturer's published product information. Mate and match accessories with raceway.
- D. Electrical non-metallic tubing (ENT): NEMA TC13 and UL1653.

2.4 CONDUIT BODIES AND FITTINGS

- A. General: Types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion-resistant screws.
- B. Metallic Conduit and Tubing: Use metallic conduit bodies. Use bodies with threaded hubs for threaded raceways.
- C. EMT Conduit Bodies 1 Inch and Smaller: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.
- D. EMT Conduit Bodies 1 Inch and Larger: Use bodies with steel set screw connectors and couplings for interior applications and steel compression gland connectors and couplings for exterior applications.
- E. Nonmetallic Conduit and Tubing: Use nonmetallic conduit bodies conforming to UL514B.
- F. Liquid-Tight Flexible Conduit Fittings: With threaded grounding cone, a steel, nylon or equal plastic compression ring, and a gland for tightening. Either steel or malleable iron only with insulated throats and male thread and locknut or male bushing with or without O-ring seal. Each connector shall provide a low resistance ground connection between the flexible conduit and the outlet box, conduit or other equipment to which it is connected.
- G. Bushings: Insulated type, designed to prevent abrasion of wires without impairing the continuity of the conduit grounding system, for rigid steel conduit, IMC and EMT, larger than $\frac{3}{4}$ " size.
- H. Expansion Fittings: Each conduit that is buried in or secured to the buildings construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subject to excessive stresses shall be provided with an expansion fitting. Expansion fittings for rigid steel conduit shall be hot-dipped galvanized malleable iron with factory installed packing and a grounding ring. Expansion fittings for rigid nonmetallic conduit shall be of the short type in runs 25' or less, and the long type in runs 26' to 80'. The long type shall be a two piece barrel and piston joint, providing 6" of the total movement range in $\frac{3}{4}$ " through 6" conduit sizes. The short type shall be a one piece, coupling with O-ring, providing 2" of total movement range in $\frac{3}{4}$ " to 2" conduit sizes.

- I. Seal Off Fittings: Threaded, zinc or cadmium coated, cast or malleable iron type for steel conduits. Fittings used to prevent passage of water vapor shall be of the continuous drain type.

2.5 WIREWAYS

- A. General: Electrical wireways shall be of types, sizes, and number of channels as indicated. Fittings and accessories including but not limited to couplings, offsets, elbows, expansion joints, adapters, hold-down straps, and end caps shall match and mate with wireway as required for complete system. Where features are not indicated, select to fulfill wiring requirements and comply with applicable provisions of NEC.
- B. Wireway covers shall be hinged type.

2.6 SURFACE RACEWAYS

- A. General: Sizes and channels as indicated on drawings. Provide fittings that match and mate with raceway. Provide internal barriers for areas with power and communications sections.
- B. Surface Metal Raceway: Construct of two piece galvanized steel with snap-on covers, with 9/32-inch mounting screw knockouts in base approximately 8 inches o.c. Finish with manufacturer's standard prime coating suitable for painting. Provide raceways of types suitable for each application required. Sizes 1-3/4" H x 4-3/4" W.
- C. Accessories:
 - 1. Couplings for joining raceway sections.
 - 2. Wire clips for conductors.
 - 3. Blank end fittings.
 - 4. Circuit breaker housings for single pole breakers.
 - 5. Device brackets for single or two gang devices.
 - 6. Combination receptacle and telephone outlet covers.
 - 7. Outlet boxes with hubs for conduit connectors.

2.7 FABRICATED MATERIALS - BOXES

- A. Outlet Boxes: Provide galvanized flat rolled sheet-steel outlet wiring boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 1/2 inch deep), including box depths as required, suitable for installation at respective locations. Construct outlet boxes with mounting holes, and with cable and conduit-size knockout openings in bottom and sides. Provide boxes with threaded screw holes, with corrosion-resistant cover and grounding screws for fastening surface and device type box covers, and for equipment type grounding.
 - 1. Outlet Box Accessories: Provide outlet box accessories as required for each installation, including box supports, mounting ears and brackets, cable clamps and metal straps for supporting outlet boxes, which are compatible with outlet

boxes being used to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.

- B. Device Boxes: Provide galvanized coated flat rolled sheet-steel non-gangable device boxes, of shapes, cubic inch capacities, and sizes (minimum 4 inch square, 1 ½ inches deep), including box depths as indicated, suitable for installation at respective locations. Construct device boxes for flush mounting with mounting holes, and with conduit-size knockout openings in bottom and ends, and with threaded screw holes in end plates for fastening devices. Provide conduit connectors and corrosion-resistant screws for equipment type grounding.
 - 1. Device Box Accessories: Provide device box accessories as required for each installation, including mounting brackets, device box extensions, switch box supports, plaster ears, and plaster ears, and plasterboard expandable grip fasteners, which are compatible with device boxes being utilized to fulfill installation requirements for individual wiring situations. Choice of accessories is Installer's code-compliance option.
- C. Raintight Outlet Boxes: Provide corrosion-resistant cast-metal raintight outlet wiring boxes, of types, shapes and sizes, including depth of boxes, with threaded conduit holes for fastening electrical conduit, cast-metal face plates with spring-hinged watertight caps suitably configured for each application, including face plate gaskets and corrosion-resistant plugs and fasteners.
- D. Junction and Pull Boxes: Provide galvanized code-gauge sheet steel junction and pull boxes, with screw-on covers; of types, shapes and sizes, to suit each respective location and installation; with welded seams and equipped with stainless steel nuts, bolts, screws, and washers. Pull boxes installed in finished spaces must be flush mounted cabinets provided with trim, hinged door and flush latch and lock to match flush mounted panelboard trim.
- E. Exterior junction or pull boxes, flush with grade:
 - 1. Junction or pull box to be mounted flush with grade shall be polymer composite raintight with screw cover lids. Box dimensions shall be 30"W x 48"L x 36"D. Covers shall be polymer composite suitable for pedestrian traffic secured to box with stainless steel screws. Box to be furnished with continuous neoprene gasket to seal cover. Conduit entry shall be on side of box with bell ends.
- F. Bushings, Knockout Closures and Locknuts: Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes, to suit respective installation requirements and applications.

PART 3 - EXECUTION

3.1 WIRING METHOD

- A. Outdoors: Use the following wiring methods:
 - 1. Exposed: Intermediate metal conduit, rigid steel conduit.
 - 2. Concealed: Intermediate metal conduit, rigid steel conduit.
 - 3. Underground, Single Run: Direct Bury cable installation or Rigid non-metallic conduit. PVC coated GRC 90° elbows.
 - 4. Underground, Grouped: Direct Bury cable installation or Rigid non-metallic conduit. PVC coated GRC 90° elbows.
 - 5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Liquid-tight flexible metal conduit.

- B. Indoors: Use the following wiring methods:
 - 1. Exposed (below 10 ft. to floor): Intermediate metal conduit, rigid steel conduit.
 - 2. Exposed (above 10ft. or in electrical room): Electrical metallic tubing.
 - 3. Concealed: Electrical metallic tubing.
 - 4. Concealed: Metal clad cable will be allowed as final branch wiring of receptacles and light fixtures (maximum total length of 25' from homerun J-box or hard piped J-box to outlet). MC is not allowed for homeruns to panels, connections to mechanical equipment. Maximum conductor size is in MC cable #8 AWG.
 - 5. Connection to Vibrating Equipment including transformers, pneumatic or electrical solenoid, and motor-operated equipment: Flexible metal conduit.
 - 6. Connection to Vibrating Equipment in Moist/Humid or Corrosive Atmosphere including pneumatic or electric solenoid, and motor-operated equipment: Liquidtight flexible metal conduit.
 - 7. Within concrete slabs: electrical non-metallic tubing, PVC coated MC cable, or rigid non-metallic conduit. PVC coated MC cable is not allowed for homeruns. Homeruns shall be in conduit. Maximum sizes and locations as approved by the Structural Engineer.
 - 8. Raceway mounted to underside of metal-corrugated sheet roof decking shall be Rigid Metal Conduit or intermediate Metal Conduit.

3.2 INSTALLATION OF RACEWAYS

- A. General: Install electrical raceways in accordance with manufacturers' written installation instructions, applicable requirements of NEC, and as follows.

- B. Complete installation of electrical raceways before starting installation of conductors within raceways.

- C. Provide supports for raceways as specified elsewhere in Division 16 and in accordance with NEC and local authorities seismic requirements.

- D. Prevent foreign matter from entering raceways by using temporary closure protection.

- E. Protect stub-ups from damage where conduits rise from below grade. Arrange so curved portion of bends is not visible above grade.
- F. Make bends and offsets so the inside diameter is not effectively reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.
- G. Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location. For intermediate steel conduit, use threaded rigid steel conduit fittings except as otherwise indicated.
- H. Run underground raceways with a minimum of bends in the shortest practical distance considering the routing and obstructions except as otherwise indicated.
- I. Install exposed raceways parallel and perpendicular to nearby surfaces or structural members and follow the surface contours as much as practical.
- J. Run exposed, parallel, or banked raceways together. Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs only where they can be installed parallel.
- K. Join raceways with fittings designed and approved for the purpose and make joints tight. Where joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system. Make raceway terminations tight. Where terminations are subject to vibration, use bonding bushings or wedges to assure electrical continuity. Where subject to vibration or dampness, use insulating bushings to protect conductors. Use expansion fittings at building expansion joints.
- L. Tighten set screws of threadless fittings with suitable tool.
- M. Terminations: Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box. Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside of the box. All conduit connections to junction boxes shall have insulated bushings.
- N. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
- O. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb tensile strength. Leave no less than 12 inches of slack at each end of the pull wire.

- P. Install raceway sealing fittings in accordance with the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:
 - 1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces, air-conditioned spaces and walk-in coolers.
 - 2. Where required by the NEC.
- Q. Stub-up Connections: Extend conduits above grade for connection to freestanding equipment with an adjustable top or coupling threaded inside for plugs. Extend conductors to equipment with galvanize rigid conduit. Where equipment connections are not made under this contract, install screwdriver-operated threaded flush plugs flush with floor.
- R. PVC externally coated rigid steel conduit: Use only fittings approved for use with that material. Patch all nicks and scrapes in PVC coating after installing conduit.
- S. All underground conduits shall be installed a minimum of 30 inches below finish grade. All other conduits shall be installed in accordance with the NEC and coordinated depth with other trades.
- T. Grounding: Install a separate green equipment grounding conductor in all raceways from the panelboard/junction box supplying the raceway to the receptacle or equipment ground terminals. Conduits will not be permitted as a ground conductor.

3.3 INSTALLATION OF ELECTRICAL BOXES AND FITTINGS

- A. General: Install electrical boxes and fittings in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.
- C. Provide raintight "in use" outlets for interior and exterior locations exposed to weather or moisture.
- D. Provide knockout closures to cap unused knockout holes where blanks have been removed.
- E. Install electrical boxes in those locations which ensure ready accessibility to enclosed electrical wiring.

- F. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.
- G. Fasten electrical boxes firmly and rigidly to surfaces to which attached.
- H. Provide electrical connections for installed boxes.
- I. Exterior junction or pull boxes shall be mounted flush with grade, unless noted otherwise or indicated to be above ground on the drawings. Boxes shall be surrounded on all sides with 6 inches minimum of concrete. Top of concrete shall flush with grade. Seal all conduit entries into box with duct seal to prevent entrance of moisture, after conductors are installed.
- J. Tap and splices, where permitted by these specifications within exterior junction boxes, shall be performed with an encapsulating watertight splice or tap kit which insulates and moisture seals the connection. Kit shall consist of the appropriate size and type mold, encapsulating resin and end sealing tape.
- K. Subsequent to installation of boxes, protect boxes from construction debris and damage.

3.4 GROUNDING

- A. Upon completion of installation work, properly ground electrical boxes and demonstrate compliance with requirements.

3.5 ADJUSTING AND CLEANING

- A. Upon completion of installation of raceways, inspect interiors of raceways; clear all blockages and remove burrs, dirt, and construction debris.

END OF SECTION

SECTION 16120

ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirement of the following Division 16 Sections apply to this section:
 - 1. Electrical Requirements

1.2 SUMMARY

- A. This Section includes wires, cables, and connectors for power, lighting, signal, control and related systems rated 600 volts and less.
- B. Related Sections: The following Sections contain requirements that relate to this section:
 - 1. Division 2 Section "Earthwork" for trenching and backfilling.
 - 2. Division 16 Section "Electrical Boxes and Fittings" for connectors for terminating cables in boxes and other electrical enclosures.

1.3 SUBMITTALS

- A. Product Data for electrical wires, cables and connectors.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the following code:
- B. NFPA 70 "National Electrical Code."
 - 1. Conform to applicable codes and regulations regarding toxicity of combustion products of insulating materials.
- C. UL Compliance: Provide components, which are listed and labeled by UL under the following standards.
 - 1. UL Std. 44 Rubber Insulated Wires and Cables
 - 2. UL Std. 83 Thermoplastic-Insulated Wires and Cables
 - 3. UL Std. 486A Wire Connectors and Soldering Lugs for
Use with Copper Conductors
 - 4. UL Std. 854 Service Entrance Cable

- D. NEMA/ICEA Compliance: Provide components which comply with the following standards:
 - 1. WC-5: Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
 - 2. WC-7: Cross Linked Thermosetting Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
- E. IEEE Compliance: Provide components, which comply with the following standard.
 - 1. Std. 82: Test procedures for Impulse Voltage Tests on Insulated Conductors.

PART 2 - PRODUCTS

2.1 WIRES AND CABLES (600 VOLT COPPER CONDUCTORS – BASE DESIGN)

- A. General: Provide suitable wire and cable for the temperature, conditions and location where installed. All wires and cables shall be new and delivered to the site in unbroken packages and reels.
- B. All wires and cables shall be of the same manufacturer throughout the entire project.
- C. Conductors: Provide solid conductors for power and lighting circuits #10 AWG and smaller. Provide stranded conductors for #8 AWG and larger.
- D. Conductor Material: All wires and cables shall be copper, single conductor rated at 600 volts, which conform to or exceed ICEA specifications and the following:
 - 1. In sizes 1/0 AWG to 4/0: Cross-linked polyethylene insulation type XHHW-2 (75 - 90°C) or THWN.
 - 2. In sizes 1 AWG and smaller: All conductors shall have heat/moisture resistant thermoplastic insulation type THWN (75°C) except as follows:
 - a. Where installed direct bury, use type UF-B (60 - 90°C).
 - b. Where conduit temperature will exceed 100°F, use type THHN (90°C).
 - c. In 120 volt incandescent fixtures, type SF-2 or SFF-2 (150 - 200°C).
 - d. In wireway of fluorescent lighting fixtures type THHN (90°C).
 - 3. Contractor may additionally submit for Owner Review – Aluminum conductors.
- E. Grounding conductors: Shall be of the same type as its associated phase conductors.
- F. All conductors shall be label with wire size, insulation rating, etc using an engraved process, computer scan on labels are not permitted.
- G. Color Coding for phase identification in accordance with Table 1 in Part 3 herein.
- H. Connectors for Conductors:
 - 1. Provide UL-listed factory-fabricated, solderless metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Use

connectors with temperature ratings equal to or greater than those of the wires upon which used.

I. Splices and Taps:

1. No. 10 AWG and smaller - Connectors for solid conductors shall be solderless, screw-on, spring pressure cable type, 600 volt, 105°C with integral insulation and UL approved for aluminum and copper conductors. Connectors for stranded conductors shall be crimp-on type with integral insulating cover.
2. No. 8 AWG and larger - Hydraulically applied crimping sleeve or tap connector sized for the conductors. Insulate the hydraulically applied connector with 90-degree, 600-volt insulating cover provided by the connector manufacturer. Insulator materials and installation shall be approved for the specific application, location, voltage, and temperature and shall not have an insulation value less than the conductors being joined.

PART 3 - EXECUTION

3.1 WIRING METHOD

A. Use the following wiring methods as indicated:

1. Install all underground wire, direct bury.
2. Install all above grade wire in raceway. Power and control wiring shall be installed in separate raceways.

3.2 INSTALLATION OF WIRES AND CABLES

- A. General: Install electrical cables, wires, and connectors in compliance with NEC.
- B. Coordinate cable and wire installation with other Work.
- C. Trenching and backfill will comply with the University of Colorado Colorado Springs construction standards. Where requirements within these documents are more stringent than University requirements, these requirements shall apply.
- D. In trenching, where rock is encountered, the contractor shall excavate 6" below the bottom of any direct bury cable and replace with compacted class b bedding material #67, or sand.
- E. Trench backfill 6" above the cable shall be sand. Backfill shall be properly placed uniformly and compacted as required. The contractor shall not backfill on muddy or frozen soil, or with muddy or frozen soil.
- F. Trench backfill from 1 foot above any conduit to grade shall be with clean earth fill, free of stones larger than 4-inches or ½ the layer thickness, whichever is smaller. Layers shall not exceed 12 inches and backfill shall be compacted to 95% standard proctor. Compaction shall be achieved by mechanical tamping or other means as determined by the contractor, which shall satisfy the compaction requirements and comply with city and county of denver standards.

- G. Do not install more conductors in a raceway than indicated on the drawings. A maximum of three branch circuits are to be installed in any one conduit on a 3-phase, 4-wire system, unless specifically noted otherwise on the drawings. When more than three branch circuits are installed in a raceway, the conductor size shall be increase per code for derating. No two branch circuits of the same phase are to be installed in the same conduit, unless specifically noted otherwise on the drawings.
- H. Where multiple circuits share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously.
- I. Minimum wire size shall be a No.12 AWG except for control or signal circuits, which may be No. 14 AWG.
- J. Unless otherwise indicated on drawings, all wiring for branch circuits shall be a minimum No. 12 AWG in ¾" conduit, protected by 20 amperes circuit breakers. If distance from panel to first outlet is 75 feet or greater for 120 volt circuits, and 125 feet or greater for 244 volt circuits, No. 10 AWG shall be installed throughout the circuit, unless noted otherwise on the drawings.
- K. Size of current carrying conductors, unless noted otherwise on drawings, shall be determined from Table 310-16 of the latest National Electric Code for the load served.
- L. Pull conductors simultaneously where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.
- M. Use pulling means including: fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.
- N. Size of conduits, unless specifically shown, shall be determined from Appendix C of the latest National Electrical Code.
- O. Keep conductor splice to minimum. All splices shall be made within junction boxes, wiring troughs and other enclosures as permitted by the National Electrical Code. Do not splice conductors in panelboards, safety switches, switchboards, motor control centers or motor control enclosures. Splices in conductors installed below grade will not be permitted, unless approved in writing by the Engineer.
- P. Install splice and tap connectors, which possess equivalent or better mechanical strength and insulation rather than conductors being spliced.
- Q. Use splice and tap connectors which are compatible with conductor material.
- R. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

- S. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturers' published torque tightening values. Where manufacturers' torque requirements are not indicated, tighten connectors and terminals to comply with tightening torque values specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Prior to energizing, check installed wires and cables with megohm meter to determine insulation resistance levels to assure requirements are fulfilled.
- B. Prior to energizing, test wires and cables for electrical continuity and for short circuits.
- C. Subsequent to wire and cable hook-ups, energize circuits and demonstrate proper functioning. Correct malfunctioning units, and retest to demonstrate compliance.
- D. Prior to completion of project, an infrared scan of switchgear and panelboard feeder equipment connection shall be performed when all loads are energized.

3.4 FEEDER TESTING

- A. Products
 - 1. Material: Contractor shall provide all necessary testing equipment and devices required to perform the test described in this section.
- B. Execution
 - 1. Visual and Mechanical Inspection
 - a. Inspect cables for physical damage and proper connection in accordance with one-line diagrams.
 - b. Test cable mechanical connections to manufacturer's recommended values using a calibrated torque wrench.
 - c. Check cable color coding with specification section 16050 and National Electrical Code standards.
 - 2. Electrical Tests
 - a. Perform insulation-resistance test on each conductor with respect to ground and adjacent conductors. Applied potential shall be 1000 volts dc for 1 minute.
 - b. Perform continuity test to insure proper cable connection.
 - 3. Test Values
 - a. Evaluate results by comparison with cables of same length and type. Investigate any insulation-resistance values less than 50 megohms.
 - b. Submit results to Engineer for approval in accordance with Section 16020.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 16 Sections apply to this section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles
 - 2. Ground Fault Circuit Interrupter Receptacles
 - 3. Plugs
 - 4. Plug Connectors

1.3 SUBMITTALS

- A. Product data for each type of product specified.
- B. Occupancy Sensors
 - 1. Submit a lighting plan clearly marked by manufacturer identifying product type, locations, orientation and coverage for each sensor.
 - 2. Submit any interconnection diagrams per major subsystems showing proper wiring.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with provisions of the following codes.
 - 1. NFPA 70 "National Electrical Code."
- B. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL, Federal Specification and comply with applicable UL and NEMA standards.

1.5 SEQUENCE AND SCHEDULING

- A. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

PART 2 - PRODUCTS

2.1 WIRING DEVICES

- A. General: Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards.
- B. Color of Devices: Color of all devices unless noted otherwise shall be black.
- C. Receptacles: As scheduled in Table 1 in Part 3 indicated herein. Comply with UL 498 and NEMA WD 1 and WD 6.
- D. Ground-Fault Interrupter (GFI) Receptacles: As scheduled in Table 1 in Part 3 indicated herein: Provide "terminal" or feed-through type ground-fault circuit interrupter, as indicated on drawings, with integral heavy-duty NEMA 5-20R duplex receptacles. Provide unit designed for installation in a 2-3/4-inch deep outlet box without adapter, grounding type, Class A, Group 1 per UL Standard 943.
- E. All exterior weatherproof receptacles shall be GFI type or GFI protected and have cast metallic "in use" covers.
- F. All devices shall be premium specification grade.

2.2 WIRING DEVICE ACCESSORIES

- A. For all devices installed which are exposed to the weather, moisture or where indicated on the drawings, device plates shall be weatherproof. Device plates shall be cast metallic type with gasketing to prevent entrance of moisture when closed.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING DEVICES AND ACCESSORIES

- A. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.
- B. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other work.

- C. Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torque requirements are not indicated, tighten connectors and terminal to comply with tightening torque requirements specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

3.2 PROTECTION

- A. Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

- A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for shortcircuits. Ensure proper polarity of connections is maintained. Subsequent to energizing test wiring devices and demonstrating compliance with requirements, operate each operable device at least six times.
- B. Test ground fault interrupter operation with both local and remote fault simulations in accordance with manufacturer recommendations.

C. TABLE 1

RECEPTACLES

Designation ⁽¹⁾	Current Rating Amps	Voltage Rating	Single/ Duplex	NEMA Config.	Hubbell Catalog #	Notes
WP/GFI	20	125	Duplex	5-20R	GFR5362	Integral GFI ⁽²⁾ In Use Weather- proof

NOTES

1. Letter designations are used where symbols alone do not clearly designate on plans locations where specific receptacle types are used.
2. Protecting downstream receptacles on same circuit is not acceptable.

END OF SECTION

SECTION 16210

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division 16 Basic Electrical Material and Methods sections apply to work specified in this section.

1.2 SUMMARY

- A. Provide all panelboards and enclosure work, including cabinets and cutout boxes, as indicated by drawings and schedules, and as specified herein.
- B. Types of panelboards, and enclosures required for the project include the following:
 - 1. Power-distribution panelboards.
 - 2. Lighting and appliance panelboards.
- C. All panelboards, disconnect switches, etc., shall be fabricated by the same manufacturer throughout the entire project.
- D. Wires/cables, bus-way, electrical boxes and fittings, and raceways required in conjunction with the installation of panelboards, and enclosures are specified in other Division 16 sections.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on panelboards, and enclosures.
- B. Wiring Diagrams: Submit wiring diagrams for panelboards showing connections to electrical power feeders and distribution branches.
- C. Submit plan view drawings at 1/4" scale showing all equipment, panelboards, disconnects and ratings, buss work, conduit areas, dimensions and mounting of equipment supplied.
- D. Submittals shall be in accordance with specification section 16010.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: The manufacturer of this equipment shall be regularly engaged in manufacture of panelboards and enclosures, of types, sizes, and ratings required and have produced similar electrical equipment, for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- B. Codes and Standards
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Article 384 as applicable to installation, and construction of electrical panelboards and enclosures.
 - 2. UL Compliance: Comply with applicable requirements of UL 67, "Electric Panelboards", and UL's 50, 869, 486A, 486B, 891, and 1053 pertaining to panelboards, accessories and enclosures. Provide panelboard units which are UL-listed and labeled.
 - 3. Special-Use Markings: Provide panelboards, constructed for special-use, with appropriate UL markings which indicated that they are suitable for special type of use/application.
 - 4. NEMA Compliance: Comply with NEMA Stds Pub/No. 250, "Enclosure for Electrical Equipment (1000 Volts Maximum)", Pub/No. PB 1, "Panelboards", and Pub/No. PB 1.1, "Instructions for Safe Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less".

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store panelboards in clean dry space. Protect units from dirt, fumes, water, construction debris and traffic; where necessary to store outdoors, store electrical components above grade and enclose with watertight wrapping.
- B. Handle panelboards carefully to prevent internal components damage, breakage, denting, and scoring enclosure finish. Do not install damaged components; replace and return damaged units to equipment manufacturer.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate installation of panelboards and enclosures with installation of wires/cables, electrical boxes and fittings, and raceway work.

PART 2 - PRODUCTS

2.1 PANELBOARDS (800 AMPS OR LESS)

- A. General: Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated on drawings, which comply with

manufacturer's standard materials; with the design and construction in accordance with published product information; equip with proper numbers of unit panelboard devices as required for complete installation.

- B. Lighting and Appliance Panelboards: Provide dead-front safety type lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown. Equipped with anti-turn solderless pressure type lug connectors approved for use with copper conductors; construct unit for connecting feeders at top of panel; equip with copper buss bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breakers, with toggle handles that indicate when tripped. Provide suitable lugs on neutral buss for each outgoing feeder required; and provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturers as panelboards, which mate and match properly with panelboards. Employ breakers that are fully rated for the available short-circuit condition but not less than 10,000 sym AIC at 120/240 volts; and 14,000 sym AIC at 277/480 volts. Where multiple single pole breakers share a common neutral conductor, provide breaker tie bars as required so overload on one pole will trip all poles simultaneously.
- C. Panelboard Enclosures: Provide galvanized sheet steel cabinet type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide fronts with adjustable trim clamps, and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges with door in door swings as indicated. Equip with interior circuit directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for surface mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate and match properly with panelboards to be enclosed.
- D. Molded-Case Circuit Breakers: Provide factory-assembled, molded-case circuit breakers of frame sizes, characteristics, and ratings including RMS symmetrical interrupting ratings indicated. Select breakers with permanent thermal and instantaneous magnetic trip, and ampere ratings as indicated on the drawings. Construct with overcenter, tripfree, toggle-type operating mechanisms with quick-make, quick-break action and positive handle trip indication. Construct breakers for mounting and operating in any physical position, and operating in ambient temperature of 40°C. Provide breakers with mechanical screw type removable connector lugs, AL/CU rated. The breakers for 277/480V panelboards shall be industrial grade; breakers that allow or direct particles of combustion resulting from fault conditions out of the breaker are not acceptable, they shall be contained within its casing. For example; GE AE series panelboards with TEY circuit breakers are not acceptable, TED breakers are acceptable.

PART 3 - EXECUTION

2.1 EXAMINATION

- A. Examine area and conditions under which panelboards and enclosures are to be installed, and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

2.2 INSTALLATION

- A. Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC standards and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.
- B. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers' published torque tightening values for equipment connectors. Where manufacturer's torque requirements are not indicated, tighten connectors and terminals to comply with torque tightening requirements specified in UL Std 486A and B.
- C. Fasten enclosures firmly to surfaces, ensuring that they are permanently and mechanically anchored.
- D. Provide properly wired electrical connections for panelboards within the enclosures.
- E. Provide engraved, plastic laminate labels for all panelboards indicating name, voltage, phase, wire and short circuit rating. Refer to Section 16050 for more information.
- F. Provide typed panelboards circuit directory card upon completion of installation work to match as-built conditions and nomenclature indicated on engineering drawings and submit directories to the Engineer for review prior to mounting in panelboard.

2.3 GROUNDING

- A. Provide equipment grounding connections as indicated herein. Tighten connection to comply with torque tightening requirements specified in UL 486A to assure permanent and effective grounds.
- B. Refer to Section 16350 for additional grounding requirements.

2.4 FIELD QUALITY CONTROL

Tests shall conform to International Electrical Testing Association (INETA) Standard ATS, "Acceptance Testing Specifications for Electrical Power Distribution Equipment".

- A. Panelboards:
 - 1. Visual and Mechanical Inspection:

- a. Inspect for physical damage and code violations.
 - b. Inspect for proper alignment, anchorage and grounding.
 - c. Inspect for proper identification of protective devices and switches.
 - d. Check tightness of accessible bolted buss joints.
 - e. Physically test all electrical or mechanical interlocks to assure proper function.
 - f. Clean interior and insulator surfaces once a month prior to job completion.
 - g. Inspect for proper operation of space heaters and thermostat settings (if they exist).
2. Electrical Tests:
- a. Measure insulation resistance of each buss section phase-to-phase and phase-to-ground.
 - b. Check panelboards for electrical continuity of circuits and for short circuits.

2.5 ADJUSTING AND CLEANING

- A. Adjust operating mechanisms for free mechanical movement.
- B. Touch-up scratched or marred surfaces to match original finishes.

2.6 DEMONSTRATION

- A. Subsequent to wire and cable hook-ups, energize and demonstrate functioning in accordance with requirements. Where necessary, correct malfunctioning units, and then retest to demonstrate compliance.

END OF SECTION

SECTION 16265

ENCLOSED SWITCHES, FUSES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section.
- B. Division 16 Basic Electrical Materials and Methods sections, apply to work of this section.

1.2 SUMMARY

- A. Provide all circuit and motor disconnect switch work including fusing, electrical connections to motors, appliance and mechanical equipment as indicated on the drawings and schedules.
- B. Types of circuit and motor disconnect switches in this section include the following:
 - 1. Equipment disconnects.
 - 2. Appliance disconnects.
- C. Applications of electrical power connections specified in this section include the following:
 - 1. To lighting fixtures.
 - 2. To grounds including earthing connections.
 - 3. To panelboards, contactors, time clocks and similar equipment.
- D. All panelboards, transformers, disconnect switches, etc., shall be fabricated by same manufacturer throughout the entire project.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on circuit and motor disconnect switches, and equipment connectors.
- B. Fuse Product Data: For each type of fuse indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

- a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
- b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 QUALITY ASSURANCE

- A. All equipment shall be in compliance with codes and standards referenced in Section 26 05 02 titled "Electrical Requirements".
- B. UL Compliance: Comply with requirements of UL 98, "Enclosed and Dead-Front Switches." Provide circuit and motor disconnect switches which have been UL listed and labeled.
- C. Comply with UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors," including, but not limited to, tightening of electrical connectors to torque values indicated.
- D. NEMA Compliance: Comply with applicable requirements for NEMA Stds Pub/No. KS 1, "Enclosed Switches," and No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."
- E. ANSI Compliance: Comply with applicable requirements of ANSI C97.1, "Low-Voltage Cartridge Fuses 600 Volts or Less."
- F. NEMA Compliance: Comply with NEMA FU1 for cartridge fuses.

1.5 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 CIRCUIT AND MOTOR DISCONNECT SWITCHES

- A. Furnish and install safety switches as required for motor outlets or other equipment. Switches shall be of size, number of poles, and fused or non-fused, as required for job conditions and the National Electrical Code.
- B. Switches shall be equipped with fuse contacts and jaws which ensure positive fuse and jaw contact by means of reinforcing spring clips or other approved means. All current carrying parts shall be silver-plated. Hinges shall be non-current carrying. Switches shall be so designed that they can be locked in either open or closed position.
- C. All safety switches shall be NEMA 1 enclosed Type "HD" (heavy duty) quick-make, quick-break, and have interlocking cover with handle that may either be front or side operating with padlocking provisions. Provide NEMA 3R weather proof enclosures where indicated on the drawings or exposed to exterior or damp locations. Incorporate rejection clips where used with Class "R" fuses.
- D. Fusible Switches: Heavy duty switches, with fuses of classes and current ratings indicated on drawings. See Section "2.3" for Fuse specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.
- E. Non-fusible Disconnects: Heavy duty switches of classes and current ratings as indicated on drawings.
- F. Double-Throw Switches: Heavy duty switches of classes and current rating as indicated on drawings.
- G. Bolted Pressure Switches: Bolted pressure switches conforming to and listed under UL Standard 977; single or double-throw arrangement as indicated. For fusible units provide fuses as indicated on drawings.
- H. Accessories:
 - 1. Electrical Interlocks: Provide number and arrangement of interlock contacts in switches as indicated on drawings or specified elsewhere in specifications.
 - 2. Special Enclosure Material: Provide special enclosure material as follows for switches indicated on drawings to be NEMA 4X: a. Stainless Steel Type 316.
b. Heavy case aluminum.
 - 3. Captive Fuse Pullers: Provide built-in pullers arranged to facilitate fuse removal.

2.2 CONNECTIONS FOR EQUIPMENT

- A. General: For each electrical connection indicated provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable

insulating tubing, cable ties, solderless wirenuts. All other items and accessories as needed to complete splices and terminations of types indicated.

- B. Metal Conduit, Tubing and Fittings:
 - 1. General: Provide metal conduit, tubing and fitting of types, grades, sizes and weights (wall thicknesses) indicated for each type service. Where types and grades are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with NEC requirements for raceways. Provide products complying with Section 16100 titled "Basic Materials and
 - a. Rigid steel conduit.
 - b. Rigid metal conduit fittings.
 - c. Liquid-tight flexible metal conduit.
 - d. Liquid tight flexible metal conduit fittings.
- C. Wires, Cables, and Connectors:
 - 1. General: Provide wires, cables and connectors complying with Division 16100 titled "Basic Materials and Methods" and "Section 16120" titled "Electrical Power Conductors and Cables."
 - 2. Wires/Cables: Unless otherwise indicated, provide wires/cables (conductors) for electrical connections which match, including sizes and rating, of wires/cables which are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (68°F).
 - 3. Connectors and Terminals: Provide electrical connectors and terminals which mate and match, including sizes and ratings, with equipment terminals and are recommended for use by equipment manufacturer for intended applications.
 - 4. Electrical Connection Accessories: Provide electrical insulating tape, heat shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wirenuts and cable ties as recommended for use by accessories manufacturers for type services indicated.

2.3 FUSES

- A. General: Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.
- B. Class RK1 dual element time-delay fuses: Provide UL Class RK1 current limiting timedelay fuses rated 600-volts, (250 volts where specified), 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit breakers, motors and panelboards.
- C. Class RK5 dual element time-delay fuses: Provide UL Class RK5 current limiting timedelay fuses rated 600 volts, (250 volts where specified), 60 Hz, with 200,000 RMS

symmetrical interrupting current rating for protecting circuit breakers, motors, and transformers.

- D. Class L time-delay fuses: Provide UL Class L time-delay fuses rated 600 volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

PART 3 - EXECUTION

3.1 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECT SWITCHES

- A. Install circuit and motor disconnect switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and NECA's "Standard of Installation," and in accordance with recognized industry practices.
- B. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.
- C. Install disconnect switches for use with motor-driven appliances, and motors and controllers within sight of controller position unless otherwise indicated.

3.2 INSTALLATION OF EQUIPMENT CONNECTIONS

- A. Install electrical connections in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC and NECA's "Standard of installation" to ensure that products fulfill requirements.
- B. Coordinate with other work, including wires/cables, raceway and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work.
- C. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.
- D. Cover splices with electrical insulating material equivalent to, or of greater insulation resistivity rating, than electrical insulation rating of those conductors being spliced.
- E. Prepare cables and wires, by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "nicking" copper conductors while skinning wire.

- F. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.
- G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturers published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torque tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torque requirements are not available, tighten connectors and terminals to comply with torque values contained in UL 486A.
- H. Provide PVC-coated conduit and fittings for highly-corrosive atmospheres.
- I. Provide flexible conduit for motor connections, and other electrical equipment connections, where subject to movement and vibration.
- J. Provide liquid-tight flexible conduit for connection of motors and other electrical equipment where subject to movement and vibration, and also where connections are subjected to one or more of the following conditions:
 - 1. Exterior location.
 - 2. Moist or humid atmosphere where condensation can be expected to accumulate.
 - 3. Water spray.
 - 4. Dripping oil, grease, or water.
- K. Fasten identification markers to each electrical power supply wire/cable conductor which indicates their voltage, phase and feeder number in accordance with Division 26 section titled "Electrical Identification." Affix markers on each terminal conductor, as close as possible to the point of connection.
- L. Provide flexible metal conduit or Type "S" rubber cords, pigtails, caps, etc., as required to constitute an operating system. All flexible cords shall have a grounding conductor. Ground all equipment. See Section 16350 titled "Grounding and Bonding" for additional requirements.
- M. Prior to roughing-in, refer to all equipment manufacturer's shop drawings for details of equipment connections. Provide receptacles as required to match the cord caps on the equipment furnished. Provide either direct wiring or receptacles for final connection to equipment as required for the particular equipment furnished regardless of the type of outlet shown on the plans.

3.3 INSTALLATION OF FUSES

- A. Install fuses as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC, and NEMA standards for installation of fuses.

- B. Coordinate work including electrical wiring, as necessary, to interface installation of fuses with other trades.
- C. Install fuses in fused switches.
- D. Provide spare fuse cabinet located in each main switchgear room. Provide spare fuse of size and type for every five (5) fuses installed. A minimum of three (3) spare fuses shall be provided for each size installed.

3.4 GROUNDING

- A. Provide equipment grounding connections, sufficiently tight to assure a permanent and effective ground for electrical disconnect switches.

3.5 FIELD QUALITY CONTROL

- A. Testing: Subsequent to completion of installation of electrical disconnect switches, energize circuits and demonstrate capability and compliance with requirements. Except as otherwise indicated, do not test switches by operating them under load. However, demonstrate switch operation through six opening/closing cycles with circuit unloaded. Open each switch enclosure for inspection of interior, mechanical and electrical connections, fuse installation, and for verification of type and rating of fuses installed. Correct deficiencies then retest to demonstrate compliance. Remove and replace defective units with new units and retest.

END OF SECTION

SECTION 16350

GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division-16 Basic Materials and Methods sections apply to work of this section.
- C. Requirements of this section apply to electrical grounding and bonding work specified elsewhere in these specifications.

1.2 SUMMARY

- A. Extent of electrical grounding and bonding work is indicated by drawings and schedules and as specified herein. Grounding and bonding work is defined to encompass systems, circuits, and equipment.
- B. Type of electrical grounding and bonding work specified in this section includes the following:
 - 1. Solidly grounded.
- C. Applications of electrical grounding and bonding work in this section includes the following:
 - 1. Underground metal piping.
 - 2. Electrical power systems.
 - 3. Grounding electrodes.
 - 4. Separately derived systems.
 - 5. Raceways.
 - 6. Lighting Standards.
- D. Refer to other Division-16 sections for wires/cables, electrical raceways, boxes and fittings, and wiring devices which are required in conjunction with electrical grounding and bonding work; not work of this section.

1.3 SUBMITTALS

- A. Product Data: Submit manufacturer's data on grounding and bonding products and associated accessories.

- B. Wiring Diagrams: Submit wiring diagrams for electrical grounding and bonding work which indicates layout of ground rods, location of system grounding electrode connections, routing of grounding electrode conductors, also include diagrams for circuits and equipment grounding connections.
- C. Submit ground riser diagram for entire project. Show bus bars with transformer ground electrode conductors, etc.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of grounding and bonding products, of types, and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, grounding electrodes and plate electrodes, and bonding jumpers whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience on projects with electrical grounding work similar to that required for project.
- C. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to electrical grounding and bonding, pertaining to systems, circuits and equipment.
 - 2. UL Compliance: Comply with applicable requirements of UL Standards No.'s 467, "Electrical Grounding and Bonding Equipment", and 869 "Electrical Service Equipment", pertaining to grounding and bonding of systems, circuits and equipment. In addition, comply with UL Std 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide grounding and bonding products which are UL-listed and labeled for their intended usage.
 - 3. IEEE Compliance: Comply with applicable requirements and recommended installation practices of IEEE Standards 80, 81, 141 and 142 pertaining to grounding and bonding of systems, circuits and equipment.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials and Components:
 - 1. Provide electrical grounding and bonding system; with assembly of materials, including, but not limited to, cables/wires, connectors, solderless lug terminals, grounding electrodes and plate electrodes, bonding jumper braid, surge arresters, and additional accessories needed for a complete installation. Where more than one type component product meets indicated requirements, selection is installer's option. Where materials or components are not indicated provide products which

comply with NEC, UL, and IEEE requirements and with established industry standards for those applications indicated.

2.2 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductors, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductors.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper 1/4 by 3 by 12 inches (6 by 76 by 300 mm) in cross section, unless otherwise indicated; with insulators.

2.3 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by Cadweld (or approved equal) manufacturer for materials being joined and installation conditions.

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Copper clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.

PART 3 – EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No.10 AWG and smaller, and stranded conductors for No.8 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned copper conductor, No.3/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements
- B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No.3/0 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits. The conduit shall not be acceptable as an equipment ground.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
- C. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 EXAMINATION

- A. Examine areas and conditions under which electrical grounding and bonding connections are to be made and notify Engineer in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected.

3.5 INSTALLATION OF ELECTRICAL GROUNDING AND BONDING SYSTEMS

- A. General: Install electrical grounding and bonding systems in accordance with manufacturer's instructions and applicable portions of NEC, NECA's "Standard of Installation", and in accordance with recognized industry practices to ensure that products comply with requirements.
- B. Coordinate with other electrical work as necessary to interface installation of electrical grounding and bonding system work with other work.
- C. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- D. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- E. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- F. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment
 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
1. Install tinned-copper conductor not less than No.4/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches (600 mm) from building foundation.
- I. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with tightening torque values specified in UL 486A to assure permanent and effective grounding.
- J. Apply corrosion-resistant finish to field-connections, buried metallic grounding and bonding products, and places where factory applied protective coatings have been destroyed, which are subjected to corrosive action.
- K. Install all connectors on clean metal contact surfaces, to ensure electrical conductivity and circuit integrity.

3.6 FIELD QUALITY CONTROL

- A. Upon completion of installation of electrical grounding and bonding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms, or less, by driving additional ground rods; then retest to demonstrate compliance.

END OF SECTION

SECTION 16450

LIGHTING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including general and supplementary conditions and Division-1 Specification sections, apply to work of this section.
- B. Division-16 Basic Electrical Materials and Methods sections apply to work specified in this section.
- C. Refer to Appendix "A" for Light Fixture Cutsheets

1.2 SUMMARY

- A. Extent, Relative location, and details of lighting fixture work are indicated on drawings and in schedules. Refer to Civil Plans for precise fixture locations.
- B. Types of lighting fixtures in this section include the following:
 - 1. High-intensity-discharge (HID). Metal halide.
 - 2. Fluorescent.
 - 3. Incandescent and quartz.
 - 4. Light Emitting Diode, LED
 - 5. Other lamps as noted on fixture schedule.
- C. Fixture: A complete lighting unit Includes lamps, wiring, controls and parts required to securely support fixture.
- D. Installation details shall be verified and coordinated with fixture type and mounting prior to ordering.
 - 1. All materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this Specification shall be furnished by the Contractor.
 - 2. Fixtures shall be manufactured in strict conformance with the Contract Drawings and Specifications.
 - 3. Specifications and scale drawings are intended to convey the salient features, function and character of the fixtures only, and do not undertake to illustrate or set forth every item or detail necessary of the work.

4. Minor details, not usually indicated on the drawings nor specified, but that are necessary for the proper execution and completion of the fixtures, shall be included, the same as if they were herein specified or indicated on the drawings.
 5. The Owner shall not be held responsible for the omission or absence of any detail, construction feature, etc., which may be required in the production of the fixtures. The responsibility of accurately fabricating the fixtures to the fulfillment of this specification rests with the Contractor.
- E. Where a catalog number and a narrative or pictorial description is provided, the written description shall take precedence and prevail.
- F. General Contractor shall provide electrical subcontractor with entire lighting specification (including fixture cut sheets, illustrations and sketches); electrical subcontractor shall provide each specified manufacturer with complete information about the fixtures they will supply.
- G. Fixture details shown may be modified by the manufacturer provided all of the following conditions have been met:
1. Cost to the Owner is reduced or equal.
 2. Fixture performance is equal or improved.
 3. Structural, mechanical, electrical, safety, and maintenance characteristics are equal or improved.
 4. Modifications have been reviewed by the Architect and have been approved by the Architect in writing.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

1. Exterior Luminaire:
 - a. Basis of Measurement: Each.
 - b. Basis of Payment: Includes wood pole installation and base compaction, luminaire pole, luminaire with lamps and accessories and connection to power source.

1.4 SUBMITTALS

Submit shop drawings, samples, and prototypes as specifically instructed below.

- A. Shop drawings shall include but not be limited to:
1. For standard catalog items with no modifications, submit catalog cut sheets prepared by the manufacturer which clearly show all elements to be supplied and all corresponding product data (including lamping; ballast manufacturer and model number; voltage; accessories or options and any miscellaneous items

- detailed in the written description of the specification). If cut sheet shows more than one (1) fixture type, all non-applicable information shall be crossed out.
2. For lamps, submit catalog cut sheets prepared by the manufacturer which clearly shows manufacturer, CRI, CT, wattage, base type, lumen output, lamp life, and any other pertinent information.
 3. The Architect/Engineer shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the fixture cut is insufficient.
 4. Maintenance Data: Submit maintenance data and parts list for each lighting fixture, accessory and also include "trouble-shooting" maintenance guide. In addition to the product data and shop drawings, a maintenance manual in accordance with general requirements of Division 1 shall be provided.
- B. Shop drawings and samples requested shall be submitted for approval before fabrication. Any material produced prior to the approval of shop drawings or samples, and not in conformance with the Contract Documents, shall be disapproved with the Contractor bearing full responsibility and cost.
- C. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on the drawings submitted for approval.
- D. Substitutions: Manufacturers or light fixtures not listed on fixture schedule must be prequalified prior to bid. For approval of all manufacturer/fixture substitutions, the bidders shall comply to specifications herein and as outlined below for submitting alternate fixtures:
1. Request for approval shall be accompanied by working fixture samples (with an appropriate lamp, complete photometric, mechanical and electrical data, list of materials and finishes and unit cost to the Owner) of both the specified brand and the proposed substitutes as required to make complete comparison and evaluation. These samples shall be in addition to those required by Lighting Fixture Specification. The above data shall be delivered separately to the Architect and the Engineer. The fixture samples shall be furnished and installed at the bidder's expense, at a location selected by the Architect. In addition, the bidder shall furnish the Architect and the Engineer with the name and location of at least one completed project where each proposed substitute has been in operation for a period of at least six (6) months, as well as the names and addresses of the Owner, the Architect and the Engineer.
 2. Point by point lighting calculations of areas affected by proposed substitution will be done by the bidder for review.

3. The Architect and Engineer shall determine whether the prototype sample complies with the specifications and shall reserve the right to disqualify any bidders.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lighting fixtures of sizes, types and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience on projects with lighting fixture work similar to that required for this project.
- C. Codes and Standards:
 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 220, 225, 250, 410, and 500 as applicable to installation and construction of building lighting fixtures.
 2. NEMA Compliance: Comply with applicable requirements of NEMA Stds Pub/No's LE 1 and LE 2 pertaining to lighting equipment.
 3. IES Compliance: Comply with IES RP-1 pertaining to office lighting practices and RP-15, regarding selection of illuminance values for interior office lighting. Comply with IES RP-8, 19, 20, and PB-15 pertaining to exterior, parking, and roadway lighting practices and fixtures.
 4. UL Compliance: Comply with UL standards, including UL 486A and 486B, pertaining to lighting fixtures. Provide lighting fixtures and components which are UL-listed or ETL listed and labeled.
 5. CBM Labels: Provide fluorescent lamp ballasts which comply with Certified Ballast Manufacturer's Association standards and carry the CBM label.
- D. Special Listing and Labeling: Provide fixture for damp locations, wet locations, recessed in rated ceilings and walls, hazardous that are UL listed and labeled for specific use.
- E. Materials and Equipment:
 1. Materials, equipment, and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standards, and as specified and as indicated on drawings. Fixture parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the fixtures.
 2. All fixtures shall be manufactured to a consistent level of quality. Size, color, and component parts shall be identical for all fixtures of the same type.

1.6 DELIVERY, STORAGE, HANDLING, AND WARRANTY

- A. Deliver lighting fixtures in factory-fabricated containers or wrappings, which properly protect fixtures from damage.
- B. Store lighting fixtures in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperature, humidity, laid flat and blocking off ground.
- C. Handle lighting fixtures carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.
- D. Provide a 5-year warranty of failure in materials, workmanship, ballast, etc., in addition to and not limited to other rights the Owner may have under the contract documents. A full warranty shall apply for the first year, and a prorated warranty for the last four years.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with other work including wires/cables, electrical boxes and fittings, and raceways to properly interface installation of lighting fixtures.
- B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The Contractor shall base bid for lighting fixtures on the manufacturers listed on the fixture schedule only.
- B. Alternate manufacturer's identification by means of manufacturer's names is to establish basic features and performance standards. Alternate manufacturer's or substitutions must meet or exceed the standards of the primary manufacturer listed.
- C. Qualifications: The contractor is allowed 60 days after the contract has been awarded to submit independent photometric tests and samples for all approved alternate fixtures. If these fixtures fail to comply with the specification requirements at that time, the Contractor will furnish acceptable fixtures at no additional cost to the Owner and with no delay to the project.

- D. Any submittals for cost reduction alternates or value engineering shall include unit prices for the specified manufacturer, the specified equal manufacturer, and the proposed alternates. Refer to Part 1.3 for approval process.

2.2 MATERIALS AND FABRICATION

- A. Provide thickness of metal required or as specified so that all fixture are rigid, stable and will resist deflection, twisting, warping or bending under normal installation procedures, loading, relamping, etc.
- B. Provide neoprene or silicone gasketing, stops, and barriers where required to prevent light leak or water and water vapor (penetration).
- C. Provide finished product with ground metal edges, tight fitting connections, hinges and closures; clean, neat edges, trims, and frames; continuous welds, ground smooth with sharp corners; all exposed screws countersunk flush.
- D. Provide positive, durable means of connection at all joints as required.
- E. All cast parts, including die-cast members, shall be of uniform quality, free from blow holes, pores, hard spots, shrinkage defects, cracks or other imperfections that affect strength and appearance or are indicative of inferior metals or alloys.
- F. Provide sufficient ventilation for lamps, ballasts and transformers including vent holes where required. Outdoor fixtures shall have corrosion resistant wire mesh screens in the vent holes.
- G. All adjustable fixtures shall be provided with reliable locking device to secure aiming angles of the fixture housing or lamp yoke as well as lamp and lens orientation devices to secure oval beam pattern lamps and/or spread lenses.

2.3 FINISHES

- A. Fixture finishes shall be applied in a manner that will assure a durable, wear resistant surface.
 - 1. Prior to finishing, all surfaces shall be free from foreign materials such as dirt, rust, oil, polishing compounds and mold release agents.
 - 2. Where necessary, surfaces shall be hot cleaned by accepted chemical means and shall receive corrosion inhibiting (phosphating) treatment assuring positive paint adhesion.
 - 3. Provide all ferrous metal surfaces with a protective finish having rest-inhibiting properties. Painted finishes shall be a minimum of 1.5 mils thick and shall have

a balance between hardness and bending properties suitable for application. White finishes shall have 87 percent minimum reflectance. Application and cleaning shall be performed so as to prevent any loss of reflectance capability.

2.4 WIRING

- A. All wiring shall comply with the following:
 - 1. All wiring devices within lighting fixtures or from the fixture to the splice with the project branch circuit wiring shall be as specified below.
 - 2. Wiring shall be protected with tape or tubing at all points where abrasion may occur.
 - 3. Wiring shall be concealed within the fixture construction except where design or mounting dictates otherwise.
 - 4. Connections of wires to terminals of lampholders and other accessories shall be made in a neat and workmanlike manner and electrically and mechanically secure with no protruding or loose strands. The number of wires extending to or from the terminals of a lampholder or other accessory shall not exceed the number which the accessory is designed to accommodate.
 - 5. Joints in wiring within lighting fixtures and connections of the fixture wiring to the wiring of the building shall be specified in Division 16.
 - 6. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout, and all points or edges over which conductors must pass and may be subject to injury or wear shall be rounded and bushed.
 - 7. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.
 - 8. Junction boxes attached to lighting fixtures shall be manufactured in accordance with the National Electrical Code and approved for the number of conductors indicated on the drawings. Supplementary junction boxes shall be installed where required to comply with Code.

2.5 MARKING OF FIXTURES

- A. Fixtures designed for voltages other than 110-125 volts shall be marked with operating voltage.
- B. Fixtures equipped for operation of rapid start lamps shall be clearly marked "USE RAPID START LAMPS ONLY."
- C. Fixtures designed for operation of lamps below the rated enclosure maximum shall be clearly marked "Lamp Watts Not to Exceed _____" to maintain the design energy load.

2.6 LAMPS

- A. Provide lamps as shown in the fixture schedule or as modified in reviewed shop drawings.
- B. Lamps as specified for the individual luminaries or lighting equipment shall be delivered and installed in fixtures and lighting equipment leaving these completely lamped and in normal operating condition.
- C. High intensity discharge lamps, unless noted otherwise, shall be color corrected, phosphor coated, mogul base metal halide lamps. The mogul base color rendering index (CRI) shall not be less than 80 and a color shift not exceeding $\pm 400^{\circ}\text{K}$, unless otherwise specified. All medium base metal halide lamps to have a CRI of not less than 80 and color shift not exceeding $\pm 200^{\circ}\text{K}$. Refer to light fixture schedule for details.
- D. Lamps shall be by the same manufacturer and produced by the following acceptable manufacturers:
 - 1. General Electric Lighting
 - 2. Osram Sylvania, Inc.
 - 3. North American Philips Lighting
 - 4. Venture Lighting International, Inc.
 - 5. Others only where specified.

2.7 LAMPHOLDERS

- A. Lamp sockets shall be rigidly attached to fixture enclosure or housing.
- B. Incandescent and high intensity discharge lamp sockets shall be made of heavy duty heatresistant porcelain.
- C. Provide nickel plated brass or nickel and silver plated contacts in all lampholders for tungsten halogen lamps, lamps in outdoor fixtures, and mogul base incandescent, metal halide or mercury vapor lamps.
- D. All lamp sockets shall be suitable for the indicated lamps and shall be set so that lamps are positioned in optically correct relation to all lighting fixture components. All adjustable sockets shall be preset at the factory for lamp specified.

2.8 HIGH INTENSITY DISCHARGE LAMP BALLASTS

- A. All high intensity discharge lamp ballasts shall conform to the following:
 - 1. All ballasts for a particular lamp type shall be of the same manufacturer and where possible all ballasts on the projects be of the same manufacturer.

2. All ballasts shall be "Class P" indicating approved integral ballast protection. Fuses in the primary leads shall be provided in addition to the "Class P" ballast.
 3. All HID magnetic ballasts to be encapsulated and have maximum crest factor 1.6.
 4. All HID ballasts shall meet U.L. standards for "Class H" operations (180°C).
 5. U.L. and ANSI specifications with labels and/or symbols of approval by the U.L. and of certification by the Certified Ballast Manufacturers (C.B.M.) as tested by the E.T.L.
 6. The component parts shall be designed, fabricated, and assembled in accordance with the latest requirements of the N.E.C.
 7. Ballasts shall provide safe and reliable operation of the specified lamps.
 8. Approved Lamp/Ballast combinations should be used to allow for maximum energy efficiency, unless otherwise specified,
 9. Identical ballasts shall be installed within each fixture type.
 10. For HID fixtures specified with remote ballasts, the contractor shall verify and coordinate the maximum distance from lamp to ballast allowed.
 11. Fixture design, fabrication, and assembly shall be such as to prevent overheating or cycling of lamps and ballasts under normal operating temperature variations.
 12. Provide the lowest sound rating available for the lamps specified and clearly show their respective sound ratings. Ballasts found by the Architect or Engineer to be unduly noisy shall be replaced without charge prior to acceptance of the work.
 13. Ballasts intended for outdoor use shall have a minimum lamp starting temperature of 0°F, except as noted otherwise.
 14. Where ballasts are remote from fixture housing, provide suitable enclosure for installation with the conduit and wire from the ballast to the lamp socket clearly marked "Caution," "High Voltage." All remote ballasts to be installed within the recommended distance from the lamp socket as per the manufacturer with access plates for maintenance and on neoprene pads for sound absorption.
 15. Provide internal disconnecting means for ballast maintenance. Disconnecting means shall disconnect all conductors, including grounded conductor.
 16. Contractor to coordinate ballast line side voltage with branch circuit voltage as shown on Contract Drawings.
 17. Provide multitap ballasts (Mvolt) whenever offered by manufacturer.
- B. Ballasts manufactured by the following are acceptable:
1. Motorola/GE
 2. Advance
 3. Universal
 4. Osram Sylvania
 5. Approved Equal

2.9 REFLECTORS

- A. Reflectors and reflecting cones or baffles shall be as follows:
 - 1. Absolutely free of any tooling marks including spinning lines, indentations caused by riveting or other assembly techniques.
 - 2. No rivets, springs, or other hardware visible after installation.
 - 3. First quality polished, buffed and anodized finish, "Alzak" or approved equal.
 - 4. Specular finish color as selected by the Architect or as specified in the fixture schedule.
- B. Other aluminum reflectors shall be as follows:
 - 1. Formed and finished as noted on the Drawings and elsewhere in the Specification.
 - 2. Reflectors free from blemishes, scratches, or indentations which would distort their reflective function.
 - 3. Finished by means of the "Alzak" process or approved equal unless otherwise noted.

2.10 LENSES

- A. All lenses secured by positive means with neoprene or silicone gasketing or washers as required to hold the lens tight within a frame or attach to housing.
- B. All glass lenses shall be heat treated (tempered) or sealed with a clear acrylic laminate layer to provide a "safety glass" rating. All lenses which require removal for relamping or normal maintenance shall be attached to the fixture housing by a minimal length of safety chain to prohibit the lens from falling and striking surrounding surfaces.
- C. Acrylic lenses shall be 100 percent virgin acrylic polymer and colorless. For lenses with pattern of pyramids or cones, specified minimum thickness refers to distance from flat surface to base of pyramids (cones), or thickness of undisturbed material. All lenses shall be a minimum .156" thick.
- D. The quality of the raw acrylic material must exceed IES, SPI, and NEMA Specifications by at least 100 percent which, as a minimum standard, shall not exceed yellowness factor of 3 after 2,000 hours of exposure in the Fade-o-meter or as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or extruded as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years.

2.11 LIGHTING FIXTURE TYPES AND CATALOG NUMBERS

- A. General: Various fixtures types required are indicated on Lighting drawing Fixture Schedule. Fixtures must comply with minimum requirements as stated herein.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which lighting fixtures are to be installed. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF LIGHTING FIXTURES

- A. Contractor to coordinate exact quantities and critical dimension with field conditions.
- B. Contractor to verify and coordinate that appropriate framing, support structures, mounting brackets, and other required structural connections are provided by the General Contractor or other trades to insure a timely, correct and neat installation of all luminaries.
- C. Contractor to coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the luminaries. Provide each light fixture with complete installation instructions. All light fixtures to be installed in strict conformance with manufacturer's recommendations and instructions.
- D. Install lighting fixtures in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation," NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.
- E. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on UL Stds. 486A and 486B and the National Electrical Code.
- F. Fasten electrical lighting fixtures and brackets securely to indicate structural supports, including poles/standards, and ensure that installed fixtures are plum and level.

3.3 FIELD QUALITY CONTROL

- A. Replace defective and burned out lamps for 3 months following the Date of Substantial Completion.
- B. At Date of Substantial Completion, replace lamps in lighting fixtures which have been operational over 400 hours and have a lamp life of less than 4,000 hours.
 - 1. Refer to Division-1 sections for the replacement/restoration of lamps in lighting fixtures, where used for temporary lighting prior to Date of Substantial Completion.
- C. Furnish stock or replacement lamps amounting to 5%, but not less than 4 lamps in each case, of each type and size lamp used in each type fixture. Deliver replacement stock as directed to Owner's storage space.

3.4 CLEANUP

- A. Clean lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints and smudges from lenses. Two weeks prior to substantial completion, re-clean all fixtures for dust, fingerprints, and smudges from all visible parts of the fixture.
- B. Protect installed fixtures from damage during remainder of construction period.
- C. At the time of final acceptance by the Owner, all lighting fixtures shall have been thoroughly cleaned with materials and methods recommended by the manufacturers, all broken parts shall have been replaced, and all lamps shall be operative.

3.5 GROUNDING

- A. Provide equipment grounding connections for lighting fixtures as indicating. Tighten connections to comply with tightening torques specified in UL STD 486A to assure permanent and effective grounds.

3.6 DEMONSTRATION

- A. Upon completion of installation of lighting fixtures, and after building circuitry has been energized, apply electrical energy to demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION

SECTION 16470

POLES AND STANDARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.
- B. Division – 16 Basic Electrical Materials and Methods sections apply to work specified in this section.

1.2 SUMMARY

- A. The section includes not limited erecting, trenching and installation of poles and standards.
- B. Applications of lighting poles and standards specified in this section include the following:
 - 1. Automobile parking lots.
 - 2. Pedestrian walkways.
- C. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 2 Section, “Earthwork” for excavation and backfilling of poles, standards, and foundations are specified in Division 2.
 - 2. Division 3 Section, “Concrete” for embedding poles, and for pole foundations.
 - 3. Wires/cables, raceways, and electrical boxes and fittings which are required in connection with electrical poles and standards are specified in Division-16.
 - 4. Exterior lighting fixtures (luminaries) and brackets which are required in connection with electrical poles and standards are specified in another Division-16 section, “Lighting Fixtures”.

1.3 SUBMITTALS

Submit shop drawings, samples, and prototypes as specifically instructed herein and as follows:

- A. Shop drawings shall include but not be limited to:
 - 1. Submit fixture shop drawings in booklet form with a separate sheet for each fixture, assembled in “luminaire type” alphabetical or numerical order, with proposed fixture and accessories clearly indicated on each sheet.
 - 2. Manufacturer’s dimensioned scale drawings showing in complete detail, the fabrication of all electrical pole standards, arms, and hardware including overall

and detail dimensions, finishes, metal thickness, type, fabrication methods, support method, ballasts, hinges, gaskets, wind loading, wire/cable connections, and all other information to show compliance with the Contract Documents.

- B. Wiring Diagrams: Submit wiring diagrams for electrical poles and standards showing connections to electrical power panel feeders, switches, and controllers. Differentiate between portions of electrical wiring which are manufacturer-installed and portions which are field-installed.
- C. Shop drawings and samples requested shall be submitted for approval before fabrication. Any material produced prior to the approval of shop drawings or samples, and not in conformance with the Contract Documents, shall be disapproved with the Contractor bearing full responsibility and cost.
- D. No variation from the general arrangement and details indicated on the drawings shall be made on the shop drawings unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect. All variations must be clearly marked as such on the drawings submitted for approval.

1.4 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of electrical poles and standards of types and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.
- B. Installer's Qualifications: Firms with at least 5 years of successful installation experience with projects utilizing electrical pole and standard work similar to that required for this project.
- C. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirement of the authority having jurisdiction and NEC Articles 220, 225, 250, 410, and 501 as applicable to installation, and construction of electrical poles and standards.
 - 2. UL Compliance: Comply with UL standards, including UL 486A and 486B, pertaining to electrical poles and standards. Provide lighting components and fittings which are UL-listed and labeled.
 - 3. ANSI/ASTM Compliance: Comply with applicable requirements of ANSI C 2, "National Electrical Safety Code", pertaining to construction and installation of lighting poles and standards.
 - 4. ASHTO Compliance: Comply with applicable requirements of American Association of State Highway and Transportation Officials Standard LTS-1; "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals".
 - 5. NEMA Compliance: Comply with NEMA Stds Pub/No's. LE 2 and TT 1 pertaining to electrical pole and standard units, materials, and installation.

6. IES Compliance: Comply with applicable requirements of IES RP-8, "Roadway Lighting", and RP-20, "Parking Facilities Lighting".

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Deliver electrical pole and standard products, and fittings in factory-fabricated containers or wrapping, which properly protect products from damage.
- B. Store electrical pole and standard products and fittings in original cartons in wellventilated space protected from moisture, construction traffic and debris.
- C. Handle electrical pole and standard products carefully to prevent breakage, denting and scoring finish. Do not install damaged units or components; replace with new.

1.6 SEQUENCING AND SCHEDULING

- A. Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of electrical pole and standard work with other work.
- B. Sequence electrical pole and standard installation work with other work to minimize possibility of damage and soiling during remainder of construction period.

PART 2 – PRODUCTS

2.1 ELECTRICAL POLE STANDARDS

- A. Metal Lighting Standards: Provide metal, raceway-type, lighting poles and standards, of sizes and types shown on schedules, comprised of shafts and tenon joints. Equip with grounding connections readily accessible from handhole or transformer base access doors; and constructed of the following materials and additional construction features:
 1. Material: Cast aluminum - pedestrian lighting – unless otherwise shown.
 2. Configuration: Anchor base type with hand hole and cover where indicated.
 3. Configuration: Transformer base type with access door and cover.
 4. Metal Lighting Standard Accessories: Provide accessories for metal lighting standards, including anchor bolts, anchor bolt cover, as recommended by lighting standard manufacturer, of sizes and materials needed to meet erection and loading application requirements.
- B. Pole base shall be designed by a professional structural engineer licensed in the state of Colorado who is hired by the manufacturer to ensure pole base meets AASHTO requirements (i.e. 100 mph with a 1.3 gust factor).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which pole standard, equipment and components are to be installed, and substrate which will support equipment. Notify Engineer in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PARKING AREA LIGHTING

- A. Install pole and standard units and products in accordance with manufacturer's written instructions, applicable requirements of NEC, NESC and NEMA standards, and with recognized industry practices to ensure that roadway and parking area lighting equipment fulfill requirements.
- B. Utilize belt slings or rope (not chain or cable) to protect finishes when raising and setting finished poles and standards.
- C. Set poles and standards plumb. Support adequately during backfilling, or when anchoring them to the foundations.
- D. Provide sufficient space encompassing hand access and cable entrance holes for installation of underground cabling and conduit.
- E. Fasten electrical lighting fixtures and brackets securely to structural supports, including poles/standards; and ensure that installed fixtures are plum and level.
- F. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B, and the National Electrical Code.

3.3 GROUNDING

- A. Provide equipment grounding connections for poles and standards. Provide a $\frac{3}{4}$ " x 10' copper rod at each pedestrian, parking lot and street lighting pole. Connect to a #6 bare copper ground wire. Tighten connections to comply with tightening torques specified in UL 486A to assure permanent and effective grounding.

END OF SECTION

SECTION 16781

CODE BLUE RADIO

PART 1 – GENERAL

1.1 RESPONSIBLE PARTY

- A. Communication Solutions & Associates Inc. is the preferred RF Integrator for the University of Colorado Colorado Springs. All questions or correspondence regarding the scope of work described within this document shall be directed to:

Communication Solutions & Associates
384 E. Garden of the Gods Road
Unit 140
Colorado Springs, CO 80907
719 578 8435
Doug@comsolwireless.net

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including general and supplementary conditions and Division-1 Specification sections, apply to work of this section.
- B. Requirements of the following Division 16 Sections apply to this Section:
1. “Electrical Requirements.”
 2. “Basic Material and Methods”
 3. “Raceway and Boxes”
 4. “Poles and Standards”

1.2 SUMMARY

- A. Extent, Relative location, and details of the code blue radio call box and work are indicated on drawings and in schedules. Refer to Civil Plans for precise fixture locations.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Exterior RF Radio Call Box:
1. Basis of Measurement: Each.
 2. Basis of Payment: Includes enclosure, RF Radio and any associated antenna, installation to wood lighting pole (pole not in scope), accessories and connection to power source, inclusive of power transformers at the unit.

1.4 SUBMITTALS

Contractor shall coordinate shop drawings with the RF Integrator as required for a complete installation.

- A. Shop drawings shall include but not be limited to:
 - 1. The Architect/Engineer shall make the final determination as to whether or not the submittal contains sufficient information and reserves the right to request a shop drawing if the fixture cut is insufficient.
 - 2. Maintenance Data: Submit maintenance data and parts list for each call box, accessories and also include "trouble-shooting" maintenance guide. In addition to the product data and shop drawings, a maintenance manual in accordance with general requirements of Division 1 shall be provided.

1.5 QUALITY ASSURANCE

- A. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles.
- B. Materials and Equipment:
 - 1. Materials, equipment, and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standards, and as specified and as indicated on drawings. Parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the fixtures.

1.6 DELIVERY, STORAGE, HANDLING, AND WARRANTY

- A. Deliver products in factory-fabricated containers or wrappings, which properly protect product from damage.
- B. Store components in original packaging. Store inside well-ventilated area protected from weather, moisture, soiling, extreme temperature, humidity, laid flat and blocking off ground.
- C. Provide a 5-year warranty of failure in materials, workmanship, etc., in addition to and not limited to other rights the Owner may have under the contract documents. A full warranty shall apply for the first year, and a prorated warranty for the last four years.

1.7 SEQUENCING AND SCHEDULING

- A. Coordinate with other work including poles, wires/cables, electrical boxes and fittings, and raceways to properly interface installation of call box.

- B. Sequence lighting installation with other work to minimize possibility of damage and soiling during remainder of construction.

PART 2 - PRODUCTS

2.1 PRODUCT DESCRIPTION

- A. Product: Motorola AC/DC Powered ACB Call Box, **RRDN4368A**. – or approved equal.
- B. The unit shall be an easily identifiable, vandal resistant communications device that is Americans with Disabilities Act (ADA) compliant, multi-functional, wall or pole mounted and weather resistant for use in outdoor applications.

2.2 CONSTRUCTION

- A. The housing shall be fabricated of powder-coated aluminum. The unit shall be 14” W x 20” H x 7.5” deep. The faceplate shall be clear Lexan for direct access to call buttons. The bottom shall have a ¾” diameter opening for power raceway connections. The back shall have four holes for the accommodation of mounting hardware.

2.3 MOUNTING

- A. The Integrator shall supply all necessary mounting hardware (straps, anchors, etc) to attach the unit to wood lighting poles (provided elsewhere in the contract documents).

2.4 ELECTRICAL

- A. All electrical components shall have a modular plug for easy service and replacement. All electrical wiring shall be concealed within the unit and shall not be visible from the outside of the unit.
- B. All electrical components in the unit shall be equipped with a fuse for protection from transient voltage conditions.
- C. The unit will be provided with 120V AC power and the integrator shall supply and install any required power transformers as necessary.

2.5 LIGHTS - ?? Does the client desire a Light?

- A. Faceplate Light: A LED Faceplate Light shall be mounted within the unit above the recessed opening which houses the communications device. This fixture will direct light onto the communications device and shall be vandal resistant.

2.6 COMMUNICATIONS

- A. The unit shall have a high quality vandal resistant and ADA compliant speakerphone communication device.
 - 1. RF interface with UCCS Campus Motorola Two-Way Radio system.

2.7 GRAPHICS

- A. The graphics shall be a durable reflective vinyl for high visibility and legibility.
- B. Standard 11" length graphics text offering shall be:
 - EMERGENCY
 - ASSISTANCE
 - SECURITY
 - COURTESY
 - POLICE
- C. Standard graphics color offering shall be:
 - Reflective Blue
 - Reflective Black
 - Reflective Green
 - Reflective Red
 - Reflective Yellow
- D. Custom graphics text, length and color shall be available by the manufacturer.

2.8 GENERAL OPTIONS

- A. The following optional equipment shall be available for the unit by the manufacturer. Please refer to the associated Architect and Engineering Specification:
 - Remote Mount Beacon/Strobe Kit
 - Pole Mount Kit

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which lighting fixtures are to be installed. Notify Contractor in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to installer.

3.2 INSTALLATION OF LIGHTING FIXTURES

- A. Contractor to coordinate exact quantities and critical dimension with field conditions.
- B. Contractor to verify and coordinate that appropriate framing, support structures, mounting brackets, and other required structural connections are provided by the General Contractor or other trades to insure a timely, correct and neat installation of all luminaries.
- C. Contractor to coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the call box. Provide each call box with complete installation instructions.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified on UL Std. 486A and 486B and the National Electrical Code.
- E. Fasten call box and brackets securely to indicate structural supports, including poles/standards, and ensure that installed fixtures are plum and level.

3.3 CLEANUP

- A. Clean call box of dirt and construction debris upon completion of installation.

3.4 DEMONSTRATION

- A. Upon completion of installation of call box, and after circuitry has been energized, demonstrate capability and compliance with existing Two-Way Radio system. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting.

END OF SECTION