THE PORT AUTHORITY OF NY & NJ

**PROCUREMENT DEPARTMENT**
**2 MONTGOMERY STREET, THIRD FLOOR**
**JERSEY CITY, NJ 07302**

**Date: 1/9/2015**

**ADDENDUM #1**

To prospective bidders on Bid # 40999 for Traffic Signal Maintenance, Inspection and Certification, Installation, Repair and Limited Construction Services at John F. Kennedy International Airport.

Due back on January 30, 2015, no later than 11:00AM

## I. CHANGES/MODIFICATIONS

**The following changes/modifications are hereby made to the solicitation document:**

*"The PANYNJ specifications included in this addendum are noted in Attachment C and are attached for reference purposes"*

This communication should be initialed by you and annexed to your bid upon submission.

In case any bidder fails to conform to these instructions, its bid will nevertheless be construed as though this communication had been so physically annexed and initialed.

THE PORT AUTHORITY OF NY & NJ

Kathy Leslie-Whelan, Assistant Director
Commodities and Services Assignments

BIDDER'S FIRM NAME: _____

INITIALED: _____

DATE: _____

QUESTIONS CONCERNING THIS ADDENDUM MAY BE ADDRESSED TO Dinesh Chheda, WHO CAN BE REACHED AT (201) 395-3432 or at dchheda@panynj.gov.

PS11All

# DIVISION 2

# SECTION 02221

# EXCAVATION, BACKFILLING AND FILLING

## PART 1. GENERAL

### 1.01 SUMMARY

A. This Section specifies requirements for excavation, backfilling and filling.

B. Definitions

1. As used herein, excavation shall mean the removal of existing pavement, concrete foundations and all materials other than bedrock (ledge rock) encountered within the limits of excavation that are not specified to be removed under Division 2 Section entitled "CUTTING, PATCHING AND REMOVAL".

2. As used herein, backfilling shall mean the filling of excavations made for construction purposes and shall extend only to existing grades or design grades, whichever are lower.

3. As used herein, filling shall mean the placement of fill material in conformance with requirements of this Section at or above existing grade or design grade, whichever is lower.

4. As used herein, suitable shall mean material conforming to the gradation, compaction, and environmental requirements of this Section.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM International)

| | |
|---|---|
| ASTM C 88 | Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate. |
| ASTM C 117 | Test Method for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing. |
| ASTM C 131 | Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. |
| ASTM C 136 | Test Method for Sieve Analysis of Fine and Coarse Aggregates. |
| ASTM D 422 | Standard Test Method for Particle-Size Analysis of Soils. |
| ASTM D 1556 | Standard Test Method for Density of Soil in Place by the Sand-Cone Method. |
| ASTM C 1557 | Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 or 2,700 kN-m/m3). |

| | |
|---|---|
| ASTM D 2167 | Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method. |
| ASTM D 2922 | Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). |
| ASTM D 3017 | Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth). |
| ASTM D 4318 | Standard Test Method for Liquid Limit, Plastic Limit and Plasticity Index of Soils. |

New Jersey Interagency Engineering Committee (NJIEC)

Standard Soil Aggregate Gradations.

## 1.03 QUALITY ASSURANCE

A. Where sheet piling or sheeting is required or is shown on the Contract Drawings, shop drawings and calculations shall be prepared, signed and sealed by a Professional Engineer, licensed in the State in which the work will be performed, who has a minimum of five years experience in the design of soil retaining structures.

## 1.04 SITE CONDITIONS

A. Protect excavations as follows:

1. Prevent water from entering excavated areas and, if it does, remove it immediately to maintain a dry condition at all times.
2. Dispose of water in a manner not to cause injury to the public health or damage to public or private property.
3. If water enters excavated areas and weakens or disturbs underlying soil, remove the weakened or disturbed soil and replace it in conformance with 3.02 A.5.
4. Where shown on the Contract Drawings or where required for protection of adjacent utilities or structures or where required for performance of the Work, secure the sides of excavations against movement as follows:
   a. Install sheet piling or sheeting held in place by waling and bracing members. Top of sheeting shall extend at least six inches above ground or as otherwise shown on the Contract Drawings.
   b. Do not excavate below the bottom of sheet piling or sheeting except as necessary to install sheeting.
   c. Fill voids behind sheeting immediately with material conforming to I-12 designation defined in 2.01 A or with other material as otherwise approved by the Engineer.
   d. Comply with all other requirements of the Specifications that may impose additional or stricter requirements.
5. For excavations extending to a depth of 5 feet or more, and where sheeting is not required to conform with 1.04 A.4 above, excavate slopes to a safe angle of repose, or protect trench excavations by use of a portable trench shield.
6. Restore all areas impacted by excavation to their original condition, matching pavement types and sections to meet original pavement grades.

B. Do not traverse paved areas with tracked vehicles or equipment, such as carry-all scrapers, which may damage such pavement unless protected to the satisfaction of the Engineer.

C. Do not place fill or backfill on frozen subgrade.

D. Do not perform rolling or other compaction at any time when the ground water level is above a plane two feet below the surface to be compacted. When the ground water level is above such plane, lower it by approved methods and maintain it below such level prior to and during the compaction operations.

E. Protect from damage trees and other vegetation that are to remain in place.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

2.01 MATERIALS

A. Fill

1. Unless otherwise shown on the Contract Drawings, fill shall consist of clean sand and gravel containing no organic matter, conforming to the following NJIEC "Standard Soil Aggregate Gradations", except that in lieu of the standard gradation given below, up to 10 percent passing the No. 200 sieve will be acceptable as I-12:

| | Total Percent Passing by Weight NJIEC Designation | | |
|---|---|---|---|
| | I-7 | I-10 | I-12 |
| Sieve Sizes | | | |
| 4 inch | | 100 | 100 |
| 2 inch | | 80-100 | |
| 1 inch | 100 | | |
| 3/4 inch | | 60-100 | 70-100 |
| 1/2 inch | 80-100 | | |
| No. 4 | | 40-100 | |
| No. 8 | 35-100 | | |
| No. 16 | 25-90 | 20-70 | |
| No. 50 | 5-50 | 5-40 | 0-75 |
| No. 100 | 0-8 | 0-30 | |
| No. 200 | 0-2 | 0-20 | 0-5 |

2. The clean sand and gravel shall not contain more than 0.1% of Wood; 4% of Brick, Mica Schist, or other friable material; or 10% of asphalt concrete. The total of all of these components shall be less than 10%. The Contractor shall submit to the Engineer a "Certificate of Clean Fill" for all imported fill materials.

3. Comply with fill designations shown on the Contract Drawings and place designated fill in the locations shown.

B. Backfill

1. Unless otherwise shown on the Contract Drawings, material shall conform to the requirements for I-12 designation.

C. Sources

1. When fill and backfill material are furnished by the Authority, refer to the Contract Drawings for the location of the existing stockpile, the NJIEC Designation (if applicable), and the estimated quantity of available material. Samples of Authority-furnished material will not be required for testing.

2. Unless otherwise approved by the Engineer, material excavated at the construction site shall be used only for backfill and shall be used to the extent that it conforms to the requirements specified in 2.01 A and as noted on Contract Drawings. Submit samples for testing by the Engineer for verification of conformance with the requirements of this Section.

3. If sufficient quantities of suitable material are unavailable from sources described in 2.01 C.1 and C.2 above, furnish material from sources off site, as directed by the Engineer. The Contractor will be compensated for the cost of furnishing only (excluding cost of placing and compacting the fill and backfill) such fill or backfill material from sources off site at the "Net Cost" thereof.

D. Recycled Concrete Aggregate

Recycled Concrete Aggregate (RCA) conforming to the requirements given below and to the gradations specified in 2.01 A.1 may be used as fill or backfill.

1. The RCA shall consist of at least 90 percent, by weight, Portland cement concrete, with the following materials making up the remaining 10 percent:

   a. Wood: 0.1 percent, maximum.

   b. Brick, Mica schist, or other friable material: 4 percent, maximum.

   c. Asphalt Concrete: 10 percent, maximum.

2. Virgin aggregate may be added to meet the 90 percent minimum concrete requirement.

3. The percentage of asphalt concrete and other deleterious material shall be determined by weighing that material retained on the No. 4 sieve, and dividing by the total weight of RCA material retained on the No. 4 sieve.

4. Soundness of Aggregates

   Loss limitation shall not be more than 10 percent loss by weight, using sodium sulfate for 5-cycle test period, or not more than 15 percent loss by weight, using magnesium sulfate for a 5-cycle test period as determined by ASTM C 88.

5. Resistance to Degradation

   Percentage loss between the original weight and the final weight of the test sample shall not exceed 45 percent as determined by ASTM C 131.

6. RCA, if used, shall be from permitted or State registered Construction and Demolition Debris Processing Facilities (C&DDPF). Obtain and submit a copy of the permit or registration to the Engineer.

   a. In New York, the source of the RCA shall be C&DDPF conforming to 6 NYSRR Part 360-16: Construction and Demolition Debris Processing Facilities.

   b. In New Jersey, the source of the RCA shall be a Class B C&DDPF conforming to NJAC - Title 7: Environmental Protection; Chapter 26A: Recycling Rules.

E. Environmental Compliance

1. Fill material brought on site must meet residential use criteria for the State in which it is used. Sample and analyze all fill material brought on site, according to the following criteria, to characterize potential contaminants and to demonstrate all contaminants are below the State's residential use clean up criteria or remediation standard threshholds.

   a. Up to 1,000 cubic yards, collect a minimum of two grab samples.

   b. Greater than 1,000 cubic yards up to 10,000 cubic yards, collect a minimum of one grab sample for every 500 cubic yards.

   c. For volumes greater than 10,000 cubic yards, follow the sampling frequency specified above and collect one grab sample per each additional 1,000 cubic yards.

   d. Analyze all samples for all parameters included in the State's residential use clean up criteria or remediation standards.

   e. Each firm and laboratory performing the sampling and analysis shall be certified and/or licensed to perform such work in the State the fill material will be used.

2. Submit to the Engineer for approval three copies of a Clean Fill Certification Report signed by a Professional Engineer licensed in the State in which the fill material will be used. The report shall include the following:

   a. Quantity of fill material for use and certification that it meets the residential use criteria.

   b. Location information for each facility supplying the fill material, including State, County, Municipality, address, and Block and Lot numbers.

   c. A copy of the current State permit for each facility supplying fill material that indicates the material produced will meet residential use criteria and a contact name, title and phone number for the facility representative responsible for permit compliance.

   d. Name, contact information, and copies of certifications and/or licenses for each entity performing the sampling and laboratory analysis. Include a signed statement by an officer of each laboratory certifying that all sampling and analysis was performed by licensed or certified personnel and in accordance with applicable State regulations, manuals, and guidance documents.

   e. A sampling plan for the samples collected, including a sample location drawing, and a completed chain of custody for the samples.

f. A summary data table, in Excel spreadsheet format, of sample analytical results compared to State residential use clean up criteria or remediation standards. The table shall present for each sample the parameters analyzed, analytical method, sample date, sample identification number, results, reporting detection limits, and units.

g. A copy of the complete laboratory report in PDF format on "read only" disc signed and sealed by the responsible individual of the laboratory completing the analyses.

h. A signed statement from the Professional Engineer certifying that this report, to the best of their knowledge, is accurate and is representative of the fill material specified herein, and that the fill material does not exceed the residential use clean up criteria or remediation standard threshholds for the State in which it will be used.

3. At the Engineer's discretion, the Engineer will perform quality assurance testing of fill material brought to the site to confirm compliance with the specified requirements. Remove and replace, at no additional cost to the Authority, fill material determined by the Engineer to be not in compliance.

4. The allowance of a small percentage of asphalt concrete in fill and RCA materials shall not be construed as a contradiction to the above requirements. If the composition of the asphalt concrete is such that the limits given in the residential use criteria for the State in which it is used are exceeded, submit material from an alternate source.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Clearing and Grubbing

Remove trees, clear and grub areas to be excavated or in which construction is to be performed, as follows:

1. Remove trees, stumps, all roots larger than 2 inches in diameter, and all matted root systems.

2. Remove all topsoil, debris, organic matter and any other objectionable material not suitable for use as backfill or fill or for support of structures or pavements.

3. Backfill all holes and other low spots resulting from clearing and grubbing with material conforming to 2.01 B or 2.01 D before proceeding with compaction of fill as specified in 3.03 or with other construction in the area.

### 3.02 EXCAVATION

A. General

1. Excavation shall consist of the removal of materials as defined in 1.01 B.1, and the removed materials shall be segregated by material type (e.g., sand fill, miscellaneous fill, sand, gravel, clay) and stockpiled at the location shown on the Contract Drawings.

2. When excavation of bedrock (ledge rock) is shown on the Contract Drawings, refer to Division 2 Section entitled "ROCK EXCAVATION" for removal requirements.

3. Excavate to elevations required for installation of permanent construction in such manner as not to disturb the subgrade below such elevations.

4. Where existing foundations or other existing construction are encountered which may cause hard spots, remove them to a minimum of two feet below subgrade for pavement or structures and backfill with material conforming to 2.01 B or 2.01 D.

5. Should the bottom of excavation be weakened or disturbed or carried below required depth:

   a. Under Footings: Compact bottom as specified in 3.03 below and replace over-excavation with the same concrete as that specified for the footing or foundation.

   b. Locations other than Under Footings: Compact bottom as approved by the Engineer and refill with material conforming to 2.01 B or 2.01 D.

6. Perform excavation around and adjacent to existing structures, pipes and conduits which are to remain in place, without damage to or movement of existing construction. Use hand excavation to locate and expose near-surface structures, pipes and conduits. When excavation is to be performed under such structures, pipes and conduits, support them in a manner as approved by the Engineer to ensure uninterrupted operation of the supported items.

B. Dewatering

1. Where excavations are to extend below the water table, prior to placement of any permanent construction or filling or backfilling any excavated area, lower the water table in such an area to two feet below the elevation of the required subgrade and maintain this condition until the construction or pavement is placed thereon.

2. Dewater in a manner to prevent the loss of ground due to the migration of soil fines into the dewatering system.

C. Trenching for Utilities

1. Shape bottom of trench to uniform invert section.

2. When excavating in soft soils which may be subject to lateral movement or bottom heave, conform to requirements shown on the Contract Drawings.

D. Disposal of Excavated Material

1. All debris and all material either unsuitable for or in excess of that required for backfill or fill, shall be reused, recycled or disposed of away from the construction site in accordance with Division 1 Section entitled "Recycling of Construction Debris Material".

E. Restrictions

1. Do not place backfill until the Engineer has inspected and approved the Work and has indicated where backfill may be placed.

2. Leave all pipe joints exposed until all tests, required by other Sections of the Specifications on such pipe, have been performed.

3. Remove all temporary structures, sheet piles, sheeting, bracing and forms and all organic materials and debris of every nature, taking care, upon the removal of sheet piling, sheeting and temporary supports, not to cause movement of adjacent ground or structures or create the danger of a slide.

## 3.03 PLACEMENT AND COMPACTION

A. Equipment

1. Steel vibratory rollers shall have provision for regulation of vibration frequency. Submit and obtain Engineer approval of the type and size of compaction, placing and spreading equipment to be used before the start of any compaction efforts.
2. Unless otherwise shown on the Contract Drawings, pneumatic-tired rollers shall have minimum weight of 20 tons and a tire pressure of between 60 and 150 psi. For aircraft pavements, the minimum roller weight shall be 50 tons.
3. When mechanical tampers are used, submit and obtain Engineer approval of the type and size of tamper before compaction efforts begin.

B. Subgrade, Excavated and Existing Surfaces

Compaction of subgrade, excavated and existing surfaces shall consist of a proofrolling operation performed as follows, unless otherwise shown on the Contract Drawings that proofrolling is not required:

1. Compact surface with a minimum of six passes of an approved vibratory steel roller operated at a speed not to exceed three miles per hour and at the optimum operating frequency recommended by the manufacturer. Overlap passes of roller a minimum of six inches.
2. In areas where surface consists of a fine grained soil, compact with a minimum of six passes of an approved pneumatic-tired roller. Overlap passes of roller a minimum of six inches.
3. In areas where use of a roller is impractical, compact surface while at or near optimum moisture content with mechanical tampers.
4. If, in the sole determination of the Engineer, the proofrolling produces noticeable weaving of the surface, excavation of unsuitable material and replacement with backfill may be required below subgrade, within the limits and to the depth as directed by the Engineer. The Contractor will compensated for any such excavation of unsuitable material below the elevation of subgrade or under footing and subsequent backfilling at the "Net Cost" thereof.

C. Backfill and Fill

1. Moisture content of backfill and fill material shall be within a range of plus or minus two percent of optimum, as determined by Procedure C of ASTM D 1557.
2. Backfill and fill shall be compacted to achieve a density of 95 percent of the maximum density as determined by Procedure C of ASTM D 1557, except where alternate density requirements are approved by the Engineer or shown on the Contract Drawings.

3. Backfill conforming with I-12 gradation, and fill conforming with I-7 and I-12 gradation, shall be placed in 14-inch, loose layers. In areas where a 14-inch layer over existing material is not adequate to support the construction equipment, increase thickness of first lift as approved by the Engineer.

4. When shown on the Contract Drawings, backfill and fill, conforming to I-10 gradation, shall be placed in 12-inch, loose layers.

5. In areas adjacent to structures and utilities as shown on the Contract Drawings, compaction equipment shall be restricted as shown on the Contract Drawings.

6. In areas where use of a roller is impractical, place fill in maximum 8-inch, loose layers and compact with approved mechanical tampers to the specified density. In pipe trenches, each layer of backfill shall be not more than 8 inches in thickness before compaction. Place backfill on both sides of the pipe, simultaneously.

7. The surface of filled or backfilled areas, which are to receive pavement or on which a structure is to be placed, shall be within plus or minus 1/2 inch of the elevations shown on the Contract Drawings and shall be free of depressions or projections greater than 1/2 inch when tested with a 16-foot straight edge.

8. The surface of filled areas at other locations shall be within plus or minus one inch of elevations shown on the Contract Drawings unless a closer tolerance is necessary to meet requirements of other Sections of the Specifications or meet requirements shown on the Contract Drawings.

## 3.04 QUALITY CONTROL

A. Field Inspection and Testing - General

1. The Engineer will test delivered field samples of material submitted from each source, for conformance with 2.01. Gradation will be determined in accordance with ASTM C 117, C 136 and D 422 and maximum density will be determined in accordance with Procedure C of ASTM D 1557. If deemed appropriate by the Engineer, Atterberg Limits will be determined on fine-grained soils in accordance with ASTM D 4318.

   a. Notify the Engineer when backfill and fill material are on site at least seven days prior to placement to allow sufficient time for testing.

   b. If the Engineer's maximum density will be used for QC testing, the Contractor must first obtain this laboratory value from the Engineer prior to placement.

2. If the sample from a source is approved, upon the Engineer's request, conduct the Engineer to that source. Additional samples will be selected and tested by the Engineer.

3. The Engineer will notify the Contractor of approval of material source within seven days after receiving samples. Approval of a source of backfill or fill material will be subject to material continuing to meet the requirements of 2.01.

4. Do not deliver any material until the Engineer has reviewed and approved material supplier and source submittal. Delivered material must receive on-site approval prior to use.

5. The Engineer will check conformance to elevations shown on the Contract Drawings and required tolerance for surface straightness.

6. Provide labor and equipment to take samples as directed and to assist the Engineer in other tests.

B. Testing Requirements for Fill and Backfill

Testing will include control tests by the Engineer, quality control testing by the Contractor, and quality assurance testing by the Engineer. Testing frequencies are dependent on the type of fill or backfill, the nature and size of the installation, and the structural significance of the installation. The minimum frequency of testing shall be as shown on the Contract Drawings.

1. Control Tests

a. Fill and backfill material field samples will be tested in the laboratory by the Engineer at the frequency shown on the Contract Drawings. These control tests consist of determining maximum density and optimum water content by Procedure C of ASTM D 1557, and gradation by ASTM C117, C136, and D 422. When deemed appropriate by the Engineer, Atterberg Limits will be determined on fine-grained soils in accordance with ASTM D 4318.

2. Quality Control Testing by the Contractor

a. Implement and maintain quality control plans and procedures that ensure all fill and backfill materials and completed construction conform to this Section. The Engineer shall be permitted access to the Contractor's plant, equipment and field operations at all times for checking compliance with the approved quality control procedures. Provide labor and equipment to take samples as directed and assist the Engineer in other tests. Repair all areas from which samples are taken to meet all requirements of this Section.

b. Perform quality control consisting of in-place density testing to determine densities achieved after compaction efforts. The frequency of testing shall be as shown on the Contract Drawings.

c. The quality control plan shall include as a minimum:

(1) Assignment of quality control responsibility to specifically-named individuals.

(2) Outline of sampling location procedures and in-place density testing methodologies and frequencies.

(3) Performance of regularly scheduled inspections of the material source in the case of RCA.

(4) Provisions for the prompt implementation of control and corrective measures.

(5) Provisions for liaison with the Engineer at all times.

(6) Performance of necessary quality control tests, including use of a nuclear gauge.

(7) Description of equipment type, calibration and maintenance; operator identity and qualifications.

d. For RCA, quality control procedures shall include, in addition to that required under 3.04 B.2.b, performing the following tests on dedicated stockpiles being produced for use under this Contract:

(1) Gradation tests (ASTM C 117 and C 136) shall be performed at least once per day.

(2) Composition tests shall be a continuous visual inspection and shall include removal of any objectionable material to ensure compliance with 2.01 B.

(3) Soundness of Aggregates (ASTM C 88) and Resistance to Degradation (ASTM C 131) shall be performed a minimum of once every two weeks, unless otherwise directed by the Engineer.

The size of the stockpiles shall be as shown on the Contract Drawings.

3. Quality Assurance Testing

a. Quality Assurance testing to verify field densities will be performed by the Engineer after compaction operations, at the frequencies shown on the Contract Drawings. Test methods may be either sand-cone (ASTM D 1556), rubber balloon (ASTM D 2167), or nuclear device (ASTM D 2922), with moisture content for nuclear method determined by ASTM D 3017. Tests will measure the density of the layer immediately below each compacted layer and the density of the uppermost or final layer.

b. Quality Assurance testing will also include periodic sampling and testing of backfill and fill materials to verify continued conformance with the requirements of 2.01 and to verify the value of maximum density used as the control value, as per 3.04 B.3.d.

c. When performing Quality Assurance testing, the Engineer will determine the density of compacted fill or backfill by in-place density tests or from undisturbed samples cut from the compacted fill or backfill as required. Notify the Engineer 72 hours prior to start of filling or backfilling to allow the Engineer time to make provisions for such testing.

d. To evaluate whether material has been compacted to specified density the Engineer will compare results of in-place density tests with results of control tests on material of the same designation using Procedure C of ASTM D 1557.

e. If fill or backfill have not been sufficiently compacted as determined by in-place density tests, the Contractor shall continue compaction effort and shall adjust the moisture content as necessary until the specified compaction is obtained, at no additional cost to the Authority.

END OF SECTION

## SECTION 02221

## EXCAVATION, BACKFILLING AND FILLING

## APPENDIX "A"

## SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Where sheet piling or sheeting is required or is shown on the Contract Drawings, submit detailed shop drawings and design calculations of the sheeting and bracing system to the Engineer for review. Submit such drawings and calculations three weeks prior to commencement of such excavation.

B. Product Data

1. Submit to the Chief of Materials Engineering, Materials Engineering Unit, Port Authority Technical Center, 241 Erie Street, Jersey City, N.J. 07310-1397, material suppliers and sources for each designation of fill or backfill used under this Contract. Include, at a minimum, the Contract location, title and number; designation of intended material use; and source and supplier of material. Submit such information at least three weeks prior to delivery of material to the site.

2. Submit a description and complete specification of the compaction equipment in accordance with 3.03 A.

C. Certificates

Submit three copies of a "Clean Fill Certification Report" and a "Certificate of Clean Fill" for all imported fill materials.

D. Quality Assurance-Quality Control

Submit a Quality Control Plan for review and approval by the Engineer in accordance with 3.04 B.2.

END OF APPENDIX "A"

# SECTION 02221

# EXCAVATION, BACKFILLING AND FILLING

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (1.01 B) | Existing grades. |
| (1.04 A.4) | Location of sheeting or sheet piling where required by the Contract to protect pavement, utilities and structures impacted by excavation, or to prevent bottom heave of the excavation. |
| (1.04 A.6) | Existing conditions adjacent to required excavations. |
| (2.01 A.1; 2.01 B.1) | Where the material excavated from the construction site will consist of hydraulic sand fill, place note on Contract Drawings stating that such excavated sand may be used for fill and backfill to the extent that it is free of extraneous materials. Similar to the requirements of 2.01 C.1, submission and testing of samples is not normally required. |
| (2.01 A.3) | Locations in which fill or backfill is required conforming with the following designation:<br>I - 7 Drainage Layer<br>I - 10 Embankment Fill<br>I - 12 Fill and Backfill<br>Provide for use of alternate materials, if job requirements permit less restrictive gradation(s). |
| (2.01 C.1) | Indicate if stockpile for fill and/or backfill, is available, with NJIEC designation (if applicable). Verify that stockpiled material is satisfactory. Show estimated volume of available material. |
| (2.01 C.2) | Provide notes on Contract Drawings, if material excavated can be used for fill or backfill even if it may not conform with the requirements specified as I-7, I-10, or I-12 but is acceptable for special condition and situation that provide construction cost savings. |
| (3.02 A.1) | Show stockpile areas on Contract Drawings for the segregated suitable or unsuitable materials. |
| (3.02 A.2) | Approximate profile of top of ledge rock, if rock excavation is required. |
| (3.02 C) | Location where prevention of lateral movement or bottom heave of soft soils is required. Include standard drawing detail. |
| (3.02 D) | If facility wants to stockpile fill, discuss changes to Contract language with Contract Engineer. |

| | |
|---|---|
| (3.03 B) | If proofrolling is not required, indicate "PROOFROLLING NOT REQUIRED" on the Contract Drawings. |
| (3.03 C.2) | Locations where alternate density is permitted or required. |
| (3.03 C.4) | Locations where I-10 material may be used. |
| (3.03 C.5) | Locations where compaction equipment are restricted. |
| (3.03 C 7, 8) | Design grades (elevations) where excavation fill or backfill is required. |
| (3.03 4 B.1) | Frequency of control tests in laboratory. |
| (3.04 B.2.b) | Frequency of in-place density tests and required length of trench. |
| | For suggested frequency of laboratory control tests (3.04 B.1) and in-place density tests (3.04 B.3.a), refer to Materials Engineering Unit Operation Bulletin entitled "Testing Procedures and Frequency for Fill and Backfill Materials". |
| (3.04 B.2.d) | Size of stockpiles and frequency of testing for RCA fill and backfill. |
| (3.04 B.3.a) | Frequency of Quality Assurance Testing to verify field density. |

B. Other Items

Ensure that the following Specification Sections are included in the Contract booklet as required:

| | |
|---|---|
| (1.01 B.1) | Division 2 Section on "CUTTING, PATCHING AND REMOVAL". |
| (3.02 A.2) | Division 2 Section on "ROCK EXCAVATION". |

END OF INSTRUCTIONS

# DIVISION 2

# SECTION 02231

# AGGREGATE BASE COURSE

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for dense graded aggregate base course (DGABC) and open graded aggregate base course (OGABC) each where shown on the Contract Drawings including the use of recycled concrete aggregate (RCA) as an alternate for virgin aggregate.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM C 88 | Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate |
| ASTM C 117 | Test Method for Material Finer than 0.075 mm (No. 200) Sieve in Mineral Aggregate by Washing |
| ASTM C 131 | Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C 136 | Method for Sieve Analysis of Fine and Coarse Aggregates |
| ASTM D 1556 | Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method |
| ASTM D 1557 | Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$(2,700 kN m/m$^3$)) |
| ASTM D 1883 | Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils |
| ASTM D 2167 | Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method |
| ASTM D 2434 | Test Method for Permeability of Granular Soils (Constant Head) |
| ASTM D 2922 | Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth) |
| ASTM D 3017 | Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth) |
| ASTM D 3665 | Practice for Random Sampling of Construction Materials |
| ASTM D 4318 | Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils |

## 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Job Conditions

1. Aggregate Base Course shall not be placed or spread unless subgrade is free of frost and standing water.

2. Do not place aggregate base course, or perform any compaction operations when ground water level is above a plane two feet below the bottom of the base course. This condition would be indicated by existing water level readings, known site conditions or by the results of probes performed by the Contractor before material placement.

3. When necessary, lower and maintain ground water below the required plane by methods approved by the Engineer.

B. Design and Tolerance

1. The compacted base course, shall have a minimum California Bearing Ratio (CBR) of 80 as determined by ASTM D 1883. In the case of open graded aggregate base course the permeability, as tested in accordance with ASTM D 2434, shall be a minimum of $1.0 \times 10^{-3}$ centimeters per second.

2. Surface of the base course shall be within plus or minus 1/2 inch of elevations shown on the Contract Drawings and free of depressions or projections greater than 3/8 inch when tested with a 16-foot straight edge applied parallel with or at right angles to the centerline.

3. Thickness of base course at any point shall not be deficient by more than 1/2 inch from the required thickness shown on the Contract Drawings.

4. The field density of the base course after compaction shall be at least 95 percent (100 percent for runways, taxiways and aprons) of the maximum density as determined by Procedure "C" of ASTM D 1557, with the exception that base course material passing the 1-1/2-inch sieve shall be used instead of the material passing the 3/4-inch sieve specified.

## 1.04 QUALITY CONTROL AND ASSURANCE

A. Provide and maintain quality control plans and procedures that shall ensure all base course materials and completed construction conform to this Section. The Engineer shall be afforded access to the Contractor's plant, equipment and field operations at all times for checking compliance with the approved quality control procedures. Provide labor and equipment to take samples as directed and assist the Engineer in other tests. Repair all areas from which samples are taken to meet all requirements of this Section.

B. The quality control plan shall include as a minimum:

1. Assignment of quality control responsibility to specifically-named individuals.

2. Outline of sampling location procedures and in-place density testing methodologies.

3. Performance of regularly scheduled inspections of the material source in the case of RCA.

4. Provisions for the prompt implementation of control and corrective measures.

5. Provisions for liaison with the Engineer at all times

6. Performance of necessary quality control tests, including use of a nuclear gauge.

C. For RCA, Quality Control procedures shall include performing the following tests on dedicated stockpiles being produced for use under this Contract:

1. Gradation tests (ASTM C 117 and C 136) shall be performed at least once per day.

2. Composition tests shall be a continuous visual inspection and shall include removal of any objectionable material to ensure compliance with 2.01B.

3. Soundness of Aggregates (ASTM C 88) and Resistance to Degradation (ASTM C 131) shall be performed a minimum of once every two weeks, unless otherwise directed by the Engineer.

D. For Contracts requiring over 500 cubic yards of aggregate base course, and where otherwise directed by the Engineer, select an area from the first day's production to be called a control strip. The control strip shall be a minimum of 2500 square feet and shall be constructed to meet the requirements of this section and in the same manner as the remainder of the course it represents. The purpose of the control strip is to have the contractor establish the compaction pattern, methods and effort required to achieve the quality requirements and to calibrate the Contractor's nuclear gage. Additional control strips shall be constructed whenever a significant change occurs in the type or source of the material and whenever a significant change occurs in the composition of the material from the same source.

E. Engineer's Sampling and Testing

1. The Engineer may elect to inspect, test, and approve aggregate base course at the source. At least five days prior to delivery of material to site, the Engineer shall be notified.

2. Base course material delivered to the construction site will be sampled and tested by the Engineer for conformance to the requirements specified in 2.01 A copy of the test analyses will be on file with the Engineer. The samples will be taken from stockpiles on site, prior to material placement operations. Minimum testing frequencies will be as follows:

<u>Aggregate Base Course Using Virgin Aggregate</u>

| | |
|---|---|
| Gradation | 1 test per Lot |
| Moisture-Density | |
| Proctor Test | 1 test per Lot |

A Lot shall be defined as one day's production but no more than 400 cubic yards.

<u>Aggregate Base Course Using Recycled Concrete Aggregate</u>

| | |
|---|---|
| Gradation | 4 tests per Lot (one test from each sublot) |
| Moisture-Density | |
| Proctor Test | 4 tests per Lot |
| Composition | 4 tests per Lot |

3. The Engineer will check base course thickness at least once every 2500 sq. ft.

4. The Engineer will determine field density of compacted base course from in-place density tests. Frequency of testing will be at least one test every 2500 square feet per lift. Locations of random sampling shall be determined in accordance with ASTM D 3665. The in-place field density shall be determined in accordance with ASTM D 2922 and ASTM D 3017, or ASTM D 2167, or ASTM D 1556.

5. The Engineer will check conformance to elevations required by the Contract Drawings and required tolerance for surface straightness.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

2.01 MATERIALS

A. Virgin aggregate for base course shall be quarry processed, crushed dolomite, limestone, gneiss, or trap rock free from coatings of clay, silt, vegetable matter, and other objectionable materials, and shall contain no clay balls.

B. Recycled concrete aggregate for base course shall be as follows:

1. The RCA shall consist of at least 90 percent, by weight, Portland cement concrete, with the following materials making up the remaining 10 percent:

   Wood-0.1%, maximum
   Brick, Mica schist, or other friable material-4%, maximum
   Asphalt Concrete-10%, maximum

2. Virgin aggregate may be added to meet the 90% minimum concrete requirement.

3. The percentage of asphalt concrete and other deleterious material shall be determined by weighing that material retained on the No. 4 sieve, and dividing by the total weight of RCA material retained on the No. 4 sieve.

C. Gradation for aggregate base course shall be as follows:

1.

| | Percentage Passing By Weight | |
|---|---|---|
| Sieve Size | DGABC | OGABC |
| 1 1/2" | 100 | 100 |
| 3/4" | 55-90 | 60-95 |
| 3/8" | | 40-80 |
| No.4 | 25-60 | 15-35 |
| No. 50 | 5-25 | 8-20 |
| No. 200 | 3-12 | 0-7 |

2. The portion passing the No. 40 sieve shall be non-plastic when tested in accordance with ASTM D 4318.

3. The aggregate base course shall have not less than 90% by weight with at least two fractured faces and 100% with at least one fractured face, and with a maximum of 7% of flat or elongated pieces. A flat piece is one having a ratio of length to width greater than five.

D. Soundness of Aggregates:

Loss limitation shall not be more than 10% loss by weight, using sodium sulfate for 5-cycle test period, or not more than 15% loss by weight, using magnesium sulfate for a 5-cycle test period as determined by ASTM C 88.

E. Resistance to Degradation:

Percentage loss between the original weight and the final weight of the test sample, shall not exceed 45% as determined by ASTM C 131.

F. Recycled Concrete Aggregate Stockpile Approval:

RCA will be sampled from lots as specified in 1.04 E.2. Each sublot of each lot shall meet all applicable test requirements of this Section. If any one sublot does not meet these requirements, the entire lot will be disapproved and shall not be used for the purposes of this Contract.

The Engineer will approve or disapprove the RCA within 4 days after sampling, unless the Engineer determines that soundness of aggregate or resistance to degradation tests specified in this Section 2.01 are required, in which case 21 days will be required for approval or disapproval. Do not deliver RCA until it has been approved by the Engineer.

After a lot has been approved, no additional material shall be added to the lot stockpile until that stockpile is exhausted. Any new stockpile formed shall be subject to testing and acceptance as described above.

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. Equipment

1. Placing and spreading equipment shall be approved by the Engineer and be capable of spreading material without segregation of aggregate sizes.
2. Steel vibratory rollers to be used for compaction, shall have provision for regulation of vibration frequency. Pneumatic rubber-tired rollers shall have a minimum weight of 20 tons and tire pressure of between 60 and 150 psi, as directed by the Engineer. All compaction equipment, including mechanical tampers when proposed, is subject to review an approval by Engineer.

B. Preparation of Subgrade

1. Verify that job conditions specified in 1.03 A have been met and there are no high points in the subgrade which would interfere with meeting the tolerance requirements specified in 1.03 B.
2. For granular subgrades, compact subgrade with a minimum of 6 passes of an approved vibratory steel roller, operating at the optimum operating frequency as recommended by the manufacturer.
3. For fine-grained soil subgrades, compact subgrade with a minimum of 6 passes of an approved pneumatic rubber-tired roller.

4. Rollers shall be operated at a speed not to exceed 3 miles per hour. Roller passes shall be overlapped a minimum of 6 inches.

5. All subgrade compaction operations shall be performed at or near optimum moisture content. In areas where use of a roller is impractical, compact subgrade with approved mechanical tampers.

6. Provide grade control as follows:

   a. Set grade stakes on a rectangular grid not more than 25 feet on centers.

   b. After firmly driving stakes, offset mark each 6 inches above the top of base course.

   c. Maintain stakes during placement and compaction of base course.

C. Placement and Compaction

1. Place base course materials evenly over the prepared subgrade with approved spreading equipment. In multi-layer construction, the previously constructed layer should be cleaned of loose of foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered by the next layer.

2. When spread, base course materials shall be at or near optimum moisture content and of a thickness such that the maximum depth of a compacted layer shall be 6 inches. In multi-layer construction, the base course shall be placed in approximately equal-depth layers.

3. Compact immediately after spreading, while at or near optimum moisture content, by rolling. The number, type and weight of rollers shall be sufficient to compact the material to the required density.

4. In areas where use of rollers is impractical, compact with manually operated equipment while at or near optimum moisture content.

5. The base course shall be maintained in a condition that will meet all specification requirements until the Work is accepted. Equipment used in the construction of an adjoining section may be routed over completed portions of the base course, provided no damage results and provided that the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

6. If, in the opinion of the Engineer, the compacted base course softened due to exposure to the elements, drain off all freestanding water and recompact the base course until density requirements are met.

D. Adjustment of Deficiencies

1. Scrape, add or remove material or replace deficient material, and recompact to meet specified density, grade or smoothness criteria.

2. In no case will the addition of thin layers of material be added to the top layer of base course to meet grade. If the elevation of the top layer is 1/2 inch or more below grade, the top layer of base shall be scarified to a depth of at least 3 inches, new material added, and the layer shall be cut back to grade and rerolled.

**END OF SECTION**

## SECTION 02231

## AGGREGATE BASE COURSE

## APPENDIX "A"

## SUBMITTALS

A. Submit to the Engineer of Materials, Engineering Materials Laboratory, Port Authority Technical Center, 241 Erie Street, Jersey City, NJ 07310-1397, all of the following:

1. The proposed source of material. Material must come from a source approved by either NYDOT or NJDOT. The Engineer will approve or disapprove within 10 working days after receipt of submittal. Do not deliver material until the Engineer has approved of the source.

2. In the case of RCA, the name of the intended supplier and certified test data demonstrating the supplier's compliance with the material requirements of 2.01, at least 21 days prior to delivery of any RCA to the construction site. The Engineer will approve or disapprove within 10 working days after receipt of submittal. Do not deliver material until the Engineer has approved of the source.

3. In the case of RCA, an actual material submittal from the proposed source may be required as the result of a new, unfamiliar or unsatisfactory supplier submittal. Two 75 pound representative samples from a dedicated stockpile proposed for use under this contract must then be supplied as follows:

   a. Submit RCA samples in clean, sturdy containers or bags that shall not permit loss of any of the material.

   b. Clearly label samples with the Contract location, title, and number; identification of the material supplied; and the location of the source.

   The Engineer will approve or disapprove within 21 days after receipt of sample. When an actual sample is required, do not deliver material to the site until Engineer has approved of the sample.

B. If the source and/or the supplier of the aggregate base course material changes, resubmittals for approval must be made in accordance with 1.05, above.

END OF APPENDIX "A"

# SECTION 02231

# AGGREGATE BASE COURSE

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (1.01) | Locations for use of DGABC and/or OGABC |
| (1.03 B.2) | Required base course elevations |
| (1.03 B.3) | Required thickness of base course |

END OF INSTRUCTIONS

# DIVISION 2

# SECTION 02553

# ASPHALT CONCRETE PAVING

## PART 1. GENERAL

### 1.01 SUMMARY

A. This Section specifies requirements for plant mix macadam base course, bottom course, top course, bridge deck membrane, tack coat and overlay of existing pavement with asphalt concrete using performance graded asphalt specified in 2.02 B.

B. Except as in 1.01 C below, recycled asphalt concrete pavement (consisting of reclaimed asphalt pavement blended with new materials) may be used to the maximum percentages specified in 1.04 C.2.b.

C. Recycled asphalt concrete shall not be used in mixes where modified asphalts or "Rosphalt 50" additive are used.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway and Transportation Officials (AASHTO)

| | |
|---|---|
| AASHTO M320 | Performance-Graded Asphalt Binder. |
| AASHTO R028 | Practice for Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV). |
| AASHTO T313 | Method of Test for Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR). |
| AASHTO T315 | Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR). |
| AASHTO T048 | Method of Test for Flash and Fire Points by Cleveland Open Cup. |
| AASHTO T240 | Method of Test for Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test). |

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM C 88 | Test Method For Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate. |
| ASTM C 117 | Test Method for Materials Finer than 75-micrometres (No. 200) Sieve in Mineral Aggregates by Washing. |
| ASTM C 127 | Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate. |
| ASTM C 128 | Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate. |

| | |
|---|---|
| ASTM C 131 | Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. |
| ASTM C 136 | Test Method for Sieve Analysis of Fine and Coarse Aggregates. |
| ASTM C 566 | Test Method for Total Evaporable Moisture Content of Aggregate by Drying. |
| ASTM C 1252 | Test Methods for Uncompacted Void Content of Fine Aggregate (as Influenced By Particle Shape, Surface Texture, and Grading). |
| ASTM D 75 | Practice for Sampling Aggregates. |
| ASTM D 242 | Specification for Mineral Filler for Bituminous Paving Mixtures. |
| ASTM D 692 | Specification for Coarse Aggregate for Bituminous Paving Mixtures. |
| ASTM D 979 | Practice for Sampling Bituminous Paving Mixtures. |
| ASTM D 995 | Specification for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures. |
| ASTM D 1073 | Specification for Fine Aggregate for Bituminous Paving Mixtures. |
| ASTM D 2041 | Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures. |
| ASTM D 2172 | Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures. |
| ASTM D 2419 | Test Method for Sand Equivalent Value of Soils and Fine Aggregate. |
| ASTM D 2726 | Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures. |
| ASTM D 3203 | Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures. |
| ASTM D 3549 | Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens. |
| ASTM D 3666 | Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials. |
| ASTM D 4125 | Test Methods for Asphalt Content of Bituminous Mixtures by the Nuclear Method. |
| ASTM D 4318 | Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. |
| ASTM D 4402 | Test Method for Viscosity Determinations of Asphalt at Elevated Temperatures Using a Rotational Viscometer. |
| ASTM D 4791 | Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate. |
| ASTM D 4867 | Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures. |
| ASTM D 5444 | Test Method for Mechanical Size Analysis of Extracted Aggregate. |
| ASTM D 5821 | Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate. |
| ASTM D 5976 | Specification for Type 1 Polymer Modified Asphalt Cement for Use in Pavement Construction. |

| | |
|---|---|
| ASTM D 6084 | Test Method for Elastic Recovery of Bituminous Materials by Ductilometer. |
| ASTM D 6307 | Test Method for Asphalt Content of Hot-Mix Asphalt by Ignition Method. |
| ASTM D 6926 | Practice for Preparation of Bituminous Specimens Using Marshall Apparatus. |
| ASTM D 6927 | Test Method for Marshall Stability and Flow of Bituminous Mixtures. |
| ASTM E 178 | Practice for Dealing With Outlying Observations. |
| ASTM E 950 | Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference. |
| ASTM E 1274 | Test Method for Measuring Pavement Roughness Using a Profilograph. |
| | Asphalt Institute – Manual Series |
| MS-2 | Mix Design Methods for Asphalt Concrete, and Other Hot-Mix Types. |
| MS-20 | Asphalt Hot-Mix Recycling. |
| | Dept. of Transportation – Federal Aviation Administration (FAA) |
| FAA ERLPM | Eastern Region Laboratory Procedures Manual. |

## 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Job Conditions

1. Apply tack coat only when the base surface is dry and the ambient temperature in shade has not been below 32 degrees F for 12 hours immediately prior to application, unless otherwise approved by the Engineer.

2. Do not place asphalt concrete upon a wet or frozen surface.

3. The minimum laydown temperature shall be 310 degrees F or greater when the base surface temperature is 50 degrees F or less and not less than 275 degrees F when the base temperature is greater than 50 degrees F. Measure the asphalt concrete temperature in the truck, at the paver.

4. For asphalt mixes containing "Rosphalt 50", the minimum laydown temperature is 350 degrees F, regardless of the base surface temperature. Measure the asphalt concrete temperature in the truck, at the paver.

5. The minimum allowable base temperature for a lift thickness is shown in the following table:

| Nominal Lift Thickness (inches) | Minimum Allowable Base Temperature (degrees F) |
|---|---|
| 2 or greater | 32 |
| 1-1/2 or greater, but less than 2 | 40 |
| Less than 1-1/2 | 50 |

6. If nominal lift thickness is two inches or greater and the base temperature is below 32 degrees F, the Engineer may approve paving operations if the Contractor can demonstrate, prior to commencing with paving, that density and mat texture uniformity can be achieved. All other requirements apply.

7. In case of sudden rain, the Engineer may at his sole discretion permit placing of mixture already in transit from the plant, provided the surface to be paved is free from pools of water and laydown temperatures conform to the above tabulation. Such permission, however, shall not be interpreted as a waiver of any of the quality requirements.

8. When using design mixes containing "Rosphalt 50" retain the services and arrange for a technical representative of the "Rosphalt 50" manufacturer to be present in the field during the first three days of installation of "Rosphalt 50" paving mix.

B. Asphalt Concrete Mix Design

1. Design asphalt concrete job mix formula based on the "Mix Design Table" specified in 2.03 A and specimen compaction temperature specified in 1.04 E.3.

2. Design top and bottom courses and bridge deck membrane to the following target values: [1]

Marshall Stability at 75 blows (ASTM D 6927) - 2150 lbs., min. except 1,000 lbs, min. for bridge deck membrane

Flow Value, 0.01 inch gradation (ASTM D 6927) - 8 to 16, except 15 to 40[2] for bridge deck membrane

Marshall Air Voids, Percent, (ASTM D 3203)[3]:

| | |
|---|---|
| Top course (except Mix I-6A, and mixes containing "Rosphalt 50") | 2.8 to 4.2 |
| Top course, Mix I-6A | 5.3 to 6.7 |
| Bottom course | 3.8 to 5.2 |
| Bridge Deck Membrane | 1.5 Max. |
| Mixes containing "Rosphalt 50" | 0 to 2.0 |

Percent Voids Filled with Asphalt:

| | |
|---|---|
| Mix I-2A; I-4A; I-5A; PA-5 | 70 to 80 |
| Mix I-4; I-5; I-6A | 65 to 80 |
| Bridge Deck Membrane | 95 to 100 |
| Mixes containing "Rosphalt 50" | 90 to 100 |

---

[1] For asphalt concrete mixes with five percent of the aggregate or greater retained on the 1" sieve, the Engineer may require the use of six-inch molds to increase the repeatability of Marshall test results. For six-inch molds Marshall stability shall be 4800 lbs. minimum at 113 blows with 22.5 lb. hammer and 18-inch drop and the flow value shall be within the 12 to 24 range.

[2] Flow may be higher than 40 if other properties meet section requirements and if approved by the Engineer.

[3] Determine by comparing bulk specific gravity (ASTM D 2726) to maximum specific gravity (ASTM D 2041).

Voids in the Mineral Aggregate (VMA), Percent, Minimum:

| | |
|---|---|
| Mix I-2A | 12 |
| Mix I-4A | 13 |
| Mix I-4; PA-5 | 14 |
| Mix I-5; I-5A | 16 |
| Mix PA-5 with "Rosphalt 50" | 16 |
| Mix I-5A with "Rosphalt 50" | 18 |
| Mix I-6A | 19 |
| Bridge Deck Membrane | 20 |

3. Plant mix macadam base course (Mix I-1) shall be a mixture designed within the gradation limits specified in 2.03 A. When approved by the Engineer, bottom course (Mix I-2A) may be used in lieu of Mix I-1 provided it meets all requirements for bottom course.

4. The design job mix formula shall indicate definite percentages passing for each sieve fraction of aggregate and the asphalt content.

5. Design new job mix formula for each asphalt plant used, whenever there is a change in material or when field conditions dictate a need for redesign.

6. When required by the Engineer, determine the tensile strength ratio of specimens of the composite paving mixture by procedures specified in ASTM D 4867. The value shall be not less than 80 percent.

C. Plant Production Requirements

1. The asphalt concrete mixture or its components shall not be heated to a temperature outside the limits specified in 3.02 A.

2. Top and bottom courses and bridge deck membrane, shall have 100 percent of the material in each lot equal, exceed or fall within the range of the following acceptance limits*:

   Marshall Stability at 75 blows (ASTM D 6927) - 1800 lbs. min, except 1000 lbs. minimum for bridge deck membrane

   Flow Value, 0.01 inch gradation (ASTM D 6927) - 8 to 16, except 15 to 40** for bridge deck membrane

   If the Percent of Material Within Tolerance Limits (PWL) of the lot is less than 90 percent, corrections for deficiencies in Marshall Stability and Flow shall be made as set forth in 3.03 C.

---

* If six-inch molds are required as set forth in 1.03 B.2, Marshall stability shall be 4000 lbs. minimum at 113 blows with 22.5 lb. hammer, 18-inch drop and the flow value shall be within the 12 to 24 range.

** Flow may be higher than 40 if other properties meet Section requirements and if approved by the Engineer.

3. Modified Asphalt Performance Grade

Modified asphalt shall meet the performance grade requirements set forth in 2.02 B, when tested in accordance with 1.04 E.12. When material fails to meet the requirements, make corrections in accordance with 3.03 E.

4. Marshall Air Voids

The target bands for Marshall air voids shall be as set forth in 1.03 B.2. Acceptance shall be on a lot basis as specified in 1.04 E.3. The acceptance of each lot will be based on the Percent of Material Within Tolerance Limits (PWL) as set forth in 4.03 B.5. Adjustment to Contract compensation will be made if the PWL of the lot is less than 90 percent as set forth in 4.03 D. If the PWL of the lot equals or exceeds 90 percent and the PWL for pavement joint density for the lot equals or exceeds 90 percent, the percentage adjustment to compensation will be between 100 and 106 as set forth in 4.03 D.

The Tolerance Limits for Marshall air voids, percent, (ASTM D 3203) are:

| | |
|---|---|
| Top course, (except Mix I-6A) | 2.0 to 5.0 |
| Top course, Mix I-6A | 4.5 to 7.5 |
| Bottom Course | 3.0 to 6.0 |
| Bridge deck membrane | 1.5 Max. |
| Mixes containing "Rosphalt 50" | 0 to 2.0 |

5. Tensile Strength Ratio

The Tensile Strength Ratio shall meet the requirement set forth in 1.04 E.15. When material that is produced fails to meet the requirements, make corrections in accordance with 3.03 F.

6. Retain the services and arrange for a technical representative of the "Rosphalt 50" manufacturer to be present in the plant during the first three days of production.

D. In-Place Pavement Requirements

1. Surface Smoothness

a. Longitudinal direction for roadways where paving lane lengths equal or exceed 500 linear feet.

The final surface shall have a Profile Index of 15.0 inches per mile or less and no deviations 0.4 inch or greater in 25 feet. Testing and acceptance will be on a lot basis as set forth in 1.04 E.10.a. Make corrections for deficiencies in surface smoothness as set forth in 3.03 A. Adjustment to Contract compensation will be made based on the Profile Index of the lot as set forth in 4.03 E.

b. Longitudinal direction for roadways where paving lane length is less than 500 linear feet.

Final surface shall be smooth and free of irregularities greater than 1/8 inch when tested with a 10-foot straight edge. Testing and acceptance will be on a lot basis as set forth in 1.04 E.10.b. Make corrections for deficiencies in surface smoothness as set forth in 3.03 A. Adjustment to Contract compensation will be made based on the Profile Index of the lot as set forth in 4.03 E.

c. Longitudinal and transverse direction for parking lots and port container storage areas.

The final surface shall not exhibit ponding of water and shall be free-draining. Testing and acceptance will be as set forth in 1.04 E.10.c. Make corrections for deficiencies as set forth in 3.03 A.

2. Density

a. In-Place Mat Density

The target for in-place mat density is 98 percent or better (97 percent for pavement on roadway structures). Acceptance will be on a lot basis as set forth in 1.04 E.5. The acceptance of each lot will be based on the Percent of Material Within Tolerance Limits (PWL), as set forth in 4.03 B.5. Adjustment to Contract compensation will be made based on the PWL of the lot as set forth in 4.03 C. The lower tolerance limit for pavement mat density is 96.3 percent (95.7 percent for pavement on roadway structures).

a. In-Place Joint Density

The target for in-place joint density is 97 percent or better (96 percent for pavement on roadway structures). Acceptance will be on a lot basis as set forth in 1.04 E.6. The acceptance of each lot will be based on the Percent of Material Within Tolerance Limits (PWL), as set forth in 4.03 B.5. Adjustment to Contract compensation will be made based on the PWL of the lot for surface course only as set forth in 4.03 F. The lower tolerance limit for pavement joint density is 93.3 percent.

b. Plant mix macadam base course shall have stone thoroughly interlocked, interstices reduced to a minimum, and creeping of mixture no longer visible and with no further increase in density achievable by additional rolling.

3. Thickness

a. Pavement courses shall conform to thicknesses shown on the Contract Drawings within the following tolerances:

| Course or Combination of Courses | Tolerance (in inches) Plus or Minus* |
|---|---|
| Thickness of top or membrane course | 1/4 |
| Total thickness of top course and bottom course | 1/4 |
| Total thickness of plant mix macadam base course, bottom course, and top course | 1/4 |
| Overlay thickness shall be measured by the tolerance in 1.03 D.4 | -- |

* All measurements for this purpose shall be to the nearest 1/8th inch.

4. Final Surface Grade

The final surface shall conform to the finished grades shown on the Contract Drawings within a target tolerance for vertical deviation of plus or minus 0.04 foot, except where closer tolerance is required for proper functioning of appurtenant structures and drainage. The final surface abutting existing pavements shall smoothly transition to the existing surface grades and shall not exhibit ponding of water. The Engineer will test the final surface, which will be accepted or rejected on a lot basis as set forth in 1.04 E.11. The Engineer will adjust Contract compensation based on the percentage of grade measurements exceeding the target tolerance as set forth in 4.03 D. For all areas when 15 percent or more of the grade measurements exceed the target grade tolerance or where any individual measurement exceeds a 0.06-foot grade tolerance, make corrections for deficiencies in final surface grade as set forth in 3.03 D.

5. In-Place Air Voids

Asphalt concrete shall have in-place air voids between 2.0 percent and 8.0 percent (9.0 percent for bottom course and materials placed on roadway structures). Asphalt concrete containing "Rosphalt 50" additive shall have in-place air voids less than 6.0 percent. The Engineer will test in-place air voids in accordance with 1.04 E.7. When material fails to meet the requirements, make corrections for deficiencies in accordance with 3.03 B.

## 1.04 QUALITY CONTROL/ASSURANCE

A. General

1. Establish, provide and maintain an effective quality control system which shall ensure that the materials and completed construction submitted for acceptance conform to Contract requirements whether manufactured or processed by the Contractor or procured from subcontractors or vendors.

2. Pre-Paving Construction Meeting

   a. A pre-paving meeting will be conducted at the construction site by the Engineer a minimum of 20 days prior to the first day of laydown to discuss Contractor (suppliers) mixes, plant quality control, field quality control, tack coat, control strip, requirements for mat and joint densities, equipment (including rollers, Material Transfer Vehicle and paver), smoothness and grade control, segregation, workmanship, quality assurance testing, incentive and disincentive criteria and any other pertinent specified requirements.

   b. Record, type and distribute meeting minutes to all attendees of the meeting within 5 days of the date of the meeting.

   c. Do not schedule the pre-paving construction meeting until all submittals pertaining to the paving operation have been submitted and approved.

3. At no additional cost to the Authority, make arrangements for the project superintendent and a qualified representative to be present at every segment of the paving operations, including, but not limited to the following:

   a. Asphalt Producer's Quality Control Manager.

   b. Contractor's representative for site quality control testing.

c. Paving crew foreman.

d. Smoothness testing personnel.

e. Survey crew chief.

4. Submit to the Engineer certification in writing stating that all of the testing equipment to be used is properly calibrated and will meet the specifications applicable for the specified test procedures. Upon Engineer's request, test samples to demonstrate an acceptable level of performance.

5. Perform quality control sampling, testing and inspection during all phases of the Work at rates sufficient to ensure that the Work conforms to the Contract requirements, and at minimum test frequencies required by 1.04 D.

B. Quality Control Plan

1. Establish and maintain a Quality Control Plan (Plan) along with all the personnel, equipment, supplies and facilities necessary to obtain samples, perform and document tests and meet specification requirements. For Contracts requiring 1,000 tons of asphalt concrete or more, the Plan is required. For Contracts requiring less than 1,000 tons of asphalt concrete, the Plan is not required.

2. Describe the Plan in a written document. Submit the written Plan to the Chief of Materials Engineering, Materials Engineering Unit for review at least 28 calendar days prior to the start of paving operations.

3. In the absence of an approved Quality Control Plan, the Authority will make no payments for materials, which are subject to specific quality control.

4. The Plan may be operated wholly or in part by the Contractor or by an independent organization but it shall in all cases remain the responsibility of the Contractor.

5. Plan Contents: The Plan shall be organized to address at least the following items:

a. Quality control organization chart.

b. Area of responsibility and authority of each individual.

c. Names and qualifications of personnel as required by 1.04 B.7.d.

d. A listing of any outside organizations such as testing laboratories that will be employed by the Contractor and a description of the services they will provide.

e. A testing plan which lists the tests required to be performed by the Contractor, the frequency of testing, sampling locations and the location of the testing facilities.

f. Procedures for ensuring that tests are performed in accordance with the testing plan, that they are documented and that proper corrective actions are taken when necessary.

g. Procedures for ensuring that testing equipment is available, that it complies with specified standards and that it has been calibrated against certified standards.

h. Procedures for verifying that tests are taken in accordance with the appropriate AASHTO and ASTM standards.

i. Procedures for daily submittal of test results to the Engineer.

j. An action plan detailing procedures to be used to correct unsatisfactory production processes and construction practices, when tests indicate materials fail to meet specifications for any of the following:

(1) Aggregate gradation.

(2) Mat and joint density.

(3) Marshall air voids.

(4) Surface smoothness.

(5) Grades.

6. Plan Elements: The Plan shall address all elements which affect the quality of the pavement including but not limited to:

a. Mix Design.

b. Aggregate Gradation.

c. Quality of Materials.

d. Stockpile Management.

e. Proportioning / Temperature Control of Mixture Components.

f. Mixing and Transportation.

g. Placing and Finishing.

h. Joints.

i. Compaction.

j. Surface smoothness and grades.

7. Quality Control Organization

a. Implement the Quality Control Plan by the establishment of a separate Quality Control Organization. Develop and submit an organization chart to show all quality control personnel integrated with other management, production, and construction functions and personnel.

b. The organization chart shall identify all quality control staff required to implement all elements of the quality control program, including inspection and testing functions for different items of work.

c. If an outside organization or independent testing laboratory is used for implementation of all or part of the Plan, the personnel assigned will be subject to the qualification requirements of 1.04 B.7.d. The organization chart shall indicate which personnel are Contractor employees and which are provided by an outside organization.

d. The Quality Control Organization shall consist of at least the following personnel:

(1) Plan Administrator

The Plan Administrator shall be an employee of the Contractor. The Plan Administrator shall have prior quality control experience on a project of size and scope comparable to those of this Contract. In addition, the Plan Administrator shall meet one of the following requirements:

(a.) Licensed Professional Engineer with one year of asphalt paving experience as approved by the Engineer.

(b.) Engineer-in-Training with two years of asphalt paving experience as approved by the Engineer.

(c.) An individual with three years of highway and/or airport paving experience as approved by the Engineer and with a Bachelor Degree in Civil Engineering, Civil Engineering Technology or Construction.

(d.) Construction Materials Technician certified at Level III by the National Institute for Certification in Engineering Technologies (NICET).

(e.) Highway Materials Technician certified at Level III by NICET.

(f.) Highway Construction Technician certified at Level III by NICET.

(g.) A NICET certified Engineering Technician in Civil Engineering Technology with 5 years of asphalt paving experience as approved by the Engineer.

Certification at an equivalent level by a State or nationally recognized organization will be acceptable in lieu of NICET certification. The Plan Administrator shall have full authority to institute any and all actions necessary for the successful operation of the Plan to ensure compliance with the Specifications. The Plan Administrator shall report directly to a responsible officer in the Contractor's organization. The Administrator may supervise Plans on more than one project provided that he can upon request be at the construction site within one hour.

(2) Quality Control Technicians

Provide a sufficient number of Quality Control Technicians to adequately implement the Plan. Quality Control Technicians shall be engineers, engineering technicians, or experienced craftsmen holding a current certificate issued by the New Jersey Society of Asphalt Technologists, Inc. (NJSAT) or other Engineer-approved certifying agency or organization. (Information regarding the certification procedure can be obtained by contacting NJSAT.)

The Quality Control Technicians shall report directly to the Plan Administrator and shall perform the following functions:

(a.) Inspection of all plant equipment used in proportioning and mixing to ensure proper calibration and operating conditions.

(b.) Performance of quality control tests necessary or desirable to adjust and control mix proportioning in accordance with the job mix formula.

(c.) Inspection of all equipment used in placing, finishing and compacting material to ensure proper operating condition.

(d.) Inspection during construction to ensure placement, joint construction and compaction is in conformance with the Specifications and will produce a finished product that meets Specification requirements.

(e.) Performance of all quality control testing as required by 1.04 D, including density monitoring.

8. Testing Laboratory

a. The Plan must provide for a fully equipped asphalt laboratory located at the plant or construction site. It shall be available for joint use by the Contractor for quality control testing and by the Engineer for acceptance testing and must have adequate equipment for the performance of the tests required by these Specifications. The Engineer shall have priority in use of the equipment necessary for acceptance testing.

b. The effective working area of the laboratory shall be a minimum of 250 square feet with a ceiling height of not less than 7.5 feet. Lighting shall be adequate to illuminate all working areas. It shall be equipped with heating and air conditioning units to maintain a temperature of 70 degrees F plus or minus 5 degrees F.

c. In addition to the equipment required for testing, the laboratory shall be equipped with a paper copier and facsimile machine to be utilized by the Engineer.

d. Keep laboratory facilities clean and maintain all equipment in proper working condition. Allow the Engineer unrestricted access to inspect the Contractor's laboratory facility and to witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies or testing personnel and procedures. When in the Engineer's opinion deficiencies may adversely affect test results, immediately suspend delivery and placement of asphalt materials and do not resume until the deficiencies are satisfactorily corrected.

9. Noncompliance

In cases where quality control activities do not comply with either the Contractor's Quality Control Program or the Contract provisions, or where the Contractor fails to properly operate and maintain an effective Quality Control Program, the Engineer may order the Contractor to replace ineffective or unqualified quality control personnel.

C. Source of Aggregate and Sampling

1. Virgin Aggregate

a. Select sources of virgin aggregates well in advance of the time the materials are required for the construction. When the aggregates are obtained from a previously approved source, submit random hot bin samples, if requested by the Chief of Materials Engineering, Materials Engineering Unit, a minimum of 14 calendar days prior to the start of production and if from a source not previously approved, submit random hot bin samples a minimum 45 calendar days prior to the start of production. Sampling of the hot bin materials for job mix formulation will be observed by the Engineer and identical samples will be obtained for verification of the job mix formulation by the Authority's Materials Engineering Unit. The Engineer may require the proposed mix formulation to be batched at the asphalt plant and tested in the presence of the Engineer.

b. Where previously used or concurrent job mix formulations are to be used, the taking of hot bin samples may be waived by the Engineer.

2. Reclaimed Asphalt Pavement

a. Where reclaimed asphalt pavement material is permitted, it shall have 100 percent passing 1/2 inch sieve and shall be a mixture of only coarse aggregate, fine aggregate, and asphalt cement, free of solvents or other contaminating substances. The fine aggregate contained in the reclaimed asphalt pavement shall have a plasticity index not greater than 4 when tested in accordance with ASTM D 4318.

(1) Maintain stockpiles of reclaimed asphalt pavement in a manner to prevent contamination with other aggregates and keep covered in order to maintain a low moisture content of the reclaimed asphalt pavement.

b. Unless otherwise shown on the Contract Drawings, the maximum proportion of reclaimed asphalt pavement permitted within each mix shall be 10 percent for top and bottom courses and 25 percent for base course.

c. Contractor's reclaimed asphalt pavement will be considered for use provided that the Engineer is notified of the intended use and that he approves the reclaimed asphalt pavement. Take at least six representative samples, each at least 7 pounds, from each stockpile. Each stockpile shall not exceed 3000 tons. Sample in accordance with ASTM D 75. Sampling will be observed by the Engineer. Take duplicate samples and submit them with mix design for verification. Test samples in accordance with ASTM D 2172 to determine asphalt cement content; test recovered aggregate in accordance with ASTM C 136 for gradation.

d. Once a reclaimed asphalt pavement stockpile has been approved for use, the stockpile shall be dedicated to the Contract and no reclaimed asphalt pavement may be added to the stockpile. If there is an insufficient amount of reclaimed asphalt pavement in the stockpile to complete the Work, a new, separate stockpile may be made and shall be tested for acceptance as aforementioned.

3. Locate stockpiles of reclaimed asphalt pavement and of new aggregate so as to prevent intermingling.

4. When more than one asphalt plant is to be used to supply asphalt concrete to the construction site, each asphalt plant shall use a similar job mix formula, as approved by the Engineer.

5. Locations and timing of random sampling will be determined by the Engineer in accordance with Section 6 of FAA ERLPM.

D. Contractor's Quality Control Tests

1. Perform all quality control tests necessary to control the production and construction processes. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, Marshall properties and temperatures. Obtain samples at the direction of the Engineer for the purpose of quality control testing. Random sampling procedures specified in Section 6 of FAA ERLPM shall be used for determining the selection of samples as follows:

   a. Take four samples of freshly mixed material per each lot (one sample from each sublot) for top, bottom, and base courses and bridge deck membrane. Take samples in accordance with ASTM D 979 from material at the mixing plant.

      A lot will be defined as one day's production for each mix. Production rates for each mix will be obtained by the Engineer from the asphalt plant at the start of each day's production. A sublot will be defined as a quarter of a lot based on the initial production forecast for the mix. Maximum lot size will be 2000 tons. If a day's production is forecast over 2000 tons, the forecast quantity shall be divided into two or more equal lots. Should actual production be greater than the initial forecast of production for a given mix, the additional production will be divided into the same sublot sizes as initially calculated. If one or two additional sublots are produced they will be added to that days lot with n=5 or 6 for sublots. If three or more additional sublots are produced in a day, an additional lot will be established for that particular day.

      If actual production is less than the initial forecast for a given mix but sufficient material was produced to constitute three sublots, a lot will be formed with three sublots (n=3). Should actual production constitute only one or two sublots, the sublots will be added either to the previous lot or the next production lot, whichever is closer in time. Each sublot shall contain a minimum of 75 tons of material.

      Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

   b. Test samples to determine asphalt content in accordance with ASTM D 2172, D 4125 or D 6307. Test recovered aggregate to determine gradation in accordance with ASTM D 5444. In addition, when automated recording plants are used, submit printouts of asphalt content to the Engineer.

   c. Prepare three plugs from each sample and test them in accordance with ASTM D 6926 using automatic compaction procedures. Determine Marshall air voids in accordance with ASTM D 3203. For each sublot, determine the maximum theoretical density in accordance with ASTM D 2041.

Voids filled with asphalt, for each plant sample, shall be computed as follows:

(1) Determine asphalt content in percentage by volume (I) using:

$$I = \frac{P_b \times G_{mb}}{G_b}$$

Where:

I = Percentage by volume of asphalt

Pb = Percentage by weight of asphalt

Gmb = Bulk specific gravity of compacted mixture

Gb = Specific gravity of asphalt

(2) Determine percent voids filled with asphalt (VF) as follows:

$$VF = \frac{I \times 100}{I + P_a}$$

Where:

VF = Percent voids filled with asphalt

I = Percentage by volume of asphalt

$P_a$ = Percent Marshall air voids

Estimate voids in the Mineral Aggregate (VMA) by adding the asphalt content in percentage by volume to the percent of air voids. Use bulk specific gravities to calculate VMA.

d. Take hot bin or feeder belt composite samples of top, bottom and base course aggregates and bridge deck membrane mixes at least twice daily and check gradation in accordance with ASTM C 136, including washing material passing No. 8 sieve in accordance with ASTM C 117.

e. At least six times daily, check and record temperatures at necessary locations to determine the temperatures of:

(1) aggregates and asphalt immediately before introduction to the pugmill or dryer drum;

(2) the mixture immediately after discharge from the pugmill or dryer drum;

(3) the mixture at the spreader on the construction site.

f. Reclaimed Asphalt Pavement

(1) Where reclaimed asphalt pavement is being used as a substitute for some of the virgin aggregate, take a sample of freshly mixed recycled asphalt concrete in accordance with ASTM D 979 and determine the moisture content at least twice daily. Moisture determinations shall be based on the weight loss, determined by heating an approximately 4-pound sample of the freshly mixed materials for one hour in an oven at 280 plus or minus 5 degrees F. The moisture content of the freshly mixed recycled asphalt concrete shall not exceed 0.5 percent.

(2) Take a sample of reclaimed asphalt pavement from the approved stockpile at least once daily and test in accordance with ASTM D 2172 to determine asphalt content and gradation in accordance with ASTM D 5444. The resulting asphalt content and aggregate gradation shall be similar to the average test results of the reclaimed asphalt pavement submitted with job mix formula. If there is a variation of plus or minus 1.0 percent in the asphalt content or plus or minus 10 percent in aggregate gradation on any sieve, a second sample shall be taken and tested in the same manner as the first sample. If the results are similar to that of the first sample, take appropriate measures to adjust the mixture to compensate for the variation in the reclaimed asphalt pavement.

g. Moisture Content of Aggregate

For the drum plants the moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C 566.

h. Moisture Content of Mixture

The moisture content of the mixture shall be determined once per lot in accordance with the procedure given in 1.04 D.1.f (1). The moisture content in the freshly mixed asphalt concrete shall not exceed 0.5 percent. If the moisture content is 0.5 percent or greater, then stop production and adjust plant operation.

i. Perform additional testing as required to ensure that mixtures produced meet the requirements of this Section.

2. Control Charts

Maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation and asphalt content. When test results exceed certain limiting values, take action to bring the asphalt concrete production process under tighter control. The Action Limit is the limiting value at which corrective actions shall be made while production may continue. The Suspension Limit is the limiting value at which production must be suspended while corrections are made. Production shall not resume until Contractor's corrections are approved by the Engineer.

Post control charts in a location satisfactory to the Engineer and keep charts current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter and the Contractor's test results. Use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If in the Engineer's opinion the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual Measurements

Establish control charts for individual measurements to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

| CONTROL CHART LIMITS FOR INDIVIDUAL MEASUREMENTS | | |
|---|---|---|
| Sieve | Action Limit | Suspension Limit |
| 1" | ±6% | ±9% |
| 3/4" | ±6% | ±9% |
| 1/2" | ±6% | ±9% |
| 3/8" | ±6% | ±9% |
| No. 4 | ±6% | ±9% |
| No. 8 | ±5% | ±7.5% |
| No. 16 | ±5% | ±7.5% |
| No. 30 | ±3% | ±4.5% |
| No. 50 | ±3% | ±4.5% |
| No. 100 | ±2% | ±3% |
| No. 200 | ±2% | ±3% |
| Asphalt Content | ±0.45% | ±0.7% |

b. Range

Establish control charts for range to control process variability for the test parameters and Suspension Limits listed below. Compute the range for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, adjust the Suspension Limits by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

| CONTROL CHART LIMITS BASED ON RANGE | |
|---|---|
| (Based on n = 2) | |
| Sieve | Suspension Limit |
| 1" | 11 % |
| 3/4" | 11 % |
| 1/2" | 11 % |
| 3/8" | 11 % |
| No. 4 | 11 % |
| No. 8 | 9 % |
| No. 16 | 9 % |
| No. 30 | 6 % |
| No. 50 | 6 % |
| No. 100 | 3.5 % |
| No. 200 | 3.5 % |
| Asphalt Content | 0.8 % |

c. Corrective Action

The Quality Control Plan shall indicate that appropriate action shall be taken when the asphalt concrete production process is out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and shall describe Contractor's actions to bring the process into control. A process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two consecutive points fall outside the Action Limit line for individual measurements.

3. Document quality control efforts using copies of the sample forms contained in the FAA ERLPM, Appendix C, in its entirety, or use Authority forms obtained from the Engineer. Make test results available to the Engineer daily.

4. If a storage silo is used:

a. Check the silo to see that it can properly store the asphalt concrete for the time involved.

b. Take samples of asphalt concrete as it is unloaded from the silo and check them for conformance to this Section. If the asphalt concrete appears segregated, stop using the storage silo until it is demonstrated to the Engineer that the condition has been corrected.

c. Silo storage time is governed by previous State DOT approval, not to exceed 24 hours.

5. Unless otherwise noted on the Contract Drawings, and subject to the approval of the Engineer, select an area to be called a Control Strip from the first day's production of each mix. Each Control Strip shall be a minimum of 100 feet long and two spreader widths wide and shall be constructed to meet the requirements of this Section and in the same manner as the remainder of the course it represents. Take three random samples at the plant and test them for stability, flow and air voids in accordance with 1.04 D.1.c. Take three randomly selected cores from the pavement mat and three along the longitudinal pavement joint and test them to determine density in accordance with 1.04 E.5 and E.6. Use the same means and methods which will be used to construct longitudinal and transverse joints as referred to in 1.04 B.6.h and 3.02 F.1 and F.2.

   The purpose of the Control Strip is to demonstrate that the pavement may be constructed using the proposed equipment and methods of operation and to obtain all quality requirements prior to the start of full production. Construct a new Control Strip whenever there is a change in equipment, methods of operation or type or source of material or whenever there is a change in the job mix formula. The Control Strip may become part of the completed pavement if it meets the requirements of this Section.

6. Include, as part of the Quality Control Plan, the use of a nuclear density device to aid in meeting the specified target densities. Calibrate the nuclear density device with the control strip cores. If other than a nuclear density device is used it shall be calibrated with an additional set of pavement cores.

7. Surface Smoothness

   Perform quality control smoothness testing of the final surface. For paving lanes 500 feet or greater in length, the testing equipment shall be capable of measuring the Profile Index of the final surface, in inches per mile using a 0.2 inch blanking band, in accordance with ASTM E 1274. As a minimum test the final surface of pavement, along the center of each paving lane once during each day of paving. Submit written test results to the Engineer after each test. Test results shall identify the location of each test including starting and end stations and offset from centerline of pavement. For paving lanes less than 500 feet, test the centerline of the paving lanes with a 10-foot long straightedge capable of marking locations which exceed the surface smoothness tolerance. Upon completion of all quality control testing and any required corrective work, the Engineer, in accordance with 1.04 E.10, will perform acceptance testing.

8. Final Surface Grade

Perform quality control surveys immediately after the top course has been compacted, to check final grades. Measure elevations at the finished grade locations shown on the Contract Drawings. Provide the Engineer with the survey results at the completion of each work period. The survey results shall identify the location of each measurement by station and offset, measured elevations to the nearest 0.01foot, required finished grades from the Contract Drawings and the difference between measured elevations and required elevations to the nearest 0.01 foot. This survey is for Contractor's quality control; acceptance of the finished surface shall be as specified in 1.04 E.11.

9. For Work performed, either wholly or in part, in the State of New Jersey, provide a representative present during all paving operations who shall be certified by the New Jersey Society of Asphalt Technologists, Inc. (NJSAT) as an Asphalt Paving Construction Technologist.

E. Engineer's Sampling and Testing

1. Produce asphalt concrete in approved automated plants equipped with interlocks and printouts meeting the requirements of ASTM D 995 and subject to the following:

   a. Plant interlocks and printouts shall be in operation during production and two (2) copies of all printouts shall be furnished to the Engineer daily.

   b. Have scales certified by an approved agency at least every 180 calendar days. Submit copies of certifications to the Engineer upon request.

2. Provide labor and equipment to take samples, except cores, to check thickness and density.

3. The Engineer will perform acceptance testing for Marshall air voids, stability and flow. Samples will be taken from trucks at the plant, in accordance with FAA ERLPM, Section 6. These samples will be from the sublots that were sampled in 1.04 D.1.a. The Engineer will prepare three plugs from each sample and test them in accordance with ASTM D 6927 using automatic compaction procedures. The specimen compaction temperatures will be within the following range as measured within 1/2 inch from the outside edge:

| Performance Grade | Temperature Degrees F |
|---|---|
| PG 64-22, PG 70-22 | 275 - 295 |
| PG 76-22 | 300 - 320 |
| PG 82-22 | 305 - 325 |
| PG 64-22 in mixes containing "Rosphalt 50" | 390 - 410 |

Air voids, voids in mineral aggregate and voids filled with asphalt will be determined in accordance with ASTM D 3203 and 1.04 D.1.c. The average test values obtained from each lot of top and bottom courses and bridge deck membrane must conform to the parameters specified in 1.03 C.

In lieu of sampling and testing in the field, the Engineer may sample and perform acceptance testing at the plant. The Contractor will be advised at the start of Work where the Engineer will sample and test.

4. For thickness determination, exclusive of overlay and bridge deck membrane pavement, the Engineer will divide each course into area lots consisting of the area covered by the lot sampled as specified in 1.04 D.1.a and he will further subdivide each lot into four equal sublots. The Engineer will take one 4-inch diameter core randomly in each sublot to check thickness of the top and bottom courses. One-fourth of all such cores will continue through the plant mix macadam base course. Thickness will be determined in accordance with ASTM D 3549.

   For bridge deck membrane, the Engineer will verify the thickness by measuring with an appropriate measuring device through the newly placed membrane course. After the measurement has been obtained, the locations shall be re-sealed to prevent any leakage.

5. Mat Density

   a. The Engineer will determine the in-place density of the Control Strip and subsequently placed pavements by taking cores at random locations as specified below.

   b. Cores taken from the top and bottom courses and bridge deck membrane in place and any other specimens taken at the construction site, sampled in accordance with the random sampling procedures as specified in 1.04 D.1, will be tested by the Engineer for bulk specific gravity in accordance with ASTM D 2726. Cores will not be taken closer than one foot from a transverse or longitudinal joint for pavement mat density determination. The in-place density of the pavement course will be the ratio of the in-place specific gravity to the laboratory Marshall bulk specific gravity expressed as a percentage.

   c. Cores taken from courses containing more than 10 percent air voids will be tested by the Engineer for density (Bulk Specific Gravity) according to the following equation:

$$S.G. = \frac{W}{12.87\, d^2 h}$$

S.G. = Bulk Specific Gravity

W = Weight, Dry Specimen (grams)

d = Measured Diameter* (inches)

h = Measured Height* (inches)

Laboratory bulk specific gravity and computation of in-place density will be as specified in 1.04 E.5.b above.

* Average of 5 equally spaced measurements around the core

d. The average in-place density determination, taken from the area covered by the lot sampled as specified in 1.04 D.1.a, will be determined by the Engineer by summing up the sublot in-place density readings obtained from a lot and dividing the total by the number of sublots. The in-place density from each sublot will be obtained using a core reading taken from each sublot on a random basis and dividing by the Marshall bulk density (ASTM D 6926 and ASTM D 2726) taken for that sublot. Any core with a thickness less than twice the largest sieve size to retain more than 5 percent of any aggregate will be discarded and additional random cores will be taken as required to ensure representative readings.

e. The Engineer will repeat the procedure specified in a. through d. above whenever a change is made in the type or source of material or whenever a new job mix formula is approved for material from the same source.

6. Joint Density

The Engineer will take one joint core from each sublot of all surface courses or from the underlying lifts as defined in 1.04 D.1.a and will test it in accordance with 1.04 E.5. For joint cores the lowest Marshall bulk density for sublots forming the joint will be used to compute the in-place density. The Engineer will take cores from directly over the longitudinal joint in line with the location of the random cores taken under 1.04 E.5.b. When a paving lane has two longitudinal joints, both joints will be cored. The in-place joint density will be determined separately for each joint, and the joint producing the lowest in-place density will be used to determine payment. Based on site and placement conditions the Engineer may elect to core only one joint.

7. In-Place Air Voids

The Engineer will calculate the in-place mat air voids for each sublot in accordance with ASTM D 3203, by comparing the bulk specific gravity (ASTM D 2726) of the cores taken as specified in 1.04 E.5.b to the maximum laboratory specific gravity (ASTM D 2041).

8. Patch all areas where samples are taken with an approved asphalt concrete or Portland cement concrete properly tamped to fill all voids and struck off flush with the surface within 24 hours after sampling.

9. The Engineer may at any time, notwithstanding previous plant approval, reject and require the Contractor to dispose of any batch of asphalt concrete mixture which is rendered unfit for use due to contamination, segregation or incomplete coating of aggregate. Such rejection may be based on visual inspection, only. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer and, if the Contractor can demonstrate in the laboratory, in the presence of and to the satisfaction of the Engineer, that such material was erroneously rejected, the Contractor will be compensated for the material.

10. Surface Smoothness

a. Longitudinal direction for roadways where paving lane lengths equal or exceed 500 linear feet:

(1) The Engineer will test the final surface of the pavement parallel to the direction of paving for smoothness. A lightweight profilometer meeting the requirements of ASTM E 950 Class 1 will be used to measure the pavement surface profile.

(2) The profilometer test results will be used to simulate California profilograph testing of the pavement. The simulation will be used to compute the Profile Index in inches per mile using a 0.2 inch blanking band, in accordance with ASTM E 1274. A third-order Butterworth low pass filter with a filter length (cutoff wavelength) of 2.0 feet will be used. Scallops will be rounded to the nearest 0.01-inch. The blanking band will be centered on a straight line determined by least - squares fit over the length of the lot. The simulation will also be used to identify any surface deviations in excess of 0.4 inch in 25 feet. Designed breaks in grade shown on the Contract Drawings will not be included in the Profile Index computations.

(3) Clean the pavement prior to testing. Testing will be performed on a lot basis. A lot is defined as 500 linear feet of paving lane. When less than 250 feet remains after dividing the pavement into 500 linear foot lots, the remaining length will be added to the adjacent lot. When more than 250 feet remains, a short lot will be tested.

(4) For paving lanes up to 20 feet in width, three measurements will be made along the centerline of paving lanes. The profile index of the lot will be computed by averaging the profile index of each measurement.

(5) For paving lanes greater than 20 feet in width, three measurements will be made at two locations, each six feet from and parallel to the centerline of the paving lane. The Profile Index of the lot will be computed by averaging the Profile Index of each of the two measured profiles.

(6) The Profile Index for the length of paving lane in each lot is converted to the Profile Index of the lot in inches per mile using the following formula:

$$PI = PT \times \frac{5280}{L}$$

Where:

PI = Profile Index, inches per mile

PT = Profile Index, inches per length in feet of paving lane in a lot

L = Length of the paving lane in the lot in feet

b. Longitudinal direction for roadways where paving lane lengths are less than 500 linear feet:

(1) The Engineer will evaluate each paving lane with a 10-foot long rolling straightedge, which marks the length of surface variations that exceed the required tolerance.

(2) The Contractor shall sweep the pavement prior to measurement.

(3) Measurement will be taken along the centerline of each paving lane.

(4) The Engineer will calculate the percentage of final surface which exceeds the required tolerance by dividing the measured length of the marked surface deficiencies by the total length of the paving lane.

c. Longitudinal and transverse direction for parking lots and port container areas:

(1) At the completion of paving, and in the presence of the Engineer, thoroughly cover the pavement with water using a water distribution vehicle. In areas that do not adequately drain the water from the surface, or hold water, remove and replace the deficient area as approved by the Engineer and in accordance with 3.03 A.

11. Final Surface Grade

The Engineer will measure grades of the final surface of each lot at the finished grade locations shown on the Contract Drawings. Where paving lanes are 20 feet or greater in width, an additional line of grades, located at the center of the paving lane and spaced at 25 feet longitudinally, will be measured. A lot is defined as 50,000 square feet of final pavement surface. The transverse limit of the lot will be the transverse limit of paving. Where paving areas are not equally divisible into 50,000 square foot lots, odd sized lots between 25,000 and 75,000 square feet will be used. The odd sized lots will be used for the area remaining after the paved area is divided into 50,000 square foot lots. Perform the survey jointly with the Engineer.

12. The Engineer will perform acceptance testing of modified asphalt to determine whether it meets the performance grade requirements set forth in 2.02 B. Samples will be collected at the asphalt plant for each lot of asphalt concrete produced, as specified in 1.04 D.1.a. The Engineer will sample the liquid asphalt from the plant storage tanks which must be equipped with a sample valve.

13. The Engineer will measure the temperature of each load of asphalt concrete. Any load of asphalt concrete with temperature exceeding 350 degrees F will be rejected (excluding mixes that contain "Rosphalt 50" additive). For mixes containing "Rosphalt 50" additive, any load produced with temperature exceeding 500 degrees F will be rejected.

14. Where there is a discrepancy between the Contractor's test results and those of the Engineer, the Engineer's test results shall govern.

15. The Engineer may perform acceptance testing during production to determine whether the asphalt concrete meets the Tensile Strength Ratio (TSR) requirements of this paragraph. For each lot of asphalt concrete, defined in 1.04 D.1.a, one sample will be obtained from a truck at the plant and tested in accordance with ASTM D 4867. Suspend production if test results indicate that the TSR is less than or equal to 80 percent. Submit a plan to the Engineer for approval indicating how the problem will be corrected and ensure that TSR values greater than 80 percent will be consistently produced before commencing production once again.

## 1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

### 2.01 MANUFACTURERS

A. Manufacturer of asphalt cement shall be approved by either the New York State Department of Transportation (NYSDOT) or the New Jersey Department of Transportation (NJDOT).

B. Modified Asphalt shall be one of the following. No substitutions permitted.

1. "Stellarflex SP" - NuStar Asphalt Refining LLC; Paulsboro, NJ.
2. "Elvaloy RET" - DuPont Co.; Wilmington, DE.
3. "Kraton" - Kraton Polymers, LLC; Houston, TX.
4. "Polykote" - Suit-Kote Corp.; Cortland, NY.
5. "Vestoplast S" modifier - Evonik Degussa Corp.; Parsippany, NJ.

C. Additive shall be the following. No substitutions permitted.

1. "Rosphalt 50" additive - Chase Construction Products/Royston Div. of Chase Corp.; Pittsburgh, PA.

### 2.02 MATERIALS

A. Aggregates

1. If the tensile strength ratio of the specimens of composite mixture is less than 80 percent, as specified in 1.03 B.6, the aggregates will be rejected unless the Contractor treats the asphalt with an approved anti-stripping agent. The amount of anti-stripping agent added to the asphalt shall be sufficient to produce a tensile strength ratio of not less than 80 percent.

2. Coarse Aggregate: Material retained on the No. 8 sieve

a. Except for use in the top lift of the top course within the roadway pavement edge markings as shown on the Contract Drawings, coarse aggregate shall conform to ASTM D 692, except as follows: use broken stone or crushed gravel having not less than 75 percent by weight of pieces with two or more fractured faces and 85 percent by weight having at least one fractured face (ASTM D 5821), with a maximum of 8 percent of flat or elongated pieces (ASTM D 4791), with a maximum percentage of wear (ASTM C 131) of 40 percent and with a magnesium sulfate loss (ASTM C 88) of not more than 12 percent for a five-cycle test period.

b. For the top lift of the top course within the roadway pavement edge markings as shown on the Contract Drawings, coarse aggregate shall conform to ASTM D 692 except as follows: use broken stone which shall be trap rock or gneiss of uniform quality obtained from a source approved by the NYSDOT or the NJDOT for use in asphalt concrete. The aggregate shall have not less than 75 percent by weight of pieces with two or more fractured faces, with a maximum of 8 percent of flat or elongated pieces (ASTM D 4791), with a maximum percentage of wear (ASTM C 131) of 30 percent and with a magnesium sulfate loss (ASTM C 88) of not more than 12 percent for a five-cycle test period.

c. A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than five.

3. Fine Aggregate: Material passing the No. 8 sieve and retained on the No. 200 sieve

Fine aggregate shall be a blend of washed, textured sand and stone screenings conforming to ASTM D 1073 with a maximum percentage of wear (ASTM C 131) of 30 percent and with a magnesium sulphate loss (ASTM C 88) of not more than 18 percent for a five-cycle test period, a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318. When tested in accordance with ASTM D 2419, the sand equivalent value shall be 35 or greater.

Textured sand shall be defined as sand which when tested in accordance with ASTM C 1252, Method A, results in uncompacted voids greater than 45.0 percent. Sand that has a low texture value and slag shall not be used.

4. Mineral filler shall conform to ASTM D 242 and shall have a ratio to asphalt cement by weight not exceeding 1.2.

B. Asphalt

Asphalt shall be one of the following, conforming to the requirements of AASHTO M320 and as specified within table entitled "Requirements for Performance Graded Asphalts" for the Performance Grade (PG) as shown on the Contract Drawings.

1. Asphalt Cement

Asphalt cement shall meet the requirements for PG 64-22, unless otherwise shown on the Contract Drawings.

2. Modified Asphalt

Modified Asphalt shall be one of the following. No substitution is permitted.

a. "Kraton" (SEBS), "Polykote", "Elvaloy RET" or "Stellarflex SP" meeting the requirements for PG 76-22 or PG 82-22 as shown on the Contract Drawings.

b. Asphalt cement modified with "Vestoplast S", may be used where PG 76-22 is specified and subject to the following:

(1) Add "Vestoplast S" to the asphalt concrete mixture at a rate of 7 percent by weight of asphalt cement, by substitution.

3. Additive

Where "Rosphalt 50" is used in a mix design, add "Rosphalt 50" additive to the asphalt concrete mixture at a rate of 2.25 percent by weight of total mix.

C. Tack Coat

1. Unless otherwise shown on Contract Drawings, tack coat shall be asphalt cement as specified in 2.02 B.1 above.

2. For mixes containing "Rosphalt 50", use bond coat in place of tack coat as specified in Specification Section 02555.

D. Resultant Asphalt Cement

Resultant asphalt cement shall be a mixture of new asphalt cement as specified in 2.02 B.1 above, asphalt cement extracted from the reclaimed asphalt pavement and recycling agents if required.

**REQUIREMENTS FOR PERFORMANCE GRADED ASPHALTS**

| PERFORMANCE GRADE (PG) | 64-22 | 70-22 | 76-22 | 82-22 |
|---|---|---|---|---|
| These Tests Performed on Original Binder: | | | | |
| Flash Point Temperature (AASHTO T048): Minimum, Degrees Celsius. | 230 | 230 | 230 | 230 |
| Dynamic Shear (AASHTO T315): G*/SIN DELTA, Minimum, 1.00 kPa, Test Temperature At 10 Rad/s, Degrees Celsius. | 64 | 70 | 76 | 82 |
| Rotational Viscosity (ASTM D 4402): Maximum, 3 Pa-s, Test Temperature, Degrees Celsius. | 135 | 135 | 135 | 135 |
| Separation Test - R&B (ASTM D 5976): Percent Difference Maximum Degrees Celsius. | -- | -- | 4.5 | 4.5 |
| These Tests Performed on Rolling Thin Film Oven Test (RTFOT) Residue: | | | | |
| Mass Loss (AASHTO T240): Maximum Percent. | 1.00 | 1.00 | 1.00 | 1.00 |
| Dynamic Shear (AASHTO T315): G*/SIN DELTA, Minimum, 2.20 kPA, Test Temperature at 10 Rad/s, Degrees Celsius. | 64 | 70 | 76 | 82 |
| Elastic Recovery (ASTM D 6084, Method A) 25 Degrees Celsius, 10 cm Elongation, Immediately Cut, 60 Minutes, Minimum Percent. | -- | -- | 75 | 80 |
| These Tests Performed on Pressure Aging Vessel (PAV) Residue: | | | | |
| Pav Aging Temperature (AASHTO R028): Degrees Celsius. | 100 | 100 | 100 | 100 |
| Dynamic Shear (AASHTO T315): G*/SIN DELTA, Maximum, 5000 kPa, Test Temperature at 10 Rad/s, Degrees Celsius. | 25 | 28 | 31 | 34 |
| Creep Stiffness (AASHTO T313): S, Maximum, 300 MPa m-Value, Minimum 0.300, Test Temperature at 60 Seconds, Degrees Celsius. | -12 | -12 | -12 | -12 |

* Varies from the New Jersey Interagency Engineering Committee Standard

## 2.03 MIXES

A. Mix Design Table

| Mix Designation and Percentage by Weight Passing Sieves | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sieve Size | Bottom Course | Top Course | | | | | | Bridge Deck Membrane |
| | I-2A | I-4A | PA-5 | PA-5 with "Rosphalt 50" | I-5A | I-5A with "Rosphalt 50" | I-6A | |
| 1 1/4" | 100 | --- | --- | --- | --- | --- | --- | --- |
| 1" | 90-100 | 100 | --- | --- | --- | --- | --- | --- |
| 3/4" | 70-84 | 78-98 | 100 | 100 | --- | --- | --- | --- |
| 1/2" | 54-68 | 64-77 | 72-98 | 88-98 | 100 | 100 | --- | --- |
| 3/8" | 44-54 | 52-67 | 60-82 | 74-84 | 80-100 | 90-100 | 100 | 100 |
| No. 4 | 28-36 | 33-46 | 40-56 | 48-58 | 55-85 | 55-65 | 85-93 | 95-100 |
| No. 8 | 17-25 | 27-35 | 31-39 | 30-40 | 32-42 | 35-45 | 74-82 | 71-79 |
| No. 16 | 12-20 | 17-23 | 19-25 | 24-32 | 20-30 | 24-32 | --- | 59-67 |
| No. 30 | 7-15 | 12-18 | 13-19 | 16-24 | 12-22 | 16-24 | 50-58 | 47-55 |
| No. 50 | 5-11 | 8-12 | 8-16 | 10-16 | 7-16 | 10-16 | 24-32 | 25-35 |
| No. 100 | 3-9 | 6-10 | 5-10 | 6-10 | 3-12 | 6-10 | 9-15 | 14-22 |
| No. 200 | 1-5 | 3-6 | 3-6 | 2-6 | 2-6 | 2-6 | 4-8 | 12-16 |
| Asphalt, Weight by Percent of Total Mixture | | | | | | | | |
| | 3.5-4.5 | 4.4-5.2 | 5.2-6.2 | ***5.0 | 5.8-6.5 | ***5.0 | 6.5-8.00 | 8.00-9.00** |

** Asphalt shall be modified asphalt as specified in 2.02 B.2 above and meet the requirements for PG 76-22.

*** Asphalt binder content prior to addition of "Rosphalt 50 LT". "Rosphalt 50 LT" shall be added to the mix at a rate of 2.25% by weight of the mix (aggregate + binder).

| FROM NEW JERSEY INTER-AGENCY ENGINEERING COMMITTEE STANDARD BITUMINOUS CONCRETE MIXTURE DESIGN TABLE | | | |
|---|---|---|---|
| Mix Designation and Percentage By Weight Passing Sieves | | | |
| | Plant Mix Macadam Base Course | Top Course | |
| Sieve Size | I-1 | I-4 | I-5 |
| 1 1/2" | 100 | ----- | ----- |
| 1" | 90-100 | 100 | ----- |
| 3/4" | 60-80 | 95-100* | ----- |
| 1/2" | ----- | 75-95* | 100 |
| 3/8" | 15-40 | 65-85* | 80-100 |
| No. 4 | 0-10 | 35-65 | 55-75 |
| No. 8 | ----- | 25-50* | 30-60* |
| No. 16 | ----- | 18-40 | 20-45 |
| No. 30 | ----- | 12-30 | 15-35 |
| No. 50 | ----- | 10-23* | 10-30 |
| No. 100 | ----- | ----- | ----- |
| No. 200 | ----- | 3-6* | 3-8* |
| Asphalt, Weight by Percent of Total Mixture | | | |
| | 2.5-3.1 | 5.2-6.5* | 5.5-7.0* |

Note No. 1 - Material passing the No. 200 sieve may consist of fine particles of the aggregate, mineral filler, or both. Material passing the No. 30 sieve shall be non-plastic when tested in accordance with the requirements of ASTM D 4318.
Note No. 2 - Lift Thickness shall be no less than two times the nominal maximum size of the aggregate (See Note No. 6).
Note No. 3 - If the aggregate does not satisfy tensile strength ratio requirements, add an approved anti-stripping agent (See 2.02 A.1).
Note No. 4 - Job Mix Formula shall follow a smooth curve within the specified limits for all sieve sizes of the Mix Design Table, but shall not fall on the maximum density line and shall not cross the maximum density line below the No. 4 sieve. The maximum density line will be determined by the Engineer by plotting the gradations on a .45 power graph paper, and drawing a straight line between the amount passing the No. 200 sieve and the amount, which is retained on the largest sieve.
Note No. 5 - Notify the Engineer if a satisfactory Job Mix formula using the Mix Design Table cannot be obtained.
Note No. 6 - Nominal maximum size is one sieve size larger than the first sieve to retain more than 10 percent of the aggregate, based on the Contractor's job mix formula.

* Varies from the New Jersey Interagency Engineering Committee Standard

B. Job Mix Formula and Checklist

1. The laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666. Before construction starts, submit to the Engineer a certification signed by the manager of the laboratory stating that it meets these requirements. The certification shall contain as a minimum:

   a. Qualifications of personnel: laboratory manager, supervising technician and testing technicians.

   b. A listing of equipment to be used in developing the job mix.

   c. A copy of the laboratory's quality control system.

2. Develop Job Mix Formula using procedures contained in Chapter V, "Marshall Method of Mix Design" of the Asphalt Institute's Manual Series No. 2 (MS-2) and, where applicable, "Asphalt Hot-Mix Recycling", Manual Series No. 20 (MS-20); and furnish information for the following checklist:

   a. General

      (1) Contractor and Contract number.

      (2) Type of bituminous mixture.

      (3) Type and source of aggregates.

      (4) Type and source of asphalt.

   b. Aggregates

      (1) Sieve analysis of each aggregate to be used in mixture in accordance with ASTM C 136. The minus 200 fraction shall be tested by the laboratory or technician doing the mix design in accordance with ASTM C 117.

      (2) Physical test of aggregates - soundness, wear, percent fractured faces and percent flat or elongated particles.

      (3) Bulk specific gravity and absorption in accordance with ASTM C 127 for coarse aggregate and ASTM C 128 for fine aggregate. The aggregate shall be sampled by the laboratory or technician doing the mix design from the plant hot bins or feeder belt.

      (4) Proportion used of each type aggregate.

      (5) Theoretical gradation of combined proportions of aggregates.

   c. Asphalt

      (1) Type and grade.

      (2) Specific gravity.

      (3) Type of antistripping agent (if required).

   d. Optimum Asphalt Content Determination in accordance with ASTM D 1559

      (1) Compactive effort (75 or 113 blows applied to specimen, each face, as appropriate).

      (2) Actual specific gravity and unit weight of each specimen.

      (3) Percentage of asphalt in each specimen.

(4) Theoretical specific gravity of each specimen calculated.

(5) Graph of stabilities vs. asphalt content.

(6) Graph of flow values vs. asphalt content.

(7) Graph of voids filled with asphalt vs. asphalt content.

(8) Graph of Marshall air voids vs. asphalt content.

(9) Graph of voids in the mineral aggregate vs. asphalt content.

(10) Graph of unit weight vs. asphalt content.

(11) Visual description of specimens at optimum asphalt content (i.e., dry, flushing, etc.).

(12) Graph of Temperature vs. Viscosity of Asphalt.

e. Summation of Established Job Mix Formula

(1) Combined gradation of aggregates.

(2) Optimum asphalt content from above graphs.

(3) Specified job mix tolerance range.

(4) Mixing Temperature.

(5) Temperature of mix at point of discharge into haul units.

(6) Compaction Temperature.

f. Summation of the Characteristics of the Mixture at Optimum Asphalt Content

(1) Stability, pounds.

(2) Flow value, hundredths of an inch.

(3) Actual specific gravity of laboratory compacted mixture.

(4) Maximum specific gravity of paving mix at optimum asphalt content in accordance with ASTM D 2041.

(5) Total voids (air), percent, in laboratory compacted mixture.

(6) Voids filled with asphalt, percent, in laboratory compacted mixture.

(7) Voids in the mineral aggregate, percent, in laboratory compacted mixture.

(8) Actual unit weight (lbs./cu. ft.) of laboratory compacted mixture.

(9) Tensile Strength Ratio - ASTM D 4867.

g. Verification of Job Mix Formula Characteristics

Where the asphalt content for the proposed Job Mix Formula does not coincide with the asphalt content used in the trial specimens, prepare an additional set of specimens for the proposed Job Mix Formula asphalt content to verify that actual Marshall results duplicate those anticipated from the curves.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Clean all underlying pavement surfaces and previous courses of all loose and foreign material by sweeping with hand brooms, power sweepers or blowers as directed by the Engineer. Remove permanent pavement markings and reflectors.

B. Verify that required grade and density tolerances of previous courses have been obtained before placing asphalt concrete.

C. Construct keyways for overlay pavements as shown on the Contract Drawings by using longitudinal or transverse cuts into the existing pavement and removing the necessary amount of pavement to provide a smooth transition from the new to existing asphalt concrete surfaces.

D. Tack Coat

1. Apply tack coat by brush on edges of all previously placed or existing pavement and surfaces of manholes and other structures that will be in contact with pavement course to be placed.

2. Apply tack coat by pressure distributor to existing pavement surface to receive new pavement course or where a course is not placed within 24 hours for roadway areas after placement of the underlying course, except as specified in 3.02 E.7 and 3.02 F.2. However, if the underlying pavement course has not been exposed to traffic and, in the opinion of the Engineer, has been kept clean, tack coat shall not be required when a course is placed beyond the time frame mentioned above.

3. Unless otherwise shown on the Contract Drawings, the tack coat shall be at an application rate and temperature range of 0.05 to 0.10 gallons per square yard and 275 to 350 degrees F, respectively. The tack coat application rate for Portland cement concrete surfaces shall be 0.10 to 0.15 gallons per square yard.

4. Protect structures such as manhole frames and covers, joints and steel faced curbs within areas to be tack coated, prior to tack coating, by masking them with tar paper, polyethylene film or other approved materials.

5. After the application of tack coat, follow immediately with placement of asphalt concrete pavement course. Take precautions necessary to maintain and protect the tack coated surface from damage until the next course is placed, including placement and removal of sand as necessary to blot up excess material.

6. All tack coated surfaces shall be paved or protected prior to opening the area to traffic.

E. Mixing Plant Requirements for Recycled Asphalt Concrete

1. Batch plants shall have an appropriately located metering device for adding the reclaimed asphalt pavement to the heated new aggregate and shall provide an accurate method for proportioning the reclaimed asphalt pavement into the mixture.

2. The batch plant's dryer may have to be operated at temperatures higher than with all new materials. If necessary, modify the dryer and the dust collection system to prevent damage.

3. Drum-mix plants shall have an appropriately located metering device for adding the reclaimed asphalt concrete to the dryer-mixer in a manner that does not damage the asphalt in the reclaimed material. Ensure that an accurate method for proportioning the reclaimed asphalt concrete into the mixture is provided. Make provisions for compensating for the moisture in the reclaimed asphalt concrete.

4. The mixing for a drum-mix plant shall be such as to achieve an intimate blending of the new and reclaimed materials and a complete coating of all aggregate particles.

5. At the Contractor's option, the batch or drum-mix plant may be equipped with a surge-storage bin at the mixture discharge point.

## 3.02 APPLICATION

A. Mixing in Plant

1. Place aggregate through a dryer and heat to temperature not exceeding 350 degrees F (excluding mixes that contain "Rosphalt 50" additive). For mixes containing "Rosphalt 50" additive, place aggregate through a dryer and heat to temperature not exceeding 550 degrees F.

2. Screen aggregate to appropriate fractions and place each fraction in a storage bin over mixer unit.

3. Use equipment conforming to ASTM D 995 for preparation of paving mixtures, except provide one bin for fine aggregate, three for coarse aggregate, and one for reclaimed asphalt pavement (if applicable).

4. Introduce aggregate into mixer at between 250 and 350 degrees F (between 450 and 500 degrees F for mixes containing "Rosphalt 50" additive) and dry mix for minimum of 5 seconds (7 seconds for mixtures containing "Vestoplast S", 10 seconds for mixes containing "Rosphalt 50" additive) before adding asphalt. Where reclaimed asphalt pavement or "Vestoplast S" is used, add to mixer after dry mixing and before asphalt cement. Where "Rosphalt 50" additive is used, add to the mixer during the dry mixing.

5. Heat asphalt to a temperature not exceeding 325 degrees F (350 degrees F for modified asphalt) and introduce it into mixer at a temperature of not less than 275 degrees F (300 degrees F for modified asphalt).

6. Mix as long as necessary, but not less than 30 seconds (not less than 70 seconds for mixes containing "Rosphalt 50" additive) after introduction of asphalt cement, to completely and uniformly coat aggregate particles.

7. Regulate temperature of mixture according to outdoor temperature and as necessary to meet minimum laydown temperatures specified in 1.03 A.3 and 4. However, asphalt concrete mix production temperatures leaving the plant shall be as follows:

| Type of Asphalt | Temperature Degrees F |
|---|---|
| Asphalt Cement | 275 - 325 |
| Modified Asphalt – PG 76-22 | 305 - 335 |
| Modified Asphalt – PG 82-22 | 310 - 340 |
| Asphalt containing "Rosphalt 50" | 410 - 450 |

Any deviation from these temperatures must be approved by the Chief of Materials Engineering, Materials Engineering Unit. Use of storage silos will be permitted provided such silos are approved as specified in 1.04 D.4.

B. Delivery, Placing and Spreading

1. Trucks used for hauling asphalt concrete mixtures shall have tight, clean and smooth metal beds free from kerosene and other solvents. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened. Trucks used for hauling asphalt concrete mixtures containing "Rosphalt 50" additive shall have heated bodies and a suitable cover, securely fastened, to protect the mixture from adverse weather.

2. Load trucks using a minimum of three drops. The first load shall be approximately 40% of the total weight of the mix to be hauled and shall be loaded into the center of the front half of the truck. The truck shall then be pulled forward so that the next 40 percent or so of the total load can be deposited into the center of the back half of the bed, near the tailgate. The vehicle shall then be moved backward so that the remaining 20 percent of the mix can be dropped into the center of the bed, between the first two piles.

3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform without stopping and starting of the paver. Hauling over freshly placed material will not be permitted until the material has been compacted, as specified herein, and allowed to cool to ambient temperature.

4. Spread evenly, screed and finish each course to tolerances and requirements specified in this Section.

5. Asphalt concrete pavers shall be self-propelled, with an activated screed, heated as necessary, and shall be capable of spreading and finishing courses of asphalt concrete which will meet the specified thickness, smoothness and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

   The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required smoothness and texture without tearing, shoving or gouging the mixture.

6. An automatic screed control system shall be used which is capable of automatically maintaining the specified screed elevation and transverse slope. The control system shall be automatically actuated from a reference system by a sensor.

   The control system shall be capable of working in conjunction with any of the following reference systems:

   a. Ski-type device 40 to 60 feet in length.

   b. Taut stringline (wire) set to grade.

c. Laser beam set to grade.

7. Before commencing each day's paving, clean the paver of any material left from previous paving operations.

8. Place asphalt concrete paving in minimum 10-foot wide strips, except the last strip, which may be a lesser width if necessary.

9. Begin along high sides of areas and proceed towards low side of areas with a one directional slope. Start on centerline and work both ways for crowned pavements.

10. The longitudinal joint in one lift shall offset the longitudinal joint in the lift immediately below by at least 1 foot; however, the longitudinal joint in the surface lift shall be at the centerline of the pavement. Transverse joints in one lift shall be offset by at least 10 feet from transverse joints in the previous lift. Within the same lift, transverse joints in adjacent lanes shall be offset a minimum of 10 feet.

11. When starting paving operations at transverse joints, provide four starting block strips under full length of paver screed. Blocks shall be of a thickness appropriate for the lift being placed.

12. The paver's hopper shall be kept half full throughout the paving day. The wings shall not be emptied until the end of the paving day. Residual material shall be disposed of off Authority property.

13. No raked asphalt concrete material shall be broadcast back onto the pavement mat. Raked material shall be placed back in the paver hopper or disposed of.

14. Use hand placing and finishing methods, as approved by the Engineer, in small areas where use of power equipment is impractical. Lutes shall be used for hand spreading.

15. After density requirements have been meet, and a minimum of one hour after completion of rolling, reduce mat temperature by the controlled application of water, as directed by the Engineer. Allow the compacted mat to cool to 140 degrees F before opening to vehicular traffic.

C. Grade Control

1. Remove grade stakes just prior to rolling of the plant mix macadam base course.

2. The Engineer will provide benchmarks and alignment controls adjacent to each area of construction, which shall be checked and maintained by the Contractor.

3. Perform Contractor's quality control surveys immediately after top course has been rolled to check final surface grades, in accordance with 1.04 D.8.

4. Establish and maintain required lines and grades, including crown and cross slope, for each course during paving operations.

5. Use only qualified surveyors licensed in the State in which Work is being performed.

D. Compaction Equipment

1. Use power rollers weighing not less than 10 tons, having wheel loads of at least 250 lbs./linear inch of combined static and dynamic force and equipped with adjustable scrapers to keep wheel surfaces clean and with efficient means of keeping them wet to prevent the mixture from sticking to the roller.

2. Use types and quantities of equipment as necessary to meet all quality and production requirements of this Section.

3. Do not use steel rollers with pits, flat spots or grooves worn into rolling surface. Roller shall be capable of reversing without backlash.

4. Keep roller on asphalt concrete to avoid contamination of pavement with foreign material.

E. Rolling

1. Commence as soon as material will sustain roller without undue displacement, cracking or shoving.

2. The speed of the roller shall at all times be sufficiently slow to avoid displacement of the hot mixture and to be effective in compaction. Immediately correct any displacement occurring as a result of reversing the direction of the roller, or from any other cause.

3. The sequence of rolling operations shall be at the discretion of the Contractor.

4. Perform rolling with types and quantity of rollers as may be necessary to satisfy all of the pavement quality requirements specified herein.

5. Do not re-roll cold in-place asphalt concrete with a steel wheel or vibratory roller to attempt to increase density. A pneumatic tire roller may be used, subject to approval by the Engineer.

6. At end of each day's operations or when paving is interrupted sufficiently to allow mixture to cool, make a stop by means of tapering the course and form a transverse joint.

7. When resuming operations, cut back joint to expose a granular surface for full depth of the course, paint exposed edge with tack coat, place fresh mixture against joint, tamp and roll.

8. Any pavement that becomes loose and broken or mixed with dirt, develops check-cracking, or is in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at no cost to the Authority. Skin patching will not be allowed.

9. For asphalt concrete mixes containing "Rosphalt 50", breakdown rolling shall begin immediately after laydown and finish rolling shall be performed when the mix temperature is between 210 degrees F and 140 degrees F.

F. Joints

1. Form all joints in such a manner as to ensure a continuous bond between the courses and to obtain the required density, as demonstrated, tested and approved in the control strip. All joints shall have the same texture as other sections of the course and shall meet the requirements for density, smoothness and grade. Minimize raking of joints. Any mix raked from joint shall be discarded and not broadcast back onto the mat.

2. For transverse joints, the roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a temporary stop. After a temporary stop and prior to the continuation of paving, the tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face before placing the adjacent lane. Apply tack coat on all newly exposed contact surfaces before placing any fresh mixture against the joint.

## 3.03 CORRECTIONS OF DEFICIENCIES

A. Deficiencies in Surface Smoothness

1. Make corrections as specified below at no cost to the Authority in the event of the following:

   a. Longitudinal Smoothness for roadways where paving lane lengths equal or exceed 500 linear feet.

      (1) The Profile Index exceeds 22.0 inches per mile, or the surface profile deviations exceed 0.4 inches in 25 feet, when tested in accordance with 1.04 E.10.a, unless the Engineer elects to accept the deficient surface subject to an adjustment to Contract compensation. Adjustments to Contract compensation will be made as set forth in 4.01 H and I.

   b. Longitudinal and transverse direction for parking lots and port container storage areas.

      (1) In areas that do not adequately drain the water from the surface, or that otherwise hold water.

   c. Longitudinal direction for roadways where paving lane length is less than 500 feet.

      (1) 15 percent of all measurements in a paving lane exceed the requirements of 1.03 D.1.c when tested in accordance with 1.04 E.10.b.

      (2) Any deviations exceeding 1/4 inch when tested with a 10-foot straightedge.

2. The area of deficiencies in surface smoothness and/or surface grade tolerance is defined as the area of the lot defined in 1.04 E.10.a.(3), b.(1), except for parking lots and port container storage areas where the area of deficiencies will be determined by the Engineer based on the results of the test specified in 1.04 E.10.c.

3. Remove and replace, or diamond grind, pavement deficient in surface smoothness, in accordance with all applicable requirements of the Contract Drawings and this Section, at times approved by the Engineer, so as not to interfere with operations of the Authority or others using the area.

4. Remove and replace shall mean milling a minimum depth of twice the nominal maximum aggregate size of the asphalt concrete and repaving to the finished grade shown on the Contract Drawings with the same type asphalt concrete mix as removed. Remove existing pavement as necessary to provide square joints for the full depth of the overlay.

5. Diamond grinding may be used to correct deficiencies in surface smoothness and surface grade tolerance subject to approval by the Engineer. However, if removal of more than 3/4 inch of pavement is required to correct any deficiency, the deficient area shall be removed and replaced.

6. Diamond grinding equipment shall be approved by the Engineer and have a minimum grinding head of 36 inches and at least 5 blades per inch of shaft. Diamond grinding shall not be performed when the temperature of the asphalt concrete surface exceeds 80 degrees F. Slurry produced from grinding operations shall be properly disposed of off Authority property.

7. Where corrections are required, the entire width of the paving lane by the length of defective area shall be corrected. In the sole opinion of the Engineer, if the deficiencies are closely spaced and correcting individual areas will adversely affect ride, the entire pavement surface shall be corrected.

8. Following the correction of deficiencies, the Engineer will retest the finished surface of the asphalt concrete. In the event the Profile Index or surface profile deviations exceed the required values, make additional corrections at no cost to the Authority.

B. Deficiencies in In-Place Air Voids of Top and Bottom Courses and Bridge Deck Membrane

1. With the exception of bridge deck membrane, any pavement sublot with in-place mat air voids less than 2.0 percent or greater than 8.0 percent (9.0 percent for bottom course and materials placed on roadway structures) shall be removed and replaced at no additional cost to the Authority. For mixes containing "Rosphalt 50" additive, any pavement sublot with in-place mat air voids greater than 6.0 shall be removed and replaced at no additional cost to the Authority. For paving lifts other than the top lift of asphalt concrete, the Engineer may elect to accept deficient material subject to an adjustment to Contract compensation. Adjustments to Contract compensation will be made as set forth in 4.01 G.

2. For bridge deck membrane, any pavement sublot found to be below the lower density limit as specified in 1.03 D.2.a or having air voids greater than 2.0 percent shall be removed and replaced at no additional cost to the Authority.

C. Deficiencies in Marshall Stability and Flow

In accordance with 1.03 C.2 for stability and flow, if the Percentage of Material Within Tolerance Limits (PWL) of a lot for either parameter as set forth in 4.03 B.5 equals or exceeds 90 percent, the lot will be acceptable. If the PWL for either parameter is less than 90 percent, determine the reason and take corrective action immediately. If the PWL is below 80 percent for either parameter, stop production and make adjustments to the mix.

D. Deficiency in Final Surface Grade

1. When more than 15 percent of all measurements within a lot exceed the grade tolerance, measured in accordance with 1.04 E.11, remove and replace or diamond grind the entire lot in accordance with 3.03 A, unless the Engineer elects to accept the deficient surface, subject to Contract compensation. Adjustments to Contract compensation will be made as set forth in 4.01 H and I.

2. When any individual measurement exceeds a grade tolerance of plus or minus 0.06 foot, remove and replace the surface of the area exceeding the tolerance in accordance with 3.03 A.

3. Following the correction of deficiencies, the Engineer will retest the final surface of the asphalt concrete. In the event grade tolerance is exceeded, make additional corrections at no cost to the Authority.

E. Deficiencies in the Performance Grade Requirements of Modified Asphalt

Remove and replace the deficient material on a lot basis, unless the Engineer elects to accept the deficient material subject to an adjustment to Contract compensation. Adjustments to Contract compensation will be made as set forth in 4.01 G.

F. Deficiencies for Tensile Strength Ratio (TSR)

Remove and replace the deficient material on a lot basis if the TSR is less than or equal to 60 percent , unless the Engineer elects to accept the deficient material subject to an adjustment to Contract compensation. Adjustments to Contract compensation will be made as set forth in 4.01 G.

## PART 4. ADJUSTMENTS TO CONTRACT COMPENSATION

### 4.01 GENERAL

A. Where the Contract requires less than 500 tons of asphalt concrete, no adjustments to Contract compensation will be made as specified herein.

B. Where the Contract requires 500 tons or more of asphalt concrete, adjustments to Contract compensation will be made as specified in 4.03 A, B, C, D, E and F.

C. Notwithstanding other adjustments to Contract compensation or corrections specified herein for various deficiencies, no payment will be made for material placed above the allowable tolerance above required grade as specified in 1.03 D.4, or for material that must be removed to correct deficiencies, or for that material placed in excess of the plus tolerance for the total thickness of each course as specified in 1.03 D.3.

D. The computations for adjustments to Contract compensation may require conversion between tons and square yards. Such conversion will be made using the actual computed weight per square yard per inch of thickness determined from the lot's average bulk specific gravity for each type of course times the density of water at 70 degrees F.

E. Adjustments to Contract compensation for in-place mat densities, in-place joint densities for surface course and Marshall air voids shall be determined by applying percentages, calculated as specified in 4.03 B, to the assigned unit price of Sixty Dollars ($60.00) or One Hundred Sixty Dollars ($160.00) for mixes containing "Rosphalt 50", per ton of asphalt concrete; or in the case of Classified Work, by applying such percentages to the actual Contract Unit Price bid for the appropriate asphalt concrete item in the Schedule of Unit Prices for Classified Work, but in no case less than Sixty Dollars ($60.00) or One Hundred Sixty Dollars ($160.00) for mixes containing "Rosphalt 50", per ton of asphalt concrete.

F. The percentage adjustment to the unit price specified in 4.01 E for Marshall air voids, mat density and joint density of the surface course shall be as follows, except as set forth in 4.01 G:

1. When all values calculated in accordance with 4.03 B are 100 percent or greater, the highest value will be used to adjust Contract compensation.
2. When all values calculated in accordance with 4.03 B are less than 100 percent, the lowest value will be used to adjust Contract compensation.
3. When values calculated in accordance with 4.03 B are both greater and less than 100 percent, the product of the highest and lowest values will be used to adjust Contract compensation.

G. When the Engineer elects to adjust Contract compensation in lieu of removal and replacement of material with deficient in-place mat air voids, tensile strength ratio or deficiencies in modified asphalt performance grade, the percentage adjustment to the unit price specified in 4.01 E will be set at 50 percent. No further adjustment will be made for Marshall air voids, mat density or joint density of the surface course.

H. Adjustments for surface smoothness and final surface grade will be based on the final test results, which will be measured after the correction of deficiencies. Reductions in payment will be determined by the following:

$$R = A \times D \times F \times T \times 0.00646$$

Where:

R = Reduction in payment per lot for surface smoothness or final surface grade, dollars

T = Thickness of final pavement lift, inches

A = Area of lot, square feet

D = Price per ton of asphalt concrete, assigned unit price or contract unit price as set forth in 4.01 E

F = Contract Unit Price Adjustment Factor specified in 4.03 D and 4.03 E

Reductions in payment for failure to meet surface smoothness and final surface grades will be calculated separately for the entire pavement or overlay surface. Deductions from Contract compensation will be made for the requirement (surface smoothness or final surface grade) which results in the greatest payment reduction. Reductions for surface smoothness or final surface grade will be in addition to all other adjustments to Contract compensation.

I. When the Engineer elects to adjust Contract compensation in lieu of correcting areas with deficiencies in surface smoothness or final surface grade, the Contract Unit Price Adjustment Factor specified in 4.01 H will set at 0.10 for surface smoothness and 0.25 for final surface grade.

## 4.02 ADJUSTMENT TO CONTRACT COMPENSATION FOR THICKNESS DEFICIENCY IN PLANT MIX MACADAM BASE COURSE

A. Where the deficiency of a plant mix macadam base course core exceeds the allowable minus tolerance in plant mix macadam base course thickness, one additional core will be taken by the Engineer in each of the other three sublots adjacent to the core taken in accordance with 1.04 E.4. Plant mix thickness for the area of entire lot will be the average of the four cores.[4] Where there is a deficiency in the average of the four cores in excess of the allowable minus tolerance, the total thickness of succeeding courses in the area of entire lot shall be increased by the amount the deficiency exceeds the allowable tolerance.

B. For each additional lot resampled in accordance with 4.02 A above, there will be deducted from the Contract compensation, in addition to adjustments for deficiencies as hereinafter specified, an amount of One Thousand Dollars ($1,000.00).

## 4.03 ADJUSTMENT TO CONTRACT COMPENSATION FOR DEFICIENCIES IN TOP AND BOTTOM COURSES AND BRIDGE DECK MEMBRANE

A. Deficiency in Thickness

Thickness of each course, excluding overlay, will be the average of the four cores in the lot for each course[5]. Deductions from Contract compensation for deficiencies in thickness of top course or total of top and bottom courses, modified as may be required by 4.02 A, will be the following amounts (deducted per square yard) for the entire area lot:

| Amount of Minus Deficiency (inches) | Amount of Payment Deduction (Dollars per Square Yard) |
|---|---|
| Greater than 1/4 and up to 1/2 | 1.00 |
| Greater than 1/2 and up to 3/4 | 2.00 |

For minus deficiencies in excess of 3/4 inch either in average of four cores or in any individual core, at the Engineer's option, remove and replace deficient pavement or place an overlay that will satisfy all requirements of this Section.

B. Deficiency in In-Place Mat Density, In-Place Joint Density and Marshall Air Voids

1. Top and bottom courses will be approved on a lot basis with each lot coinciding with that defined in 1.04 D.1.a.

2. Density

a. In-place mat density specified in 1.03 D.2.a will be evaluated for Section compliance using the average of the random sublot in-place density determinations from cores of the area covered by the lot specified in 1.04 D.1.a.

---

[4] In determining average thickness, if any core exceeds required thickness by more than 1/2 inch, the thickness of that core will be assumed to be 1/2 inch in excess of required thickness.

[5] In determining average thickness, if any core exceeds required thickness by more than 1/4 inch, the thickness of that core will be assumed to be 1/4 inch in excess of required thickness.

b. In-place joint density specified in 1.03 D.2.b will be evaluated for Section compliance using the average of random sublot in place joint density determinations from cores of the area covered by the lot specified in 1.04 D.1.a.

3. Marshall air voids will be evaluated for Section compliance using the average of the random sublot void determinations from hot mix samples from the lot specified in 1.04 D.1.a.

4. The Engineer will check each lot for in-place mat densities, in-place joint densities for surface courses only, and Marshall air voids with adjustments to Contract compensation based on the Percentage of Material Within Tolerance Limits (PWL) as determined by 4.03 B.5 below and by the "Table For Estimating Percent of Lot Within Tolerance Limits-PWL (Standard Deviation Method)". No deficient lot will be approved without an adjustment to Contract compensation made in accordance with the tables entitled "Adjustment to Contract Compensation For In-Place Mat Density and Marshall Air Voids" and "Adjustment to Contract Compensation for In-Place Joint Density".

5. Method of Estimating Percentage of Material Within Tolerance Limits (PWL)

a. Locate sampling positions on the lot by use of random sampling procedures specified in FAA ERLPM, Section 6.

b. Make a measurement at each location, or take a test portion and make the measurement on the test portion in accordance with 1.04 D and E.

c. Determine the average value of all samples ( $\overline{X}$ ).

d. Find the standard deviation (Sn) by use of the following formula:

$$S_n = \sqrt{d_1^2 + d_2^2 + d_3^2 + ... + d_n^2/n-1}$$

Where

$S_n$ = standard deviation of the number in the set

$d_1, d_2,$ = deviation of the individual sample values $X_1, X_2, . . .$ from the average value that is,

$d_1$ = $(X_1 - \overline{X})$, $d_2 = (X_2 - \overline{X})$, $d_n = (X_n - \overline{X})$

n = number of sublots

e. Find the Lower Quality Index (QL) by subtracting the lower tolerance limit (L) from the average values ( $\overline{X}$ ) and dividing the result by standard deviation (Sn).

$$Q_L = \frac{\overline{X} - L}{S_n}$$

f. Find the Upper Quality Index (QU) by subtracting the average value ( $\overline{X}$ ) from the upper tolerance limit (U) and dividing the result by standard deviation (Sn).

$$Q_U = \frac{U - \overline{X}}{S_n}$$

g. The percentage of material above lower tolerance limit (PL) and the percentage of material below upper tolerance limit (PU) will be found by entering the "Table For Estimating Percent of Lot Within Tolerance Limits - PWL (Standard Deviation Method)" with QL and QU, using the column appropriate to the total number (n) of sublots and reading the number under the column headed "Percent Within Tolerance Limits (PWL)". If the values fall between values shown on the table, use the next higher value for PL or PU.

h. For asphalt concrete properties with only a lower tolerance limit (stability, mat density, joint density), the Percentage of Material Within Tolerance Limits (PWL) equals PL. For asphalt properties with upper and lower tolerance limits (air voids and flow) determine PWL using the following formula:

$$PWL = (P_U + P_L) - 100$$

i. If the tests within a lot include a very large or a very small value which appears to be outside the limits of variation, the Engineer will check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value will be discarded when computing Percentage of Material Within Tolerance Limits (PWL).

C. Adjustment to Contract compensation for each lot will be made in accordance with the formula contained in the table entitled "Adjustment to Contract Compensation For In-Place Mat Density and Marshall Air Voids" by entering the appropriate row with the value of PWL and performing the calculation indicated for that PWL to determine the percentage adjustment of the unit price (specified in 4.01).

| ADJUSTMENT TO CONTRACT COMPENSATION FOR IN-PLACE MAT DENSITY AND MARSHALL AIR VOIDS | |
|---|---|
| Percentage of Material Within Tolerance Limits (PWL) | Percentage Adjustment of the Unit Price (specified in 4.01 E and 4.01 F) |
| 96-100 | 106 |
| 90-96 | PWL + 10 |
| 80-90 | 0.5 (PWL) + 55 |
| 65-80 | 2.0 (PWL) – 65 |
| Below 65 | [6] |

[6] The lot shall be removed and replaced to meet Section requirements as ordered by the Engineer. In lieu thereof, and subject to the provisions in 3.03 B for mandatory removal and replacement, the Contractor and the Engineer may agree in writing that, for purposes of practicality, the deficient lot shall not be removed and adjustment to Contract compensation shall be made at 75 percent of the unit price specified in 4.01 E.

D. Deficiency in Final Surface Grade Tolerance

Adjustment to Contract compensation for each lot will be made using the table entitled "Adjustment to Contract Compensation for Exceeding Final Surface Grade Tolerance" by entering the appropriate row with the percentage of all measurements within a lot which exceed the grade tolerance, measured in accordance with 1.04 E.11, and by reading the number under the column headed "Contract Unit Price Adjustment Factor".

| ADJUSTMENT TO CONTRACT COMPENSATION FOR EXCEEDING FINAL SURFACE GRADE TOLERANCE | |
|---|---|
| Measurements Exceeding Grade Tolerance (Percent) | Contract Unit Price Adjustment Factor |
| 0.0 – 5.0 | 0.00 |
| 5.1 – 10.0 | 0.05 |
| 10.1 – 15.0 | 0.25 |
| 15.1 and up | Corrective work required as specified in 3.03 D |

The Contract Unit Price Adjustment Factor is used to calculate adjustments to Contract compensation as specified in 4.01 H.

E. Deficiency in Surface Smoothness

Adjustment to Contract compensation for each lot will be made using the table entitled "Adjustment to Contract Compensation for Surface Smoothness", by entering the appropriate row with the Profile Index, measured and calculated in accordance with 1.04 E.10, and by reading the number under the column headed "Contract Unit Price Adjustment Factor".

| ADJUSTMENT TO CONTRACT COMPENSATION FOR SURFACE SMOOTHNESS | |
|---|---|
| Average Profile Index (inches per mile) | Contract Unit Price Adjustment Factor |
| 0.0 - 15.0 | 0.00 |
| 15.1 - 16.0 | 0.02 |
| 16.1 - 17.0 | 0.04 |
| 17.1 - 18.0 | 0.06 |
| 18.1 - 20.0 | 0.08 |
| 20.1 - 22.0 | 0.10 |
| 22.1 and up | Corrective work required as specified in 3.03 A |

The Contract Unit Price Adjustment Factor is used to calculate adjustments to Contract compensation as specified in 4.01 H.

F. Adjustment to Contract compensation for each lot will be made in accordance with the formula contained in the table entitled "Adjustment to Contract Compensation for In-Place Joint Density" by entering the appropriate row with the value of PWL and by performing the calculation indicated for that PWL to determine the percentage adjustment of the unit price (specified in 4.01 E.).

| ADJUSTMENT TO CONTRACT COMPENSATION FOR IN-PLACE JOINT DENSITY | |
|---|---|
| Percentage of Material Within Tolerance Limits (PWL) | Percentage Adjustment of the Unit Price (specified in 4.01 E and 4.01 F) |
| 96 – 100 | 106 |
| 90 – 96 | PWL + 10 |
| 80 – 90 | 0.25 x PWL + 77.5 |
| 65 – 80 | PWL + 17.5 |
| Below 65 | [7] |

[7] The lot shall be removed and replaced to meet Section requirements as ordered by the Engineer. In lieu thereof, and subject to the provisions in 3.03 B for mandatory removal and replacement, the Contractor and the Engineer may agree in writing that, for purposes of practicality, the deficient lot shall not be removed and adjustment to Contract compensation shall be made at 75 percent of the unit price specified in 4.01 E.

**TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE LIMITS - PWL (STANDARD DEVIATION METHOD)**

| Percent Within Tolerance Limits (PWL) | Positive Values of $Q_L$ or $Q_U$ n = Number of Sublots | | | | | |
|---|---|---|---|---|---|---|
| | n = 3 | n = 4 | n = 5 | n = 6 | n = 7 | n = 8 |
| 99 | 1.1541 | 1.4700 | 1.6714 | 1.8008 | 1.8888 | 1.9520 |
| 98 | 1.1524 | 1.4400 | 1.6016 | 1.6982 | 1.7612 | 1.8053 |
| 97 | 1.1496 | 1.4100 | 1.5427 | 1.6181 | 1.6661 | 1.6993 |
| 96 | 1.1456 | 1.3800 | 1.4897 | 1.5497 | 1.5871 | 1.6127 |
| 95 | 1.1405 | 1.3500 | 1.4407 | 1.4887 | 1.5181 | 1.5381 |
| 94 | 1.1342 | 1.3200 | 1.3946 | 1.4329 | 1.4561 | 1.4716 |
| 93 | 1.1269 | 1.2900 | 1.3508 | 1.3810 | 1.3991 | 1.4112 |
| 92 | 1.1184 | 1.2600 | 1.3088 | 1.3323 | 1.3461 | 1.3554 |
| 91 | 1.1089 | 1.2300 | 1.2683 | 1.2860 | 1.2964 | 1.3032 |
| 90 | 1.0982 | 1.2000 | 1.2290 | 1.2419 | 1.2492 | 1.2541 |
| 89 | 1.0864 | 1.1700 | 1.1909 | 1.1995 | 1.2043 | 1.2075 |
| 88 | 1.0736 | 1.1400 | 1.1537 | 1.1587 | 1.1613 | 1.1630 |
| 87 | 1.0597 | 1.1100 | 1.1173 | 1.1191 | 1.1199 | 1.1204 |
| 86 | 1.0448 | 1.0800 | 1.0817 | 1.0808 | 1.0800 | 1.0794 |
| 85 | 1.0288 | 1.0500 | 1.0467 | 1.0435 | 1.0413 | 1.0399 |
| 84 | 1.0119 | 1.0200 | 1.0124 | 1.0071 | 1.0037 | 1.0015 |
| 83 | 0.9939 | 0.9900 | 0.9785 | 0.9715 | 0.9672 | 0.9643 |
| 82 | 0.9749 | 0.9600 | 0.9452 | 0.9367 | 0.9325 | 0.9281 |
| 81 | 0.9550 | 0.9300 | 0.9123 | 0.9025 | 0.8966 | 0.8928 |
| 80 | 0.9342 | 0.9000 | 0.8799 | 0.8690 | 0.8625 | 0.8583 |
| 79 | 0.9124 | 0.8700 | 0.8478 | 0.8360 | 0.8291 | 0.8245 |
| 78 | 0.8897 | 0.8400 | 0.8160 | 0.8036 | 0.7962 | 0.7915 |
| 77 | 0.8662 | 0.8100 | 0.7846 | 0.7716 | 0.7640 | 0.7590 |
| 76 | 0.8417 | 0.7800 | 0.7535 | 0.7401 | 0.7322 | 0.7271 |
| 75 | 0.8165 | 0.7500 | 0.7226 | 0.7089 | 0.7009 | 0.6958 |

**TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE LIMITS - PWL (STANDARD DEVIATION METHOD)**

| Percent Within Tolerance Limits (PWL) | Positive Values of $Q_L$ or $Q_U$ n = Number of Sublots | | | | | |
|---|---|---|---|---|---|---|
| | n = 3 | n = 4 | n = 5 | N = 6 | n = 7 | n = 8 |
| 74 | 0.7904 | 0.7200 | 0.6921 | 0.6781 | 0.6701 | 0.6649 |
| 73 | 0.7636 | 0.6900 | 0.6617 | 0.6477 | 0.6396 | 0.6344 |
| 72 | 0.7360 | 0.6600 | 0.6316 | 0.6176 | 0.6095 | 0.6044 |
| 71 | 0.7077 | 0.6300 | 0.6016 | 0.5878 | 0.5798 | 0.5747 |
| 70 | 0.6787 | 0.6000 | 0.5719 | 0.5583 | 0.5504 | 0.5454 |
| 69 | 0.6490 | 0.5700 | 0.5423 | 0.5290 | 0.5213 | 0.5164 |
| 68 | 0.6187 | 0.5400 | 0.5129 | 0.4999 | 0.4924 | 0.4877 |
| 67 | 0.5878 | 0.5100 | 0.4836 | 0.4710 | 0.4638 | 0.4592 |
| 66 | 0.5563 | 0.4800 | 0.4545 | 0.4424 | 0.4354 | 0.4310 |
| 65 | 0.5242 | 0.4500 | 0.4255 | 0.4139 | 0.4073 | 0.4031 |
| 64 | 0.4916 | 0.4200 | 0.3967 | 0.3856 | 0.3793 | 0.3753 |
| 63 | 0.4586 | 0.3900 | 0.3679 | 0.3575 | 0.3515 | 0.3477 |
| 62 | 0.4251 | 0.3600 | 0.3392 | 0.3295 | 0.3239 | 0.3203 |
| 61 | 0.3911 | 0.3300 | 0.3107 | 0.3016 | 0.2964 | 0.2931 |
| 60 | 0.3568 | 0.3000 | 0.2822 | 0.2738 | 0.2691 | 0.2660 |
| 59 | 0.3222 | 0.2700 | 0.2537 | 0.2461 | 0.2418 | 0.2391 |
| 58 | 0.2872 | 0.2400 | 0.2254 | 0.2186 | 0.2147 | 0.2122 |
| 57 | 0.2519 | 0.2100 | 0.1971 | 0.1911 | 0.1877 | 0.1855 |
| 56 | 0.2164 | 0.1800 | 0.1688 | 0.1636 | 0.1613 | 0.1592 |
| 55 | 0.1806 | 0.1500 | 0.1408 | 0.1363 | 0.1338 | 0.1322 |
| 54 | 0.1447 | 0.1200 | 0.1125 | 0.1090 | 0.1070 | 0.1057 |
| 53 | 0.1087 | 0.0900 | 0.0843 | 0.0817 | 0.0802 | 0.0792 |
| 52 | 0.0725 | 0.0600 | 0.0562 | 0.0544 | 0.0534 | 0.0528 |
| 51 | 0.0363 | 0.0300 | 0.0281 | 0.0272 | 0.0267 | 0.0264 |
| 50 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

G. Additional Tests

1. In the event the Contractor elects to question the original density test results obtained from a particular lot for either the mat density or joint density, the Contractor may request additional testing of that lot in writing within 48 hours of receipt of the written test results from the Engineer. Upon written request received from the Contractor for such additional testing, the Engineer will test one additional sample from each sublot from randomly selected locations in the pavement where the lot was placed. The redefined test will consist of the Engineer's original samples and the additional Contractor's requested samples. The "Percent of Material Within Tolerance Limits-PWL" will be determined in accordance with 4.03 B.5. The value will be used to determine any adjustment to Contract compensation. Only one resampling per lot will be permitted.

2. Additional tests requested by the Contractor shall be paid for by the Contractor to the Authority at the rate of One Thousand Dollars ($1,000) per lot tested.

## 4.04 ADJUSTMENT TO CONTRACT COMPENSATION FOR CHANGES IN THE INDEX PRICE OF ASPHALT CEMENT

A. General

An adjustment to Contract compensation will be made for changes in the index price of the asphalt cement in asphalt concrete and plant mix macadam base and for tack coat, as set forth in 4.04 C, provided that the Contract requires a total of 500 tons or more of asphalt concrete and plant mix macadam base course.

B. Engineer’s Method of Measurement

1. Asphalt concrete including top course and bottom course and plant mix macadam base course will be measured by the ton. The weight will be determined by one of the following methods:

   a. A weigh ticket printed by an automatic printer system used in conjunction with an automated batching and mixing system. The printed ticket shall show the date, the individual weights of the various components of the asphalt concrete or plant mix macadam base course mixture in a batch, the total weight of each batch and the sum of the all batch weights in the truckload. At the completion of each day's work, a producer's representative shall certify in writing that the total weight supplied was correct.

   b. A weigh ticket printed by an automatic scale showing the tare and gross weights of the truck as determined for each trip and the time and date indicating when the empty truck was tarred and when the loaded truck departed from the plant. Time and date may be printed automatically by a time clock. However, the net weight must be documented on each delivery ticket by a State certified weigh master.

   c. In the event of a breakdown of an automatic printer system, weigh tickets showing the gross, tare and net weight of each truck, as entered and certified by a weigh master, will be accepted for a period not exceeding the necessary repair time as certified by a State licensed repairman.

A weigh ticket shall be furnished for each truckload. Material will not be accepted unless accompanied by a weigh ticket, which shall be legible and clearly indicate the printed heading of the supplier and location of the batch plant, the title of the Contract for which delivery is intended, the time and date, truck number, lot number and mix number of material being furnished and the total net weight in each truckload.

2. Tack coat will be measured by the gallon at a temperature of 285 degrees F.

C. Asphalt Price Adjustment

1. The asphalt price adjustment for the asphalt cement in asphalt concrete or plant mix macadam base course will be determined monthly using the following formula:

$$Ac = (A - BA) \times T$$

Where Ac = Asphalt Cement Price Adjustment, in dollars
A = Asphalt Cement Price Index[8], in dollars per ton
BA = Basic Asphalt Cement Price Index[9], in dollars per ton
T = Tons of New Asphalt Cement[10]

2. The asphalt price adjustment for tack coat will be determined on a monthly basis using the following formula:

$$At = (A - BA) \times (C) \times (G) \times 0.003986$$

Where At = Asphalt Cement Price Adjustment for tack coat, in dollars
C = Petroleum Content of the Tack Coat in Percent by Volume: Use 1.0 for asphalt cement and cutbacks
A = Asphalt Cement Price Index[8], in dollars per ton
G = Tack Coat Furnished in Gallons and Applied at 285°F, where one gallon is equal to 0.003986 ton
BA = Basic Asphalt Cement Price Index[9], in dollars per ton

3. Should a monthly Asphalt Cement Price Index increase 50 percent or more over the Basic Asphalt Cement Price Index, no additional asphalt concrete, or plant mix macadam base shall be furnished for the Contract without written approval from the Engineer.

4. Should a monthly Asphalt Price Index decrease from the Basic Asphalt Price Index, payments will be decreased accordingly.

---

8 The Asphalt Cement Price Index is the price in dollars per ton (English Units), published by the New Jersey Department of Transportation for the area North of Route 195, for the month during which the asphalt concrete paving or tack coat application occurred.

9 The Basic Asphalt Cement Price Index is the price in dollars per ton (English Units), published by the New Jersey Department of Transportation, for the area North of Route 195, for the month immediately prior to the month during which bids are received.

10 The weight of asphalt cement eligible for price adjustment including all conventional and modified asphalt concrete and plant mix macadam base course will be determined by multiplying the percentage of new asphalt cement in the approved job mix formula by the weight of asphalt concrete mixture, measured in accordance with 4.04 B.

5. Asphalt price adjustments will not be made in those months for which the Monthly Asphalt Cement Price Index has changed by less than five percent from the Basic Asphalt Cement Price Index.

6. If the Asphalt Cement Price Index is adjusted more than once in a month, the asphalt price adjustment may be made.

END OF SECTION

## SECTION 02553

## ASPHALT CONCRETE PAVING

## APPENDIX "A"

## SUBMITTALS

A. Submit to the Chief of Materials Engineering , Port Authority Technical Center, 241 Erie Street, Jersey City, New Jersey, 07310-1397, for approval, all Job Mix Formulae with Checklist (specified in 2.03 B) for each type of asphalt concrete mix, from each plant and each new source of material at least 10 days prior to the start of production.

B. Submit certified test data, location of each type aggregate to be used and quantities to be obtained from each location and make arrangements for the Materials Engineering Unit to obtain samples from each such location for checking against the samples submitted. Take all samples in accordance with requirements of ASTM D 75 and ASTM D 242.

C. If requested, submit to the Chief of Materials Engineering, Materials Engineering Unit samples of each type aggregate to be used and from each source with proper identification as to source, type of aggregate and Contract number. Submit in clean, sturdy bags and in the following amounts for each sample when requested:

| | |
|---|---|
| Reclaimed Asphalt Pavement (when used) | 50 lbs. |
| Coarse Aggregate | 25 lbs. |
| Fine Aggregate | 25 lbs. |
| Mineral Filler | 5 lbs. |

D. Submit for each type asphalt cement proposed for use to the Chief of Materials Engineering, Materials Engineering Unit the following for approval. Resubmit the data each time asphalt cement from a different source is proposed.

1. The name and location of the supplier(s).
2. An analysis of such asphalts by the supplier, certifying that the results of tests comply with the requirements of AASHTO M320 and this Section.
3. If requested, submit four 1-quart samples of the asphalt cement.

E. Submit for each additive proposed for use to the Chief of Materials Engineering, Materials Engineering Unit, the following for approval:

1. The name and location of the supplier(s).
2. An analysis of such additive by the supplier, certifying the chemical properties and compliance with this Section.
3. If requested, submit a sample of the additive, in the manufacturer's original sealed bag or container.

F. For mixes containing "Rosphalt 50" additive, the manufacturer ,Chase Construction Products/Royston Division of Chase Corporation, may request samples of aggregates, asphalt cement and/or additives to be submitted to them in their laboratory to develop or verify the Job Mix Formulae.

G. In lieu of submitting samples of aggregates, asphalt cement and/or additives, the Engineer may verify the Job Mix Formulae at the plant.

H. Submit quality control plan and control charts to the Chief of Materials Engineering, Materials Engineering Unit, for approval, at least 5 days prior to the start of production.

I. Submit to the Chief of Materials Engineering, Materials Engineering Unit, the name of the supplier and an analysis of the asphalt tack coat to be used on the Contract.

END OF APPENDIX "A"

# SECTION 02553

# ASPHALT CONCRETE PAVING

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (3.03 A.4) | Final surface grade. |
| (1.03 D.1.3) | Pavement course thickness. |
| (1.04 C.2.b) | Percentage of Reclaimed Asphalt Pavement permitted, if different from values given. |
| (1.04 D.5) | Specify area of control strip, if required to avoid or minimize disruption of critical facility operations. |
| (2.02 A.2.a-b) | Specify area for use of Trap Rock or Gneiss as Coarse Aggregate. |
| (2.02 B) | Asphalt Binder Performance Grade to be used for each mix. |
| (2.02 C; 3.01 D.3) | Tack coat and application requirements, if different from values given. Include Specification Section 02555 for mixes that contain "Rosphalt 50". |
| (3.01 C) | Keyways for overlay pavements. |
| (1.03 D.1.4; (1.04.D.8; 3.02 C.3; 3.03 A.2; 3.03 A.4; 4.03 B) | Final pavement grades. |

B. Appendix "A" - Submittals

Modify submittals as required.

C. Designer Note

This specification requires the designer to indicate on the Contract Drawings the mix designations for each use and the type of "asphalt" binder to be used in each case.

| MINIMUM DESIGN LIFT THICKNESS | |
|---|---|
| I-4A | 2-1/2" |
| I-4 | 1-1/2" |
| PA-5 | 1-1/2" |
| I-5 | 1" |
| I-5A | 1" |
| I-6A | 3/4" |
| Bridge Deck Membrane | 1/2" |

END OF INSTRUCTIONS

# DIVISION 3

# SECTION 03200

# CONCRETE REINFORCEMENT

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for furnishing and installing concrete reinforcement.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway and Transportation Officials (AASHTO)

| | |
|---|---|
| AASHTO M32 | Steel Wire, Plain, for Concrete Reinforcement |
| AASHTO M55 | Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement |
| AASHTO M221 | Welded Deformed Steel Wire Fabric for Concrete Reinforcement |
| AASHTO M31 | Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| AASHTO M284 | Epoxy-Coated Reinforcing Steel Bars |

American Concrete Institute (ACI)

| | |
|---|---|
| ACI 315 | Details and Detailing of Concrete Reinforcement |
| ACI 318 | Building Code Requirements for Reinforced Concrete |

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM A 82 | Steel Wire, Plain, for Concrete Reinforcement |
| ASTM A 184 | Fabricated Deformed Steel Bar Mats for Concrete Reinforcement |
| ASTM A 185 | Steel Welded Wire, Fabric, Plain, for Concrete Reinforcement |
| ASTM A 497 | Welded Deformed Steel Wire Fabric for Concrete Reinforcement |
| ASTM A 615 | Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| ASTM A 767 | Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement |
| ASTM A 775 | Epoxy-Coated Reinforcing Steel Bars |

American Welding Society (AWS)

| | |
|---|---|
| AWS D 1.4 | Structural Welding Code - Reinforcing Steel |

Concrete Reinforcing Steel Institute (CRSI)

Manual of Standard Practice Placing Reinforcing Bars

1.03 BRIDGE WORK

For Work of this Section involving bridges, the Contractor shall comply with the applicable provisions of "Standard Specifications for Highway Bridges" of the American Association of State Highway and Transportation Officials (AASHTO). Materials shall be in accordance with AASHTO designations where shown after the ASTM designation in parenthesis. Where not shown, comply with ASTM Designation.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver concrete reinforcement in bundles marked with metal tags indicating size, length and mark number.

B. Store and handle materials to prevent corrosion, damage to coating or contamination that could impair bond.

1.05 SUBMITTALS

For submittals see Appendix "A".

## PART 2. PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars: ASTM A 615 (AASHTO M31), deformed, Grade 60, unless otherwise shown on the Contract Drawings.

Coated bars where shown on the Contract Drawings shall comply with the following:

1. Galvanized Reinforcing Bars

   ASTM A 767, Class-I hot-dip galvanized, after fabrication and bending.

   Repair sheared and cut ends and damaged coating with a zinc-rich formulation conforming to ASTM A 767 in accordance with the material manufacturers' recommendations.

2. Epoxy-coated Reinforcing Bars: ASTM A 775 (AASHTO M284)

   Repair sheared and cut ends and damaged coating with an epoxy patching material conforming to ASTM A 775 (AASHTO M284) in accordance with the patching material manufacturers recommendations.

B. Welded Wire Fabric

Types shall be as shown on the Contract Drawings and shall comply with the following:

1. Plain, ASTM A 185 (AASHTO M55), flat sheets for size W5 and larger and coiled rolls for sizes below W5.

2. Deformed, ASTM A 497 (AASHTO M221), flat sheets for sizes D5 and larger and coiled rolls for sizes below D5.

C. Fabricated Steel Bar Mats

Fabricated steel bar mats shall be in accordance with ASTM A 184, when shown on the Contract Drawings, and as follows:

1. Bar grade, size and spacing as shown on the Contract Drawings.
2. Welded connections, unless otherwise shown on the Contract Drawings.

D. Steel Wire

Steel wire shall comply with ASTM A 82 (AASHTO M32), plain finish, unless otherwise shown on the Contract Drawings.

## 2.02 ACCESSORIES

A. Tie Wire

Provide minimum 16-gage, annealed type. Provide nylon, plastic or epoxy-coated wire for use with epoxy-coated and galvanized reinforcing bars, if any.

B. Supports for Reinforcement

Provide bolsters, chairs, spacers, and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use galvanized steel wire bar type supports complying with CRSI standards and as follows:

1. For supporting epoxy-coated reinforcing bars, use plastic coated supports, or supports fabricated from or coated with a dielectric material.
2. For slabs-on-grade, use supports with horizontal plate runners.
3. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, use supports with plastic capped legs (CRSI, Class 1).
4. Where architectural concrete is shown on the Contract Drawings, use plastic side form spacers.

## 2.03 FABRICATION

A. Fabricate concrete reinforcement as shown on the Contract Drawings and on approved shop drawings, in accordance with ACI 315 "Tolerances".

B. Bend all concrete reinforcement cold. Heating of bars or wire fabric is prohibited.

C. Where welding of concrete reinforcement is shown on the Contract Drawings, weld in accordance with AWS Dl.4.

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. Place concrete reinforcement as shown on the Contract Drawings and on approved shop drawings. Where not shown on the Contract Drawings, comply with CRSI "Placing Reinforcing Bars".

B. Clean concrete reinforcement of loose rust, mill scale, earth, ice, and other materials that reduce or destroy bond with concrete.

C. Accurately position, support and secure concrete reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support concrete reinforcement by chairs, runners, bolsters, spacers, and hangers in accordance with CRSI Manual of Standard Practice". Do not interfere with placement of embedded items.

D. When a vapor barrier is shown on the Contract Drawings, do not cut or puncture during concrete reinforcement placement.

E. Place concrete reinforcement to obtain covers shown on the Contract Drawings for concrete protection, or in accordance with ACI 318 "Concrete Protection for Reinforcement", if not shown on the Contract Drawings. Arrange, space and securely tie bars and bar supports to hold concrete reinforcement in position during concrete placement operations. Set ties so ends are directed into concrete, not toward exposed concrete surfaces.

F. Install welded wire fabric in lengths as long as practical. Lap adjoining pieces at least one full mesh and lace splices with wire, but in no case shall lap be less than requirements of ACI 318 "Splices of Welded Deformed Wire Fabric in Tension" or "Splices of Welded Plain Wire Fabric in Tension". Offset end laps in adjacent widths to prevent continuous laps in either direction.

G. After concrete placement, do not field bend partially embedded concrete reinforcement except as shown on the Contract Drawings.

H. Repair damaged bars and welds, if any, in accordance with 2.O1A.

END OF SECTION

## SECTION 03200

## CONCRETE REINFORCEMENT

## SUBMITTALS

## APPENDIX "A"

The following items shall be submitted to the Engineer, except as otherwise noted.

A. Shop Drawings

1. As per Division 1, "Shop Drawings, Catalog Cuts and Samples".
2. Details indicating placement, cover, splice locations, lap lengths, mechanical splice hardware, grade, bar size, length, mark number, bending schedule, bending diagram, weld designations, type of coating, material used to repair coating, and types of chairs, spacers, hangers and tie wire for all concrete reinforcement.
3. All proposed changes to the size, spacing or arrangement of the reinforcing steel shown on the Contract Drawings shall be clearly flagged as such on the shop drawings.

B. Catalog Cuts, Material Certification and Test Results

1. As per Division 1, "Shop Drawings, Catalog Cuts and Samples".
2. Catalog cuts for chairs, spacers, hangers and mechanical splices.
3. Certification from the applicator of epoxy that the epoxy-coated reinforcing bars meet the requirements of ASTM A 775 (AASHTO M284).
4. Test results and certification from the galvanizer that the weight, application and testing of zinc coating conforms with specifications and ASTM A 767.
5. Certified mill test reports for all concrete reinforcement.

C. Samples

1. As per Division 1, "Shop Drawings, Catalog Cuts and Samples".
2. Mechanical Splice Hardware.
3. Material used to repair coating.

D. Design Computations

1. Design computations for all proposed changes to the size, spacing or arrangement of the concrete reinforcement shown on the Contract Drawings.

END OF APPENDIX "A"

# SECTION 03200

# CONCRETE REINFORCEMENT

## INSTRUCTIONS TO SPECIFIER

A. General

1. In Appendix "A", select submittals required for work of the Contract and delete the ones not required. Do not request submittals on the Contract Drawings, any additional submittals required shall be added to Appendix "A".
2. No uncoated reinforcing steel nor any other embedded metal dissimilar to zinc, should be permitted in close proximity to zinc-coated reinforcing bars except as part of a cathodic-protection system. Zinc-coated bars should not be coupled to uncoated bars.
3. Epoxy-coated reinforcing steel shall not be permitted to be used in close proximity to galvanized or uncoated bars. Exceptions shall be made with the approval of the Principal Engineer.

B. Contract Drawings

Ensure that the Contract Drawings show:

1. The proper ASTM designation for materials below or, in the case of bridges, the proper AASHTO designation.
2. Grade of reinforcing steel, if other than 60 ksi (2.01 A).
3. Galvanized reinforcing bars, if any (2.01 A.1).
4. Epoxy-coated reinforcing bars, if any (2.01 A.2).
5. Galvanized plain or deformed welded wire fabric, if any (2.01 B.1 or 2.01 B.2).
6. Specifically designate "fabricated steel bar mats", if any (2.01 C).
7. Connections of fabricated steel bar mats if other than welded (2.01 C.2).
8. Specifically designate "architectural concrete" surfaces, if any (2.02 B.4).
9. Welded splices, if any (2.03 C).
10. Sizes, locations, and extent of steel bars and mesh reinforcing (3.01 A).
11. Vapor barriers, if any (3.01 D).
12. Concrete, reinforcement cover (3.01 E).
13. Field bends of partially embedded reinforcement, if any (3.01 G).

END OF INSTRUCTIONS

# DIVISION 3

# SECTION 03302

# PORTLAND CEMENT CONCRETE, SHORT FORM

## PART 1. GENERAL

### 1.01 SUMMARY

This Section and its appendices specify requirements for Portland Cement Concrete mix proportions, materials used in concrete mixes, placing and curing.

### 1.02 REFERENCES

The following is a listing of the publications, standards and codes referenced in this Section, of which the latest edition shall govern:

American Association of State Highway and Transportation Officials (AASHTO)

| | |
|---|---|
| AASHTO HB | Standard Specifications for Highway Bridges. |
| AASHTO M182 | Burlap Cloth Made From Jute or Kenaf. |
| AASHTO T 26 | Standard Method of Test for Quality of Water to Be Used in Concrete. |

American Concrete Institute (ACI)

| | |
|---|---|
| ACI 211 | Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete. |
| ACI 301 | Specifications for Structural Concrete for Buildings. |
| ACI 304R | Guide for Measuring, Mixing, Transporting and Placing Concrete. |
| ACI 305R | Hot Weather Concreting. |
| ACI 306R | Cold Weather Concreting. |
| ACI 308 | Standard Practice for Curing Concrete. |
| ACI 318 | Building Code Requirements for Structural Concrete. |

ASTM International (ASTM)

| | |
|---|---|
| ASTM C 31 | Practice for Making and Curing Concrete Test Specimens in the Field. |
| ASTM C 33 | Specification for Concrete Aggregates. |
| ASTM C 39 | Test Method for Compressive Strength of Cylindrical Concrete Specimens. |
| ASTM C 94 | Specification for Ready-Mixed Concrete. |
| ASTM C 138 | Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete. |
| ASTM C 143 | Test Method for Slump of Hydraulic Cement Concrete. |
| ASTM C 150 | Specification for Portland Cement. |
| ASTM C 171 | Specification for Sheet Materials for Curing Concrete. |
| ASTM C 172 | Practice for Sampling Freshly Mixed Concrete. |

| | |
|---|---|
| ASTM C 173 | Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method. |
| ASTM C 231 | Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method. |
| ASTM C 260 | Specification for Air Entraining Admixtures for Concrete. |
| ASTM C 309 | Specification for Liquid Membrane-Forming Compounds for Curing Concrete. |
| ASTM C 311 | Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete. |
| ASTM C 494 | Specification for Chemical Admixtures for Concrete. |
| ASTM C 618 | Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete. |
| ASTM C 989 | Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars. |
| ASTM C 1064 | Test Method for Temperature of Freshly Mixed Hydraulic Cement Concrete. |
| ASTM C 1315 | Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete. |
| ASTM D 1751 | Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types). |
| ASTM D 1752 | Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction. |
| ASTM D 3665 | Practice for Random Sampling of Construction Materials. |
| ASTM D 5199 | Test Method for Measuring the Nominal Thickness of Geosynthetics. |
| | Federal Specifications |
| SS-S-1401 | Sealants, Joint, Non-Jet-Fuel-Resistant, Hot-Applied, for Portland Cement and Asphalt Concrete Pavements. |
| | New Jersey Department of Transportation (NJDOT) |
| | Standard Specification for Road and Bridge Construction. |

## 1.03 ENVIRONMENTAL REQUIREMENTS

A. Cold Weather Requirements

1. Cold weather concrete construction shall conform to ACI 306R.
2. Do not mix or place concrete when the ambient temperature is below 35 deg F, or when conditions indicate that the temperature will fall below 35 deg F within 72 hours, unless the areas to receive fresh concrete are insulated or enclosed and heated to maintain 50 deg F as approved by the Engineer.
3. Reinforcement, forms and soils with which concrete will be in contact shall be completely frost-free. If required, apply heat to raise their temperature to a minimum of 35 deg F. The use of chemicals to eliminate frost will not be permitted.

B. Hot Weather Requirements

1. Hot weather concrete construction shall conform to ACI 305R.

2. Do not place concrete for pavements, overlays, bridge decks or ramps when the ambient temperature exceeds 90 deg F or when the rate of evaporation exceeds 0.2 lbs/ft2/hr, in accordance with ACI 305R, Figure 2.1.5. Schedule Work so that concrete can be placed during the coolest part of the day (late afternoon or at night).

3. If the concrete temperature reaches 92 deg F as measured in accordance with ASTM C 1064, it will be rejected.

1.04 QUALITY CONTROL

A. Maintain a level of Quality Control sufficient to consistently achieve the end result performance properties specified herein. In addition:

1. Submit the approved mix proportions. Forward to the Engineer all delivery tickets, which shall carry an automated, time-date stamp and shall indicate the batch weights of all batching constituents.

2. Ensure that all plant mixing equipment and trucks are calibrated and approved by either the New Jersey or New York State Department of Transportation.

3. Ensure that all personnel performing concrete testing are, at a minimum, certified ACI Level I Concrete Laboratory Testing Technicians or Grade I Concrete Field Testing Technicians, as appropriate.

1.05 SUBMITTALS

A. See Appendix "A" for submittal requirements.

B. Do not deliver any concrete to the construction site until all approvals have been obtained.

## PART 2. PRODUCTS

2.01 MANUFACTURERS AND SOURCES OF SUPPLY

A. Use no cement, fly ash, slag or fine or coarse aggregates that have not been approved by either the New Jersey or New York State Department of Transportation.

2.02 MATERIALS

A. Cement: Conforming to ASTM C 150, Type I and II; conforming to Type III where early strength gain is required and permitted; or to other standards specified on the Contract Drawings.

B. Fly Ash: Conforming to ASTM C 311 and ASTM C 618, Class F or Class C, except the maximum loss on ignition shall be less than 4%.

C. Slag: Conforming to ASTM C 989, Grade 100 or 120.

D. Aggregates: Fine and coarse aggregates shall conform to ASTM C 33.

E. Water: Conforming to AASHTO T 26. Shall be clean and potable for both mixing and curing concrete.

F. Air Entraining Agent: Conforming to ASTM C 260.

G. Admixtures: All admixtures shall conform to ASTM C 494. They shall contain not more than 0.05% chloride ions and shall be used in accordance with the manufacturer's recommendations. Submit dosage charts to the Engineer; dosage charts shall state the effects of concrete temperatures from 50 deg F to 90 deg F. All admixtures shall be manufactured by one of the following:

1. Euclid Chemical Company.
2. W.R. Grace & Company.
3. Master Builders Technologies.
4. Sika Corporation.

H. Curing Materials

1. Liquid Membrane Forming Curing Compound shall be one of the following:
   a. "DOT Resin Cure (Type II)", as manufactured by Conspec Marketing & Manufacturing Company, Inc.
   b. "Euco Kurez Vox (White)", as manufactured by Euclid Chemical Company.
   c. "1200 White", as manufactured by W.R. Meadows.
   d. Or an approved equal meeting the requirements specified in 2.02 H.2.
2. Liquid Membrane Forming Curing Compound: Conforming to ASTM C 1315 and to the following:
   a. For horizontal exterior applications, curing membranes are restricted to ASTM C 309 Type 2, Class B materials.
   b. For other exterior applications ASTM C 309 Type 1 D, Class B membranes are acceptable.
   c. For interior applications only, ASTM C 309 Type 1, Class B membranes are acceptable.
   d. Curing membranes shall be wax free when used on concrete where overlays, coatings, paints, sealers or any topping is to be applied, or where vehicular, pedestrian or aircraft traffic will pass over.
   e. Membranes shall be volatile organic compound (VOC) compliant for the States of both New York and New Jersey. Submit certification of compliance to the Engineer upon request.
   f. The membrane shall restrict the loss of water to not more than 0.40 kilograms per square meter in 72 hours at a coverage rate of 300 square feet per gallon per coat for Type I curing compounds, and 200 square feet per gallon per coat for Type 2 curing compounds when tested in accordance with ASTM C 156.

3. Burlap: Conforming to AASHTO M 182, Class 3, weighing approximately 9 oz./sq. yd. dry.

4. Sheet Material: Conforming to ASTM C 171.

   a. Shall be white burlap polyethylene sheet.

5. Cotton Mats: Conforming to ASTM D 5199 with a minimum thickness of 40 mils, ASTM C 156 with a maximum water loss of 0.0065 oz./in.2, ASTM D 4833 with a minimum puncture strength of 70 pounds and ASTM E 1347 with a minimum reflectance of 75%. The following cotton mats may be used in lieu of burlap for wet curing operations:

   a. "Transguard 4000", as manufactured by Reef Industries, Inc., Houston, Texas.

   b. Or an approved equal conforming to the requirements specified in 2.02 H.5.

I. Evaporation Retardant: Use one of the following:

1. "Euco-Bar", as manufactured by Euclid Chemical Company.

2. "E-Con", as manufactured by L&M Construction Chemicals, Inc.

3. "Confilm", as manufactured by Master Builders Technologies.

4. "SikaFilm", as manufactured by Sika Corporation.

5. "Aquafilm", as manufactured by Conspec Marketing & Manufacturing Company, Inc.

J. Expansion Joints (Except For Bridge Decks), Contraction Joints and Waterstops:

1. Waterstops shall be of types and sizes shown on the Contract Drawings.

2. Premoulded expansion joint filler, when shown on the Contract Drawings:

   a. Cork type shall be ASTM D 1752, Type II.

   b. Bituminous type shall be ASTM D 1751.

3. Joint Sealant when shown on Contract Drawings: Federal Specification SS-S-1401, latest revision.

## 2.03 MIX PROPORTIONS

A. Develop mixes in accordance with the latest editions of ACI 211, ACI 301 and ACI 318 to produce design performance criteria in accordance with the Contract Documents, with a degree of excess as determined by Chapter 5 of ACI 318, and to meet all of the applicable performance criteria as specified in the Contract Documents. Prior to concrete construction and after approval of all materials to be used in the concrete, submit a mix proportion showing that all performance criteria have been met. Mix proportions submitted shall be based upon laboratory trial mix test results and/or mixes successfully used within the two years preceding the date of the submittal of the mix for the Work of this Section. Verify that the independent testing laboratory used to develop the mix proportions and to perform testing has AASHTO Accreditation for all test methods required to be performed and for development of the required mix. Ensure that the technical staff preparing the mix proportions and performing the associated testing is certified by ACI for all the tests being performed. Submit to the Engineer proof of certifications prior to the start of development of the mix proportion and testing. The mix shall include copies of test reports, including test dates, and a complete list of materials, including type, brand and source. The mix proportion shall also conform to the following:

1. Substitute either fly ash or slag at the minimum rate of 15% by weight of cement. The maximum rates of substitution shall be 30% for fly ash and 40% for slag. Fly ash and slag substitution up to 50% in the same mix may be permitted upon approval by the Engineer.

2. Compute water to cement ratio by dividing the weight of all the water in the mix including that from admixtures and aggregates, plus added water, by the total weight of cementitious material computed by adding the total weight of cement plus fly ash, or slag. In order to meet the specified water to cement ratio, account for admixtures which increase the water to cement ratio by 0.01 or greater.

3. Do not add High Range Water Reducer to the concrete mix at the plant. Deliver High Range Water Reducer to the construction site in a tank fixed to the truck in such a way that the tank discharges directly into the mixing drum, or add High Range Water Reducer to the drum from a calibrated dispensing unit. A calibrated dispensing unit shall be defined as a manufactured dispenser with clear volume indications marked on the outside of the unit. If used, it shall be available at all times during the concrete placement for re-dosing purposes. Submit a re-dosing chart showing the dosages necessary to increase the slump, in inches per cubic yard of concrete remaining in the drum, over the range of concrete temperatures from 50 deg to 90 deg F. If re-dosing occurs, use the re-dosing chart but do not under any circumstances allow the total dosage to exceed the maximum dosage recommended by the manufacturer. Mix the load in the truck for a minimum of an additional 5 minutes prior to releasing the load.

4. The percentage of air in the mix shall fall within the range as outlined in the table shown in 2.04 A.2 entitled "Air Content Target Range for Freshly Mixed Concrete". Determine air content by testing in accordance with ASTM C 231 for normal and heavyweight concrete mixes or ASTM C 173 for lightweight concrete.

## 2.04 QUALITY ACCEPTANCE LIMITS

A. Develop mixes to meet the following performance criteria Quality Acceptance Limits unless otherwise noted on the Contract Drawings:

1. Compressive Strength (ASTM C 39): The design compressive strength at 28 days as shown on the Contract Drawings.

2. Air Content (ASTM C 138, ASTM C 173 or ASTM C 231): The minimum and the maximum limits shall be as specified in the table below:

AIR CONTENT TARGET RANGE FOR FRESHLY MIXED CONCRETE

| MAXIMUM SIZE AGGREGATE (SIZE #) | AIR CONTENT | | |
|---|---|---|---|
| | Min. | | Max. |
| 2" or above (# 467 and above) | 3.5% | - | 7.5% |
| 1-1/2" (# 57) | 4.0% | - | 8.0% |
| 1" (# 67) | 4.5% | - | 8.5% |
| 1/2" (# 8) | 5.5% | - | 9.5% |
| 3/8" | 6.0% | - | 10.0% |

Note: For a specified compressive strength greater than 5000 psi, the minimum and maximum air content, as indicated above, shall both be reduced by 1.0%. For all concrete applications not exposed to freeze-thaw cycling or deicing chemicals, no air entrainment is required.

B. For concrete where riding surface tolerances are required, as shown on the Contract Drawings, meet the following requirements:

1. Surface smoothness deviations shall not exceed 1/8 inch in 10 feet. Correct any deficiencies as specified in 3.07 C.

2. Vertical deviation from the grade shown on the Contract Drawings shall not exceed plus or minus 0.04 foot at any point.

C. Specified concrete finishes, as shown on the Contract Drawings, shall conform to the requirements set forth in 3.03 D.2. Correct deficiencies as specified in 3.07 D.

# PART 3. EXECUTION

## 3.01 BATCHING AND MIXING CONCRETE

A. Measurement of Proportions

1. All concrete batching shall be in conformance with ASTM C 94 and ACI 304R.

2. For very high early strength concrete requiring 2000 psi or greater in 6 hours or less time, the method of batching shall be restricted to (1) a calibrated mobile mixer, or (2) a transit mixer that is loaded at the construction site with bulk bags of very high early strength cement. Bulk bags shall contain sufficient very high early strength cement by weight to batch for a minimum of 3 cubic yards of concrete.

B. Mixing Concrete

1. Plants and truck mixers shall conform to ASTM C 94 and shall be either New Jersey or New York State Department of Transportation inspected and approved. Make documentation of such conformance available to the Engineer at all times.

   a. Routinely inspect mixers and immediately repair or withdraw from use mixers that are found to be mechanically unsatisfactory.

2. The Engineer may permit one re-tempering of the concrete subject to the following:

   a. The addition of water to the concrete mix at the construction site will not be permitted for mix proportions with a water to cement ratio of 0.40 or less. For all other mixes, water may be added, but the total amount of water may not exceed the approved mix proportion water to cement ratio.

   b. High range water reducer re-dosing shall conform to the manufacturer's approved re-dosage chart and shall not exceed the manufacturer's recommended limitation, nor shall it retard the initial set of the concrete by more than 30 minutes.

   c. Concrete that is re-mixed or re-tempered after it has partially hardened or has attained its initial set will be rejected.

   d. The Engineer reserves the right to reject concrete that has not been placed within 90 minutes from the time the cement had first contact with water, or if the concrete temperature reaches 92 deg F as measured in accordance with ASTM C 1064.

## 3.02 PRE-PLACEMENT FIELD REQUIREMENTS

A. Prior to any construction site delivery of concrete, furnish, deliver and maintain insulated curing boxes of sufficient size and strength to contain all the cylinder specimens made by the Engineer in any two (2) consecutive Work periods. Such boxes shall be equipped to regulate the temperature in the range of 60 deg F to 80 deg F, or 68 deg F to 78 deg F when the design compressive strength is 6000 psi or greater, and to provide the moisture to maintain the curing conditions specified in ASTM C 31. When the ambient temperature is greater than 80 deg F, maintain the temperature of the concrete specimens in the required range by immersing them in a water bath. Cover the water bath to prevent direct sunlight from raising the water temperature. Locate the boxes where directed by the Engineer. Protect the boxes from vibration and other disturbances during specimen curing.

B. Pump Concrete

1. Grout used to prime the pump line shall not be included in the placement. Make provisions for the disposal of the grout at the end of the pump line outside Authority property and at no cost to the Authority. Placement shall not begin until concrete is visible at the end of the pump line.

2. Permit no water to enter the pump hopper at any time during placement operations.

3. Submit written procedures for pumping to the Engineer for approval. The procedures shall contain, but not be limited to, pumping scheme, pump description, line diameter, line length and the number of turns and line offsets.

C. Preparation for Placing Concrete

1. Straighten bent dowels, whether placed under this Contract or by others, using tools approved by the Engineer. Do not apply heat to dowels.

2. Clean all dowels and all steel that will be embedded in concrete of all loose rust, scale, paint, grease and other objectionable materials.

3. Examine coated reinforcement for integrity of coating. Repair all damaged areas in accordance with the requirements of Section 03200 entitled "Concrete Reinforcement". The repair crew shall be available at the time of examination.

4. Check all locking devices for formwork to ensure that they are in place and properly secured.

5. For preparation of surfaces to receive concrete, conform to 3.03 and the Contract Drawings for all procedures, equipment limitations and requirements to be performed prior to placing concrete.

6. Provide vent holes (1/4-inch diameter, minimum) in edge angles and embedded plates at joints where vibrating alone will not ensure elimination of voids. Submit to the Engineer for review shop drawings of all vent hole locations and procedures for placement of concrete at joints.

7. Make provisions for the concrete to pass through the reinforcing steel without segregating during placement.

## 3.03 APPLICATION

A. Bonding New Concrete to Existing Concrete

Where new concrete will be placed against existing concrete surfaces:

1. Before starting concrete placement, abrasive blast or shot blast existing concrete surfaces. Abrasive blasting shall conform to Section 02574 entitled "Abrasive Blasting of Pavements".

2. Thoroughly clean existing concrete surfaces of dust, concrete particles and other debris to the satisfaction of the Engineer.

3. Immediately prior to placing concrete, moisten existing concrete with water. Remove puddles of standing water.

4. Broom a thin layer of material from the leading edge of the concrete being placed into the wetted surfaces. Do not allow broomed material to dry before covering it with additional material as required for final grade.

B. Placing Concrete

1. Place concrete only in the presence of the Engineer and by methods approved by him.

2. For concrete cast against earth or an approved compacted subgrade, and for concrete overlays, place concrete against surfaces in a saturated surface dry condition.

3. Prior to placing concrete remove all standing water or puddles.

4. Do not place concrete on or next to frozen surfaces.

5. Transfer concrete from mixer to place of deposit rapidly to prevent formation of cold joints.

6. Use equipment and methods for placing that will permit rapid placement of fresh concrete of the required consistency and preclude segregation.

7. The method and equipment used to transfer concrete from mixer to forms will be subject to prior approval by the Engineer.

8. Subject to the foregoing requirements, convey concrete by approved means to its final position.

9. Except where otherwise approved by the Engineer, consolidate concrete by internal mechanical vibration subject to the following:

   a. Type, number and method of application of vibrators will be subject to prior approval by the Engineer.

   b. In locations where spading is approved in lieu of mechanical vibration, spade coarse aggregate away from the forms and into the plastic mass; rod concrete around embedded materials and into corners and spaces to be filled.

10. Avoid formation of laitance and accumulation of excessive water on surface of concrete as it is deposited. Remove any accumulated bleed water by approved means before placing other concrete.

11. Place concrete so as to require as little re-handling as possible.

12. Deposit concrete as near to joints as possible without disturbing them.

13. Thoroughly consolidate concrete.

14. Screed and float concrete for riding surfaces as it is placed and use an approved evaporation retardant or fog spray.

C. Concrete Placing and Finishing Equipment for Slab and other Riding Surfaces

1. For slab or overlays less than 8 inches thick, vibrating surface pans or screeds will be allowed.

2. Manual tools, such as bull floats, trowels, brooms and other similar hand tools are acceptable.

D. Consolidation and Finishing

1. Slabs and other Riding Surfaces

   a. Machine finishing shall conform to NJDOT's *Standard Specifications for Road and Bridge Construction*, Subsection 1005.02, 03 and 04.

   b. Finishing at and adjacent to joints shall conform to NJDOT's *Standard Specifications for Road and Bridge Construction*, Subsection 405.03.02 Item C.

   c. Strike off and screed concrete as soon as it is placed. Use an approved portable screed.

   d. After the concrete has been struck off and consolidated, further finish it by means of a longitudinal float. After floating, any excess water and laitance in excess of 1/8-inch thick shall be removed and disposed of outside of Authority property.

   e. While the concrete is still in a workable condition, immediately fill, strike off, consolidate and refinish any depressions with freshly mixed concrete. Cut down and refinish high areas.

2. Specified concrete finishes, as shown on the Contract Drawings, shall be in accordance with the following requirements:

a. "Smooth Finish": A surface of concrete obtained by the use of special forms as specified in Division 3 Section entitled "Concrete Formwork". Remove all fins and other irregularities in the exposed surfaces of concrete by rubbing the irregularities with a carborundum brick and clean fresh water. Any mortar patches shall be rubbed with a carborundum brick as above specified.

b. "Scored Finish": A surface of concrete obtained by roughening in an approved manner or by etching with sharp-pointed steel tools to key or otherwise improve the mechanical bond of the surface. Such scoring shall roughen at least ten percent of the area so scored.

c. "Float Finish": A surface of concrete obtained by the use of a wood float. Apply float finish to horizontal surfaces immediately after screeding and before initial setting has begun.

d. "Trowel Finish": A surface of concrete obtained (after screeding and floating) by the use of a steel trowel to produce a dense, smooth, even surface suitable for painting or the application of floor covering. Do not start troweling until the surfaces have set sufficiently to sustain knee boards without damage. Troweling shall eliminate all irregularities and leave the concrete surface with a smooth, hard finish, free from marks and blemishes and all to the satisfaction of the Engineer.

e. "Traction Finish": A monolithic layer of abrasive concrete having a minimum thickness of 3/4 inch and which shall be "Emericrete SH", as manufactured by the Sika Corporation, or approved equal. Prepare the base and install the monolithic layer in accordance with the recommendations of the manufacturer of the abrasive concrete. Give the surface a wood float finish. Round the sides and edges of pavement slabs with an approved edging tool to the minimum radius obtainable, all in the sole opinion of the Engineer.

f. "Burlap Finish": A surface of concrete obtained by the use of a burlap drag, after screeding and floating the surface of the concrete. Drag the burlap in one direction in a straight line before initial setting has begun and in such a manner that the full width of the slab being finished is dragged in one operation. Rinse or wash burlap as often as necessary to prevent the presence of hardened particles and consequent scarring of the concrete.

g. Fill stair treads and platforms of steel stairs with mortar mixed in the proportions of one part Portland cement to three parts of fine aggregate, mixed with water to a satisfactory consistency. Coat the surface of the mortar with 3 pounds of aluminum oxide crystals per square yard of surface, uniformly applied, and trowel the surface to a smooth hard finish. Aluminum oxide crystals shall be grade AL203 crystals ranging from No. 12 to No. 30 in size and shall contain not more than six percent of iron or other impurities.

h. "Broom Finish" shall be achieved as follows:

(1) Finish the concrete when the water sheen has practically disappeared. Use push broom or floor brush type, not less than 18-inches wide and made of good quality bass or bassine fibers not more than 4-1/2 inches long and with handles longer than half the width of the slab.

(2) Use an adequate number of brooms to keep up with other operations. Achieve proper finish prior to initial set of the concrete.

(3) Wash and thoroughly dry brooms at frequent intervals and remove worn or damaged brooms from the construction site.

(4) Draw broom across previously finished surface from the centerline to each edge of the slab with a slight overlap of strokes.

(5) Corrugations made in surface shall be uniform, approximately 1/16 inch in depth, and not more than 1/8 inch in depth.

(6) Complete brooming before concrete reaches a condition that would result in the surface becoming torn or unduly roughened and before initial set of concrete.

(7) Immediately following brooming, carefully finish the edges of slab along sides and at joints with an approved edging tool to form a smooth rounded surface of required radius and subject to the following:

(a.) Where corners or edges of slabs have crumbled and at any areas which have leaked sufficient mortar to make proper finishing difficult, remove loose fragments and soupy mortar, fill solidly with a mixture of correct proportions and consistency and finish.

(b.) Edges shall be smooth, true to line and free of unnecessary tool marks.

i. "Saw Cut Grooved Surface" for deck slabs and overlays shall conform to the requirements of the NJDOT's *Standard Specifications for Road and Bridge Construction*, Division 500 Subsection 507.03.02 Item L.

j. Concrete Curbs and Sidewalks

(1) Give sidewalks a "Float Finish", tool edges and joints for a width of 2 inches and round corners to a radius of 1/4 inch with an approved edging tool.

(2) Install expansion joints at not more than 20-foot intervals in sidewalks with matching joints in curbs. Use 1/4 inch bituminous joint filler.

(3) Score sidewalks in squares as approved by the Engineer.

3. Removal of Forms

Removal of forms shall be subject to the following:

a. Remove forms in accordance with the requirements of Section 03100 entitled "Concrete Formwork".

b. After removal of forms, patch areas of concrete which in the opinion of the Engineer show excessive honeycomb by cutting out defective areas and keying and refilling them with a mortar of cement and sand in the same proportions as in the approved concrete mix design.

c. After forms are removed, cure sides of slabs greater than 12 inches in thickness in accordance with 3.04.

d. Immediately after removal of forms, holes and voids in the surfaces of concrete, resulting from bolts and ties, shall be wetted and filled with a mortar containing cement and fine aggregate in the same proportions as in the approved concrete mix design, and utilizing cement which shall produce mortar of the same color as the concrete. Finish exposed mortar surfaces smooth and even with a wood float, except that surfaces exposed to view in the finished structure shall be finished with a steel trowel to match adjacent surfaces. Promptly remove all fins and other surface irregularities by chipping, grinding or other methods approved by the Engineer to achieve a uniform finish. Where no specific surface finish for formed concrete surfaces is shown on the Contract Drawings, no further finishing will be required.

## 3.04 CURING

A. Carefully cure all concrete. Submit a curing procedure plan for approval by the Engineer prior to placing any fresh concrete. Perform curing in accordance with ACI 308 and the following specifications. Commence curing procedures immediately after the fresh concrete has been placed.

1. Provide suitable means, such as insulating blankets or heated enclosures, for maintaining a concrete temperature of at least 50 deg F after placement, until it has attained 4,000 psi. At the end of this period, remove protection in such a manner that the drop in temperature of any portion of concrete is gradual and does not exceed the provisions of ACI 306R Table 3.1 during the first 24 hours after removal of protection.

2. Allow all concrete to attain 4,000 psi compressive strength or the specified design compressive strength, whichever is lower, before being exposed to freeze-thaw cycles.

3. Choice of curing material and method shall be as approved by the Engineer.

B. Liquid Membrane Forming Curing Compounds and Sheet Materials for Curing

1. Immediately after placing or finishing, commence the curing process of concrete not covered by forms from loss of moisture by placing a curing membrane on the surface. Use one of the curing materials listed in 2.02 H, which may be supplemented by initially using an evaporation retardant listed in 2.02 I, as long as wet curing is not required, subject to the following:

a. Burlap polyethylene sheet or cotton mats, if used, shall be lapped at edges and ends at least 1 foot and shall have all ends and edges taped to adjacent sheets or surfaces to completely seal areas to be cured. Secure in a sufficient manner that will not allow the film, the sheets or the securing mechanism to be removed by wind forces, resulting in fresh concrete exposure without protection. Presoak burlap for 24 hours prior to use in conformance with AASHTO M 182.

b. Apply white pigmented liquid membrane forming curing compound as soon as surface moisture has evaporated by approved pressure spraying or distributing equipment in two uniform full applications perpendicular to each other and as recommended by the manufacturer. Allow the first coat to become tacky before applying the second coat. Each application shall be the full quantity recommended by the manufacturer. The entire surface shall be white after the second application.

2. Recoat areas subjected to heavy rainfall within 3 hours after rain.

3. Follow manufacturer's recommendations for agitation during application and warming where necessary during cold weather. Do not use liquid membrane forming curing compound where the surface being cured is to receive a finish that will be bonded to the concrete surface or where a floor hardener is to be applied, unless a certification of compatibility and a minimum five year performance record is submitted in advance to the Engineer for approval.

4. The Engineer will check for uniformity through random sampling and testing. Testing may include determination of membrane infrared spectrum, pH, specific gravity and solids content.

## 3.05 JOINTS

A. Construction Joints

1. Number, locations and details shall be as shown on the approved shop drawings.

2. Planes of joints shall be normal to direction of pressure and shall include suitable keys and dowels.

3. Avoid lips and other irregularities between adjoining sections of concrete. Secure forms tightly against previously placed concrete.

B. Expansion and Contraction Joints

1. After curing concrete, clean grooves or saw cuts to receive joint sealant by scrubbing with a mechanical wire brush to loosen dirt and other foreign matter. Blow out loose matter with filtered compressed air.

2. Install joint sealant to finish flush with concrete surface, except where otherwise shown on the Contract Drawings.

C. Saw Cut Control Joints

1. Saw cut each control joint at a point in the curing cycle when a thumb print can not be made on the surface and as soon as the concrete can support the weight of the saw and the operator without marring the surface or disturbing the final finish. At a minimum, perform these two checks every hour until the control joints can be cut. Unless otherwise shown on the Contract Drawings, saw cut depth shall be a minimum of 10% of the slab thickness or one inch whichever is greater. Saw shall produce a cut that does not ravel or damage the concrete. If approved for use, a liquid membrane forming curing compound must be applied prior to cutting. In general, cut control joints for standard concrete within 6 to 8 hours of concrete placement, and within 2 to 4 hours for very high early strength concrete. However, the timing of cuts shall ultimately depend on the mix proportion and the ambient temperature.

## 3.06 QUALITY ASSURANCE TESTING, SAMPLING AND INSPECTIONS

A. During mixing and placing of concrete the Engineer will perform Quality Assurance testing on samples taken from the end of the line or at the point of discharge in accordance with ASTM C 172. The Engineer will take samples of concrete from each Work period based on random sampling procedures described in ASTM D 3665.

1. The Engineer may perform the following quality assurance tests: slump, air content, compressive strength, unit weight, temperature and water to cement ratio. If any of these tests indicate results out of tolerance with those specified herein, or on the Contract Drawings, or as given in the approved mix proportion, the concrete may be rejected.

a. Compressive Strength: A minimum of six cylinders will be made for each 50 cubic yards or a portion thereof in accordance with ASTM C 31 and tested in accordance with ASTM C 39 at the time requirements specified in the Contract.

b. Slump Test: Performed during placement in accordance with ASTM C143. The Engineer will perform one test for each set of test specimens.

c. Unit Weight: The plastic unit weight of concrete will be determined in accordance with ASTM C 138. The Engineer will perform one test for each set of test specimens.

d. Air Content Test: Performed during placement in accordance with ASTM C 138, ASTM C 231 or ASTM C 173. The Engineer will perform one test for each set of specimens.

B. In accordance with the Section of Division 1 entitled, "Inspections and Rejections", provide labor and means for obtaining all samples required for trial batches and field-testing performed by the Engineer, at no additional cost to the Authority.

1. Provide representative samples, in the quantities requested by the Engineer, of all concrete ingredients, including cement, fly ash, slag, fine and coarse aggregate, admixtures, evaporation retardant and liquid membrane forming curing compound during any day of production when the Engineer requests a sample. Take such samples in the presence of the Engineer at the point of storage, at either the concrete producer's plant or the construction site that will be used for the Work of this Contract. For cement, fly ash and slag samples, either use a sampling port on the silo, drop material in a loader bucket between loads or take samples from the boot using a "Sample Thief" during loading.

## 3.07 CORRECTION OF DEFICIENCIES

A. Concrete that is found not to meet the requirements of 3.07 A.1, 3.07 A.2, 3.07 A.3 or 3.07 B will be considered deficient. Repair deficient concrete as specified in 3.07 C or in accordance with Engineer's directions at no additional cost to the Authority.

1. The calculated average of any three consecutive compressive strength tests shall be equal to or shall exceed the specified compressive strength.

2. No individual compressive strength test result shall be below the specified compressive strength by more than 500 psi. When the specified compressive strength is 5000 psi or more, no individual compressive strength test result shall be below the specified compressive strength by more than 0.10 of the specified strength.

3. If either or both of the requirements specified in 3.07 A.1 and 2 are not met, investigate the in-place compressive strength in accordance with ACI 318, Section 5.6.5 at no additional cost to the Authority. If the average of the compressive strength test results of the cores is less than 85% of the specified compressive strength or if the compressive strength of a single core is less than 75% of the specified compressive strength the concrete shall be considered deficient. At the Engineer's direction, either remove and replace concrete or accept a 50% reduction in payment for the in-place cost of the concrete.

B. Cracking Deficiency: Concrete slabs or structures that exhibit any cracks prior to opening to vehicular operations or loading will be considered deficient. At Engineer's direction either remove and replace deficient concrete or seal cracks in accordance with Section 03734 entitled "Concrete Crack Repair".

C. Diamond Grinding and Partial Depth Removal

1. Cured riding surfaces that do not meet the smoothness or finished grade requirements set forth in 1.04 B shall be corrected, to obtain the specified smoothness deviation, as follows:

a. High spots between 1/8 inch and 1/2 inch and surfaces that exceed the finished grade requirements shall be identified and ground with diamond grinding equipment.

b. Low spots between 1/8 inch and 1/2 inch and surfaces that are below the finished grade requirements shall be corrected by partial depth removal of the entire slab to 1 inch below rebars by hydrodemolition or by other approved means and by constructing an overlay in conformance with this Section.

2. The diamond grinding equipment shall be as approved by the Engineer and shall have a grinding head at least 36-inches wide.

3. Where grinding is required, grind the entire width of the riding surface by the length of defective area. In the sole opinion of the Engineer, if the deficiencies are closely spaced and grinding individual areas will adversely affect ride, grind the entire surface.

4. Dispose of slurry produced from grinding operations off Authority property.

5. Perform diamond grinding, partial depth removal and construction of an overlay, if required to correct deficiencies, at no additional cost to the Authority.

D. If concrete finishes do not meet specifications, re-finish or remove as directed by the Engineer, at no additional cost to the Authority.

END OF SECTION

# SECTION 03302

# PORTLAND CEMENT CONCRETE, SHORT FORM

## APPENDIX "A"

## SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. List of materials for Work of this Section.

B. Shop Drawings of forms and test pour details at least 15 calendar days before the test.

C. Shop Drawings for number, location and details of contraction, control, expansion and construction joints at least 15 days prior to concrete placement.

D. Catalog Cuts, Material Certification and Test Results

1. At least 35 calendar days prior to concrete placement, the following:

   a. Name and address of proposed concrete supplier, type of plant, documentation of State Certification for plant and ready mix trucks, AASHTO Accreditation certification for the independent testing laboratory.

   b. Material certifications, source, brand name and test results (where required) of cement, fine and coarse aggregate, fly ash, slag and concrete admixtures following guidelines of Appendix "B".

   c. Brand names and chemical compositions of form oil or release agents, evaporation retardant and liquid membrane curing compounds.

   d. Certification that admixtures conform to the requirements of 2.02 F and G. submitted with Appendix "B", "Concrete Materials and Mix Proportion Data". Include dosing and re-dosing charts, which shall demonstrate the effects of concrete temperatures from 50 deg F and 90 deg F.

   e. Surface Preparation Plan for surfaces on which concrete will be placed.

   f. Type, number and method of application of concrete vibrators.

   g. Method of concrete placement and consolidation adjacent to joint assemblies and embedded hardware.5

   h. Control Joint Location Plan.

   i. Method of curing and curing and materials.

E. Samples

1. Cement, stone, sand, fly ash, slag, admixtures, evaporation retardant and curing compound. Furnish these to the Engineer in whatever quantities he may require. This applies to all mix proportions, including changes to an approved mix proportion.

2. At the request of the Engineer, submit cement, fly ash and/or slag Mill Certifications at any time.

F. Construction Procedures and Quality Control Documents and Plans

1. At least 35 calendar days prior to concrete placement, the following:

   a. Cold and Hot Weather Concreting Plans to the Engineer in accordance with 1.03. Materials and methods for protecting concrete from freezing.

   b. Pumping Procedure Plan, including, at a minimum, the pumping scheme, pump description, line diameter, line length and the number of turns and line offsets.

   c. Method and sequence (timing) of adding concrete admixtures, high range water reducers, non chloride accelerators.

   d. Mixing and placement procedures and methods, as well as catalog cuts of equipment for installation. For hand mixes, submit the methods of proportioning, mixing (including minimum time requirements), transferring and placing the concrete.

   e. Curing Procedure Plan in accordance with 3.04 A, including the method and materials for curing.

   f. Materials and procedures for filling cracks and patching honeycombs and/or spalls.

2. Daily copy of batch records in accordance with 1.04 A.1.a.

G. Concrete Mix Proportions

1. Appendix "B", "Concrete Materials and Mix Proportion Data" at least 35 calendar days prior to concrete placement in accordance with 2.03 A. To substantiate the mix proportion, submit all data and field results in accordance with 2.03 A.

2. ACI Level I or II Laboratory Testing Technician and Grade I Concrete Field Testing Technician certification for all personnel performing concrete testing.

3. Written request to the Engineer for approval if a change in the weights of fine and coarse aggregate and cement is required in the approved mix proportion.

4. AASHTO accreditation for all testing to be performed by the independent laboratory in the formulation and testing of mix proportion.

H. Design Computations

1. If required by the Engineer or noted on the Contract Drawings, have design computations signed and sealed by a Professional Engineer licensed in the state where Work is being done.

END OF APPENDIX "A"

## SECTION 03302

## PORTLAND CEMENT CONCRETE, SHORT FORM

## APPENDIX "B"

## CONCRETE MATERIALS AND MIX PROPORTION DATA

A. Materials

1. Cement: Type……..… Source/Brand …….
2. Sand: Fineness……..…... Modulus…….. Source……
3. Stone: Size……..…. Class…… Source……
4. Fly Ash: Type…… Source……
5. Slag: Grade……...…… Source……
6. Admixtures (Source/Brand):……..
7. Air Entraining Agent……..
8. Non Chloride Accelerator…….……..
9. Retarder……..
10. Water Reducer..…….…..……
11. Water Reducer Retarder……..
12. High Range Water Reducer.……..
13. High Range Water Reducer Retarder.…….……

B. Mix Proportion

1. Proposed method of placement: Transit Mixer/Portable Mixer/ Pumping/Pipe Diameter:……
2. Proportion of Ingredients

Cement ……. lbs./cu. yd.

Fly Ash …… lbs./cu. yd.

Slag ……. lbs./cu. yd.

Stone …….……. lbs./cu. yd.

Sand …….….. lbs./cu. yd.

Water ……...….. lbs./cu. yd……... gallons

Air Entraining Agent: …… ounces/cu. yd.

Admixtures (specify type and amount):

..……..... at ……. ounces/cu. yd.

.....……..... at ……. ounces/cu. yd.

.....……..... at ……. ounces/cu. yd.

……..…….. at ……. ounces/cu. yd.

3. Mix Properties:

Compressive Strength: f'c = ....……... psi at …… days/hours

Slump: ....……. inches

Water to Cementitious Ratio: ....…….

Air Entrainment: ....……. %

Sand/Stone Ratio:

Combined aggregate gradation chart (% retained on each sieve)

Unit Weight: ....……. lbs./cu. ft.

C. Conformance with ACI 318

Attach a report on mix design and test/statistical data documenting conformance with ACI 318, Chapter 5, or ACI 304R, Chapter 8, as they apply to the Work of the Contract.

D. Concrete Supplier/Batch Plant

1. Name: .....……...

2. Address: .....……..

3. Contact Name: …….

4. Telephone number/Fax number/E-mail address:

……..

5. Quality Control technician(s):

Name(s): .....……...

…….……..

…….……..

Telephone number(s):

……..

…….…….

END OF APPENDIX "B"

# SECTION 03302

# PORTLAND CEMENT CONCRETE, SHORT FORM

## INSTRUCTIONS TO SPECIFIER

IMPORTANT: This Section is not applicable to concrete subject to chloride exposure. It can be used for non chloride exposed primary structural members and items such as curbs, sidewalks, minor sign and post footings, minor manholes, duct banks and utility works. Discuss with the Principal Engineer and obtain his/her approval prior to using this Section. The Specifier shall review all items listed in Appendix "A". Remove all items that are not applicable to this Contract and add to Appendix "A" under the proper headings any submittal items that are intended to be shown on the Contract Drawings. Review the final Appendix "A" with the Senior/Principal Engineer in charge.

A. General: Do not use this Section for:

1. Precast concrete.
2. Concrete placed under water.
3. Concrete for which exposed aggregate, colored finish, non-slip aggregate finish or finishes other than those in 3.03 are specified.

B. Ensure that Contract Drawings show:

1. Minimum concrete strength (f'c), maximum size of aggregate, and whether normal or lightweight concrete shall be used, for each type of structural element. All items required by the instructions for Section 03302 shall be included.
2. Joint Sealant, if any (2.02 J).
3. Location of all control joints and designate where installation of joint sealant is to be finished other than flush with concrete surface.
4. Locations, details and lists of approved products for all construction, expansion and control joints (3.05).
5. At edge angles and joint assemblies where consolidation of concrete will be difficult, vent holes and specific procedures to prevent formation of voids shall be reviewed with the Senior/Principal Engineer in charge and shown on drawings (3.02 C.6).
6. Site-specific procedures, equipment limitations, all necessary precautions for removal operations to avoid damage to existing construction and requirements for preparation of surfaces on which concrete will be placed (3.02 C.5) including requirements for preparation of existing concrete surfaces, if different from those given in 3.03 A.
7. Type and extent of finishes (3.03 D).
8. Specify minimum formwork stripping strength to be achieved, if any (3.03 D.3.a).
9. Areas of concrete where riding surface tolerances are required, if any (2.04 B).
10. Locations of all control joints and designate where installation of joint sealant is to be finished other than a 1/4-inch recess below the concrete surface. Also, the depth of control joints if different from that specified in 3.05 C.

C. Ensure that Section 03200 entitled "CONCRETE REINFORCEMENT", Section 03100 entitled "CONCRETE FORMWORK" and Section 02574 entitled "ABRASIVE BLASTING OF PAVEMENTS" are also included.

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16000

# ELECTRICAL GENERAL REQUIREMENTS

## PART 1. GENERAL

### 1.01 SUMMARY

Unless otherwise shown on the Contract Drawings, or unless otherwise specified in other Sections of these Specifications, the general requirements specified in this Section are applicable to all electrical work of this Contract. Additional requirements applicable to individual Sections of these Specifications are specified in those Sections, or are shown on the Contract Drawings.

### 1.02 REFERENCES

The following is a listing of publications referenced in this Section:

| | |
|---|---|
| | American National Standards Institute (ANSI) |
| ANSI C 2 | National Electrical Safety Code |
| | American Society of Testing and Materials (ASTM) |
| ASTM D 178 | Standard Specification for Rubber Insulation Matting |
| | National Fire Protection Association (NFPA) |
| NFPA 70 | National Electrical Code |
| | Occupational Safety and Health Administration (OSHA) |

### 1.03 QUALITY ASSURANCE

A. Any entity performing Work shall have had experience on at least two projects involving quantities and complexities at least equal to those required under this Division or the applicable Section thereof.

B. All workmen performing under this Division shall be skilled workers of the trade involved. Where specialty work, such as splicing or welding are required, submit proof of training, experience and work history for each workman, for review by the Engineer. Only approved workmen shall perform specialty work.

C. All electrical work shall be performed under the supervision of an electrical contractor, licensed in the state (and the city as required) in which the work is to be performed. Submit a copy of the qualifying license for review by the Engineer.

D. All calculations required by this and other various Sections of these Specifications, or as shown on the Contract Drawings, shall be certified and sealed by a Professional Engineer licensed in the state in which the work is to be performed, and shall be submitted to the Engineer for review.

E. Various Sections of these Specifications contain the requirement for the specific material or equipment to be furnished with an experience statement "satisfactorily used for purposes similar to those intended herein" or words of similar intent and a statement that specifies the required experience time. These statements shall mean that the manufacturer of the material or equipment being furnished for the work specified in this Contract shall have manufactured similar material or equipment to that specified, for at least the time specified.

F. In various Sections of this Division there is a statement that refers to the length of required experience that must be satisfied.

G. Polyvinyl Chloride (PVC): PVC conduits, PVC-insulated power wiring, or items containing PVC, except PVC-insulated wiring for communications systems, remote control, signaling, and power limited circuits, shall not be installed in any indoor area. PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits shall be furnished and installed in accordance with NFPA 70.

H. Asbestos

Asbestos or items containing asbestos shall not be furnished or installed.

I. Conformance Labels

All electrical materials and equipment for which there is a nationally recognized standard shall bear the conformance labeling of the third party inspection authority, such as Underwriters Laboratories Inc., Factory Mutual, ETL, or approved equal. Where the phrase "where there are established UL standards, shall bear the UL label", or words of similar intent appear in other Sections, the instructions for the conformance label above shall apply.

## 1.04 CODES AND STANDARDS

A. The electrical installation shall conform to all requirements of ANSI C2, NFPA 70, and the codes and standards specified in other Sections, all local codes and the requirements of OSHA, which would be applicable if the Authority were a private corporation.

B. Standards publications of technical organizations and regulatory agencies are referenced in other Sections, and unless stricter requirements are indicated, materials and equipment so specified shall be manufactured, tested and installed to conform, as a minimum, to the requirements of such reference standards and publications.

C. Installations for aeronautical markers, lighting, guidance signs, and other work as shown on the Contract Drawings, shall comply with the standards of the Federal Aviation Administration (FAA), where applicable.

D. In case of conflict between provisions of codes, laws, and ordinances, the more stringent requirement shall apply.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturers' original unopened protective packaging.

B. Store materials in original packaging in a manner to prevent soiling, physical damage, wetting or corrosion prior to installation.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible maintain protective coverings until installation is complete and remove such covers as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces to the satisfaction of the Engineer.

## 1.06 SUBMITTALS

A. Submit not less than the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of DIVISION 1 - GENERAL PROVISIONS:

1. Catalog cuts to be reviewed and approved by the Engineer.
    - a. Conduit, and fittings
    - b. Wire and cable
    - c. Wiring devices
    - d. Multi-outlet assemblies
    - e. "Standard" outlet and junction boxes
    - f. Medium voltage cable, splicing and termination kits
    - g. Lightning arresters
    - h. Capacitors
    - i. Panel boards and cabinets
    - j. General purpose transformers
    - k. Circuit breakers
    - l. Lighting fixtures
    - m. Pulling devices and end seals
    - n. Special pull and junction boxes
    - o. Supporting devices
2. Shop Drawings
    - a. Substation and high-voltage transformers
    - b. Switchgear
    - c. Switchboards
    - d. Motor control centers
    - e. Emergency lighting battery systems

B. Training, experience and work history for certified splicers and welders.

C. Calculations where required by the Specifications or the Contract Drawings.

D. Working drawings for the installation sequence of medium voltage cables, and other systems where shown on the Contract Drawings, including the reel designations for each leg of the installation. Drawings shall include the calculations for pulling tensions and sidewall pressure of all cable pulls, including identification of manhole locations with splices and manholes that will be "pulled-through" without splicing. Calculations must be certified and sealed by a Professional Engineer licensed in the State in which the work is to be performed.

E. A final copy of the records and certified test reports for all tests, to the Engineer for review, for not less than the following:

1. Primary cable and terminators insulation testing.
2. Insulation testing of 600V (nominal) cables rated 100 amperes (#3 AWG) and above.
3. Ground resistance test of each service ground.
4. Ground fault circuit breaker and receptacle testing.
5. Setting of all adjustable overcurrent devices.
6. Setting or size of all overload elements installed, indicating the following:
   a. Motor designation
   b. Nameplate horsepower, full load current, voltage and phases.
   c. Operating current and voltage.
   d. Overload element size or setting.
7. Emergency power distribution equipment and system test results.

F. One set of prints of Contract Drawings neatly marked up to show any deviations in the actual installation from the conditions shown on the Contract Drawings as issued, and showing the exact location of all equipment and conduit runs, as actually installed.

G. Nameplate designations

H. Operation and maintenance manuals, where required by the Specifications or the Contract Drawings.

## 1.07 SPECIAL TERMS

Throughout this and other Sections of this Division the term "Authority" is used. In PATH contracts, substitute the term "PATH" is deemed substituted for the term "Authority".

## PART 2. PRODUCTS

### 2.01 MATERIAL AND EQUIPMENT TO BE FURNISHED

Equipment and materials furnished shall be new and unused, prior to this installation, first grade commercial quality and shall be essentially the standard cataloged products of a manufacturer regularly engaged in the manufacture of the products. Only those items specifically shown on the Contract Drawings as existing, relocated or Authority furnished shall be reused in this installation. Rebuilt or remanufactured equipment will not be permitted.

### 2.02 IDENTIFICATION

A. All parts of equipment, such as switchboards, panel boards, safety switches, motor starters, circuit breakers, time clocks, contactors and similar items shall be identified by name, function or control with laminated plastic nameplates consisting of two black sheets with one white sheet bonded to and between the two outer sheets and having letters machine engraved in the face sheet to the depth of the white plastic. Nameplates shall not be smaller than 1 inch x 3 inches with characters not less than one-quarter inch. Where letter sizes are not specified, use one-inch high letters for panel boards, switchboards and motor control centers and one quarter inch high elsewhere. Nomenclature shall be according to a schedule approved by the Engineer.

B. All device plates other than lighting switch plates, telephone and 120 volt, single phase, 15 or 20 ampere receptacles, shall have black or white (as directed) silk-screened lettering Helvetica Medium type face (or other type face as directed by the Engineer) designating:

1. System
2. Voltage (where applicable)
3. Number of phases (where applicable)
4. Current rating (where applicable)
5. Frequency (where applicable)

C. Before placing orders for nameplates or silk-screened device plates, submit a typewritten list to the Engineer for review.

D. The outside of the covers of all junction or pull boxes located above hung ceilings and the inside of the covers of all junction or pull boxes exposed shall be labeled with an indelible marker indicating the operating voltage and the system contained therein.

E. All device plates of receptacles connected to a standby or emergency power distribution system shall be labeled with an orange plastic nameplate, engraved with the panel board and circuit number to which the receptacle is connected. Nameplate character engraved shall be not less than one-quarter inch in height.

F. Unless otherwise shown on the Contract Drawings, all panel boards, switchboards, switchgear, circuit breakers, switches and transformers connected to a standby or emergency power distribution system shall be finished Federal Safety Orange in color.

## 2.03 RUBBER MATTING

A. Provide continuous insulated rubber matting not less than 36 inches wide and not less than one quarter inch thick in one piece in front of:

1. Substation Transformers
2. Switchgear
3. Switchboards
4. Motor control centers
5. Panel boards
6. On each side and end of a standby or emergency generator set
7. Other locations as shown on the Contract Drawings

B. Matting shall conform to ASTM D 178, Type 2.

# PART 3. EXECUTION

## 3.01 GENERAL

A. Work of this Division shall include all labor, material and apparatus necessary for the completion of all electrical work as shown on the Contract Drawings and as hereinafter specified, left ready for satisfactory operation.

B. Coordinate with Authority operations and construction by other trades.

1. Coordinate with the Work of all trades as necessary to facilitate timely completion, avoid unnecessary cutting and patching and to insure proper installation and operation of all equipment.
2. Coordinate all components and aspects of the work, in order to minimize power shutdowns to the power distribution systems. Should any part of the Work require an "off-hours" shutdown in excess of 8 hours, supply temporary services or feeders as required to maintain operation of the existing systems and equipment.
3. Furnish to appropriate trades, shop drawings, catalog cuts and instructions necessary for construction of concrete bases, concrete encasement, anchor bolts, and other construction required to accommodate installations under other Sections.
4. Obtain all wiring diagrams and other instructions required for proper electrical connection of equipment installed or furnished under other Divisions of these Specifications and coordinate the installation, wiring and connections for equipment furnished under this Division, or other various Divisions.

C. The arrangement of electrical equipment and conduit runs as shown on the Contract Drawings and described in the Specifications is schematic. Locate and install electrical work in coordination with other trades so that all electrical equipment and material is installed with working clearances in accordance with NFPA 70. Route conduit to avoid interference with existing installation and with work to be performed by other trades.

D. The location of equipment and motors shown on the Contract Drawings shall be subject to minor revisions due to field conditions or coordination with other trades without any increase in Contractor's compensation. Prior to roughing-in, verify the exact location of all electrical connections to equipment and motors from reviewed shop drawings and field verification.

E. Maintain records of all inspections, testing, overload and overcurrent settings throughout the construction and any corrective actions taken, and submit records to the Engineer for review.

F. All electrical work shall be subject to inspection by the Engineer. Correct any deficient work, as required for the approval of the Engineer.

G. Any equipment, materials, wiring or labor that are a necessary part of the electrical work and to its proper performance, although not specifically mentioned herein or shown on the Contract Drawings, shall be furnished and installed as if called for in detail, without additional cost to the Authority.

## 3.02 REMOVALS, RELOCATIONS, RECONNECTIONS, RESTORATIONS

A. Relocate existing equipment and materials as shown on the Contract Drawings.

B. Unless otherwise shown on the Contract Drawings, existing equipment and materials that are to be removed and not required to be relocated under this Contract, will become the property of the Contractor and shall be removed from the property of the Authority, and shall be properly disposed of. Disposal of equipment and materials shall comply with all local, state and Federal laws and regulations as if the Authority was a private corporation.

C. Unless specifically shown on the Contract Drawings, salvaged equipment and materials shall not be reused in the installation.

D. If existing electrical feeders, wiring, conduit, lighting fixtures or equipment interfere with the installation of new construction of any trade, the existing electrical feeder, wiring and conduit shall be rerouted or the equipment relocated in a manner approved by the Engineer to permit installation of the new construction. Where existing circuits or devices, or portions of the existing wiring system are to remain in service, but are interrupted by the construction, continue the existing wiring to maintain the remainder of the wiring system in operation.

E. Notify the Engineer immediately of any damage caused by the Contractor to existing wiring, services or feeders that are to remain in service. Repair the damage in a workmanlike manner to restore to service, at no cost to the Authority.

F. Before shutdown or discontinuation of service on any circuit, system or feeder, coordinate such activities with the Engineer in order to minimize shutdown periods. Provide a minimum of two weeks notice in writing to the Engineer before performing any shutdowns. The minimum period may be reduced with the express written permission of the Engineer.

## 3.03 LOCATION OF EQUIPMENT

A. Unless otherwise shown on the Contract Drawings, the location of outlets or devices, from finished floor to center of plate or device, shall be as follows:

1. Lighting switches: 48 inches.
2. Thermal switches: 48 inches.
3. Receptacles: 16 inches.
4. Telephone outlets: 16 inches.
5. Fire alarm stations: 48 inches.
6. Fire alarm horn/light signals: 7 feet, 6 inches.
7. Clocks: 7 feet, 8 inches.

B. Unless otherwise shown on the Contract Drawings, the location of equipment, from finished floor to top of enclosures shall not exceed 6 feet, 6 inches, and shall not protrude more than 4 inches if higher than 27 inches.

1. In exposed or public locations, panel boards and cabinets shall generally be flush mounted and all covers shall be identical in layout and size, and shall be installed to maintain a level and straight top and bottom alignment.
2. In concealed locations, or in closets or electrical or mechanical rooms, or non-public locations, panel boards and cabinets shall generally be surface mounted and shall be installed to maintain a level and straight top alignment.

## 3.04 DISSIMILAR METALS

A. Dissimilar metals shall mean those metals that are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating so as to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

B. Transitions in raceways, from one metal to a dissimilar metal shall only be made at boxes or other enclosures, except where shown on the Contract Drawings.

## 3.05 NAMEPLATES

Secure nameplates on equipment or walls with stainless steel or brass screws.

## 3.06 RUBBER MATS

A. Install rubber mats in front of each panelboard, switchboard, motor control center, switchgear and substation transformers, and along each side and the end or each generator set, or as shown on the Contract Drawings.

B. Rubber mats, when installed, shall lay flat without curling.

## 3.07 CUTTING AND PATCHING

A. Perform all cutting and patching of existing construction required for installation of all materials and equipment as specified in this Division.

B. Perform all patching to match existing adjacent construction to the satisfaction of the Engineer and using the best possible workmanship of the various trades involved.

## 3.08 FINAL FIELD TESTS

A. The entire electrical installation shall be inspected prior to final acceptance testing, thoroughly cleaned, and damaged finishes touched up after final completion and prior to final acceptance testing being performed. Not less than 30 days prior to the testing, furnish a test plan, to the Engineer for review, outlining all aspects of the testing, including tests to be performed and the expected results.

B. Perform the following field test in the presence of the Engineer to demonstrate the reliability of the electrical installation. Give the Engineer a minimum of one-week advance notice of such tests.

1. Operate all electrical systems and equipment for a period of 24 hours, unless in the opinion of the Engineer, a different test period is required, to prove the operation and performance of a system and its equipment.

2. Should the foregoing test reveal any defects, promptly correct such defects and re-run the tests until the entire installation conforms to the requirements of these Specifications and the Contract Drawings.

C. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Engineer in conformance with standards herein specified.

D. In addition to the tests outlined above, after completion of the electrical system and prior to occupancy:

1. The following equipment and devices, as a minimum, shall be thermographically inspected utilizing a Hughes Aircraft Probeye infrared detector, or approved equal, with videotaping attachment.

a. High voltage cable splices and connections.

b. Switchboard.

c. Transformer.

d. Switchgear.

e. Panelboards.

f. Motor Control Centers.

g. Automatic transfer switch and emergency power system connections.

h. Chiller motor and starter connections.

i. All 600 volt (nominal) cable connections rated 100 amperes (#3 AWG) or greater.

j. Other equipment as shown on the Contract Drawings.

2. The inspection shall be made by an independent inspection company such as Infrared Services, Inc, Montville, N.J., General Electric Apparatus Service Division, or approved equal. The inspection shall be made with all equipment, motors, lighting fixtures, and miscellaneous loads operating and with all equipment covers removed. Inspection reports complete with color photographs of the infrared scan and control photographs indicating the ambient temperature and any hot spots of each item inspected shall be submitted to the Engineer for approval. Any equipment, connections or devices indicated to be operating improperly performing equipment shall be replaced or repaired by the Contractor at no cost to the Authority. The cost of the inspections and necessary repairs shall be included in the Contract.

E. Demonstrate to the Engineer equipment or systems installed or modified in this Contract.

1. After completion of all testing, and prior to placing equipment or systems in operation, demonstrate the features and operation of the equipment or systems to the Engineer, and all other staff or interested parties, as designed by the Engineer, so that operational and maintenance personnel are familiarized with the equipment and systems, as follows:

   a. Switchboards and panelboards.

   b. Transformer.

   c. Switchgear.

   d. Motor control centers.

   e. Fire alarm and smoke detection systems.

   f. Automatic transfer switches

   g. Standby/Emergency generator sets.

   h. Other equipment as shown on the Contract Drawings.

2. Provide the necessary accessories, test equipment, and personnel, for each demonstration.

3. Complete all arrangements for the demonstrations through the Engineer.

4. Upon the completion of each demonstration or instructional session, obtain "sign-off" from the Engineer. The "sign-off" shall state that the demonstration or instructions for use were provided, that they were complete and were given to the designated personnel.

**END OF SECTION**

# SECTION 16000

# ELECTRICAL GENERAL REQUIREMENTS

## INSTRUCTIONS TO SPECIFIER

A. General

ENSURE THAT THIS SECTION IS INCORPORATED IN ALL CONTRACTS, IN ADDITION TO THE VARIOUS SECTIONS REQUIRED FOR THE SPECIFIC WORK.

B. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (1.03 D) | Changes to, or additional general requirements not in this or other Sections of these Specifications. |
| (1.03 D) | Calculations required but not shown in this or other Sections of these Specifications. |
| (1.06 E) | Installation sequence of cables and other systems as required. |
| (2.01) | Identify all material furnished by the Authority, or existing or relocated items that shall be reused. |
| (2.02 F) | Panelboards, switchboards, switchgear, circuit breakers, switches, and transformers connected to standby or emergency power that will not be finished Federal Safety Orange in color. |
| (2.03 A.7) | Rubber matting in front of items other than 2.03 A.1 through 2.03 A.6. |
| (3.01 B) | Location of equipment and motors. |
| (3.02 A) | Relocated existing equipment and materials. |
| (3.02 B) | Identify existing equipment and materials that are to be removed and not relocated that will be kept by the Authority. |
| (3.02 C) | Identify salvaged equipment and materials to be reused. |
| (3.03 A, B) | Outlets, devices or equipment not located as per the Specification. |

C. Coordinate with other disciplines, and specifically ARCHITECTURAL, for locations of devices, in areas such as:

a. Lavatories, toilets and sink areas

b. Kitchens.

c. Laboratories.

d. Cabinetry and casework areas.

e. Vehicle garages - generally 4 feet.

f. Control centers, supervisory desks or other "high-tech" installations.

| | |
|---|---|
| (3.06 A) | Rubber mat locations, other than as noted. |
| (3.08 D.1.j) | Equipment to be thermographically inspected other than as noted in 3.08 D.1. a through i. |
| (3.08 E.1.h) | Demonstrate features and operation of equipment and systems other than as noted in 3.08 E.1 a through g. |

D. Other Items

Ensure that the Specifications include the various Sections required for the type of work shown on the Contract Drawings.

**END OF INSTRUCTIONS**

# DIVISION 16

# SECTION 16115

# UNDERGROUND CONDUIT SYSTEMS

## PART 1. GENERAL

### 1.01 SUMMARY

A. This Section specifies requirements for underground conduits, manholes, handholes, vaults and accessories.

B. Definitions

1. Conduit: A single enclosed raceway for wires or cables; duct.
2. Ductbank: A structure containing one or more ducts or conduits.
3. Conduit System: A combination of conduit, conduits, manholes, handholes, and vaults joined to form an integrated whole.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

| | |
|---|---|
| | American National Standards Institute (ANSI) |
| ANSI C 2 | National Electrical Safety Code |
| ANSI C 80.1 | Rigid Steel Conduit - Zinc Coated |
| | American Society for Testing and Materials (ASTM) |
| ASTM A 185 | Steel Welded Wire Fabric, Plain, for Concrete Reinforcement |
| | Institute of Electrical and Electronics Engineers, Inc. (IEEE) |
| IEEE 837 | Standard for Qualifying Permanent Connections Used in Substation Grounding |
| | National Electrical Manufacturers Association (NEMA) |
| NEMA RN 1 | Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit |
| NEMA TC 2 | Electric Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80) |
| NEMA TC 14 | Filament-Wound Reinforced Thermosetting Resin Conduit and Fittings |
| | National Fire Protection Association (NFPA) |
| NFPA 70 | National Electrical Code |
| OSHA | Occupation Safety and Health Administration |

Underwriters Laboratories Inc. (UL)

| | |
|---|---|
| UL 6 | Rigid Metal Conduit |
| UL 514B | Fittings for Conduits and Outlet Boxes |
| UL 467 | Electrical Grounding and Bonding Equipment |
| UL 651 | Schedule 40 and 80 Rigid PVC Conduit |
| UL 651A | Type EB and A Rigid PVC Conduit and HDPE Conduit |

## 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The underground conduit system shall be furnished and installed in accordance with this section and as specified on the Contract Drawings.

A. Components of the underground conduit system manufactured, supplied, and installed shall comply with the requirements of NFPA 70, all local codes, and the requirements of OSHA.

## 1.04 QUALITY ASSURANCE

A. The manufacturer shall have had a minimum of three years experience within the last five years in manufacturing the products of the type(s) and size(s) described in this Section. Those products shall have been satisfactorily used for purposes similar to those intended herein. The Contractor shall provide a list of installations and contracts for which the manufacturer has produced such materials.

B. All electrical materials and equipment for which there is a nationally recognized standard, shall bear the conformance label of the nationally recognized third party inspection authority, such as Underwriters Laboratories Inc. (UL), Factory Mutual (FM), or ETL.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging. Protective caps shall be removed immediately prior to installation of conduit.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

## 1.06 SUBMITTALS

For submittal requirements see Appendix "A".

## PART 2. PRODUCTS

### 2.01 MATERIALS

A. General

1. Location, types and sizes of conduits and conduit systems are shown on the Contract Drawings.
2. Conduits shall be supplied in standard lengths in accordance with applicable UL standards.
3. Unless otherwise shown on the Contract Drawings, conduit or duct shall be type RGS as specified in this Section.

B. Rigid Metal Conduit

1. RGS - Galvanized steel conduit (heavy-wall) shall be hot dipped galvanized after cutting and threading and shall conform to UL 6 and ANSI C 80.1.
2. RGS-PV - PVC coated, galvanized steel conduit (heavy-wall) shall be hot dipped galvanized after cutting and threading, shall be coated with 40 mils of PVC and shall conform to NEMA RN 1, Type A 40.
3. All preformed elbows shall be similar in construction to and of a type designed for use with the appropriate conduit and shall conform to UL 6.
4. All fittings shall be threaded.

C. Rigid Nonmetallic Conduit

1. PVC-T - Schedule 20 (thin-wall) polyvinyl chloride (PVC) conduit shall conform to UL 651A.
2. PVC-H - Schedule 40 (standard-wall) polyvinyl chloride (PVC) conduit shall conform to UL 651.
3. PVC-80 - Schedule 80 (extra heavy-wall) polyvinyl chloride (PVC) conduit and elbows shall conform to NEMA TC 2 and UL 651.
4. Fiberglass reinforced epoxy conduit shall be glass filament wound, embedded in ultra-violet resistant epoxy. Conduit fittings and elbows shall conform to NEMA TC 14 and the following:
   a. FGS-T - Standard-wall conduit, wall thickness shall be not less than 70 mils for all sizes. Type FGS-T conduit shall be used only where encased in concrete.
   b. FGS-S - Heavy wall conduit, UL listed, with a wall thickness not less than 70 mils for conduits less than 4 inch trade size, not less than 90 mils for conduits 4 inch trade size and not less than 110 mils for conduits larger than 4 inch trade size. Type FGS-H shall be used where direct buried, encased in concrete, or where conduit risers extend to above grade, in accordance with the requirements of the UL listing.
   c. FGS-E - Extra-heavy wall conduit, with a wall thickness not less than one-quarter inch. Type FGS-E conduit shall be used for exposed exterior conduit runs on bridges and elevated structures.

5. Elbows, fittings, offsets, etc. shall be preformed and similar in materials and construction to the conduit.

6. Couplings shall be of a type to provide a watertight installation of the conduit system.

D. Manholes, Handholes, and Vaults

1. Precast manholes, handholes, and vaults shall be as shown on the Contract Drawings. Concrete shall be in accordance with the requirements of the Section entitled "CONCRETE" of these Specifications.

2. Cast-in-place manholes, handholes, and vaults conforming in size and strength to the precast manholes, handholes, and vaults shown on the Contract Drawings may be substituted, subject to the approval of the Engineer.

3. Continuous inserts shown on the Contract Drawings shall be hot-dipped galvanized steel, and shall be supplied complete with end caps and waxed cardboard closure strips. All metallic parts shall have a hot-dipped galvanized finish.

4. Racking assemblies shall be capable of being mounted on the continuous inserts supplied in manhole, handhole, and vault walls, without modification, utilizing hot-dipped galvanized spring nuts and bolts.

   a. The racking assemblies shall, at a minimum, include supports on each wall of the manhole, handhole, or vault, with arms on each support for each cable or arc-proofed cable group. Each arm shall have insulators to support each cable or cable group. Provide additional arms and insulators as shown on the Contract Drawings.

   b. Racking assembly arms and insulators, for installation on existing supports, shall match the existing supports without modification.

5. Manhole, handhole, and vault frames and covers shall be as shown on the Contract Drawings.

6. Provide pulling hooks shall be Hubbard Co. No. 9119, or approved equal.

E. Grounding Assemblies

1. Grounding bushings shall be plated malleable iron body, insulated type, rated 150 degrees C.

2. Ground rods shall be minimum 3/4-inch diameter, copper-clad steel. Unless otherwise shown on the Contract Drawings, ground rods shall be 10 feet long.

3. Unless otherwise shown on the Contract Drawings, conductors for grounding assemblies within manholes, handholes, or vaults shall be copper, minimum #4 AWG.

4. Ground rod connections shall be either exothermic welds, or high-strength compression-crimp system conforming to the requirements of IEEE 837 and UL 467, or approved equal.

5. Ground cable clamps shall be split-bolt, high strength, copper alloy connectors.

## PART 3. EXECUTION

### 3.01 EXAMINATION

A. Inspect all conduit, equipment and accessories prior to installation. Replace any damaged items.

### 3.02 PREPARATION

A. The Contractor shall be responsible for field verification of dimensions and existing underground utilities.

### 3.03 INSTALLATION

A. General

Underground conduit systems shall be installed in accordance with the requirements of ANSI C 2, NFPA 70 and as shown on the Contract Drawings.

B. Excavation and Backfill

Excavation and backfill for underground conduits, handholes, manholes and shall be in accordance with the applicable requirements of the Section entitled "EXCAVATION, BACKFILLING AND FILLING" of these Specifications.

C. Concrete Encased Conduit

1. Concrete encasement of conduit shall conform to the details shown on the Contract Drawings and the requirements of the Section entitled "CONCRETE" of these Specifications.
2. The dead-ending of conduit shall be accomplished as shown on the Contract Drawings.
3. No variation from a straight line of greater than 1/2 inch in fifty feet will be permitted when installing a concrete encased conduit.
4. Reinforce junctions with existing concrete encased conduit, or existing systems, with W8 x W4 - 10 x 10 welded wire fabric, conforming to ASTM A 185, encased in four inches additional thickness of concrete around each set of conduits. The additional encasement shall extend at least four feet in each direction from the junction.
5. Where the placing of concrete is interrupted for one hour or more, reinforce the concrete encasement at the point of interruption with W4 x W4 - 10 x 10 welded wire fabric, conforming to ASTM A 185.
6. Preformed or precast conduit may be substituted for the field-encased type, subject to the approval of the Engineer. All precast conduit shall meet the same requirements specified herein or shown on the Contract Drawings.
7. All conduits shall leave or enter structures perpendicularly.
8. Changes in direction of conduits shall be made by bends having a minimum radius of 15 feet. Elbows or sweeps to equipment or foundations shall have a radius not less than 10 times the trade diameter of the conduit.

9. Conduits shall be installed in true alignment and shall be sloped for drainage toward manholes or handholes. All free ends of empty conduits shall be sealed to prevent water entrance.

10. Openings for conduits in manhole construction shall be sealed and made watertight in an approved manner.

11. Transitions between conduits of different materials shall be made using the manufacturer's standard adapters.

12. Terminations of rigid nonmetallic conduits in manholes, handholes, and other concrete structures, shall be made with end bells, set flush with the inside face of the concrete.

13. Terminations of rigid metal conduits in manholes, handholes, vaults and other concrete structures, shall be made with insulated grounding bushings, projecting 2 inches beyond the inside face of the concrete.

D. Direct-Buried, Rigid Nonmetallic Conduit (PVC-H or FRE)

1. Direct-buried conduits shall be laid on firmly tamped and graded stone-free sand not less than 2 inches deep. Backfill in contact with the conduits shall be sand to a minimum of 3 inches above the conduits and the remainder of the backfill shall be unfrozen, stone-free earth. Buried depth shall be as shown on the Contract Drawings.

2. Conduit entering or exiting manholes, handholes, vaults, and other concrete structures shall be a 10-foot length of rigid metal conduit protected with two coats of asphaltic paint.

3. Terminations of conduits in manholes, handholes, vaults, and other concrete structures shall be made with insulated grounding bushings projecting 2 inches beyond the inside face of the concrete.

E. Manholes, Handholes, and Vaults

1. Set precast manholes, handholes, and vaults so that they are firmly and fully bedded at required grades.

2. Set frames and covers using mortar and masonry as required. Radially laid concrete brick shall have 1/4-inch thick vertical joints at inside perimeter. Lay all concrete brick in a full bed of mortar and completely fill all joints. Where more than one course of concrete brick is required, stagger vertical joints.

3. Set racking assemblies as required so that the unsupported length of wires or cables shall not exceed 30 inches.

F. Vertical Adjustment of Existing Manholes, Handholes, and Vaults

1. Adjust the top elevation of existing structures to suit new finished grades in accordance with the details shown on the Contract Drawings.

2. Existing frames and covers shall be carefully removed, cleaned of all mortar fragments to the satisfaction of the Engineer and reset at the required elevation in accordance with the requirements shown on the Contract Drawings.

G. Grounding

1. Install a complete grounding system in each manhole or vault, and in selected handholes shown on the Contract Drawings. Electrically bond all arm supports, insulated grounding bushings, and ground rods together.

2. After installation, coat all bare surfaces or connections in the grounding system with asphaltic paint.

H. TESTING

1. Test conduits, in the presence of the Engineer, by pulling through each conduit a flexible cylindrical mandrel having an outside diameter not more than 1/4 inch smaller than the inside diameter of the conduit, but nominally 85 percent of the trade diameter, whichever is larger. Only nylon cable of adequate strength shall be used to pull the mandrel through the conduit system. The use of rope will not be permitted.

I. Connections to Existing Conduits

1. Where conduits installed under this Contract are connected to existing conduits, test the entire run to the nearest box, manhole, handhole, vault or equipment enclosure, including all existing conduits installed by others, that will be used under this Contract.

2. Where any work shall be performed in conduits emanating from a manhole, handhole, vault or equipment enclosure, all existing spare conduits (conduits containing no electric wire or cable) shall be tested to the nearest manhole, handhole, vault or equipment and a pull line shall be left in place in each such conduit.

3. Report immediately to the Engineer any defect or stoppage found in portions of the conduit system not installed under this Contract. Do not attempt to rectify any defect or stoppage found in conduit not installed under this Contract unless specifically instructed to do so by the Engineer. The Contractor's compensation for the rectifying of such defects or stoppages at the direction of the Engineer will be determined in accordance with the clause of the Contract providing compensation for Extra Work.

4. The Engineer shall be the sole judge as to whether a defect or stoppage exists. Perform all tests required by the Engineer to enable him to make his decision.

3.04 ADJUSTMENTS

A. Conduit Cleaning

After installation of conduits, manholes, handholes, vaults, accessories and completion of all concreting operations, if any, carefully clean and clear all conduits of all obstructions and foreign matter to the satisfaction of the Engineer.

**END OF SECTION**

## SECTION 16115

## UNDERGROUND CONDUIT SYSTEMS

## APPENDIX A

## SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop Drawings

1. Handholes
2. Vaults
3. Frames and covers
4. Manholes, including "exploded" views with complete details as to the location of all existing and new conduits, wires and cables identified by permanent feeder numbers, racking assemblies and grounding assemblies. Manhole drawing blanks will be furnished by the Engineer.

B. Catalog Cuts

1. Conduit
2. Racking assemblies
3. Grounding assemblies
4. Continuous inserts

END OF APPENDIX "A"

# SECTION 16115

# UNDERGROUND CONDUIT SYSTEMS

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (2.01 A.1) | Locations, types and sizes of conduits and conduit systems |
| (2.01 D.1) | Precast manholes, handholes, and vaults |
| (2.01 D.2) | Cast-in-place manholes, handholes and vaults |
| (2.01 D.3) | Continuous inserts |
| (2.01 D.4.a) | Additional racking assembly arms and insulators other than specified |
| (2.01 D.5) | Manhole, handhole, and vault frames and covers |
| (2.01 E.2) | Ground rod size, other than specified |
| (2.01 E.3) | Ground conductor size, other than specified |
| (3.03 A) | Underground conduit system requirements |
| (3.03 C.1) | Details of concrete encased conduit |
| (3.03 C.2) | "Dead-ending" of conduit |
| (3.03 C.6) | Special requirements of preformed or precast conduits |
| (3.03 D.1) | Required depth of direct-buried conduit |
| (3.03 F.1) | Details of vertical adjustment of existing manholes, handholes and vaults |
| (3.03 F.1) | Required top elevation(s) of vertically adjusted structures |
| (3.03 G.1) | Selected handholes requiring complete grounding system |
| (3.03 I.1) | Conduit installed by others |

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section:

| | |
|---|---|
| (2.01 D.1) | ”CONCRETE" |
| (3.03 B) | "EXCAVATION, BACKFILLING AND FILLING" |

C. Recommended Manufacturers

(2.01 B.1) Rigid galvanized steel conduit; shall be as manufactured by OCAL, Occidental Coating Company or approved equal.

(2.01 B.2) PVC coated rigid galvanized steel conduit; shall be as manufactured by Robroy Industries or approved equal.

(2.01 C) Polyvinyl Chloride conduit; shall be as manufactured by Carlon Company or approved equal.

(2.01 C.4) Fiberglass reinforced epoxy conduit; shall be as manufactured by Smith Fiberglass Products, Inc., or approved equal.

(2.01 D.2) Manholes, handholes and vaults; shall be as manufactured by Berri-Roche or approved equal.

(2.01 D.5) Manhole and handhole frames and covers; shall be as manufactured by Campbell Foundry or approved equal.

(2.01 D.3) Continuous Inserts; shall be as manufactured by Unistrut Corporation or approved equal.

(2.01 D.4) Manhole and Handhole Racking assemblies; shall be as manufactured by A.B. Chance or approved equal.

(2.01 E.4) Grounding clamps and connections; shall be as manufactured by Burndy Corporation, Cadweld, or approved equal.

(2.01 E.2) Ground Rods; shall be as manufactured by Cadweld, or approved equal.

(2.01 E.1) Grounding bushings; shall be as manufactured by O-Z/Gedney. or approved equal.

D. Coordination With Other Sections

1. This Section applies specifically to exterior Underground Conduit Systems. For installation of a complete Underground Conduit System ensure that the following Sections, at a minimum, are incorporated in the Specifications:

   RACEWAYS
   WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
   WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)
   ARCPROOFING

E. This Section applies specifically to exterior Underground Conduit Systems. Those continuations or extensions of the Conduit System that are in or under buildings or other structures are incorporated into the Section entitled "RACEWAYS".

**END OF INSTRUCTIONS**

# DIVISION 16

# SECTION 16120
# WIRES, CABLES, SPLICES, TERMINATIONS
# (600 VOLTS OR LESS)

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for wires, cables, splices, terminations, and appurtenances for electrical systems of 600 volts or less.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM B 1 | Hard-Drawn Copper Wire |
| ASTM B 2 | Medium-Hard-Drawn Copper Wire |
| ASTM B 3 | Soft or Annealed Copper Wire |
| ASTM B 8 | Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft |
| ASTM B 33 | Tinned Soft or Annealed Copper Wire for Electrical Purposes |
| ASTM B 174 | Bunch-Stranded Copper Conductors for Electrical Conductors |
| ASTM B 189 | Lead-Coated and Lead-Alloy-Coated Soft Copper Wire for Electrical Purposes |
| ASTM D 2802 | Ozone-Resistant Ethylene-Propylene-Rubber Insulation for Wire and Cable |
| ASTM D 3005 | Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape |
| ASTM E 662 | Standard Test Method for specific Optical Density of Smoke Generated by Solid Materials |

Federal Specifications (FS)

| | |
|---|---|
| HH-I-553 | Insulation Tape, Electrical (Rubber, Natural and Synthetic) |

Insulated Cable Engineers Association (ICEA)

| | |
|---|---|
| ICEA S-19-81 | Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 3) |
| ICEA S-61-402 | Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 5) |
| ICEA S-66-524 | Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 7) |
| ICEA S-68-516 | Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (NEMA WC 8) |
| ICEA T-33-655 | Guide for Low Smoke, Halogen-Free (LSHF) Polymeric Cable Jackets |

Institute of Electrical and Electronics Engineers (IEEE)

| | |
|---|---|
| IEEE 383 | Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations |
| IEEE 837 | Standard for Qualifying Permanent Connections Used in Substation Grounding |

Military Specifications

| | |
|---|---|
| MIL C-24643 | Electrical Cable and Cord for Shipboard Use, Testing for Low Smoke and Halogens |

National Fire Protection Association (NFPA)

| | |
|---|---|
| NFPA 70 | National Electrical Code |

Naval Engineering Standards

| | |
|---|---|
| NES 713 | Determination of Toxicity Index of Products of Combustion From Small Specimens of Materials |

Underwriters Laboratories Inc. (UL)

| | |
|---|---|
| UL 44 | Rubber-Insulated Wires and Cables |
| UL 62 | Flexible Cord and Fixture Wire |
| UL 83 | Thermoplastic-Insulated Wires and Cables |
| UL 467 | Grounding and Bonding Equipment |
| UL 510 | Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape |
| UL 854 | Service-Entrance Cables |
| UL 1581 | Reference Standard for Electrical Wires, Cables, and Flexible Cords |
| UL 1685 | Standards for Safety Vertical Tray Fire Propagation and Smoke Release Test for Electrical and Optical Fiber Cables |

1.03 QUALITY ASSURANCE

A. Wires and cables which have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

B. Tapes for splices or terminations shall be dated by the tape manufacturer to indicate that they have been manufactured no longer than six months prior to use in the Work of this Section.

C. Polyvinyl Chloride (PVC): PVC-insulated power wiring and items containing PVC, except PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits, shall not be installed in indoor area. PVC-insulated wiring for communications systems, remote control, signaling, and power-limited circuits shall be furnished and installed in accordance with NFPA 70.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Single conductor wire or cable sizes #4/0 AWG and larger that are to be installed in the same raceway shall be paralleled by the cable manufacturer prior to shipment. Cable assembly overall diameter shall be kept to a minimum.

B. Wire and cable sizes #4/0 AWG and larger shall be provided with fctory-applied caps unless otherwise shown on the Contract Drawings. End seals shall be heat-shrink, irradiated, modified polyolefin, and shall be sized for individual wires and cables.

C. Store material in a clean, dry space and protect it from the weather.

1.05 SUBMITTALS

See Appendix "A" for submittals requirements.

## PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide wires, cables, wire and cable splicing, terminating and arcproofing materials of manufacturers as shown on the Contract Drawings.

## 2.02 WIRES AND CABLES

A. General

1. Definitions

   a. Wire shall be defined as a solid or stranded conductor smaller than No. 6 AWG with or without insulation.

   b. Cable shall be defined as a single conductor No. 6 AWG or larger, or two or more conductors of any size wire under a common covering.

2. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings. Where not indicated, provide proper wire and cable selection to comply with this section and NFPA 70 Standards.

3. Unless otherwise shown on the Contract Drawings, solid conductors shall be soft or annealed copper, conforming to ASTM B 33 (tinned), ASTM B 189 (lead-coated or lead-alloy coated), or ASTM B 3 (uncoated). Unless otherwise specified in this Section or unless otherwise shown on the Contract Drawings, stranded copper conductors shall be concentric stranding conforming to ASTM B 8.

4. Unless otherwise shown on the Contract Drawings, cable jackets for interior use shall be low smoke, low toxicity, non-halogen, flame retardant type and shall meet the following performance characteristics:

   a. Cables shall pass the flame propagatory and smoke release criteria according to the test method of UL 1685.

   b. The halogen content of cable jackets shall not exceed 0.2 percent according to the test method of MIL-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".

   c. The toxicity index of cable jackets shall not exceed 4.0 according to the test method of NES 713.

   d. The cable jackets shall comply with ICEA T-33-655 for smoke generation.

   e. The acid gas content of cable jackets shall not exceed a maximum of 3.0 percent according to the test method of MIL-C-24643.

5. Use the additional performance characteristics for wires and cables which will be installed in subway areas, substations, tunnels, etc. where stringent flame retardency, low smoke, low toxicity, zero halogen and good circuit integrity during a fire are required.

   a. Wires shall pass the flame propagatory criteria according to the test method of VW-1.

   b. The halogen content of both the wire and cable insulation and cable jacket(s) shall not exceed 0.2 percent according to the test method of MIL-C-24643. The Authority classifies 0.2 percent or less halogen content as "non-halogen".

   c. The toxicity index of both the wire and cable insulation and cable jacket(s) shall not exceed 2.0 according to the test method of NES 713.

   d. The acid gas content of both wire and cable insulation and cable jacket(s) shall not exceed a maximum of 2.0 percent according to the test method of MIL-C-24643.

e. The wire and cable insulation materials shall pass the smoke generation test in accordance with ASTM E 662. Wire and cable insulation when tested on a specimen of 80 mils thick slab shall not exceed the following values:

| | |
|---|---|
| Flaming Avg. Ds (4 minutes) | 100 |
| Flaming Avg. Dm (20 Minutes) | 200 |
| Non-Flaming Avg. Ds (4 minutes) | 100 |
| Non-Flaming Avg. Dm (20 minutes) | 350 |

f. The cable jacket materials shall pass the smoke generation test in accordance with ASTM E 662. Wire and cable jacket when tested on a specimen of 80 mils thick slab shall not exceed the following values:

| | |
|---|---|
| Flaming Avg. Ds (4 minutes) | 50 |
| Flaming Avg. Dm (20 minutes) | 150 |
| Non-Flaming Avg. Ds (4 minutes) | 50 |
| Non-Flaming Avg. Dm (20 minutes) | 250 |

6. Color-Coding for Power and Lighting Conductors

a. Insulation or covering of wires and cables shall be actory color-coded by the use of colored compounds or coatings. The color-code shall be followed cnsistently throughout the performance of the Work.

b. Upon written request of the Contractor, the Engineer may permit the use of the following methods in lieu of the wire or cable manufacturer's color-coding, when limited quantities of wire and cable are involved, for sizes #8 AWG and larger.

(1) For dry locations only, spiral application of 3/4 inch wide, colored pressure sensitive plastic tape, half lapped for a distance of not less than six inches may be used. To prevent unwinding, the last two wraps of tape shall be applied with no tension.

(2) For wet or dry locations, application of three, 3/16 inch wide, colored, fungus-inert, self-extinguishing, self-locking, nylon cable ties spaced 3 inches apart may be used. The ties shall be snugly applied with a special tool or pliers, and any excess removed.

(3) Each wire and cable shall be color-coded at all terminal points, in all manholes, boxes, or other similar enclosures.

(4) Color markings shall be applied so as not to obliterate the manufacturer's identification markings.

c. Color code chart shall be as follows:

| | System Voltage | |
|---|---|---|
| Conductor | 208Y/120V | 480Y/277V |
| Phase A | Black | Brown |
| Phase B | Red | Orange |
| Phase C | Blue | Yellow |
| Neutral | White | Gray |
| Ground | Green | Green |

7. All wires, cables, splices and terminations, for which there are established UL standards, shall bear the UL label.

B. General-Purpose Wires and Cables

Unless otherwise shown on the Contract Drawings, general purpose wires and cables shall be as follows:

1. General-purpose wires and cables shall be single conductor, ASTMB8, Class B stranded for sizes #8 AWG and larger, and solid for sizes #10 AWG and smaller.

2. Select from the following list of UL wire and cable types:

a. Type XHHW: Flame retarding, Cross-linked-polyolifin insulation, conforming to UL 44, for dry locations only.

b. Type XHHW-2: Flame retardant, Cross-linked-polyolifin insulation, conforming to UL 44.

c. Type THWN: Flame retardant, moisture and heat resistant thermoplastic insulation with a nylon jacket or equivalent; Double rated THHN-THWN gasoline-oil resistant II; conforming to UL 83.

The use of this cable shall be in accordance with the requirements of paragraph 1.03C of this Section.

d. Type USE: Heat and moisture resistant ethylene- propylene-rubber insulation with heavy duty thermosetting chlrosulphanated polyethylene or heavy- duty neoprene jacket; multiple rated "USE-RHH-RHW"; conforming to ASTM D 2802, ICEA S-68-516, UL 44 and UL 854. Unless otherwise indicated, Type USE shall be the only wire and cable used for underground installations.

C. Overhead Service Cables

Unless otherwise shown on the Contract Drawings, overhead service cables shall be two or more type SE, ASTM B 8, Class B or Class C stranded, hard-drawn copper conductors, ethylene-propylene-rubber insulation, with heavy duty neoprene or heavy duty thermosetting chloro-sulphonated polyethylene jacketed, marked "sunlight resistant", conforming to ASTM D 2802, UL 44 and UL 854. Cable shall be factory assembled with copper-clad messenger conforming to ICEA S-68-516.

D. Portable Cords

Unless otherwise shown on the Contract Drawings, portable cords shall be as follows:

1. Type S shall be 60 degrees C rated, with heavy-duty thermosetting insulation and jacket, conforming to UL 62, 600-volt rated.
2. Type SO shall be oil resistant, 60 degrees C rated, with heavy-duty thermosetting insulation and jacket, conforming to UL 62, 600-volt rated.
3. Type G or Type W shall be 90 degrees C rated, with ethylene-propylene-rubber insulation and Hypalon jacket, 600-volt rated.
4. Special types shall be used only where shown on the Contract Drawings.

E. Lighting Fixture Wires

Unless otherwise shown on the Contract Drawings, lighting fixture wires shall be stranded only, and shall be Type SF-2, silicone rubber insulated conforming to UL 62.

F. Grounding Wires and Cables

Unless otherwise shown on the Contract Drawings, grounding wires and Cables shall be as follows:

1. Insulated
   a. Solid for sizes #8 AWG and smaller; ASTM B 8, Class B stranded for sizes #6 AWG and larger; and of the same insulation type as the power conductors.
   b. Covering shall be a continuous green color and conform to ASTM B 33 and UL 44.
2. Uninsulated
   a. General

      Solid for sizes #8 AWG and smaller; ASTM B8, Class B stranded for sizes #6 AWG and larger.
   b. In raceways

      Soft-drawn and conforming to ASTM B 3.
   c. Direct buried or encased in concrete

      Soft-drawn, medium-hard-drawn, or hard-drawn and conforming to ASTM B 1, B 2 or B 3, respectively.

G. Control Wires and Cables

Unless otherwise shown on the Contract Drawings, control wires and cables shall be as follows:

1. Single conductor wires and cables shall be ASTM B 8, Class B stranded, type XHHW or XHHW-2 flame retardent, cross-linked-polyolifin insulation. Both shall conform to UL44 and ICEA S-66-524.

2. Multiconductor cables shall be ASTM B 8, Class B or Class C stranded, Control Cable Type B, conforming to ICEA S-61-402. Color-coded as per ICEA S-61-402, Method No. 1 for NFPA 70 applications (with white and green) or ICEA S-19-81, for paired conductor cables. Select from the following list of cable types.

   a. Individual ethylene-propylene rubberinsulation with overall flame retardent, cross-linked-polyolifin jacket; conforming to ICEA S-68-516, UL 44, and UL 1581.

   b. Individual ethylene-propylene-rubber insulation with individual and overall flame-retardent, cross-linked polyolifin jackets; conforming to ICEA S-68-516 and UL 44.

   c. Individual flame retardent, cross-linked-polyolifin insulation with and overall flame retardent, cross-linked-polyolifin jacket; conforming to ICEA S-66-524.

   d. Individual cross-linked-polyolifin insulation with overall polyvinyl chloride jacket conforming to ICEA S-66-524.

   e. Individual polyolifin insulation with individual and overall polyvinyl chloride jackets conforming to ICEA S-61-402.

H. Switchboard Wires and Cables

Unless otherwise shown on the Contract Drawings, switchboard wires and and cables shall be as follows:

1. Switchboard wires and cables shall be single conductor, ASTM B 8, Class B stranded, except that for wires and cables crossing hinged joints and swinging panels, and where "Extra Flexible" wire or cable is shown on the Contract Drawings, conductors shall be ASTM B 174, Class K stranded.

2. Wires and cables shall be Type SIS, cross-linked-thermosetting-polyethylene insulation, conforming to ICEA S-61-402, IEEE383 and UL 44.

I. Cable Tags

1. Dry Locations

   a. Fiberglass tags, 1/16 inch thick and 3/4 inch wide, indented with letters and numbers 5/16 inch high, with #14 AWG copper or nylon, weather-resistant cable ties.

   b. Lighting branch circuit wiring and single conductor signal and control wiring may be identified with "Quiklables" manufactured by W. H. Brady Company, or approved equal.

2. Wet Locations

Stainless steel metal tags, No. 28 gauge and 3/4 inch wide, embossed with letters and numbers 5/16 inch high, with #14 AWG copper or nylon, weather-resistant cable ties, or stainless steel cable ties.

## 2.03 SPLICING, TERMINATING AND ARCPROOFING MATERIALS

A. General

1. All splicing, terminating and arcproofing materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other, or of the wire or cable itself.
2. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

B. Connectors

Subject to compliance with requirements of this Section, provide connectors of the following types:

1. Solderless, uninsulated, high conductivity, corrosion resistant, compression connectors conforming to UL 467 and IEEE 837;
2. Insulated, indenter type compression butt connectors;
3. Insulated, integral self-locking flexible shell, expandable spring connectors;
4. Uninsulated, indenter type compression pigtail connectors;
5. Welded type connectors.

C. Terminals

Subject to compliance with requirements of this Section, provide terminals of the following types:

1. Solderless, uninsulated, high conductivity, corrosion resistant, compression terminals conforming to UL 467 and IEEE 837;
2. Insulated, compression terminals;
3. Solderless, high conductivity, corrosion resistant, hex screw type, bolted terminals;
4. Welded type terminals.

D. Shrinkable Tubing

Subject to compliance with requirements of this Section, provide shrinkable tubing of the following types:

1. Either irradiated modified polyvinyl chloride or irradiated modified polyolefin heat shrinkable tubing;
2. Cold shrinkable tubing.

E. Tapes and Sealers

1. Vinyl Tapes

Flame-retardent, cold and weather-resistant, 3/4 inch or 11/2 inches wide, as required, and conforming to UL 510 and ASTM D 3005.

a. For interior, dry locations, provide 7 mils, conforming to ASTM D 3005 (Type I); Scotch (3M) No. 33, or approved equal.

b. For exterior or damp and wet locations, provide 8.5 mils, conforming to ASTM D 3005 (Type II); Scotch (3M) No. 88, or approved equal.

2. Rubber Tapes

Ethylene-propylene, rubber-based, 30-mil splicing tape, rated for 130 degrees C operation; 3/4inch and wider (1, 1 1/2, 2 inches) as shown on the Contract Drawings or approved by the Engineer, conforming to Federal Specification HH-I-553 (Grade A); Scotch (3M) No. 130C, or approved equal.

3. Insulating Putty

Rubber-based, 125-mil elastic filler putty; 1 1/2 inches wide; Scotch (3M) Scotchfil, or approved equal.

4. Silicone Rubber Tapes

Inorganic silicone rubber, 12-mil, 130 degrees C rated, anti-tracking, self-fusing tape; 1 inch wide; Scotch (3M) No. 70, or approved equal.

5. Sealer

Liquid applied, fast-drying sealant; Scotch (3M) Scotchkote, or approved equal.

F. Resin Filled Splices

1. Epoxy Molded Type

Two-piece, snap-together molded bodies, sized for wire or cable, with two-part low viscosity polyurethane insulating and sealing compound, rated for 600 volts, using crimp-type wire connector; Scotch (3M) No. 82-A1, 82-A2 or 82-A3 compound, or approved equal.

2. Re-Enterable Type

Transparent, molded bodies clamped with stainless steel strain-relief bar and shield continuity connectors, sized for wire or cable, with loosely woven polyester spacer web and jelly-like urethane formulation for permanent re-entry capability; Scotch (3M) No. 78-R1 thru 78-R5, with No. 2114 compound, or approved equal.

G. Arcproofing Materials

1. Fire resistant tapes shall be Scotch (3M) No. 77, or approved equal.

2. Glass cloth binding tapes shall be Scotch (3M) No. 69, or approved equal.

H. Special splicing materials and methods shall be as shown on the Contract Drawings.

## 2.04 SHOP TESTS

A. For quantities as shown on the Contract Drawings, regular dielectric-withstand and insulation-resistance in water tests for wires and cables shall be performed in accordance with UL44.

B. Flame tests for wires and cables shall be performed in accordance with IEEE 383.

C. The test results shall be certified for each reel/coil/box of wire or cable.

D. Factory inspection and witnessing of tests by the Engineer shall be required for all wires and cables furnished under this Contract. The Engineer reserves the right to require additional testing, or to waive factory inspection or witnessing of tests. The Contractor shall notify the Engineer 14 days in advance of the scheduling of such factory tests.

# PART 3. EXECUTION

## 3.01 PREPARATION

A. Prior to pulling wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

## 3.02 INSTALLATION

A. Wire and Cable Installation

1. General

a. Keep wires and cables dry at all times.

b. Seal wire and cable ends with watertight end seals if splicing or terminating does not follow at once.

c. Before splicing or terminating wires and cables, make a thorough inspection to determine that water has not entered the wires and cables or that the wires and cables have not been damaged.

d. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

2. General Purpose Wires and Cables

a. Minimum wire or cable size shall be #12 AWG for light and power service.

b. Wires or cables shall be at least #10 AWG for the entire length of branch circuits, where distances to first outlets are as follows:

(1) 100 feet or more on 480Y/277 Volt systems.

(2) 70 feet or more on 208Y/120 Volt systems.

3. Lighting Fixture Wires

a. For wiring within lighting fixtures only, where sizes #14 AWG or smaller are required, use Type SF-2 fixture hookup wire. Type SF-2 wire shall not be used for wiring end-to-end connected fluorescent fixtures.

b. For connecting lighting fixtures to branch circuit conductors, use either Type RHH-VW-1, XHHW or USE, up to 90 degrees C, in dry locations.

4. Grounding Wires and Cables

a. Use bare, uninsulated wire and cable only where shown on the Contract Drawings or where approved by the Engineer.

b. Insulated grounding cable shall be of the type specified in this Section or as shown on the Contract Drawings.

5. Control Wires and Cables

Control wires and cables shall not be smaller than #14 AWG unless otherwise shown on the Contract Drawings.

B. Splicing and Terminating

1. General

Splicing and terminating shall be as specified in this Section. Details of special splicing and terminating shall be as shown on the Contract Drawings. Any splicing or terminating methods other than those specified below, for which the components are in accordance with the requirements of this Section, shall be submitted to the Engineer for approval.

2. General Purpose Wires and Cables

a. Splices in dry locations for sizes #10 AWG and smaller

Splicing shall be completed using one of the following:

(1) Insulated, integral, self-locking flexible shell, expandable spring connectors shall be applied to the twisted conductors. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(2) Compression type, insulated butt connectors shall be applied to the butted conductors by means of an appropriate crimping tool, providing controlled indentation. Two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

(3) Compression type, pigtail connectors shall be applied to the conductors by means of an appropriate crimping tool, providing controlled indentation. The connector shall be covered with a polyamide cap and two, half-lapped layers of vinyl tape, extending to a distance of not less than one inch from the connector, shall be applied.

b. Splices in dry locations for sizes #8 AWG and larger

Splicing shall be completed using all of the following:

(1) Connectors shall be split sleeve solderless type or solderless compression type.

(2) Fill indents of connectors with Scotchfil insulation putty.

(3) Apply rubber splicing tape equal to the original insulation rating.

(4) Apply two, half-lapped layers of vinyl tape, or a shrinkable tubing.

c. Splices in wet locations

(1) Same as dry locations specified in 3.02B.2.a and 2.b, except that after vinyl tape is applied, cover with two coats of sealer or shrinkable tubing.

(2) Resin-filled splice shall be covered with two, half-lapped layers of vinyl tape and two coats of sealer or shrinkable tubing.

d. Terminations in dry locations for sizes #10 AWG and smaller

Terminations shall be compression terminals, insulated or uninsulated.

e. Terminations in dry locations for sizes #8 AWG through #3/0 AWG

(1) Ring tongue terminals shall be solderless, uninsulated compression crimp type.

(2) Ring tongue lugs shall be bolted hex screw type.

f. Terminations in dry locations for sizes #4/0 AWG and larger.

Ring tongue terminals shall be solderless, uninsulated compression crimp type.

g. Terminations in wet locations

In addition to the dry location terminations specified in 3.02 B.2.d, 2.e and 2.f, cover the entire termination area with two, half-lapped layers of vinyl tape and apply two coats of sealer over the tape.

3. Overhead Service Cables

Splices and terminations in overhead service cables shall be the same as specified in 3.02 B.2.c and 2.g, respectively, appropriate for overhead service.

4. Portable Cords

a. Splices shall not be made in portable cords.

b. Terminations shall be made only at apparatus to be served or at branch circuit connection by means of any of the following:

(1) Insulated, integral, self-locking flexible shell, expandable spring, or crimp type connectors;

(2) Insulated, crimp type, compression connectors;

(3) Uninsulated, ring tongue terminals for connection to wire terminal strip block.

5. Lighting Fixture Wires

   Connections to branch circuit and to fixture wiring shall be made by either insulated, integral, self-locking flexible shell, expandable spring, or crimp type connectors.

6. Grounding Wires and Cables

   a. Splices and terminations shall be installed in accordance with the manufacturer's recommendations.

   b. In hazardous or classified locations, splices and terminations shall be solderless high conductivity, corrosion resistant, compression type connectors and terminations shall be clamp type pressure connectors, suitable for such use.

   c. All underground connections shall be covered with two coats of asphalt base paint.

7. Control Wires and Cables

   a. Splices shall be made in accordance with the requirements specified in 3.02 B.2.c and shall be enclosed in a re-enterable splicing case. Where shielded cable is shown on the Contract Drawings, the shielding shall be continued through the splice. Shields shall be grounded at one location only unless otherwise shown on the Contract Drawings.

   b. Terminations shall be insulated, indenter type ring tongue terminals.

8. Switchboard Wires

   a. No splices are permitted.

   b. Terminations shall be insulated, indenter type ring tongue terminals.

C. Arcproofing

1. Arcproofing shall be applied where shown on the Contract Drawings.

2. Arcproofing, which has been disturbed for any reason, shall be reinstalled as soon as possible after the disturbance.

3. Arcproofing shall be installed as follows:

   a. Wires and cables shall be grouped by circuit and arcproofing applied over the group of wires and cables comprising one circuit. Splices shall be arcproofed individually and the taping shall join with and be overlapped by the group taping.

   b. Arcproofing shall be applied in two wrappings of half-lapped tape, bound with glass cloth tape applied at the ends of the fire resistant tape, and at intervals not to exceed 24 inches along the entire length of the cables. The two wrappings shall be applied with opposing-lays.

   c. Arcproofing shall be extended into the conduit opening or end bell of the raceway entering a handhole, manhole or box.

   d. Arcproofing tape shall be 1 1/2 inches wide where the diameter of the individual cable, or of the circumscribed circle for the circuit group, is less than 1 3/4 inches. For larger diameters, the tape shall be 3 inches wide.

D. Identification of Wires and Cables

1. Each wire and cable shall be identified by its circuit in all cabinets, boxes, manholes, handholes, wireways and other enclosures and access locations, and at all terminal points.

2. The circuit designations shall be as shown on the Contract Drawings. Tags shall be attached to wires and cables in such a manner as to be readily visible.

3. The tag ties shall be wrapped around all conductors comprising the circuit or feeder to be identified.

4. Wires and cables which are arcproofed shall also be identified outside the applied arcproofing.

## 3.03 FIELD TESTS

Test all wires and cables up to equipment installed under this Contract with a 1000-volt Megohmmeter. Furnish the Engineer with a copy of the "Megger" readings together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than that required by applicable codes, promptly replace the materials involved, at the Contractor's expense, and retest.

END OF SECTION

# SECTION 16120

# WIRE, CABLES, SPLICES, TERMINATIONS

# (600 VOLTS OR LESS)

## APPENDIX A

## SUBMITTAL REQUIREMENTS

A. Submit Catalog Cuts for the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Wires and cables for each type and size;
2. Splice kit materials and installation procedures.

B. Submit certified shop test reports for wires and cables.

C. Submit field test results for wires and cables, including "Megger" readings with the test method used.

END OF APPENDIX "A"

# SECTION 16120

# WIRES, CABLES, SPLICES, TERMINATIONS

# (600 VOLTS OR LESS)

## INSTRUCTIONS TO SPECIFIER

1.01 Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (1.04 B) | List cables to be furnished without factory-applied caps. |
| (2.01) | Show manufacturers of wires, cable wires, and cable splicing, terminating and arcproofing materials on contract drawing. List a minimum of 2 manufacturers and include "a approved equal". If an item is unique or sole source, then a sole source letter will be required. |
| (2.02 A.1) | Show locations, types, sizes and numbers of and cables. |
| (2.02 A.2) | Specify special type of conductors that are not soft or annealed copper. |
| (2.02 A.5) | The wires and cables specified in this paragraph are not easily available. Large quantities and/or a prepurchase may be required. |
| (2.02 B.2) | Specify any general-purpose wires and cables not listed in this paragraph. |
| (2.02 D) | Specify special types of portable cords not listed in this paragraph. |
| (2.02 E) | Specify any special type lighting fixture wires that is not Type SF-2. |
| (2.02 F) | Specify any special type grounding wires and cables not covered by the specification of this paragraph. |
| (2.02 G) | Specify any special control wire and cable not covered by the specification of this paragraph. |
| (2.02 H) | Specify any special switchboard wire and cable not covered by the specifications of this paragraph. |
| (2.03 E.2) | Show size of rubber tape as specified. |
| (2.03 H) | Show any special splicing materials and methods not specified in this section. |
| (3.02 A.4.a) | Show any bare grounding wire to be installed. |
| (3.02 A.4.b) | Show any special grounding wire to be installed. |

| | |
|---|---|
| (3.02 A.5) | Show any control wire other than #14 AWG to be installed. |
| (3.02 B) | Shown any special splicing and terminating details not specified in this section. |
| (3.02 B.7.a) | Show control cable shields that are to be grounded in more than one location. |
| (3.02 C.1) | Show locations where arcproofing is to be applied. |
| (3.02 D.2) | Show all circuit designations. |

1.02 Other Items

Specify required submittals by editing Appendix A "Submittal Requirements"

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16125

# TRAFFIC SIGNAL CABLES

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for traffic signal cables.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section. The engineer is responsible for ensuring that the current edition of these references is utilized during the design process:

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM B3 | Standard Specification for Soft or Annealed Copper Wire. |
| ASTM B8 | Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft. |
| ASTM B33 | Standard Specification for Tinned Soft or Annealed Copper Wire for Electrical Purposes. |

Electrical Testing Laboratories, Inc. (ETL)

International Municipal Signal Association (IMSA)

| | |
|---|---|
| IMSA | Official Wire And Cable Specifications (Series 19/20-600 Volts) |

National Electrical Manufacturers Association (NEMA)

| | |
|---|---|
| NEMA TS 2 | Traffic Controller Assemblies with NTCIP requirements |

National Fire Protection Association (NFPA)

| | |
|---|---|
| NFPA 70 | National Electrical Code (NEC) |

Underwriters Laboratories, Inc. (UL)

### 1.03 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two years prior to installation shall not be used in the Work of this Section.

### 1.04 DELIVERY, STORAGE, AND HANDLING

A. Store material in a clean, dry space and protect from weather.

1.05 SUBMITTALS

See Appendix "A" for submittals requirements.

## PART 2. PRODUCTS

2.01 MATERIALS

A. Traffic signal cable wires shall be soft annealed copper wire in accordance with ASTM B33 for tinned coated conductors or ASTM B3 for bare copper conductors and shall be stranded copper conductors with concentric stranding conforming to ASTM B8.

B. Color-Coding for Conductors

1. Insulation or covering of wires and cables shall be factory color-coded by the use of colored compounds or coatings, consistently following the color-code throughout the performance of the Work.

2. Color-code for conductors shall meet the IMSA Cable Specifications as shown in Table 16125.2.01-1.

**Table 16125.2.01-1 Conductor Cable Assignments**

| Cable | Function | Wire Color Code | Number |
|---|---|---|---|
| **Two-Conductor** | Pedestrian Push Button | 14/2C-A Black | 1 |
| | Neutral | 14/2C-A White | 2 |
| **Five Conductor (One Pedestrian Signal)** | Spare | 14/5C-A Black | 1 |
| | Neutral | 14/5C-A White | 2 |
| | Don’t Walk | 14/5C-A Red | 3 |
| | Walk | 14/5C-A Green | 4 |
| | Spare | 14/5C-A Orange | 5 |
| **Five-Conductor (Traffic Signal)** | Green Arrow (Spare) | 14/5C-A Black | 1 |
| | Neutral | 14/5C-A White | 2 |
| | Red | 14/5C-A Red | 3 |
| | Green | 14/5C-A Green | 4 |
| | Yellow | 14/5C-A Orange | 5 |
| **Ten-Conductor (Traffic Signal)** | Green Arrow (Spare) | 14/10C-A Black | 1 |
| | Neutral (1) | 14/10C-A White | 2 |
| | Red (1) | 14/10C-A Red | 3 |
| | Green (1) | 14/10C-A Green | 4 |
| | Yellow (1) | 14/10C-A Orange | 5 |
| | Arrow Neutral(spare) | 14/10C-A Blue | 6 |
| | Neutral (2) | 14/10C-A White-Black | 7 |
| | Red (2) | 14/10C-A Red-Black | 8 |
| | Green (2) | 14/10C-A Green-Black | 9 |
| | Yellow (2) or Yellow Arrow | 14/10C-A Orange-Black | 10 |

C. All wires, cables, splice and terminations for which there are established UL standards shall bear the UL label.

D. Traffic Signal Cable:

1. Shall meet the requirements specified herein, shall be Underwriters Laboratories (UL) and Electrical Testing Laboratories (ETL) approved and shall bear such approval labels.

2. Conductors shall be stranded copper of the gauge and number shown on the Contract Drawings. Standard conductor size for traffic signal cable applications shall be #14 AWG. Where voltage drop exceeds 5%, the conductor size for the traffic signal cable shall be #12 AWG.

3. Ground wire (7 strand, #8 AWG and color-coded green) is to be installed continuous throughout the traffic signal system a secured to all ground rods, cabinets, pull boxes, traffic signal bases and any other material requiring grounding as shown on the Contract Drawings.

4. Cables shall have a 600-volt rating, shall be factory tested for each conductor insulation resistance and for continuity of conductors and shall conform to the following International Municipal Signal Association (IMSA) Specifications:

   a. Cable in conduit and raceways: IMSA Specification 191 for polyethylene insulated polyvinylchloride jacketed signal cable, with individual color-coded conductors and black outer jacket.

   b. Aerial Cable: IMSA Specification 193 for polyethylene insulated polyvinylchloride jacketed signal cable with integral messenger, with individual color-coded conductors and black outer jacket.

## 2.02 CONSTRUCTION FEATURES

A. Cable Tags

1. Dry and Wet Locations

   a. Polyethylene tags, 0.025 inches thick and 1-1/2 inches wide, with letters and numbers 7/8-inch wide, with 2-14 AWG nylon, weather-resistant cable ties.

   b. PVC tags, 0.025 inches thick and 9/16-inch wide, with letters and numbers 5/16-inch wide, with 2-14 AWG nylon, weather-resistant cable ties.

B. Splicing and Terminating

1. All splicing and terminating materials shall be compatible so that no one material will adversely affect the physical or electrical properties of any other, or of the wire or cable itself.

2. All materials for making splices and terminations shall be specifically designed for use with the type of wire or cable, insulation and installation and operating conditions of the specific application.

3. All cable terminations shall meet the requirements of NEMA TS 2.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Prior to pulling wires and cables, clean raceway systems of all foreign matter and perform all operations necessary so as not to cause damage to wires and cables while pulling.

B. Prior to pulling wires and cables into underground conduit systems, place a feeding tube approved by the Engineer at the entrance end of such systems.

### 3.02 INSTALLATION

A. Locations, types, sizes and numbers of wires and cables are shown on the Contract Drawings. Where not indicated, provide traffic signal cable selection to comply with this Section and NFPA 70 standards. All work shall be accordance with the Contract Drawings.

B. Keep wires and cables dry at all times.

C. Use adequate lubrication when installing cables in conduits or raceways. Any pulling compounds shall be compatible with the finish of the wires and cables furnished.

D. Pull wires and cables through conduits in such a manner as not to overstress or stretch any wire. Do not score, twist or damage the protective covering or insulation. In the pulling of wire or cable into conduits where the strain on the wire or cable may prove excessive, use wire lubricant. Without exception, provide all cables and wires in junction or pull boxes with an adequate amount of slack formed around the interior of the box.

1. Provide one coil of slack wire to allow for proper connection of all wiring. The allowable slack specified below shall be the minimum amount of slack required. Secure conductors to the cable racks using nylon cable ties:

   a. Three (3) feet minimum in all pole bases

   b. Seven (7) feet minimum in rectangular hand holes

   c. Ten (10) feet minimum in base of controller cabinet

2. In circular hand holes, provide one coil of slack wire, five feet minimum, secured in a loop with nylon cable ties and placed in the bottom.

3. At certain locations or under certain conditions additional slack may be necessary, as shown on the Contract Drawings.

E. Cables and wires installed in a conduit system shall be properly trained through the hand holes to permit racking and connection to traffic signal poles and controller cabinets.

F. For wiring trained through existing hand holes, if any, which are not equipped with cable racks, furnish and install a cable rack assembly. Provide ground bushing and bonding wire on all metallic conduit ends within such hand holes. Cable rack assemblies for installation in existing hand holes, if any, shall consist of four cable racks, including inserts and fasteners. All work shall be accordance with the Contract Drawings.

G. After cables have been installed and pending permanent splicing, make a thorough inspection to determine that water has not entered the wires and cables and that the wires and cables have not been damaged. Carefully seal the end of each section of cable in hand holes and service panels or cabinets using rubber tape, and paint with a sealing type of waterproof compound. All cables in hand holes shall be placed on cable racks while waiting to be permanently spliced.

H. Install cable terminations and terminate cables with insulated locking spade terminals conforming to NEMA TS 2.

I. Splicing of Cable:

1. Cable shall be run between units of equipment without splices except in pole bases or unless otherwise shown on the Contract Drawings.

2. Where joints or splices are specified:

a. Make them with compression solderless connector and secured mechanically and electrically. Thoroughly clean conductors with a minimum of insulation removed.

b. Insulate joints and splices with insulating tape and provide one and one half times the insulation equivalent to that of the original conductor. Insulate the taped joints and splices with resin splicing kits.

J. Identification of Wires and Cables

1. Identify each wire and cable by its signal number in all cabinets, boxes, manholes, hand holes, wire ways and other enclosures, access locations and at all terminal points.

2. The signal number designations shall be as shown on the Contract Drawings. Attach tags to wires and cables in such a manner as to be readily visible.

3. Wrap tag ties around all conductors comprising the signal number to be identified.

## 3.03 FIELD TESTS

A. Test all wires and cables up to equipment installed under the Contract with a Megohmmeter. Furnish the Engineer with a copy of the "Megger" readings together with an outline of the method used. If, in the opinion of the Engineer, any reading is lower than that required by codes that would apply if the Authority were a private corporation, promptly replace the materials involved, at the Contractor's expense, and retest.

B. When each wiring system is completed and before any connection is made to operating equipment, perform the following tests on each circuit in the presence of the Engineer to determine whether the installations are in acceptable working order:

1. Tests for continuity.
2. Tests for ground.
3. Tests for insulation resistance performed between circuit wires and from circuit wires to ground. Upon completion of the electrical system with fuses removed, or devices removed from the circuit, and before energizing, the insulation resistance shall not be less than 150 megohms between conductors, or between conductor and ground on those circuits with a total single conductor length of 1,500 feet and over, and no less than 175 megohms for those circuits with a single conductor length of less than 1,500 feet.

C. Perform tests on the system as a whole. Circuits shall be complete, including all splicing from the control cabinet to all the devices it services.

END OF SECTION

## SECTION 16125

## TRAFFIC SIGNAL CABLES

## APPENDIX A

## SUBMITTALS

1.01 Submit Catalog Cuts for the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Wires and cables for each type and size;

B. Termination and splice kit materials and installation procedures.

C. Furnish four copies of wire and wiring test results identifying the observed readings with their respective circuits. Identify test results with the Contract title, the date of the test and the atmospheric conditions. The Contractor is responsible for recording data and preparing the report with test results.

1. Submit certified shop test reports for wires and cables.

2. Submit field test results for wires and cables, including "Megger" readings with the test method used.

END OF APPENDIX "A"

# SECTION 16125

# TRAFFIC SIGNAL CABLES

## INSTRUCTIONS TO SPECIFIER

Ensure that the Contract Drawings show the following items specified in the text:

| Article | Description |
|---|---|
| 2.01 D.2 | Show the gauge and number of wires. |
| 3.02 A | Provide locations, types, sizes and numbers of wires and cables. |
| 3.02 D.3 | Provide locations of additional cable slack. |
| 3.02 J.1 | Provide locations of splice points. |
| 3.02 K.2 | Show signal number designations. |

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16135

# BOXES AND FITTINGS

## PART 1. GENERAL

### 1.01 SUMMARY

A. This Section specifies requirements for electrical boxes and fittings.

B. Types of electrical boxes and fittings specified in this Section are:

1. Outlet Boxes
2. Device Boxes
3. Pull Boxes
4. Junction Boxes
5. Conduit Bodies
6. Fittings

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

| | |
|---|---|
| | National Electrical Manufacturers Association (NEMA) |
| NEMA OS1 | Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports |
| NEMA OS2 | Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports |
| NEMA 250 | Enclosures for Electrical Equipment (1000 Volts Maximum) |
| | National Fire Protection Association (NFPA) |
| NFPA 70 | National Electrical Code |
| | Underwriters Laboratories Inc. (UL) |
| UL 50 | Cabinets and Boxes |
| UL 514A | Metallic Outlet Boxes |
| UL 514B | Fittings for Conduit and Outlet Boxes |
| UL 514C | Nonmetallic Outlet Boxes, Flush Device Boxes, and Covers |
| UL 886 | Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations |

### 1.03 QUALITY ASSURANCE

Boxes and fittings, of types and sizes required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years. A list of acceptable manufacturers is shown on Contract Drawing.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturer's original, unopened, protective packaging.

B. Store materials in a clean, dry space and protect them from weather.

C. Handle in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

1.05 SUBMITTALS

"Submittal Requirements" shall be in accordance with APPENDIX A.

## PART 2. PRODUCTS

2.01 MATERIALS

A. General

1. Locations, types and sizes of boxes and fittings are shown on the Contract Drawings.

2. Boxes and fittings shall be metallic, unless otherwise shown on the Contract Drawings, and shall conform to NEMA 0S1, NEMA 250, UL 50, UL 514A, UL 514B, and NFPA 70.

3. Nonmetallic boxes and fittings, shown on the Contract Drawings, shall conform to NEMA 0S2, NEMA 250, UL 50, UL 514C, and NFPA 70.

4. Boxes and fittings to be located in hazardous (classified) areas, as shown by "area plans" on the Contract Drawings shall conform to UL 886 & NFPA 70.

5. All electrical materials and equipment, for which there are established UL standards, shall bear the UL label.

6. Where the sizes or dimensions of a box are not shown on the Contract Drawings, all boxes, whether for use on power, communications, signaling, control, telephone, or other purposes, shall be sized as follows:

a. In straight pulls, the length of the box shall not be less than 8 times the trade diameter (nominal inside diameter) of the largest raceway.

b. Where angle or "U" pulls are made, the distance between each raceway entry inside the box and the opposite wall of the box shall not be less than 6 times the trade diameter of the largest raceway. The distance shall be increased for additional entries by the amount of the sum of the diameters of all other raceway entries in any row on the same wall of the box. The distance between raceway entries enclosing the same conductor shall not be less than 6 times the trade diameter of the larger raceway.

c. Where a conduit entry is in the wall of a box opposite a removable cover, the minimum distance between the entry and the cover shall be as follows:

| Conduit Size | Distance Between Entry and Cover |
|---|---|
| Up to 1-1/4” | 4” |
| 1-1/4” and 1-1/2” | 6” |
| 2” and 2-1/2” | 8” |
| 3” and larger | 12” |

d. The minimum depth of a box shall be not less than two times the trade diameter of the conduit entries in a single row and not less than 1-1/2 times the sum of the trade diameter of the largest raceway in each row for multiple rows.

7. Weatherproof cast boxes shall be used for exterior or damp locations. Weatherproof boxes shall be hot-dipped galvanized cast-steel or cast-aluminum. Cast boxes shall be threaded conduit entrance type provided with mounting lugs. Materials shall match the type of conduit i.e., galvanized steel or aluminum, used in the conduit run.

8. Covers for boxes located in public spaces or where shown on the Contract Drawings shall be furnished with tamper-resistant hardware.

9. Cover plates for outlet boxes are specified in the Section 16140 entitled "WIRING DEVICES".

B. Interior Outlet and Device Boxes

1. Provide galvanized, flat-rolled, sheet-steel interior outlet wiring boxes, of types, shapes and sizes, including box depths, to suit each respective location and installation; construct boxes with stamped knockouts in back and sides, and with threaded screw holes with corrosion-resistant screws for securing box covers and wiring devices.

2. Outlet boxes shall be of proper sizes and shapes for conduits and wires entering them, and equipped with plaster ring or cover as necessary for the wiring devices to be installed.

3. Boxes for switches and receptacles shall be 4-inch square, minimum 2 1/8-inch deep, for up to two devices; solid, ganged boxes for over two devices; and installed so that device covers shall be tight and plumb with wall finish.

4. Provide suitable barrier in boxes where two or more 277-volt switches are to be installed, to isolate each on its own phase.

5. Boxes for lighting fixture installation shall be 4-inch square, minimum 2 1/8-inch deep, and provided with 3/8-inch studs.

6. Boxes to be installed in ceilings, plenums, or spaces used for supply or return of environmental air shall be UL listed for such use, without holes, openings or penetrations, and complete with gasketed cover plates.

7. Provide all sheet-steel boxes with suitable knockouts.

C. Exterior Outlet and Device Boxes

1. Provide corrosion-resistant, cast metal, weatherproof outlet wiring boxes, of types, shapes and sizes, including box depths, to suit each respective location and installation.

2. For outlet boxes to be installed flush or recessed in exterior walls, provide galvanized, sheet-steel boxes, with suitable depth and tile, plaster or masonry rings for the wall construction.

3. Provide cast-metal faceplates with spring-hinged, waterproof caps suitably configured for each application, including faceplate gaskets and stainless steel or brass screws or fasteners. Faceplate material shall match the type of box i.e., galvanized steel or aluminum.

D. Junction and Pull Boxes

1. General

a. Unless otherwise shown on the Contract Drawings, provide galvanized, code-gauge, sheet-steel junction and pull boxes and covers for interior locations and cast-metal boxes and covers for exterior locations of types, shapes and sizes to suit each respective location and installation, and equipped with stainless steel hinges, nuts, bolts, screws and washers.

b. Junction or pull boxes having any dimension larger than 36 inches shall contain racks or supports for all cables or conductors.

c. Provide pull boxes with suitable insulating barriers where shown on the Contract Drawings or required by code. Vertical-offset pull boxes shall contain cable supports at turns to prevent cables from resting on corners.

d. Where shown on the Contract Drawings, provide boxes with provisions for padlocking.

e. Special boxes shall be as shown on the Contract Drawings.

f. Where shown on the Contract Drawings, catches or vault handles shall be lockable. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently.

g. All covers in exposed exterior locations, or other areas as shown on the Contract Drawings, shall be gasketed.

h. For covers heavier than 20 pounds or more than 24 inches in any dimension, provide two replaceable studs, located on each side of the box flange, to support the cover during installation.

i. Boxes containing, or designated for, conductors operating at greater than 600 volts (phase-to-phase) shall be constructed of minimum 12-gauge steel.

2. Interior Junction and Pull Boxes

a. Finished Areas

(1) Junction and pull boxes, located in finished areas and having any dimension larger than 12 inches, shall be furnished with flush-mounting, lockable, hinged covers, similar to adjacent panelboard cabinets. Locks shall be keyed alike for the same service, such as power, communications, signal or telephone. Each service type shall be keyed differently. Hinged covers shall contain catches to keep covers closed. Covers having any dimension larger than 36 inches and all multiple-section doors shall contain 3-point vault handles. Covers shall be furnished shop-primed for field painting, and shall be finished with a color as selected by the Engineer.

(2) Boxes having any cover dimension 12 inches or less shall be furnished with flush-mounting, screw-on covers, unless otherwise shown on the Contract Drawings.

b. Unfinished Areas

Junction and pull boxes, located in electrical or telephone closets or rooms, in mechanical equipment rooms, in areas above hung or accessible ceilings or in areas shown on the Contract Drawings as "unfinished," shall be furnished with screw-on covers for boxes having any cover dimension 24 inches or less, and with either single or multiple-section hinged covers for boxes having any cover dimension larger than 24 inches.

3. Exterior Junction and Pull Boxes

a. Junction and pull boxes, located in sidewalks, decks and in areas shown on the Contract Drawings as "finished", shall be furnished with flush-mounting, screw-on covers.

(1) Boxes having any cover dimension 24 inches or less shall be cast-steel. Boxes shall be furnished with asphaltic paint finish on surfaces to be embedded in earth or concrete.

(2) Covers having any dimension larger than 24 inches shall be cast-steel "sidewalk" frames and covers, suitable for installation on a concrete box or handhole.

b. Unfinished Areas

Junction and pull boxes, located in areas shown on the Contract Drawings as "unfinished", shall be furnished with screw-on covers for boxes having any cover dimension 24 inches or less, and with hinged, bolt-on covers for boxes having any cover dimension larger than 24 inches.

E. Floor Boxes

Provide cast-steel, waterproof, adjustable floor boxes with threaded-conduit entrance hubs, and vertical adjusting rings, gaskets, brass floor plates and flush, screw-on covers. All unused conduit openings shall be closed with appropriate plugs.

F. Conduit Bodies

Provide galvanized, cast-metal, conduit bodies, of types, shapes and sizes to suit each respective location and installation; construct with threaded-conduit entrance hubs, removable covers, and stainless steel or brass screws.

G. Bushings, Locknuts and Knockout Closures

Provide corrosion-resistant knockout closures and conduit locknuts, and insulated, malleable-iron, conduit bushings and offset connectors, of types and sizes to suit each respective use and installation.

H. Supporting Devices

Provide inserts, expansion shield lugs, bolts with nuts and washers, shims or any other type of fastening devices required to secure boxes, in accordance with the Section 16190 entitled "SUPPORTING DEVICES". Unless otherwise shown on the Contract Drawings, all fasteners shall be hot-dipped galvanized and of sizes and types recommended by the equipment manufacturer and as approved by the Engineer.

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. Install boxes and conduit bodies at the locations shown on the Contract Drawings and as required by NFPA 70 at any other location where they are required to facilitate the pulling, supporting or connection of wires and cables.

B. Securely mount all boxes in a manner approved by the Engineer and support the boxes independently of conduits entering them.

C. Install boxes and conduit bodies in classified (hazardous) locations in accordance with their listing or label requirements. Conduit seal fittings shall be packed and filled only after proper operation of equipment and systems has been demonstrated and approved by the Engineer.

D. Paint exteriors of boxes exposed in mechanical equipment rooms or in electrical rooms or closets or spaces shown as "unfinished" on the Contract Drawings, and the exteriors of boxes installed above hung or accessible ceilings, as follows:

1. Emergency: Orange
2. Fire Alarm: Red
3. High Voltage: Red with 1-inch, white block letters reading “HIGH VOLTAGE” on each exposed face and cover.

E. All installations shall conform to NFPA 70.

F. Dissimilar Metals

1. "Dissimilar metals" shall mean those metals which are incompatible with one another in the presence of moisture, as determined from their relative positions in the Electrochemical Series, or from test data.

2. Where dissimilar metals come in contact, paint the joint both inside and out with approved coating to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.

END OF SECTION

## SECTION 16135

## BOXES AND FITTINGS

## APPENDIX A

## SUBMITTAL REQUIREMENTS

Submit the following, for approval in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts

1. All boxes and fittings.

B. Shop Drawings

1. Special boxes.
2. Boxes larger than 12 inches.
3. Ancillary equipment if shown on Contract Drawings.

END OF APPENDIX "A"

# SECTION 16135

# BOXES AND FITTINGS

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following:

(1.03) List of a minimum of three manufacturers concluded with the statement "or approved equal".

1. Suggested manufacturers for boxes other than special boxes are:

   Appleton, Electric
   Crouse Hinds, Co.
   Hubbell Inc.
   O-Z/Gedney
   Square D, Co.

2. List of a minimum of three manufacturers of special boxes concluded with the statement "or approved equal". The specifier must ascertain suitable manufacturers of special boxes.

| | |
|---|---|
| (2.01 A.1) | Location, types and sizes of boxes and fittings |
| (2.01 A.2, 3) | Note any boxes that are to be nonmetallic |
| (2.01 A.4) | "Area Plans" for limits of hazardous (classified) locations |
| (2.01 A.8) | Location of covers for boxes in areas other than public areas, that require tamper-resistant hardware |
| (2.01 D.1.a) | Locations of boxes other than sheet-steel (interior) or cast-metal (exterior) |
| (2.01 D.1.c) | Locations of all boxes requiring insulating barriers |
| (2.01 D.1.d) | Locations of boxes requiring padlocks |
| (2.01 D.1.e) | Locations and design of special boxes |
| (2.01 D.1.f) | Locations of catches and handles that require locks |
| (2.01 D.1.g) | Locations of covers that require gaskets in areas other than exposed exterior locations |
| (2.01 D.2.a.(2) | Locations of all boxes with either dimension less than 12 inches or that do not have flush covers |
| (2.01 D.2.b) | Locations of "unfinished" areas for interior junction and pull boxes |
| (2.01 D.3.a) | Locations of "finished" areas for exterior junction and pull boxes |
| (2.01 D.3.b) | Locations of "unfinished" areas for exterior junction and pull boxes |
| (2.01 H) | Locations of fasteners other than hot-dipped galvanized, or special sizes or types |
| (3.01 A) | Locations of boxes and conduit bodies |
| (3.01 D) | Locations of "unfinished" areas for painting |

B. Other Items

Ensure that the Specifications include the following Sections referenced in "Boxes And Fittings" Section 16135:

(2.01 A.9) "WIRING DEVICES", Section 16140

(2.01 H) "SUPPORTING DEVICES", Section 16190

1. Indicate additional submittal requirements on Contract Drawings.

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16140

# WIRING DEVICES

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for wiring devices.

### 1.02 REFERENCES

The wiring devices specified in this Section shall be constructed, installed and tested in accordance with requirements of the following publications:

| | |
|---|---|
| | Federal Specifications |
| W-C-596 | Electrical Power Connector, plug, Receptacle and Cable |
| W-S-896 | Outlet Toggle and Lock, Flush Mounted Switches |
| | Institute of Electrical and Electronic Engineers (IEEE) |
| IEEE 241 | Electric Power Systems in Commercial Buildings |
| | National Electrical Manufacturers Association (NEMA) |
| NEMA WD 1 | General Requirements for Wiring Devices |
| NEMA WD 6 | Wiring Devices - Dimensional Requirement |
| | National Fire Protection Association (NFPA) |
| NFPA 70 | National Electrical Code |
| | Underwriters Laboratories Inc. (UL) |
| UL 20 | General Use Snap Switches |
| UL 498 | Electrical Attachment Plugs and Receptacles |
| UL 917 | Clock-Operated Switches |
| UL 943 | Ground Fault Circuit Interrupters |
| UL 1054 | Special - Use Switches |

### 1.03 QUALITY ASSURANCE

Wiring devices, of types and ratings required, shall have been satisfactorily used for purposes similar to those intended herein for not less than three years.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in manufacturer's original, unopened, protective packaging.

B. Store materials in clean, dry space and protect them from weather.

C. Handle in manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements of this Section, provide wiring devices of the acceptable manufacturers as shown on Contract Drawings.

B. All devices for wall system outlets shall be furnished by one manufacturer.

C. All device plates shall be furnished by one manufacturer.

2.02 CONSTRUCTION FEATURES

A. General

1. All wiring devices shall be heavy-duty, specification grade, conforming to the NEMA configurations and requirements of NEMA WD 1 and UL 498, including the requirements for pressure-blade contacts. NEMA configurations shall be as shown on the Contract Drawings and shall match the requirements of the connected appliances.

2. Locations, types and sizes of wiring devices shall be as shown on the Contract Drawings.

3. All devices shall be one gang wide, except as required for devices rated greater than 20 Amp.

4. All devices shall be terminated with screw terminals or screw-driven pressure clamps. Patented spring or torsion pressure clamps shall not be used.

5. All electrical materials and equipment, for which there are established UL standards, shall bear the UL label.

B. Switches

Switches shall be silent operating type, 20 Amp, 120 - 127 Volts AC, T-rated, flush mounted, conforming to requirements of Federal Specification W-S-896 and UL 20, 917 and 1054. Single-pole or double-pole, and 3-way or 4-way devices shall be as shown on Contract Drawings.

C. Receptacles

1. Duplex convenience receptacles shall be 125 V, straight blade, 2-pole, 3-wire grounding type units with break-off terminal ties for two-circuits application. Receptacles shall be 15 Amp or 20 Amp as shown on Contract Drawings.

2. Single receptacles shall be 20 Amp, 125 V, straight blade, 2-pole, 3-wire, grounding type units.

3. Clock outlets shall be single recessed receptacles rated 15 Amp, 125 V, 2-pole, 3-wire grounding type with a combination plate cover and clock hanger bracket.

4. Floor service receptacle outlets shall be furnished with 20A, 125V, 2-pole 3-wire grounding type duplex receptacle. Were shown on contract drawings receptacle shall be flush mounted in floor box or installed in metallic above-floor service fitting.

5. Factory assembled "poke through" assembly device shall be furnished with 20A, 125v, 2-pole, 3-wire grounding receptacle and capable of maintaining floor fire rating of 3 hours.

6. Ground fault circuit interrupter receptacle shall be 20A, 125V, 60 Hz heavy duty grounding type duplex receptacle with ground fault circuit interrupter with solid-state ground fault sensing device having 5 (±1) milliampere ground-fault trip level and shall be "feed through" ready, for protecting downstream receptacles on a single circuit; suitable for installation in a 2-1/2" deep outlet box without adapter.

7. Special purpose receptacles as shown on Contract Drawings shall conform to requirements of NEMA WD 6.

D. Device Plates

1. All device plates shall be 0.04" thick minimum with struck-up beveled edges and free of sharp corners and burrs. All device plates shall be one-piece sectional plates shall not be used.

2. Unless otherwise shown on Contract Drawings, all device plates for wall outlets shall be satin finish anodized aluminum.

3. Device plates for wall telephone outlets shall contain a bushed hole.

4. Device plates for exposed work shall be stamped steel.

E. Color Selection

Wiring devices shall be available in standard white, ivory, gray, brown and black. The Engineer will select different colors for various areas and for different devices. No wiring device shall be ordered or installed until the engineer's final color selections have been made.

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. Install wiring devices in accordance with manufacturer's installation procedures and applicable requirements of NFPA 70 and IEEE 241.

B. In areas where exposed conduit is used, receptacles and switches shall be surface mounted as shown on the Contract Drawings.

C. Receptacles and switches located in finished areas, where concealed conduits are used shall be flush-mounted and provided with approved cover plates, installed level and plumb, with all four corners and edges in contact with finish surface.

### 3.02 FIELD TESTS

Prior to energizing circuitry, test wiring for electrical continuity and short circuits. Ensure proper polarity of connections is maintained. Subsequent to energization, test wiring devices to demonstrate compliance with requirements of this Specification.

### 3.03 PROTECTION

After receptacles and wall plates have been installed, exercise care in use of convenience outlets. Prior to final inspection, replace devices that have been damaged.

END OF SECTION

# SECTION 16140

# WIRING DEVICES

## APPENDIX A

## SUBMITTAL REQUIREMENTS

Submit for approval the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS:

A. Shop drawings

1. Installation details for surface mounted receptacles and switches
2. Installation details for "poke-through" assemblies
3. Installation details for floor service receptacles

B. Catalog cuts

1. Receptacles
2. Switches
3. Wallplates
4. Ground fault circuit interrupter receptacles
5. Poke-through assembly devices

END OF APPENDIX "A"

# SECTION 16140

# WIRING DEVICES

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items:

(2.01 A) List of a minimum of three manufacturers concluded with the statement "or approved equal".

1. Suggested manufacturers are:

Arrow-Hart Division, Crouse-Hinds Co.
Bryant Electric
General Electric Co.
Hubbell Inc.
Leviton Mfg. Co. Inc.

(2.02 A.1) NEMA configurations of wiring devices to be shown in Symbol listing devices

(2.02 A.2) Location, types and sizes of wiring devices

(2.02 B) Single-pole or double-pole, and 3-way or 4-way switches

(2.02.C.1) 15 Amp of 20 Amp duplex receptacles

(2.02.C.4) Types of fittings for floor service outlets

(2.02.C.7) Special purpose receptacles

(2.02.D.2) Other than satin finish anodized aluminum device plates

(3.01.B) Surface-mounting details for receptacles and switches

B. Other Items

Ensure that the Specifications include the following:

Section 16135, "Boxes and Fittings"

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16320

# DRY - TYPE TRANSFORMERS
# GENERAL PURPOSE - 600 VOLTS OR LESS

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for general purpose, dry-type transformers 600 volts or less.

### 1.02 REFERENCES

(Not Used)

### 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

The transformers shall be designed, manufactured and tested in accordance with the applicable provisions of the codes, standards and recommendations of the following entities:

American Welding Society (AWS)
American National Standards Institute (ANSI)
Institute of Electrical and Electric Engineers (IEEE)
National Electric Manufacturers Association (NEMA)
National Fire Protection Association (NFPA)
Underwriter Laboratories Inc. (UL)

In addition, specific provisions cited herein and as shown on the Contract Drawings shall govern for the associated specific application.

### 1.04 QUALITY ASSURANCE

A. The manufacturer of transformers shall have manufactured equipment of the voltage and KVA rating(s) described herein and as shown on the Contract Drawings, and they shall have been satisfactorily used for the purposes similar to those intended herein for a minimum of three years. When directed by the Engineer, the Contractor shall have the manufacturer provide a list of installations and contracts for which he has produced such materials.

B. All Work of this Section shall be performed and completed in a thorough, workmanlike manner and shall follow the best modern practice in the manufacture of high-grade equipment. All Work of this Section shall be performed by mechanics skilled in their respective trades.

C. All parts shall be made accurately to standard gauge, where applicable, for ease of replacement and repairs.

D. All material selected for the manufacture of the transformer units shall be the best available for the purpose for which they are intended to be used, considering strength, ductility, durability and the best engineering practice.

E. All parts shall be readily accessible and like parts shall be interchangeable insofar as possible.

F. Surfaces to be welded shall be clean and free from dirt, rust or other foreign matter. The welding processes shall be in accordance with the requirements specified by AWS.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Transformers shall be delivered complete, in the manufacturer's original, unopened protective packaging. All accessories, including but not limited to meters, temperature gauges, lightning arrestors, fan controls and relays, shall be in place and wired. Packing materials shall be such as to prevent damage to components due to vibration, jarring, or the like during transportation and handling.

B. Accessories or spare parts shipped loose shall be delivered in the manufacturer's original unopened protective packaging and shall be identified with a non-corrosive tag.

C. The transformers shall be handled in a manner to prevent damage to finished surfaces.

D. Where possible, maintain protective coverings until installation is complete and remove such coverings as part of final cleanup.

E. Touch up any damage to finishes to match adjacent surfaces.

## 1.06 SUBMITTALS

A. Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

1. Shop Drawings

   a. Physical dimensions of each transformer.

   b. Nameplate drawing for each transformer.

   c. Drawings showing location of all specified accessories.

   d. Technical specification for proposed transformer.

   e. Wiring diagram of fan cooling provisions.

   f. Details of current transformers.

2. Catalog Cuts

   a. Temperature gauges.

   b. Lightning arrestors.

B. Submit six copies of the certified test reports.

## PART 2. PRODUCTS

### 2.01 CONSTRUCTION FEATURES

A. General

Unless otherwise shown on the Contract Drawings, transformers shall conform to the following requirements:

1. Transformers shall be self-cooled, with properly designed steel enclosures. Openings for ventilation or similar use shall be so designed as to deflect foreign objects inserted through these openings away from contact with energized parts. Enclosures shall be suitable for floor or wall mounting, as required to fit within the constraints of each specific application. Transformers larger than 112.5 KVA shall be designed for floor mounting only. Outside dimensions of enclosures shall not exceed the dimensions shown on the Contract Drawings.

2. Transformers shall be provided with four 2 1/2 percent full capacity taps in the primary winding, two above and two below the nominal voltage rating. The taps shall be factory-wired to terminals accessible only by removal of external access plates or panels.

3. The maximum temperature at any spot on the exterior surface of the enclosure shall not exceed 50 degrees C rise above a 40 degrees C ambient.

4. Each transformer as a unit shall be capable of withstanding the stresses resulting from operating conditions, including external and internal short circuits, without distortion or other damage.

B. Core and Coil

1. Core and coil shall be completely isolated from the enclosure by rubber vibration isolating pads. The core shall be visibly grounded to the enclosure by a flexible grounding conductor, sized in accordance with applicable NEMA, IEEE and ANSI standards.

   a. Transformer neutral lead shall be ungrounded and brought-out to an isolated terminal.

   b. The enclosure shall include ground connection lugs for the incoming and outgoing conduits, and provisions for grounding the isolated neutral lead, all as shown on the Contract Drawings.

2. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below saturation to allow for a minimum of 10 percent overvoltage excitation. Cores shall be clamped with structural angles and bolted to the enclosure to prevent damage during shipment or rough handling. All laminations shall be cut with the direction of the grain and be free of burrs, core plated and stacked without gaps.

3. Windings shall be copper-formed wire or sheet, continuous from start to finish. Splices in windings will not be permitted. Material incorporated must have at least a minimum of one year of proven field usage. Accelerated laboratory tests will not be acceptable.

4. Internal primary and secondary bus shall be rectangular copper. All buses shall be hot-dipped, silver-plated over the entire area where incoming or internal cable or bus are to be bolted.

5. Transformer impedance shall be within 7-1/2 percent of the impedance value shown on the Contract Drawings.

6. All joints and leads to the transformer terminals shall be braced or welded.

7. The basic impulse level (BIL) windings shall be a minimum of 10 KV.

C. Insulation Systems

Transformers shall be vacuum-impregnated with non-hygroscopic thermosetting varnish.

1. Transformer capacity shall be based upon a temperature rise of 80 degrees C for transformers 30 KVA and larger, and 115 degrees C for transformers less than 30 KVA above an ambient temperature of 40 degrees C.

   a. Transformer design for 115 degrees C rise shall be capable of delivering a 15 percent continuous overload, above nominal rating, without exceeding 150 degrees C rise above a 40 degrees C ambient temperature.

   b. Transformer design for 80 degrees C rise shall be capable of delivering a 30 percent continuous overload, above nominal rating, without exceeding 150 degrees C rise above a 40 degrees C ambient temperature.

2. Transformer insulation systems shall be 220 degrees C for transformers 30 KVA and larger, and 185 degrees C for transformers less than 30 KVA. All insulating materials shall conform to the requirements of NEMA ST 20, for 220 degrees C, UL recognized insulation systems.

D. Sound Levels

Transformers shall operate at sound levels at or below ANSI C 89.1, and as follows:

| Transformer Size | Maximum Sound Level |
|---|---|
| 0.1 to 9 KVA | 40 db |
| 10 to 50 KVA | 45 db |
| 51 to 150 KVA | 50 db |
| 151 to 300 KVA | 55 db |
| 301 to 500 KVA | 60 db |

E. Painting

The entire transformer enclosure shall be degreased, cleaned, phosphatized, primed and finished with two coats of ANSI 61 light gray, baked enamel.

## 2.02 FACTORY INSPECTION AND TESTS

A. The Engineer reserves the right to inspect each transformer 112.5 KVA and larger at the factory and to witness each factory test. The Engineer shall be notified 15 working days in advance of each test. Failure to notify the Engineer of testing may necessitate retesting in the presence of the Engineer at no additional cost to the Authority.

B. The accuracy of the calibration of all instruments to be utilized during the tests shall be ascertained and recorded at the beginning of the tests.

C. Factory tests shall include, but not be limited to, the following:

Submit certified test data of new transformer designs, or of electrically duplicate transformer designs. The required test data shall be:

1. Efficiency at 25, 50, 75 and 100 percent load.
2. Percent regulation at 80 and 100 percent power factor.
3. No load and full loss in watts.
4. Impedance based on reference temperature.
5. Sound level in db of transformer in enclosure.
6. Average temperature rise based on 40 degrees C ambient temperature.

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. Install transformers in accordance with the Contract Drawings, the manufacture's instructions and in compliance with the applicable requirements of ANSI, IEEE, NFPA and UL.

B. All conduit and bus connections to the transformer enclosures shall be made with flexible or other approved vibrationless connectors.

### 3.02 FIELD TESTS

A. General

1. Provide all labor and materials for functional tests required. Unless otherwise shown on the Contract Drawings, power for the tests will be furnished by the Authority.
2. Should the tests reveal any defects in transformers installed under this Section, promptly correct such defects and rerun the tests until the entire installation is satisfactory to the Engineer.

B. Perform the following field test in the presence of the Engineer to demonstrate the proper phasing of each transformer installation and submit a written field report to the Engineer for record:

1. Verify that the proper phase sequence is maintained.
2. Use a phase sequence meter or demonstrate the proper rotation of a small 3-phase motor whose direction of rotation was verified prior to the transformer installation.
3. Should the foregoing test reveal any incorrect phasing, promptly correct such defects and retest until the entire installation is satisfactory to the Engineer.

**END OF SECTION**

# SECTION 16320

# DRY - TYPE TRANSFORMERS
# GENERAL PURPOSE
# 600 VOLTS OR LESS

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (10.4 A) | Voltage and KVA ratings(s). |
| (2.01 A) | Project specific requirements modifying the specification requirements. |
| (2.01 A.1) | Limitations on enclosure dimensions. |
| (2.01 B.5) | Impedance value. |
| (3.01 A) | Locations and installation requirements. |
| (3.02 A.1) | Power source for field tests, if other than Authority furnished power. |

## END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16450

# GROUNDING

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for grounding.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

| | |
|---|---|
| | Administrative Code |
| | Electrical Code of the City of New York |
| | American National Standards Institute (ANSI) |
| ANSI C 2 | National Electrical Safety Code |
| | Institute of Electrical and Electronics Engineers (IEEE) |
| IEEE Std 142-1991 | Recommended Practice for Grounding of Industrial and Commercial Power Systems |
| IEEE Std 1100-1992 | Recommended Practice for Powering and Grounding Sensitive Electronic Equipment |
| | National Fire Protection Agency (NFPA) |
| NFPA 70 | National Electrical Code |
| | Underwriters Laboratories Inc. (UL) |
| UL 467 | Grounding and Bonding Equipment |

### 1.03 QUALITY ASSURANCE

A. Components and installation shall comply with NFPA 70, "National Electric Code."

B. Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in NFPA 70 Article 100.

### 1.04 SUBMITTALS

See Appendix A for Submittal Requirements.

## PART 2. PRODUCTS

### 2.01 GENERAL

Furnish grounding elements for switchgear, transformers, cabinets panelboards, starters, and miscellaneous electrical equipment, for all non-current-carrying metallic portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C 2, NFPA 70, and building codes which would be applicable, if the Authority were a private corporation.

### 2.02 MANUFACTURERS

Subject to compliance with the requirements of this Section, provide grounding products of manufacturers as shown on the Contract Drawings.

### 2.03 GROUND RODS

Ground rods shall be copper clad steel. Unless otherwise shown on the Contract Drawings, the rods shall be 3/4-inch diameter by 10 feet long.

### 2.04 GROUNDING CONDUCTORS

A. Provide grounding conductors in accordance with the requirements of NFPA 70, Sections entitled "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)," "WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)," and "TAXIWAY/RUNWAY WIRES AND CABLES," as applicable, and as specified on the Contract Drawings.

B. Equipment grounding conductors shall be green insulated.

C. Isolated grounding conductors shall be green insulated with yellow striping.

### 2.05 ABOVE GRADE CONNECTIONS

Connectors to piping, fencing, and conduit systems shall be listed and labeled as grounding connectors for the materials used.

### 2.06 BELOW GRADE CONNECTIONS

Buried Cable and ground rod connections shall be exothermic welds. Welded connections shall be provided in kit form and selected for the specific types, sizes, and combinations of conductors shown on the Contract Drawings.

### 2.07 GROUNDING BUSHINGS

Grounding Bushing shall be insulated type.

### 2.08 LIGHTNING PROTECTION COMPONENTS

Lightning protection components shall be provided as specified in Section entitled "LIGHTNING PROTECTION SYSTEM."

## PART 3. EXECUTION

### 3.01 INSTALLATION

A. General

Install grounding elements for switchgear, transformers, cabinets, panelboards, starters, and miscellaneous electrical equipment, for all metallic non-current carrying portions of the entire electrical system and for exposed non-electrical systems located in electrical substations or switchgear rooms as required by ANSI C 2, NFPA 70 and building codes which would be applicable, if the Authority were a private corporation.

B. Install grounding as shown on the Contract Drawings.

C. Grounding and bonding equipment for use in connection with interior wiring systems shall conform to UL 467.

D. Install separate insulated equipment grounding conductors with circuit conductors to maintain grounding system at equipotential. Raceway system shall not be utilized as the equipment ground.

E. Connect exposed metallic piping or ductwork of any non-electrical system that is located in an electric substation or switchgear room, to ground in the room. Where the run through the room exceeds 15 feet in length, make ground connections at both the entering and leaving points of the piping or ductwork.

F. Ground all non-current-carrying metallic enclosures of electrical conductors, or exposed non-current-carrying metallic parts of electrical equipment, or of power apparatus.

G. Connections:

1. General

   Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

2. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.

3. Make connections with clean bare metal at points of contact.

4. Make all connections of grounding connector cables to ground rods by exothermic welding method. Welds that are puffed up, or that show convex surfaces indicating improper cleaning are not acceptable.

5. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure-type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to the ground bus in the housing. Bond electrically non-continuous conduits at both entrances and exits with grounding bushings and bare grounding conductors.

6. Tighten grounding and bonding conductors and terminals, including screws and bolts, in accordance with manufacturer's published torque-tightening values for connectors and bolts.

7. Where insulated grounding conductors are connected to ground rods, or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

H. All sensitive electronic equipment including computers and other components specified on the Contract Drawings, shall be connected to an isolated grounding system. The isolated grounding system shall be installed as specified on the Contract Drawings. The isolated grounding system and the electrical power equipment grounding system must be connected together at a single point, as shown on the Contract Drawings and in accordance with the requirements of NFPA 70, and all applicable local codes. Utilization of a grounding electrode separate from, and not connected to, the electrical power equipment grounding system is not acceptable

I. All ground rods in grounding loops shall have less than 5 ohms resistance to ground. All individual or isolated ground rods shall have a maximum of 25 ohms resistance to ground. The maximum overall grounding system resistance to ground shall be as shown on the Contract Drawings.

## 3.02 FIELD TESTS

Make ground resistance tests at all ground rods to verify that grounding system is at equipotential and to ensure compliance with the requirements specified in 3.01 I above, in the presence of the Engineer, and prepare all test results in tabulated form indicating location and time of each test and soil resistivity measured. If ground resistance on a grounding resistance test is higher than the value specified in 3.01 I, either increase the length of the rod or add more rods to the grounding system until the required ground resistance is achieved.

END OF SECTION

# SECTION 16450

# GROUNDING

## APPENDIX "A"

## SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples" of Division 1 - GENERAL PROVISIONS:

A. Catalog Cuts for ground rods, connectors and connection materials, and grounding fittings.

B. Ground Resistance Test Results.

END OF APPENDIX "A"

# SECTION 16450

# GROUNDING

## INSTRUCTIONS TO SPECIFIER

A. Contract Drawings

Ensure that the Contract Drawings show the following items specified in the text:

| | |
|---|---|
| (2.03) | Special length ground rods (other than 10 - foot) |
| (2.04 A) | Ground conductor sizes based on available short circuit current, overcurrent protection devices specified, and cable insulation melting point characteristics |
| (2.05) | Type of connectors to be used |
| (2.06) | Type of exothermic welding kit to be used |
| (3.01 B) | Grounding plans and details |
| (3.01 H) | Components and systems requiring isolated grounding, and details of computer grounding system such as the use of a signal reference ground. |
| (3.01 I) | Maximum overall grounding system resistance to ground |

B. Other Items

Ensure that the Specifications include the following Sections referenced in this Section, as applicable.

| | |
|---|---|
| (2.04 B) | "WIRES, CABLES, SPLICES, TERMINATIONS (600 VOLTS OR LESS)" "WIRES, CABLES, SPLICES, TERMINATIONS (MEDIUM VOLTAGE)" "TAXIWAY AND RUNWAY CABLES" |
| (2.07) | “LIGHTNING PROTECTION SYSTEM" |

C. Submittals

Specify required submittals by editing Appendix A, "Submittal Requirements."

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16452

# ELECTRICAL BONDING

## PART 1. GENERAL

SUMMARY

This Section specifies requirements for furnishing, installing and testing an electrical bonding system for corrosion control/stray current mitigation on all underground structures.

1.01 REFERENCEs

| | |
|---|---|
| | American Society for Testing and Materials (ASTM) |
| ASTM B 3 | Soft or Annealed Copper Wire |
| ASTM B 8 | Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft |
| | Military Specifications (MIL) |
| MIL A-18001 | Anode, Corrosion Preventative Zinc, Slab, Disk and Rod Shapes |
| | National Association of Corrosion Engineers (NACE) |
| NACE RP 0169 | Control of External Erosion on Underground or Submerged Metallic Pipe Systems |

1.02 DESIGN AND PERFORMANCE REQUIREMENTS

The Electrical Bonding System shall be designed, manufactured and installed in accordance with the latest revision of applicable standards ASTM, MIL and NACE. In case of conflict between various standards, the more stringent requirement shall apply.

1.03 QUALITY ASSURANCE

A. The Contractor shall provide the Electrical Bonding System design, certified by a NACE accredited Corrosion Engineer, licensed as a Professional Engineer in the state in which the work is to be performed, and experienced in corrosion control procedures. Submit the qualifications of the Corrosion Specialist, for review by the Engineer.

B. Electrical bonding devices, of type and sizes required, shall have been satisfactory used for the purposes similar to those herein, for not less than three years.

1.04 DELIVERY, STORAGE AND HANDLING

A. Store materials in original packaging in a manner to prevent soiling, damage, wetting or corrosion prior to installation.

B. Handle in a manner to prevent damage to finished surfaces.

C. Where possible, maintain protective coverings until installation is complete and remove such covers as part of final cleanup.

1.05 SUBMITTALS

See Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

2.01 MANUFACTURERS

Subject to compliance with requirements of this Section, provide electrical bonding materials and equipment of the manufacturers listed on the Contract Drawings.

2.02 MATERIALS

A. Electrical Bonding Devices

Unless otherwise shown on the Contract Drawings, furnish materials and products in accordance with the following requirements:

1. Cables shall be stranded copper, #8 AWG minimum, conforming to ASTM B 3 and B 8, insulated with 0.11 inches of high molecular weight polyethylene.

2. Zinc Reference Electrode shall conform to the requirements of MIL A-18001, 1-1/4 inches by 1-1/4 inches by 9 inches long, 5 pound, 1/4" dia. steel core package electrode, and in accordance with the following requirements:

   a. Lead wire shall comply with 2.02.A.1, and shall be factory connected to the anode center with the connection sealed in cast epoxy resin encapsulation.

   b. Electrode shall be packaged in a permeable package cloth sack, total weight as recommended by the manufacturer, containing compacted backfill of mixture with the following requirements:

| Material | Percent |
|---|---|
| Hydrated Gypsum | 50 |
| Bentonite | 50 |

   c. Epoxy resin encapsulation shall be two-piece, snap-together molded bodies, sized for cable, with two-part low viscosity polyurethane insulating and sealing compound, rated for 600 volts.

B. Buried cable and ground rod connection shall be exothermic welded.

C. Junction boxes shall be in accordance with Section 16135, entitled "BOXES AND FITTINGS".

## PART 3. EXECUTION

### 3.01 EXAMINATION

A. Verify that electrical insta5llations, structural, mechanical and other related work satisfy the requirements for performance of the work for this Section in accordance with the Contract Documents.

B. Report immediately to the Engineer any electrical, structural or related construction defects in areas where bonding devices are to be installed, and do not attempt to rectify any defect unless specifically instructed to do so by the Engineer.

C. Provide control and inspection of all exothermic bonding connections before casting them in concrete and for proper electrical connections of all underground structural members.

### 3.02 PREPARATION

Before installation of electrical bonding devices, the Contractor shall investigate the site condition to determine, what preparatory work, if any, will be needed.

### 3.03 INSTALLATION

A. General

1. Install electrical bonding devices in accordance with approved printed manufacturer's installation procedures, and as specified.
2. Coordinate with other trades, to electrically bond all structural steel and reinforcing bars, embedded in the concrete below grade. Bonding shall be completed in closed circuit to minimize corrosion activity, and shall conform to the Corrosion Specialist design.

B. Bonding Connections

1. Bond bare or uncoated reinforcing steel using single insulated conductors or straps, exothermically welded to steel beams.
2. Cross bond all bare or reinforcing steel, using exothermic welds.
3. Make welds in accordance with manufacturer's requirements.

C. Conductors

1. Use continuous, insulated conductors, without splices, between welded connections.
2. At the end of line of bonded steel beams, connect the insulated header cable, using exothermic welds, and terminate this cable inside the test junction box as shown on Contract Drawings. Where structural beams or steel members are coated, clean and coat with coal tar epoxy after completion and cooling of welded area.

D. Test Electrode Wells and Junction Boxes

1. Bury electrodes of type and at locations shown on the Contract Drawings. Excavate and backfill holes in accordance with the manufacturer's written instructions and in accordance with the following requirements:

   a. Wet packaged electrode thoroughly before backfilling the hole.

   b. Use fine clay soil, free from stones and bricks, for backfilling.

2. Install header cables of size, and at location shown on the Contract Drawings.

3. Install test junction box of type, and at locations, shown on the Contract Drawings in accordance with Section 16135 entitled "BOXES AND FITTINGS".

4. Run electrode lead wires to test junction boxes as shown on the Contract Drawings.

5. Install size and type of conduit shown on the Contract Drawings, in accordance with the requirements of Section 16110 entitled "RACEWAYS".

6. Install cable, leaving slack in test junction boxes.

7. Use exothermic welds, sealed with cast epoxy resin encapsulation, for splices made in direct buried cable.

E. Identification

Identify all cables, in each test junction box, using fiber tags (1/16 inch thick and 3/4 inches wide) intended with letters and numbers 5/16 inch high, fastened to cables with #14 AWG weatherproof copper wire.

F. Field Tests

Test that materials are installed and connected as shown on the Contract Drawings, and as required by the Corrosion Specialist's certified design.

1. Test the complete Electrical Bonding System to ensure electrical continuity. The tests must show that the elements of the structure are electrically bonded and prepared for connection to the test box.

2. Testing shall be in accordance with NACE RP 0169 requirements.

3. All test data shall be included in a final report, prepared by the Corrosion Specialist, indicating the initial conditions, with a listing of further recommendations pertaining to the maintenance and periodic testing of the system(s).

4. The Contractor shall correct any deficiencies discovered during the tests.

**END OF SECTION**

# SECTION 16452

# ELECTRICAL BONDING

## APPENDIX A

## SUBMITTAL REQUIREMENTS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts, and Samples", Division 1 - GENERAL PROVISIONS:

A. The Electrical Bonding System design, certified by a NACE accredited Corrosion Specialist, licensed as a Professional Engineer in the state in which the work to be performed.

B. Shop Drawings

1. Details of bonding of structural steel and reinforcing bars encased in concrete below grade.
2. Steel and concrete shop drawings, including all required welds, bonding connections and recoating or patching of protective coatings.
3. Layout drawings of test electrodes, cabling and test junction boxes.

C. Submit 12 copies of all test data, and the final report.

D. Submit qualifications of the Corrosion Specialist and a copy of NACE certificate.

END OF APPENDIX "A"

# DIVISION 16

# SECTION 16571

# VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for vehicular traffic signal heads, including light emitting diode (LED) signals.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section. The engineer is responsible for ensuring that the current edition of these references is utilized during the design process:

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM B85 | AluminumAlloy Die Castings |

Federal Communications Commission (FCC)

| | |
|---|---|
| Title 47 | Telecommunications |

Federal Highway Administration (FHWA)

| | |
|---|---|
| MUTCD | Manual on Uniform Traffic Control Devices |

Institute of Transportation Engineers (ITE)

| | |
|---|---|
| ITE ST-017B | Equipment and Material Standards of the Institute of Transportation Engineers |
| | Vehicle Traffic Control Signal Heads –Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules |
| ITE ST-052 | Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement |

National Electrical Manufacturers Association (NEMA)

| | |
|---|---|
| NEMA TS 2 | Traffic Controller Assemblies with NTCIP Requirements |
| NEMA 250 | Enclosures for Electrical Equipment (1,000 Volts Maximum) |

Port Authority Of New York and New Jersey

Traffic Signal Design and Drawing Preparation Guidelines

Underwriters Laboratories, Inc. (UL)

UL 94VO Tests for Flammability of Plastic Materials for Parts in Devices and Appliances

US Department of Defense Military Standards

MIL-STD-883 Test Method Standard Microcircuits

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Vehicular traffic signal heads shall conform to requirements specified in this Section. Where specific requirements are not listed herein, the vehicular traffic signal heads shall, as a minimum, conform to the requirements of the standards and publications listed in Article 1.02 herein.

B. The units furnished as Work of this Section shall be of the size, number of indications, colors and faces shown on the Contract Drawings, constructed to standard similar dimension sections or combination head arrangements with lenses, polycarbonate (or aluminum alloy) housings, mounting brackets and hardware, polycarbonate (or aluminum) reflectors, lamps, visors, safety chains and, where shown on the Contract Drawings, with backplates. All work shall be accordance with the contract drawings.

C. Aluminum housings and visors in the quantities shown shall be furnished only if specified on the Contract Drawings as polycarbonate signal indications are preferred except where aluminum indications are required as described in the PANYNJ Traffic Signal Design and Drawing Preparation Guidelines.

D. Vehicular traffic signal heads shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein. Special or custom-built components may be used only upon written approval from the Engineer.

E. Use modular type construction with assemblies, subassemblies and modules that are available from a second source of supply wherever possible.

F. All assemblies, subassemblies and modules shall be readily accessible for removal, testing or replacement without removal of other modules, assemblies or components. Components shall be located so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Test points shall be provided to facilitate troubleshooting.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The vehicular traffic signal head equipment shall operate over an ambient temperature range from -40°F to +165°F (-40°C to 74°C). Operation of the vehicular traffic signal head equipment shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

B. The equipment shall be protected against the intrusion of dust and moisture to protect all internal components.

C. The equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

## 1.05 QUALITY ASSURANCE

A. Verify that all LED vehicular traffic signal heads have undergone Design Qualification (DQ) testing prior to shipment as specified herein and ITE ST-017B. Failure of any LED signal to meet requirements of the DQ tests shall be cause for rejection. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide DQ process and test results documentation to the Engineer.

B. All LED vehicular traffic signal heads shall undergo the following production Quality Assurance (QA) testing prior to shipment in accordance with ITE ST-017B. Failure of any LED signal to meet requirements of the QA tests shall be cause for rejection. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide QA process and test results documentation to the Engineer.

1. Signal Burn-in.
2. Maintained Minimum Luminous Intensity.
3. Power Factor.
4. Current.
5. Visual Inspection.

C. After delivery of equipment, invite the Engineer to perform a construction site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or testing hereof, the Contractor shall repair or replace the equipment at no cost to the Authority, even though the equipment had been inspected for shipment. After such satisfactory replacement and/or repair and the Engineer's subsequent written approval, the equipment may be installed.

D. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Section and with the Contract Drawings. Continue testing until the results are satisfactory to the Engineer. If any equipment has been damaged or if, for any reason, the equipment does not comply with this Section, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide installation process and test results documentation to the Engineer. Perform any repairs, construction and modifications required to comply with the Specifications and the Contract Drawings.

## 1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be delivered to the construction site in original unopened containers or bundles with labels, which clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants and other causes.

## 1.07 SPARE EQUIPMENT

A. For items with no second source of supply for replacement assemblies, provide spare equipment in quantities as shown on the Contract Drawings.

1.08 SUBMITTALS

For submittals requirements, see Appendix "A" of this Section.

## PART 2. PRODUCTS

2.01 MATERIALS

A. Head Housing and Door:

1. Polycarbonate housings and visors shall be molded, ultraviolet and heat stabilized, flame retardant, unaffected by the heat of the lamp used and permanently colored in accordance with the Contract Drawings.
2. Virgin metal die cast aluminum alloy conforming to ASTM B85 of one of the following alloys:
   a. S12A (A14130)
   b. S12B (A04130)
   c. SC84A (A13800)
   d. SC84B (A03800)
   e. SG100B (A03600)

B. Backplates: 1/8-inch thick minimum, black Acrylonitrile Butadiene Styrene (ABS), ultraviolet (UV) stabilized plastic sheet with hair cell finish on the front side, smooth finish on the back side and 3-inch corner radii. Vacuum formed backplates shall have a 5/8-inch flange on all sides providing rigidity and structural integrity. Backplates shall be designed to precisely fit manufacturer's signal head and supplied with necessary mounting hardware.

C. All bolts, nuts, washers and lock washers supplied shall be stainless steel.

2.02 CONSTRUCTION FEATURES

A. General:

1. Design signal head equipment for operation from line voltage at 120 +/-3 VAC RMS nominal and over a voltage range from 80 VAC RMS to 135 VAC RMS, 60 Hz +/- 3 Hz, AC line power. Variations in operating line voltage shall have no visible effect on luminous intensity and shall not vary by more than 10% over the entire operating voltage range.
2. Furnish and install signal heads, mounting brackets, attachments and fittings for a wind load pressure resulting from a wind speed in accordance with the current edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

3. Aluminum signal heads, bracket arms, and mounting attachments shall receive three coats of paint, each of which shall be baked after application. The first or primer coat shall be a nonlead or chromium containing paint for aluminum surfaces. The second and third coats shall be Federal Yellow Matching Color No. 13538 (unless otherwise specified in the contract drawings) conforming to Federal Standard No. 595B, except for the underside of visor, which shall be flat black enamel. Each coat shall be baked on separately. All metal surfaces to be painted shall be suitably cleaned of all foreign deposits, oil and grease, and then neutralized for priming. Paint separate parts before assembly. Do not paint stainless steel housing latching assembly.

4. Unless specified otherwise, equipment shall be fabricated in accordance with ITE ST 017B.

5. Identify all wire terminations and terminal block connections. Terminate cables with insulated locking spade terminals conforming to NEMA TS-2.

   a. At mast arm installations, bring separate continuous #14 AWG, 19 strand wires from the terminal block of the signal head to bottom of the standard.

   b. At overhead span installations, secure separate continuous traffic signal cables to the span wire and terminate on the traffic signal head terminal block with a continuous run to the base of the pole.

B. Vehicular Traffic Signal Heads:

1. Shall be of the size, number of indications, color and faces as shown on the Contract Drawings.

2. The Vehicular Traffic Signal Heads shall consist of LED modules as specified herein and as shown on the Contract Drawings.

3. Polycarbonate housings and visors:

   a. The polycarbonate housing shall be one piece molded or shall be fabricated from two or more pieces joined into a single piece. The housing thickness shall be a minimum of 0.090 inches thick. All sections shall be identical and interchangeable with each other and shall be so designed that they interlock with each other forming a weatherproof assembly. Hinges or lugs shall be located inside each section for attaching the reflector assembly. Each signal section shall be dust-tight.

      The polycarbonate-housing door of each section shall be a one-piece unit with an opening of sufficient diameter to accommodate the lens. On one side of the door, at top and bottom, there shall be a hinge for perfect alignment of the door. On the opposite side of the door, there shall be a wingnut assembly-locking device for even gasket pressure. Twelve-inch signal sections shall be secured with two wingnut assemblies. Hinge pins and locking device shall be stainless steel.

   b. Each polycarbonate signal face shall be provided with polycarbonate visor. Polycarbonate visors shall be a minimum of 0.100-inch thick, formed from sheet polycarbonate or assembled from one or more injection, rotational or blow molded polycarbonate sections of black homogeneous colored material with a lusterless finish. Sections shall be joined using thermal, chemical or ultrasonic bonding.

   c. Polycarbonate signal faces that require backplates shall be provided with ABS backplates, a minimum of 1/8-inch thick.

4. Aluminum housings and visors in the quantities shown shall be furnished only if specified on the Contract Drawings.

a. The housing for each signal face shall be of unitized sectional construction and shall consist of as many sections as necessary to provide the signal indications shown on the Contract Drawings. Rigidly and securely fasten sections together into a weathertight signal face. Adjustable traffic signal heads shall consist of two or more signal faces fastened to and supported by a pipe assembly and suitable entrance fittings. No special tools shall be required to fasten the signal heads together.

(1) Arrange each housing with openings in the top and bottom so that it may be rotated about a vertical axis between waterproof supporting brackets or trunnions and shall be capable of being securely fastened at increments of not more than five degrees of rotation, designed to accommodate standard 1-1/2-inch pipe brackets.

(2) The top and bottom of each housing shall have integral cast locking rings or other provisions to provide positive interlocking and indexing. The top and bottom housing coupler shall be free of sharp edges and protrusions that might damage the conductor cable insulation and shall provide sufficient space for the entrance of the required signal cable. Provide tees or crosses equipped with pipe plug knobs or caps at the top and bottom of the housings that can be removed to assist in wiring. As an alternative, flat arms or spiders will be acceptable for use on the bottom of adjustable signals. One-section beacons may be supplied without bottom bracket arms.

(3) Each signal face shall be locked by engagement of serrations in the end signal sections engaging with similar serrations in the mounting bracket assembly. The serrations shall be recessed and integral with the signal section. All signal brackets shall be designed for use with a tabbed lock ring to lock the signal face in position.

(4) Housing construction shall permit the assembly of 12-inch signal sections with 8-inch signal sections of the same manufacturer. The assembly shall permit the joining of 8-inch sections to 12-inch sections, either above or below for vertical mounted signals and either to the right or left for horizontally mounted signals.

b. Provide neoprene gaskets between the body of the housing and the doors. The door shall be hinged and forced tightly against the gasket and the housing by a simple stainless steel locking mechanism.

(1) Cast hinge lugs integral with the door. All other exterior hardware such as hinge pins, lens or clips shall be stainless steel. The locking device shall operate without the use of tools.

(2) Arrange hinges to allow convenient re-lamping. On the outside of the door, there shall be a rim encircling the lens opening to prevent any light leakage between optical systems.

(3) Each door shall contain four Number 1024 tapped holes equally spaced and straddling the vertical centerline through bosses on the door to accommodate visor clip connections on the outside and lens clip connections on the inside of the door.

c. The visors shall be separate and removable from the doors, held in place by stainless steel fastenings attached to the door in such a manner as to prevent the possibility of any light leakage between the door and the visor hood, which might be discernible from the side. Fabricate visors of sheet aluminum, not less than 0.050 inches thick, and equip with bayonet slots or other provisions to permit snap-on attachment and rotation of the visor. Visors shall be of the type shown on the Contract Drawings. Paint the inside of the visors flat black to minimize light reflection to the sides of the signal.

d. Aluminum signal faces that require backplates shall be provided with ABS backplates, a minimum of 1/8-inch thick.

5. Provide each completed vehicular traffic signal head with a barrier type terminal block, equipped with connectors for the lamp receptacle leads and screw terminals for the field wires, located within the bottom section of the signal unit. The terminal board for standard three-section units shall be a four-position, eight-terminal, barrier-type strip. Attach the white, red; orange and green colorcoded section leads to one side of each terminal strip leaving the opposite terminals for field wires. All wires shall be stranded 18 AWG minimum with an insulation rating of 221°F (105°C). Greater than three-section head clusters shall be designed accordingly.

6. The housing assembly shall accommodate the installation and/or replacement of LED vehicular traffic signal head as specified herein.

7. Furnish and install geometrically programmed louvers, angle visors, or programmable traffic signal heads where shown on the Contract Drawings. The entire surface of louvers used in front of signal lenses shall be painted a flat black to minimize light reflection to the sides of the signals.

C. Optically Programmable Vehicular Signal Heads:

1. Optically programmable vehicular signal heads, if any, shall be located as shown on the Contract Drawings. Such units shall permit the visibility zone of the indication to be determined optically without louvers or other external blocking device. The projected indication may be selectively visible or veiled anywhere within 15 degrees of the optical axis. No indication shall result from external illumination nor shall one light unit illuminate a second.

2. The optical system shall be comprised of an electronically programmable signal head with an array of LEDs as the illumination source and have the following characteristics:

a. Housing shall contain thermal control measures for increased signal life;

b. Automatic changes to signal intensity based on ambient lighting conditions;

c. Accommodate projection of diverse, selected signal displays to separate portions of the roadway such that only one display will be apparent to any viewer. This includes the ability to limit both horizontal and vertical viewing angles;

d. The ability to electronically steer beam from the ground; and

e. LEDs in accordance with Article 2.02 D of this Specification.

3. Mount the signals to standard 1-1/2-inch pipe fittings as a single section, as a multiple section face, or in combination with other signals, as shown on the Contract Drawings. Provide the signal sections with an adjustable connection that permits incremental tilting from 0 to 10 degrees above or below the horizontal while maintaining a common vertical axis through couplers and mounting. Terminal connection shall permit external adjustment about the mounting axis in 5-degree increments. Construct the signal such that it can be installed with ordinary tools and serviced with no tools.
   a. Visor, backplate and adapter attachments shall conform and readily fasten to mounting surfaces without affecting the water and light integrity of the signal.
   b. Arrange the programmed signal heads for rigid mounting to maintain optical orientation with the roadway.
4. The optic unit shall be comprised of a separately accessible housing. Each signal head shall include a covered terminal block for screw attachment of field wires.
5. Provide each signal section with integral means for regulating its intensity between limits as a function of individual background illumination.
   a. The light intensity mechanism shall not produce electrical noise or interference sufficient to adversely affect the operation of solidstate electronic equipment used in the traffic signal controllers and associated auxiliary equipment and shall not cause false tripping of the conflict monitors.

D. LED Vehicular Traffic Signal:
1. General
   a. LED vehicular traffic signal shall not require special tools for installation when used as a retrofit replacement for existing traffic signal lamps.
   b. LED vehicular traffic signal shall fit into new or existing traffic housings built in accordance with ITE ST-017B without any modification to the housing.
   c. LED vehicular traffic signal shall be weather tight, shall fit securely in the housing and shall connect directly to existing electrical wiring.
   d. Installation of a retrofit replacement LED vehicular traffic signal into the existing signal housing shall require only the removal of the existing optical unit components, i.e., lens, lamps, gaskets and reflector.
   e. Each retrofit kit shall include all necessary components to complete conversion, including a one-piece gasket.
2. LED Signal Lens
   a. The LED signal lens shall be a replaceable part, without the need to replace the complete LED signal.
   b. The LED signal lens may be tinted with the appropriate color to enhance on/off contrast. The material used to tint the lens shall not affect the luminous intensity or chromaticity and shall be uniform across the face of the lens.
   c. The LED signal lens shall be polycarbonate and shall withstand ultraviolet light (direct sunlight) exposure for a minimum time period of five years without exhibiting evidence of deterioration.
3. LED Signal Construction
   a. The LED signal shall be a single, self-contained device, not requiring on-site assembly, for installation into the existing traffic signal housing.

b. All LEDs shall be rated for 100,000 hours or more at 77°F (25°C) and 20 milliamps.

c. All internal LED and electronic components shall be adequately supported to withstand mechanical shock and vibration from high winds and other sources.

d. The signal enclosure shall be made of UL 94VO flame-retardant materials. The lens is excluded from this requirement.

e. The LED signal shall have a prominent and permanent vertical indexing indicator for correct indexing and orientation inside the signal housing.

f. Each individual LED signal shall be identified for warranty purposes with the manufacturer's name, serial number and operating characteristics, such as rated voltage and power consumption.

g. The LED arrow signal pattern shall conform to ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules for color, size and shape. The LED arrow signal shall not require a specific orientation or have a variance in light output, pattern or visibility for any orientation.

h. The LED ball signal shall conform to ITE ST-017B and Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement for color, size and shape.

i. The beam color, intensity and radiation pattern shall conform to the requirements for maintained minimum luminous intensity for LED signal and chromaticity as specified in ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

j. Red LED ball signals shall be AllnGaP (Aluminum Indium Gallium Phosphorus), ultra bright type, and incandescent look. AlGaAs (Aluminum Gallium Arsenide) LEDs are not permitted.

k. Green LED ball signals shall be GaN (Gallium Nitride), ultra bright type, and incandescent look.

l. Yellow LED ball signals shall be AllnGaP (Aluminum Indium Gallium Phosphorus), ultra bright type, and incandescent look. ALGaAs (Aluminum Gallium Arsenide) LEDs are not permitted.

4. Environmental Requirements

a. LED signal shall satisfy all the environmental requirements specified in Article 1.04 of this Section.

b. LED signal, when properly installed with gasket, shall be protected against dust and moisture intrusion per requirements of NEMA 250 Type 4 enclosures to protect all internal LED, electronic and electrical components.

5. Luminous Intensity

a. The Maintained Minimum Luminous Intensity shall be in accordance with ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

6. Chromaticity

   a. The measured chromaticity coordinates of the LED signal shall conform to the chromaticity requirement of ITE ST-017B Vehicle Traffic Control Signal Heads – Part 3: Light Emitting Diode (LED) Vehicle Arrow Traffic Signal Modules and ITE ST-052 Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement.

7. Electrical

   a. The LED signal shall operate from a 60 +/- 3 Hz AC line over a voltage range of 80 VAC RMS to 135 VAC RMS. The current drawn shall be sufficient for compatibility and proper triggering and operation of load switches and conflict monitors in the signal controller units.

   b. Nominal operating voltage for all measurements shall be 120 +/- 3 VAC RMS.

   c. The 8-inch nominal and 12-inch nominal LED ball shall consume no more than 20 watts and 30 watts respectively. The 8-inch nominal and 12-inch nominal LED arrow shall not consume more than 15 watts and 20 watts respectively.

   d. The forward current, as measured through each LED, shall not exceed 60% of the LED manufacturer's maximum current rating when operating at 77°F (25°C).

   e. The LEDs shall emit no visible light when subjected to a 120 VAC, 4-milliamp leakages current from a NEMA-rated solid-state load switch (load switch in the off state).

   f. The LEDs shall be wired in series parallel strings. The failure of any one LED, and its associated string of LEDs, shall not cause the loss of more than 20% of the light output of the complete LED signal.

   g. The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified above.

   h. The LED circuitry shall include voltage surge protection against high-repetition noise transients and low-repetition noise transients as stated in NEMA TS 2.

   i. The LED signal, including its circuitry, shall meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of noise.

   j. The LED signal shall provide a power factor of 0.90 or greater over the operating voltage range and temperature range specified above.

8. Total harmonic distortion (current and voltage) induced in an AC power line by an LED signal shall not exceed 20% over the operating voltage range and temperature range specified above**.**

9. Design Qualification Testing:

   Complete and document the Design Qualification testing described below. Carry out all Design Qualification testing after a burn-in (module energized for a minimum of 24 hours at 100 percent duty cycle and at an ambient temperature of 140°F (60°C)). Signals submitted for test shall be representative of typical production units.

   a. The LED signal shall be measured for chromaticity per the requirements of this Section and ITE ST-017B using a spectroradiometer at an ambient temperature of 77°F (25°C).

   b. The LED signal shall be measured for power factor per the requirements of this Section by an independent testing laboratory.

c. The LED signal shall be measured for total harmonic distortion per the requirements of this Section by an independent testing laboratory.

d. The LED signal shall be tested for electronic noise per the requirements of this Section with reference to Class A emission limits referenced in FCC Title 47 Subpart B, Section 15 by an independent testing laboratory.

e. The LED signal shall be tested for compatibility with controller unit, conflict monitor and load switches. These tests are to be conducted in accordance with ITE ST-017B.

f. The LED signal shall be tested for transient immunity (e.g., early electronic component mortality failures, component reliability problems) using NEMA TS 2 by an independent testing laboratory.

g. Mechanical vibration testing shall be performed on the LED signal, by an independent testing laboratory, in accordance with MIL-STD-883, Test Method 2007, using three 4-minute cycles along each x, y, and z axis, at a force of 2.5 Gs, with a frequency sweep from 2 Hz to 120 Hz. The loosening of the lens or of any internal components or any other physical damage shall be cause for rejection.

h. The maintained minimum luminous intensity testing shall be in accordance with ITE ST-017B

E. Electrical Connections:

1. Wire the traffic signal heads to implement the signal operations shown on the Contract Drawings and in accordance with Article 2.02 A of this Specification.

F. Mechanical Connections:

1. Furnish safety chain and bolted connections securing the signal heads to the mast arm on all installations. The safety chain shall be a minimum of 1/4-inch hot dipped galvanized coil proof straight link chain with 5/16-inch stainless steel bolts, nuts, flat and lock washers.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit catalog cuts and shop drawings outlining the construction and operation details of all equipment for prior Engineer approval as specified in Article 1.08. No equipment shall be procured until the Engineer has given written approval.

B. Related equipment to be removed and not required for relocation under the Contract, if any, as shown on the Contract Drawings, shall remain the property of the Authority. Deliver all removed existing above ground traffic signal equipment to the electrical shop location as specified on the contract drawings. The Contractor shall notify the Engineer prior to delivery. Removed equipment, if any, shall not be used in a new installation unless specifically called for on the Contract Drawings. All other equipment designated on the Contract Drawings to be removed shall be disposed of by the Contractor, if the Engineer, in writing, directs the Contractor to dispose of the equipment.

3.02 INSTALLATION

A. Install signal head equipment in accordance with the guidelines specified in the FHWA MUTCD and as shown on the Contract Drawings.

B. Arrange signal heads for mounting on span wire, mast arms, post tops or vertical pole bracket mounts as shown on the Contract Drawings.

1. For span wire mounting, furnish the signal heads with a wire outlet fitting and a span wire clamp comprised of a shoe, lock bar, and two "U" bolts, equipped with a balance adjuster. Assemble the heads so that they hang plumb and include means for adjusting the signal heads to the proper vertical alignment, including circuit disconnect hangers, extension pipes and swivel balancer assemblies. In addition to the upper suspension fitting, provide signal heads with similar mounting attachments for securing the signal to a span or tether wire as called for on the Contract Drawings.

2. Furnish signal heads for Vertical, Horizontal and Mid-mast arm mounting with a mount consisting of upper and lower horizontal arms attaching to the top and bottom of the signal head housing. The horizontal arm shall attach to a vertical member that in turn clamps to the mast arm. The mast arm mount shall have provision for adjusting the vertical, angular and rotational positioning of the head in relation to the mast arm so that it is plumb, in line with other signal heads and properly oriented in relation to traffic, including the use of extension pipes, plumbizers, and swivel balancers. Safety chains securing the signal heads to the mast arm are required. Conceal wiring within the mounting assembly.

3. Furnish post top mounted signal heads with a post top type slip fitter mount that is designed for use with a tabbed serrated lock ring to lock the signal face in position.

4. Furnish vertical pole bracket mount signal heads with upper and lower horizontal brackets equipped with pole plates for attachment to the pole with stainless steel straps.

C. Until the installed signal heads are placed into operation, they shall be covered with an opaque material and turned off. The material shall be adequately fastened to the signal heads in a neat, secure, and weather-proof manner.

D. After installation of equipment, the Engineer may perform a site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or testing hereof, the Contractor shall repair or replace the equipment at no cost to the Authority, even though the equipment had been inspected previously. After such satisfactory replacement and/or repair and Engineer’s subsequent written approval, the equipment may be tested as per Article 1.05 D.

3.03 FIELD TESTS

A. Perform initial installation test in accordance with Article 1.05 D.

END OF SECTION

## SECTION 16571

## VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

## APPENDIX "A"

## SUBMITTALS

Submit the following to the Engineer in accordance with Division 1 GENERAL PROVISIONS entitled "Shop Drawings, Catalog Cuts, and Samples":

A. Submit the following to the Engineer within fortyfive (45) days after acceptance of Proposal:

1. A list of manufacturers of equipment to be furnished for the Work of this Section.
2. Detailed drawing(s) for signal head equipment, backplates, visors, lens, mounting brackets and hardware including recommended mounting instructions. The submittal shall include the environmental tolerance provisions of the proposed equipment, including the material that the housing, backplates, visors, lens, mounting brackets and hardware were fabricated from. Include within this documentation electrical schematic wiring diagrams for the equipment, defining terminal identification number assignment.
3. Five complete sets and one reproducible master set of all test process and results. This shall include but not limited to the Quality Assurance (QA) process and test results documentation, Design Qualification (DQ) process and test results documentation and installation process and test results documentation.
4. A complete set of reproducible Mylar shop drawings for the signal head equipment, from which clear prints can be made.
5. Five complete sets and one reproducible master set of operations and maintenance instructions including preventive and corrective maintenance.
6. One compact disk containing electronic files of a complete master set of shop drawings for the Vehicular Traffic Signal equipment, operations and maintenance instructions including preventive and corrective maintenance.

END OF APPENDIX "A"

# SECTION 16571

# VEHICULAR TRAFFIC SIGNAL HEADS AND MOUNTING HARDWARE

## INSTRUCTIONS TO SPECIFIER

List of items required to be shown on the Contract Drawings:

| Article | Description |
|---|---|
| 1.03 B | Specify the size, number of indications colors and faces. Specify sections or combination head arrangements and indication type. Specify housings, visors, backplates, and mounting hardware, along with the respective material types. |
| 1.03 C | Specify the size, number and location of aluminum housings and visors. |
| 1.07 A | Specify replacement assemblies or spare equipment. |
| 2.01 A | Specify the color of signal heads and equipment. |
| 2.02 B | Specify the size, type, number of indications, color and faces. |
| 2.02 B.3 | Specify the size, number and location of polycarbonate housings and visors. Specify locations and configuration of backplates. |
| 2.02 B.4 | Show the number of aluminum traffic signal head sections and visors to provide the signal indications shown. Specify locations and configuration of backplates. |
| 2.02 B.7 | Specify visors or programmable traffic signal heads. |
| 2.02 C.1 | Show locations of optically programmable vehicular signal heads. |
| 2.02 C.3 | Show the mounting of the signals to standard 1-1/2-inch pipe fittings. |
| 2.02 E.1 | Show the wiring of the traffic signal heads to implement the signal operations. Specify the cable size and number of conductors. |
| 3.01 B | Specify equipment to be removed and not required for relocation. Specify removed equipment, if any, which shall be used in a new installation. |
| 3.02 | Show locations and specify mounting of Vehicular Traffic Signal Heads on span wire, mast arms, post tops and vertical pole bracket mounts. |
| 3.02 B.1 | Specify a span or tether wire if needed. |

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16572

# TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND POLE FOUNDATIONS

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for traffic signal poles, mast arms, span wire and pole foundations.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM A36 | Carbon Structural Steel |
| ASTM A123 | Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A153 | Zinc Coating (Hot-Dip) on Iron and Steel Hardware |
| ASTM A193 | Alloy Steel and Stainless steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications |
| ASTM A194 | Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both |
| ASTM A325 | Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength |
| ASTM A370 | Methods and Definitions for Mechanical Testing of Steel Products |
| ASTM A475 | Zinc-Coated Steel Wire Strand |
| ASTM A563 | Carbon and Alloy Steel Nuts |
| ASTM A572 | High-Strength Low-Alloy Columbium-Vanadium Structural Steel |
| ASTM A595 | Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use |
| ASTM A615 | Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement |
| ASTM B108 | Aluminum-Alloy Permanent Mold Castings |

| | |
|---|---|
| ASTM B221 | Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes |
| ASTM B228 | Concentric-Lay-Stranded Copper-Clad Steel Conductors |
| ASTM F436 | Hardened Steel Washers |
| ASTM F1554 | Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength |

Federal Highway Administration (FHWA)

| | |
|---|---|
| MUTCD | Manual on Uniform Traffic Control Devices |

National Fire Protection Association (NFPA)

| | |
|---|---|
| NFPA 70 | National Electrical Code (NEC) |

## 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Traffic signal poles, mast arms, span wire and pole foundations shall conform to requirements specified herein; and where specific requirements are not listed herein, the traffic signal poles shall, as a minimum, conform to the requirements of the standards and publications listed in 1.02.

B. Traffic signal poles, mast arms, span wire and pole foundations furnished as Work of this Section shall be as shown on the Contract Drawings, constructed to standard similar dimension sections.

C. Traffic signal poles, mast arms, span wire and pole foundations shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein. Special or custom-built components may be used only upon written approval from the Engineer.

## 1.04 ENVIRONMENTAL REQUIREMENTS

A. Equipment shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

## 1.05 QUALITY ASSURANCE

A. Provide independent test certification of foundations, poles, bases, span wires, guy wire and mast arms to show compliance with the load requirements.

B. Submit complete design calculations signed and sealed by a professional engineer licensed in the state in which the traffic signals are to be installed to the Engineer for approval. Calculations shall include design of all elements necessary to construct the proposed signal structure including but not limited to: transformer and shoe bases, base plates, poles, span wires, guy wires, non-standard foundations and anchorages, connections and mast arms.

Design criteria shall be in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 6th Edition, 2013 with Latest Interims and as follows:

1. Steel Mast Arm Traffic Signals

   a) Design Life: 50 years

   b) The design wind pressure, $P_z$, shall be calculated using Equation 3.8.3-1. The basic wind speed, V, to be used in Equation 3.8.3-1 shall be 110 mph.

   c) All steel traffic signals shall be designed for fatigue to resist the following equivalent static wind load effects: Galloping, Vortex Shedding (as applicable), Natural Wind Gust, and Truck Induced Gust. Fatigue design shall be in accordance with Chapter 11 and the following:

      1) For traffic signals with mast arms greater than 50' in length, use Fatigue Category I.

      2) For traffic signals with mast arms 50' or less in length, use Fatigue Category II.

   d) The base plate thickness shall be equal to or greater than the anchor bolt diameter.

   e) A double nut connection between the base plate and the anchor bolt shall be used. The distance between the bottom of the lower nut and the top of the foundation shall be no more than 1 ½" or the diameter of the anchor bolt, whichever is less.

2. Aluminum Traffic Signals

   a) Design Life: 25 years

   b) The design wind pressure, $P_z$, shall be calculated using Equation 3.8.3-1. The basic wind speed, V, to be used in Equation 3.8.3-1 shall be 110 mph.

   c) Fatigue Design shall be waived.

3. Span Wire Supported Traffic Signals

   a) Design Life

      1) Permanent Installation: 25 Years

      2) Temporary Installation: 10 Years

   b) The design wind pressure, $P_z$, shall be calculated using Equation 3.8.3-1. The basic wind speed, V, to be used in Equation 3.8.3-1 shall be 110 mph.

C. After installation, inspect the equipment in the presence of the Engineer to show compliance with the requirements of this Section. Continue inspection until the results are satisfactory to the Engineer. Perform any repairs, construction and modifications as required to comply with the Specifications without additional cost to the Authority.

## 1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver all materials to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants or other causes.

## 1.07 SUBMITTALS

For submittals see Appendix "A".

# PART 2. PRODUCTS

## 2.01 MATERIALS

A. Furnish poles and mast arms of material shown on the Contract Drawings as follows:

1. Aluminum poles and mast arms: ASTM B221, Alloy 6063-T6.
   a) Rotary ground, paper protection wrapped.
   b) Anodized aluminum poles and arms in the quantities shown, shall be furnished only if specified on the Contract Drawings.
   c) Furnish powder coated poles and arms if a color is specified on the contract plans.
2. Aluminum struts and plates: ASTM B221, Alloy 6063-T6
3. Steel poles and mast arms: ASTM A572, Grade 50 with a minimum yield point of 50,000 psi and a minimum tensile strength of 65,000 psi or ASTN A 595 Grade A with a minimum yield point of 55,000 psi and a minimum tensile strength of 65,000 psi. These values shall be guaranteed by the manufacturer after fabrication and documented by the submission of certified copies of physical tests performed on material lots from which items were fabricated.
   a) The steel poles and mast arms shall be galvanized in accordance with ASTM A123.
   b) Furnish powder coated poles and arms if a color is specified on the contract plans.
4. Timber poles shall be Douglas Fir.

B. Shoe Bases/Base Plates:

1. Aluminum:
   a) ASTM B108, Alloy 356-T6.
   b) ASTM B221, Alloy 6005-T5 at handhole reinforcement
2. Steel: In accordance with 2.01 A.3.

C. Transformer Bases:

1. Aluminum: ASTM B108, Alloy 356-T6.
2. Furnish powder coated transformer bases and bolt covers in the quantities shown if a color is specified on the contract plans.

D. Clamps:

1. Cast Aluminum pole clamps: ASTM B108, Alloy 356-T6.
2. Steel: In accordance with 2.01 A.3.

E. Connection Devices:

1. Aluminum: ASTM B221, Alloy 6061-T6.
2. Steel: ASTM A36.

F. Bolts, Nuts and Washers:

1. Steel Traffic Signal Pole Installations:
   a) Bolts
      1) Anchor bolts shall be ASTM F1554, Gr. 55
      2) Bolts used for structural connections shall be ASTM A325
   b) Nuts and Washers:
      1) Nuts for use with anchor bolts shall be in accordance with ASTM A 563A Heavy Hex.
      2) Washers for use with anchor bolts shall be in accordance with ASTM F436.
   c) Galvanize bolts, nuts and washers in accordance with ASTM A153.
2. Aluminum Traffic Signal Pole Installations:
   a) Bolts
      1) Anchorage Assembly
         a. Anchor bolts shall be ASTM F1554, Gr. 55. Hot Dip Galvanize in accordance with ASTM A153.
         b. Heavy Hex Cap Screw shall be stainless steel ASTM A193 Gr. 8
      2) Bolts used for structural connections shall be stainless steel in conformance with ASTM A193 Grade B8, size as noted or as determined by the manufacturer.
   b) Nuts and Washers
      1) Anchorage Assembly
         a. Nuts embedded within foundation shall be ASTM A 563A Heavy Hex. Embedded nuts shall be hot dip galvanized in accordance with ASTM A153.
         b. Washers embedded within foundation shall be ASTM F436. Embedded washers shall be hot dip galvanized in accordance with ASTM A153.
         c. Coupling nut shall be ASTM A 563A Heavy Hex. Coupling nut shall be hot dip galvanized in accordance with ASTM A153.
         d. Flat washers and lock washers shall be Type 304 stainless steel.
      2) Nuts used in structural connections shall be stainless steel in accordance with ASTM A194 Gr. 8

3) Washers used in structural connections shall be made from Type 304 stainless steel.

G. Span Wire, Tether Cable & Accessories:

1. Span wire cable: ASTM A475, Extra High Strength Grade with Class A weight zinc coating. Diameter shall be as shown on the Contract Drawings.

2. Tether wire, where required, shall be 5/16-inch diameter, ASTM A475 Extra High Strength Grade with a Class A weight zinc coating.

3. Fabricate wire dead ends with heat-treated aluminum alloy strand vice yoke and cartridge and case hardened plated steel alloy jaws.

4. Span wire attachment shall be 3/4-inch diameter galvanized eye through bolts with double nut and curved stubbing washer.

5. The working load and breaking strength of all hardware attached to wire shall meet or exceed the working load and breaking strength of the wire to which it is attached.

H. Guy Wire Cable & Accessories:

1. Guy wire cable: ASTM A475, Extra High Strength Grade with a Class A weight zinc coating. Diameter shall be as shown on the Contract Drawings.

2. Guy wire attachment shall be a guy strand vise with a 3/4-inch angle thumb eye bolt and 3/4-inch diameter galvanized through bolts with double nut and curved stubbing washer.

3. Guy guard shall be a minimum of 8 ft.

4. Helix anchor shall be provided as shown on the Contract Drawings.

5. The working load and breaking strength of all hardware attached to wire shall meet or exceed the working load and breaking strength of the wire to which it is attached.

I. Foundations:

1. Concrete Category VI shall be monolithically poured, cast-in-place and of the size and shape shown on the Contract Drawings.

2. Reinforcement shall be placed as shown on the Contract Drawings. All reinforcement shall be ASTM A615, Grade 60. Reinforcement shall be epoxy coated where shown.

J. Grounding:

1. All poles shall be grounded, meeting or exceeding the NFPA 70 National Electrical Code (NEC) standards.

K. Safety Chain:

1. Safety chain shall be hot dipped galvanized 1/4-inch coil proof straight link chain fabricated in accordance with ASTM A36 and galvanized in accordance with ASTM A123.

## 2.02 CONSTRUCTION FEATURES

A. General:

1. Traffic signal poles shall be of the following types as shown on the Contract Drawings:

   a) Span wire poles: Poles for supporting a steel cable or cables to which are attached traffic signals and overhead signs.

   b) Mast arm poles: Vertical pole(s) and approximately horizontal arm(s) to which are attached traffic signals and overhead signs.

   c) Post-top mount poles: Vertical pole(s) used for mounting traffic or pedestrian signals directly on post top.

   d) Bracket mount poles: Vertical pole(s) used to support traffic or pedestrian signals, bracketed from side.

2. Pole shapes shall be round, unless otherwise noted and of length shown on the Contract Drawings. The length of span wire poles shall allow for the wire sag shown after all signals and signs are installed.

3. Anchor bolts shall be designed for the orientation of the pole as shown on the Contract Plans. Provide anchor bolts, nuts and washers for each pole supplied.

4. Shop paint shall be rust-inhibitive, non-lead or chromium-based oil/alkyd primer on non-galvanized steel fabrications, junction box frames and covers and exterior exposed metallic conduits and anchor bolts. Field paint all uncoated steel with rust-inhibitive, non-lead primer tinted to distinguish it from shop paint coating; and finish paint one coat of black graphite or foliage green paint.

B. Pole Construction:

1. Fabricate pole of material listed in Section 2.01 with a uniform wall thickness and a uniform taper, starting at the butt end, decreasing in diameter at a rate of not more than 0.14 inches, but not less than 0.07 inches per foot of length.

2. The maximum base diameter of span wire poles shall be 0.70 inches per foot of pole length.

3. Equip poles with removable end caps and a 1/2-13 threaded bolt, grounding terminal accessible through a hand hole.

4. Fabricate aluminum shafts free of longitudinal welds.

5. Fabricate steel shafts of one-piece construction with full-length high frequency resistance welds. Use submerged arc welds for all poles.

6. Steel Poles - Connection plate used to secure mast arm to pole shaft shall be fabricated from a steel plate drilled/tapped to accept bolts from mast arm and welded to pole in accordance with details and techniques described in shop drawings. Connection shall exhibit fatigue behavior and produce stress levels consistent with what is shown in the design calculations.

C. Shoe Base/Base Plate Construction:

1. Steel Poles - Weld base plate to shaft in accordance with details and techniques described in shop drawings. Connection shall exhibit fatigue behavior and produce stress levels consistent with values shown in design calculations.

2. Aluminum Poles - Equip shoe base with gussets, as needed, slots sized to accommodate the anchor bolts shown, and shoe base anchor bolt covers.

D. Transformer Base Construction

1. Equip aluminum transformer and pedestal bases with an aluminum hand hole door and stainless steel mounting hardware. A grounding clip shall be located on wall opposite door opening.

2. Attach removable type transformer base to pole shaft by bolting to a shoe base welded to shaft. Attach rotary transformer base into a reinforced collar arrangement that shall accept pole shaft. Arrange shaft disconnections so that no special tools are required for unbolting disconnection.

E. Mast Arm Construction: Fabricate arm of material, length and configuration shown on the Contract Drawings. Provide a hole with smooth wiring cable guide in flange plates on shaft and on mast arms at signal location for complete internal wire routing.

1. Aluminum Mast Arms:

a) Fabricate arms of one-piece horizontal plane ovalized aluminum tubing of minimum 0.125-inch wall thickness, with welded vertical struts.

b) For truss type mast arms, design for both free swinging and adjustable fixed vertical signal mounting. Join outboard ends of arms by welding a one-piece extrusion shaped to accept arm members back to back and maintain a 1/4-inch minimum separation between tubes. Extend upper arm to form a 2-inch slipfitter at outboard end and provide a welded signal strap to mount free-swinging signal.

c) Secure mast arm to pole shaft with aluminum plate clamp welded to inboard end of arm and a matching pole back clamp, with four stainless steel through bolts and locknuts for attachment.

2. Steel Mast Arms:

a) Fabricate with longitudinal high frequency resistance welds and provide a uniform taper starting at the butt end, decreasing in diameter at a rate of not more than 0.14 inches, but not less than 0.07 inches, per foot of length.

b) Fabricate arms in one piece for lengths up to and including 40’. For mast arms over 40’, fabricate of two piece construction with an overlap joint length of 1 1/2 times the maximum inside diameter of the outer shaft, and secure with a through bolt and locknut.

c) Provide a removable galvanized steel end cap secured with stainless steel screws.

d) Connection plate used to secure mast arm to pole shaft shall be fabricated from a steel plate drilled to fit mast arm and circumferential welded in accordance with details and techniques described in shop drawings. Connection plate shall be secured to the plate provided on the pole shaft with ASTM A325 through bolts with nuts, galvanized in accordance with ASTM A153. Connection shall exhibit fatigue behavior and produce stress levels consistent with what is shown in the design calculations.

F. Hand Holes: Equip poles, other than transformer base mounted poles, with hand holes. The bottom of the hand hole shall be set a minimum distance, equal to the pole diameter, above the top of the base plate. The hand hole size shall be in accordance with details shown on Contract Drawings.

1. Internally reinforce poles with metal of a cross section area at least equal to the cross section area of hole area removed.

2. Provide removable door flush with outside of shaft.

G. Ground Lug: Equip poles and transformer bases with ground lug.

H. Safety Chain: Furnish and install hot dipped galvanized 1/4-inch coil proof straight link chain with stainless steel bolts, nuts and washers at all mast arm signal head installations.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit calculations, catalog cuts and shop drawings for prior Engineer approval as specified in Articles 1.03 and 1.05 herein. Procure no equipment until the Engineer has given written approval.

B. Related equipment to be removed and not required for relocation under the Contract, if and where shown on the Contract Drawings, shall remain the property of the Authority and shall be delivered to a location in the Port District as designated by the Engineer. Removed equipment, if any, shall not be used in a new installation unless specifically shown on the Contract Drawings.

C. Verify that each pole foundation and anchor bolt pattern has been installed using the proper anchor bolt circle for the pole base.

### 3.02 INSTALLATION

A. Poles

1. Attach pole shaft by bolting shoe base to transformer base or to the foundation. Locate hand hole to face away from traffic.

2. Use shims or leveling nuts to align pole. Shim stack should be no greater than ¼” tall.

3. Traffic signal poles shall be bonded and grounded according to the NEC. Furnish and install a ground cable from the pole’s ground lug to a ground rod at the nearest manhole.

4. Install mast arms and span wires so traffic signal heads and signs meet minimum elevation requirements as shown on the Contract Drawings, in accordance with AASHTO standards and MUTCD guidelines.

B. Span Wire:

1. Fasten signal control cable to the span wire by non-corrosive metal lashing, messenger rings or weather resistant plastic cable bands, at no greater than 15-inch intervals. Hang signal heads and brackets from the span wire so that the bottoms of the signal heads on each approach are aligned horizontally. The signal cable shall follow the lowest path to the signal heads.

2. Determine the length of span wire required to span the distance between poles, allowing sufficient length for fastening and sag to produce a final assembly that is consistent with the Contract Drawings.

3. Determine all the loads for the span wire and arrange for the cable manufacturer to verify the cable shown is adequate for the loads shown

4. In order to restrict excessive signal movement, install a tether cable to stabilize signal heads, if and where shown on the Contract Drawings. Attach tether cable to the edge shown on the signal head in the Contract Plans.

5. Drill through pole at an approximate straight angle at each connection to receive the eye through bolts. In no case shall the span wire pull or strain on the eye bolt at an angle greater than 10 degrees plus or minus from straight.

6. Furnish and install galvanized thimble eyebolts to connect ground wires to round signal poles. Circumferential pole clamps, as an alternative to galvanized thimble eyebolts, may be used to connect span wires to the top of polygonal shaped signal poles, where applicable.

C. Foundations:

1. Concrete foundations shall be cast-in-place.

2. Foundations shall rest on firm ground and shall be poured monolithically. Conduit and anchor bolts shall be placed in proper position and shall be held in place by means of a template until the concrete sets. Foundation concrete shall reach sufficient strength and shall have set a minimum of 24 hours prior to removing forms. Exposed portions of foundations shall be neatly finished with a wood float followed by brushing with a wet, soft-haired brush. Construct tops of foundations to a finished grade elevation of 1 inch above final grade sidewalk, unless otherwise shown. Where sidewalks are not constructed or do not exist, finish foundations to an elevation of 2 inches above the final grade of the surrounding lawn or earth, unless otherwise shown.

3. Conduit installed in foundations shall be set plumb. The conduit shall terminate with a coupling flush with the top of the foundations and shall be provided with a close nipple. Conduit shall be provided with pipe caps during the placement of the concrete. When the finishing of the foundation is complete, the pipe caps shall be removed and insulated grounding bushings shall be installed. If the wiring is not immediately installed, the bushings shall be installed with push-penny plugs.

4. Anchor bolts installed in the foundation shall be set plumb. Once the foundation concrete has reached its design strength, connect pole to foundation as shown on the Contract Plans.

## 3.03 INSPECTION

Perform final installation inspection in accordance with 1.05 C.

END OF SECTION

## SECTION 16572

## TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND FOUNDATIONS

## APPENDIX "A"

## SUBMITTALS

Submit the following in accordance with the requirements of "Shop Drawings, Catalog Cuts and Samples" of Division 1 - GENERAL PROVISIONS.

A. Shop Drawings

1. Details of all traffic signal pole elements including, but not limited to: bases, base plates, poles, cables, arms, mounting brackets, attachments, fittings, welds, anchor bolt details, anchor bolt layout, material finishes, and other information required to fabricate and construct the signal structure.

B. Catalog Cuts, Material Certifications, and Test Results

1. Certified test results for steel poles and mast arms in accordance with Article 2.01A.3.
2. Certification for anchor bolt strength in accordance with Article 2.01 F.
3. Certification for span wire, guy wire, and tether wire strength in accordance with Article 2.01 G and H.
4. Certification for helix anchors shall be provided.

C. Samples

D. Construction Procedures and Quality Assurance Documents

E. Design Computations

Design computations for all traffic poles in accordance with Article 1.05 B.

END OF APPENDIX "A"

# SECTION 16572

# TRAFFIC SIGNAL POLES, MAST ARMS, SPAN WIRE AND FOUNDATIONS

## INSTRUCTIONS TO SPECIFIER

A. The Specifier shall review all items listed in Appendix "A". Remove all items that are not applicable to this project and add to the Appendix "A" under the proper headings any submittal items intended to be shown on the Contract Drawings.

B. Ensure that the Contract Drawings indicate:

1. Maximum pole heights, minimum vertical clearance between the bottom of the signal heads and signs and the top of roadway.
2. Foundation details including anchor bolt size, quantity, depth of embedment and bolt circle diameter.
3. Indicate that the Contractor's Professional Engineer shall verify the anchor bolts shown and the bolt circle diameter used are adequate to transfer all effects generated by the loads and load combinations investigated in the design calculations to the foundation below.
4. For span wire installations, show upper tether wire, if required.

C. List of items required to be shown on the Contract Drawings:

| Article | Description |
|---|---|
| 1.03 B | Specify the location of the poles, mast arms, span wires and foundations. |
| 2.01 A.1.b | Specify if and where anodized aluminum poles are used. |
| 2.01 C.2 | Specify if and where powder coated transformer bases and bolt covers are used. |
| 2.01 H.4 | Specify helix anchor material, helix and shaft size, helix configuration and depth below ground surface. |
| 2.01 I.1 | Specify foundation material, size and shape. |
| 2.02 A.2 | Specify maximum pole height and the minimum clearance between the bottom of the signal heads and signs and the top of roadway. |
| 2.02 A.3 | Specify the bolt circle diameter, anchor bolt layout, size and embedment depth |
| 2.02 A.4 | Specify finish and color. |
| 3.01 B | Specify equipment to be removed and/or relocated. |
| 3.02 A.4 | Specify minimum roadway clearance for signal head and signs. |
| 3.02 B.2 | Specify span length. |
| 3.02 B.4 | Specify upper tether wire, if required. |

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16573

# PEDESTRIAN TRAFFIC SIGNALS, PUSHBUTTONS AND MOUNTING HARDWARE

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for Pedestrian Traffic Signal equipment including Light Emitting Diode (LED) Countdown Pedestrian Traffic Signals, Audible-Tactile Pedestrian Signal System (APS) and Pushbutton Assemblies along with all incidental wiring and mounting hardware. The Audible-Tactile Pedestrian Signal System shall consist of all electronic control equipment, mounting hardware, pushbuttons and signs, which are designed to provide both a pushbutton with a raised vibrating tactile arrow on the button, along with a variety of audible sounds for different pedestrian signal functions.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section. The engineer is responsible for insuring that the current edition of these references is utilized during the design process:

American Association of State Highway and Transportation Officials (AASHTO)

Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

Americans with Disabilities Act (ADA)

ADA Accessibility Guidelines for Buildings and Facilities

Public Rights-of-Way Accessibility Guidelines

American National Standards Institute (ANSI)

ANSI C 78A-21 Bulb, Medium Screw Base

American Society for Testing and Materials (ASTM)

ASTM B 85 AluminumAlloy Die Castings

Federal Communications Commission (FCC)

Title 47 Telecommunications

Federal Highway Administration (FHWA)

MUTCD Manual on Uniform Traffic Control Devices

Institute of Transportation Engineers (ITE)

ITE ST-017B Equipment and Material Standards of the Institute of Transportation Engineers

Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules

International Electrotechnical Commission (IEC)

| | |
|---|---|
| IEC 61000 | Electromagnetic compatibility (EMC) |

National Electrical Manufacturers Association (NEMA)

| | |
|---|---|
| NEMA TS 2 | Traffic Controller Assemblies with NTCIP Requirements |
| NEMA 250 | Enclosures for Electrical Equipment (1,000 Volts Maximum) |

Underwriters Laboratories, Inc. (UL)

| | |
|---|---|
| UL 94VO | Tests for Flammability of Plastic Materials for Parts in Devices and Appliances |

US Department of Defense Military Standards

| | |
|---|---|
| MIL-STD-883 | Test Method Standard Microcircuits |

## 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. Where specific requirements are not listed herein, pedestrian traffic signals shall conform to the requirements of the standards and publications listed in Article 1.02 herein.

B. The units furnished and installed as Work of this Section shall be LED Countdown Pedestrian Traffic Signals in the quantities shown on the Contract Drawings. Furnish and install Audible-Tactile Pedestrian Signal Systems and Pedestrian Pushbuttons in the quantities shown only if specified on the Contract Drawings.

C. The units furnished and installed as Work of this Section shall have polycarbonate housings in the quantities shown on the Contract Drawings. Furnish and install Pedestrian Traffic Signals with aluminum housings in the quantities shown only if specified on the Contract Drawings.

D. Pedestrian Traffic Signals shall consist of readily available and proven equipment, fully consistent with their intended design and operation as specified herein and shown on the Contract Drawings. Special or custom-built components may be used only upon written approval from the Engineer.

E. Pedestrian Traffic Signals shall use modular type construction with assemblies, sub-assemblies and modules that are available from a second source of supply wherever possible.

F. All assemblies, sub-assemblies and modules shall be readily accessible for removal, testing or replacement without removal of the other modules, assemblies or components. Components shall be located so that there is visibility and access for the use of hand tools and standard test probes where maintenance is required. Test points shall be provided to facilitate troubleshooting.

## 1.04 ENVIRONMENTAL REQUIREMENTS

A. All Pedestrian Traffic Signals, APS, and Pushbutton Assemblies shall satisfy all the environmental requirements specified in this Section.

B. The Pedestrian Traffic Signals, APS, and Pushbutton Assemblies shall operate over an ambient temperature range from -30°F to +165°F (-34°C to +74°C). Operation of the Pedestrian Traffic Signals, APS, and Pushbutton Assemblies shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

C. Pedestrian Traffic Signals and Pushbutton Assemblies shall be protected against the intrusion of dust and moisture to protect all internal components. Pedestrian Traffic Signals, with properly installed gaskets, shall be protected against dust and moisture intrusion per requirements of NEMA 250 for Type 4 enclosures to protect all internal LED, electronic and electrical components.

D. Pedestrian Traffic Signals and Pushbutton Assemblies shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning, and electromagnetic/electrical interference.

E. APS shall meet the following criteria:

1. Operate over the range of relative humidity from 0% to 95%, non-condensing;
2. NEMA TS 2 Section 2.1 Transient Voltage Protection requirements;
3. NEMA TS 2 Section 2.1 Mechanical Shock and Vibration requirements;
4. IEC 61000-4-4, IEC 61000-4-5 Transient Suppression requirements;
5. FCC Title 47, Part 15, Class A Electronic Noise requirements;
6. Pushbutton Station (PBS) Enclosure shall meet NEMA 250 – Type 4X Enclosure requirements; and
7. The central control unit and station monitor enclosures shall meet NEMA 250 – Type 1 requirements.

## 1.05 QUALITY ASSURANCE

A. Arrange for all LED signals to undergo Design Qualification (DQ) testing prior to shipment as specified herein and in accordance with ITE ST-017B. Failure of any LED signals to meet requirements of the DQ tests shall be cause for rejection. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide DQ process and test results documentation to the Engineer.

B. Ensure that all LED signals undergo the following production Quality Assurance (QA) testing prior to shipment in accordance with ITE ST-017B. Failure of any LED signal to meet any requirement of the QA tests shall be cause for rejection. If any equipment has been damaged or if for any reason the equipment does not comply with all requirements and test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide QA process and test results documentation to the Engineer.

1. Signal Burn-in
2. The Maintained Minimum Luminous Intensity shall meet Luminous Intensity requirements in accordance with ITE ST-017B.
3. Power Factor
4. Current
5. Visual Inspection

C. After delivery of equipment, invite the Engineer to perform a construction site inspection of the equipment. If in the Engineer's opinion any equipment has been damaged or if for any reason the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority, even though the equipment had been inspected for shipment. After satisfactory replacement and/or repair and subsequent Engineer's written approval, the equipment may be installed.

D. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Section and with the Contract Drawings. Continue testing until test results are satisfactory to the Engineer. If any equipment has been damaged or if for any reason the equipment does not comply with the requirements or test standards specified, the Contractor shall repair or replace the equipment at no cost to the Authority. Provide installation process and test results documentation to the Engineer. Perform any repairs, construction or modifications required to comply with the Specifications and the Contract Drawings.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Arrange for all materials to be delivered to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants and other causes.

1.07 SPARE EQUIPMENT

A. For items with no second source of supply for replacement assemblies, provide spare equipment in quantities as shown on the Contract Drawings.

1.08 SUBMITTALS

For submittals requirements, see Appendix “A” of this Section.

## PART 2. PRODUCTS

2.01 MATERIALS

A. Pedestrian Signal Housing and Door:

1. Polycarbonate housings and doors shall be molded, ultraviolet and heat stabilized, flame retardant, unaffected by the heat of the lamp used and permanently colored in accordance with the Contract Drawings. Housings and doors shall be made of UL 94VO flame-retardant materials. The lens is excluded from this requirement.

2. Virgin metal die cast aluminum alloy conforming to ASTM B 85 of one of the following alloys:

   a. S12A (A14130)

   b. S12B (A04130)

   c. SC84A (A13800)

   d. SC84B (A03800)

   e. SG100B (A03600)

B. All bolts, nuts, washers and lock washers supplied shall be stainless steel.

## 2.02 CONSTRUCTION FEATURES

A. General:

1. Furnish and install Pedestrian Traffic Signals for operation on 120 +/-3 VAC RMS, 60 Hz, AC line power, unless otherwise shown on the Contract Drawings. Signals shall operate over a voltage range from 80 VAC RMS to 135 VAC RMS, 60 Hz +/-3 Hz, AC line power. Variations in operating line voltage shall produce no visible effect on luminous intensity and shall not vary by more than 10% over the entire operating voltage range. The current drawn shall be sufficient to ensure compatibility and proper triggering and operation of load switches in the signal controller units.
2. Furnish and install signal heads, mounting brackets, attachments and fittings for a wind load pressure resulting from a wind speed in accordance with the current edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.
3. Aluminum signal housings, pushbutton housings, bracket arms, mounting attachments and hardware shall have three coats of paint, each of which shall be baked after application. The first or primer coat shall be a non-lead/non-chromium containing paint for aluminum surfaces. The second and third coats shall be Federal Yellow Matching Color No. 13538 conforming to Federal Standard No. 595, except for the message face and the Z-crate visor, which shall be flat black enamel. Each coat shall be baked on separately. All metal surfaces to be painted shall be suitably cleaned of all foreign deposits, oil and grease, and then neutralized for priming. Paint separate parts before assembly. Stainless steel assemblies and polycarbonate components shall not be painted.
4. Unless specified otherwise, equipment shall be fabricated in accordance with ITE ST-017B.
5. Identify all wire terminations and terminal block connections. Terminate cables with insulated spade terminals conforming to NEMA TS-2. Bring separate continuous #14 AWG, 19 strand wires from the terminal block of the signal head to bottom of the standard.

B. LED Countdown Pedestrian Signals

1. The number and usage of LED Countdown Pedestrian Traffic Signals shall be as shown on the Contract Drawings.
2. LED Countdown Pedestrian Signal shall be a standalone unit that provides pedestrians with numerical timing along with the “WALKING PERSON” or “UPRAISED HAND” international symbols in solid form. The unit’s countdown timer shall operate in conjunction with the pedestrian signal indication’s flashing “UPRAISED HAND”.
3. The signal section shall be designed to display a steady “WALKING PERSON,” flashing “UPRAISED HAND,” and steady “UPRAISED HAND” symbol that complies with ITE Standard ST-011B for the size specified in a single housing. The signal section shall be used for existing installations, where applicable, and all new installations unless otherwise directed by the Engineer.
4. Physical and Mechanical Requirements
   a. The unit shall be supplied new, complete with housing for new installations or without the housing for on-site assembly into existing 16-inch housings as shown on the Contract Drawings.

b. For retrofit replacement the LED signal section shall fit into existing signal housings without the need to modify the housing or to modify or remove the reflector.

(1) LED pedestrian traffic signals shall not require special tools for installation when used as retrofit replacements for existing incandescent traffic signals.

(2) LED pedestrian traffic signals shall fit into the existing traffic signal housings built to ITE ST-017B without any modification to the housing.

(3) LED pedestrian traffic signals shall be weather tight, shall fit securely in the housing and shall connect directly to existing electrical wiring by means of push-on type connectors.

(4) Installation of retrofit replacement LED pedestrian traffic signals into existing incandescent signal housings shall require only the removal of the existing optical unit components, i.e., lens, lamps, gaskets and reflector.

(5) Ensure that each retrofit kit includes all necessary components to complete conversion, including a one-piece gasket.

c. Construct the unit of materials conforming to ASTM specifications.

5. An LED countdown pedestrian traffic signal unit shall, unless otherwise specified, include a single-piece polycarbonate housing, an illumination light source, a polycarbonate message lens, a single-piece polycarbonate swing door frame, a blank-out Z-crate type sun visor and other appropriate hardware and mounting brackets. Design the signals to fit both standard post top and side of pole mounting brackets, including clamshell type mounting hardware, as shown on the Contract Drawings. All components and field-wiring terminal shall be readily accessible from the front by opening the signal door.

a. Polycarbonate housings shall be one-piece molded, ultraviolet-resistant, heat-resistant, flame-retardant, unaffected by the heat of the lamp used, permanently colored, and shall be a minimum of 0.090 inches thick.

b. Polycarbonate doors shall be one-piece molded, ultraviolet-resistant, heat-resistant, flame-retardant, permanently colored, and shall have a sufficient-sized opening to accommodate the lens. On one side of the door at top and bottom there shall be a hinge to ensure perfect alignment of the door.

6. Aluminum unit shall include a single-piece cast aluminum housing, an illumination light source, a polycarbonate message lens, a single-piece cast aluminum swing door frame, a blank-out Z-crate type sun visor and other appropriate hardware and mounting brackets. Design the signals to fit both standard post top and side of pole mounting brackets, including clamshell type mounting hardware, as shown on the Contract Drawings. All components and field-wiring terminal shall be readily accessible from the front by opening the signal door.

a. The signal casting shall be one-piece corrosion-resistant aluminum alloy die casting complete with integral cast top, bottom, sides and back. Provide integral cast hinged lug pairs, two at the top and two at the bottom, for operation of a swing door.

b. The doorframe shall be one-piece corrosion-resistant aluminum alloy die casting complete with two integral cast hinged lug pairs at the bottom of the door and two latch slots at the top of each door.

c. Attach the door to the housing by means of stainless steel spring pins with captive stainless steel wing nuts and washers. The case when properly mated to other signal components and mounting hardware shall provide a dustproof and weather-resistant enclosure, with easy access to all components for servicing and replacement.

7. The lens of the unit shall be polycarbonate UV stabilized and a minimum of 1/8-inch thick.

8. Provide each LED countdown pedestrian traffic signal with a Z-crate type visor designed to eliminate sun phantoms, installed directly into the signal doorframe parallel to the face of the message board and held in place by means of stainless steel screws.

   a. Injection-molded polycarbonate, ultraviolet-resistant, heat-resistant, flame-retardant, unaffected by the heat of the lamp used, permanently colored egg crate visor meeting pattern dimensions specified below.

   b. The aluminum visor shall consist of straight horizontal louvers and zigzag pattern horizontal louvers with every other formed louver reversed so as to form square cells but rotated 45 degrees from the horizontal to provide diamond shaped cells when assembled, with each diamond bisected by a straight louver joint welded to maintain a firm construction, all enclosed in a mounting frame constructed of 0.040-inch minimum thickness aluminum.

9. The housing shall have neoprene gaskets between the body of the housing and the doors. The door shall be hinged and forced tightly against the gasket and the housing by a simple stainless steel locking mechanism.

10. Provide a screw-in type terminal block assembly with an aluminum base that is bolted to the signal housing for termination of the returned field wires. Field wiring shall be as specified herein unless otherwise shown on the Contract Drawings.

11. Indications shall be made visible by LED illumination, and shall be bright and uniform displays even under strong ambient light.

   a. The “UPRAISED HAND” and “WALKING PERSON” signal-indication-bearing surface of the unit shall overlay each other and shall display either a Portland Orange colored LED “UPRAISED HAND” or lunar white colored LED “WALKING PERSON.” These displays shall provide a uniform light dispersion of the “UPRAISED HAND”/“WALKING PERSON” symbols and shall conform to all applicable ITE electrical requirements. Each symbol shall be in solid format, with the interior of the symbol illuminated and containing a number of LEDs to maintain a uniform appearance.

   b. The countdown display message-bearing surface shall be supplied with two LED numerals to display a count from “00" to “99" in Portland Orange color. The display segments that comprise the numerals shall be approximately 0.5-inches wide and shall be formed by two or more rows of LEDs.

   c. The message lenses, except for the solid symbol, shall be obscured by a black opaque background. When not illuminated, the symbols shall not be distinguishable by pedestrians at the far end of the controlled crossing.

12. "UPRAISED HAND" and "WALKING PERSON" symbols shall each be a minimum of 11 inches in height and 7 inches in width for nominal 16-inch pedestrian signal housings and 9 inches in height and 5.25 inches in width for nominal 12-inch pedestrian signal housings. The countdown display numbers numerals shall be a minimum 7 inches in height and 3.75 inches in width. They shall be configured as shown in Section 4E.04 of the MUTCD.

13. Design the optical system for pedestrian traffic signals utilizing LED illumination so as to minimize the return of outside rays entering the unit. The system shall consist of a polycarbonate message lens and a LED solid-state signal module.

    a. The lens material shall be clear, UV stabilized, refraction type polycarbonate plastic. Fit the inside of the lens with a one- piece sponge neoprene gasket fitted around the lens perimeter to create a weatherproof seal whenever the lens, doorframe and case are properly mated.

    b. Mount the LED pedestrian traffic signal so as to be impervious to shocks generated during shipping, handling and installation. Removal and installation of the module shall not require the use of tools.

    c. Provide the LED pedestrian traffic signal with colored leads conforming to ITE ST-017B. The leads shall be 18 AWG, 19 strands, wired to the respective terminals of the field wire terminal block.

14. The Portland Orange "UPRAISED HAND" and countdown number shall utilize AlInGaP (Aluminum Indium Gallium Phosphorus) LEDs. The substrate material may be either transparent or absorbing. The white LEDs "WALKING PERSON" shall be InGaN (Indium Gallium Nitride).

15. Luminous Intensity

    a. Maintain minimum luminous intensity in accordance with ITE ST-017B.

    b. The luminous uniformity of the "UPRAISED HAND", "WALKING PERSON" symbols' and countdown display indication's illumination shall maintain a ratio of not more than 1 to 5 between the minimum and maximum luminous intensity measurements (in $cd/m^2$), as measured in 12mm (0.5in) diameter spots.

    c. LED pedestrian traffic signal shall be designed so that when operated over the specified ambient temperature and voltage ranges, the signal shall attract the attention of, and be readable to, a pedestrian (both day and night) at all distances from 10 ft. to the full width of the area to be crossed.

16. Chromaticity

    a. The measured chromaticity coordinates of the LED-based pedestrian traffic signal modules shall conform to the chromaticity requirement of ITE ST-017B.

    b. The color uniformity of the LED pedestrian traffic signal shall conform to the requirement of ITE ST-017B Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules.

    c. The measured chromaticity coordinates of the individual LED light sources used in the Countdown Timer shall conform to the chromaticity requirements of the Pedestrian "UPRAISED HAND" symbol of the of ITE ST-017B Pedestrian Traffic Control Signal Indications – Part 2: Light Emitting Diode (LED) Pedestrian Traffic Signal Modules.

17. Electrical

    a. Nominal operating voltage for all measurements shall be 120 +/-3 VAC RMS.

b. The “UPRAISED HAND” and “WALKING PERSON” LED displays and the countdown display numerals shall consume no more than 15 watts each.

c. All LEDs shall be rated for 100,000 hours or more at 77°F (25°C) and 20 milliamps.

d. The forward current, as measured through each LED, shall not exceed 60% of the LED manufacturer’s maximum current rating or the LED manufacturer's recommended drive current to achieve a minimum of 100,000 hours of operation without catastrophic failure, whichever is less, when operating at 77°F (25°C).

e. The LEDs shall not emit visible light when subjected to a 120 VAC, 4-milliamp leakage current from a NEMA solid-state load switch (load switch in the off state).

f. The LEDs shall be wired in series parallel strings. The failure of any one LED, and its associated string of LEDs, shall cause the loss of not more than 20% of the light output of the complete LED display.

g. The LED circuitry shall prevent flicker at less than 100 Hz over the voltage range specified above.

h. The LED circuitry shall include voltage surge protection against high-repetition noise transients and low-repetition noise transients as stated in NEMA TS 2.

i. The LED pedestrian traffic signal, including its circuitry, shall meet Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of noise.

j. The LED pedestrian traffic signal shall maintain a power factor of 0.90 or greater over the operating voltage range and temperature range specified above.

k. Total harmonic distortion (current and voltage) induced in an AC power line by an LED signal display shall not exceed 20% over the operating voltage range and temperature range specified above**.**

l. Each LED pedestrian traffic signal shall be operationally compatible with the traffic signal equipment that it is designed and intended to interface with. The equipment includes all controllers, conflict monitors, current monitors, switch packs and flashers.

18. Operational Requirements

a. The countdown timer shall be designed to count down to zero only during the “Pedestrian Clearance” time. During the steady “UPRAISED HAND” indication, the display shall always be dark. All units shipped shall be delivered configured to count down to zero from the pedestrian clearance time.

b. The unit, when connected to the appropriate pedestrian switch pack outputs, shall have an automatic learn mode in order to learn and store the pedestrian times in its memory and to self adjust for subsequent changes in pedestrian timing. The individual “Walk” and “Clearance” times shall be stored in two separate counters.

c. Following power restoration to the unit after a power outage of greater than two seconds the unit shall remain dark for one pedestrian cycle to learn, to acquire the current pedestrian timing and to replace any values that were stored in memory prior to the power outage with the newly acquired values. The unit shall display the newly acquired times on the next pedestrian cycle.

d. The unit shall detect changes in pedestrian timing during normal operation and act upon them as described below:

(1) The countdown timer shall automatically re-program itself should it detect any increase in pedestrian timing. The increased timing shall be displayed on the subsequent pedestrian cycle.

(2) The countdown timer shall ignore any shortened pedestrian cycle that produces a shortened pedestrian clearance time equal to or less than two seconds.

(3) The countdown timer shall detect any reductions in pedestrian timing (such as those occurring during a traffic preemption cycle) and shall display on the subsequent pedestrian cycle the timing stored in its memory prior to the shortened pedestrian cycle.

(4) The countdown timer shall re-program itself should it detect two consecutive identical shortened pedestrian cycles and shall display this timing on the next pedestrian cycle.

(5) The unit shall be designed to suspend any timing and go dark when, for any reason, the switch pack output displays an "UPRAISED HAND" steady condition during the timing of a pedestrian walk or clearance and if the timer has not arrived at the "zero" count in the cycle.

e. The countdown timer shall be capable of timing consecutive complete pedestrian cycles outputted by the traffic control system.

f. The unit shall be designed to operate during and following a preemption cycle as described in this Section.

(1) The timer shall recognize if the walk or clearance times have been truncated or shortened.

(a.) During some preemption events, the walk condition, if displayed, would be truncated by the traffic controller and would then proceed immediately to time the full pedestrian clearance interval. Should this condition be detected, the timer shall detect the termination of the walk and the beginning of pedestrian clearance and shall begin timing of the clearance interval stored in its memory toward zero.

(b.) During other preemption events the Walk condition, if displayed, would be truncated by the traffic controller and would then proceed immediately to time a shortened pedestrian clearance interval. Should this condition be detected, the timer shall detect the termination of the walk and the beginning of pedestrian clearance and shall begin timing of the clearance interval stored in its memory toward zero. Once the switch pack output displays a steady "UPRAISED HAND" condition during the timing of this pedestrian clearance interval and if the timer has not arrived at the "zero" count in the cycle, the timer shall go dark.

(c.) There are also preemptions that immediately eliminate both the walk and clearance outputs. In these cases the pedestrian indication shall immediately cycle to a steady "UPRAISED HAND" indication. If this occurs, the countdown timer shall recognize the steady "UPRAISED HAND" indication and the timer shall go dark.

(2) At the cycle following a preempted time, the countdown timer shall display the correct time as initially programmed and shall not be affected by the reduced time. If the reduced time is equal to or less than two seconds, the countdown shall ignore this and shall continue to display the correct time as initially programmed.

g. The countdown timer shall be designed to retain the pedestrian timing stored in its memory for all power outages of less than one second and to continue timing of the pedestrian timing if the traffic control system has resumed pedestrian timing following the duration of outage. For outages of between one and two seconds, memory may or may not be retained. For all power outages greater than two seconds, the unit shall resume operation as described for power outages above.

C. Audible-Tactile Pedestrian Signal System (APS)

1. The type, number and location of APS shall be as shown on the Contract Drawings.
2. The System shall support from 2-16 PBS's per intersection (maximum of 4 pushbuttons per channel) controlled by a single base unit located in the traffic control cabinet.
3. The System shall be able to be set to vibrate a tactile arrow button during the "WALK" interval following a button push and/or every time the walk comes up.
4. The System shall have the field-selectable function known as "Locating Tone". This means that during the "FLASHING DON'T WALK" and the "DON'T WALK" intervals, the system shall provide a locating tone that emanates from the PBS. The system shall provide at least three different sounds to choose from.
5. The System shall have the field selectable function known as "Extended Push Activation". This means that the audible "WALK" message will only be activated and sound during the "WALK" interval if the button is depressed for a field selectable minimum period of time (from 0 to 6 seconds). Also, for the following walk phase, the volumes have a separately settable minimum and maximum volume level.
6. The System shall have the field selectable function known as "Informational Message". This means that a custom message giving the location of the street to cross and the intersection (or other information) will be vocalized only when the button is depressed for a minimum field selectable time.
7. The System shall provide a "Wait" message that plays once the button is activated until the walk cycle goes into effect. This message must have the field selectable option of OFF or playing every 4, 6, 8 or 10 seconds.
8. The System shall have standard "Travel Direction" options that can be selected at the time of installation.
9. The System shall have at least four field selectable walk sound options including a cuckoo, a chirp, a rapid tick or custom voice message.
10. The System shall provide 3 Ped-clearance sound choices including audible countdown (field selectable). The audible countdown shall represent the time remaining during the pedestrian clearance interval. Timing is automatically adjusted to "CLEARANCE INTERVAL" timing.
11. The System shall provide two language capabilities, selectable by user, as a custom feature.
12. The System shall provide Emergency preemption message in conjunction with a preemption system as a selectable feature.
13. "LOCATE" tone and "WALK"/"FLASHING DON'T WALK" audible feature must have independent settable minimum and maximum volume limits.
14. All sounds for all PBS's must be synchronized.

15. The system shall have an ambient sensing microphone located in the pedestrian station in a non-visible, environmentally protected housing.
16. All sounds levels shall adjust automatically in response to ambient noise over a 60-dB range with additional control to have the sound level at ambient, 5dBA or 10dBA over ambient, to a maximum of 100 dBA.
17. The system shall have an independent ambient adjustment setting for the locate tone that allows the locate tone volume to be set to play below the ambient noise level.
18. The system shall utilize high quality digital audio technology by using 12-bit samples at a 16k Hz sample rate audio amplifier and must have total harmonic distortion of less than 3%.
19. The firmware and voice messages shall be updatable via a USB or other communication port at the PBS. There shall be no requirement for the hardware to be changed out to update.
20. The System shall have the option to mute sounds on all crosswalks except activated crosswalk (selectable feature).
21. The System shall have no field replaceable fuses. All fuses shall be self-resetting.
22. The System shall have the ability to have two separate program configurations with all features available that can be turned on through an external input.
23. All field selectable options must be settable using an infrared remote or via other communication means such as Ethernet with password security.
24. Central Control Unit and Management Module
    a. Shall be installed inside the traffic signal controller cabinet and powered by the AC supply mains (115 VAC).
    b. Shall control up to 16 PBS's in a maximum of 4 channels up to 4 PBS's per channel.
    c. Shall control up to four Pedestrian channels, receiving its timing from the pedestrian signals.
    d. Shall be able to self-test all PBS's and put a channel into recall should a PBS fail the self-test.
    e. Shall provide optically isolated general purpose inputs.
    f. Shall be provided with a cable interface harness assembly.
    g. Shall be provided with an interface connection board.
    h. Shall have Ethernet access to PBS's through the unit to be able to change the settings of PBS as well as monitor the self-test events of the PBS's and report back to the central control.
    i. Shall have internal memory to store a minimum of 100 hundred events with a date-time stamp for each event.
    j. Shall have an internal real-time clock capable of updating and synchronizing its time with an NTP server.
    k. Firmware for the unit shall be updated by USB or other communication port on the unit.
    l. The unit shall have a minimum of the following built-in conflict monitoring systems:
        (1) Monitors the PBS and the pedestrian signals and powers off the channel upon a conflict.

(2) Processors monitor each other and reset the unit upon loss of internal communication.

m. Shall provide the ability to test each individual communication channel to each PBS allowing the user to detect problems due to faulty/incorrect wiring.

n. Shall provide the user the ability to restore an entire intersection's configuration settings from a saved file.

25. Pedestrian Pushbutton Station (PBS)

a. PBS shall be a single fixture that contains the vibro-tactile 2" ADA-compliant pedestrian pushbutton with directional tactile arrow, a weatherproof speaker, and the appropriate sign for each location.

b. All audible sounds shall emanate from the PBS.

c. The external housing shall not have any polycarbonate or plastic parts.

d. PBS's must require only two wires coming from the traffic control cabinet for each phase / crosswalk.

e. Each PBS shall have a system unique ID.

f. SPEAKER: 8 Ohms, 12 Watt maximum, weather-proof.

g. PUSHBUTTON: ADA compliant with raised arrow on the button plunger. Cast Aluminum, Nickel plated and powder coated for color contrast. The arrow on the PBS shall be able to be changed to one of four directions.

h. PUSHBUTTON: Uses Piezo switch technology rated to greater than 20 million operations.

i. VIBRATOR POWER: Arrow button shall pulse at 20 Hz with a 0.003 inch displacement against an applied 2 lb force.

j. CONFLICT WALK MONITOR: Circuitry shall have a separate microcontroller that independently monitors the main microcontroller outputs and "Walk Mode" for conflict condition, the PBS is reset in case of conflict detection.

k. The firmware and voice messages shall be updatable via a USB or other communication port at the PBS. There shall be no requirement for the hardware to be changed out to update.

l. VOLTAGE TRANSIENT PROTECTION: Meets applicable NEMA TS 2 requirements.

m. Meets or exceeds NEMA 250 type 4X enclosure requirements.

n. CONSTRUCTION:

(1) FRAME: Cast Aluminum, Powder Coated.

(2) MESSAGE SIGN: Aluminum, Powder Coated, Ink Markings.

(3) PUSHBUTTON: Aluminum, Powder Coated.

(4) MESSAGE SIGN: Aluminum sign panel with panel detail as per the sign legend on the Contract Drawings. Sign shall include a transparent braille overlay for the message on the sign referencing the pushbutton and its associated crossing.

o. PBS must indicate to the user via a pilot light that the button has been pushed, in either the Don't Walk interval or Clearance interval, by illuminating a pilot light on the front of the PBS and by providing a momentary tactile pulse.

p. The audible walk indication shall be a programmed with a speech walk message and shall provide a clear message that the walk interval is in effect, as well as to which crossing it applies. They shall conform to Section 4E.11 of the current edition of the MUTCD.

D. Pedestrian Pushbutton Assemblies (Non-APS):

1. The number and location of pedestrian pushbutton assemblies (non-APS) only if shown on the Contract Drawings.
2. Pushbutton assemblies shall include the complete pushbutton housing, integral frame and instruction sign, suitable wiring from the terminals of the pushbutton to the base of the support. All pushbuttons shall operate on logic ground.
3. Pushbuttons shall be of the latching type.
4. The pushbutton assembly shall meet or exceed all accessibility guidelines with a vandal-proof design. The actuator shall have a diameter greater than 2 inches and shall be made of polished stainless steel or anodized aluminum and assembled with stainless steel components. The conical shaped actuator shall extend 0.4-inches above the bezel of the switch housing with the activated force for less than 3 pounds.
5. The pushbutton shall clearly indicate by means of tactile arrows which crosswalk signal is actuated by each pushbutton. The tactile arrow shall be located on the pushbutton, have a high visual contrast (light on dark or dark on light), and shall be aligned parallel to the direction travel on the associated crosswalk.
6. An accessible pedestrian pushbutton shall incorporate a locator tone that conforms to Section 4E.12 of the current edition of the MUTCD.
7. Construct the assembly housings of integral cast aluminum designed to mount securely on any curved surface from 4 inches in diameter to 16 inches in diameter. The pushbuttons shall operate on no more than 18-volt circuits and shall register a demand with the traffic signal controller for the pedestrian timing of the appropriate phase.
8. Provide an instruction sign in conformance with MUTCD requirements and as shown in the Contract Drawings.
9. All exposed screws shall be stainless steel and tamper-proof.

E. Pushbutton poles, if any, shall consist of a traffic signal pedestal and base complete with all mounting hardware including a weather-tight pole cap as detailed on the Contract Drawings.

F. Extension brackets for pushbuttons shall be provided to achieve an unobstructed horizontal reach of 10 inches or less unless otherwise specified on the Contract Drawings. Extension brackets shall be of heavy duty construction and of the same manufacturer as the pushbutton or per recommendations of the pushbutton manufacturer. The extension bracket shall be bolted or banded to the pole as per the Contract Drawings and all wires shall be routed inside of the bracket to protect from vandalism.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit catalog cuts and shop drawings for prior Engineer approval as specified in Article 1.08. No equipment shall be procured until the Engineer has given written approval.

B. Any traffic signal controller assembly or related equipment shown on the Contract Drawings to be removed and returned to the Engineer shall remain the property of the Authority. Deliver all removed existing above ground traffic signal equipment to the location as specified on the Contract Drawings. The Contractor shall notify the Engineer prior to delivery. Removed equipment shall not be used in a new installation unless specifically called for on the Contract Drawings. All other equipment designated on the Contract Drawings to be removed shall be disposed of by the Contractor, if the Engineer, in writing, directs the Contractor to dispose of the equipment.

### 3.02 INSTALLATION

A. Install Pedestrian Traffic Signals in accordance with the guidelines specified in the MUTCD at locations shown on the Contract Drawings.

B. The orientation of the Pedestrian Traffic Signal shall be convenient to the pedestrians intending to cross the roadway controlled by the pedestrian signals.

C. Drill and tap each pole to which the Pedestrian Traffic Signal is to be attached and install the necessary nipples and bushings to secure the Pedestrian Traffic Signal to the poles. The connections of Pedestrian Traffic Signal to the pole shall be weatherproof.

D. Wire the pedestrian traffic signals and pushbutton assemblies to implement the signal operations shown on the Contract Drawings. Route a separate continuous multiple conductor cable to each pedestrian traffic signal and pushbutton assembly. The cable size and number of conductors shall be as shown on the Contract Drawings. Wire each pedestrian signal and pushbutton assembly in accordance with the Contract Drawings.

E. Until the installed signal heads are placed into operation, they shall be covered with an opaque material and turned off. The material shall be adequately fastened to the signal heads in a neat, secure, and weather-proof manner.

F. After installation of equipment, the Engineer may perform a site inspection of the equipment. If any equipment has been damaged or if, for any reason, the equipment does not comply with the requirements or testing hereof, the Contractor shall repair or replace the equipment at no cost to the Authority, even though the equipment had been inspected previously. After such satisfactory replacement and/or repair and Engineer's subsequent written approval, the equipment may be tested as per Article 1.05 D.

### 3.03 FIELD TESTS

A. Perform installation test in accordance with Article 1.05 D.

END OF SECTION

## SECTION 16573

## PEDESTRIAN TRAFFIC SIGNALS, PUSHBUTTONS AND MOUNTING HARDWARE

## APPENDIX “A”

## SUBMITTALS

Submit the following to the Engineer in accordance with Division 1 GENERAL PROVISIONS entitled "Shop Drawings, Catalog Cuts, and Samples."

A. Submit the following to the Engineer within forty-five (45) days after receipt by him of the acceptance of his Proposal:

1. A list of manufacturers of equipment to be furnished for the Work of this Section.
2. Detailed drawing(s) for Pedestrian Traffic Signal equipment, including recommended mounting instructions. The submittal shall include the environmental tolerance provisions of the equipment, including the material that the housing, visors, lens, mounting brackets and hardware are fabricated from. Included within this documentation shall be electrical schematic wiring diagrams for the equipment, defining terminal identification number assignment.
3. A complete set of reproducible Mylar shop drawings for the Pedestrian Traffic Signal equipment, from which clear prints can be made.
4. Five complete sets and one reproducible master set of operations and maintenance instructions including preventive and corrective maintenance.
5. One compact disk containing electronic files of a complete master set of shop drawings for the Pedestrian Traffic Signal equipment, operations and maintenance instructions including preventive and corrective maintenance.
6. Five complete sets and one reproducible master set of all test process and results. This shall include, but not be limited to, the Quality Assurance (QA) process and test results documentation, Design Qualification (DQ) process and test results documentation and installation process and test results documentation.

END OF APPENDIX A

# SECTION 16573

# PEDESTRIAN TRAFFIC SIGNALS, PUSHBUTTONS AND MOUNTING HARDWARE

## INSTRUCTIONS TO SPECIFIER

List of items required to be shown on the Contract Drawings:

| Article | Description |
|---|---|
| 1.03 B / 2.02 B.1 | Specify number of LED Countdown Pedestrian Signals, APS and Pedestrian Pushbuttons, if required. |
| 1.03 C | Specify number of Pedestrian Traffic Signals with aluminum housings (if applicable). |
| 1.03 D | Specify the Pedestrian Traffic Signals consistent with their intended design and operation. |
| 1.05 D | Specify any particular testing procedures not previously described (if applicable). |
| 1.07 A | Specify replacement assemblies or spare equipment. |
| 2.01 A | Specify the color of pedestrian traffic signals and related equipment. |
| 2.02 A.1 | Specify power operation other than 115 volts, single-phase AC power. |
| 2.02 B.4.a | Specify whether pedestrian traffic signal is supplied with housing or without housing for a retrofit in existing housing. |
| 2.02 B.5/6 | Specify the signal's mounting brackets to fit both standard post top and side of pole, including clamshell type mounting hardware. |
| 2.02 B.10 | Specify non-standard field wiring (if applicable). |
| 2.02 C.1 | Specify Audible-Tactile Pedestrian Signal System (APS) locations and type. |
| 2.02 C.25.n(4)/ 2.02 D.8 | Specify Pedestrian Pushbutton instruction sign. |
| 2.02 D.1 | Specify the number and location of Pedestrian Pushbutton Assemblies (Non-APS). |
| 2.02 F | Specify pushbutton extension brackets. |
| 3.01 B | Specify equipment to be removed and not required for relocation. Specify removed equipment, if any, which shall be used in a new installation. |
| 3.02 D | Specify the wiring of the Pedestrian Traffic Signals and Pushbutton Assemblies to implement the signal operations. Specify the cable size and number of conductors. |

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16680

# INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

## PART 1. GENERAL

### 1.01 SUMMARY

This Section specifies requirements for inductive detection cable and detector sensor unit.

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section. The engineer is responsible for ensuring that the current edition of these references is utilized during the design process:

American Society for Testing and Materials (ASTM)

| | |
|---|---|
| ASTM D1248 | Polyethylene Plastics Molding and Extrusion Materials for Wire and Cable |
| ASTM D2308-02 | Thermoplastic Polyethylene Jacket for Electrical Wire and Cable |

International Municipal Signal Association (IMSA)

| | |
|---|---|
| IMSA Series 50/51 | Loop Inductance Detection Cable and Wire Specification |

Institute of Transportation Engineers (ITE)

| | |
|---|---|
| ITE ST – 017B | Equipment and Material Standards of the Institute of Transportation Engineers |

National Electrical Manufacturers Association (NEMA)

| | |
|---|---|
| NEMA TS 1 | Traffic Control Systems |

National Fire Protection Association (NFPA)

| | |
|---|---|
| NFPA 70 | National Electrical Code (NEC) |

Port Authority of New York and New Jersey

Traffic Signal Design and Drawing Preparation Guidelines

Underwriters Laboratories, Inc. (UL)

| | |
|---|---|
| UL 467 | Grounding and Bonding Equipment |

### 1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. The inductive detection cable and equipment shall conform to requirements specified in this Section. Where specific requirements are not listed herein, such equipment shall, as a minimum, conform to the requirements of the standards and publications listed in Article 1.02.

B. The detector sensor units furnished under this Section shall be dual-channel detector units in the quantities shown on the Contract Drawings.

C. The detector sensor unit shall respond to changes in the inductance of the sensor loop/lead-in combination(s) connected to its loop input terminals. The unit shall develop a detection output when there is a sufficiently large change in the magnitude of the connected inductance.

1. The detector sensor unit shall detect all motor vehicle types that normally traverse the public roadways, including motorcycles. The detector sensor unit shall detect all vehicles that are stopped and shall detect all vehicles moving at speeds up to 80 miles per hour within the detection zone of the inductive loop.

1.04 ENVIRONMENTAL REQUIREMENTS

A. The detector sensor unit shall operate without degradation or damage under ambient shock (thermal and mechanical), vibration, lightning and electromagnetic/electrical interference at the construction site.

B. The detector sensor unit shall operate over an ambient temperature range from -30°F to +165°F (-34°C to +74°C). Operation of the detector sensor unit shall not be degraded by rain, snow, fog or normally encountered ambient humidity conditions.

1.05 QUALITY ASSURANCE

A. Wires and cables that have been manufactured more than two years prior to installation shall not be used.

B. Verify that sealer is within the manufacturer's established shelf life and has been dated by the sealer manufacturer to so indicate.

C. Sawcutting equipment shall be capable of sawcutting concrete and asphalt pavement to depths of two inches.

D. Air compressor shall be capable of providing the pressure and volume of air sufficient to clear loop sawcut slots of moisture and debris.

E. After installation, test the equipment in the presence of the Engineer to show compliance with the requirements of this Section. Continue testing until the results are satisfactory to the Engineer. Perform all repairs, construction and modifications required to comply with the Specifications at no additional cost to the Authority.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver all materials to the construction site in original unopened containers or bundles with labels that clearly identify the manufacturer and product name, including storage requirements and instructions.

B. Properly store and handle all materials delivered to prevent deterioration or damage due to moisture, temperature change, contaminants or other causes.

1.07 SPARE EQUIPMENT

A. For items with no second source of supply for replacement assemblies, provide spare equipment in quantities as shown on the Contract Drawings.

1.08 SUBMITTALS

Refer to Appendix "A" for submittal requirements.

## PART 2. PRODUCTS

2.01 CONSTRUCTION FEATURES

A. General:

1. All wiring shall be in accordance with the requirements of NFPA 70 National Electrical Code (NEC) as shown on the Contract Drawings. No wiring shall be exposed. Provide electrical connection by barrier type terminal blocks, as defined in NEMA TS 1. Identify all wire terminations and terminal block connections. Locate connections readily accessible for maintenance. Make wire and cable terminations with insulated spade terminals, as defined in NEMA TS 1. Soldering of terminal connections will not be permitted.

B. Detector Sensor Unit:

1. Detector sensor units shall meet the requirements of NEMA TS 1 and in ITE ST-017B. Provide units of solid-state design that employ digital techniques, unless otherwise shown on the Contract Drawings. The units shall conform to requirements of Article 1.03 herein.

2. Detector sensor units shall be as described below and as shown on the Contract Drawings. Provide each detector unit and/or circuit board with a unique serial number.

a. Shelf-mounted, case-contained units shall include two detection channels and shall operate on an input voltage from 89 VAC RMS to 135 VAC RMS. Power supply shall be contained in the unit. Dual-channel units shall interface with two 10-pin mating connectors, MS311106A-18-1S or approved equal for relay output as described above. Provide varistors between power line leads to limit peak transient voltage to 270 VDC.

3. Provide each detector channel with an isolated output circuit such that detection is indicated by either of the following, based upon the application and the requirements of Article 1.03 herein:

a. An output relay, with a contact or resistive load rating of 2 milliamperes through 1 ampere at 18 to 28 volts, 5 amperes at 120 VAC and, 1 ohm maximum closed contact resistance; or

4. Inductive tuning of loops shall be automatic for all types of configurations. The units shall accommodate loop circuits in the range of 20 to 2,500 microhenries. Tuning controls of any kind for this function will not be acceptable. Each unit or detection channel shall be self-retuning on initial turn-on and self-retuning within 30 seconds

of reactivation or restoration of electrical power. The sensor units shall automatically accommodate those after-tuning changes in the loop/lead-in electrical characteristics as might reasonably be expected to occur in undamaged, properly installed loops, without producing a false output or change in sensitivity.

5. Each unit or detection channel shall be capable of operation in one of the following two modes which shall be front panel switch selectable:

   a. Pulse mode: A vehicle passing over a loop shall cause a programmable output pulse of from 100 to 150 millisecond duration. In this mode, the detector shall rephase two seconds after initiation of the above described output pulse. The rephase sequence shall allow for detection of the smallest detectable vehicle within a maximum of 4 minutes subsequent to detection of a stopped vehicle in the loop field.

   b. Presence mode: Continuous output based on continuous occupancy of the loop field. Minimum hold time for the smallest detectable vehicle shall be four minutes and no more than 120 minutes with a 3-turn compact loop and minimum cable lead-in.

6. Each channel of the units shall have three modes of operation; delay, extension and normal that is neither delay nor extension.

   a. In the delay mode, delay the channel output for the time set. If a vehicle departs before the time set, an output shall not occur and the timer is reset. The delay time shall be settable in the range from 1 to 63 seconds. Settability shall be within one second in the 1-15 second range and within two seconds in the 16-63 second range.

   b. In the extension mode, extend the channel output after the vehicle departs the zone of detection for the time set. If a new vehicle arrives before the extension timer times out, the timer shall be reset, the output shall be maintained and the timer shall resume timing when the vehicle departs. The extension time shall be settable in the range from 0.25 to 15.75 seconds. Settability shall be within ½ second.

7. Should continuous detection exceed the presence time programmed, the sensor unit shall retune to the current environment. Operation of a detection channel shall not terminate if the loops are defective through either single point leakage to ground or short to ground. Circuitry in the detection channel shall be such that output response to an open loop is selectable as either a detection or no detection.

8. Provide means such that no detection channel adversely interacts with any other channel installed in the same cabinet.

9. Provide an overcurrent protection device on all sensor units. For shelf-mounted, case-contained units, the circuit breaker shall be accessible from the front or back of the unit. Other overcurrent protection devices may be mounted internally for shelf-mounted units. Lightning protection shall be as specified in ITE ST-017B.

10. Grounding of all sensor units and cables shall be as specified in the NFPA 70 and UL 467.

11. Equip each sensor unit with an indication light or meter for each output circuit to identify when the detector unit is sensing a vehicle. Provide a sensitivity control for each detection channel with a minimum of three sensitivity selections for each channel. All controls and indicators shall be readily accessible from the front panel.

C. Detector Loop Lead-in Cable:

1. Induction loop lead-in cable shall consist of two NEC No. 14 AWG stranded tinned copper conductors insulated with 0.030-inch minimum high molecular weight, heat stabilized, color polyethylene insulation, conforming to both ASTM D1248, Type I, Class B, Grade 4 and IMSA Standard 50-2.

2. Twist the conductors together at the rate of seven turns per foot. Use non-hygroscopic fillers to form a firm compact cylindrical core. Provide a non-hygroscopic core tape with aluminum or copper shield and a ground drain wire.

3. The outer jacket shall consist of an extruded, black, polyethylene jacket, conforming to both ASTM D2308-02 and IMSA Standard 50-2**.**

D. Inductance Loop Wire:

1. Inductance loop wire shall be single conductor No. 14 AWG; polyethylene insulated stranded copper with a 600-volt rating, and shall conform to the requirements of IMSA Standard 51-7. Mark the exterior jacket of the wire at regular intervals with the proper type letter or letters, the manufacturer's name or trademark, the AWG size and the maximum rated voltage.

   a. Protect the loop wire by a continuous flexible polyethylene tubing of 0.184-inch minimum inner diameter, 0.031-inch minimum wall thickness, and 0.26-inch maximum outer diameter, having a smooth bore. The tubing shall be highly abrasion resistant and shall remain flexible from -22°F to +212°F (-30°C to +100°C).

E. Loop Embedding Sealer:

1. Provide detector loop sealer to encapsulate traffic signal loop wires embedded in roadway. The sealer shall be cold applied and may be a one- or two-component system, the viscosity of which shall be sufficient to allow the material to be either poured or placed under pressure and to fully encapsulate the loop wire. The sealer shall be curable at temperatures of 40°F (4°C) and above.

   a. When the sealer is bonded to common paving material, it shall have sufficient strength and resiliency to withstand stresses due to vibrations and differences in expansion and contraction as a result of temperature changes or traffic conditions and shall be compatible with the sheathing or covering of inductance loop wires.

   b. Cured sealer shall be resistant to most chemicals and solvents, including salts, acids and hydrocarbons. Packaged stability of the components in original unopened containers, stored in temperatures from 32°F to 100°F (0°C to 38°C) shall be a minimum of six months.

## PART 3. EXECUTION

### 3.01 PREPARATION

A. Before manufacture or procurement of equipment, submit detailed specifications, catalog cuts and shop drawings outlining the construction and operation details of all equipment for prior Engineer approval as specified in Article 1.07. Procure no equipment until the Engineer has given written approval.

B. Any detector sensor unit or related equipment shown on the Contract Drawings to be removed and returned to the Engineer shall remain the property of the Authority. Deliver all removed existing above ground traffic signal equipment to the location specified on the Contract Drawings. The Contractor shall notify the Engineer prior to delivery. Removed equipment shall not be used in a new installation unless specifically called for on the Contract Drawings. All other equipment designated on the Contract Drawings to be removed shall be disposed of by the Contractor, if the Engineer, in writing, directs the Contractor to dispose of the equipment.

3.02 INSTALLATION

A. Saw cut a rectangular shaped channel of the dimensions shown on the Contract Drawings with an access channel from each loop to the edge of the roadway. Cut the corners of the channels diagonally to assure a clean smooth radius.

B. Blow channel free of debris and moisture after the trench has been cut. If the loop is not immediately installed, install a backer rod filler to prevent the channel from collapsing. At curbs, if any, install a suitable conduit through the curb below the roadway level and terminate in the access channel.

C. Locate the sensor loop(s) connected to the detector unit input terminals at the zone(s) of detection as shown on the Contract Drawings. Connect the sensor loops to the detector sensor units by means of lead-in cable.

D. Install the loop detector wire in its polyethylene tubing continuous without splices, joints, kinks or curls, and no straining or stretching of the tubing around the corners of the channel or junction box. Use a wooden or plastic tool with rounded corners to seat the tubing in the bottom of the channel. After the wire is in place, recheck for slack, raised portions and tightness. If any of the foregoing is found, they shall be corrected. Twist the lead-in wires together with a minimum of seven turns per foot from the loop channel to the nearest junction box.

E. Extend the twisted loop wire from the channel to the nearest junction box. At this point connect to the detector lead-in cable. Install detector lead-in cables continuously without splices from the cabinet housing the sensor electronics to the junction box nearest the loop. Make connection of the lead-in cable to the loop wire with a compression solderless connector secured mechanically and electrically with the proper tool as per ITE ST017B. Clean the conductor with a minimum of insulation removed. Insulate all joints with a resin splicing kit.

F. Lead-in Detector Cable:

1. Terminate the lead-in cable inside controller cabinet at a surge voltage protected terminal strip. Provide a minimum of 3 feet of lead-in cable in each cabinet. Group and tag terminations with cable identification tags that show the loop designations per the Contract Drawings. Secure the conductors to the cable racks using nylon cable ties. Maximum lead-in cable length, unless otherwise shown on the Contract Drawings, shall be 850 feet from field junction box to controller cabinet.

2. Provide induction loop detector leads with slack of:

a. Seven feet in rectangular junction boxes and secure cables to the cable racks using nylon cable ties.

b. Five feet in circular junction boxes and secure all slack cable at the bottom of the box with nylon cable ties. Form the slack cable and wires around the interior of the junction box.

G. After successful testing of the loop in accordance with Article 3.03 A.1, seal the channel with a joint sealant mixed and applied in accordance with manufacturer's instructions. Completely fill the channel with the joint sealant with no air bubbles below the surface. The loop sealer shall be flush with the roadway. Remove joint sealant that is accidentally applied to the roadway surface. Allow the joint sealant to sufficiently harden before allowing traffic to move over the area.

1. At sloping roadway apply the joint sealant in a manner that prevents the joint sealant from running out of the trench and onto the roadway.

H. When the roadway in the area of the loop detector is to be resurfaced, or when constructing a new section of roadway, install the loop detector immediately below the top layer of pavement. The joint sealant shall be hardened before the installation of the pavement.

3.03 FIELD TESTS

A. Perform initial installation test in accordance with Article 1.05 E.

1. Prior to installation of loop sealer, test each loop with a 500-volt megohmmeter. The tested resistance from each loop lead to ground shall be a minimum of 50 megohms. Test each loop for continunity with an ohmmeter. End-to-end resistance shall not exceed five ohms.

2. Perform an inductance test to determine the inductance of the loop. Submit in writing a tabulation of all test results for all loops. Provide a loop inductance meter to perform the inductance tests. If the loop inductance does not conform to the requirements shown on the Contract Drawings, adjust the number of turns of wire in the trench and retest the inductance of the loop.

END OF SECTION

## SECTION 16680

## INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

## APPENDIX "A"

## SUBMITTALS

A. Submit the following to the Engineer in accordance with Division 1 – GENERAL PROVISIONS entitled "Shop Drawings, Catalog Cuts and Samples":

1. A complete set of detailed drawings including reproducible shop drawings on Mylar, from which clear prints can be made. Included within this documentation shall be electrical wiring diagrams defining terminal identification number assignment.

2. Catalog Cuts and Data Sheets: Complete manufacturer's data including chemical resistance, material properties and test methods for loop embedding sealer and characteristics of detector sensor, loop and loop lead-in.

END OF APPENDIX "A"

## SECTION 16680

## INDUCTIVE DETECTION CABLE AND DETECTOR SENSOR UNIT

## INSTRUCTIONS TO SPECIFIER

List of items required to be shown on the Contract Drawings:

| Article | Description |
|---|---|
| 1.03 B | Specify number of dual-channel detector units, if required. |
| 1.07 A | Specify replacement assemblies or spare equipment. |
| 2.01 A | Specify wiring used in accordance with the requirements of the NFPA 70 National Electrical Code. |
| 2.01 B.1 | Specify detector sensor units if other than solid-state design employing digital technologies are required. |
| 3.01 B | Specify equipment to be removed and not required for relocation. Specify removed equipment, if any, which shall be used in a new installation. |
| 3.02 A | Specify saw cut dimensions and shape. |
| 3.02 C | Specify the sensor loop(s) that are connected to the detector unit input terminals. |
| 3.02 F.1 | Specify maximum lead-in cable length if greater than 850 feet from field junction box to controller cabinet. |

END OF INSTRUCTIONS

# DIVISION 16

# SECTION 16715

# VIDEO DETECTION SUBSYSTEM

## PART 1. GENERAL

### 1.01 SUMMARY

This section specifies requirements for a Video Detection Subsystem, referred to hereinafter as VIDS. The VIDS detects the presence of vehicles at a specific point, and from presence data, determine other metrics including vehicle counts, vehicle speed, vehicle occupancy, presence of vehicles in restricted lanes, and wrong way moving vehicles. A VIDS consists of the following components:

1. One of more Video Detection Camera(s)
2. Video Image Processor (VIP) to perform the detection processing
3. Incidental hardware, such as video camera mounting brackets and extensions as required for the proper installation and aiming of the equipment
4. Lens Adjustment Module (LAM) to adjust the camera lens view from the controller cabinet at the time of installation

### 1.02 REFERENCES

The following is a listing of the publications referenced in this Section:

<u>American Society for Testing and Materials (ASTM)</u>

ASTM A 36 – Steel
B 209 – Aluminum and Aluminum-Alloy Sheet and Plate

<u>Federal Communications Commission</u>

Code of Federal Regulations, Title 47 Part 15

<u>National Electrical Manufacturers Association (NEMA)</u>

NEMA TS 2 Traffic Controller Assemblies with NTCIP Requirements

<u>National Transportation Communications for Intelligent Transportation Systems (ITS) Protocol (NTCIP)</u>

<u>Occupational Safety and Health Administration (OSHA)</u>

Title 29, Part 1910. Subpart A. Standard 1910.7 - Recognition Process for Nationally Recognized Testing Laboratories

<u>Port Authority of New York and New Jersey (PANYNJ)</u>

Standards and Guidelines for Port Authority Technology

1.03 DESIGN AND PERFORMANCE REQUIREMENTS

A. VIDS equipment shall support and be programmable for a variety of detection situations and camera placement locations, including:

1. Presence/passage detection of moving and stopped vehicles
2. Detection based on vehicle direction of travel
3. Detection based exclusively on stopped vehicles
4. Speed measurement
5. Occupancy
6. Vehicle Classification (at least four classes: automobile, bus, small truck and large truck)
7. Programmable detector delay functionality for detected entity before call is placed.
8. Pedestrian detection, including both detection of moving pedestrians within a crossing as well as detection of waiting (stopped) or approaching (moving) pedestrians to a crossing.
9. Bicycle detection

B. Count Detection Performance. Count vehicles using a zone based detection system, meeting the following performance requirements:

1. At least 96% accuracy under normal operating conditions (day and night)
2. At least 93% accuracy under artifact conditions. Artifact conditions are combinations of weather and lighting conditions that result from shadows, fog, rain, snow, day/night and night/day transitions.
3. Collect volume count data for traffic on all lanes of the roadway.
4. Collect volume count data over time intervals that contain a minimum of 100 vehicles to ensure statistical significance.

C. Presence Detection Performance. Detect the presence of vehicles, using a zone based detection system, meeting the following performance requirements:

1. Accurately provide demand presence detection.
2. The maximum probability of not detecting a vehicle for demand presence is less than 1% under all operating conditions.
3. In the presence of artifact conditions, the maximum number of extraneous (false) movement calls is less than 7%.
4. To ensure statistical significance, calculate the demand presence accuracy over time intervals that contain a minimum of 100 turning movements.
5. Achieve these performance specifications with a minimum of two detection cameras coupled with a VIP function to provide adequate roadway coverage to sample the random arrival patterns of vehicles at the stop line.
6. Do not include movements where vehicles do not pass through the presence detectors, or where they stop short or stop beyond the combined detection zones in the calculation of the demand presence accuracy.

D. Speed Detection Performance. Measure vehicle speed, using a zone-based detection system, meeting the following performance requirements:

1. Measure average (arithmetic mean) speed of multiple vehicles in the absence of occlusion with:
   a. At least 98% accuracy under normal operating conditions (days and nights)
   b. At least 95% accuracy under adverse conditions (i.e., rain, fog, or snow).
   c. Maintain these levels of accuracy for vehicles traveling between 20 mph and 80 mph.
2. Include more than 10 vehicles in the average speed measurement to ensure statistical significance.
3. Measure individual vehicle speeds with:
   a. At least 95% accuracy under all operating conditions for vehicles approaching the video detection camera (viewing the front end of vehicles)
   b. At least 90% accuracy for vehicles receding from the video detection camera (viewing the rear end of vehicles)

E. These specifications apply to vehicles that travel through both the count and speed detector pair and do not include partial detection situations created by lane-changing maneuvers.

## 1.04 ENVIRONMENTAL REQUIREMENTS

A. Furnish field equipment and associated control and electronics equipment for outdoor installation and use. Field assemblies shall be compliant with the requirements of NEMA Standard No. TS-2, Section 2, "Environmental Standards and Test Procedures," except as amended and supplemented herein. Mount all field equipment in sealed enclosures, as appropriate; to ensure that water, dust and other contaminants cannot enter internal assemblies. Furnished field equipment shall be suitable for use in the environmental conditions described in 1.04 C.

B. Furnish equipment with a circuit design that compensates for adverse effects due to temperature in the specified environmental range. Field equipment shall not require programming changes to compensate for different environmental conditions.

C. Unless otherwise noted, field assemblies shall be stable when subjected to any combination of the following conditions:

1. Ambient Temperature Range: -30°F to +165°F (-34°C to +74°C).
2. Relative Humidity: 0% to 95%, non-condensing
3. Rain or Snow Precipitation Rate: 4 inches per hour
4. Vibration: 2g, up to 200 Hz sinusoidal
5. Shock: 5g 10 ms half sine wave
6. Wind Velocity (gust): 110 mph

## 1.05 QUALITY ASSURANCE

A. Contractor's Qualifications. At any time after the opening of the proposal, the Engineer may give oral or written notice to one or more bidders to furnish information that demonstrates to the satisfaction of the Authority a minimum of five

years of experience and technical expertise in performing contracts comparable in size and complexity, and that the work was performed skillfully, on time and in a satisfactory manner. Submit a complete list, consisting of a minimum of three installations, at least one of which is located in the United States, which included work comparable in type, size, and complexity to the Work of this Contract and have been in satisfactory operation for a minimum of the last three consecutive years. Information shall be furnished within seven (7) days thereafter.

B. Schedule and conduct a pre-installation conference to review and coordinate the work as described herein.

C. After delivery of the VIDS, a site inspection may be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements hereof, then the Engineer will notify the Contractor in writing. In this situation, repair or replace the equipment at no cost to the Authority even though the equipment had been approved for shipment. After such satisfactory replacement and/or repair and subsequent Engineer's written approval, install the equipment.

D. After installation, test the VIDS in the presence of the Engineer to show compliance with the requirements of this Section. Continue testing until the results are satisfactory to the Engineer. Perform any repairs, construction, or modifications as required to comply with these Specifications without additional cost to the Authority.

1.06 DELIVERY, STORAGE AND HANDLING

A. Bear the costs of all shipping to the site and of all unusual storage requirements. Make appropriate arrangements and coordinate with authorized personnel at the site for the proper acceptance, handling, protection, and storage of delivered materials.

B. Bear responsibility for the movement of material, either at the time of delivery or subsequently until final installation. Bear responsibility for all costs associated with this movement.

C. Bear responsibility for the safe storage of all equipment until final acceptance. In the event of equipment disappearance from the site, bear full responsibility and all costs associated with equipment replacement at no additional cost to the Authority.

D. Furnish spare parts as recommended by the manufacturer. At a minimum, and unless otherwise noted on the Contract Drawings, supply one spare replacement for each component of the VIDS Subsystem.

1.07 SUBMITTALS

See Appendix "A" for additional submittal requirements.

1.08 WARRANTY

A. Notwithstanding the Contract Drawings, any inspection or approval by the Engineer of the equipment or its installation, or the existence of any patent or trade name, the Contractor nevertheless warrants and represents that all equipment and the other items including the software, firmware and other items supplied to the Engineer hereunder and all workmanship are in accordance with the Contract, fully fit for performance and operate in accordance with the requirements of the Contract Documents. The Contractor guarantees that all equipment and other items to be supplied meet original manufacturer's specifications. The Contractor guarantees all

equipment and other items to be supplied and workmanship against defects or failures in workmanship and materials, excepting to the extent of defects or failures which the Contractor demonstrates to the satisfaction of the Engineer have arisen by reason of accident, abuse or negligence or fault of the Authority, its agents, employees, Licensees or invitees, and not due to fault on the Contractor's part. In the event of defects or failures in said equipment, or other items, or workmanship or any part thereof, then upon receipt of notice thereof from the Engineer, the Contractor's warranty obligations for the Equipment are to repair or replace and make operational all equipment components at no cost to the Authority within 48 hours of being notified of the condition.

B. Unless otherwise stated in the respective technical parameters for specific VIDS devices, remedy all defects for a period of one year. This one year period starts after issuance of the certificate of final completion for all work excluding maintenance for the Contract. Assume responsibility to adhere to this warranty period.

C. The VIDS software shall be warrantied for a minimum of 3 years from the date of delivery to the Authority which includes, but not limited to, software upgrades, documentation revisions, and the media on which the software is supplied being free from defects in material and workmanship. Provide, repair, or replace software components as describer during the warranty period at no cost to the Authority.

## PART 2. PRODUCTS

### 2.01 CONSTRUCTION FEATURES

A. General

1. Construct all equipment in a workmanlike manner and present a neat and finished appearance when completed. Full operation of the equipment based on the manufacturer's manual/user guide shall commence immediately upon the energizing of the Subsystem's power source

2. Furnish hardware and software consisting of only off-the-shelf products, ready for installation, requiring minimum custom hardware or software development. Configure the VIDS with commercial off-the-shelf products that are available from multiple manufacturers and suppliers. Furnish hardware, software and communications protocols that conform to Authority's Standards and Guidelines for Port Authority Technology. Wherever possible, use modular construction with assemblies, sub-assemblies and modules that are available from a second source of supply.

3. Furnish all necessary cables, connectors, and wiring to provide a fully operational VIDS.

4. Furnish all necessary mounting hardware and brackets necessary for the operation of the VIDS.

B. Video Detection Camera

The following are the requirements for the Video Detection Camera:

1. A pre-focused lens from the factory, as required for operation.

2. Produces images with a ¼" CCD sensing element with horizontal resolution of at least 470 TV lines and vertical resolution of at least 400 lines.

3. Provides an effective pixel size of 768 by 494 pixels.
4. Operates at a maximum frame rate of 30 frames per second (FPS).
5. Provides useable video and resolvable features in the video image when those features have luminance levels as low as 1 lux at night and as high as 10,000 lux.
6. Is equipped with an integrated 12X zoom lens with zoom and focus capabilities that can be changed using either configuration computer software or a hand-held controller.
7. A lens with a horizontal viewing range of at least 4° to 48°.
8. Provides video in NTSC format
9. Provides direct real-time iris and shutter speed control.
10. Provides an optical filter and appropriate electronic circuitry to suppress 'blooming' effects at night.
11. Able to monitor a minimum of 6 to 8 travel lanes simultaneously, when placed at a mounting height that minimizes vehicle occlusion and equipped with a lens to match the width of the road.
12. Uses an input of 89-135 VAC, 50/60 Hz
13. Housed in a NEMA Type 4 Enclosure, constructed of steel, aluminum, or aluminum alloy and meeting the requirements of ASTM A 36 or ASTM B 209.
    a. Enclosure shall allow the video detection camera to operate satisfactorily over an ambient temperature range specified in 1.04 while exposed to precipitation as well as direct sunlight.
    b. Enclosure shall allow the video detection camera horizon to be rotated during field installation
    c. Enclosure shall allow rear access of the enclosure for connection of the factory-fabricated power, communications and video signal cable(s), while still maintain the NEMA Type 4 requirements.
    d. Enclosure shall contain a heater at the front of the enclosure to prevent the formation of ice and condensation in cold weather, as well as to assure proper operation of the lens' iris mechanism. The heater shall not interfere with the operation of the video detection camera/CCD array electronics, nor cause interference with the video signal.
    e. Enclosure shall contain a sun shield to minimize solar heating and glare, protruding beyond the front edge of the environmental enclosure and including a provision to divert water flow to the sides of the sunshield. Enclosure shall allow the sunshield to be adjusted to prevent direct sunlight entering the lens or hitting the faceplate.
    f. Shall include all mounting hardware as specified by the enclosure manufacturer, with all nuts, bolts, and locknuts being constructed of stainless steel, regardless of the material specified by the manufacturer.
14. Meet FCC Title 47 Part 15 Class A requirements for electromagnetic interference.

C. Video Imaging Processor (VIP)

1. Support video input from up to two cameras and video output for up to two video feeds.

2. Provide two video connections for input, and one composite video connection for outputs, switchable to view any of the video inputs via pushbutton. Each video connection is a 75 Ohm, 1 Vpp BNC Connection which inputs and outputs video in NTSC format.
3. Provide at least 4 open collector inputs and 4 open collector outputs. For more outputs (up to a maximum of 24 per video feed), extension modules may be used.
4. Provide LED lights which show the open or closed status of each contact closure output, and LED lights depicting the overall status of the VIP unit.
5. Provide a minimum of one USB port for connecting a mouse or laptop to the VIP.
6. Provide a minimum of one RS-232 port for connecting a laptop to the VIP.
7. Provide a composite video output for connecting a monitor to the VIP.
8. Provide an Ethernet connection to connect to a central control system.
9. Support video input at a maximum frame rate of 30 frames per second.
10. Be mountable in a NEMA Type C or D rack.
11. Power input is 12 or 24 VDC.
12. Provide interface to support the adjustment of zoom and focus of the detection camera(s).
13. Maintain a non-volatile operations log, to include the following, at a minimum:
    a. Revision numbers for the current VIP hardware and software components in operation
    b. Title and comments for the detector configuration
    c. Date and time the last detector configuration was downloaded to the VIP
    d. Date and time the operation log was last cleared
    e. Date and time communications were opened or closed with the VIP
    f. Date and time of last power-up
    g. Time-stamped, self-diagnosed hardware, software errors that aid in Subsystem maintenance and troubleshooting
14. VIP Detection Zone Programming. Support detection zone programming using either a portable computer or mouse/monitor combination, using the mouse/monitor combination or an external laptop. Provide the following functionality for the interface:
    a. Support a minimum of 20 detection zones placed anywhere in the field of view of the Video Detection Camera.
    b. Superimpose detection zones on the video detection camera video stream.
    c. Place, size, and orient detection zones to provide optimal roadway coverage for vehicle detection
    d. Modify detector parameters for site geometry to optimize performance
    e. Edit previously defined detector configurations
    f. Add detectors for additional traffic applications
    g. Combine the output of several detectors with logical operators and as directed by the Engineer, modify the cumulative state based on delay or extension timers and the state of any associated signal phase
15. Provide the following upload/download capabilities:
    a. Download detector configurations from the computer to the VIP

b. Upload the current detector configuration that is running in the VIP
c. Back up detector configurations by saving them to the computer's removable or fixed disks
d. Perform the upload, store, and retrieve functions for video snapshots of the VIP's view

16. Be capable of verifying the real-time detection operation of the VIP through the following means:
    a. Viewing the video detection camera output with any standard video display device (monitor)
    b. Be capable of selectively transmitting:
        i. Camera video only
        ii. Camera video overlaid with the current real-time detection state of each detector

17. The time interval duration used for data storage shall be user-selectable, including at a minimum: 20 seconds, 30 seconds, 1 minute, 5 minutes, 15 minutes, and 60 minutes.

D. Mounting

1. Mount all VIDS equipment in accordance with the manufacturer's guidelines, and as shown on the Contract Drawings.

2. Provide equipment with mounting brackets and hardware for rigidly attaching video detection camera(s) to poles/structures without requiring any machining operation. Provide mounting hardware which allows for adjustment of the vertical position on the pole. Provide mounting hardware for the Detector transmitter unit and the receiver unit. Mounting hardware shall have capability to adjust the angular orientation of the optical axis in both the horizontal and vertical planes over the required angular range for optimal field of view. Allow for directional adjustment and aiming after initial installation.

3. Install poles, foundations, and equipment consisting of readily available and proven equipment, fully consistent with their intended design and operation as specified herein. Special or custom-built components may be used only upon Engineer's written approval.

E. Electrical & Power

1. Each VIDS component shall operate utilizing standard utility 120V AC+/- 10%, 60HZ. Power conditioning equipment shall be included with the VIDS for any component that requires more stringent power requirements from that which is supplied by the local utility in the jurisdiction for which the Subsystem is to be installed.

2. Provide video output of the video detection camera which is isolated from earth ground.

3. Provide video connections from the video detection camera and VIP to the interface panel which are isolated from earth ground.

4. Provide video output, communication, and power stages of the video detection Subsystem which include transient protection to prevent damage to the video detection subsystem due to voltage transients occurring on the cable leading from the video detection subsystem to other field terminations.

5. Provide cable from the camera to the control cabinet in a single continuous section with a factory-installed connector at the camera.
   a. Use video cables of type RG59 or RG11, as recommended by the VIDS manufacturer.
   b. Splices are not permitted.
   c. Provide cable which is UV-stabilized, and as specified by the camera manufacturer in pre-manufactured continuous lengths, as defined in the shop drawings.
6. Field verify the required cable length(s) prior to placing an order for the cable(s).
7. Install appropriate devices meeting UL and ETL standards in the VIDS enclosure and local control cabinets to protect the VIDS electronics from over-voltage situations, such as lightning strikes and power surges over the lines. Circuitry protection includes, but is not limited to telephone line and RS-232 Data Line protectors to guard against circuit damage resulting from voltage surges on all communications lines.
8. Install separate protection devices at each VIDS location that are readily accessible for ease of replacement. The components shall be plug-in or screw-in units, which require virtually no system downtime to replace. The devices shall be clearly and permanently labeled.

F. Communications Protocol Requirements

1. Comply with the NTCIP requirements for the communications interface between the device and the Operations Control Center (OCC); and between the device and laptop computer (NTCIP components).
   a. Utilize the most recent published or amended NTCIP standards, later published versions may be allowed, by the Engineer. Each NTCIP Standard can be found at www.ntcip.org.
      i. Conform to the applicable NTCIP standards. To claim conformance with the NTCIP referenced standards, fulfill the mandatory requirements and objects as identified in the referenced standards for the implementation of NTCIP devices.
      ii. For each NTCIP component, support the optional requirements and objects as specified in these Specifications, as defined by the appropriate standards and any standards it references.
   b. Application Level
      i. Conform to NTCIP 2301 and fulfill all the General Requirements and SNMP Requirements in NTCIP 2301. The device shall respond to requests from the OCC or a laptop computer with the same Application Profile used by the request. The device shall support the receipt of Application data packets at any time allowed by the subject standards.
      ii. Provide a completed Protocol Requirements List (PRL) as contained in NTCIP 2301, Annex A to indicate which options of this NTCIP standard were implemented. The PRL is a listing of mandatory and optional requirements specified within the corresponding standard. Use the PRL to indicate which requirements each NTCIP component supports.
   c. Transport Level

i. Use a routable protocol for the communications link between the device and the OCC. Conform to NTCIP 2202 and fulfill all its mandatory requirements. Support the Transmission Control Protocol (TCP) options defined by the standard. For response datagrams, use the same Transport Profile used in the request. Support the receipt of datagrams conforming to any of the identified Transport Profiles at any time.

d. Subnet Level

i. Unless otherwise specified in these Specifications, use Ethernet communications for the communications link between the device and the OCC over the optical fiber. For each NTCIP component, conform to NTCIP 2104 using the Internet protocol, conform to IEEE 802.3 standards, and support 10Base2 or 10BaseF physical layer configuration.

e. Provide the latest version of the manufacturer's Maintenance/Diagnostics Laptop software, which executes all commands and monitors/modifies all settings available within the device using the same NTCIP object definitions required above regardless of whether these are utilized.

f. If there is an ambiguous statement in the NTCIP standards referenced by this Specification, contact the NTCIP Coordinator (at www.ntcip.org), and request a proper interpretation of the statement. Notify the Engineer of the resolution within 3weeks.

g. Intellectual Property Rights. Submit all communication protocol and NTCIP object documentation to the Engineer including written authorization that the Authority can use any and all parts of these communication protocols and comments for its beneficial use. If additional NTCIP objects beyond the referenced standards are needed to support functionality required in the Contract Documents, notify the Engineer, in writing before factory acceptance testing. Clearly document the proposed object(s) including how the object is used, and all variables. An approval from the Engineer in writing is required for each proposed additional object prior to commencing the Factory Acceptance Test.

2. Comply with the following requirements for the communications interface between the device and any software to control, maintain and diagnose the field equipment, if this interface is specified in the Contract Documents. This includes any software that may reside on a central server, a workstation at an operations center; or any maintenance / diagnostic laptops required.

a. Intellectual Property Rights. Grant permission for the use of any and all parts of these communications protocol and commands by any party authorized by the Authority for its beneficial use.

3. Configuration and Diagnostics

a. Allow configuration and diagnostics of the VIDS to be performed both remotely and via direct connection to the VIP with a portable computer.

b. Allow a user to update the embedded software with a new software or firmware release and interact with a PC client/server application for all of the various detection requests supported by the VIDS.

c. Use a RS-232 or USB port as the communications diagnostics configuration and diagnostics port.

d. Use the UDP/IP message packet and routing standard as the communications protocol. Use this protocol throughout the field network of video detection subsystems, hubs and the host PC server application or traffic control system.

## 2.02 FACTORY ACCEPTANCE TESTS

Perform all Factory Acceptance Tests designated in this and other VIDS subsystem specifications. The Engineer may elect to witness these tests. The purpose of this Test is to verify the conformance of the equipment with the design, performance, mechanical, electrical, environmental and functional requirements specified.

1. The Factory Acceptance Test shall comply with 3.04.A of this Section.
2. Provide all test equipment, test facilities, and personnel required for the performance of the Factory Acceptance Test. Pay for all costs incurred for the conduct of this Test. Perform the Factory Acceptance Test at the manufacturer's facilities or at an independent testing laboratory.
3. The Factory Acceptance Tests shall include the appropriate tests detailed in NEMA Standard TS-2-1998, Traffic Controller Assemblies with NTCIP Requirements, Section 2, "Environmental Requirements". These tests shall include, but not be limited to the temperature, transient, voltage, humidity, power interruption, and shock (impact) tests. The Factory Acceptance Test shall minimally include the vibration test.
4. The Engineer may waive, in writing, the performance of the Factory Acceptance Test if the signed certificates of compliance or calibration clearly meet or exceed all performance, mechanical, electrical and environmental requirements of these Specifications. Submit all requests in writing along with the necessary signed certificates of compliance and calibration to the Engineer two weeks prior to when the test plans are required. Without written approval, all factory test procedures shall be submitted as specified in the Contract Drawings.
5. NTCIP Standard Conformance Testing. For equipment using NTCIP standards for communications, test for conformance to the standard(s) used.
   a. For NTCIP standards that have applied the Systems Engineering Process (SEP), test for the proper implementation, as defined by the standard, of all mandatory and included optional requirements, as specified in the Protocol Requirements List (PRL).
   b. For NTCIP standards that have not applied the Systems Engineering Process, test for the proper implementation, as defined by the standard, of all mandatory and included optional objects, as specified in the conformance groups of the standard.
   c. Prior to testing, submit a detailed test design specification, test cases, and test procedures for Engineer’s approval. For NTCIP standards containing test cases and test procedures, use those provided in the standard.

## PART 3. EXECUTION

### 3.01 EXAMINATION

A. Before delivering the equipment to the installation site, investigate the site conditions to determine the best method of shipment, what preparatory work, if any, will be needed to bring the equipment onto the site, and what will be the best and quickest method of unloading the equipment and setting it in place.

B. Report immediately to the Engineer any electrical, structural or related construction defects in areas where equipment is to be installed. Do not attempt to rectify any defect unless specifically instructed by the Engineer.

C. Before unloading the equipment, an on-site inspection will be made by the Engineer. If any equipment has been damaged or for any reason does not comply with the requirements of the Contract Drawings, the Contractor will be notified in writing. In such a situation, replace the equipment at no cost to the Authority.

### 3.02 REMOVALS

A. Deliver any equipment designated to be removed and returned to the Authority, as shown on the Contract drawings, to a facility location designated by the Engineer. Do not reuse removed equipment unless specifically called for on the Contract Drawings.

B. Any VIDS-related equipment shown on the Contract Drawings to be removed and returned to the Engineer shall remain the property of the Authority. Deliver all removed VIDS-related equipment to the location as specified on the Contract Drawings. The Contractor shall notify the Engineer prior to delivery. Removed equipment shall not be used in a new installation unless specifically called for on the Contract Drawings. All other equipment designated on the Contract Drawings to be removed shall be disposed of by the Contractor, if the Engineer, in writing, directs the Contractor to dispose of the equipment.

### 3.03 INSTALLATION

A. Install equipment and components in accordance with the Contract Drawings and approved submittals.

B. Set work accurately in location and alignment. Provide anchorage devices and fasteners where necessary for installation and connection to other construction.

C. Prior to energizing, test all field-installed wiring for continuity and connection. Tag-identify all terminations.

D. Optimize the real time detection performance of the VIDS by following the recommendations of the manufacturer. Develop guidelines and obtain the approval of the Engineer prior to installation. The factors to be taken into consideration for optimization are:

1. The traffic application
2. Video detection camera mounting location
3. The number of travel lanes to monitor
4. The sizing, placement, and orientation of vehicle detectors
5. Traffic approaching and/or receding from the video detection camera’s field of view

6. Minimizing the effects of lane-changing maneuvers

E. Using either a mouse/monitor combination or a laptop provided by the Contractor, configure the VIP for detection. Provide flexible detection zone placement anywhere and at any orientation within the field of view. Develop a configuration Plan and obtain the approval of the Engineer prior to configuring the VIP. Standard configurations to be used are:

1. Detection zones placed across travel lanes for optimal count accuracy
2. Detection zones placed parallel to travel lanes for optimal presence detection accuracy of moving or stopped vehicles
3. A single detection zone to replace one or more conventional detector loops connected in series
4. Detection zones overlapped for optimal roadway coverage
5. Selective groups of detectors logically combined into a single output by using optional delay and extend timing and signal state information
6. Achieve optimal detection when the video detection camera placement provides an unobstructed view of each travel lane where vehicle detection is required. Obstructions are not limited to fixed objects; obstruction of the view can also occur when vehicles from a lane nearer to the video detection camera obscure the view of a travel lane further away from the camera.

3.04 FIELD QUALITY CONTROL

A. General. At minimum, perform a field test, a subsystem test, and a 30-day operational test. If VIDS is installed with a new traffic signal controller(s), the procedure for activation of new traffic signals at PANYNJ facilities shall govern and any information notwithstanding outlined below shall be performed in conjunction with traffic signal controller activation.

1. Perform initial installation test in accordance with 1.05 D and as specified herein.
2. After installation, test the VIDS in the presence of the Engineer to show compliance with the requirements of this Section and with the applicable sections of the Traffic Signal Pre-Final/Turn-On Checklist. Continue testing until the results are satisfactory to the Engineer. Perform all repairs, construction and modifications required to comply with the Specifications at no additional cost to the Authority.
3. After malfunctions are corrected, a 30-day operational test period shall commence. In the event of a failure of any component, the final period countdown shall come to a halt. After said malfunctions are corrected, restart the 30-day test.
4. After satisfactory completion of the 30-day operational test, provide documentation for the installation to the Engineer for Asset Commissioning. Said documentation shall be completed and returned to the Engineer without additional cost to the Authority.
5. Furnish and maintain required test equipment. Use test equipment having a calibration certification in accordance with the manufacturer's recommendations.
6. Equipment that fails any test within the approved test plan will be considered defective and will be subject to rejection by the Engineer. In the event a defect is

determined, identify whether it is limited to a specific unit or could be a problem in all such units.

7. In the event that the equipment malfunctions during the test period, the Engineer may declare a subsystem defect and require replacement of all equipment, at no additional cost to the Authority. When a subsystem defect is declared, restart the test in progress for that specific subsystem. Begin the test period when all similar equipment is replaced and retest has been successfully completed.

B. Field Tests. Perform all field tests designated for VIDS Devices in the presence of the Engineer.

1. Perform field tests on each piece of equipment after installation but before connecting equipment to the rest of the subsystem, to verify that all requirements described in this Contract are met.

2. Provide the required test equipment, including a portable computer and test software.

3. If any device or component fails to pass a field tests more than twice, replace it with a new device component of the same make and model, and repeat the entire field test until proven successful.

C. Subsystem Tests. Perform a Subsystem test at each installation location indicated on the Contract Drawings after all equipment has been field tested. Demonstrate that the equipment operates as intended to the satisfaction of the Engineer. Demonstrate to the satisfaction of the Engineer that the subsystem is properly integrated with the communications network and can be operated remotely. This requirement may be waived if the communications infrastructure is not yet available.

1. Conduct a Subsystem test to verify that the subsystem meets the functional and integration requirements described in the Contract Drawings.

2. Verify that all functional requirements of the Specifications have been met for each subsystem. Conduct the test by using the VIDS devices and ancillary components with the communications subsystem. Demonstrate full control of the devices from a remote center. Demonstrate proper communication with the devices and that devices meet the functionality of local/remote troubleshooting and diagnostics as shown on the Contract Drawings.

3. No time extensions will be granted to perform the operational test due to any failures.

D. 30-day Operational Test. Request from the Engineer in writing to begin the 30-day Operational Test after all Subsystem Tests have been successfully completed. Upon receiving approval from the Engineer, perform a 30-day Operational test.

1. Demonstrate to the satisfaction of the Engineer the repeated ability of the VIDS to detect the presence of a vehicle in each detection situation that intended for the VIDS.

2. Demonstrate to the satisfaction of the Engineer the accuracy of collected speed data by simultaneously measuring vehicle speeds with the VIDS and a radar gun provided by the Contractor, and comparing the results (if applicable).

3. Demonstrate to the satisfaction of the Engineer the accuracy of vehicle count data by simultaneously performing a traffic count with the VIDS, and via a manual method, and comparing the results (if applicable).

4. Demonstrate to the satisfaction of the Engineer the ability of the VIDS to properly classify a vehicle by simultaneously using the VIDS to classify a vehicle and manually classifying a vehicle (if applicable).

5. Demonstrate to the satisfaction of the Engineer the ability of the VIDS to correctly interface with a traffic controller.

6. During this 30-day Operational test, the equipment will be placed into normal operation by the Authority.

7. During the 30-day Operational test, bear responsibility for all preventive and remedial maintenance of the systems and subsystems being tested.

8. Provide technical personnel familiar with the VIDS system and subsystems within 24 hours of notification of the need for their service.

9. Any errors or equipment malfunctions encountered by the Authority will be submitted in writing to the Contractor. Address and resolve each item or comment submitted by the Authority to the satisfaction of the Engineer. The replacement of equipment may result in restarting the 30-day Operational test at the discretion of the Engineer.

E. Systems Acceptance. Request from the Engineer in writing to begin the System Acceptance Test after the 30-day Operational Tests have been successfully completed. Upon receiving approval from the Engineer, the System Acceptance will begin.

1. Systems Acceptance will be provided in writing by the Engineer. The date of Systems Acceptance will be the date of written acceptance by the Engineer.

2. Correct all defects or omissions noted on all final inspections at no additional cost to the Authority before Systems Acceptance is provided.

3. Submit all documentation, as required in Appendix ‘A’, before Systems Acceptance is provided.

4. Complete all training courses as required in 3.05 herein, before Systems Acceptance is provided.

## 3.05 TRAINING

The vendor/supplier shall provide the following training:

A. Operations Training. Provide training to users responsible for regular operations of the equipment, prior to the start of the 30-Day Operational Test. The exact schedule of the courses will be determined by the Engineer. At minimum, include the following items in the Operations Training Course:

1. An overview of VIDS operations and functions.

2. A complete description of VIDS hardware and software.

3. Hands-on start-up, operation, configuration, and shut-down of the VIDS at the VIDS cabinet and the configuration software for all access privilege types, e.g., operator and administrator.

4. A thorough review of all material contained in VIDS procedures.

B. Maintenance Training. Provide training to users responsible for regular maintenance of the equipment, prior to the start of the 30-Day Operational Test. The exact schedule of the courses will be determined by the Engineer. At minimum, include the following items in the Maintenance Training Course:

1. An overview of VIDS operations and functions, including a summarized repetition of the training covered under the Operations Training Course.
2. A complete description of VIDS hardware and software.
3. Theory of operation of all VIDS components.
4. A complete description and demonstration of all diagnostic routines.
5. Instruction in VIDS "trouble-shooting" and problem identification procedures.
6. Instruction on how to configure VIP and VIP Camera via the VIDS cabinet and the remote interface/software.
7. Hands-on operation and invocation of diagnostic capabilities of the VIDS at the VIDS cabinet and the configuration software.
8. Instructions on minor servicing procedures in the field or by means of appropriate training models.
9. Complete description of recommended preventive maintenance procedures.

C. Training shall be conducted at an Authority facility. All space requirements for training shall be provided with the training plan. If training requirements cannot be accommodated at an Authority facility, notification will be provided as comments to the training plan. Provide a location within the port district, if the Authority cannot accommodate the space requirements of the training.

D. Conduct Training. Conduct independent sets of training classes for each course at the scheduled times and locations consistent with the approved training plan. Conduct training around the clock to coincide with the normal shifts of the operations, supervisory and maintenance personnel as directed by the Engineer. Class sizes shall contain no more than 10 students for classes conducted indoors or 5 students for field sessions, and all classes shall include hands on training to all participants. Conduct each class in a maximum of one four-hour session on any given day. Conduct class sessions on consecutive days when possible. Conduct the full complement of training courses over a period of time directed by the Engineer to accommodate shift personnel, vacations and make up sessions.

E. Provide sufficient training materials for all students in each class, including, at minimum: a course outline, a graphical presentation, all operations and maintenance manuals, test equipment and tools, and any other information needed as determined by the Engineer. Use documentation defined in Appendix 'A' 1.02 of this Section. If there is any discrepancy between training material and documentation, update the documentation.

**END OF SECTION**

## SECTION 16715

## VIDEO DETECTION SUBSYSTEM

## APPENDIX "A"

## SUBMITTALS

A. Submit the following to the Engineer within forty-five (45) days after receipt by the Contractor of the acceptance of his Proposal:

1. Names and locations of at least three users who have had a minimum of one-year experience with the software and equipment to be furnished for Work of this Section. These users may be contacted by the Engineer to verify equipment performance, replacement and spare parts availability, delivery and other items as deemed helpful by the Engineer.
2. For approval, a list of manufacturers of equipment and software to be furnished under the Work of this Section.

B. Submit to the Engineer for approval not less than thirty (30) days prior to the intended start date for the training courses an outline of the curriculum for each course.

C. Prepare and furnish complete operation and maintenance manuals for the VIDS for approval not less than thirty (30) days prior to the intended start date for the training courses. Provide manuals that describe all operating and maintenance procedures for the personnel who use and operate the equipment. Include in the manuals a general description of the equipment, and its configuration, and shall state its intended use. The manuals shall, at a minimum, include the following:

1. Equipment operation
2. Complete installation procedures
3. Complete performance specifications (functional electrical, mechanical, and environmental)
4. Complete and accurate troubleshooting, diagnostics, and maintenance procedures.
5. Field wiring and equipment wiring or circuit board schematic diagrams indicating "factory" and "field" wiring.
6. Complete nomenclature and commercial number of replacement parts, including current prices, listing of spare parts initially provided and a second source of supply where applicable, cross-referenced as to component designation.
7. Each manufacturer's printed operating and maintenance instructions.
8. List of recommended cleaning agents and procedures.
9. List of recommended test equipment including manufacturer's name, address and model number.

D. Submit the following to the Engineer in accordance with Division 1 – GENERAL PROVISIONS entitled "Shop Drawings, Catalog Cuts and Samples":

1. Catalog Cuts and Data Sheets: Detailed drawing(s) for all equipment and outdoor environmental housings of the VIDS, including recommended mounting instructions, demonstrating compliance with NEMA environmental standards and in accordance with NEMA testing procedures, including external icing, hose down and corrosion protection.
2. Provide wiring and conduit details indicating wires, terminals, and size and routing of each respective element.
3. Provide a function drawing (i.e. schematic or one-line drawing) of the proposed network communications.
4. Provide a document which identifies the name, model number, serial number, warranty and technical support phone numbers for all subsystem devices and components for each VIDS site to facilitate project maintenance.
5. Provide communications diagram describing all subsystems and components, including connections to VIDS devices (where applicable).
6. Provide manufacturers' current catalog cut and installation sheet for each product used in the System specified in other Sections of this Contract.
7. Provide design calculations for any proposed mounting structure. Design calculations shall be performed in accordance with the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.
8. Prior to procurement of the equipment, submit detailed drawing(s) for all equipment including recommended VIDS mounting instructions.
9. Furnish a function drawing (i.e. schematic or one-line drawing) illustrating the interrelationship between the various components in relation to the traffic signal controller and all other associated devices so as to graphically define the integrated system with overall dimensions and internal arrangement of the VIDS equipment in the cabinet. The function drawing shall be appended by a cabinet wiring diagram demonstrating detailed wiring within the cabinet. Procure no equipment until the Engineer has given written approval.
10. A complete set of reproducible shop drawings for the VIDS and associated equipment and five sets of prints thereof. Include a bill of materials with the manufacturer's name and part numbers, electrical schematic wiring diagrams for each different type of equipment, and connection diagrams to the printed-circuit-board level for the entire VIDS subsystem defining terminal identification number assignment.
11. Submit a detailed plan for configuring the components of the VIDS to optimize for the intended type of detection.
12. VIDS components shall be manufactured and assembled according to the product specifications. Submit to the Engineer a signed verification upon delivery of VIDS components.
13. User Guide: Include at a minimum; a description of the VIDS subsystems operating procedures written for non-technical personnel. Clearly describe the functions

supported by the subsystem and the step by step procedures with examples containing diagrams, drawings and pictures of the user controls.

E. Supply the software with full documentation on a CD-ROM.

F. Provide documentation containing a complete, detailed description of the communications protocol and commands between the device and any software specified and provided by these Specifications to control, maintain and diagnose the field equipment. Provide and allow the use of any part and all of the communications protocol and commands by any party authorized by the Authority for its beneficial use, regardless of what parties are involved.

G. For devices using NTCIP standards for the communications interface, provide a CD-ROM containing ASCII versions of the following Management Information Base (MIB) files in Abstract Syntax Notation 1 (ASN.1) format.

H. For testing of the VIDS subsystem, the Contractor shall adhere to the following:

1. Notify the Engineer of the date, time, and place of each test at least 14 days prior to the date the test is planned to be conducted. Conduct the test in the presence of the Engineer.

2. Provide test plans, test procedures, copy of all test documentation.

3. Test Report: Upon completion and testing of the installed subsystem, submit test reports to the Engineer in a booklet form, tabulating all field tests and measurements performed.

4. Upon completion of testing and the 30-day operations test, submit a written report identifying equipment, software and components adjusted, repaired, or replaced during the 30-day test. Include testing results in the report, tabulating all field tests and measurements performed.

**END OF APPENDIX "A"**

## SECTION 16715

## VIDEO DETECTION SUBSYSTEM

## INSTRUCTIONS TO SPECIFIER

A. The Specifier shall review all items listed in Appendix "A". Remove all items that are not applicable to this project and add to the Appendix "A" under the proper headings any submittal items intended to be shown on the Contract Drawings.

B. List of items required to be shown on the Contract Drawings:

| Article | Description |
|---|---|
| 1.03A | Specify application of the VIDS. |
| 1.06D | Specify the replacement quantities for items with no second source of supply. |
| 2.01D | Specify all details, mounting or otherwise, that require shop drawings and/or calculations. |
| 3.02 | Specify equipment to be removed and not required for relocation. Specify removed equipment, if any, which shall be used in a new installation. |
| 3.03A | Show locations and routings of conduit and cables for both the VIDS and communication feeds. Show Detection Camera location(s). |
| 3.03E | Show detection zones. |
| 3.04 | Specify any additional testing requirements. |

**END OF INSTRUCTIONS**