DIVISION 900 – MATERIALS DETAILS

SECTION 901 – PCC MATERIALS

901.01 Hydraulic Cement

(a) General

At the time cement is incorporated into the work, it shall meet the quality requirements of these specifications.

Cement which has been in storage may be tested prior to use, and if tests show that it does not meet the requirements specified, it will be rejected.

A means for storing and protecting the cement against dampness shall be provided. Cement which has become partially set or which contains lumps or caked cement will be rejected. Cement salvaged from discarded or used sacks shall not be used.

Different kinds or brands of cement, or cement of the same brand from different mills, even if tested, shall not be mixed during use unless allowed, and then only as directed. They shall not be used alternately in any one pour for any structure, unless otherwise approved.

(b) Portland Cement

Portland cement shall conform to the requirements of the following cited specifications except as noted.

1. Requirements

Cement	Specifications
Air-Entraining Portland Blast-Furnace Slag Cement	AASHTO M 240, Type IS-A
Air-Entraining Portland Cement	AASHTO M 85, Type IA or IIIA
Air-Entraining Portland-Pozzolan Cement	AASHTO M 240, Type IP-A
Portland Blast-Furnace Slag Cement	AASHTO M 240, Type IS
Portland Cement	AASHTO M 85, Type I, II, or III
Portland-Limestone Cement	AASHTO M 240, Type IL
Portland-Pozzolan Cement	AASHTO M 240, Type IP

The exceptions to AASHTO M 240 are as follows:

a. The amount of pozzolan shall be limited to 20% ±5% by weight of the portland-pozzolan cement for the types IP and IP-A.

b. The pozzolan in the portland-pozzolan cements, types IP and IP-A, shall be in accordance with ASTM C618, class C or class F with the loss on ignition of the pozzolan limited to a maximum of 3%.

c. The pozzolan in the portland-pozzolan cements, types IP and IP-A, shall be interground with the portland cement clinker.

2. Acceptance Criteria

Portland cements and blended cements will be accepted based upon the manufacturer's or manufacturer/distributor's documented ability to consistently furnish these materials in accordance with the applicable AASHTO requirements.

a. General Requirements

Cements shall comply with the applicable requirements of 901 and will be accepted by certification from qualified manufacturers or manufacturer/distributor. The manufacturer is defined as the plant producing the cement. A manufacturer or manufacturer/distributor shall become qualified by establishing a history of satisfactory quality control of cement produced as evidenced by results of tests performed by a testing laboratory which is regularly inspected by the Cement and Concrete Reference Laboratory of the National Institute of Standards and Technology. Proof of such inspection shall be furnished upon request. All certifications shall be prepared by the manufacturer or distributor in accordance with the applicable requirements of 916. If a manufacturer or distributor elects to supply portland cement with a higher sulfur trioxide content in accordance with footnote B from Table 1 in AASHTO M 85, it shall supply all of the required supporting data to the Department's Division of Materials and Tests prior to supplying such cement. A QPL of Cement Sources will be maintained by the Department.

The manufacturer or manufacturer/distributor shall conduct sufficient tests to ensure that adequate quality control is maintained and that cement furnished is in accordance with the specification requirements. Documentation pertaining to cement shipped on certification shall be maintained for a period of at least three years and shall be provided when requested.

Random samples of cement will be obtained at the concrete plant. If the sample is not in accordance with the specification requirements, an investigation will be conducted. A copy of the findings and conclusions resulting from the investigation will be furnished to the Contractor. Unless the investigation finds the Department is responsible for the failure to comply, the cost of the investigation plus any required corrective action will be assessed to the Contractor.

b. Requirements for Domestic Source Qualification

Cement manufacturers requesting to be qualified to supply cement shall provide the following:

(1) For the initial qualification, the manufacturer shall provide to the Department's Division of Materials and Tests a QCP in accordance with the applicable requirements of ITM 806. The QCP shall also include the location and type of samples taken, and a monthly summary of mill test data for the previous year's production. A current Safety Data Sheet shall be submitted as an integral part of the initial qualification package.

(2) To maintain qualification, a monthly average of mill test data shall be submitted to the Department's Division of Materials and Tests. If a specific type of cement is not manufactured in a given month, the monthly submittal shall state "No type _____ cement was manufactured during the month of _____, 20____".

c. Requirements for Foreign Source Qualification

Foreign cement manufacturers or their domestic distributors requesting to be qualified to supply cement shall provide the following:

(1) For the initial qualifications, the manufacturer and distributor shall provide to the Department's Division of Materials and Tests a QCP in accordance with the applicable requirements of ITM 806. The QCP shall also include the location and type of samples taken, and a summary of complete test results from the proposed cement source. A current Material Safety Data Sheet shall be submitted as an integral part of the initial qualification package. The QCP shall explain the linkage between the cement being furnished and the manufacturer's/distributor's quality control data, relative to ship-loads, barge-loads, railroad car-loads, and other applicable loads.

(2) Once the initial qualifications have been met, the manufacturer or distributor shall be required to furnish the cement test results for each shipment prior to Department cement usage for the first five cement shipments, which are intended for Department use. The test results for all five of these cement shipments shall fully comply with the required material specifications. If not, this requirement will be continued for subsequent cement shipments until five consecutive

cement shipment test results fully comply with the required material specifications, or Department source approval is withdrawn due to the inability to consistently supply satisfactory cement.

(3) To maintain qualification after compliance with the previous requirements, a monthly submission of all cement shipment test results for cement which is intended for Department usage shall be submitted to the Department's Division of Materials and Tests. If no cement shipments are received during a given month, the monthly submittal shall state "No cement was received during the month of _____, 20____".

d. Certification

Only manufacturers and manufacturer/distributors included on the QPL of Cement Sources may furnish cement on certification.

A sample certification form addressing all of the required information is included in ITM 804. Alternate procedures and forms will be considered when requested, and will be approved if there is a positive link between the cement furnished and the manufacturer's quality control data.

(c) Masonry Cement

Masonry cement shall be in accordance with ASTM C91, except the air content test and the water retention test may be waived.

(d) Rapid Hardening Hydraulic Cement

Rapid hardening hydraulic cement shall be calcium sulfoaluminate, CSA, cement furnished from a manufacturer or manufacturer/distributor on the Department's list of Cement Sources. A source may be added to the QPL by completing the requirements of ITM 806, Procedure U.

901.02 Fly Ash Used as a Pozzolan

(a) General

Fly ash is the finely divided residue that results from the combustion of ground or powered coal. In general, class F fly ash is produced from burning anthracite or bituminous coal and class C fly ash is produced from burning lignite or subbituminous coal.

Fly ash will be accepted from one of the sources on the QPL of Pozzolan Sources. Fly ash from different sources or different types of fly ash shall not be mixed or used alternately in the same construction unless authorized in writing. Fly ash will be subject to random assurance sampling and testing by the Department. Failure of these

random samples to meet the specified requirements will be cause for suspension of the fly ash source approval.

(b) Acceptance Criteria

Acceptance is based upon the supplier's documented ability to consistently furnish material in accordance with the specified requirements.

1. Requirements

The fly ash shall be in accordance with AASHTO M 295 for class C or class F, with the following exceptions:

Loss on Ignition, LOI, max. % 3
Autoclave Expansion or Contraction, max. % 0.5
Fineness: Amount retained when wet-sieved on
No. 325 (45 µm) sieve, max. % 30

On days when fly ash is being accumulated for use as a pozzolan, the supplier shall obtain a minimum of one sample per day and furnish test results for moisture content, loss on ignition, and No. 325 (45 µm) sieve residue for each sample.

For each 2,000 t produced, a complete AASHTO M 295 analysis shall be performed on a sample composited randomly from the daily samples. The method of randomization shall be subject to approval by the Department.

2. Test and Calibration Procedure

The testing procedures followed shall be in accordance with ASTM C311 or other methods approved in writing by the Department.

The minimum frequency for calibration of test equipment is:

a. The No. 325 (45 µm) sieve shall be calibrated every 100 determinations or every six months, whichever comes first.

b. The muffle furnace used for LOI determinations shall have a newly installed thermocouple every six months.

c. The analytical balances and scales shall be calibrated each year.

d. The concrete compression machine shall be calibrated annually.

e. The Blaine apparatus shall be calibrated annually.

f. All instrumentation used for rapid chemical analysis shall comply with applicable requirements of ASTM C114 using NIST Fly Ash reference materials.

3. Documentation

Fly ash suppliers requesting approval shall supply the following:

a. For the initial approval, a current Materials Safety Data Sheet and a summary of results for all specified tests for six consecutive months shall be submitted. No test results shall be more than one year old at the time of request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly. The results of the daily tests shall be available by telephone during normal working hours.

c. The fly ash suppliers shall furnish a QCP in accordance with the applicable requirements of ITM 806. The QCP shall ensure the Department of a continuous supply of fly ash complying with the requirements. This QCP will be reviewed to determine its adequacy.

d. Certification:

(1) For source approval, the supplier shall furnish a Certification, Other indicating the class of fly ash, the name, location, and unit of the generating plant. It shall state that all fly ash shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. It shall further indicate that the power company will participate in appropriate inspection and assurance testing. A sample certification form is provided in ITM 804.

(2) For certification of test reports, the test results generated in accordance with 901.02(b)1 shall be summarized and submitted monthly. The reports shall state the name and location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving fly ash represented by these results.

901.03 Slag Cement Used as a Pozzolan

(a) General

Slag cement shall consist of the non-metallic product, consisting essentially of silicates and aluminosilicates of calcium and other bases, that is developed in a molten

condition simultaneously with iron in a blast furnace. A glassy granular material is formed when molten blast furnace slag is rapidly chilled by immersion in water. This material is then ground to cement fineness, producing slag cement.

Slag cement will be accepted from one of the sources on the QPL of Pozzolan Sources. Slag cement from different sources or different grades of slag cement shall not be mixed or used alternately in the same construction unless approved in writing. Slag cement will be subject to random assurance sampling and testing by the Department. Failure of these random samples to be in accordance with the specified requirements will be cause for suspension of the slag cement source approval.

(b) Acceptance Criteria

Slag cement will be accepted based on the manufacturer's or manufacturer/ distributor's documented ability to consistently furnish these materials in accordance with the applicable ASTM and AASHTO requirements.

1. Requirements

Slag cement shall be in accordance with ASTM C989 for grade 100 or 120.

For each 2,500 t produced, a complete ASTM C989 analysis shall be performed on a sample composited randomly from the daily samples. The method of randomization shall be subject to approval by the Department.

2. Test and Calibration Procedure

The testing procedures followed shall be in accordance with ASTM C989 or other methods approved in writing by the Department.

The minimum frequency for calibration of test equipment is:

a. The No. 325 (45 µm) sieve shall be calibrated every 100 determinations or every six months, whichever comes first.

b. The analytical balances and scales shall be calibrated each year.

c. The concrete compression machine shall be calibrated annually.

d. The Blaine apparatus shall be calibrated annually.

e. All instrumentation used for rapid chemical analysis shall be in accordance with the applicable requirements of ASTM C114 using NIST reference materials.

3. Documentation

Slag cement suppliers requesting approval shall supply the following:

a. For the initial approval, a current Safety Data Sheet and a summary of results for all specified tests for six consecutive months shall be submitted. No test results shall be more than one year old at the time of request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly. The results of the daily tests shall be available by telephone during normal working hours.

c. The slag cement suppliers shall furnish a QCP in accordance with the applicable requirements of ITM 806. The QCP shall ensure the Department of a continuous supply of slag cement which is in accordance with the requirements. This QCP will be reviewed to determine its adequacy.

d. Certification:

(1) For source approval, the supplier shall furnish a Certification, Other indicating the grade of slag cement, the name, location, and type of manufacturing facility. It shall state that the slag cement shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. A sample certification form addressing all of the required information is provided in ITM 804.

(2) For certification of test reports, the test results generated in accordance with 901.03(b) shall be summarized and submitted monthly. The reports shall state the name and location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving slag cement represented by these results.

901.04 Silica Fume Used as a Pozzolanic Mineral Admixture

(a) General

Silica fume will be accepted from one of the suppliers on the QPL of Pozzolan Sources. Silica fume from more than one of these suppliers shall not be mixed or used alternatively in the same construction unless authorized in writing. Silica fume will be subject to random assurance sampling and testing by the Department. Failure of the random samples to meet the specified requirements will be cause for suspension of the silica fume supplier's approval.

(b) Acceptance Criteria

Acceptance of silica fume will be based on the manufacturer's documented ability to consistently furnish material in accordance with the specified requirements.

1. Requirements

The silica fume shall be in accordance with AASHTO M 307 with the following exceptions:

a. Reactivity with cement alkalies shall not be required.

b. The oversize, amount retained on the No 325 (45 µm) sieve, in accordance with ASTM C1240, shall be conducted.

c. The oversize, amount retained on the No. 325 (45 µm) sieve, shall not be more than 10%.

d. Accelerated pozzolanic activity index, in accordance with ASTM C1240, shall be conducted in lieu of strength activity index.

e. The accelerated pozzolanic activity index shall be a minimum of 85% at seven days.

f. The increase of drying shrinkage of mortar bars at 28 days shall be conducted in accordance with ASTM C1240.

g. The increase of drying shrinkage of mortar bars at 28 days shall be not more than 0.10%.

2. Frequency of Testing

a. The manufacturer shall obtain a minimum of one sample for each 400 t of material produced. Test results for moisture content, and loss on ignition, shall be furnished for each sample.

b. For each 2,000 t produced, a complete AASHTO M 307 analysis shall be performed on a sample composed randomly from daily samples. The method of randomization shall be subject to approval by the Department. The optional chemical requirements identified in AASHTO M 307 shall be reported in addition to the increase of drying shrinkage of mortar bars as well as the standard chemical and physical requirements.

3. Test and Calibration Procedure

The minimum frequencies for calibration of test equipment shall be as follows:

a. The analytical balances and scales shall be calibrated annually.

b. The concrete compression machine shall be calibrated annually.

c. The Blaine apparatus shall be calibrated annually.

d. All instrumentation used for rapid chemical analysis shall be in accordance with AASHTO T 105.

4. Documentation

Silica fume suppliers requesting approval shall supply the following to the Department's Division of Materials and Tests:

a. For initial approval, a current Material Safety Data Sheet and a summary of results for all specified tests for six consecutive months shall be submitted. No test results shall be more than one year old at the time of the request.

b. To maintain approval, a summary of results for all specified tests shall be submitted monthly.

c. A QCP in accordance with the applicable requirements of ITM 806 shall be submitted. The QCP shall ensure the Department a continuous supply of silica fume complying with the material requirements and calibration procedures. This QCP will be reviewed by the Department's Division of Materials and Tests to determine its adequacy.

d. Certification:

(1) For approval, the supplier shall furnish a Certification, Other indicating the name, location, and type of manufacturing facility, which includes the metallurgical process and furnace. It shall state that the silica fume shipped for use on Department projects will be produced under appropriate quality control and shall be in accordance with the specified requirements. A sample certification is provided in ITM 804.

(2) For certification of test reports, the results generated in accordance with 901.04(b) shall be summarized and

submitted monthly. The reports shall state the name and location of the testing facility, and shall be signed by the chemist or technical manager. This certification shall also identify the concrete plants receiving silica fume represented by these results.

901.05 Chemical Anchor System

Chemical anchor systems shall be furnished from the QPL of Chemical Anchor Systems. Chemical anchor systems may be added to the QPL by completing the requirements of ITM 806, Procedure F and passing required laboratory testing.

(a) Requirements

Chemical anchor systems shall be in accordance with the following:

1. Chemical anchor systems shall be two part systems which are capable of anchoring deformed steel reinforcing bars and grouting load transfer dowels.

2. Chemically anchored steel reinforcing bars shall be capable of withstanding a tensile load equal to the yield strength of a #7, grade 60, epoxy coated, deformed steel reinforcing bar.

3. Chemical anchor systems shall be capable of filling the entire annular space between the concrete and the steel reinforcing bar or dowel and remain in place until the chemical anchor is completely cured.

(b) Laboratory Testing

The Department will test chemical anchor systems in accordance with ITM 807.

901.06 PCC Sealer/Healers

PCC sealer/healers shall be furnished from the QPL of PCC Sealer/Healers. PCC sealer/healers may be added to the QPL by completing the requirements in ITM 806, Procedure F and passing required laboratory testing.

(a) Requirements

PCC sealer/healers shall be in accordance with the following:

1. PCC sealer/healers shall be two part systems, capable of sealing and healing cracks in PC pavement.

2. PCC sealer/healers shall be capable of restoring the original integrity of a PCC beam broken in flexure.

3. All four beams used for testing sealer/healers shall break at a location different from the original break or with a flexural strength greater than or equal to 550 psi.

4. The viscosity of PCC sealer/healers shall be sufficient to penetrate a crack 1/32 in. wide and 6 in. in depth.

(b) Laboratory Testing

The Department will test PCC sealer/healers in accordance with ITM 808.

901.07 Rapid Setting Patch Materials

Rapid setting patch materials shall be selected from the QPL of Rapid Setting Patch Materials. A rapid setting patch material may be added to the QPL by completing the requirements in ITM 806, Procedure F.

(a) Normal Weather Mixes

Normal weather rapid setting patch materials shall be used for ambient temperatures of 32 to 85°F.

(b) Hot Weather Mixes

Hot weather rapid setting patch materials shall be used for ambient temperatures above 85°F.

(c) Requirements

Rapid setting patch materials shall be capable of being utilized in patches ranging from 1 in. to full depth without bonding agents.

These products shall not contain soluble chlorides as an ingredient of manufacture or require chemical additives. The color shall be similar to PCC.

They shall be single packaged dry mix requiring only water just prior to mixing. They shall be packaged in 40 to 60 lb bags with a neat yield of approximately 0.40 cu ft and shall allow at least a 50% extension, by weight with a 3/8 in. or a 1/2 in. round aggregate. The minimum shelf life shall be 12 months.

Mixing shall be conducted with small concrete mixers or with a drill or paddle mixer and shall be suitable for finishing with hand tools.

Rapid setting patch materials shall be in accordance with ASTM C928 with the following exceptions.

Physical Tests	Specifications	Requirements
Setting Time: Normal Weather Hot Weather	ASTM C266 Initial at 72°F Final at 72°F Initial at 95°F Final at 95°F	 10 – 20 min 12 – 35 min 10 – 20 min 12 – 35 min
Compressive Strength, min.* 1 h 2 h 24 h 28 days	ASTM C109	72°F, Normal 2,000 psi 3,000 psi 5,000 psi 8,000 psi
Compressive Strength, min.* 3 h 24 h 28 days	ASTM C109	95°F, Hot 3,000 psi 5,000 psi 8,000 psi
Relative Dynamic Modulus Procedure B, 300 cycles	ASTM C666	95% min.
Slant Shear Bond Strength, min. 28 days	ASTM C882	2,500 psi
Flexural Strength, 24 h mortar only mortar – aggregate extension	ASTM C78	 500 psi 600 psi
Length Change, maximum 28 days (air storage)	ASTM C157 modified C928	 -0.075%
Scaling Resistance 5 cycles 25 cycles 50+ cycles	ASTM C672	 0 rating, No scaling 0 rating, No scaling 1.5 rating, Very slight to Slight scaling
* Material used shall be neat rapid setting patch material mixed in accordance with the manufacturer's installation instructions.		

All rapid setting patch materials complying with the specified physical requirements will be subjected to a field performance demonstration. The field performance demonstration will take place as directed. Rapid setting patch materials shall be used to patch a designated site, typical of a standard repair. The site will be evaluated after one year's exposure. Approval will be based on visible signs of distress, such as cracking, crazing, scaling, spalling, wearing, edge fraying, corner cracking, or debonding.

(d) Test Report

Testing shall be performed by a recognized laboratory in accordance with ITM 806. Test reports shall not be more than five years old on January 1 of the approval year.

901.08 Packaged, Dry, Combined Materials for Mortar and Concrete

These materials shall be in accordance with ASTM C387. All packages shall be identified as conforming to ASTM C387. The markings shall also show the kind and type of material, the net weight in each bag, the yield in cubic feet or yield in square feet per inch of thickness, and the amount of water recommended for mixing to produce a 2 in. to 3 in. slump.

The following exceptions to ASTM C387 shall apply for packaged patching products used in accordance with 710. The limits of the following shall be shown on the type B certification.

Physical Tests	Specifications	Requirements
Compressive Strength, min. 24 h 28 days	ASTM C109 on 2 in. cubes (neat)	 2,000 psi 5,000 psi
Length Change, max. 28 days (air storage) 28 days (water storage)	ASTM C157, modified C928	 -0.09% +0.03%
Slant/Shear Bond Strength, min. 28 days	ASTM C882 modified*	 2,000 psi
Modulus of Elasticity Minimum @ 28 days Maximum @ 28 days	ASTM C469	 3,000,000 psi 5,000,000 psi
* Product scrubbed into substrate or as recommended by the manufacturer.		

901.09 Air-Cooled Blast Furnace Slag for Retaining Walls

If ACBF or coarse aggregate is used, and soil, B borrow, structural backfill, or coarse aggregate is to be placed above the ACBF or coarse aggregate, a single layer of geotextile shall be placed on top of the ACBF or coarse aggregate in accordance with 616.11. A type C certification in accordance with 916 shall be provided for the geotextile materials.

ACBF shall be in accordance with the pH, chlorides, sulfates, organic content, resistivity, and permeability requirements of structure backfill as listed in 211.03.1. It shall also be in accordance with ITM 212. Total sulfides shall also be determined in accordance with EPA 376.1, using the 100-mL pH water samples obtained during the ITM 212 test, and shall not exceed 400 ppm.

The ACBF shall have a maximum corrosion rate as follows if tested in accordance with ASTM G59.

(a) Zinc corrosion rate, first two years ..... 15 µm/yr/side
(b) Zinc corrosion rate, to depletion ..... 4 µm/yr/side
(c) Carbon-steel corrosion rate ..... 12 µm/yr/side.

901.10 Components of MSE Retaining Walls

(a) PCC Components

1. Face Panels

Precast concrete face panels shall be produced from a source listed on the QPL of Certified Precast Concrete Producers, in accordance with ITM 813. Concrete shall have a compressive strength equal to or greater than 4,000 psi at 28 days.

The target water/cementitious ratio for the concrete mix design shall not exceed 0.435. The cement content and target water/cementitious ratio of the concrete mix design shall be sufficient to obtain the specified minimum 28-day compressive strength. Air entraining admixture and chemical admixture Type A, B, C, D, or E from the QPL of PCC Admixtures and Admixture Systems may be used.

Ground-reinforcement connection hardware and reinforcing bar lifting devices shall be set in place and secured prior to beginning casting, in accordance with the dimensions and tolerances shown on the working drawings.

a. Production Control Testing and Inspection

The manufacturer shall provide for all testing and inspection services during each day's production of the panels. The frequency of production control testing shall be based on a lot of 50 panels, or fraction thereof, for each day's production. Sampling and testing of the plastic concrete shall be in accordance with 505.01, or the ASTM equivalent. A minimum of one water/cementitious ratio, and slump, air content, and relative yield tests shall be run per production lot, per day. A minimum of two 6 in. by 12 in. cylinders shall be cast per day's production lot for compressive strength determination. Cylinders shall be cured in the same manner as the panels they represent. Relative yield, air content, and slump of the concrete shall be in accordance with 702.05. Compressive strength shall be determined in accordance with AASHTO T 22 or ASTM C39, with lot acceptance based on the average of 2 cylinders tested at an age no greater than 28 days. Panels shall not be shipped until the compressive strength meets or exceeds the 28 day requirement.

If the cylinder-test results do not satisfy the requirements described herein, and additional cylinders for testing are not available, the manufacturer may core the panels. The wall manufacturer shall randomly select two panels from the lot for coring in accordance with AASHTO T 24 or ASTM C42. The wall manufacturer shall obtain one core on the backside of each panel with a device that produces uniform test samples without coring completely through the panel. Coring shall not be located within 6 in. of the panel fasteners or the edges of the panels, and shall avoid the panel's reinforcing steel. The wall manufacturer shall fill the core holes with equivalent concrete materials or rapid setting patch materials, and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. If rapid setting patch material is used, mixing and curing shall be in accordance with the manufacturer's recommendations. Compressive strength testing shall be performed on

the cores. If the average strength-test results from the cores satisfy or exceed the requirements described herein, the production lot panels may be shipped.

b. Casting

The panels shall be cast on a flat area, with the front face of the form at the bottom, and the back face at the upper part. Tie strip guides shall be set on the rear face. The concrete in each unit shall be placed without interruption and shall be consolidated as necessary to prevent the formation of segregation or cleavage planes. Clear form oil from one manufacturer shall be used throughout the casting operation.

c. Curing

The panels shall be cured for a sufficient length of time such that the concrete develops the specified compressive strength.

d. Removal of Forms

The forms shall remain in place until they can be removed without damage to the unit.

e. Concrete Finish

The concrete surface for the front panel face shall have a surface finish produced from contact with the form. The rear face of the panel shall be screeded to eliminate open pockets of aggregate and surface distortions in excess of 1/4 in.

f. Tolerances

All panels shall be manufactured within the tolerances as follows:

(1) Panel Dimensions

Lateral position of tie strips shall be within 1 in. All other dimensions shall be within 3/16 in.

(2) Panel Squareness

Squareness, as determined by the difference between the two diagonals, shall not exceed 1/2 in.

(3) Panel-Surface Finish

Surface defects on smooth formed surfaces measured on a length of 5 ft shall not exceed 1/8 in. Surface defects on textured finished surfaces measured on a length of 5 ft shall not exceed 5/16 in.

g. Compressive Strength Verification

Verification of the panels compressive strengths will be conducted by the Engineer. The frequency of verification testing will be one test for every 750 panels per manufacturer with a minimum of one test per contract. One panel will be randomly selected and two locations will be selected for coring. In the presence of the Engineer, the Contractor shall obtain two 4 in. cores on the backside of the panel without coring completely through the panel. The Contractor shall refill the core holes with rapid

setting patch materials and trowel to produce a smooth finish. Excess material removed during troweling shall not be reused. Mixing and curing of the patching materials shall be in accordance with the manufacturer's recommendations.

The Engineer will test the cores in accordance with AASHTO T 24. The verification test results will be averaged and shall be in accordance with 901.10(a)1a. If the initial verification test results do not satisfy the requirements described herein, the Engineer will randomly select two different panels for additional verification testing. If the additional verification tests satisfy the requirements described herein, no further action is required. If the test results still do not satisfy the requirements described herein, installation of panels shall cease and the Engineer will conduct an investigation. Panels manufactured on the same dates as the panels cored for verification tests that have already been installed will be considered and adjudicated as a failed material in accordance with 105.03. The Engineer will conduct verification testing until three consecutive dates of production satisfy the strength requirements described herein. The Contractor or wall manufacturer shall make arrangements so that panels from three consecutive dates of production are accessible for coring. Installation of panels may resume once acceptable verification testing results are achieved.

h. Rejection

Units shall be subject to rejection due to their failure to be in accordance with the requirements specified above. The following defects may result in rejection:

(1) Defects which indicate imperfect molding.

(2) Defects which indicate honeycombed or open texture concrete.

(3) Defects in the physical characteristics of the concrete, such as broken or chipped concrete, or color variations or dunnage marks on the front face due to excessive form oil or other reasons.

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection.

Repair of concrete, if allowed, shall be completed in a manner which is acceptable to the Engineer. Repair to concrete surfaces that are to be exposed to view after completion of construction shall be subject to approval.

i. Marking

The place and date of manufacture, and production lot number shall be shown on the rear face of each panel.

j. Handling, Storage, and Shipping

All panels shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, or excessive bending stresses. Panels in storage shall be supported on blocking located immediately adjacent to tie strips to avoid bending the tie strips.

2. Coping

The coping may be precast or cast-in-place.

(b) Joint Spacers and Joint Covering

The horizontal and vertical joint spacers shall include compression blocks, pins, or other manufacturer's recommended materials to provide a uniform joint.

The joint cover shall be either a non-woven needle-punch polyester geotextile or a woven monofilament polypropylene. The joint cover shall be attached to the rear face of the panels with a manufacturer's recommended adhesive.

A letter certifying that the joint spacers and joint cover adhesive material supplied is in accordance with the manufacturer's recommendations shall be provided prior to use of the materials.

SECTION 902 – ASPHALT MATERIALS

902.01 Asphalt

Asphalt is defined as a cementitious material obtained from petroleum processes. Asphalts shall be sampled and tested in accordance with the applicable requirements of 902.02.

(a) Performance Graded Asphalt Binders

Performance graded asphalt binders shall be supplied by a supplier on the QPL of Performance-Graded Asphalt Binder Suppliers. A binder will be considered for inclusion on the QPL by following ITM 581.

Performance graded, PG asphalt binders shall be in accordance with the following:

GRADE	58-28	64-22	64-28	70-22	70-28	76-22
ORIGINAL BINDER						
Flash Point, minimum, °C	230					
Viscosity, maximum, 3 Pa·s, Test Temp, °C	135					
DSR, G*/sin δ (delta), minimum, 1.00 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
ROLLING THIN-FILM OVEN RESIDUE						
Mass Loss, maximum, %	1.00					
DSR, G*/sin δ (delta), minimum, 2.20 kPa, Test Temp. @ 10 rad/s, °C	58	64	64	70	70	76
PRESSURE AGING VESSEL (PAV) RESIDUE						
PAV Aging Temperature, °C	100 (Note 1)					
DSR, G*sin δ (delta), maximum, 5,000 kPa, Test Temp. @ 10 rad/s, °C	19	25	22	28	25	31
Physical Hardening	Report (Note 2)					
Creep Stiffness, S, maximum, 300 MPa, m-value, minimum, 0.300, Test Temp. @ 60 s, °C	-18	-12	-18	-12	-18	-12

Notes: 1. Oven temperature tolerance shall be ±0.5°C.
2. Physical Hardening is performed on a set of asphalt beams according to AASHTO T 313, Section 12.1, except the conditioning time is extended to 24 h ±10 minutes at 10°C above the minimum performance temperature. The 24 h stiffness and m-value are reported for information purposes only.

A PG 58-28 or PG 64-22 binder may be modified by in-line blending with styrene butadiene rubber, SBR, polymer latex at the HMA plant in accordance with ITM 581. A PG 58-28 may be modified to a PG 64-28 and a PG 64-22 may be modified to a PG 70-22.

A type A certification in accordance with 916 shall be provided for SBR polymer latex. The results of the following shall be shown on the certification.

Property	Requirements
Total Polymer Solids, % by weight	60 – 72
Butadiene, % by weight, min.	68
Residual Styrene, % by weight, max.	0.1
Ash, % of total polymer solids by weight, max.	3.5
pH	9 – 11
Viscosity, Brookfield model RVF, Spindle No. 2 @ 20 rpm @ 25°C, max.	2,000

The minimum SBR polymer latex content shall be 2.5 %. The SBR polymer latex content may be reduced below the minimum content provided, if the following requirements are met:

1. An AASHTO accredited laboratory shall blend the PG binder and SBR polymer latex at the proposed SBR polymer latex content and test and grade the modified PG binder in accordance with AASHTO M 320.

2. The laboratory test results verifying the blend and compliance with 902.01(a) shall be submitted to the Engineer for approval.

3. The source of the PG Binder or SBR polymer latex shall not be changed.

1. Sampling

An acceptance sample and backup sample shall be taken from the asphalt delivery system at the HMA plant. A copy of a load ticket identifying the binder source shall be submitted with the samples. The Engineer will take immediate possession of the samples.

2. PG Binder Testing

The Department will perform complete testing in accordance with AASHTO M 320. Complete PG binder testing will consist of RTFO DSR and PAV BBR testing. Rotational viscosity and flashpoint tests are not required. If the material is not in accordance with the specifications, the material will represent one week of HMA production and be adjudicated as a failed material in accordance with 105.03.

3. Appeals

If the Contractor does not agree with the acceptance test results, a request may be made in writing for additional testing. The appeal shall be submitted within 15 calendar days of receipt of the Department's written results. The basis of the appeal shall include complete AASHTO M 320 test results.

(b) Asphalt Emulsions

Asphalt emulsions shall be from a supplier listed on the QPL of Asphalt Emulsion Suppliers. An emulsion will be considered for inclusion on the QPL by following ITM 593. Asphalt emulsions may contain additives to improve handling and performance characteristics. Failure of an emulsion to perform satisfactorily in the field shall be cause for rejection, even though it passes laboratory tests. The grade used shall be in accordance with the table for asphalt emulsions as shown herein. A type A certification in accordance with 916 shall be provided for the asphalt emulsion. The results of the tests listed in ITM 804 shall be shown on the certification.

The requirements for asphalt emulsions are as follows:

RS-2, HFRS-2, and SS-1h shall be in accordance with AASHTO M 140 except the cement mixing test is waived.

CRS-2P and HFRS-2P shall be in accordance with AASHTO M 316. The distillation temperature shall be 350°F.

CSS-1h shall be in accordance with AASHTO M 208.

1. Asphalt Emulsion Warranted Micro-Surfacing

The polymer modified asphalt emulsion shall be a quick-set, CSS-1h emulsion in accordance with AASHTO M 208 except the cement-mixing test is waived. The polymer material shall be milled or blended into the asphalt or blended into the emulsifier solution prior to the emulsification process. The minimum polymer solids content will be 3.0% based on the residual of the emulsion. Mix set additives shall be added as required to provide control of the quick-set properties. Additional requirements shall be in accordance with the following:

Characteristics	Test Method	Requirements
Residue by Distillation, % (Note)	AASHTO T 59	62+
Softening Point, °F (°C)	AASHTO T 53	140+ (60+)
Viscosity @ 140°F (60°C)	AASHTO T 202	8000+
Elastic Recovery @ 77°F (25°C), %	AASHTO T 301	60
Note: The distillation temperature for this test shall be 350°F (175°C).		

2. Asphalt Emulsion Ultrathin Bonded Wearing Course

Characteristics		Test Method	Min.	Max.
Viscosity, Saybolt Furol @ 77°F (25°C), s		AASHTO T 59	20	100
Storage Stability Test, 24 h, % (Note 1)		AASHTO T 59		1
Sieve Test, %		AASHTO T 59		0.05
Residue by Distillation, % (Note 2)		AASHTO T 59	63	
Oil Distillate by volume of emulsified asphalt, %		AASHTO T 59		2
Demulsibility, %	w/35 mL, 0.02 N CaCl2 or	AASHTO T 59	60	
	w/35 mL, 0.8% DSS	AASHTO T 59		
Tests on Residue from Distillation				
Penetration (0.1 mm) at 77°F (25°C), 100g, 5 s		AASHTO T 49	90	150
Elastic Recovery @ 39°F (4°C), %		AASHTO T 301	58	
Notes: 1. After 24 h, the emulsion shall be a homogeneous color. 2. Except maximum temperature of 400 ±10°F (205 ±5°C).				

3. Asphalt Emulsion Recycling

Characteristics (Note 1)	Test Method	Min.	Max.
Viscosity, Saybolt Furol, @ 77 °F (25°C), SFS	AASHTO T 59	20	100
Sieve Test, No. 20, retained on sieve, %	AASHTO T 59		0.10
Storage Stability Test, 24 hr, %	AASHTO T 59		1
Residue by Distillation, % (Note 2)	AASHTO T 59	64	
Oil Distillate by volume of emulsified asphalt, %	AASHTO T 59		1
Penetration, 77°F (25°C), 100 g, 5 s, dmm	AASHTO T 49	50	200

Notes:

1. The asphalt emulsion shall be selected for the project by the asphalt emulsion supplier based on the Contractor's mixture design. The penetration of the supplied asphalt emulsion shall be within ±25 dmm of the penetration of the design asphalt emulsion. The asphalt emulsion shall be received on the job site at a temperature no greater than 120ºF (50°C).

2. Modified AASHTO T 59 – distillation temperature of 350 ±9°F (175 ±5°C) with a 20-minute hold.

Characteristics[1]	Test Method	AE-90	AE-90S	AE-NT	AE-F	AE-150	AE-PL
Test on Emulsion							
Viscosity, Saybolt Furol at 77°F (25°C), min.	AASHTO T 59			15		50	
Viscosity, Saybolt Furol at 77°F (25°C), max.	AASHTO T 59			100	100		115
Viscosity, Saybolt Furol at 120°F (50°C), min.	AASHTO T 59	50	50			75	
Viscosity, Saybolt Furol at 120°F (50°C), max.	AASHTO T 59					300	
Demulsibility w/35 mL, 0.02N CaC12, % min.	AASHTO T 59		30				
Demulsibility w/50 mL, 0.10N CaC12, % min.	AASHTO T 59	75					
Oil Distillate by Distillation, mL/100 g Emul[2] max.	AASHTO T 59	4.0	3.0	4.0	4.0	7.0	3.0
Residue by Distillation, % min.	AASHTO T 59	65	65[4]	50	27	65	30
Residue by Distillation, % max.	AASHTO T 59				35		
Sieve Test, % max.	AASHTO T 59	0.10	0.10	0.30	0.10	0.10	0.10
Penetrating Ability, mm, min.	902.02(w)						6
Stone Coating Test, %	902.02(t)3a	90				90	
Settlement, % max.	AASHTO T 59	5		5			
Storage Stability, % max.	AASHTO T 59		1				
Tests on Residue							
Penetration (0.1 mm) at 77°F (25°C), 100g, 5 s, min.[3]	AASHTO T 49	100	90				
Penetration (0.1 mm) at 77°F (25°C), 100g, 5 s, max.[3]	AASHTO T 49	200	150	40	90		
Penetration (0.1 mm) at 77°F (25°C), 50g, 5 s, min.[3]	AASHTO T 49					100	
Penetration (0.1 mm) at 77°F (25°C), 50g, 5 s, max.[3]	AASHTO T 49					300	
Ductility at 77°F (25°C), mm, min.	AASHTO T 51	400					
Ash Content, % max.	AASHTO T 111	1.0	1.0	1.0	1.0	1.0	1.0
Float Test at 140°F (60°C), s, min.[3]	AASHTO T 50	1200	1200			1200	
Force Ratio	AASHTO T 300		0.3				
Elastic Recovery, at 39°F (4°C)	AASHTO T 301		58				

Notes:
(1) Broken samples or samples more than 14 days old will not be tested.
(2) Oil distillate shall be in accordance with ASTM D396, table 1, grade No. 1.
(3) The Engineer may waive the test.
(4) Maximum temperature to be held for 15 minutes at 350 ±9°F (175 ±5°C).

100

(c) Cutback Asphalts

Cutback asphalts shall be composed of an intimate homogeneous mixture of an asphalt base and a suitable distillate designed for medium, or slow curing. Cutback asphalts may also contain an additive as an aid in uniformly coating wet, damp, or dry aggregates used in patching mixtures or HMA pavements. These asphalts shall not contain more than 0.3% water as determined by ASTM D95, shall not separate when allowed to stand, and shall not foam when heated to permissible temperatures. When an additive is used, it shall be incorporated homogeneously in the asphalt at the point of manufacture. The temperature of the cutback asphalt shall not be higher than shown for that grade in 902.03. A type A certification in accordance with 916 shall be provided for cutback asphalt. The results of the following shall be shown on the certification.

1. Medium Curing Asphalts With and Without Additives

Medium curing asphalts with and without additives shall be in accordance with the following:

Characteristics	Grades			
	MC-70 MCA-70	MC-250 MCA-250	MC-800 MCA-800	MC-3000 MCA-3000
Flash Point (Open Tag.), °C[4]…….	38+	66+	66+	66+
Kinematic Viscosity at 60°C (cSt)[2]…	70 - 140	250 - 500	800 - 1600	3000 - 6000
Saybolt-Furol Viscosity at 50°C (s)…	60 - 120			
Saybolt-Furol Viscosity at 60°C (s)…		125 - 250		
Saybolt-Furol Viscosity at 83°C (s)…			100 - 200	300 - 600
Distillation[1]				
Distillate (% of total distillate to 360°C MC-70 @ 225°C):				
to 225°C……	0 - 20	0 - 10		
to 260°C……	20 - 60	15 - 55	35+	15+
to 316°C……	65 - 90	60 - 87	45 - 80	15 - 75
Residue from distillation to 360°C (volume % by difference)……	55+	67+	75+	80+
Tests on Residue from Distillation[1]				
Penetration, 25°C, 100 g, 5 s, - (0.1 mm)				
(without additive)……...	120 - 250	120 - 250	120 - 250	120 - 250
(with additive)……	120 - 300	120 - 300	120 - 300	120 - 300
Ductility, 25°C (10 mm)[3]……...	100+	100+	100+	100+
Solubility in organic solvents, %.	99.5+	99.5+	99.5+	99.5+

Notes:
(1) Test may be waived when approved.
(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Kinematic viscosity test shall prevail.
(3) If the ductility at 25°C is less than 100, the material will be acceptable if its ductility at 16°C is 100+.
(4) Flash point by Cleveland Open Cup may be used for products having a flash point greater than 80°C.

2. Slow Curing Asphalts With and Without Additives

120 Slow curing asphalts with and without additives shall be in accordance with the following:

Characteristics	Grades			
	SC-70 SCA-70	SC-250 SCA-250	SC-800 SCA-800	SC-3000 SCA-3000
Flash Point (Cleveland Open Cup), °C	66+	79+	93+	107+
Kinematic Viscosity at 60°C (cSt)(2)	70 - 140	250 - 500	800 - 1600	3000 - 6000
Saybolt-Furol Viscosity at 50°C (s)…. Saybolt-Furol Viscosity at 60°C (s)…. Saybolt-Furol Viscosity at 83°C (s)….	60 - 120	125 - 250	100 - 200	300 - 600
Distillation(1) Total Distillate to 360°C (% by volume)……. Float Test of Distillation Residue at 50°C (s)……..	10 - 30 20 - 100	4 - 20 25 - 110	2 - 12 50 - 140	5 75 - 200
Ductility of Asphalt Residue at 25°C (10 mm)(1)…...	100+	100+	100+	100+
Solubility in organic solvents, %(1)	99.5+	99.5+	99.5+	99.5+

Notes: (1) Test may be waived when approved.
(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Kinematic viscosity test shall prevail.

(d) Utility Asphalt

The asphalts shall be uniform in character and shall not foam when heated to 350°F. Utility asphalts shall be in accordance with the following:

Characteristics/Grades	UA-I	UA-II	UA-III
Softening Point (Ring & Ball), °C	46 - 63	63 - 85	79.5 - 96
Penetration of Original Samples(1) (0.1 mm) at 4°C, 200 g, 60 s, min…… at 25°C, 100 g, 5 s…… at 46°C, 50 g, 5 s……..	 10 50 - 100 100 min.	 10 25 - 45 130 max.	 10 15 - 35 90 max.
Ductility @ 25°C, 50 mm/min, 10 mm, min.(1)	30	10	2.5
Solubility in Organic Solvents, % min.(1)	99.0	99.0	99.0
Flash Point (Cleveland Open Cup), °C, min.(1)	225	225	225
Penetration of Residue from Thin Film Oven Test, 25°C, 100 g, 5 s, (0.1 mm) min.(1)	30	15	10

(1) Test will be performed when complete physical characteristics are needed or desired.

A type A certification in accordance with 916 shall be provided for utility asphalt.
130 The results of the above shall be shown on the certification.

(e) Asphalt for Coating Corrugated Metal Pipe

Asphalt for coating corrugated metal pipe shall be in accordance with the following:

Physical Properties	Min.	Max.
Softening Point (Ring & Ball), °C	93	110
Penetration of Original Samples (0.1 mm) at 4°C, 200 g, 60 s……... at 25°C, 100 g, 5 s……...	 20 35[(1)]	
Solubility in Organic Solvents, %	99.0	
Flash Point (Cleveland Open Cup), °C	232	
Flow Test, mm		6.4
Shock Test	3 of 4 specimens shall pass	
[(1)] May be 30 minimum provided all four shock test specimens pass.		

A type A certification in accordance with 916 shall be provided for asphalt coating to the pipe fabricator on corrugated metal pipe. The results of the above shall be shown on the certification.

902.02 Sampling and Testing Asphalt Materials

The tests and AASHTO references are as follows:

(a) Sampling Bituminous Materials ..... AASHTO R 66

The following exceptions to AASHTO R 66 shall apply:

1. Samples may be obtained at any time before material is incorporated into the work.

2. Samples for all grades of asphalt emulsion shall be a minimum of 1/2 gal. The size of samples of other liquid material may be 1 qt.

3. Samples of liquid materials shall be obtained at one of the following:

   a. bulk storage tanks from sampling valves located in the tank or line and asphalt plant storage tanks from sampling valves located in the tank
   b. transports from sampling valves
   c. distributors from valves
   d. other storage or locations as approved
   e. sampling by other recognized devices may be approved
   f. sampling valves beyond the in-line blending location.

(b) Water in petroleum products, except the solvent or carrier may be toluene ..... ASTM D95

(c) Density, Specific Gravity, or API Gravity of Crude Petroleum and Liquid Products by Hydrometer Method ..... ASTM D1298

(d) Specific Gravity of Semi-Solid Bituminous Materials ..... AASHTO T 228

(e) Specific Gravity of Solid Pitch and Asphalt ..... ASTM D71

(f) Flash Point (Open Cup)

1. When the flash point is higher than 175°F, "Flash Point by Cleveland Open Cup" ..... AASHTO T 48

2. When the flash point is 175°F, or lower, "Flash Point with Tag Open Cup" ..... AASHTO T 79

(g) Softening Point of Bituminous Materials, Ring and Ball ..... AASHTO T 53

(h) Penetration of Bituminous Materials ..... AASHTO T 49

(i) Loss of Heating ..... ASTM D6

(j) Solubility in Organic Solvents, except the solvent may be 1,1,1,-Trichloroethane ..... AASHTO T 44

(k) Inorganic Matter or Ash ..... AASHTO T 59

(l) Saybolt-Furol Viscosity ..... AASHTO T 72

(m) Ductility of Binder Material, except that the conditioning period of the specimens may be shortened, and that only one normal test will be required. Shortened conditioning period: The specimen shall be allowed to cool in air for at least 30 minutes. It shall then be trimmed and placed in the water bath for a period of 60 to 90 minutes before testing. In case of failure or dispute, three normal tests will be required and specimens shall be conditioned as in AASHTO T 51.

(n) Distillation of Cutback Asphaltic Products, except the length of condenser tube may be 400 mm ±24 mm..... AASHTO T 78

(o) Float Test for Bituminous Materials..... AASHTO T 50

(p) Kinematic Viscosity of Asphalts ..... AASHTO T 201

(q) Absolute Viscosity of Asphalts ..... AASHTO T 202

(r) Effect of Heat and Air on Asphalt Materials, Thin-Film Oven Test ..... AASHTO T 179

(s) Effect of Heat and Air on a Moving Film of Asphalt, Rolling Thin Film Oven Test ..... AASHTO T 240

(t) Testing Asphalt Emulsions..... AASHTO T 59

The following exceptions to AASHTO T 59 shall apply:

1. For the Residue by Distillation test, the specified aluminum alloy still shall be the referee still.

2. When tests on the residue are not required, the % of residue for emulsion grades RS-2 and AE-90 only, may be determined by the Residue by Evaporation test of AASHTO T 59. The % of residue shall be determined by the Residue of Distillation test in all cases of failure or dispute.

3. The stone coating test shall be performed as follows on a mixture of 465 ±1 g of reference stone and 35.0 ±0.1 g of asphalt emulsion:

   a. For AE-90 the mixture of stone and asphalt shall be mixed vigorously for 5 minutes. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated.

   b. For AE-150 the mixture of stone and asphalt shall be mixed vigorously for 5 minutes and then allowed to stand for 3 h. At the end of this time, the mixture shall again be mixed vigorously for 5 minutes. At the end of the mixing period, the mix shall be rinsed by running sufficient tap water at the

side of the container to completely immerse the mix. The tap water shall then be poured off and the rinsing step repeated as necessary until the rinse water pours off essentially clear. The stone shall remain a minimum of 90% coated.

4. For the Demulsibility test, normally only one test will be required. In case of failure or dispute, the specified procedure in AASHTO T 59 will be followed.

5. For oil portion from Residue by Distillation, report the number of milliliters of oil per 100 g of emulsion.

(u) For coating test for cutback asphalts with additive, 20 g of 20 to 30 mesh Ottawa sand shall be placed in a clean 2 oz (60 mL) wide-mouthed jar and covered with 25 g of distilled water at room temperature. One gram of the liquid asphalt to be tested shall be placed gently upon the surface of the water so that it floats and does not contact the sand. The lid shall then be placed on the jar and tightened securely. If the liquid asphalt to be tested is grade 70 or 250, the jar and contents shall be shaken vigorously for 30 s. If the grade is 800 or 3,000, the jar and contents shall be immersed in a 115°F water bath for 5 minutes to bring the contents of the jar to a temperature of approximately 100°F. The jar shall then be shaken vigorously for 30 s. After shaking, the asphalt coating on the sand shall be observed under a constant, strong light. Complete coating of the sand is required.

(v) Stripping tests for HMA mixtures using binder materials, with or without additives, shall be performed as follows:

1. **Test 1.** A sample of produced mixture, 500 g, minimum, shall be obtained for testing. The size of test specimen and the amount of distilled water shall be:

Approximate Size of Aggregate	Minimum Weight of Test Specimen	Amount of Distilled Water
Sand	100 g	400 mL
12	100 g	400 mL
11	150 g	600 mL
9	200 g	600 mL

Place the specimen in the boiling distilled water and stir with a glass rod at the rate of one revolution per second for 3 minutes. The aggregate shall retain a minimum of 90%

of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

2. **Test 2**. Approximately 500 g of produced mixture shall be heated to 250°F in a laboratory oven for 2 h; stirred and cooled to 200°F. Then a portion of the mix shall be placed in boiling distilled water, quantity of mix and quantity of boiling water shall be as specified in Test 1, and stirred with a glass rod at the rate of one revolution per second for 3 minutes. The aggregate shall retain a minimum of 90% of its asphalt film compared with the remainder of the sample, upon completion of this procedure.

Note: The purpose of these tests is to determine the relative compatibility of the aggregate and asphalt, and to detect tendency of Asphalt Emulsions to re-emulsify. Test 2 may be performed as a method of determining whether compatibility can be achieved, Test 1 having given unsatisfactory results.

(w) Penetrating Ability of AE-PL.

1. Apparatus and Equipment:

a. Sand mixture:

(1) Dry Ottawa Sand (AASHTO T 106)..... 90 parts

(2) Dry Reference Limestone Dust, portion passing No. 50 (300 mm) sieve only.
Reference Limestone Dust used by the Department is Limestone Calcium Carbonate manufactured by France Stone Co. The Department will furnish approximately 5 lb of Reference Limestone Dust upon request..... 10 parts

(3) Water..... 3 parts

b. Container, 6 oz ointment tin

c. Ruler or other measuring device

d. Timing device readable in seconds

e. Compacting Device. Rimac Spring Tester or other device suitable for compacting sand by applying a 20 psi load. The compacting device shall include an adapter consisting of

two metal discs slightly smaller in diameter than a 6 oz ointment tin separated by a spacer 1 to 2 in. The 2.54 in. diameter discs used in determining weight of coating in AASHTO T 65 or ASTM A90 are satisfactory.

f. Small, square ended spatula or putty knife

2. Procedure:
Thoroughly mix Standard Ottawa Sand, Reference Limestone Dust, and water. Weigh 190 ±1 g of sand mixture into a 6 oz ointment tin. Level surface of sand with a spatula. Place the compacting adapter on the sand surface and slowly, over a period of about 5 s, compact the sand until the 20 psi load is achieved, which is approximately 100 lb on the Rimac Spring Tester. Remove the compacting device, avoiding disturbance to the sand surface. Quickly pour 12 g of the emulsion from a height of about 4 in. onto top of sand mixture. Start timer at start of pour. Stop timer when all emulsion penetrates into sand mixture. Delay 2 minutes then remove sand and mixture from one side of ointment tin, about 1/2 of mixture. Measure to determine average depth of penetration into sand mixture. Penetration time shall be 100 s or less; penetration depth shall be 1/4 in. or more.

(x) Flow Test for Asphalt for Coating Corrugated Metal Pipe.....AASHTO M 190

(y) Shock Test for Asphalt for Coating Corrugated Metal Pipe.....AASHTO M 190

(z) Viscosity Determinations of Asphalt Binder Using Rotational Viscometer.....AASHTO T 316

(aa) Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer.....AASHTO T 315

(bb) Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel.....AASHTO R 28

(cc) Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer.....AASHTO T 313

902.03 Application Temperatures

Binder materials for the several applications indicated in the specifications shall be applied at temperatures not to exceed those shown in the following:

Type and Grade of Material	Maximum Application Temperature, °F	
	Spray	Mix
MC-70, MCA-70	150	
MC-250, MCA-250	225	200
MC-800, MCA-800	250	225
MC-3000, MCA-3000	275	250
SC-70, SCA-70	200	
SC-250, SCA-250	225	225
SC-800-3000, SCA-800-3000	250	250
All Emulsions	160	180
All Penetration and Viscosity, Utility and Pipe Coating	350	325
PG Binders	(see Note)	(see Note)
Note: In accordance with manufacturer's recommendations.		

SECTION 903 – CLASSIFICATION OF SOILS

903.01 Definitions

All of the soils shall be tested and classified in accordance with AASHTO M 145, and in accordance with the grain-size classification procedure as follows:

Soil Classification	Definition
Boulders	Retained on 3 in. (75 mm) sieve
Gravel	3 in. (75 mm) to No. 10 (2.0 mm) sieve
Coarse Sand	No. 10 (2.0 mm) to No. 40 (425 µm) sieve
Fine Sand	No. 40 (425 µm) to No. 200 (75 µm) sieve
Silt	0.075 to 0.002 mm
Clay	Smaller than 0.002 mm
Colloids	Smaller than 0.001 mm

903.02 Soils Having 0% to 19% Retained on No. 10 (2.00 mm) Sieve

These soils shall be classified as follows:

10

Classification	Sand and Gravel, %	Silt, %	Clay, %
Sand	80 – 100	0 – 20	0 – 20
Sandy Loam	50 – 80	0 – 50	0 – 20
Loam	30 – 50	30 – 50	0 – 20
Silty Loam	0 – 50	50 – 80	0 – 20
Silt	0 – 20	80 – 100	0 – 20
Sandy Clay Loam	50 – 80	0 – 30	20 – 30
Clay Loam	20 – 50	20 – 50	20 – 30
Silty Clay Loam	0 – 30	50 – 80	20 – 30
Sandy Clay	50 – 70	0 – 20	30 – 50
Silty Clay	0 –20	50 – 70	30 – 50
Clay	0 – 50	0 – 50	30 – 100

903.03 Soils Having 20% or More Retained on No 10 (2.00 mm) Sieve and More Than 20% Passing No. 200 (75 µm) Sieve

These soils shall be classified in accordance with 903.02, followed by a term describing the relative amount of gravel as follows:

20% to 35%: "with some gravel"
36% to 50%: "and gravel"

903.04 Soils Having 20% or More Retained on No. 10 (2.00 mm) Sieve and Less Than 20% Passing No. 200 (75 µm) Sieve

These soils shall be classified as follows:

Classification	Gravel, %	Sand, %	Silt, %	Clay, %
Gravel	85 – 100	0 – 15	0 – 15	0 – 15
Sandy Gravel	40 – 85	15 – 40	0 – 20	0 – 20
Gravelly Sand	20 – 40	40 – 80	0 – 20	0 – 20
Sand and Gravel	20 – 50	20 – 50	0 – 20	0 - 20

If the gradation of a given sample is not in exact accordance with the requirements for a given classification, it shall be placed in the classification to which it comes the closest.

903.05 Organic Soils

The following classification system shall be used for organic soils in accordance with AASHTO T 21 and AASHTO T 267.

Classification	Organic Content, %
With Organic Matter*	4 - 15
Organic Soil (A-8)*	16 - 30
Peat (A-8)	More than 30
* Soils classified in accordance with 903.02 shall also include this classification.	

903.06 Marly Soils

The following classification system shall be used for marly soils with calcium and magnesium carbonate content in accordance with ITM 507.

Classification	Percentage
With Trace Marl*	1 - 9
With Little Marl*	10 - 17
With Some Marl*	18 - 25
Marly Soil (A-8)	26 - 40
Marl (A-8)	More than 40
* Soils classified in accordance with 903.02 shall also include this classification.	

SECTION 904 – AGGREGATES

904.01 Aggregates

Aggregates shall consist of natural or manufactured materials produced from but not limited to limestone, dolomite, gravels, sandstones, steel furnace slag, SF, air-cooled blast furnace slag, ACBF, granulated blast furnace, GBF, wet bottom boiler slag, or other geologic rock types approved by the Engineer.

A source will not be considered for acceptance of material until a preliminary investigation has been made. As part of this investigation, samples will be obtained and tests conducted to determine the quality and classification of the aggregates in accordance with ITM 203.

Two types of samples are required for the preliminary investigation: ledge samples for crushed stone sources and production samples for crushed stone, natural sand and gravel, and slag sources.

Ledge samples will be obtained from bedrock units as they naturally occur in the proposed working face of the quarry. Ledges will be identified, at a minimum, by their differences in color, texture, and geological formation.

Production samples will be obtained from stockpiles of finished materials.

Aggregates, except those used for precast concrete units or fine aggregates used for snow and ice abrasive, shall be supplied by a Certified Aggregate Producer in accordance with 917. Structure backfill may be obtained from a non-CAPP source in accordance with 211.02. SF for SMA mixtures shall also require the following.

(a) Specific gravity quality control tests shall be completed at a frequency of one test per 2,000 t produced.

(b) Target bulk specific gravity shall be established using the average of the first four tests.

(c) Subsequent individual tests shall be within 0.050 of the target bulk specific gravity.

(d) Moving average of four consecutive tests shall be within 0.040 of the target bulk specific gravity.

(e) Tests outside these ranges shall require the material to be isolated from the approved stockpile until action has been taken to eliminate the cause of the non-conformity. Any non-conforming test shall be followed immediately by a corrective action. Corrective actions shall include, but are not limited to,

investigation for assignable cause, correction of known assignable cause, and retesting.

(f) If it is determined that a new target is necessary, a request shall be made in writing to the District Testing Engineer to establish the new target.

Dolomite aggregates are defined as carbonate rock containing at least 10.3% elemental magnesium when tested in accordance with ITM 205.

Polish resistant aggregates are defined as those aggregates in accordance with ITM 214. Aggregates meeting these requirements will be maintained on the QPL of Polish Resistant Aggregate Sources.

Sandstone aggregates shall only be used in HMA surface or SMA surface mixtures. Sandstone aggregates are defined as a sedimentary rock composed of siliceous sandgrains containing quartz, chert, and quartzose rock fragments in a carbonate matrix or cemented with silica, calcite, or dolomite. The Department's Division of Materials and Tests will determine identification of sandstone.

Steel furnace slag, SF, may be used in aggregate shoulders, HMA surface or SMA surface mixtures, dumped riprap, and snow and ice abrasives. SF slag coarse aggregate may be used in HMA base and HMA intermediate mixtures if the deleterious content is less than 4.0% when tested in accordance with ITM 219. RAP with steel slag may be used in accordance with 401.06, 402.08, and 410.06.

Adjustments in weight shall be made to compensate for the difference in specific gravity of slag compared to natural aggregate when payment is on a weight basis. The following typical values for specific gravity will be used: natural aggregate both fine and coarse, 2.6; ACBF slag coarse aggregate, 2.3; ACBF slag fine aggregate, 2.6; GBF slag fine aggregate, 2.1; and SF slag both fine and coarse, 3.4. The contract quantity shall not be adjusted on any pay item less than 500 t.

When slag is furnished as an aggregate, the approximate quantity of tons to be supplied will be determined by multiplying the pay item quantity of tons by the specific gravity of slag divided by 2.6. The adjusted contract quantities will be determined by multiplying the accepted quantity of tons by 2.6 divided by the specific gravity of the slag.

At time of use, aggregates shall be free from lumps or crusts of hardened or frozen materials.

Composite stockpiling of natural sand fine aggregate from multiple sources into one stockpile will be allowed provided the fine aggregates are within a range of 0.030 for the bulk specific gravity (dry) and a range of 0.5% for the absorption. The range of bulk specific gravity (dry) and absorption values shall be the difference between the

average values for each of the fine aggregate sources within the stockpile as determined by the Department's Division of Materials and Tests. A written request for the composite stockpiling shall be made to the Department's Division of Materials and Tests.

904.02 Fine Aggregates

Fine aggregates are defined as 100% passing the 3/8 in. (9.5 mm) sieve and a minimum of 80% passing the No. 4 (4.75 mm) sieve. Characteristics of fine aggregates are as follows:

Characteristic	PCC	HMA	SMA
Physical			
Organic Impurities, AASHTO T 21 lighter than or equal to, Color Standard (Note 1)….	3		
Acid Insoluble, ITM 202…….		(Note 2)	
Soundness			
Freeze and Thaw, AASHTO T 103, Procedure A, % max. (Note 3)…….	10.0	10.0	10.0
Brine Freeze and Thaw, ITM 209, % max. (Note 3)	12.0	12.0	12.0
Sodium Sulfate Soundness, AASHTO T 104, % max. (Note 3)…….	10.0	10.0	10.0

Notes:

1. When subjected to the colormetric test for organic impurities and a color darker than the standard is produced, it shall be tested for effect of organic impurities on strength of mortar in accordance with AASHTO T 71. If the relative strength at seven days is less than 95% it shall be rejected.

2. The fine aggregate, including blended fine aggregate, used in HMA Surface 4.75 mm mixtures shall have a minimum acid-insoluble content of 40%, except when using ACBF or GBF slag sands, the minimum acid-insoluble content shall be 25%. Acid-insoluble requirements shall not apply to crushed gravel, limestone, or dolomite sands.

3. AASHTO T 104 and ITM 209 may be run at the option of the Engineer, in-lieu of AASHTO T 103.

(a) For Portland Cement Concrete

Fine aggregate for use in PCCP or bridge decks shall be natural sand. Fine aggregate for other PCC shall be natural sand or crushed limestone, dolomite, gravel, or ACBF.

Natural sand which has been used as foundry sand when tested in accordance with ITM 215, and complying with IDEM Class III or Class IV in accordance with 329 IAC 10-7-4 may be used in precast concrete units or precast concrete pipe. When foundry sand is used, the precast concrete manufacturer shall maintain a copy of the Waste Classification issued by IDEM and an indemnification statement shall accompany the precast items to each contract.

(b) For HMA Mixtures

Fine aggregates for use in HMA shall be natural sand or crushed limestone, dolomite, gravel, sandstone, SF, or ACBF. SF sand may be used in HMA surface mixtures. SF sand may only be used in HMA base and HMA intermediate mixtures if SF in accordance with 904.01 is used to produce the SF sand. The amount of crushed limestone sand shall not exceed 20% by volume of the total aggregate used in HMA surface mixtures with ESAL equal to or greater than 3,000,000, except limestone sands manufactured from aggregates on the QPL of Polish Resistant Aggregate Sources will not be limited. If soundness testing cannot be conducted, the aggregate shall come from a Category I source in accordance with ITM 203.

The fine aggregate angularity value of the total blended aggregate material from the fine and coarse aggregates, and recycled materials shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows:

Fine Aggregate Angularity		
Traffic ESAL	Depth from Surface	
	≤ 4 in.	> 4 in.
< 3,000,000	40*	40
3,000,000 to < 10,000,000	45	40
≥ 10,000,000	45	40
* For 4.75 mm mixtures, the fine aggregate angularity shall be 45 for < 3,000,000 ESAL.		

Fine Aggregate Angularity, Method A..... AASHTO T 304

The fine aggregate angularity value shall not apply to OG mixtures.

(c) For SMA Mixtures

Fine aggregate for SMA shall be limestone, dolomite, crushed gravel, SF, or ACBF. Crushed gravels shall have a minimum fine aggregate angularity of 45 in accordance with AASHTO T 304, Method A. Fine aggregates shall be non-plastic in accordance with AASHTO T 90.

(d) For Pneumatically Placed Mortar

Fine aggregate shall be natural sand suitable for use with a pneumatic cement gun. Fine aggregate shall be size No. 15, or size PP in accordance with 904.02(h), or an approved gradation from a CAPP source.

(e) Mortar Sand

Fine aggregate for mortar shall consist of uniformly graded natural sand in accordance with gradation requirements of 904.02(h) for size No. 15 or an approved gradation from a CAPP source.

(f) Mineral Filler for SMA

Mineral filler shall consist of dust produced by crushing stone, portland cement, or other inert mineral matter having similar characteristics. Mineral filler shall be in accordance with the gradation requirements of 904.02(h) for size No. 16 or as approved by the Engineer. Mineral filler shall be in accordance with ITM 203 or from an ACBF slag source. The sieve analysis of mineral filler shall be conducted in accordance with AASHTO T 37 except as noted in 904.06. Mineral filler shall be non-plastic in accordance with AASHTO T 90.

(g) Snow and Ice Abrasives

Snow and ice abrasives shall be fine aggregates or cinders in accordance with the gradation requirements of 904.02(h) for size S&I.

When steel slag is used for snow and ice abrasives, and payment is on a tonnage basis, the pay quantity shall be adjusted in accordance with 904.01.

(h) Sizes of Fine Aggregates

Sizes (Percent Passing)						
Sieve Sizes	23	24	15	16	PP	S&I
3/8 in. (9.5 mm)	100	100				100
No. 4 (4.75 mm)	95 - 100	95 - 100			100	
No. 6 (3.35 mm)			100			
No. 8 (2.36 mm)	80 - 100	70 - 100	90 - 100		85 - 95	
No. 16 (1.18 mm)	50 - 85	40 - 80				
No. 30 (600 µm)	25 - 60	20 - 60	50 - 75	100	50 - 65	
No. 50 (300 µm)	5 - 30	7 - 40	15 - 40		15 - 25	0 - 30
No. 80 (180 µm)				95 - 100		
No. 100 (150 µm)	0 - 10	1 - 20	0 - 10		0 - 10	
No. 200 (75 µm)	0 - 3	0 - 6	0 - 3	65 - 100		0 - 7

(i) Sampling and Testing

Sampling and testing shall be conducted in accordance with the following AASHTO and ITMs.

Acid Insoluble Content..... ITM 202
Amount of Material Finer than
No. 200 (75 µm) Sieve* ..... AASHTO T 11
Brine Freeze and Thaw Soundness..... ITM 209
Control Procedures for Classification
of Aggregates..... ITM 203
Determining the Plastic Limit and
Plasticity Index of Soils..... AASHTO T 90
Mortar Strength ..... AASHTO T 71
Organic Impurities..... AASHTO T 21
Sampling Aggregates..... AASHTO T 2

Sampling Stockpiled Aggregates	ITM 207
Sieve Analysis of Aggregate*	AASHTO T 27
Sieve Analysis of Mineral Filler*	AASHTO T 37
Soundness*	AASHTO T 103, AASHTO T 104
Specific Gravity and Absorption, Fine Aggregate	AASHTO T 84

* Except as noted in 904.06.

904.03 Coarse Aggregates

Coarse aggregates are defined as having a minimum of 20% retained on the No. 4 (4.75 mm) sieve. Coarse aggregates shall not contain adherent fines that are detrimental to the end product as defined in ITM 211.

The coarse aggregate shall comply with the quality requirements and the additional requirements in accordance with 904.03(a). However, coarse aggregate may be rejected based on previous performance service records. Class AP is defined as the highest classification and Class F the lowest. Blending of material for compliance with gradation or crushed particle requirements may be approved when requested in writing. Blending of aggregate products to improve the quality classification of the finished product will not be allowed.

(a) Classification of Aggregates

Characteristic Classes	AP	AS	A	B	C	D	E	F
Quality Requirements:								
Freeze and Thaw Beam Expansion, % max. (Note 1)	.060							
Los Angeles Abrasion, % max. (Note 2)	40.0	30.0	40.0	40.0	45.0	45.0	50.0	
Freeze and Thaw, AASHTO T 103, Procedure A, % max. (Note 3).....	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Sodium Sulfate Soundness, % max. (Note 3)	12.0	12.0	12.0	12.0	16.0	16.0	20.0	25.0
Brine Freeze and Thaw Soundness, % max. (Note 3).....	30	30	30	30	40	40	50	60
Absorption, % max. (Note 4).....	5.0	5.0	5.0	5.0	5.0			
Additional Requirements:								
Deleterious, % max.								
Clay Lumps and Friable Particles	1.0	1.0	1.0	1.0	2.0	4.0		
Non-Durable (Note 5)	4.0	2.0	4.0	4.0	6.0	8.0		
Coke					(See Note 6)			
Iron.....					(See Note 6)			
Chert (Note 7)	3.0	3.0	3.0	5.0	8.0	10.0		
Weight per Cubic Foot for Slag, lb, min.	75.0		75.0	75.0	70.0	70.0	70.0	
Crushed Particles, % min. (Note 8)								
Compacted Aggregates.....			20.0	20.0	20.0	20.0		

Notes:

1. Freeze and thaw beam expansion shall be tested and re-tested in accordance with ITM 210.

2. Los Angeles abrasion requirements shall not apply to BF.

3. Aggregates may, at the option of the Engineer, be accepted by the Sodium Sulfate Soundness or Brine Freeze and Thaw Soundness requirements.

4. Absorption requirements apply only to aggregates used in PCC and HMA mixtures except they shall not apply to BF. When crushed stone coarse aggregates from Category I sources consist of production from ledges whose absorptions differ by more than two percentage points, the absorption test will be performed every three months on each size of material proposed for use in PCC or HMA mixtures. Materials having absorption values between 5.0 and 6.0 that pass AP testing may be used in PCC. If variations in absorption preclude satisfactory production of PCC or HMA mixtures, independent stockpiles of materials will be sampled, tested, and approved prior to use.

5. Non-durable particles include soft particles as determined by ITM 206 and other particles which are structurally weak, such as soft sandstone, shale, limonite concretions, coal, weathered schist, cemented gravel, ocher, shells, wood, or other objectionable material. Determination of non-durable particles shall be made from the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve. Scratch Hardness Test shall not apply to crushed stone coarse aggregate.

6. ACBF and SF coarse aggregate shall be free of objectionable amounts of coke, iron, and lime agglomerates.

7. The bulk specific gravity of chert shall be based on the saturated surface dry condition. The amount of chert less than 2.45 bulk specific gravity shall be determined on the total weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve for sizes 2 through 8, 43, 53, and 73 and on the total weight (mass) of material retained on the No. 4 (4.75 mm) sieve for sizes 9, 11, 12, and 91.

8. Crushed particle requirements apply to gravel coarse aggregates used in compacted aggregates. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821.

(b) Coarse Aggregate Angularity for HMA and SMA

The coarse aggregate angularity, CAA of the total blended aggregate, including recycled materials, shall meet or exceed the minimum values for the appropriate ESAL category and position within the pavement structure as follows.

Coarse Aggregate Angularity		
Traffic ESAL	Depth from Surface	
	≤ 4 in.	> 4 in.
< 3,000,000	75	50
3,000,000 to < 10,000,000	85/80*	60
≥ 10,000,000	95/90*	95/90*
* Denotes two faced crush requirements.		

For SMA mixtures, the total blended aggregate shall be 100% one face and 95% two face crushed.

220 Coarse Aggregate Angularity ..... ASTM D5821

Coarse aggregate angularity requirements do not apply to 4.75 mm HMA mixture designation.

(c) Flat and Elongated

The coarse aggregate shall contain 10% or less flat and elongated particles. A flat and elongated piece is defined as a particle having a ratio of length to thickness greater than 5. Determination of flat and elongated particles shall be made from the weight (mass) of material retained on the 3/8 in. (9.5 mm) sieve and each sieve size greater
230 than the 3/8 in. (9.5 mm) sieve.

Flat and Elongated..... ASTM D4791

Flat and elongated requirements do not apply to 4.75 mm HMA mixture designation.

(d) Surface Aggregate Requirements

The surface mixture aggregates selection shall be based on the ESAL category as follows.

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1. HMA Coarse Aggregate

a. ESAL Category 2 and type B surface mixtures. All coarse aggregate types including ACBF slag, SF slag, sandstone, crushed dolomite, polish resistant aggregate, crushed stone and gravel may be used.

b. ESAL Category 3 and type C surface mixtures. ACBF slag, SF slag, sandstone, crushed dolomite, polish resistant

aggregate or any combination thereof shall be used. Crushed stone or gravel shall not be used unless the aggregate is classified as a crushed dolomite or polish resistant aggregate.

c. ESAL Category 4 and type D surface mixtures. High friction aggregates including ACBF slag, SF slag, sandstone or aggregates in accordance with ITM 221 shall be used and at a minimum shall comprise 50% by volume of the coarse aggregate.

Crushed dolomite and polish resistant aggregates may be used up to a maximum 50% by volume of the coarse aggregate material retained on the No. 4 (4.75 mm) sieve when blended with a high friction aggregate.

Crushed stone and gravel may be used up to a maximum 20% by volume of the coarse aggregate material retained on the No. 4 (4.75 mm) sieve when blended with a high friction aggregate.

2. SMA Coarse Aggregate

SF slag, sandstone, crushed dolomite and polish resistant aggregates in accordance with 904.03(a) may be used in SMA mixtures provided the mixtures are designed in accordance with ITM 220.

(e) Sizes of Coarse Aggregates

Sieve Sizes	Coarse Aggregate Sizes (Percent Passing)											
	Coarse Graded										Dense Graded	
	2	5	8	9	11, SC 11[5]	12, SC 12[5]	SC 16[5]	43[1]	91	93PG[6]	53[1]	73[1]
4 in. (100 mm)												
3 1/2 in. (90 mm)												
2 1/2 in. (63 mm)	100											
2 in. (50 mm)	80 - 100											
1 1/2 in. (37.5 mm)		100						100			100	
1 in. (25 mm)	0 - 25	85 - 98	100					70 - 90	100		80 - 100	100
3/4 in. (19 mm)	0 - 10	60 - 85	75 - 95	100				50 - 70			70 - 90	90 - 100
1/2 in. (12.5 mm)	0 - 7	30 - 60	40 - 70	60 - 85	100	100	100	35 - 50		98 - 100	55 - 80	60 - 90
3/8 in. (9.5 mm)		15 - 45	20 - 50	30 - 60	75 - 95	95 - 100	94 - 100			75 - 100		
No. 4 (4.75 mm)		0 - 15	0 - 15	0 - 15	10 - 30	50 - 80	15 - 45	20 - 40		10 - 60	35 - 60	35 - 60
No. 8 (2.36 mm)		0 - 10	0 - 10	0 - 10	0 - 10	0 - 35		15 - 35		0 - 15	25 - 50	
No. 16 (1.18 mm)							0 - 4					
No. 30 (600 µm)						0 - 4		5 - 20		0 - 5	12 - 30	12 - 30
No. 200 (75 µm)[2]								0 - 6.0			5.0 - 10.0[4]	5.0 - 12.0
Decant (PCC)[3]		0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5	0 - 1.5			0 - 1.5			
Decant (Non-PCC)	0 - 2.5	0 - 2.5	0 - 3.0	0 - 2.5	0 - 2.5	0 - 2.0			0 - 2.5	0 -2.0		
Decant (SC)					0 - 1.5	0 - 1.5	0 - 1.5					

Notes:

(1) The liquid limit shall not exceed 25 (35 if slag) and the plasticity index shall not exceed 5. The liquid limit shall be determined in accordance with AASHTO T 89 and the plasticity index in accordance with AASHTO T 90.

(2) Includes the total amount passing the No. 200 (75 µm) sieve as determined by AASHTO T 11 and AASHTO T 27.

(3) Decant may be 0 - 2.5 for stone and slag.

(4) When slag is used for separation layers as defined in 302.01, the total amount passing the No. 200 (75 µm) sieve shall be 10.0 to 12.0.

(5) Seal coat (SC) aggregates shall be 85% one face and 80% two face crushed. The Flakiness Index in accordance with ITM 224 shall be a maximum of 25%.

(6) Pea gravel shall be generally uncrushed gravel, with a maximum of 20% crushed particles, and shall meet the gradation requirements of 93PG. Determination of crushed particles shall be made from the weight (mass) of material retained on the No. 4 (4.75 mm) sieve in accordance with ASTM D5821.

(f) Sampling and Testing

Sampling and testing will be in accordance with the following AASHTO, ASTM, and ITMs.

Amount of Material finer than No. 200 (75 µm) Sieve*	AASHTO T 11
Brine Freeze and Thaw Soundness	ITM 209
Clay Lumps and Friable Particles	AASHTO T 112
Control Procedures for Classification of Aggregates	ITM 203
Crushed Particles	ASTM D5821
Dolomite Aggregates	ITM 205
Flat and Elongated Particles	ASTM D4791
Freeze and Thaw Beam Expansion	ITM 210
Lightweight Pieces in Aggregates*	AASHTO T 113
Los Angeles Abrasion	AASHTO T 96
Micro-Deval Abrasion	AASHTO T 327
Polished Resistant Aggregates	ITM 214
Sampling Aggregates*	AASHTO T 2
Sampling Stockpiled Aggregates	ITM 207
Scratch Hardness	ITM 206
Sieve Analysis*	AASHTO T 27
Soundness*	AASHTO T 103, AASHTO T 104
Specific Gravity and Absorption*	AASHTO T 85
Unit Weight and Voids in Aggregates	AASHTO T 19

*Except as noted in 904.06

904.04 Riprap

Riprap shall consist of SF for dumped riprap only, sound stone, stone masonry, or other approved material, free from structural defects and of approved quality. Stone containing shale, unsound sandstone, or other material that will disintegrate readily, shall not be used.

(a) Dumped Riprap

Dumped riprap shall be broken concrete, masonry, or stone removed from an old structure; broken pieces removed from concrete pavement, base, or monolithic brick pavement; or broken rock from class X, class Y, unclassified excavation, or solid rock excavation. Material provided from sources outside the right-of-way shall be coarse aggregate, Class F or higher.

(b) Grouted Riprap

Grouted riprap material shall be in accordance with dumped riprap or revetment riprap.

(c) Revetment, Class 1, and Class 2 Riprap

The material shall be coarse aggregate, Class F or higher. Gradation shall be in accordance with 904.04(f).

(d) Uniform Riprap

The material shall be coarse aggregate, Class F or higher in accordance with 904.03(a). Gradation shall be in accordance with 904.04(f). Either type A or type B may be utilized.

(e) Precast Concrete Riprap

Precast concrete riprap shall consist of unreinforced concrete units of the thickness specified and shall be in accordance with the details shown on the plans. The precast concrete units shall be in accordance with ASTM C139 except the fine aggregates shall be in accordance with 904.02(a) and the coarse aggregates, class A or higher, shall be in accordance with 904.03. The minimum compressive strength shall be 2,500 psi for an average of three units and 2,300 psi for individual units. The maximum water absorption shall be 12 lb/cu ft for an average of three units.

(f) Sizes of Riprap

Gradation Requirements					
Percent Smaller					
Size, in.	Revetment	Class 1	Class 2	Uniform A	Uniform B
30			100		
24		100	85 - 100		
18	100	85 - 100	60 - 80		
12	90 - 100	35 - 50	20 - 40		
8				100	
6	20 - 40	10 - 30	0 - 20	35 - 80	95 - 100
3	0 - 10	0 - 10	0 - 10		35 - 80
1				0 - 20	0 - 20
Depth of Riprap, min.	18 in.	24 in.	30 in.		

The maximum dimension of individual pieces shall not be greater than three times the minimum dimension. The riprap will be visually inspected for size, shape, and consistency.

904.05 Structure Backfill

The material shall be of acceptable quality, free from large or frozen lumps, wood, or other extraneous matter. It shall consist of suitable sand, gravel, crushed stone, ACBF, or GBF. Structure backfill shall be in accordance with one of the gradations shown in the table below, or coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 in accordance with the gradation requirements of 904.03(e). Coarse aggregate No. 5, No. 8, No. 9, No. 11, No. 12, No. 53, or No. 73 shall be crushed stone or ACBF, class D or higher.

Sieve Sizes	Nominal Sizes and % Passing					
	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	1/2 in. (12.5 mm)	No. 4 (4.75 mm)	No. 30 (600 µm)
2 1/2 in. (63 mm)	100					
2 in. (50 mm)	90 - 100	100				
1 1/2 in. (37.5 mm)	70 - 100	90 - 100	100	100		
1 in. (25.0 mm)	55 - 95	70 - 100	85 - 100			
3/4 in. (19.0 mm)	45 - 90	55 - 95	70 - 100			
1/2 in. (12.5 mm)	35 - 85	40 - 90	55 - 95	85 - 100	100	100
No. 4 (4.75 mm)	20 - 65	20 - 70	25 - 75	45 - 85	90 - 100	
No. 8 (2.36 mm)	10 - 50	10 - 55	15 - 60	25 - 75	75 - 100	
No. 30 (600 µm)	3 - 35	3 - 35	3 - 35	5 - 45	15 - 70	70 - 100
No. 200 (75 µm)	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8	0 - 8

904.06 Exceptions to AASHTO Standard Methods

(a) Exceptions to AASHTO T 2

Stockpile sampling shall be in accordance with ITM 207, unless otherwise approved.

(b) Exceptions to AASHTO T 11, T 27, and T 37

1. When tests are performed in the field where ovens are not available, test samples may be dried in suitable containers over open flame or electric hot plates with sufficient stirring to prevent overheating, then cooled to constant weight.

2. The balance shall be a Class G2 general purpose balance in accordance with AASHTO M 231.

(c) Exceptions to AASHTO T 27 for Coarse Aggregates

The size of test samples for coarse aggregate shall be as follows:

Aggregate Size	**Minimum Weight of Test Sample**
No. 2	25 lb
No 5, 8, 43, 53, 73, and 91	13 - 18 lb
No. 9	9 - 13 lb
Structure Backfill	
2 in. (50 mm)	25 lb
1 1/2 in. (37.5 mm) and 1 in. (25.0 mm)	13 - 18 lb
1/2 in. (12.5 mm)	9 - 13 lb
No. 4 (4.75 mm) and No. 30 (600 µm)	10 oz

(d) Exceptions to AASHTO T 85

The in-water weight shall be determined following the 15 h soaking period prior to determining the SSD weight.

(e) Exceptions to AASHTO T 103 and T 104

1. Counting the number of individual particles coarser than the 3/4 in. (19.0 mm) sieve will not be required.

2. For testing ledge rock, the ledge samples shall be crushed to obtain test samples for the designated increments passing the 1 1/2 in. (37.5 mm) sieve and retained on the No. 4 (4.75 mm) sieve. The factors used to calculate the weighted average loss are 30%, 40%, and 30% of the 1 1/2 in. (37.5 mm) - 3/4 in. (19.0 mm), 3/4 in. (19.0 mm) - 3/8 in. (9.5 mm), and 3/8 in. (9.5 mm) - No. 4 (4.75 mm) increments, respectively.

3. In the case of ledge rock, modify sections 3.3 and 6.2 of AASHTO T 103 and AASHTO T 104 respectively. When the sample received is deficient in material of a component size of any test portion, that material will be supplemented with the available component size to provide the test portion.

4. Modify section 8 of AASHTO T 103 and section 10 of AASHTO T 104. For materials designated as a coarse aggregate, the weighted loss will be calculated considering the material retained on the No. 4 (4.75 mm) sieve as 100% of the sample, and only the total weighted loss reported. In AASHTO T 104 sections 10.1.3.2 and 10.1.3.3 shall not apply, and unless otherwise noted only new solution will be used.

SECTION 905 – MASONRY UNITS

905.01 Clay or Shale Brick

Brick shall be in accordance with the following specifications.

(a) Sewer Brick

Sewer brick shall be in accordance with ASTM C32, grade SS.

(b) Manhole Brick

Manhole brick shall be in accordance with ASTM C32, grade MS.

(c) Building Brick

Building brick shall be in accordance with ASTM C62, grade SW.

905.02 Concrete Brick

Concrete brick intended for use in construction of manholes, catch basins, and similar structures, or as building bricks, shall be in accordance with ASTM C55.

905.03 Concrete Masonry Blocks

Concrete masonry blocks may be rectangular or segmented and, when specified, shall have ends shaped to provide interlock at vertical joints. Solid masonry units shall be in accordance with ASTM C139. Hollow load-bearing masonry units shall be in accordance with ASTM C90, normal weight.

905.04 Precast Concrete Curbing

Precast concrete curbing shall consist of precast portland cement concrete curb units constructed to the length, shapes, and other details shown on the plans. These units shall be reinforced with steel reinforcement when shown on the plans. Steel reinforcement shall be in accordance with 910.01.

When required for driveways, crossings, closures, or for other reasons a depressed or modified section of curb is indicated, curbing with the required modification shall be furnished.

905.05 Detectable Warning Surfaces

The detectable warning surface in concrete curb ramps shall be constructed using materials from the QPL of Detectable Warning Surfaces, which is maintained by the Department's Division of Materials and Tests. A surface manufacturer wishing to add a product to the QPL shall comply with Procedure L of ITM 806.

(a) Brick detectable warning surfaces shall consist of clay, shale, or similarly naturally occurring earthy substance, subjected to heat treatment at elevated temperatures to form bricks or pavers. The dimensions of the brick shall be 8 in. in length, 4 in. in width including any spacing lugs. The thickness of the brick shall be 2 in., excluding dome height and edge chamfers. The truncated domes on the surface shall be formed integral with the main body of the detectable warning surface and be present on the brick prior to heat treatment. The size and physical requirements of the bricks shall be in accordance with ASTM C902 for weather and traffic environment classifications Class SX, Type II, respectively. The truncated domes may be ground off to meet the cap thickness requirement for compressive strength testing.

(b) Brick detectable warning surfaces shall be predominantly red-brown in color and shall be uniform throughout the brick. The color will be determined from the average of five color readings for detectable warning surfaces when measured at the top surface between the raised truncated domes and determined in accordance with ASTM E1349, CIE Illuminant D65, 10° Standard Observer,

using instrument geometry of 45°/0°, and the CIE L*a*b* color system. The tested bricks shall be within the limits as follows:

	Minimum	Maximum
L*	35.0	50.0
a*	6.0	36.0
b*	0.0	30.0

The value of a* shall not be less than 90% of the value of b*. The color difference of any installed brick after one year of exposure or of an individual detectable warning surface from the average color for any product or model from a manufacturer shall not be greater than 5.0 ΔE* units. The color shall be uniform throughout the detectable warning surfaces.

(c) Cast iron detectable warning surfaces shall be manufactured from gray iron in accordance with AASHTO M 105, Class No. 30A as a minimum. The truncated domes shall be as shown on the plans. The tops of the domes and the space between domes shall have a non-slip textured surface. The minimum thickness of the casting shall be 0.20 in. The minimum thickness shall not be measured within the area of integral reinforcing ribs or bracing, domes or the textured surface.

(d) The height range of the truncated domes shall be between 0.18 in. and 0.26 in. The design values shall be within the ranges identified in the Standard Drawings. No more than two truncated domes per surface may be out of tolerance for dimensions.

(e) Detectable warning surfaces that are not classified as brick in accordance with 905.05(a) or cast iron in accordance with 905.05(c) will be considered. The detectable warning surfaces shall meet the color requirements of 905.05(b) and the truncated dome requirements of 905.05(d).

905.06 Precast Concrete Units Not Otherwise Covered

These units shall be cast in substantial permanent steel forms. Structural concrete shall attain a minimum 28-day compressive strength of 3,000 psi as determined in accordance with AASHTO T 22. When air entrained concrete is specified, it shall have an air content of from 5% to 8% by volume. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units shall not exceed 9%. Additional reinforcement shall be provided as needed to handle the precast units.

SECTION 906 – JOINT MATERIALS

906.01 Joint Fillers

Joint fillers shall be preformed materials intended to be used in PCCP or as otherwise specified. Joint fillers shall be in accordance with AASHTO M 213 or ASTM D8139. A type B certification in accordance with 916 shall be provided for joint fillers. The limits of the following shall be shown on the certification.

Property	Test Method
Compressive Strength	ASTM D8139
Recovery	ASTM D8139
Extrusion	ASTM D545
Heat Resistance	ASTM D8139
Asphalt Content	ASTM D545
Water Absorption	ASTM D545
Freeze Thaw Resistance	ASTM D8139
Density	ASTM D545

906.02 Joint Sealing Materials

(a) Joint Sealers

Joint sealers shall consist of materials which are intended to be used in sealing joints and cracks in pavements and structures.

1. Silicone Joint Sealants

a. Physical Requirements

Silicone joint sealants shall be in accordance with ASTM D5893.

b. Field Evaluation

All silicone joint sealants complying with the physical requirements will be subjected to a field evaluation before approval for general use is granted. The Department will maintain a QPL of Joint Sealants, which comply with the physical requirements and field evaluation.

c. Specific Requirements for Installation of Silicone Joint Sealant

The sealant shall be stored in the original unopened container at or below 90°F. The sealant shall be placed when the ambient temperature is above 40°F. The equipment used shall be adequate for the placement of the sealant and shall meet the sealant manufacturer's recommendations. Air compressors used for the placement of this sealant shall be equipped with traps which remove moisture and oil from the air.

The sealants which are self-leveling shall be identified as such on the QPL of Joint Sealants, and will not require tooling. Sealants not identified as self-leveling on the QPL shall be tooled or applied in such a manner which causes them to wet the joint

faces. Such sealants which are not formulated for self-leveling will not position properly in the joint under its own weight. A backer rod as set out herein shall be used to control sealant configuration and facilitate tooling. Applicable joint configurations shall be as shown on the plans. After a joint has been sealed, all surplus joint sealer on the pavement surfaces shall be promptly removed. Traffic shall not be allowed over sealed joints until the sealer is tack free.

The sealant shall be delivered in containers plainly marked with manufacturer's name or trademark.

2. Hot Poured Joint Sealant

The sealant shall be in accordance with ASTM D6690, Type II. The material shall be tested in accordance with ASTM D5329 except that after blotting, the surface of the blocks shall be blown dry with compressed air. A type A certification in accordance with 916 shall be provided for hot poured joint sealant. The results of the following shall be shown on the certification.

Property	Requirement
Cone Penetration at 25°C	90 maximum
Softening Point °C	80 minimum
Bond, non-immersed	Three 12.5 ±0.2 mm specimens pass 3 cycles at 50 % ext. at -29°C
Resilience, %	60 minimum
Asphalt Compatibility	Pass

The sealing compound shall be delivered in the manufacturer's original sealed container. Each container shall be legibly marked with the name of the manufacturer, the trade name of the sealer, the manufacturing batch number or lot, the pouring temperature, and the safe heating temperature.

The sealant shall be used in accordance with the manufacturer's recommendations. A backer rod as set out herein shall be used to provide the joint configuration in accordance with the standard drawings.

3. Preformed Elastomeric Joint Seals

This joint shall be in accordance with ASTM D2628. A type A certification in accordance with 916 shall be provided for joint seals. The results of the following shall be shown on the certification.

Property	ASTM Test Method	Requirement
Tensile strength, minimum, psi (MPa)	D412	2000 (13.8)
Elongation at break, minimum, %	D412	250
Hardness, Type A durometer, points	D2240	55 ±5
Oven aging, 70 h at 212°F (100°C)	D573	
Tensile strength, loss, maximum, %		20
Elongation, loss, maximum, %		20
Hardness, Type A durometer, points change		0 to + 10
Oil Swell, ASTM Oil 3, 70 h at 212°F (100°C) Weight change, maximum, %	D471	45
Ozone resistance	D1149	
20 % strain, 300 ppm in air, 70 h at 104°F (40°C)		no cracks
Low-temperature stiffening, 7 days at 14°F (-10°C)	D2240	
Hardness, Type A durometer, points change		0 to + 15
Low-temperature recovery, 72 h at 14°F (-10°C) 50 % deflection, minimum, %	D2628	88
Low-temperature recovery, 22 h at - 20°F (-29°C), 50 % deflection, minimum, %	D2628	83
High-temperature recovery, 70 h at 212°F (100°C), 50 % deflection, minimum, %	D2628	85
Compression-deflection, at 80 % of nominal width, minimum, lbf/in. (N/m)	D2628	3.5 (613)

4. Polychloroprene Joint Membrane and Adhesive

Polychloroprene joint membrane shall be general purpose, heavy duty polychloroprene sheeting with nylon fabric reinforcement. The sheeting shall be in accordance with the following:

Property	Test Method	Requirement
Thickness	ASTM D751	0.094 in. ±0.01 in.
Breaking Strength, Grab Test, minimum	ASTM D751	700 lbf x 700 lbf (Longitudinal x transverse)
Adhesive Strip, 1 in. by 2 in.	ASTM D751	9 lbf minimum
Burst Strength	ASTM D751	1,400 psi minimum

A type B certification in accordance with 916 shall be provided for the polychloroprene joint membrane. The limits of the above shall be shown on the certification.

The adhesive used to attach the polychloroprene joint membrane to concrete shall be a black styrene-butadiene rubber base material compatible with both concrete and polychloroprene. The adhesive shall be in accordance with the following:

Property	Test Method	Minimum	Maximum
Viscosity, cps	ASTM D2196, RVF #6 sp @ 20 rpm	7,500	18,000
Solids, %	ASTM D1259	28	35
Weight per gal., lb	ASTM D1875	6.6	7.0

A type C certification in accordance with 916 shall be provided for the polychloroprene joint adhesive.

5. Hot Poured Joint Adhesive

Joint adhesive is a hot applied asphalt material that is used to seal the longitudinal construction joint formed between the adjacent HMA pavement courses.

Joint adhesive shall be in accordance with the following:

Test	Method	Test Result
Softening Point, °F (°C)	AASHTO T 53	> 170 (77)
Ductility @ 77°F (25°C), mm	AASHTO T 51	> 300
Ductility @ 39°F (4°C), mm	AASHTO T 51	> 300
Apparent Viscosity @ 400°F (204°C), cP	ASTM D2669	4,000 – 11,000
Asphalt Compatibility	ASTM D5329	Pass
Cone Penetration @ 77°F (25°C), mm	ASTM D5329	50.0 – 100.0
Flow @ 140°F (60°C), mm	ASTM D5329	< 5
Resilience @ 77°F (25°C), %	ASTM D5329	> 30
Tensile Adhesion @ 77°F (25°C), 1 in. specimen, %	ASTM D5329	> 500
Flexibility @ 0°F (-18°C)	ASTM D3111	Pass
Flash Point, °C (°F)	AASHTO T 48	> 219 (426)

A type A certification in accordance with 916 shall be provided for hot poured joint adhesive. The results of the above shall be shown on the certification.

(b) Backer Rod

The rod is to act as a bond breaker, to control the thickness of the bead, and to provide support for any required tooling of the sealant.

1. Requirements

When hot poured material is used, compatibility of the backer rod with the hot sealant shall be verified before use. The backer rod shall be a closed cell expanded polyethylene foam or an isomeric polymer foam rod. Diameter and placement shall be as shown on the plans.

2. Certification

A type C certification in accordance with 916 shall be provided for the backer rod.

906.03 Preformed Expansion Joint Filler

Preformed expansion joint filler, PEJF, shall be preformed materials intended to be used at bridge component interfaces that are not required to be watertight. PEJF shall be either extruded polystyrene, XPS, or expanded polystyrene, EPS in accordance with ASTM C578. The compressive resistance shall be less than 40 psi, as measured in accordance with ASTM D1621. Water absorption shall be less than 1%, as measured in accordance with ASTM C272. PEJF will be by accepted by visual inspection.

906.04 Blank

906.05 Blank

906.06 Blank

906.07 Bridge Expansion Joints

Type S and Type M joints, including anchor assemblies, shall be shop fabricated, delivered and installed as a continuous unit for lengths up to 46 ft. Joints longer than 46 ft shall be furnished in continuous units or in appropriate shorter sections as shown on the working drawings and approved by the Engineer. Joints used in stage construction shall be furnished in sections appropriate to accommodate the work. All steel joints furnished in sections shall be spliced with welds, with ends prepared for welding in the shop. All welds shall be in accordance with 711.32.

Type PCF joints shall be fabricated, delivered, and installed in lengths no less than 6 ft. Sections of joint shall be field spliced using silicone sealant in accordance with the manufacturer's recommendations. Joints shall be furnished with the fewest number of splices possible, and sections less than 6 ft in length shall not be used unless required to complete the remaining length at the ends of a joint or construction phase.

The profile of the joint in the roadway area shall conform to the roadway cross section. Where changes in direction are required, such as at curbs or concrete rails, the sections shall be cut to the bevel required to produce the same cross section on each piece being joined. Slider plates shall be provided at curbs, walkways, and concrete rails as part of the completed joint assembly. The slider plate shall be the same material as the extrusion and shall be galvanized in accordance with ASTM A123.

All welds in contact with the elastomeric seals shall be ground smooth. Metal surfaces in direct contact with the elastomeric seal shall be cleaned and treated in accordance with the manufacturer's recommendations to provide a high strength bond between the elastomeric seal and mating metal surfaces. The elastomeric seals shall be clean and free of foreign materials.

All exposed structural steel surfaces, except stainless steel or polytetrafluoroethylene coated, shall be shop painted in accordance with 619.

(a) Type SS

Structural steel shall be in accordance with ASTM A36, ASTM A588, ASTM A1011, ASTM A242, or Merchant Quality 1010, 1020.

Sealant and grouts shall be in accordance with the manufacturer's recommendation.

The elastomer shall be neoprene in accordance with ASTM D5973 except that the physical requirements in Table 1 for low temperature recovery, high temperature recovery, and compression-deflection properties will not apply.

The strip seal shall be furnished in one continuous length for the entire limits of the installed joint. Field splicing of the strip seal will not be allowed. Miter cut, vulcanized shop splices will be required in the strip seal. The shop vulcanization of the strip seal splice may be either a hot or cold process so long as the process produces a splice of equal or greater strength than the elastomer.

A type B certification in accordance with 916 shall be provided for the elastomer. The limits of the following shall be shown on the certification.

A type C certification in accordance with 916 shall be provided for the structural steel and polyurethane sealant.

(b) Type M

This joint shall consist of prefabricated multiple elastomeric seals, separator beams, and support bars. The structural design of the joint shall be in accordance with AASHTO LRFD Bridge Construction Specifications and shall be for the same design loading as the bridge structure at which it is to be installed, but not less than HS 20-44 truck loading and impact. The joint shall be designed to accommodate the movement shown on the plans.

The joint assembly shall be preset by the manufacturer in accordance with the approved working drawings, joint setting data and specifications. The assembly shall be properly secured for shipping and contain provision for final field adjustment at the time of installation. The manufacturer shall furnish a copy of the installation instructions prior to the placement of these joints.

Structural steel shall be in accordance with ASTM A36, ASTM A1011, ASTM A242, ASTM A588, or Merchant Quality 1010, 1020 in accordance with ASTM A576.

Sealant and grout shall be in accordance with the joint manufacturer's recommendation.

Elastomer shall be neoprene in accordance with ASTM D3542.

A type B certification in accordance with 916 shall be provided for the elastomer. The limits of the following shall be shown on the certification.

A type C certification in accordance with 916 shall be provided for the structural steel and polyurethane sealant.

Bearings above and below the support bar shall be a nylon or urethane compound with polytetrafluorethylene riding surfaces. All components of the system shall be accessible to periodic inspection and component replacement if necessary.

The elastomer seals shall be in accordance with the requirements as follows:

1. be held in place by compressive forces throughout the normal limits of joint movement;

2. be supplied and installed in one piece;

3. have corner locked edges for a watertight fit;

4. not be any part of the load bearing riding surface;

5. be installed using seal lubricant-adhesive or be mechanically clamped in position to produce a watertight seal;

6. have a shape which promotes self removal of foreign material during normal joint operation;

7. be recessed 1/2 in. below the riding surface throughout the normal limits of joint movement;

8. be held in position by the separator beams;

9. have a hollow box shape for joints utilizing urethane equilibrium control spacers or a strip seal configuration for joints using a mechanical linkage to maintain equidistant separator beam spacing. The joint shall have a maximum opening of 3 in. per seal.

The separator beams shall be in accordance with the requirements as follows:

1. provide the riding surface across the joint;

2. have an extruded or machined shape suitable to hold the seals;

3. be stable against tipping, tilting, or lifting during application of traffic loads by use of a suitable shape and connection to the support bar;

4. be supported individually on their own independent support bars;

5. maintain equidistant spacing through use of suitable urethane equilibrium type control spacers to counter the compressive forces of the seals or through a positive horizontal mechanical linkage or proportioning bar.

The support bars shall be in accordance with the requirements as follows:

1. incorporate stainless steel sliding surfaces to minimize resistance to joint movements;

2. be supported above, below, and laterally as required to prevent lifting, to transmit bearing loads, and to maintain positioning of the bar.

All support bar boxes and joint housings shall have top, bottom, and sides made of steel plate with 1/2 in. minimum thickness. Anchorages shall consist of looped No. 5 reinforcing bars welded to 1/2 in. steel plates spaced at 9 in. centers. Non-welded steel to steel contact will not be allowed.

(c) Type PCF

Pre-compressed foam joints, PCF, shall be furnished from the Department's list of approved PCF Bridge Joints. PCF joints may be added to the approved list by completing the requirements of ITM 806, Procedure C.

These products shall consist of a highway grade silicone faced self-expanding foam expansion joint seal, a field-applied epoxy adhesive, and a field-applied silicone sealant. The foam seal shall be able to accommodate the thermal movement range shown on the plans and shall have a movement capability of no less than +50% to -50% of the nominal material size. The silicone facing material shall accommodate a minimum elongation of 1,200%.

The foam seal shall be accordance with the following requirements:

Property	ASTM Test Method	Requirement
Temperature Service Range	C711	-40ºF to 185ºF
UV Resistance	G155 or C793	No changes or cracking at 2,000 h

906.08 High Density Bearing Strip

The strip shall be nontoxic multipolymer plastic in accordance with the following requirements:

Property	Test Method	Requirement
Compressive Strength	ASTM D695	8,000 to 9,000 psi
Coefficient of Linear Expansion	ASTM D696	7.62×10^{-4} mm/mm/ºC to 1.27×10^{-3} mm/mm /ºC

A type B certification in accordance with 916 shall be provided for the high-density bearing strip. The limits of the compressive strength test and measurement of the coefficient of linear expansion shall be shown on the certification for the high-density bearing strip.

SECTION 907 – CONCRETE, CLAY, AND PLASTIC DRAINAGE COMPONENTS

907.01 Non-Reinforced Concrete Pipe

This pipe shall be in accordance with AASHTO M 86 for the specified diameter and strength classes. When used for underdrain, each section of pipe shall not exceed 3 ft in length.

907.02 Reinforced Concrete Pipe

This pipe shall be in accordance with AASHTO M 170 for the specified diameters and strength classes. Precast concrete units shall be from a source listed on the QPL of Certified Precast Concrete Producers, in accordance with ITM 813. Unless otherwise specified, pipe wall design and use of elliptical reinforcement in circular pipe are optional.

The pipe provided shall be in accordance with the class and D-load rating shown on the plans.

When the pipe listed below is specified or allowed, it shall be in accordance with the class noted.

Extra Strength Reinforced Concrete Pipe.....Class IV
Heavy Duty Reinforced Concrete Pipe.....Class V
Reinforced Concrete Pipe.....Class III
Reinforced Concrete Sewer Pipe.....Class II.

Precast reinforced concrete end sections shall be in accordance with the cited specifications to the extent to which they apply.

The manufacturer of the steel reinforcement shall furnish to the pipe manufacturer

a mill test report. The pipe manufacturer shall certify, on furnished forms that:

(a) The placement of the steel reinforcement is in accordance with the Standard Specifications.

(b) The area of steel reinforcement per linear foot of pipe is in accordance with or exceeds the specification requirements.

(c) Based on the steel reinforcement manufacturer's mill test report, the steel used in the pipe is in accordance with the specification requirements.

(d) Copies of the steel reinforcement manufacturer's mill test reports shall be on file and available to review for five years.

907.03 Reinforced Concrete Horizontal Elliptical Pipe

This pipe shall be in accordance with AASHTO M 207. Precast concrete units shall be from a source listed in the Department's list of Certified Precast Concrete Producer, in accordance with ITM 813.

907.04 Precast Concrete Manholes, Inlets, and Catch Basins

These units shall be in accordance with AASHTO M 199. References to diameter are applicable to corresponding dimensions in other than circular sections. Absorption tests will not be required for flat top or base slabs.

Precast concrete units shall be from a source listed in the Department's list of Certified Precast Concrete Producer, in accordance with ITM 813.

No more than three holes shall be cast or drilled in each section for the purpose of handling.

In addition to the requirements of AASHTO M 199, the manhole steps shall be permanently marked with the specific step designation, and the manufacturer's identification. This marking shall remain exposed after installation.

Steps shall be selected from the QPL of Manhole Steps. Requests for adding steps to the QPL shall be accompanied by: a certified test report demonstrating compliance with AASHTO M 199; instruction for proper installation; complete product description including the ancillary equipment required for installation; and a sample step. The Department may perform a laboratory evaluation of specific steps and may not add steps to the QPL which are not furnished with ancillary installation equipment.

907.05 Precast Reinforced Concrete Structure Sections

Precast reinforced concrete structure sections shall be from a source listed on the QPL of Certified Precast Concrete Producers, in accordance with ITM 813. A water-reducing admixture from the QPL of PCC Admixtures and Admixture Systems may be used.

Handling devices or holes will be allowed in each structure section. Holes for handling shall be filled with material in accordance with 901.07, 901.08, or with precast concrete plugs which shall be secured with portland cement mortar or other approved adhesive before backfilling. Drilled handling holes shall be filled with portland cement mortar. Prior to backfilling the structure, all holes shall be covered with joint wrap material with a minimum width of 9 in.

The section ends shall be of such design and shall be so formed that when the structure sections are erected, they shall make a continuous line of structure with a smooth interior free of irregularities. The ends of the structure sections shall be normal to the walls and centerline, except where beveled ends are specified. The surface of the structure sections shall be cast from a smooth steel form or troweled surface. Trapped air pockets causing surface defects shall be considered as part of a smooth steel form finish.

(a) Box

Box structure sections shall be in accordance with ASTM C1577 and the exceptions to ASTM C1577 listed in 714.04. Not more than four holes may be cast, drilled, or otherwise made in each box section for the purpose of handling or laying.

(b) Three-Sided

Three-sided structure sections shall be in accordance with ASTM C1504 and the exceptions to ASTM C1504 listed in 723.04. Not more than six holes shall be cast, drilled, or otherwise made in each section for the purpose of handling or laying.

907.06 Precast Reinforced Concrete Headwalls, Wingwalls, Footings and Spandrel Walls

Precast concrete units shall be from a source listed on the QPL of Certified Precast Concrete Producers, in accordance with ITM 813. A water-reducing admixture from the QPL of PCC Admixtures and Admixture Systems may be used.

Handling devices or holes will be allowed in each wingwall and spandrel wall section. Not more than four holes shall be cast or drilled in each section for the purpose of handling or setting. Weep holes shall be provided in all wingwalls.

Headwalls, wingwalls, and spandrel walls shall be free of fractures and shall be given a finish in accordance with 702.21.

The concrete compressive strength for headwalls, wingwalls, and spandrel walls shall have a minimum 28-day compressive strength of 4,000 psi, as determined by compressive strength testing of concrete cylinders. The concrete compressive strength for footings shall have a minimum 28-day compressive strength of 2,000 psi, as determined by compressive strength testing of concrete cylinders.

Structural steel used in bolted connections of headwalls or wingwalls to a box-structure section, or of wingwalls to a three-sided-structure section or spandrel wall,

shall be in accordance with 910.02(a), and zinc coated after fabrication in accordance with ASTM A153.

Bolts and studs shall be hot dipped in accordance with 910.02(g)1. Nuts shall be in accordance with ASTM A563, grade A, Hex style; unless specified otherwise. Washers shall be in accordance with ASTM F844, unless specified otherwise. Bolts, nuts and washers shall be hot dip zinc coated.

907.07 Joint Membrane System for Precast Reinforced Concrete Box Structure Sections

The Contractor may elect to use an approved self-adhering membrane system in lieu of the detail shown on the plans.

Joint membrane systems shall be in accordance with the following requirements.

Property	ASTM Test Method	Requirement
Thickness, minimum	D3767, Procedure A	59 mil
Tensile Strength, minimum	Grab Tensile Strength, D4632	650 N
Elongation, minimum	Grab Tensile Strength, D4632	20%
Bursting Strength, minimum	Mullen Burst, D3786	290 psi
Peel Strength, minimum	D903	850 N/m
Permeance, maximum	E96, Water Method	1.05 Perm

The membrane system shall be supplied in roll widths of at least 12 in. The membrane shall be a composite sheet material composed of a non-woven fabric and a polymer membrane material. The membrane shall be protected by a release paper.

A type B certification in accordance with 916 shall be provided for the joint membrane system. The limits of the above shall be shown on the certification.

907.08 Clay Pipe

This pipe shall be in accordance with ASTM C700 for the specified diameters and strength classes for circular non-perforated pipe. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self centering feature. The pipe may be glazed or unglazed, unless otherwise specified.

907.09 Perforated Clay Pipe

This pipe shall be in accordance with ASTM C700 for the specified dimensions and strength classes. It may be glazed or unglazed, unless otherwise specified. Where vitrified clay culvert pipe is furnished, a pipe end section compatible to that as required for concrete or metal pipe shall be used.

907.10 Drain Tile

This pipe shall be in accordance with AASHTO M 178 for concrete or ASTM C4 for clay for the specified material, diameters, and quality classes.

Precast concrete units shall be from a source listed on the Department's List of Certified Precast Concrete Producers, in accordance with ITM 813. Standard quality drain tile shall not be used. When specified, the pipe spigot shall have integral spacer lugs to provide for an annular opening and self-centering feature.

Clay drain tile furnished under this specification shall be covered by a type C certification in accordance with 916.

907.11 Pipe Joint Sealant

A type B certification in accordance with 916 shall be provided for the material for the sealing of joints of bell and spigot or tongue and groove concrete or clay pipe or culverts furnished under this specification. The material shall not contain asbestos fibers. The limits of the following shall be shown on the certification.

(a) Preformed Flexible Joint Sealants

Joint sealants shall be either bitumen or butyl rubber in accordance with ASTM C990. The results of the following tests shall be shown on the type B certification.

Property	Test Method
Hydrocarbon Blends	ASTM D4 (bitumen) or D297 (butyl)
Ash-Inert Mineral Matter	AASHTO T 111
Volatile Matter	ASTM D6
Specific Gravity @ 77°F	ASTM D71
Ductility @ 77°F	AASHTO T 51 or ASTM D113
Flash Point	ASTM D92
Fire Point	ASTM D92
Softening Point	ASTM D36
Compression Index @ 77°F and 32°F	ASTM C972
Cone Penetration @ 77°F and 32°F, 150 g, 5 s, mm/10	ASTM D217
Chemical Resistance	ASTM C990

(b) Bituminous Mastic Sealant

A cold applied, mineral filled, bituminous joint sealing compound that can be applied to the joints with a trowel when the air temperature is between 20° and 100°F.

The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal and shall not flow, crack, or become brittle when exposed to the atmosphere.

The mastic shall also be in accordance with the following. The results of the tests shall be shown on the type B certification.

Property	Minimum	Maximum
Grease cone penetration unworked, 77°F, 150 g, 5 s, ASTM D217, mm/10	125	275
Non-Volatile, 10 g, 220° - 230°F, 24 hr	75%	
Loss on Heating, 325°F, 5 hr, 50 g		20%
Inorganic Content (complete burn, 1200° to 1400°F)	15%	45%
Flash Point, ASTM D92 or D1310	100°F	
Fire Point, ASTM D92 or D1310	150°F	
High Temperature Resistance to Flow	No sag	
Cold Temperature Flexibility	No cracks	

The test for high temperature resistance to flow shall be as follows: trowel joint mastic approximately 1/2 in. thick on a porous concrete slab or piece of concrete block. Place in oven at 140°F for 10 h.

The test for cold temperature flexibility shall be as follows: trowel joint mastic approximately 1/4 in. on heavy kraft paper or very light gauge sheet metal. Condition in a freezer at 10°F for 3 h. Bend the sample over a 1 in. diameter pin or mandrel.

907.12 Joint Mortar

Pipe joint mortar shall consist of 1 part portland cement and 2 parts sand with water as necessary to obtain the required consistency. Mortar shall be used within 30 minutes after its preparation.

907.13 Rubber Type Gaskets

Ring gaskets for pipe shall be in accordance with ASTM C1619, class C. A type B certification in accordance with 916 shall be provided for the rubber type gaskets. The limits of the following shall be shown on the certification.

Property	Test Method
Tensile Strength and Elongation	ASTM D412
Hardness	ASTM D2240
Oven-age tensile reduction, of original	ASTM D573 and D412
Oven-age elongation reduction, of original	ASTM D573 and D412
Compression Set	ASTM D395
Immersion, water	ASTM D471
Ozone resistance	ASTM D1149
Splice Strength Classification	ASTM D2527

907.14 Blank

907.15 Blank

907.16 Thermoplastic Pipe Requirements

A QPL of thermoplastic pipe and liner pipe will be maintained by the Department. The list will specify the manufacturer and thermoplastic pipe designation. All of these

materials shall comply with the applicable AASHTO or ASTM requirements listed in the following table and will only be accepted from qualified manufacturers. The manufacturer is defined as the plant which produces the thermoplastic pipe. The manufacturer shall become qualified by establishing a history of satisfactory quality control of these materials as evidenced by the test results performed by the manufacturer's testing laboratory.

Summary of Thermoplastic Pipe Specification Requirements				
Pipe Material	Standard Specification	AASHTO	ASTM	Manufacturer Requirement
Corrugated Polyethylene Drainage Tubing	907.17(a)	M 252		ITM 806, Procedure O
Corrugated Polyethylene Pipe	907.17(b)	M 294*		ITM 806, Procedure O
Corrugated Polypropylene Pipe	907.19	M 330		ITM 806, Procedure O
Perforated PVC Semicircular Pipe	907.18		D3034	ITM 806, Procedure A
Profile Wall PVC Pipe	907.22	M 304		ITM 806, Procedure O
Profile Wall Polyethylene Pipe	907.20		F894	ITM 806, Procedure A
Schedule 40 PVC Pipe	907.24(b)		D1785 or D2665	916, Type C Cert.
Smooth Wall Polyethylene Pipe	907.21		F714	ITM 806, Procedure A
Smooth Wall PVC Pipe	907.23	M 278	F679	ITM 806, Procedure A
Type PSM PVC Pipe and Fittings	907.24(a)		D3034	ITM 806, Procedure A
* Pipe in accordance with AASHTO M 294 shall be manufactured with virgin materials.				

907.17 Corrugated Polyethylene Drainage Tubing and Pipe

230

(a) Corrugated Polyethylene Tubing

Tubing and fittings shall be in accordance with AASHTO M 252. Perforations shall be required for tubing used as a longitudinal underdrain. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

(b) Corrugated Polyethylene Pipe

Pipe and fittings shall be in accordance with AASHTO M 294. Pipe shall be manufactured with virgin materials, and be marked with the code "V". Pipe shall not

be manufactured with recycled materials. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

907.18 Perforated PVC Semicircular Pipe

Perforated PVC semicircular pipe may be used as an alternate to 6 in. or less diameter pipe or tile. Pipe shall be in accordance with ASTM D3034, SDR 35. This semicircular pipe shall have a smooth top and a smooth, semicircular bottom, nominally 4 5/8 in. in diameter, with perforations uniformly distributed along the top of the bottom section in accordance with AASHTO M 252 perforation requirements. The top section shall extend a minimum of 1/2 in. beyond the top of the semicircular section. The top section shall be approximately 6 3/8 in. wide including the sloping overhangs on each side. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.19 Corrugated Polypropylene Pipe

Pipe and fittings shall be in accordance with AASHTO M 330. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

907.20 Profile Wall Polyethylene Pipe

Pipe and fittings shall be either closed profile or ribbed open profile in accordance with ASTM F894. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.21 Smooth Wall Polyethylene Pipe

Pipe shall be in accordance with ASTM F714 for nominal diameters of 39 in. or less. Fittings shall be in accordance with ASTM F1055. The pipe sizes shall be in accordance with ISO sizing system. The pipe dimension ratio shall be 26 or less. The resin used in manufacturing this type of pipe shall have a minimum cell classification of 335434C in accordance with ASTM D3350 or a minimum grade of PE4710 in accordance with ASTM F714.

Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.22 Profile Wall PVC Pipe

Pipe and fittings shall be in accordance with AASHTO M 304. Perforations shall be required when used as a longitudinal underdrain or end bent drain pipe. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

907.23 Smooth Wall PVC Pipe

Pipe and fittings shall be in accordance with AASHTO M 278 for pipe sizes 4 in. through 15 in., and ASTM F679 for pipe sizes 18 in. through 27 in. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

907.24 Smooth Wall Pipe for Outlets

Pipe and pipe fittings shall be smooth wall, non-perforated plastic pipe. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure A.

(a) Type PSM PVC Pipe and Fittings

Pipe and fittings shall be in accordance with ASTM D3034, SDR 23.5.

(b) Schedule 40 PVC Pipe

Pipe shall be in accordance with ASTM D1785 or D2665 and shall have a minimum pipe stiffness of 150 psi at 5% deflection when determined in accordance with ASTM D2412. Material furnished under this specification shall reference ASTM D1785 or ASTM D2665 in the product print line. A type C certification in accordance with 916 shall be provided for the schedule 40 PVC pipe.

907.25 Thermoplastic Liner Pipe

Thermoplastic liner pipe shall be HDPE or PVC pipe with sufficient rigidity to withstand the installation operation and shall exhibit a minimum amount of distortion. The liner pipe shall be free from visible cracks, holes, foreign inclusions, or other defects. A type A certification in accordance with 916 shall be provided for the HDPE liner pipe. The results of the tests listed in ITM 804 shall be shown on the certification.

(a) Solid Wall HDPE Liner Pipe

Solid wall HDPE liner pipe shall be in accordance with ASTM F714. The maximum standard dimension ratio, SDR, as defined in ASTM F412 for the liner pipe shall be 32.5. The actual calculated minimum dimension ratio, DR, as defined in ASTM F412 for the liner pipe shall be 30.0. The resin used in the manufacture of the liner pipe shall have a minimum cell classification of 345464C in accordance with ASTM D3350 or a minimum grade of PE4710 in accordance with ASTM F714. A 12 in. section of the liner pipe shall show no evidence of splitting, cracking, or breaking when compressed between parallel plates to 40% of its outside diameter within 2 to 5 minutes. Thermoplastic liner pipe may be added to the QPL by completing the requirements of ITM 806, Procedure Q.

(b) Profile Wall HDPE Liner Pipe

Profile wall HDPE liner pipe shall be in accordance with ASTM F894. The minimum liner ring stiffness constant, RSC, shall be 160 for circular installations and 250 for deformed installations. Thermoplastic liner pipe may be added to the QPL by completing the requirements of ITM 806, Procedure A.

(c) Profile Wall PVC Liner Pipe

Profile wall PVC liner pipe shall be in accordance with ASTM F949. Thermoplastic liner pipe may be added to the QPL by completing the requirements of ITM 806, Procedure A.

907.26 Solvent Cements for PVC Pipe and Pipe Fittings

Solvent cement for PVC pipe and fittings shall be in accordance with ASTM D2564. A type C certification in accordance with 916 shall be provided for the solvent cements.

907.27 Elastomeric Seals

Elastomeric seals for joining plastic pipe shall be in accordance with ASTM F477. A type B certification in accordance with 916 shall be provided for the seals. The limits of the following shall be shown on the certification.

Test	ASTM
Tensile Strength	D412 or D1414
Ultimate Elongation	D412 or D1414
100% Modulus	D412 or D1414
Hardness (Durometer)	D2240 or D1414
Low-Temperature Hardness	D2240 or D1414
Compression Set	D395 Method B, or D1414
Accelerated Aging	D573
Immersion, water	D471
Ozone Resistance	D1149
Elastomer Compound Effect on Pipe	F477
Force Decay (Stress Relaxation)	F913

907.28 Reinforced Thermosetting Resin Pipe and Pipe Fittings

Reinforced thermosetting resin pipe and accompanying fittings shall be in accordance with ASTM D2996 for the specified sizes. The short-term rupture strength hoop tensile stress shall be a minimum of 30,000 psi. All pipes shall be pigmented resin throughout the wall thickness. The color of the pipe shall match color No. 26400 of SAE-AMS-STD-595. Painting, gel-coating, or exterior coating of the pipe to obtain the specified color shall not be done. Pipe shall be tested in accordance with ASTM G154 for 2,500 h of accelerated weathering following cycle 2 as defined in Appendix X2. After testing, the surface of the pipe shall show no fiber exposure, crazing, or checking, and may have only a slight chalking or color change. An adhesive recommended by the manufacturer shall be used for joining pipe and fittings. A type A certification in accordance with 916 shall be provided for reinforced thermosetting resin pipe/fittings. The results of the following shall be shown on the certification.

Test	ASTM
Wall Thickness and Diameter	D3567
Short-Term Hydrostatic Failure Strength	D1599
Stiffness Factor (for direct-bury only)	D2412, based on 5% deflection

A lot will be defined as the production quantity in a given calendar month for each pipe diameter, not to exceed 10,000 lft. The accelerated weathering test shall be performed once for each pipe material formulation that is provided. A new accelerated weathering test will be required if the pipe material formulation changes. Test results

shall be provided to the Engineer at the time of delivery and shall be from tests performed on the formulation representative of the pipe delivered.

SECTION 908 – METAL PIPE

908.01 Blank

908.02 Corrugated Steel Pipe and Pipe-Arches

Corrugated steel pipe and pipe-arches shall be type I, IA, IR, II, or IIA in accordance with AASHTO M 36.

Corrugated steel pipe, pipe-arches, and coupling bands shall be zinc coated steel or aluminum coated steel in accordance with AASHTO M 36, except as noted herein. They may be fabricated with circumferential corrugations and riveted lap joint construction or with helical corrugations or spiral ribs with continuous lock or welded seam extending from end to end of each length of pipe. Reforming the ends of helical corrugated pipe to form circumferential corrugations will be allowed to enable use of circumferential corrugated coupling bands.

The reforming shall be limited to the length required to accommodate the coupling bands and in such a manner that there is not appreciable slippage of the seam or a plane of weakness created.

Polymer precoated galvanized corrugated steel pipe type IA and pipe-arch type IIA have an outer shell of corrugated sheet with helical corrugations and an inner liner of smooth sheet attached to the shell with a helical lock seam.

Fittings, including stub-tee connections and saddle connectors specified in 715.06, shall be shop fabricated. Damage to the coating on fittings shall be repaired in accordance with AASHTO M 36.

If the pipe or pipe-arch invert is to be paved, it shall first be coated over half its circumference in accordance with 908.07. The paved invert shall then be constructed in accordance with 908.07.

Sheet metal used to fabricate pipe shall be the same brand from the same manufacturer in any one length of finished pipe.

The manufacturer shall furnish to the fabricator a certified mill report for materials shipped to the fabricator. This certified mill report shall list the kind of base metal, actual test results of the chemical analysis and mechanical tests of each heat, the thickness, the weight of coating, and shall certify that the material complies with specified requirements for the type of metal furnished.

The fabricator shall certify, on furnished forms that:

(a) the fabricated structure has been manufactured in accordance with these Standard Specifications;

(b) based on the sheet manufacturer's certified mill report, the materials used in fabricating the structure were tested and the test results are in accordance with the specified requirements; and

(c) copies of the sheet manufacturer's certified mill report shall be on file and available to review for five years.

908.03 Blank

908.04 Corrugated Aluminum Alloy Pipe and Pipe-Arches

Pipes, pipe-arches, and coupling bands shall be in accordance with AASHTO M 196. The pipe shall be type I, IA, II, or IIA. If the pipe invert is to be paved, it shall be in accordance with 908.07.

The sheet manufacturer's certified mill report and the fabricator's certification shall be in accordance with the applicable requirements of 908.02.

Where aluminum alloy pipe culvert is furnished, aluminum alloy end sections shall also be furnished. All component parts shall be aluminum alloy.

908.05 Blank

908.06 Metal End Sections

The end section's metal shall be in accordance with AASHTO M 36 or M 196, whichever is applicable. The sheet metal manufacturer's certified mill report and the fabricator's certification shall be in accordance with the applicable requirements of 908.02.

End sections consisting of multiple panels shall have lap seams which shall be tightly jointed with 3/8 in. galvanized rivets or bolts.

All steel pipe end sections shall have a toe plate anchor constructed of 0.138 in. thick galvanized steel. The toe plate anchor shall be match punched to fit holes in the skirt lip, and shall be supplied loose, and complete with 3/8 in. diameter galvanized bolts.

Straps for pipe end sections shall be either galvanized No. 6 reinforcing bars or zinc coated 3/8 in. diameter aircraft cable.

908.07 Fully Bituminous Coated Corrugated and Lined Steel Pipe and Pipe-Arches

The material, fabrication, the manufacturer's certified mill report, and fabricator's certification shall be in accordance with the applicable requirements of 908.02. Coupling bands shall be fully bituminous coated.

After fabrication, the pipe or pipe-arch shall be fully bituminous coated.

Connecting or coupling bands shall be of the two-piece type when used with coated pipe of 36 in. diameter or larger.

The asphalt material for coating shall be in accordance with 902.01(e). Samples of the asphalt material will be obtained from the working tank prior to or during coating of the pipe, or from strippings off the pipe after coating. When applied to the pipe, the asphalt material shall be free from impurities. The metal shall be free from grease, dust, or moisture. Either process set out below may be used for application.

(a) When the pipe is not preheated, the temperature of the asphalt at the time of immersion shall be 400°F ±5°F. The duration of the immersion in the asphalt shall be in accordance with the following:

Thickness, inches	0.052	0.064	0.079	0.109	0.138	0.168
Minimum Immersion Time for 1st Dip, minutes	2.0	2.5	3.0	5.0	6.5	8.0

(b) When the pipe is preheated it shall be brought to a temperature of 300°F and the asphalt shall be heated to a temperature of 380°F ±5°F before the pipe is dipped.

In either process, the pipe shall be dipped a second time or more if necessary, to give a minimum thickness of 0.05 in.

If paved invert is specified, the pipe or pipe-arch shall first be fully coated as required. Additional bituminous material shall be applied in the bottom section to form a smooth pavement. Except where the upper edges intersect the corrugations, the pavement shall have a minimum thickness of 1/8 in. above the crests of the corrugations. The pavement shall be applied to the lower quarter of the circumference.

The manufacturer of the asphalt material shall furnish to the pipe fabricator the type of certification specified in the Frequency Manual and in accordance with 916 for each shipment or lot of asphalt material. The pipe fabricator shall keep these certifications on file and available to review for five years. In addition, samples from the working tank will be obtained for verification of requirements.

908.08 Polymer Precoated Galvanized Corrugated Steel Culvert Pipe and Pipe-Arches

The pipe or pipe-arch and coupling bands shall be in accordance with AASHTO M 245 with additions in accordance with 908.02. The polymer precoated galvanized steel sheets shall be in accordance with AASHTO M 246, grade 10/10.

908.09 Structural Plate Pipe, Pipe-Arches, and Arches

(a) Steel

Steel structural plate pipe, pipe-arches, and arches shall be constructed from individually galvanized corrugated steel plates as described herein. For pipes and pipe-arches having a thickness less than 0.280 in., the bottom plates shall be of the next greater thickness than that specified for the top and side plates, not including corner plates for pipe-arches. The individual plates shall be in accordance with AASHTO M 167 and AASHTO LRFD Bridge Construction Specifications.

The materials and fabrication shall be as follows:

1. The minimum corner plate radius of the arc joining the top and bottom plates of pipe-arches shall be 18 in. for openings up to and including 131 sq ft and 31 in. for openings over 131 sq ft. The minimum radius of the arc shall be 31 in. for openings from 98 sq ft up to and including 214 sq ft.

2. Assembly bolts shall be high strength heavy hex in accordance with ASTM F3125, grade A 325, or ASTM A449. Nuts shall be heavy hex and in accordance with ASTM A563, grade C3. Washers shall be in accordance with ASTM F436. Assembly bolts, nuts, and washers shall be hot dip galvanized in accordance with ASTM F2329, or be mechanically galvanized in accordance with ASTM B695, Class 55.

3. The sheet manufacturer's certified mill report and the fabricator's certification shall be furnished in accordance with 908.02, except the documents shall be in accordance with the applicable requirements of AASHTO M 167.

(b) Aluminum Alloy

Aluminum alloy structural plate pipe, pipe-arches, and arches shall be in accordance with AASHTO M 219. The sheet manufacturer's certified mill report and the fabricator's certification shall be furnished in accordance with 908.02.

908.10 Cast Iron Soil Pipe

This pipe shall be in accordance with ASTM A74. Markings shall be in accordance with ASTM A74 or ANSI A 40.1.

908.11 Steel Pipe

This item shall be electric-fusion, arc-welded steel pipe in accordance with ASTM A139, grade B, or electric-resistance welded pipe in accordance with ASTM A53, type E, grade B, as applicable. A type C certification in accordance with 916 shall be provided for the steel pipe.

908.12 Straps, Hook Bolts and Nuts Used in Anchors

Straps shall be of the type and size shown on the plans. Reinforcing bars used for straps shall meet the applicable requirements of 910.01 and shall be galvanized in accordance with ASTM A767, class I. Aircraft cable used for straps shall be made of zinc coated steel wire, 3/8 in. nominal diameter, consisting of seven 19-wire flexible steel strands, with a minimum breaking strength of 14,000 lb. The cable shall be in accordance with Military Specification MIL-W-83420D.

Hook bolts and nuts shall be of the size shown on the plans, shall be in accordance with ASTM A307, and shall be galvanized in accordance with ASTM F2329. Threads shall be American Standard Coarse Thread Series Class 2 fit. Threads shall be cleaned after galvanizing to provide a free running fit. Maximum oversizing of the nut threads shall be 1/64 in.

908.13 Blank

908.14 Slotted Drain or Slotted Vane Drain Pipe

Slotted drains shall be manufactured from helically corrugated steel pipe in accordance with AASHTO M 36. At the end of the pipe there shall be two annular corrugations to allow the corrugated band to fully mesh with the pipe.

The grated assembly shall be made of structural steel in accordance with ASTM A36, Grade 36. The assembly shall be suitably welded to the pipe and galvanized after assembly in accordance with AASHTO M 111. The grate shall be of the size and spacing shown on the plans and shall be welded on both sides to each bearing bar with a 3/16 in. fillet weld.

The size and thickness of the corrugated steel slotted drain pipe shall be as shown on the plans.

Slotted vane drain pipe shall be smooth wall PVC in accordance with 907.23, and shall be of the diameter specified. The casting shall be in accordance with 910.05(b). The finish shall be standard black asphalt emulsion. Individual units shall have a minimum weight of 155 lb.

SECTION 909 – PAINT AND LIQUID EPOXY

909.01 General Requirements

All necessary facilities for inspection of materials and manufacture of coatings, paints, and ingredients shall be granted. Free access to all parts of the premises where any or all of these products are being prepared shall be allowed. Safety Data Sheets shall be provided.

Paints and coatings shall be furnished ready for use without modification and shall not settle, cake, curdle, liver, gel, or develop excessive change in viscosity between

time of manufacture and time of use. It shall remain capable of being readily dispersed with a paddle, or other approved methods, to a consistency appropriate for the intended use. Paints and coatings may be sampled and tested at any time prior to use. Paints and coatings that are part of an approved structural steel coating system shall be submitted in an unopened, full, and complete kit for testing. If, for any reason, re-sampling and re-testing following initial or prior approval is indicated, the latest test results shall prevail over all previous tests for material that has not been used. Previously approved paint or coating that are stored for future use may be re-sampled and re-tested.

Paints and coatings shall be delivered in new containers of such strength, durability, design, fabrication, and material that the paint shall be suitably protected in transit and in storage against any change in characteristics which would cause rejection on the basis of laboratory or field evaluation. Each container shall bear a label which shows the name and address of the manufacturer, kind of paint or coating, formula identification, date of manufacture, and lot or batch number. The container shall be so filled that the net weight of the material in the container shall be the product of the weight per gallon at 77°F and the stated number of gallons in the container.

All containers shall be labeled in accordance with the OSHA requirements for labeling of hazardous chemicals as described in the Hazardous Communications Standard.

909.02 For Metal

Paints for metal surfaces shall be in accordance with the requirements shown below.

(a) Zinc Primers

Both inorganic zinc primer and organic zinc primer for use on faying surfaces at all slip-critical structural bolted connections using ASTM F3125, grade A325 or grade A490, high strength heavy hex bolts in primary members shall meet class B slip coefficient in accordance with Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints as adopted by the Research Council on Structural Connections.

1. Multi-Component Inorganic Zinc Silicate Primer

Inorganic zinc primers shall be multi-component and of the self-cure type which, when mixed and applied in accordance with these specifications, shall cure without the use of a separate curing solution. Multi-component inorganic zinc silicate primers shall have a maximum of three components. The components of each primer shall be packaged in such proportions that when the full quantity of each component is mixed together, the specified mixed primer shall be yielded.

Inorganic zinc primers shall be in accordance with AASHTO M 300.

2. Organic Zinc Primer

Organic zinc primer shall be a self-curing type primer. It shall be in accordance

with SSPC Paint Specification No. 20, Type II. The organic zinc primer shall be compatible with inorganic zinc and finish coat paints already on the bridge. The color shall be able to produce a distinct contrast with blast cleaned metal surface and the finish coat. The cured organic zinc film shall be compatible with a top coating of waterborne finish coat paint.

The organic zinc primer shall also be in accordance with the following requirements.

Viscosity, ASTM D562, Krebs Units ..... 70 - 100
Viscosity variation from the initially approved
formulation, ASTM D562, Krebs Units, max. ..... ±10
Volatile organic compounds, ASTM D3960, max. ..... 419 g/L
Weight/volume, ASTM D1475, 25°C, min. ..... 2.040 kg/L
Weight/volume variation from the initially approved
formulation, max. ..... ±0.048 kg/L
Dry time, ASTM D1640, 6 mils wet film thickness
on a tin-coated steel panel, max.:
Set-to-touch ..... 1 h
Dry hard ..... 24 h
Total solids of sample, ASTM D2369 ..... 70 – 100%
Total solids variation from the initially approved
formulation, ASTM D2369, %, max. ..... ±2.0
Pigment by mass of total solids[A], min. ..... 83 %
Metallic zinc in zinc dust, ASTM D521, min. ..... 94 %
Metallic zinc by mass of pigment, ASTM D521, min. ..... 84 %
Metallic zinc by mass of total solids[B], min. ..... 72 %

[A] The pigment by mass of total solids shall be calculated as follows:

$$\text{Pigment by mass of total solids, \%} = \frac{A}{B} \times 100\%$$

where:

A = % pigment extracted from sample
B = % total solids of mixed sample

[B] The metallic zinc by mass of total solids shall be calculated as follows:

$$\text{Metallic zinc by mass of total solids, \%} = \frac{(C \times D)}{E}$$

where:

C = % metallic zinc in pigment
D = % pigment extracted from sample
E = % total solids of mixed sample

The infrared spectrum of the vehicle when extracted from the organic zinc primer, in accordance with ASTM D3168, shall match the infrared spectrum of the vehicle of the sample submitted for formulation approval.

The cured film shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, Table 1. The cured paint shall not contain any other material which will require characterization as a hazardous waste for the disposal of the dried film.

3. Approval of Formulation

The manufacturer shall obtain approval of the formulation prior to furnishing the primers. Only zinc primers from the QPL of Coating Formulations shall be used. Zinc primers will be placed and maintained on the QPL of Coating Formulations in accordance with ITM 606.

(b) Epoxy Intermediate Paint

Epoxy intermediate paint shall be a two-component coating consisting of an epoxy resin and a curing agent, together with prime and filler pigments, colorants, gellant, leveling agents and solvents. When mixed, this coating shall be suitable for application over inorganic and organic zinc primers and shall be compatible with a polyurethane finish coat. The color of this coating shall contrast significantly from the other coatings within the coating system.

The mixed paint shall be in accordance with the following requirements.

Volatile organic compounds, ASTM D3960, max. ..... 336 g/L
Volume solids, ASTM D2697, min. 60%
Set-to-touch, ASTM D1640, 6 mils wet film thickness, max. ..... 4 h
Weight/volume variation from the initially approved
formulation, ASTM D1475, 25°C, max. ..... 0.060 kg/L
Total solids variation from the initially approved
formulation, ASTM D2369, max. 3.0%

The coating shall be applied within the pot life recommended by the paint manufacturer with no evidence of gelation. The coating shall be in a free-flowing condition and easily sprayed.

The infrared spectrum of each component and of the mixed coating shall match the spectrums of the initially approved batch.

(c) Polyurethane Finish Coat

Polyurethane finish coat shall be a two-component polyester or acrylic aliphatic polyurethane suitable for use as a finish coat over epoxy intermediate paint.

The mixed paint shall be in accordance with the following requirements.

Volatile organic compounds, ASTM D3960, max. ..... 336 g/L
Volume solids, ASTM D2697, min. 60%
Set-to-touch, ASTM D1640, 5 mils wet film thickness, min. ..... 30 minutes
Total solids ASTM D2369, min. 70%
Specular gloss, 60°, ASTM D523, min. 75
Viscosity, ASTM D562, Krebs Units, max. 100
Contrast ratio, ASTM D2805, 5 ±0.5 mils wet film thickness,
dried 24 h on opacity chart 2A or 2C, min. 0.95
Dry hard, ASTM D1640, 5 mils wet film thickness, max. ..... 24 h

The infrared spectrum of each component and of the mixed coating shall match the spectrum of the initially approved batch.

The color of the dried paint film shall match the color number of SAE-AMS-STD-595 as follows:

Color No.	Color
13538	Yellow
13711	Buff
14260	Green
15450	Light Blue
17038	Black
17886	White

(d) Waterborne Finish Paint

The waterborne finish coating shall be a single package, high build acrylic emulsion for use as a finish coat over inorganic and organic zinc primers. It shall be compatible with and adhere to the cured zinc primers.

1. Vehicle Component

The vehicle shall consist of an acrylic emulsion together with the necessary antifoamers, cosolvents, coalescing agent, preservatives, and antifreeze in order to produce a coating in accordance with this specification.

2. Pigment Component

The active pigment shall consist of titanium dioxide in accordance with ASTM D476, type IV, and non-reactive color retentive tinting pigments. The pigment shall contain extenders and additives as required for proper application.

3. Mixed Paint Properties

The mixed paint shall be in accordance with the following requirements.

Viscosity, ASTM D562, Krebs Units ..... 80 – 110
Weight/volume, ASTM D1475, variation from
the initially approved formulation, 25°C, max. ..... 0.024 kg/L

Pigment grind, ASTM D1210, Hegman, min. 5
Total solids, % by weight, ASTM D2369, min. 48
Dry time, ASTM D1640, 3 mils wet film thickness
on a tin coated steel panel, max.:
Set-to-touch ..... 1 h
Dry hard..... 24 h
Contrast ratio, ASTM D2805, 5 ±0.5 mils wet film thickness
dried 24 h on opacity chart 2A or 2C, min. 0.97
Specular gloss, 60°, 10 ±0.5 mils wet film thickness
on a tin coated steel panel, dried 48 h, ASTM D523, max. 30
pH, ASTM E70..... 7.0 – 9.5
Volatile organic compounds, ASTM D3960, max. ..... 180 g/L

The infrared spectrum of the vehicle when extracted from the mixed paint in accordance with ASTM D3168 shall match the infrared spectrum of the sample submitted for formulation approval.

The mixed paint shall be in accordance with the requirements of Sections 5.4 through 5.17 of SSPC Paint Specification No. 24.

The cured waterborne finish paint shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, Table 1. The cured paint shall not contain any other material which will require characterization as a hazardous waste for the disposal of the dried film.

4. Color

The color of the dried paint film shall match the color number of SAE-AMS-STD-595 as follows:

Color No.	Color
23538	Yellow
23717	Buff
24227	Green
24466	Light Green
25526	Light Blue
27038	Black
27780	White

5. Approval of Formulation

The manufacturer shall obtain approval of the formulation prior to furnishing the waterborne finish paint. Only waterborne finish paint from the QPL of Coating Formulations shall be used. Waterborne finish paint formulations will be placed and maintained on the QPL of Coating Formulations in accordance with ITM 606.

(e) Finish Coat for Weathering Steel

The finish coat shall be an aliphatic polyurethane or a waterborne acrylic paint,

and the dried paint film shall match color No. 20045 of SAE-AMS-STD-595. It shall be suitable for use as a finish coat over epoxy intermediate paint. The mixed paint shall be in accordance with the following requirements.

For aliphatic polyurethane paint:

Weight/volume, ASTM D1475, 25°C, min. ..... 1.200 kg/L
Total solids, % by weight, ASTM D2369, min. 60
Volatile Organic Compounds, ASTM D3960, max. ..... 336 g/L
Specular gloss, 60°, ASTM D523, max. 25

For waterborne acrylic paint:

Weight/volume, ASTM D1475, 25°C, min. ..... 1.200 kg/L
Total solids, % by weight, ASTM D2369, min. 48
Volatile Organic Compounds, ASTM D3960, max. ..... 180 g/L
Specular gloss, 60°, ASTM D523, max. 25

909.03 Structural Steel Coating System

This coating system shall consist of an inorganic zinc primer, an epoxy intermediate paint, and a polyurethane finish coat for the painting of steel bridges and other structural steel. All of the coatings within any coating system shall be manufactured by the same manufacturer and shall be compatible with one another. All coatings shall be in accordance with 909.02.

(a) Toxicity

The cured film of each coating within the structural steel coating system shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, Table 1 or contain any other material which will require characterization as a hazardous waste for the disposal of the dried film.

(b) Evaluation

The coating system shall be evaluated by the NTPEP Structural Steel Coatings Program. The certified report from NTPEP shall include specific identification of the formulation or system being submitted for consideration. It shall also include all test results for the specific coating formulation or coating system. The certified report from NTPEP will be accepted as the certified test report required for approval. The coating system shall be in accordance with all of the applicable acceptance criteria contained within 909.02. In addition, the finish coat shall maintain a minimum of 60% specular gloss retention relative to the initial gloss and a maximum color change of 6 ΔE for Test No. 3, Cyclic Weathering Resistance.

(c) Approval of Structural Steel Coating System

The manufacturer shall obtain approval of each structural steel coating system prior to furnishing any of these coatings. Only structural steel coating systems from the QPL of Structural Steel Coating Systems shall be used. Structural steel coating

systems will be placed and maintained on the QPL of Structural Steel Coating Systems in accordance with ITM 606.

909.04 Field Paint for Wood or Metal

The primers for field paint shall be formulated for minimal surface preparation, provide adhesion to the substrate and be compatible with the finish coat. The primers shall not contain lead, chromium, or other heavy metals which would require classification as a hazardous waste upon removal. The primers shall comply with the current IDEM VOC regulations and shall be used as follows:

a. For unpainted galvanized steel and other ferrous metals, use one coat of a zinc dust-zinc oxide pigmented primer.

b. For non-ferrous metals, use one coat of primer formulated for use on non-ferrous metals.

The field paint finish coat shall be an exterior type coating. It shall be chalk resistant, gloss retentive, and suitable for application by brush, roller, or spray. This coating shall comply with the current IDEM VOC regulations and shall not contain lead, chromium, or other heavy metals which would require classification as a hazardous waste upon removal. The color of this coating shall be as specified.

909.05 White and Yellow Waterborne Traffic Paint

White and yellow waterborne traffic paints shall consist of an emulsion of pigmented binder.

When glass beads are induced into the paint lines, the paint shall provide capillary action in the interstices and voids between the glass beads sufficient to cause the level of paint to raise approximately 2/3 the diameter of the glass beads. This capillary action shall not cause complete envelopment of the glass beads. The paint as furnished shall not contain glass beads. The paint shall be ground to a uniform consistency, and it shall enable satisfactory application by the pressure-spray type of painting equipment. The painting equipment shall use a pressurized bead application method that is designed to apply 4 to 6 in. reflectorized paint lines at paint temperature up to 150°F. The paint shall be capable of being applied at speeds of 10 to 15 mph.

The paint shall not darken under the heating conditions of application, or show appreciable discoloration due to sunlight exposure and aging of the paint lines. The paint shall be furnished ready for use without thinning, screening, or other modifications and shall not settle, cake, curdle, liver, gel, or have an excessive change in viscosity in the container during a period of one year after manufacture. The paint shall be capable of being stirred to a uniform consistency. The paint shall be able to withstand variations of temperatures when stored outside in the containers as delivered, and in an environment above 40°F. All paint furnished under these specifications will be rejected if it contains skins, thickened or jelly-like layers, lumps, coarse particles, dirt, or other foreign materials which prevent the proper application

of the paint, or produces a non-uniform paint line. All paint which cannot be transferred by pumps on the paint equipment from the shipping containers and through the paint equipment due to excessive clogging of screens, filters, or paint guns will be rejected.

The paint shall dry to a no-tracking condition in less than 60 s. The no tracking condition shall be determined by actual application of the paint on the pavement at a wet film thickness of 15 mils with glass beads at a rate of 6 lb/gal. The paint lines for the determination of no-tracking condition shall be applied with the specialized painting equipment operated so as to have the paint at application temperatures up to 140°F at the spray guns. This maximum no tracking time shall not be exceeded when the pavement temperature varies from 50 to 120°F, and with all relative humidity conditions providing that the pavement is dry. The no tracking time shall be determined by passing over the paint line 60 s after the paint application, in a simulated passing maneuver at a constant speed of 30 to 40 mph with a passenger car. A paint line with no visual deposition of the paint to the pavement surface when viewed from a distance of approximately 50 ft from the point where the vehicle crossed the paint line shall be considered as showing a condition of no tracking and being in accordance with the requirement.

1. Composition Requirements

The exact composition of the waterborne traffic paint shall be left to the discretion of the manufacturer, provided that the finished product is in accordance with all of the specification requirements.

The pigment portion of these paints shall be a combination of prime and extender pigments as required to produce either white or yellow waterborne traffic paint in accordance with the color and other requirements of the finished product. The yellow waterborne traffic paint pigment shall contain pigment yellow Color Index No. 65, or 74, or 75 or a combination of each. The white waterborne traffic paint pigment shall contain titanium dioxide in accordance with ASTM D476. The non-volatile portion of the vehicle shall be composed of a 100% acrylic polymer.

The cured film of waterborne traffic paint shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, Table 1 or contain any other material which will require characterization as a hazardous waste for the disposal of the dried film.

2. Specific Requirements

	Min.	Max.
Volume solids, ASTM D2697, %	58.0	--
Total solids by mass, ASTM D2369, %	73.0	--
Pigment by mass, ASTM D3723, %	45.0	57.0
Vehicle solids by mass of the vehicle, %	44.0	--
Viscosity, ASTM D562, Krebs Units	75	95
Weight/volume, ASTM D1475, 25°C, kg/L	1.498	--
Weight/volume @ 25°C, variation from the manufacturer's initially approved batch, ASTM D1475, kg/L.	--	0.024
Dry time, ASTM D711, 15 mils wet film thickness, airflow of less than 50 cu ft/min, without glass beads	--	10 min
Reflectance Factor, Y, C.I.E. illuminant, C, 2° standard observer, ASTM E1349, 15 mils wet film thickness, air dried a minimum of 16 h, % White..... Yellow.....	 84 50	 -- 57
Color, yellow only, x - y C.I.E. Coordinates for the strong limits of FHWA color chart PR1, 15 mils wet film thickness, air dried a minimum of 16 h, measured on white background, C.I.E. illuminant, C, 2° standard observer, % deviation	Match the strong limits	±6.00
Coarse material retained on a No. 30 sieve, ASTM D185, %	--	0.05
Bleeding ratio, Federal Specifications TT-P-1952B, except asphalt saturated felt paper shall be in accordance with ASTM D226, Type I	0.97	--
Contrast ratio, ASTM D2805, 10 mils wet film thickness on opacity chart 2A or 2C, air dried a minimum of 16 h	0.96	--
Volatile organic compounds, ASTM D3960 from May 1 thru September 30, g/L from October 1 thru April 30, g/L	 -- --	 105 150
Abrasion resistance, Federal Specifications TT-P-1952B, L	190	--
Freeze-thaw stability, Federal Specifications TT-P-1952B, change in consistency, Krebs Units	--	10
Heat stability, Federal Specifications TT-P-1952B, change in consistency, Krebs Units	--	10
Scrub resistance, ASTM D2486, with abrasive medium and shims, cycles	300	--
Water resistance, Federal Specification TT-P-1952B	Film shall not soften, blister, wrinkle, or lose adhesion	
Flexibility, Federal Specifications TT-P-1952B	No cracking or flaking of film	
Infrared spectrum of the vehicle ASTM D3168	Shall match spectrum of manufacturer's previously submitted samples	

Dilution test shall be capable of dilution with water at all levels without curdling or precipitation such that wet paint can be cleaned up with water only.

909.06 Blank

909.07 Blank

909.08 Blank

909.09 Blank

909.10 Non-Epoxy PCC Sealers

Non-Epoxy PCC sealers shall be selected from the QPL of Non-Epoxy Portland Cement Concrete Sealers. A non-epoxy PCC sealer may be added to the QPL by completing the requirements in accordance with ITM 806, Procedure C.

(a) Properties

The non-epoxy PCC sealer shall be in accordance with NCHRP 244, Series IV, Southern Climate Weathering Test and possess the following properties.

Property	Requirement
Reduction of Chloride Ion Content	90% of the Control
Active Ingredients, minimum, Silane Based	40%

(b) Test Report

The testing shall be performed by a recognized laboratory in accordance with ITM 806.

The non-epoxy PCC sealers shall be delivered to the jobsite in unopened containers with the manufacturer's numbered seal intact.

909.11 Epoxy-Resin-Base System for Bonding Plastic Concrete to Hardened Concrete

Two-component, epoxy-resin bonding systems for use in bonding freshly mixed concrete to hardened concrete shall be in accordance with ASTM C881 for type II, grade 2, and the class consistent with the ambient temperature as follows. Class A for use below 40°F; class B for use between 40°F and 60°F; and class C for use above 60°F. A type C certification in accordance with 916 shall be provided for the epoxy-resin-base system.

909.12 Epoxy Resin Additives for Injection into Concrete

The epoxy resin adhesive shall be of low enough viscosity such that it flows to the next open port in the surface seal material. The adhesive shall be capable of penetrating crack widths down to 0.005 in. The adhesive shall be capable of bonding to dry or damp surfaces. The adhesive shall exhibit a slant shear strength exceeding the concrete strength when tested fully cured in accordance with AASHTO T 237.

The surface seal material shall have adequate strength to hold injection fittings in place and to resist injection pressures adequately to prevent leakage during injection.

A type C certification in accordance with 916 shall be provided for the epoxy resin adhesive.

SECTION 910 – METAL MATERIALS

910.01 Reinforcing Bars, Dowel Bars and WWR

(a) General

Unless otherwise specified, bars for concrete reinforcement shall be deformed billet steel, grade 60. Tie bar assemblies used in lieu of bent tie bars shall be in accordance with the minimum total ultimate strength and minimum total yield strength requirements specified for bent tie bars; bend test and elongation will not be required. Coiled reinforcing bars shall only be used for fabrication of spiral and ring reinforcement or for rectangular ties and stirrups. When approved by the Engineer, coiled reinforcing bars may also be used for supports in accordance with 703.06.

Reinforcing bars and WWR shall be furnished by selecting materials made by a manufacturer or fabricator on the QPL of Uncoated Reinforcing Bar and WWR Manufacturers in accordance with ITM 301, except for WWR used for pneumatically placed mortar. WWR used for pneumatically placed mortar will be accepted by a type A certification in accordance with 916. When shipped to the project site, the reinforcing bars and WWR shall be accompanied by the type of certifications specified in ITM 301 and in accordance with 916.

(b) Specific Requirements

1. Billet Steel Bars

Billet steel bars shall be in accordance with ASTM A615.

2. Threaded Tie Bar Assembly

The threaded tie bar assembly shall be deformed billet steel, grade 60 or higher, in accordance with 910.01(b)1 and a coupling device. The minimum strength of the tie bar assembly shall be 125% of the designated yield strength of the bar from which it is manufactured. Where epoxy coated threaded tie bar assemblies are specified, an epoxy coating with a minimum film thickness of 6 mils shall be applied to the coupling device and epoxy coated reinforcing bars shall be provided in accordance with 910.01(b)9 with the exception that the epoxy coated bar is not required to be furnished from the QPL of Reinforcing Bar and WWR Epoxy Coaters.

3. Splicing Systems

Reinforcing bar splicing systems shall be selected from the QPL of Reinforcing

Bar Splicing Systems. A manufacturer may request to have a splicing system added to the QPL by submitting three randomly selected epoxy coated bars of each bar designation to be included as a splicing system on the list. The samples furnished shall be assembled. The splicing system will be tested for tensile strength in accordance with ASTM A370 and shall reach the specified ultimate tensile strength on all three samples for each bar size submitted. The manufacturer shall identify the grade or grades of reinforcing bar for which the system is being submitted. Splicing systems demonstrating consistent, repeatable, and passing test results will be added to the QPL. Qualified bar designations will be noted on the list.

4. Blank

5. Deformed and Smooth Steel WWR

Deformed and smooth steel WWR shall be in accordance with ASTM A1064, except as follows:

a. The wire used in manufacturing the WWR shall be drawn, not galvanized, unless otherwise specified.

b. WWR shall be furnished in flat sheets.

c. When epoxy-coated WWR is specified, it shall receive a type 1 coating in accordance with ASTM A884. Repairing or patching of the coating shall be in accordance with ASTM A884 with the patching material in accordance with ASTM A775 Annex A2. The average coating thickness shall be 9 to 14 mils after cure. Epoxy coated WWR shall be furnished by selecting WWR coated from an applicator's plant on the QPL of Reinforcing Bar and WWR Epoxy Coaters and in accordance with ITM 301.

d. When galvanized WWR is specified, it shall be in accordance with ASTM A1060, including repair or renovation of the coating. It shall be coated after fabrication.

e. The size and spacing of the WWR shall be provided as specified. If over-sized wire is proposed for substitution, the Contractor shall obtain written approval from the Engineer prior to delivery. The WWR shall be identified as the size provided, not the size originally ordered.

6. Blank

7. Uncoated Seven-Wire Strand

Uncoated seven-wire strand shall be in accordance with ASTM A416. The strand shall have the minimum tensile strength and initial tension shown on the plans.

A type A certification in accordance with 916 shall be provided for uncoated seven-wire strand. In addition to the lot number, the results of the following shall be shown on the certification.

Property	Test Standard
Size	
Cross Sectional area	
Yield strength	ASTM A416
Breaking strength	ASTM A416
Strand composition	
Modulus of elasticity	ASTM A416
Load elongation curve	ASTM A416

8. Steel Spiral Reinforcement

Steel spiral reinforcement shall be either:

a. deformed billet steel, ASTM A615, grade 60; or

b. cold drawn steel wire, ASTM A1064.

9. Epoxy Coated Reinforcing Bars

Epoxy coated reinforcing bars shall be furnished by selecting bars coated from an applicator's plant on the QPL of Reinforcing Bar and WWR Epoxy Coaters and in accordance with ITM 301. The epoxy coating material shall be selected from the QPL of Epoxy Coating Materials.

Epoxy coated reinforcing bars shall be in accordance with ASTM A775, except as follows.

a. the bars shall be in accordance with 910.01(b)1;

b. the coating color shall contrast with the color of iron oxide;

c. tensile and bend tests shall be performed on the bars. If an examination of the bend test specimen suggests the need, the adhesion of the coating shall be checked by subjecting additional specimens to the 120° bend test. Hairline cracks without bond loss will be acceptable provided there are not more than two and the length of either crack does not exceed 1/4 in. The average coating thickness shall be 9 to 14 mils after cure. The thickness measurements shall be made in accordance with ASTMD7091. The coating thickness shall be an average based on 12 individual readings. No specific

correction for the base preparation process shall be applied to the thickness measurements;

d. epoxy coated reinforcing bars furnished by coaters on the QPL of Reinforcing Bar and WWR Epoxy Coaters shall be accompanied by the types of certifications specified in ITM 301 and in accordance with 916;

e. repair and handling procedures shall be in accordance with 703.04. The patching material shall be in accordance with ASTM D3963.

Epoxy coated support devices for epoxy coated reinforcing bars shall be in accordance with ASTM A775, except as follows.

a. the steel shall be in accordance with 910.01(b)1;

b. the coating color shall contrast with the color of iron oxide;

c. the coating thickness shall be 6 to 20 mils after cure. The thickness measurements shall be made in accordance with ASTM D7091.

10. Dowel Bars

Dowel bars shall be plain billet steel in accordance with ASTM A615, grade 40 or higher, except that the bend test and elongation requirements will not apply. The dowel bar area and weight for the nominal bar diameter shall be as follows.

Nominal Bar Diameter, in.	Cross Sectional Area, sq in.	Weight, lb/ft
1	0.79	2.670
1 1/4	1.23	4.172
1 1/2	1.77	6.008

Dowel bars shall be coated with an epoxy coating material selected from the QPL of Epoxy Coating Materials. The coating thickness after cure shall be a minimum of 7 mils. Dowel bars shall not have burring or other deformation restricting slippage in concrete. Dowel bar ends shall be saw cut. Chips from the cutting operation shall be removed from coated bars.

Dowel bars shall be furnished by selecting bars made by a coater and manufacturer on the QPL of Reinforcing Bar and WWR Epoxy Coaters and in accordance with ITM 301. When shipped to the project site, the dowel bars shall be accompanied by the types of certifications specified in ITM 301 and in accordance with 916.

(c) Inspection, Sampling, and Testing

All reinforcing bars may be inspected, sampled, and tested after delivery to the project.

910.02 Structural Steel

(a) Structural Steel

Unless otherwise specified, structural steel shall be in accordance with ASTM A709, grade 36.

(b) Weathering Steel

Steel in accordance with ASTM A709 that has an atmospheric corrosion resistance index that meets or exceeds the index value shown in ASTM A709.

(c) High Strength Structural Steel

This steel, when specified, shall be in accordance with ASTM A709, grade HPS 100W; ASTM A709, grade 50; or ASTM A709, grade 50W.

The corrosion resistance of ASTM A709, grade 50W steel shall be at least four times that of structural carbon steel. The steel fabricator, when placing the order, shall state that the steel is for bridge use, and that the steel shall be used in the bare, unpainted condition.

All fasteners used in conjunction with ASTM A709, grade 50W steel shall be friction type high strength heavy hex bolts in accordance with ASTM F3125, grade A325 type 3. A certification in accordance with 916 and 910.02(g)2.d shall be provided for high-strength steel bolts. The results of the following shall be shown on the certification.

Property	Test Method
Chemical Composition	ASTM F3125, Table 3
Hardness	ASTM F3125, Table 7
Tensile Properties	ASTM F3125, Table 5
Proof Load	ASTM F3125,Table 5
Zinc Coating (Hot Dip Process)	ASTM A153
Zinc Coating (Mechanically Deposited)	ASTM B695
Rotational Capacity Testing (Type 3 Bolt)	ASTM F3125

All plates and bars produced from ASTM A572 steel over 3/4 in. in thickness shall be “killed fine grain practice”.

(d) High Performance Steel

High performance steel, HPS, shall be in accordance with ASTM A709. In addition to the conditions listed in Section 6.7 of ASTM A709, high performance steel

may be furnished as hybrid/mixed design structural components using high performance steel plates in combination with high strength, low alloy steel plates and shapes, for welded or bolted applications in bridge construction.

The impact testing requirements for HPS in accordance with 10.1 and 10.2 of ASTM A709 shall meet temperature zone 2.

(e) Charpy V-Notch Toughness Tests

Structural steel, except members exempted below, shall meet the longitudinal Charpy V-Notch test requirement as specified in the following table for the type or types of steel specified or furnished. Sampling and testing procedures shall be in accordance with ASTM A673. The H frequency of heat testing shall be used. Charpy V-Notch test data shall be included on the mill test reports for structural steel specified in 711.08 and 916.

ASTM Designation	Thickness, in.	Foot-Pounds Joule @ 40°F
A709, grade 36		15
A709, grade 50*	Up to 4 in. mechanically fastened Up to 2 in. welded	15 15
A709, grade 50W*	Up to 4 in. mechanically fastened Up to 2 in. welded Over 2 in. to 4 in. welded	15 15 20
* If the yield point of the material exceeds 65,000 psi, the temperature for the CVN value for acceptability shall be reduced by 15°F for each increment of 10,000 psi above 65,000 psi.		

This test requirement shall apply to all structural steel members and components except diaphragms, cross frames, stiffeners, lateral bracing, railroad ballast retainers and components, shoe assemblies, expansion joints, and compression members of trusses.

(f) Mill Test Reports

Mill test reports for structural steel shall be in accordance with 711.08 and 916 and shall include Charpy-Impact test data as set out in 910.02(e).

(g) High Strength Bolts, Nuts, and Washers

1. General Use

High strength heavy hex bolts shall be in accordance with ASTM F3125, grade A325. Type 3 bolts shall be provided if the structural steel is to remain unpainted. High strength heavy hex nuts shall be of the grade and finish specified in ASTM F3125 and ASTM A563. Washers shall be of the type specified in ASTM F3125 and ASTM F436. The bolts, nuts, and washers shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55.

2. Assembly of Structural Steel in Bridges

High strength bolts, nuts, and washers used in the assembly of structural steel in bridges, excluding shoes and bearing assemblies, shall be provided in accordance with 910.02(g)1 and the following additional requirements.

a. Bolts

The maximum tensile strength shall be 150,000 psi for bolts 1 in. or less in diameter. The maximum tensile strength shall be 120,000 psi for bolts greater than 1 in. in diameter. The maximum hardness shall be 33 Rc.

b. Nuts

The nuts shall be in accordance with ASTM A563, grade DH; or ASTM A194, grade 2H.

c. Tests

(1) Rotational Capacity

High strength fasteners shall be subjected to the rotational capacity test in accordance with ASTM F3125. The fastener shall complete two times the required number of turns from snug tight conditions in accordance with AASHTO LRFD Bridge Construction Specifications, in a Skidmore-Wilhelm calibrator or equivalent tension measuring device without stripping or failure. During this test, the maximum recorded tension shall be at least 1.15 times the required fastener tension indicated in AASHTO LRFD Bridge Construction Specifications. The measured torque required to produce the required fastener tension shall not exceed the value obtained by the following equation.

$$\text{Torque} = 0.25\ PD$$

where:

Torque = Measured Torque, (foot-pounds)
P = Measured Bolt Tension, (pounds)
D = Nominal Diameter (feet).

(2) Proof Loads

Proof load tests for bolts shall be conducted in accordance with ASTM F606, Section 3.2.3. Proof load test for nuts shall be conducted in accordance with ASTM F606, Section 4.2.

(3) Wedge Tension Test

The wedge tests of full size bolts shall be conducted in accordance with ASTM F606, Section 3.5.

d. Certification

The supplier shall provide a certification of compliance with all requirements for high strength bolts, nuts, and washers used in the assembly of structural steel in

bridges. The certification, in addition to complying with the applicable requirements of 916, shall include the lot number on the shipping package and indicate when or where all testing was performed.

(h) Bolts other than High Strength Bolts

1. General

Bolts shall be unfinished, turned, or ribbed bolts in accordance with ASTM A307, grade A. Bolts shall have single, self-locking nuts or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

Bolts, nuts, and washers utilized in the U channel steel post splice as shown on the plans shall be in accordance with ASTM A449, SAE J429-G7.9, or ASTM F3125, grade A325 and shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55.

2. Unfinished Bolts

Unfinished bolts shall be furnished unless other types are specified.

3. Turned Bolts

The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal and standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt or the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed. Bolts furnished shall provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

4. Ribbed Bolts

The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 in. greater than the nominal diameter specified for the bolts. Ribbed bolts shall be furnished with round heads conforming to requirements of ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to allow the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an over-sized bolt used as a replacement.

910.03 Permanent Metal Forms

Metal bridge deck falsework and supports shall be fabricated from steel sheet, zinc-coated structural steel in one of the following grades: 33, 37, 40, 50 Class 1, 80

Class 1, or 50 Class 3, having a coating designation of G165, oiled but not chemically treated, all in accordance with ASTM A653.

A type A certification in accordance with 916 shall be provided for permanent metal forms. The results of the following shall be shown on the certification for each gauge.

Property	ASTM
Yield Strength, ksi	A653*
Tensile Strength, ksi	A653*
Elongation in 2 in., %	A653*
Weight of Zinc Coating	A653*
* The minimum mechanical requirements as stated in ASTM A653 for the respective grade shall be provided on the type A certification in addition to the test results.	

The materials will also be sampled at the work site as specified in the Frequency Manual. The sample will include a representative portion of a panel of each gauge, thickness, to be used and a representative portion of each type and size of hardware necessary to erect the panels, excluding the fasteners.

910.04 Steel Forgings and Steel Shafting

(a) Carbon Steel Forgings

Steel forgings shall be in accordance with ASTM A668 for carbon steel forgings for general industrial use. Class F forgings shall be furnished unless otherwise specified.

(b) Cold Finished Carbon Steel Shafting

Shafting shall be in accordance with ASTM A108 for cold finished carbon steel bars and shafting. Grade designation 1016-1030, inclusive, shall be furnished unless otherwise specified.

(c) Alloy Steel Forgings

Alloy steel forgings shall be in accordance with ASTM A668 for alloy steel forgings for general industrial use. Class G forgings shall be furnished unless otherwise specified.

(d) Certification

Steel forgings and steel shafting shall be covered by a mill certification reporting the test results of:

1. chemical analysis;
2. heat treatment, not required for shafting;
3. tensile strength, yield strength, and elongation.

Elongation is not required for shafting.

910.05 Castings

The casting design shall be proof loaded to 178 kN in accordance with AASHTO M 306. Castings shall be in accordance with the plan dimensions and to the following requirements for the designated materials. A certified inspection report shall be submitted by the manufacturer with each shipment of castings, except as otherwise provided herein. Inspection and testing shall be done by the manufacturer. The certified inspection report shall list the casting number, and the type of material, including the class of gray iron, and the grade of ductile iron. It shall state that inspection and testing has been performed, that all parts shipped meet the pertinent specification requirements, and that all component parts fit. The supporting test results, including proof load data, shall be retained and be available on request for a period of seven years. All castings shall have the manufacturer's identification and the date of manufacture cast on an exposed surface.

Acceptance of castings will be based on the certified inspection report, visual inspection, and check measurements.

(a) Steel Castings

Chromium alloy steel castings shall be in accordance with ASTM A743. Grade CA15 shall be furnished unless otherwise specified.

(b) Iron Castings

Iron casting shall be gray iron castings in accordance with ASTM A48, class No. 35B, unless otherwise specified. Tension tests will be required for all castings including drainage castings.

Castings shall be true to pattern in form and dimensions. A tolerance of ±1/8 in. in general dimensions as shown on the plans will be allowed with the exception that the tolerance in the dimensions of grates or covers and the openings into which they fit shall be limited to ±1/16 in. Each casting shall weigh at least 95% of the manufacturer's specified weight of the type specified and shall be cast to the dimensions shown on the plans. They shall be free from sponginess, cracks, blowholes, warping, sand inclusions, cold shots, cold shuts, chilled iron shrinks, or any defects which would affect the strength and value for the intended purpose. The castings shall completely fill the molds and shall not be removed until properly cooled. The casting date and a casting code number shall be cast on each casting.

All corners of the castings shall be filleted and outside corners and edges shall be rounded to a radius of not less than 1/8 in. All contact surfaces between different castings shall present a firm and even bearing without rattling or rocking. The lid frame bearing surfaces on all round castings shall be machine milled to provide true bearings around the entire circumference. All other contact surfaces shall be ground.

All castings shall be cleaned of molding or core sand, rust, scale, and foreign material just prior to shipment. Iron castings shall be delivered unpainted.

(c) Ductile Iron Castings

These castings shall be in accordance with ASTM A536. Grade 65-45-12 shall be furnished unless otherwise specified. In addition, they shall be in accordance with all requirements of 910.05(b), except the first paragraph.

(d) Malleable Castings

These castings shall be in accordance with ASTM A47. Grade No. 32510 or 35018 shall be furnished unless otherwise specified. In addition, they shall be in accordance with all requirements of 910.05(b), except the first paragraph.

(e) Carbon Steel Castings

These castings shall be in accordance with ASTM A27. The grade shall be 60-30, 65-35, or 70-36.

Castings shall be true to pattern in form and dimensions and free from pouring faults, sponginess, cracks, blowholes, and any defects in positions affecting their strength and value for the service intended.

Blowholes appearing on finished castings shall be located so that a straight line laid in any direction does not cut a total length of cavity greater than 1 in. in any 1 ft nor shall any single hole exceed 1 in. in any dimension or have an area greater than 1/2 sq in. Blowholes shall not be deep enough to affect the strength of the casting adversely.

Minor defects which do not impair strength may, with approval, be welded by an approved process. Defects shall be removed in solid metal by chipping, drilling, or other satisfactory methods and, after welding, the castings shall be annealed if required. Castings which have been welded without permission will be rejected. No sharp unfilleted angles or corners will be allowed.

910.06 Bronze and Copper Alloy

(a) Bronze Castings

Bronze castings shall be in accordance with ASTM B22, alloys C91100 or C91300. A type A certification in accordance with 916 shall be provided for bronze casting. In addition to the number of casting or total weight, the results of the following shall be shown on the certification.

Property	Test Standard
Chemical composition	ASTM B22
Tensile strength	ASTM B22
Yield strength	ASTM B22
Elongation	ASTM B22
Brinell hardness	ASTM B22
Compression deformation limit	ASTM B22

(b) Copper Alloy Plates

Copper alloy plates shall be in accordance with ASTM B100. A type A certification in accordance with 916 shall be provided for copper alloy plates. In addition to the copper alloy UNS No. designation, the results of the following shall be shown on the certification.

Property	Test Standard
Chemical composition	ASTM B100
Dimensions	ASTM B100
Tensile strength	ASTM B100
Yield strength	ASTM B100
Elongation	ASTM B100
Permanent set under 100 ksi	ASTM B100
Brinell hardness	ASTM B100
Rockwell hardness	ASTM B100

910.07 Steel Components of MSE Retaining Walls

(a) Backing Mats, Clevis Connector, Connector Bar, and Wire-Facing

1. Backing Mats

Backing mats shall be smooth steel welded wire reinforcement in accordance with 910.01(b)5. Galvanization, if required, shall be in accordance with ASTM A1060. The Engineer will test samples in accordance with ASTM A1064.

2. Clevis Connector

Clevis connectors, if used, shall be attached to the alignment templates using the bars provided with the forms. The vertical and horizontal alignment of the connectors shall be ±1/8 in. The holes inside the loops shall be free of all concrete and debris, loose or otherwise.

The clevis connector shall be fabricated of cold-drawn steel wire in accordance with ASTM A1064. Loops shall be galvanized in accordance with ASTM A641, class 5 or class C.

A type A certification in accordance with 916 shall be provided for clevis connector. The results of the following shall be shown on the certification.

Property	Test Standard
Tension	ASTM A1064
Bend	ASTM A1064
Coating adhesion	ASTM A123/A153
Coating thickness	ASTM A123/A153
Average weight of coating	ASTM A123/A153

3. Connector Bar

The connector bar, if used, shall be fabricated of cold-drawn steel wire in accordance with ASTM A1064, and galvanized, if so shown on the plans, in accordance with ASTM A641, class 5 or class C.

A type A certification in accordance with 916 shall be provided for connector bars. The results of the following shall be shown on the certification.

Property	Test Standard
Coating adhesion	ASTM A123
Coating thickness	ASTM A123
Average weight of coating	ASTM A123
Coating flexibility	ASTM A123

4. Wire-Facing

Wire-facing shall be smooth steel WWR in accordance with 910.01(b)5. Galvanization, if required, shall be in accordance with ASTM A1060. All wire-facing shall be handled, stored, and shipped so as to eliminate the danger of excessive bending stresses. The Engineer will test samples in accordance with ASTM A1064.

(b) Ground Reinforcement

The ground reinforcement shall be either a deformed steel strip or a welded-wire grid. The grid or strip used shall be consistent with that used in the pullout test and shall be consistent throughout the project.

The grid shall consist of not less than two longitudinal wires, perpendicular to the wall, welded to equally-spaced cross ribs capable of developing passive pressure with the fill. The deformed strip shall be of constant width. The strip thickness shall vary only from the undeformed section to the deformed section as required to produce the pullout resistance.

The face-panel edges shall be configured to conceal the joints. All horizontal and vertical joints shall be covered with a joint cover to prevent backfill leakage while passing water.

Ground-reinforcement units shall be hot rolled from bars to the required shape and dimensions. Physical and mechanical properties of the units shall be in accordance with ASTM A572, grade 65. Tie strips shall be shop fabricated with hot-rolled steel in accordance with the minimum requirements of ASTM A1011, grade 50. Galvanization for ground-reinforcing units and tie strips shall be in accordance with ASTM A123, coating grade 85, for strip-type reinforcements or ASTM A641, class 5 or class C, for bar mat or grid-type reinforcements.

All ground-reinforcement units and tie strips will be inspected to ensure that they are true to size and free from defects which can impair their strength and durability.

A type A certification in accordance with 916 shall be provided for ground reinforcement. The results of the following shall be shown on the certification.

Property	Test Standard
Yield strength	ASTM A572/A1011
Coating thickness	ASTM A123/A641
Coating adhesion	ASTM A123/A641

(c) Fasteners

Fasteners shall consist of 1/2 in. diameter, bolts, nuts, and washers and shall otherwise be in accordance with 910.02(g)1 with the exception that the hardware shall be coated in accordance with ASTM F2329.

The supplier shall provide a certificate of compliance with all requirements for high strength bolts, nuts, and washers used in the assembly of MSE retaining walls. The certification, in addition to complying with the applicable requirements of 916, shall include the lot number and heat number on the shipping package and indicate when or where all testing was performed.

(d) Alignment Pins

The rods used to align the face panels during construction shall be 3/4 in. diameter and 12 in. in length. The rods shall be mild steel, PVC, or fiberglass. A type C certification in accordance with 916 shall be provided for the alignment pins.

910.08 Steel Bin-Type Retaining Wall Units

Wall units shall consist of adjoining closed-face cells filled with structure backfill to form a gravity-type retaining structure. The cells shall be constructed of members in accordance with AASHTO M 218 that are bolted together.

The necessary bolts and appurtenances shall be provided for complete assembly of the units into a continuous closed-face wall of connected bins.

Working drawings shall be submitted in accordance with 105.02.

The units shall present a uniform workmanlike appearance once assembled. The base metal shall be not less than 16 gauge.

The steel sheets shall be galvanized on both sides in accordance with ASTM A123, coating grade 85. All sheets will be inspected to ensure that they are true to size and free from defects, which may impair their strength and durability.

A type A certification in accordance with 916 shall be provided for bin-wall sheets. The results of the following shall be shown on the certification.

Property	Test Standard
Yield strength	AASHTO M 218
Coating thickness	ASTM A123/A641
Coating adhesion	ASTM A123/A641

910.09 Guardrail

Guardrail of the same type shall be interchangeable regardless of the source. Guardrail materials shall be in accordance with the applicable AASHTO or ASTM requirements listed herein and will only be accepted from qualified manufacturers on the QPL of Guardrail Manufacturers. Qualification requirements for the manufacturers shall be in accordance with ITM 806, Procedure O.

Steel beam rail shall be galvanized, corrugated sheet steel beams in accordance with AASHTO M 180 as modified herein. The rails, including terminal sections, shall be either class A, base metal nominal thickness of 0.105 in., 12 gauge, or class B, base metal nominal thickness or 0.135 in., 10 gauge. They shall be type 2, zinc coated with 3.60 oz/sq ft minimum single spot and 4.00 oz/sq ft minimum triple spot. Tests for adherence of the coating may be made including the test specified in ASTM A123, when deemed necessary.

Where beam rail is set on a curve of 150 ft radius or less, the rail plate shall be shop curved with its traffic face concave or convex as required. The radii of curvature shall be in increments of 10 ft from a radius of 150 to 50 ft inclusive and in increments of 5 ft from a radius of 50 ft to and including 20 ft.

The steel channels specified on the plans shall be standard 5 in. channels weighing 6.7 lb/ft. The material shall be in accordance with ASTM A36. The channel shall be galvanized in accordance with ASTM A123 after fabrication. The weight of zinc coating per area of actual surface shall average not less than 2 oz/sq ft for any individual piece of channel.

Construction details for the rails and channels shall be as shown on the plans. Whenever field fabrication, as approved, requires cutting or drilling, the cut or drilled member shall be coated with a high zinc dust-zinc oxide paint in accordance with Federal Specification TT-P-641, type II, or Military Specifications DOD-P-21035. When spray paints are used, two coats shall be applied.

910.10 Guardrail Posts

Guardrail posts shall be either steel or timber as specified and shall be in accordance with the following requirements.

(a) Steel Guardrail Posts

The dimensions of the steel guardrail posts shall be as shown on the plans. The material shall be in accordance with ASTM A36. The posts shall be galvanized in accordance with ASTM A123 after fabrication. However, the weight of zinc coating

per square foot of actual surface shall not average less than 2.0 oz for an individual post.

The weight of the W6 x 15 post, after fabrication and coating, shall not be less than 14.60 or more than 16.00 lb/ft.

Construction details shall be as shown on the plans. Whenever field fabrication, as approved, requires cutting or drilling, the cut or drilled member shall be coated with a high zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641, or Military Specifications DOD-P-21035. When spray paints are used, two coats shall be applied.

(b) Timber Guardrail Posts

Timber guardrail posts shall be in accordance with 911.02(f). Dimensions and construction details shall be as shown on the plans.

910.11 Guardrail Accessories, Fittings, and Hardware

These items consist of brackets, splice plates and bars, post anchors, diaphragms, clamps and clamp bars, end caps, connections, anchor rod assemblies, deadmen, bolts, screws, nuts, washers and blockouts of the type, dimensions, and design shown on the plans. They shall be in accordance with the requirements set out below. Items of the same type shall be interchangeable regardless of the source.

(a) For Steel Beam Guardrail

1. Post brackets, bars, plates and shapes for bridge railing brackets, and plate washers shall be in accordance with ASTM A36. Post brackets, bars, and plates and shapes for bridge railing brackets shall be galvanized in accordance with 910.10(a). Plate washers shall be galvanized after fabrication in accordance with ASTM A153. The weight of the W6 x 15 post bracket shall be in accordance with 910.10.

2. Splice plates and rail portion of bridge railing brackets shall be class B, type 2, in accordance with the first paragraph of 910.09(a).

3. Bolts and nuts of the sizes specified on the plans shall be in accordance with ASTM A307. Cut washers and lock washers shall be standard round steel washers of the sizes specified on the plans. The diameter of cut washers shall be 1 3/4 in. for 5/8 in. bolts and 2 in. for 3/4 in. bolts with a thickness of 0.134 in. ±0.026 in. measured at the hole. The bolts, nuts, and washers shall be coated after fabrication by either hot dip galvanizing in accordance with ASTM F2329 or mechanically galvanizing in accordance with ASTM B695, Class 55.

4. Whenever approved field fabrication requires cutting or drilling, the cut or drilled members shall be coated with a high zinc dust-zinc oxide paint conforming to Federal Specification TT-P-641, type II, or Military Specifications DOD-P-21035. When spray paints are used, two coats shall be applied.

5. Pipe spacers of the size specified on the plans shall be galvanized after fabrication in accordance with ASTM A153, class C. The weight of coating per square foot of actual surface shall average no less than 1.25 oz for the specimen tested and shall be no less than 1 oz for any individual specimen.

6. For breakaway cable terminal, and cable terminal anchor system, the rail element, standard bolts, nuts, and washers shall be in accordance with 910.09 and requirements 1 and 3 of 910.11(a).

7. For cable terminal anchor system, the anchor bracket, end plate, soil plate, bearing plate, strut and yoke shall be in accordance with AASHTO M 270, grade 250. They shall be zinc coated after fabrication in accordance with AASHTO M 111. The steel tube shall be in accordance with ASTM A500, grade B and zinc coated in accordance with AASHTO M 111. The post sleeve shall be in accordance with ASTM A53, grade B and zinc coated in accordance with AASHTO M 111. The stud shall be in accordance with ASTM A307, and zinc coated in accordance with AASHTO M 111. The threads shall be in accordance with ANSI B1.13M and shall be M24 by 3, class 6g pitch. The swaged fitting shall be in accordance with ASTM A576, grade 1035, zinc coated in accordance with AASHTO M 111, and shall be annealed for cold swaging. A lock pin hole to accommodate a 1/4 in. plated spring-steel pin shall be drilled through the head of the swaged fitting.

8. Timber blockouts shall be in accordance with 911.02(f). Alternate material blockouts shall be in accordance with 926.03.

High strength heavy hex bolts shall be in accordance with ASTM F3125, grade A325 or ASTM A449. High strength heavy hex nuts shall be in accordance with ASTM A563 Bolts, nuts, and washers shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. Foundation plates and bearing plates shall be in accordance with ASTM A36, and shall be galvanized after fabrication in accordance with ASTM A123, except the weight of zinc coating per square foot of actual surface shall average no less than 2.0

oz and shall be no less than 1.8 oz for any individual specimen. Welding shall be in accordance with AWS D1.1.

Terminal posts shall be fabricated from tubing meeting ASTM A500, grade B, or ASTM A501 and from plates meeting ASTM A36. Welding shall be in accordance with AWS D1.1. They shall be galvanized after fabrication in accordance with ASTM A123, except the weight of zinc coating per square yard of actual surface shall average no less than 2.0 oz. The average for any component part, including paddle plate, tubing, or base plate, shall be no less than 1.8 oz.

The steel pipe in the type 5 anchor and the steel spacer tube in the transition type WGB shall be Schedule 40.

Tapered washers may be of steel or malleable iron, and galvanized in accordance with ASTM A153.

The wire rope used in the cable assemblies shall be in accordance with AASHTO M 30 and shall be 3/4 in. preformed, 6 by 19, wire strand core or independent wire rope core, IWRC, galvanized, right regular lay, manufactured of improved plow steel, with a minimum specified breaking strength of 42,800 lbf. The swaged fitting, stud, and nut shall develop the breaking strength of the wire rope. The fitting shall be galvanized in accordance with ASTM A123 before swaging. After galvanizing, the head and nut may be tapped 0.023 in. over the ANSI B1.1, class 2B tolerance.

(b) For Steel Tube Guardrail

1. Channels and bars for connections, splice bars, and diaphragms shall be in accordance with ASTM A36.

2. Cap screws shall be stainless steel in accordance with ASTM A276, type 304 or 430.

3. Rail end caps shall be malleable iron castings in accordance with ASTM A47, grade 35018, or steel castings in accordance with ASTM A27, grade 70-36.

4. Cut washers and lock washers shall be standard round steel washers. The diameter of cut washers shall be 1 1/2 in. and 1/8 in. thick measured at the hole. Washers shall be coated after fabrication in accordance with requirement 3 of 910.11(a).

5. All materials other than cap screws and washers shall be galvanized after fabrication in accordance with ASTM A123.

6. When field fabrication, as approved, requires cutting or drilling, the cut or drilled members shall be coated with a high zinc

dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641 type II or Military Specifications DOD-P-21035. When spray paint is used, two coats shall be applied.

910.12 Blank

910.13 Steel Fence Posts

Tubular steel fence posts and line posts shall meet the following specifications and the requirements as shown on the plans.

(a) Line Posts

Line posts shall be in accordance with AASHTO M 281 and galvanized in accordance with AASHTO M 111, coating grade 65.

Line posts for farm field fence shall be furnished with anchor plates. End, corner, pull, and gate posts for farm field type fence shall be furnished with braces and all fittings and details required to make a complete installation as shown on the plans.

(b) Tubular Steel Fence Posts

Two groups of tubular steel fence posts are included in these specifications. Tubular section posts shall have heavy malleable iron caps or pressed galvanized steel caps. Such caps shall be made to provide a drive fit over the outside of the section to exclude moisture. The weight per foot for tubular posts and braces shall be no less than 90% of the weight specified. Unless specified otherwise, the tubular steel fence post shall be group 1.

1. Group 1

Tubular steel fence posts for group 1 shall be hot-dipped zinc-coated and shall be in accordance with ASTM F1083 except tests shall be conducted on sample posts selected as being representative of the posts furnished. The weight per foot will be acceptable provided it is at least 90% of the specified weight.

2. Group 2

Tubular steel fence posts for group 2 shall have a minimum 50 ksi yield strength and be in accordance with AASHTO M 181, except that the inner pipe surface may be galvanized in lieu of a zinc rich coating or hot dipped aluminum coated, Type 2, meeting the chemical requirements of AASHTO M 274. The aluminum coated, Type 2, steel fence posts shall be manufactured by roll forming aluminum coated, Type 2, steel strip and electric resistance welding it into tubular form. The outside of the weld area shall be metallized with commercially pure aluminum to a thickness sufficient to provide resistance to corrosion equal to that of the remainder of the outside of the post. The aluminum coating weight (mass) shall be a minimum of 0.75 oz/sq ft average, and 0.70 oz/sq ft for an individual test specimen, as measured in accordance with ASTM A428. Specimens for determining weight of coating shall be obtained in accordance with ASTM F1083.

(c) Fence Fastenings

When fastenings are necessary for attaching the farm field fence to the posts, they shall be either galvanized or aluminum coated No. 9 wire, or galvanized or aluminum coated clamps of the manufacturer's standard design. The coating weights shall be a minimum of 0.60 oz/sq ft and 0.30 oz/sq ft for galvanized and aluminum coated, respectively. A sufficient quantity of individual tie wires or clamps shall be furnished to provide for five attachments of the fencing to each line post and one tie wire for each strand of barbed or tension wire.

Line posts for chain link type fence shall be furnished with the necessary tie wires or fabric bands for fastening the fabric to the posts. These fastenings shall be made of aluminum strip or wire of approved gauge and design or of galvanized steel wire and may be in accordance with the manufacturer's standard design. If galvanized steel wire ties are furnished, the wire shall be no smaller than No. 9 gauge. A sufficient quantity of individual ties or bands shall be furnished to provide for attaching the fabric to each line post each 1 ft or as called for on the plans.

910.14 Sign Posts

(a) Steel, Flanged, Channel Posts

1. General Requirements

Posts shall be made from open hearth, basic oxygen, or electric furnace steel rolled from standard tee rails or new billets. The steel used in the posts shall conform to the physical properties of ASTM A499, grade 60, and to the chemical compositions of ASTM A1 for 91 lb/yd or larger steel rails.

Posts fabricated from other steels will be acceptable providing that the following criteria are met. A notarized copy of a dynamic crash test report shall be furnished substantiating that the posts manufactured from this material, when double mounted in a 7 ft span, conform to the breakaway requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, except that the maximum change in velocity shall not exceed 16 ft/s. For two posts in a 7 ft path, impact performance may be estimated by multiplying the vehicle energy loss observed in a single post crash test by 2. This estimated double post energy loss may then be used to calculate an estimated impact velocity change and momentum change for a double post sign design. The minimum yield strength shall be 60,000 psi and the minimum tensile strength shall be 90,000 psi.

The tensile strength shall be determined by either the standard Rockwell Hardness test, Brinnel Hardness test, or by actual tensile test. The Rockwell Hardness shall be a minimum of B 91. The yield strength shall be determined by the manufacturer by actual test. Tensile and yield strengths and chemical composition shall be determined by the average from the three latest test results the manufacturer has available at the time of shipment. These test results need not be made on the materials from which the posts were made. However, the tests shall have been made within 90 days of shipment.

A type B certification in accordance with 916 shall be provided for the posts, except those used for temporary construction signs, temporary traffic signs, and temporary panel signs. The limits of the following shall be shown on the certification.

Property	Requirement
Dimensions	ASTM A499
Chemical composition	ASTM A1
Yield strength	Minimum 60,000 psi
Tensile strength	Minimum 90,000 psi
Elastic modulus value	910.14(a)3

Posts shall be of uniform flanged channel or U section such that the area of contact between the post and the sign is symmetrical about the vertical axis of both sign and post. The back of each post shall be formed in a manner to ensure a solid bearing surface over the entire length of the post when mounted back to back. The bearing surface on the back of the post shall be flat. The length shall be as specified with a tolerance of ±1 in. Sign posts shall be punched with 58 holes which shall be 3/8 in. in diameter located on the center-line and spaced on 1 in. centers beginning 1 in. from the top. The remainder of the post shall be punched with 3/8 in. holes on 1 in. or 2 in. centers.

The finished posts shall be machine straightened and have a smooth uniform finish free from cracks, flaws, injurious seams, laps, blisters, and edges which are ragged, sharp, and imperfect, or other defects affecting their strength, durability, or appearance. The maximum variation in straightness shall be no more than 1/4 in. in any 5 ft of length, or exceed in inches 1/4 times the number of feet of length divided by 5. Bolt holes of the diameter specified shall be accurately spaced vertically and centered horizontally so that holes will register for back to back application. All holes and sheared ends shall be commercially free from burrs.

The steel sign posts shall be galvanized in accordance with ASTM A123.

Galvanizing shall be the final process after all fabrication and punching has been completed. Posts saw cut after galvanizing shall have the cut surface treated with a zinc-based solder in rod form which complies with ASTM A780. The cut surface shall not be treated until the fuse plate is installed and all bolts are tightened. The top of the fuse plate shall be 1 in. below the bottom of the sign.

Posts saw cut before galvanizing shall have temporary fasteners provided with sufficient strength to prevent warping or deforming of the post during the galvanization process. The surface under the temporary fasteners shall be treated with an approved zinc solder meeting the above mentioned specifications. The surface shall be treated before the fuse plate is installed. The break-away stubs shall be galvanized a minimum of 8 in. below the top of the concrete foundation.

Steel posts shall be wired or strapped securely in bundles of not more than 2,000 lb. They shall be nested in rows with the edges intermeshed so as to form a rectangular bundle and shall be fastened in such a manner that they do not slip or rub against each other and cause damage to the finish. Care shall be taken during shipment to prevent the bundles from rubbing against each other and causing damage. Excessive damage to the finish during shipment will be cause for rejection of the damaged posts.

2. Deflection Test Requirements

Posts will be tested as a simple beam with the flange in compression on non-restricting supports 24 in. apart. Test specimens shall be 28 in. ±1/4 in. long. A load of 1,500, 3,500, or 4,600 lb, depending on the type of post, shall be applied at the center of the span with a mandrel of not less than 1 in. in diameter. Application of the load shall be at a speed of not to exceed 0.03 in. per minute. Deflection of the post upon application of the total load shall not exceed 0.16 in. The load shall then be removed. Deflection of the post 1 minute after removal of the load shall not exceed 0.01 in.

3. Type of Posts

Posts shall conform to the following table and to deflection tests required in 910.14(a)2.

Type	Minimum Elastic Section Modulus	Loading
A	.200	1,500 lb
B	.400	3,500 lb
C	.560	4,600 lb
Abb*	.670	**
Bbb*	1.190	**

* Back to Back
** Back to Back post shall be tested singly for deflection prior to assembly.
Note: The elastic section modulus values shall be included in the type B certification.

(b) Wide Flange Posts

Structural steel members for the support of signs shall be in accordance with ASTM A36 and ASTM A709, grade 36. These members shall be galvanized in accordance with ASTM A123. Base plates and stiffeners shall be in accordance with the requirements of ASTM A709, grade 36. Fuse and hinge plates shall be in accordance with the requirements of ASTM A36 and shall be galvanized in accordance with ASTM A123. All bolts and nuts shall be high strength heavy hex and be in accordance with ASTM F3125, grade A325, and ASTM A563. Washers shall be in accordance with ASTM F436. Direct Tension Indicator hardware shall be in accordance with ASTM F959.

All holes shall be drilled. All cutting shall preferably be saw cuts however flame cuts as specified in 711.13 may be allowed. Metal projecting beyond the plane of the

plate face will not be allowed.

(c) Structural Steel Posts

Steel members for the support of signs shall be standard shapes as specified and shall be in accordance with 910.02(a). These members shall be galvanized in accordance with ASTM A123. A type C certification in accordance with 916 shall be provided for the structural steel posts.

(d) Structural Aluminum Posts

These posts shall be standard shapes as specified and shall be aluminum in accordance with ASTM B221 alloy 6061-T6. A type C certification in accordance with 916 shall be provided for the structural aluminum posts.

(e) Square Steel Posts

A type B certification in accordance with 916 shall be provided for the square steel posts. The limits of the following shall be shown on the certification.

1. Steel

Square steel posts shall be roll formed and in accordance with one of the following:

a. ASTM A1011, hot rolled carbon sheet steel in either 0.105 in. or 0.075 in. with a minimum yield strength of 60,000 psi. The ultimate tensile strength shall not exceed 79,800 psi or have an elongation measured over 2 in. greater than 20%.

b. ASTM A1008, cold rolled high strength steel, 0.075 in. with a minimum yield strength of 60,000 psi. This shall apply to the 2 in. by 2 in. size posts only.

c. ASTM A653, cold rolled high strength steel, 0.075 in. with minimum yield strength of 60,000 psi. The ultimate tensile strength shall not exceed 79,800 psi or have an elongation measured over 2 in. greater than 20%. This requirement shall apply to the 2 in. by 2 in. size posts only.

Yield strengths and chemical composition shall be determined from the three latest test results performed by the steel manufacturer. These test results may not be determined on materials from which the delivered posts were made. However, the tests shall have been performed within 90 days of shipment. The certification shall include the range of test results and the section modulus value in accordance with 910.14(a)3.

2. Fabrication

The posts shall be corner welded and scarfed as necessary to allow sections to telescope within each other. The finished posts shall be machine straightened and have a smooth uniform finish free from cracks, flaws, injurious seams, laps, blisters, and

edges which are ragged, sharp, and imperfect, or other defects affecting their strength, durability, or appearance. The maximum variation in straightness shall be no more than 1/4 in. in any 5 ft of length. Cut holes or knockout holes of 7/16 in. diameter shall be spaced on 1 in. centers, on the centerlines of all four sides in true alignment, and opposite to each other for back to back applications. All holes and sheared ends shall be free from burrs.

3. Protective Coating

The protective coating shall be applied using one of the following:

a. Before fabrication, both sides of the rolled sheet steel shall be galvanized in accordance with ASTM A653, coating designation G90.

b. After fabrication, a triple coating system on the outside of the posts consisting of galvanizing with zinc which is in accordance with ASTM B6 weighing 0.60 ±0.15 oz/sq ft followed by a chromatic conversion coating weighing 15 ±5 µg/sq in. and a clear organic exterior coating with a dry film thickness of 0.2 ±0.1 mil. The interior surface of the posts shall receive a double in-line application of a zinc rich organic coating with a total dry film thickness of 1.2 ±0.6 mil. The dried zinc rich organic coating film shall contain a minimum of 77% total zinc. Samples from the posts which use these protective coatings shall be exposed to salt fog testing in accordance with ASTM B117 for a total of 500 h. The samples shall be examined at both 100 and 500 h of salt fog testing and rated for corrosion. At 100 h the corrosion rating shall be a minimum of 9 and at 500 h the corrosion rating shall be a minimum of 6 when determined in accordance with ASTM D1654.

(f) Portable Construction Sign Trailer

The portable construction sign trailer, not including the signs and lights, shall weigh no more than 300 lb and shall not be fabricated with heavier than 3 by 3 in. angles, 2 1/2 in. pipe, or 3 by 2 in. rectangular tubing. The rim size of the wheels shall not exceed 12 in. Axle assemblies with differential housings shall not be used.

910.15 Delineator Posts

Posts shall be in accordance with 910.14(a)1.

Physical requirements for the finished delineator posts shall be:

Width of flange face	2 to 2 3/8 in.
Width of back	3/4 to 7/8 in.
Depth from face of flange to back	7/8 to 1 1/8 in.
Length	7.0 ft ±1 in.

Weight ..... 1.0 to 1.5 lb/ft

Delineator posts shall be punched with a minimum of twenty-four 1/4 in. holes on the centerline spaced on 1 in. centers beginning 1 in. from the top.

910.16 Copper Flashing

Copper flashing shall be soft copper and shall be in accordance with ASTM B370, except the minimum copper content shall be 99.5%. The weight per square foot will be determined by weighing individual samples. If the first sample is not in accordance with the tolerances for 16 oz sheet, two additional samples shall be tested and both shall comply with the specified tolerances. The sample shall withstand being cold bent through an angle of 180° flat upon itself, without failure of the outside of the bent portion. A type C certification in accordance with 916 shall be provided for copper flashing.

910.17 Bronze or Copper Alloy Plates

Bronze or copper alloy to be used for self lubricating bearing plates shall conform to one of the following requirements based on the design unit loading set out on the plans.

Design Unit Loading not over	Shall Conform to ASTM
A. 3,000 psi	B22, Alloy C86300
B. 2,500 psi	B100, Alloy C51000
C. 2,000 psi	B22, Alloy C91100
D. 1,000 psi	B22, Alloy C90500*
* Up to 2.5% lead allowed.	

The sliding surfaces of the plates shall be provided with cylindrical recesses with a depth necessary to provide proper containment of the lubricant. The recesses shall be arranged in a geometric pattern so that each successive row will overlap in the direction of motion. The total area of the recesses shall comprise no less than 25% and no more than 35% of the total area of the plate.

The surface finish of bearing areas shall be in accordance with ANSI B46.1 #125. The lay of tool marks shall be in the direction of expansion or contraction of the structure. If the surface is ground, grinding knurls may be omni-directional. Flat bearing surfaces shall be flat to a tolerance of ±0.0005 in. Curved bearing surfaces shall be machined to a tolerance of ±0.0005 in. in each 1 in. of length perpendicular to the circular section. The radius of curved bearing surfaces shall have the following tolerances.

	Positive Tolerance	Negative Tolerance
Concave Surface	0.010 in.	0.000 in.
Convex Surface	0.000 in.	0.010 in.

The lubricant shall be of the solid type. It shall consist of graphite and metallic substances having lubricating properties with a lubricating binder. The lubricant shall be free of any material that causes abrasive or corrosive action on the metal surfaces. It shall withstand the atmospheric elements. The lubricant shall be compressed into the recesses of the bearing plate by hydraulic pressure to form a dense non-plastic lubricating insert.

At the time of assembly in place, the steel surfaces which bear on the self-lubricating bearing plate shall be lubricated with additional lubricant furnished by the manufacturer. White lead, tallow, or other coating shall be removed before the application of the lubricant.

The coefficient of friction between the self-lubricating plate and the steel plates in contact with them shall not exceed 0.10 when subjected to twice the designed loading.

A type C certification in accordance with 916 shall be provided for the bronze or copper alloy plates.

910.18 Fence, Fittings, and Gates

(a) Farm Field or Woven Wire Fence

This fence shall be in accordance with ASTM A116. The wire shall be No. 9 gauge (3.8 mm). The design shall be 1047-6-9. The coating shall be class 3. The method of securing the vertical stays to the horizontal wires may be either of those shown on the plans. Diagonal braces shall be in accordance with 910.18(b)3.

A type C certification in accordance with 916 shall be provided for the fence, fittings, and gates.

(b) Steel Fabric Chain Link Fence

This fence shall be in accordance with ASTM A392 for galvanized steel fabric or ASTM A491 for aluminum coated steel fabric. The height of the fabric shall be 48 in. unless otherwise specified. It shall be of No. 9 gauge (3.8 mm) wire woven in 2 in. mesh. The fabric shall be knuckled at the top and bottom selvages when the height is less than 72 in. Fabric of 72 in. in height or higher shall be knuckled at the top and shall have the twisted and barbed finish at the bottom. For galvanized fabric, coating shall be done after weaving and shall be class II, average of two or more specimens no less than 2.0 oz/sq ft and no less than 1.8 oz/sq ft for any individual specimen. For aluminum coated fabric, coating shall be class II, 0.40 oz/sq ft minimum.

The fabric shall be furnished with ties required for fastening it to the top and bottom tension wires. These fastenings may be of aluminum wire or strip of approved gauge and design, or of galvanized steel wire in accordance with the manufacturer's standard design. If galvanized steel wire ties are furnished, the wire shall be no smaller than No. 12 gauge (2.7 mm). Sufficient ties shall be furnished to provide for attaching

to the top and bottom tension wires each 24 in. Fittings necessary to make complete installation shall be pressed or rolled steel, forged steel, cast steel, or malleable iron.

Steel fabric chain link fence shall be as shown on the plans and as set out above.

A type C certification in accordance with 916 shall be provided for the steel fabric chain link fence.

1. Tension Wire

Tension wire intended for use on the top or bottom of steel chain link fence or on the bottom of farm field fence when specified shall be spring coil or crimped steel wire with an initial diameter of 0.177 ±0.005 of an in., a minimum breaking load of 1,950 lb, and a coating of either zinc or aluminum. The minimum weight (mass) of coating shall be 0.80 oz/sq ft for galvanized wire and 0.40 oz/sq ft for aluminum coated steel wire. The weight of aluminum coating shall be determined in accordance with ASTM A428.

A type C certification in accordance with 916 shall be provided for the tension wire.

2. Stretcher Bars, Truss Rods, and Turnbuckles

Stretcher bars shall be 3/16 by 3/4 in. flat bars. These bars, truss rods, turnbuckles, and necessary fittings shall be of good commercial quality steel, malleable iron, or wrought iron. They shall be galvanized in accordance with ASTM A153 after fabrication. The turnbuckles shall be made from drop forged malleable iron. They shall have a minimum take up of 4 in. The fittings may be pressed or rolled steel, forged steel, cast steel, or malleable iron.

3. Braces

Braces shall be made of steel pipe with bolted steel couplings or connections. Steel pipe shall be in accordance with ASTM F1083. They shall be galvanized as set out therein. Fabrication or manipulation that causes minor damage to the galvanized coating shall be corrected by approved application of a high zinc dust-zinc oxide paint conforming to the requirements of Federal Specification TT-P-641 type II or Military Specifications DOD-P-21035. When spray paints are used, two coats shall be applied. Damaged braces will be rejected.

4. Barbed Wire

Barbed wire used at the top and bottom of farm field fence, or as otherwise specified, and in accordance with 603 shall be in accordance with applicable provisions of ASTM A121. It shall be composed of No. 12 1/2 gauge (2.5 mm) galvanized or aluminum coated steel wire with four round 14 gauge (2.0 mm) barbs at approximately 5 in. spacing. The galvanized coating shall be in accordance with class 3 in Table 2. The minimum aluminum coating shall be in accordance with class 60 for the line wire and class 20 for the barb wire. The weight of coating shall be determined in accordance with ASTM A428. The use of aluminum barbs, in accordance with

ASTM B211, alloy 5052-H38, nominal diameter No. 12 gauge, will be allowed.

The use of barbed wire with No. 15 1/2 gauge (1.70 mm), high tensile strength line wires, and No. 16 1/2 gauge (1.47 mm) barbs will be allowed. The barbs shall be round with four points and spaced at approximately 5 in. intervals. The barbed wire shall be in accordance with ASTM A121. The galvanized coating shall be in accordance with class 3 in Table 2.

A type C certification in accordance with 916 shall be provided for the barbed wire.

5. Bridge Railing Pedestrian Fence

Fence posts and horizontal rails shall be in accordance with 910.13(b)1. The zinc-coating weight shall not be less than 2 oz/sq ft.

Base plates shall be steel in accordance with ASTM A709, grade 36 or 50. Galvanization shall be in accordance with AASHTO M 111. The zinc-coating weight shall not be less than 2 oz/sq ft.

The chain link fabric shall be coated wire of 9 gauge, with a mesh size of 2 in. The zinc-coating weight of fabric shall not be less than 2 oz/sq ft. The zinc-coating weight of brace bands, fabric ties, fence post loop caps, fence post caps, horizontal rail end cups, tension bands, and tension bars shall not be less than 1.2 oz/sq ft.

A type C certification in accordance with 916 shall be provided for the bridge railing pedestrian fence.

(c) Aluminum Fabric Chain Link Fence

This fence shall be in accordance with the applicable requirements of 910.18(b) except for composition of materials. Requirements for the various component parts of aluminum fence shall be as shown in Table 1.

Table 1

Item	ASTM Reference	Alloy	Additional Information
Fabric	B211	Al-clad 5056 or 6061-T94	
Barbed Wire - Line	B211	5062-0, H38, or 6061-T89	2-strand dia. 0.110 in. 4-pt barb. dia. 0.080 in. 5 in. space
Barbs	B211	5052-H38	
Tension Wire	B211	Al-clad 5056 or 6061-T94	Dia. 0.192 in.; Note 1
Hog Ring Fasteners	B211	6061-T94	Dia. 0.110 in.
Wire Ties	B211	1100-H18	Dia. 0.148 in.
Flat Band Ties	B211	3003-H14	1.2 in. wide; 0.06 in. thick
Stretcher Bars	B211	6063-T6	3/4 in. by 1/4 in.; square edges
Truss and Brace Rods	B211 or B221	6061-T6	Dia. 3/8 in.
Turn Buckles	B26 (cast parts), B211 (wrought)	356.0-T6 6061-T6	
Bands	B221	6063-T6	1/8 in. by 1 in. beveled edge
Bolts	B211 or B221	2024-T4	ASA B 18.2 hexagon threads class 2, 2A, or 2B
Nuts	B211 or B221	6061-T6	
Expansion Sleeves	B210	3003-H18	1.695 in. ID by 0.078 in.; wall drawn type. 6 in. long; self-centering
Post Tops, Rails and Brace Ends	B26 or B108	356.0T6	Fabricated in permanent molds or sand castings
Top and Brace Rails	B241 and B429	6063-T6	1 1/4 in. pipe; Note 2
Barbed Wire Extension Arms	B26 or B108	356.0T6	Fabricated as for post tops; sheet castings
Line Posts	B241 and B429	6063-T6	2 in. pipe; Note 2
Corner Posts	B241 and B429	6063-T6	2 1/2 in. pipe; Note 2

Note 1: Aluminum coated steel wire in accordance with 910.18(b) may be used.
Note 2: ANSI schedule 40 pipe, plain ends.

1160 **(d) Gates**

Gate posts sizes shall be as follows:

ANSI Nominal Pipe Size	Swing Gate Opening, (inclusive)	
	Single Gate	Double Gate
2 1/2 in.	Up to 6 ft	Up to 12 ft
3 1/2 in.	7 to 13 ft	13 to 26 ft
6 in.	14 to 18 ft	27 to 36 ft
8 in.	19 to 32 ft	37 to 64 ft

1. Steel Gates

Steel gate posts shall be standard weight, galvanized, steel pipe in accordance with ASTM F1083 and furnished with all necessary fittings. Post sizes shall be as set out above. The gate frames shall be of standard weight, galvanized, steel pipe in accordance with ASTM A53; of 1 1/2 in. (38.1 mm) nominal size; and shall have welded joint or riveted construction using galvanized pressed steel or malleable fittings. Areas welded after galvanizing shall be coated with a material conforming to the requirements of Federal Specification TT-P-641, type II or Military Specifications DOD-P-21035. When spray paints are used, two coats shall be applied. Fabric coverings for gates shall be in accordance with 910.18(a) or 910.18(b). These gates shall be furnished with necessary fastenings, hinges, center stops, and locking devices galvanized after fabrication in accordance with ASTM A153.

2. Aluminum Gates

Aluminum gate post sizes shall be in accordance with 910.18(d). They shall be ANSI schedule 40 pipe and in accordance with ASTM B241 or B429, alloy 6063-T6. Gate frames shall consist of 1 1/2 in. schedule 40 pipe assembled by welding or with fittings. Pipe shall be in accordance with ASTM B241 or B429, alloy 6063-T6. Welding material and procedures shall be in accordance with the applicable AWS provisions. Formed sheet fittings shall be in accordance with ASTM B209, alloy 6061-T6. Gate hinges may be offset type wrought aluminum, ASTM B209, alloy 6061-T6, or galvanized malleable iron. Fabric shall be in accordance with 910.18(c).

910.19 Overhead Sign Structures

The complete structure with signs in place shall be able to withstand wind pressure in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. The structure shall be designed to resist fatigue of the material in accordance with the AASHTO specifications.

All prefabricated structural units shall be packed so that there is no injury or defacement during transportation to the point of destination.

All bolts, nuts, and washers for bridge bracket assemblies shall be stainless steel in accordance with ASTM F738M.

Strain poles for cable span signs shall be in accordance with 922.10(a). Each strain pole shall include three band-type attachments for span wire clamps. Such attachments shall be galvanized in accordance with ASTM A153. Cable shall be in accordance with 922.10(e)2. Each cable shall include three wire rope clips at each end. Anchor bolts shall be in accordance with 922.10(c)5. All sign mounting hardware except for the extruded aluminum bar shall be galvanized in accordance with ASTM A153.

Gratings for the walkway shall be of aluminum in accordance with ASTM B221, alloy 6061-T6 or 6063-T6. Cross bars and bent connecting bars shall be of aluminum

in accordance with ASTM B221, alloy 6061, 6063 or 3003 conforming to ASTM B210.

A type C certification in accordance with 916 shall be provided for the overhead sign structure.

(a) Aluminum Trusses for Overhead Sign Structures, Box Truss and Dynamic Message Sign Structure Truss

Extruded tubes and other shapes shall be of aluminum in accordance with ASTM B221, B241, or B429, alloy 6061-T6. All other castings shall be of aluminum in accordance with ASTM B26, alloy 356.0-T6. Gusset, flange and stiffner plates shall be of aluminum in accordance with ASTM B209, alloy 6061-T6. Plates shall be free of sharp edges and irregularities.

Bolts, nuts, screws, and flat washers shall be passivated type 304 stainless steel. Bolts and screws shall be in accordance with ASTM A193, grade B8. Hexagon nuts and washers shall be in accordance with ASTM A194, grade 8. High strength bolts, nuts and washers for chord splice connections, with matching lock nuts having steel inserts, shall be in accordance with 910.02(g) and shall be galvanized in accordance with AASHTO M 232, class C or D.

Neoprene pads shall be ultraviolet rated and shall conform to the requirements in 915.04.

Welding material and procedures shall be in accordance with 803 and applicable AWS provisions.

Certified proof of the qualifications for a minimum of two welders shall be presented after the contract is awarded and before fabrication is started. This certification shall be from a commercial or public testing laboratory and qualifications shall be based on welding of aluminum alloy, 6061-T6 with consumable electrode type welding using aluminum alloy ER5356 filler material. Welders shall qualify by passing the requirements set out in 803.04.

Welding shall be checked by visual inspection. Poor welding workmanship shall be rejected.

Each complete structure shall be free from any misfits or structural deficiencies prior to shipment.

(b) Steel Overhead Sign Structures, Cantilever, Monotube, Tri-Chord, Bridge Attached, and End-Supports for Box Truss and Dynamic Message Sign Structure

End-support members for box truss and dynamic message sign structure shall be fabricated from constant cross-section tubular steel or extruded steel shapes as indicated on the drawings. Sections used for end-support columns, diagonal and

horizontal members shall be constant cross-section tubular members in accordance with ASTM A53, type E or S, grade B, minimum yield strength of 35,000 psi. Constant cross-section tubular steel with greater yield strength may be used with written approval, however, structural dimensions shall remain as shown on the plans. Sections used for cross support beams shall be constant cross-section extruded W-shapes in accordance with ASTM A709, grade 36. Base plates shall be in accordance with ASTM A36. Base plates for columns shall develop the full strength of the columns. Structures shall be galvanized after fabrication in accordance with ASTM A123.

Support columns for the cantilever structure shall be fabricated from constant cross-section tubular steel as indicated on the drawings. Column sections shall be in accordance with ASTM A53, type E or S, grade B as shown on the plans. Members shall have minimum yield strength of 35,000 psi. Constant cross-section tubular steel with greater yield strength may be used, with written approval, however, structural dimensions shall remain as shown on the plans. Base plates shall be in accordance with ASTM A36. Base plates shall develop the full strength of the columns.

Cantilever arms shall be either double arms or quadri-chord trusses as shown on the plans.

Cantilever arms shall be fabricated from octagonal tubular member with 0.14 in./ft taper and in accordance with ASTM A595, grade A or B, or ASTM A572, grade 50. Quadri-chord arms shall be of constant cross-section tubular members in accordance with ASTM A53, type E or S, grade B as shown on the plans. Members shall have minimum yield strength of 35,000 psi. Steel with greater yield strength may be used, with written approval, however, structural dimensions shall remain as shown on the plans. Structures shall be galvanized after fabrication in accordance with ASTM A123. Plates shall be free of sharp edges and irregularities.

High strength bolts, nuts and washers for chord to column connections, with matching lock nuts having steel inserts, shall be in accordance with 910.02(g) and shall be galvanized in accordance with AASHTO M 232, class C or D.

Bolts, U-bolts, nuts, screws, and flat washers shall be passivated type 304 stainless steel. Bolts and screws shall be in accordance with ASTM A193, grade B8. Hexagon nuts and washers shall be in accordance with ASTM A194, grade 8.

Bridge attached structures shall be fabricated from constant cross-section tubular steel in accordance with ASTM A53, type E or S, grade B with a minimum yield strength of 35,000 psi. Constant-cross section tubular steel with greater yield strength may be used, with written approval. However, structural dimensions shall remain as shown on the plans. Structures shall be galvanized after fabrication in accordance with ASTM A123.

Tri-chord truss structures shall be made of constant cross-section tubular members in accordance with ASTM A53, type E or S, grade B minimum yield strength of 35,000

psi. Monotube structures shall be made of tapered tubular members in accordance with either ASTM A595, grade A or B, or ASTM A573, grade 50. Structures shall be galvanized after fabrication in accordance with ASTM A123.

The J hook shall consist of one 3/8-in. steel bar in accordance with ASTM A307. It shall be spot welded to the inside of the end-support member. The J hook shall be hot-dip galvanized prior to welding or in the final assembly with the support column.

Anchor bolts, nuts, and washers shall be in accordance with ASTM F1554, grade 36. A hexagon nut, leveling nut, and flat washer shall be furnished with each anchor bolt. Top ends of anchor bolts and associated hardware as shown on the plans, shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55.

Base plate skirts shall be 10 gauge galvanized steel.

Welding material and procedures shall be in accordance with 711.32 and applicable AWS provisions.

Welding shall be checked by visual inspection. Poor welding workmanship shall be rejected.

Each complete structure shall be free from any misfits or structural deficiencies prior to shipment.

Strain poles shall be anchor bolt type complete with hand-holes and pole top or cap. They shall meet the requirements set out above for cantilever sign structures. Each pole is to include three band-type attachments for span wire clamps. The band shall be from material in accordance with ASTM A572, grade 50; ASTM A606; or approved equal. The bands shall not be of the U-bolt type. The poles shall have maximum deflections as shown below when loaded 18 in. from the top with a 100 lb load.

Pole Size	Deflection
15 in. by 30 in.	0.16 in.
14 in. by 26 in.	0.12 in.

The steel flanges at the center of the cross beam and at the ends of the horizontal arms shall be fastened to the tapered or straight sections by means of two circumferential welds. One of the circumferential welds shall weld the outside of the flange firmly to the tube. The flange connection shall develop fully the strength of the tubular sections being joined together by means of the flange connections.

Gusset, flange, and base plates shall be in accordance with ASTM A36 and shall be galvanized after fabrication in accordance with ASTM A123. Base plates for upright poles shall develop the full strength of the poles. Castings for the vertical pole top and horizontal arm and cap shall be in accordance with ASTM A126 and shall be

galvanized with a minimum coating of 2 oz/sq ft. High strength heavy hex bolts and nuts, except anchor bolts, shall be in accordance with ASTM F3125, grade A325, Type 1, and ASTM A563. Two nuts for use in plumbing upright poles shall be furnished with each anchor bolt. Anchor bolts for overhead steel structures shall be in accordance with 910.19(a). Bolts, nuts, washers, and the top ends of anchor bolts shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. Welding shall be in accordance with 711.32.

Beam clamp details and sign support assemblies shall be galvanized in accordance with ASTM A153. Clamps shall be fabricated of high strength, low alloy steel in accordance with ASTM A242, ASTM A606, or approved equal. Stainless steel U-bolts may be used in lieu of the clamps for the attachment of the sign hangers to the arms of double arm cantilevers. The U-bolts shall be in accordance with 910.19(a) for stainless steel hardware.

910.20 Steel Bridge Railing Components

Materials for steel bridge railing components shall be in accordance with the following:

(a) Railing and posts tubing shall be in accordance with ASTM A500, grade B.

(b) Posts, connection plates, splice bars, base plates, and anchor channel bars shall be in accordance with ASTM A709, grade 36. High strength steel posts and connection plates shall be in accordance with ASTM A709, grade 50.

(c) Steel bolts, nuts, and cap screws shall be in accordance with ASTM A307.

(d) Railing end caps shall be steel castings in accordance with ASTM A27, grade 70-36.

(e) Threaded rods, nuts, and washers shall be in accordance with ASTM A449, ASTM A563, and ASTM F436, respectively.

(f) Steel washers shall be standard round cut or lock washers, as shown on the plans.

(g) Cap screws shall be stainless steel in accordance with ASTM A276, type 304, 305, or 430.

(h) Anchor bolts shall be galvanized and in accordance with 910.02(g)2. Threads may be cut or rolled.

(i) Railing tubing, posts, connection plates, splice bars, base plates,

anchor channel bars, and railing end caps shall be galvanized after fabrication in accordance with AASHTO M 111.

Bolts, nuts, cap screws, washers, and lock washers shall be galvanized after fabrication in accordance with AASHTO M 232.

(j) A type A certification in accordance with 916 shall be provided for the anchor bolts. The results of the following shall be shown on the certification for the anchor bolts.

Property	ASTM Test Standard
Tensile strength	F3125 or A449
Proof load	F3125 or A449
Hardness	F3125 or A449
Coating thickness and weight	A153 class C or B695 class 55
Rotational capacity	F3125

A type C certification in accordance with 916 shall be provided for the steel bridge railing components.

910.21 Steel Sheet Piling

Steel sheet piling shall be in accordance with ASTM A328, ASTM A1011, or ASTM A653.

910.22 Grating for Grated Box End Sections

(a) Type I Grated Box End Sections

Steel pipe and steel tubing for grating shall be in accordance with ASTM A53, type E or S, grade B or ASTM A501, electric-resistance welded or seamless. Such pipe and tubing shall be galvanized in accordance with ASTM A123. All other related hardware shall be galvanized in accordance with ASTM A153.

Pipe with a 4 in. outside diameter and in accordance with ASTM A513, type 5, may be used as an alternate to the 4 in. outside diameter pipe specified. The pipe used as an alternate shall have a minimum wall thickness of 5/16 in. and a minimum yield strength of 50,000 psi. Steel tube of 4 in. by 4 in. by 3/8 in. and in accordance with ASTM A500, grade B, will also be allowed as an alternate to the 4 in. outside diameter pipe specified.

(b) Type II Grated Box End Sections

Structural steel grates shall be ASTM A36 for end sections having widths less than or equal to 3 ft and shall be ASTM A572, grade 50 for widths greater than 3 ft.

A type B certification in accordance with 916 shall be provided for the pipe, tubing, tube, and grates. The limits of the following shall be shown on the certification.

Welding, as shown on the plans, shall be in accordance with 711.32 and AWS D1.1.

Test	ASTM
Tensile Strength, Yield Strength, Outside Diameter, Wall Thickness, Galvanization Coating Thickness	A53, type E or S, grade B
Tensile Strength, Yield Strength, Wall Thickness, Outside Diameter (Round) or Unit Weight (Square/Rectangular), Galvanization Coating Thickness	A501
Tensile Strength, Yield Strength, Bar Dimensions	A36
Tensile Strength, Yield Strength, Bar Dimensions	A572, grade 50
Wall Thickness, Outside Diameter, Yield Strength	A513, type 5
Tensile Strength, Yield Strength, Tube Dimensions, Wall Thickness	A500, grade B

SECTION 911 – WOOD MATERIALS

911.01 Untreated Lumber

(a) General

Untreated lumber is a saw mill product which may be further manufactured by sawing, resawing, passing lengthwise through a standard planing machine, drying, cross cutting to length, and machining but is not treated with preservatives.

1. Boards

Yard lumber less than 2 in. thick and more than 1 in. wide is a board.

2. Dimension Lumber

Lumber from 2 in. to but not including 5 in. thick and 2 in. or more wide is dimension lumber.

3. Structural Lumber

Lumber that is 2 in. or more thick and 4 in. or more wide intended for use where working stresses are required is structural lumber. The grading of structural lumber is based on the strength and use of the entire piece. The grade of lumber shall be as shown on the plans or as otherwise specified.

4. Sawn Timbers

Solid sawn pieces with a nominal dimension of 5 in. or more in the least dimension is timber. Timbers may be classified as beams, stringers, posts, caps, sills, girders, or purlins. Timber for structural purposes shall be no less than 6 in. in width or thickness. Dimensions and grade of timber shall be as shown on the plans or as otherwise specified.

5. Timbers, Round

These timbers are used in the original round form, such as poles, posts, and mine timbers. Round timbers, such as posts and poles, shall be entirely peeled. All limbs and knots shall be trimmed flush. Unless otherwise approved or shown on the plans, no minus tolerances will be allowed on the specified diameter.

6. Yard Lumber

Lumber of all sizes and patterns intended for general building purposes is yard lumber. The grading of yard lumber is based on the intended use of the particular grade and is applied to each piece with reference to its size and length when graded without consideration to further manufacture.

7. Surfaced or Dressed Lumber

This is lumber that is dressed by running it through a planer.

8. Rough Sawn Lumber

This is lumber that has been sawn, edged, and trimmed, but not dressed.

(b) Species and Grade

Only Coastal Douglas-fir, red oak group, redwood, southern yellow pine, and white oak group will be allowed, except as set out elsewhere herein. Redwood lumber shall not be used in bridges where it is a permanent part of the structure.

Except as otherwise provided, all lumber furnished under these specifications shall be of the species and grades specified.

Softwood lumber shall be graded in accordance with grade rules which conform with the basic provisions of the American Softwood Lumber Standard PS 20. It shall be grade marked and shall be in accordance with the applicable grading rules or specifications of the following agencies for the species indicated.

Coastal Douglas-fir – West Coast Lumber Inspection Bureau
Southern Yellow Pine – Southern Pine Inspection Bureau
Redwood – Redwood Inspection Service

Red and White Oak Group, Hardwood Lumber, shall be grade marked and shall be in accordance with the applicable grading rules of the National Hardwood Lumber Association.

If lumber is not to be graded as provided above, it may be green or seasoned, but shall be sound, free from excessive wane, unsound loose or hollow knots, knot holes, shakes, or other defects which would impair strength or durability for the use intended. Pin holes, shot holes, or occasional grub holes in oak are not classified as defects. If approved and if the proposed use of the material is stated on the purchase order, grade markings may not be required on native red or white oak groups furnished from local

sources or on emergency orders or small orders of Coastal Douglas-fir and southern yellow pine.

Lumber for temporary bridges or other temporary structures may be of any species and grade which meets approval.

(c) Inspection

All lumber regardless of grade markings may be inspected for grades and quality at the point of origin or final destination. If, during inspection of a lot of lumber, it becomes apparent that the quantity of rejections exceed 20%, the entire lot may be rejected.

(d) Tolerances

Tolerances for rough sawn, or dressed lumber shall be in accordance with the National Lumber Grades Authority Grade Rule standards for each species.

(e) Untreated Piling

Untreated piles shall be in accordance with ASTM D25 and the following. All piling shall be cut from white or red oak, dense southern yellow pine, fir, or cypress, preferred in the order listed. They may be of other species, subject to approval, which can withstand driving without showing excessive brooming or splitting.

The butts and tips shall be sawn square with the axis of the pile. Alternatively, the tips may be tapered to a point of not less than 16 sq in. with the tip so formed that the centerline of the pile passes through the tip.

Unless otherwise specified, all piles shall be clean-peeled before driving. No strip of the inner bark remaining on the pile shall be more than 3/4 in. wide. There shall be at least 1 in. of bark free surface between two such strips. Not less than 80% of the surface shall be clean wood. All knots shall be trimmed flush with the body of the pile.

After peeling, piles shall have diameters as indicated below unless otherwise approved or required.

Length of Pile	Diameter, inches		
	Tip, min.	3 in. from Butt, min.	Butt, max.
Less than 20 ft	8	11	20
20 ft and less than 40 ft	8	12	20
40 ft and less than 60 ft	7	13	20
60 ft and more	6	13	20

911.02 Treated Lumber

(a) General

Treated lumber shall be preservative-treated by pressure processes in accordance

with AWPA Standards T1 and U1 or AASHTO M 133. Other AWPA Standards applying to specific items are set out in 911.02(b), 911.02(c), 911.02(e), and 911.02(g). Lumber to be treated shall be in accordance with 911.01, except as modified in 911.02(b), 911.02(c), and 911.02(e). The lumber may be inspected at the treating plant. Preservatives shall be in accordance with 911.02(h). Wherever ammoniacal or alkaline copper quat azole or wherever copper preservative is utilized, only stainless steel or hot dipped galvanized fasteners and hardware shall be used. Galvanizing for fasteners shall be in accordance with ASTM A153. Galvanizing for hardware shall be in accordance with ASTM A653, coating designation G185. Fasteners and hardware in contact with one another shall be of the same base material and coating if applicable, and shall be used consistently throughout the treated wood article or structure.

(b) Bridge Lumber

This shall be southern yellow pine or Coastal Douglas-fir. There shall be no heartwood requirements and the amount of sapwood shall not be limited. Wane will not be allowed on any treated plank for flooring and may be excluded elsewhere when so specified. Lumber for bridges shall be treated with a preservative in accordance with applicable provisions of AWPA Standards T1 and U1, Commodity Specification A: Sawn Products, use category UC4B.

(c) Piling

Timber piling, before treatment, shall be in accordance with 911.01(e) except piles shall be southern yellow pine or Coastal Douglas-fir. The outer and inner bark shall be removed before treatment. Unless otherwise specified, piling shall be treated with a preservative in accordance with the applicable requirements of AWPA Standards T1 and U1, Commodity Specification E: Round Timber Piling, use category UC4C.

(d) Blank

(e) Sign Posts

Wood sign posts shall be cut from southern yellow pine, Coastal Douglas-fir, or other species as specified. Posts shall be surfaced four sides.

Dimensions shall be in accordance with the plans. There will be a length tolerance of ±2 in. Both butt and top ends shall be sawn square. All outer and inner bark shall be removed. One way sweep, not exceeding 1 in. between the top and butt, will be acceptable. Short crooks will not be allowed.

The posts shall be sound timber. No splits, shakes, excessive cracks, loose decayed or hollow knots will be allowed. Occasional pin, shot, or grub holes in oak, or bird pecks in other timbers, will not be considered defects. All posts shall be entirely treated with preservatives in accordance with all applicable provisions of AWPA Standards T1 and U1, Commodity Specification A: Sawn Products, use category UC4A.

(f) Sawn Timber Posts and Blockouts

The requirements for posts and blockouts prior to treatment shall be in accordance with AASHTO M 168 and as modified below.

1. Species and Grades

Timber posts shall be of the species listed, and shall be in accordance with the grading requirements specified in Table A. Timber blockouts shall be of the species listed, and shall be in accordance with the grading requirements specified in Table B. Timber posts and blockouts shall have the cross section and length dimensions as shown on the plans.

Table A

Special and Grading Requirements for Sawn Timber Guardrail Posts		
Species	Posts and Timbers Grade	Grading Rules Agencies[a]
Softwoods		
Coastal Douglas-fir	No. 1 or better	WWPA or WCLIB
Southern Pine	No. 1 or better	SPIB
[a] WWPA (Western Wood Products Assoc.); WCLIB (West Coast Lumber Inspection Bureau); and SPIB (Southern Pine Inspection Bureau).		

Posts and blockouts shall be graded in accordance with grading rules based on principles and methods specified in ASTM D245. Where there is a conflict between AWPA and ASTM standards, AWPA will prevail. Where there is a conflict between either AWPA or ASTM standards and this specification, this specification will prevail.

All material shall show the approved grading agency stamp indicating mill origin, species, and grade.

Table B

Species and Grading Requirements for Sawn Timber Guardrail Blockouts		
Species	Posts and Timbers Grade	Grading Rules Agencies[a]
Softwoods		
Coastal Douglas-fir	No. 2 or better	WWPA or WCLIB
Southern Pine	No. 2 or better	SPIB
[a] WWPA (Western Wood Products Assoc.); WCLIB (West Coast Lumber Inspection Bureau); and SPIB (Southern Pine Inspection Bureau).		

2. General Requirements

Posts and blockouts shall be in accordance with the following general requirements.

a. Decay

Posts and blockouts shall be free from decay before treatment.

b. Unsound Wood

Posts containing unsound wood will be rejected. Blockouts may contain small

spots of unsound wood provided they are well scattered.

c. Grounds for Rejection

Posts and blockouts shall be sound. No sapwood rot will be allowed. Ring shake will not be allowed. Grub holes in the butt, 1/2 in. or less in diameter, are not considered defects. Posts or blockouts containing ant holes will not be accepted. Any post or blockout which contains any defect which is detrimental to the post or blockout will be rejected.

d. Dimensional Tolerances

Posts and blockouts shall be sawn square to within -1/2 in. of the specified cross-sectional dimensions. A tolerance of ±2 in. will be allowed on the specific length of the posts. A tolerance of -1/2 in. will be allowed on the specified length of the blockouts.

3. Pressure Treating Posts and Blockouts

Pressure treating posts and blockouts shall be in accordance with the following requirements and AWPA Standards T1 and U1, Commodity Specification A: Sawn Products, use category UC4B.

a. Machining

Posts and blockouts shall be sawn to their final shape and holes bored prior to treatment.

b. Inspection Before Treatment

The treater shall be responsible for ensuring that the material has the required approved grading agency stamp before treatment is commenced. The stamp or marking shall be applied on a wide face at the trimmed end. The stamp shall be applied such that it remains readable after treating. Material that has been air dried or kiln dried shall be inspected for moisture content in accordance with AWPA Standard M2.

c. Preservative Treatment

All posts and blockouts shall be treated with a preservative as specified herein.

d. Material for Preservative Treatments

The preservative used for treating posts and blockouts shall be in accordance with the appropriate AWPA or AASHTO Standards.

e. Treatment Methods

Timber for guardrail posts and blockouts shall be treated to be in accordance with AWPA Standard T1, and the requirements specified herein.

f. Sorting and Spacing

The material in a charge shall consist of the same species or consist of species within one group shown in table C. The material shall have similar moisture content and be of similar form and size. Blockouts and posts may be treated in the same charge.

Table C

Species Groupings for Treatment in Same Charge	
Group	Species
A	Southern Pine
B	Coastal Douglas-fir

g. Conditioning

Conditioning shall be in accordance with AWPA Standard T1.

h. Inspection During Treatment

The treater shall determine that the preservatives used are in accordance with the requirements herein. The minimum frequency of the preservation analysis shall be each charge for the occasional single charge inspected. The minimum frequency for consecutive treatments from the same working tank shall be the first and at least one of every five additional charges, selected at random. Preservative samples shall be taken as appropriate so as to be representative of the solution in the treating cylinder.

i. Retentions

The minimum retentions shall be in accordance with AWPA Standards T1 and U1.

j. Penetration

The penetration requirements shall be in accordance with AWPA Standard T1, table B6.

k. Inspection After Treatment

Following treatment, the charge shall be physically inspected in accordance with AWPA Standard M2, section 4. All treated material shall bear the quality mark of the inspection agency. All inspections shall be completed at no cost to the Department. All non-compliant material shall be removed from the remaining acceptable material before shipment.

l. Branding

All post and blockouts shall be clearly and permanently branded or marked on one of the wide faces. The brand shall be within 12 in. of the top of the post. The brand shall show the treater's identification, the plant designation, and the year of treatment. The month may also be included. The brand shall also show the species, the preservative type, and retention, all in accordance with AWPA Standard M6.

m. Conformance

The treating plant supplying the material shall be responsible for and will be required to supply a certificate indicating the species, grade, preservative type, retention, year, and name of treater. The certificate shall also include all of the other information which is listed in AWPA Standard M2, section 6.2.

n. Records

Copies of treating records, analysis records, and other records which may be necessary to determine accordance with specifications shall be made available to Department personnel or their designated representatives upon their request. Required information shall be that which is listed in AWPA Standard M2, section 6.2. These records shall be retained by the treating plant for five years from the date of material shipment.

o. Independent Inspections

The Department may inspect the material or call for a non-Departmental inspection to verify that it is in accordance with all specifications.

4. Field Treatment of Posts and Blockouts

Cuts, holes, or injuries to the surface of posts and blockouts which occur after pressure treatment shall be field-treated with copper naphthenate in accordance with AWPA Standard M4.

5. Rejection for Degrade After Treatment

Guardrail posts or blockouts developing the following degrade prior to installation will be rejected regardless of prior approvals.

a. single checks greater than 3 in. deep or checks opposite each other totaling more than 3 in. deep, measured with a probe not more than 1/16 in. thick;

b. single checks 1/4 in. wide or wider measured at the widest point, and extending more than 1/3 of the length of the post or blockout;

c. single checks greater than 3/8 in. wide measured at the widest point;

d. splits greater than 3 in. long which are in the plane of the bolt hole;

e. crooks or bows exceeding 1 in. per 10 ft length; and all twists;

f. combinations of checks, splits, or shakes which are otherwise in accordance with the specifications but which may cause the post or blockout to separate into several pieces.

(g) Recreational Applications

Lumber and timber that will be used in facilities where human contact will occur, such as handrails, pedestrian facilities including decking and picnic tables, shall be

treated in accordance with AWPA Standards U1 or UC4A, or AASHTO M 133. A type C certification in accordance with 916 shall be provided for the lumber/timber.

(h) Preservatives

Preservatives shall be in accordance with current AWPA or AASHTO M 133 Standards as modified by EPA regulation.

Waterborne preservatives shall be in accordance with AASHTO M 133 or AWPA Standards.

SECTION 912 – CONCRETE CURING MATERIALS AND ADMIXTURES

912.01 Curing Materials

Curing materials shall be in accordance with the following requirements.

(a) Burlap Cloth made from Jute or Kenaf

This material shall be new, or reclaimed and thoroughly vacuum cleaned burlap. Burlap from sugar, salt, or fertilizer bags shall not be used. The burlap shall weigh no less than 10 oz/sq yd and shall be in strips of not less than 40 in. or more than 120 in. wide and no less than 2 ft longer than the width of the pavement being cured.

(b) Waterproof Paper Blankets

These blankets shall be in accordance with ASTM C171.

(c) White Polyethylene Sheeting, Film

The sheeting shall be in accordance with ASTM C171.

(d) White Burlap Polyethylene Sheet

These sheets shall be in accordance with ASTM C171.

(e) Liquid Membrane Forming Compounds

Materials shall be selected from the QPL of Liquid Membrane Forming Curing Compounds.

Storage of liquid membrane forming compounds shall be in accordance with the manufacturer's recommendations. Compounds shall be kept from freezing and shall not be applied when the ambient temperature is less than 40ºF. Compounds that are more than one year past the date of manufacture shall not be used.

Products may be added to the QPL of Liquid Membrane Forming Curing Compounds by completing the requirements in ITM 806, Procedure F. Testing shall be performed by a recognized independent laboratory approved by NTPEP. In order to maintain approval, the manufacturer shall submit an annual recertification letter to the Department by January 1 of each year. The manufacturer shall also submit a type

A certification for a single batch every four months to the Department's Division of Materials and Tests.

1. Wax-Based, White Pigmented

These compounds shall meet or exceed requirements of ASTM C309, Type 2, Class A, when tested in accordance with ASTM C156.

2. Resin-Based, White Pigmented

These compounds shall be in accordance with ASTM C309, Type 2, Class B, 100% Poly-alpha-methylstyrene, PAMS, resin with the following exceptions:

PAMS Curing Compound Properties		
Physical Tests	Specification	Requirement
Total solids, % by weight of compound	ASTM D2369	≥ 42
Reflectivity, % in 72 h	ASTM E1347	≥ 65
Loss of water, kg/m² in 24 h	ASTM C156	≤ 0.15
Loss of water, kg/m² in 72 h	ASTM C156	≤ 0.40
Infrared Spectrum, vehicle	Match reference IR scan	100% poly-alpha-methylstyrene
V.O.C. Content, g/L	326 IAC 8-15	< 350
Long-Term Settling Test, ml/100 ml in 72 hrs	NTPEP	≤ 2.0

Samples of PAMS curing compound may be obtained randomly for verification at the point of incorporation into the work in accordance with 106.02. Verification testing will include:

1. Total Solids
2. Reflectance
3. Long-Term Settling Test

(f) Polyethylene Film

The sheeting shall be in accordance with ASTM C171.

912.02 Curing-Sealing Materials

Curing-sealing materials are single application curing and sealing products for portland cement concrete.

A QPL of PCC Curing-Sealing Materials will be maintained by the Department. The QPL will identify pre-qualified products, specify the manufacturer and product designation, and include application instructions.

In order to have a product added to the QPL of PCC Curing-Sealing Materials, a type A certification in accordance with 916 shall be provided for the curing-sealing

materials. Such certification shall state that the product is in accordance with the requirements of NCHRP 244 Series IV Southern Climate Weathering Test, and ASTM C309, type 1.

(a) The certification shall be in accordance with the applicable requirements of 916, and shall include a dated test report. The test report shall substantiate full compliance with the specifications and establish when the testing was started. Test reports older than seven years on January 1 of the approval year will not be accepted.

(b) If irregularities are found in the results required for such certification, copies of the original data may be required prior to reconsideration of the certification.

(c) Tests shall be conducted by a state highway agency testing laboratory or a testing laboratory regularly inspected by CCRL. Proof of such inspection shall be furnished with the test report.

After a product has been qualified, it will be added to the QPL of PCC Curing Sealing Materials. The product will remain on the list until test results on file are seven years old, provided that there are no changes in raw materials, formulation, or procedures for manufacture. Results more than seven years old or products in which there has been a change in raw materials, formulation, or procedures for manufacture shall be recertified in order to remain on the QPL.

A curing-sealing material that performs unsatisfactorily in the field will be removed from the QPL.

912.03 Admixtures for Use in Concrete

Admixtures for use in PCC shall be selected from the QPL of PCC Admixtures and Admixture Systems. An admixture may be added to the QPL by completing the requirements in ITM 806, Procedure D. Admixtures containing chloride added as an ingredient of manufacture will not be acceptable.

(a) Air Entraining Admixtures

Air entraining admixtures are materials to be added to PCC mixtures at the mixer for the purpose of entraining air.

(b) Chemical Admixtures for Concrete

Chemical admixtures are materials to be added to PCC mixtures at the mixer for purposes indicated below.

1. Type A

Type A is a water reducing admixture that reduces the quantity of mixing water required to produce concrete of a given consistency.

2. Type B

Type B is a retarding admixture that retards the setting of concrete.

3. Type C

Type C is an accelerating admixture that accelerates the setting and early strength development of concrete.

4. Type D

Type D is a water reducing and retarding admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and retards the setting of concrete.

5. Type E

Type E is a water reducing and accelerating admixture that reduces the quantity of mixing water required to produce concrete of a given consistency and accelerates the setting and early strength development of concrete.

6. Type F

Type F is a high range water reducing admixture, HRWR, that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater.

7. Type G

Type G is a high range water reducing and retarding admixture, HRWRR, that reduces the quantity of mixing water required to produce concrete of a given consistency by 12% or greater, and retards the setting of concrete.

8. High Range Water Reducing Admixture System

HRWR admixture system is a combination of admixtures that act as a type F admixture within a concrete mixture. The system consists of chemical admixtures and an air entraining admixture. One of the components shall be a type F admixture. Components shall be in accordance with 912.03 for their respective types.

9. High Range Water Reducing and Retarding Admixture System

HRWRR admixture system is a combination of admixtures that act as a type G admixture within a concrete mixture. The system consists of chemical admixtures and an air entraining admixture. One of the components shall be a type F or a type G admixture. One of the components shall retard the setting of the concrete. Components shall be in accordance with 912.03 for their respective types.

(c) Test Report

Testing shall be performed by a recognized laboratory in accordance with ITM 806.

1. Air entraining admixtures shall be in accordance with AASHTO M 154.

2. Chemical admixtures shall be in accordance with AASHTO M 194 for their respective types.

3. Test reports shall not be more than five years old on January 1 of the approval year. New submittals of test reports more than five years old will be accepted, if all subsequent five year limited retest reports, are submitted. Subsequent limited retest results shall comply with the dating and age requirements specified above and shall include the following tests as a minimum requirement for compliance:

   a. infrared analysis, residue by oven drying, and specific gravity;
   b. water content and time of setting;
   c. flexural strength at 3, 7, and 28 days;
   d. relative durability.

912.04 Latex Modifiers

Latex modifiers are an admixture to be added to the concrete mixture at the continuous mixer. The latex shall be one of the latex modifiers on the QPL of Latex Modifiers.

The formulated latex admixture shall be a non-toxic, film forming, polymeric emulsion in water to which all stabilizers have been added at the point of manufacture and shall be homogeneous and uniform in composition. A type B certification in accordance with 916 shall be provided for the latex modifiers. The limits of the following shall be shown on the certification.

Polymer Type	Styrene Butadiene
Stabilizers	Anionic and Nonionic Surfactants
Antifoaming Agent	Polydimethylsiloxane
Percent Solids, % by Mass	46.0 minimum
Mass Per Gallon	8.4 lb at minimum
pH (as shipped)	9.0 - 11.0
Freeze/Thaw Stability	5 Cycles, -15° to 25°C
Shelf Life	2 Years, minimum
Color	White

912.05 Foaming Agent

Foaming agents used in making preformed foam for cellular concrete grout shall be in accordance with ASTM C869. A type C certification in accordance with 916 shall be provided for the foaming agent.

912.06 Synthetic Fibers for Use in PCC

(a) General

Synthetic, non-metallic, fibers are used for concrete three-dimensional

reinforcement to promote post-crack control, and improve the long-term performance of PCC. Synthetic fibers shall be introduced into PCC mixtures at a minimum dosage rate of 4.0 lb/cu yd at the batching plant or a ready-mix truck.

(b) Acceptance

Synthetic fibers for use in PCC shall be selected from the QPL of Synthetic Fibers. Hybrid fibers which include a combination of macro and micro fibers will be accepted. Synthetic fibers may be added to the QPL by completing the requirements in ITM 806, Procedure F.

(c) Requirements

Synthetic fibers shall be Type III in accordance with ASTM C1116 and ASTM D7508 with the following exceptions:

1. Aspect Ratio – Length/Equivalent Diameter,
   minimum 70
   maximum..... 100
2. Length (macro fiber)..... 1.5 to 2.25 in.
3. Tensile Breaking Strength, min. ..... 70,000 psi
4. Modulus of Elasticity, min. ..... 800,000 psi

(d) Acceptance Testing of Hardened Fiber-Reinforced Concrete

Testing shall be in accordance with ASTM C1579 and ASTM C1609, using roller supports meeting the requirements of ASTM C1812.

Testing of fiber-reinforced concrete shall be performed by a recognized independent commercial laboratory, regularly inspected by the CCRL for PCC materials, to ensure that the properties of the fiber-reinforced concrete are in accordance with the following:

Required Hardened Fiber-Reinforced Concrete Properties		
Physical Test	Specification	Requirement
Equivalent Residual Flexural Strength ($f_{T,150}^{150}$ or f_e^3)*, min.	ASTM C1609	150 psi
Equivalent Flexural Strength Ratio ($R_{T,150}^{150}$ or R_e^3)*, min.	ASTM C1609	25%
Crack Reduction Ratio, (CRR), min. reduction	ASTM C1579	>85%
* The specimens shall be tested when the concrete ultimate flexural strength at peak stress (f_p) is a minimum of 650 psi. For 6 by 6 by 20 in. FRC beam the maximum required net deflection value of 1/150 of the 18 in. span length is 0.12 in.		

SECTION 913 – SOIL TREATMENT MATERIALS

913.01 Water

Water shall be clean and free of oil, algae, salt, acid, alkali, sugar, vegetable, or other substance injurious to the finished product. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials. Water shall be tested in accordance with the test methods listed in the table below. To be acceptable for use, the results of the water testing shall be in accordance with the results as follows:

Property	Test Method	Result
pH	ASTM D1293	6.0 to 8.0
Chloride Ions	ASTM D512	less than 300 ppm
Sulfate (SO_4)	ASTM D516	less than 500 ppm
Total Solids	ASTM C1603	less than 1,500 ppm

A type A certification in accordance with 916 shall be provided for non-potable sources. The results of the tests listed in the table above shall be provided on the certification.

Water known to be of potable quality may be used without testing.

913.02 Calcium Chloride

Calcium chloride shall be in accordance with AASHTO M 144 and shall be:

(a) Type S, grade N1, class A
(b) Type S, grade N3, class A or B
(c) Type L

913.03 Sodium Chloride

Sodium chloride shall be in accordance with AASHTO M 143. Rock salt shall be used for de-icing purposes. Either rock salt or evaporated salt may be used for stabilization.

913.04 Lime

Lime shall be a hydrated lime when used in masonry or a hydrated lime, quicklime, or lime by-product when used for soil modification.

(a) Hydrated Lime for Masonry

Hydrated lime used in masonry shall be in accordance with ASTM C207, Type N.

(b) Lime for Soil Modification

Hydrated lime, quicklime, or lime by-product used for soil modification shall be from the QPL of Soil Modifiers. A product will be considered for inclusion on the QPL by following ITM 806, Procedure P and shall meet the following requirements.

1. Hydrated Lime and Quicklime

Hydrated lime and quicklime shall be in accordance with AASHTO M 216.

2. Lime By-Products

Lime by-products shall be hydrated lime or quicklime by-products in accordance with ASTM C25 having the following requirements.

a. The lime by-products shall contain a minimum of 60% total calcium and magnesium oxides (non-volatile basis).

b. Available calcium hydroxide plus magnesium oxide calculated as calcium hydroxide shall be a minimum of 30%.

c. Soluble sulfate shall not be more than 5%.

d. Sieve analysis shall be performed in accordance with ASTM C110. The lime by-products gradation shall be as follows:

Sieve	% Retained (Max.)
No. 4 (4.75 mm)	5
No. 30 (600 µm)	15
No. 100 (150 µm)	30

913.05 Blank

913.06 Bentonite Grout

Bentonite grout shall be untreated, sodium bentonite, finely ground with not more than 5% retained on the No. 200 (75 µm) sieve. It shall be free of lumps and materials that can prevent mixing into a fluid free of lumps of unmixed bentonite. Calcium bentonite will not be accepted.

The grout shall be proportioned at 2 lb of pure bentonite powder per gal. of potable water. Deviations from these proportions shall be subject to approval.

SECTION 914 – ROADSIDE DEVELOPMENT MATERIALS

914.01 Special Topsoil for Roadside Development

This topsoil shall consist of loose friable soil, free of refuse, stumps, large roots, rocks over 2 in. in diameter, brush, weeds, or other material which would be detrimental to the proper development of vegetative growth. It shall be capable of supporting normal vegetation as demonstrated by the growth of healthy vegetation on

it. It shall not be taken from a source known to contain any of the noxious weeds defined as such in the Indiana State Seed Law, IC 15-4-1.

Topsoil shall have a pH value of 6.2 to 7.4. Testing for pH value shall be performed in accordance with AASHTO T 289. Agricultural limestone may be added to topsoil in order to raise the pH to meet specification requirements. The addition of agriculture limestone shall be determined based on tests performed by a laboratory qualified by the Department. Topsoil shall not be incorporated into the work until it is approved.

914.02 Temporary Seed

Temporary seed will be approved for use by visual inspection of the Engineer. Temporary seed may be purchased from any commercial source provided the seed's package is clearly marked and labeled by the manufacturer as to its content and weight.

914.03 Fertilizer

Fertilizer shall be standard commercial fertilizer with an analysis of 12-12-12.

Tests will not be required, but fertilizer standards shall be governed by the rulings of the Indiana State Seed Commissioner.

914.04 Grass, Legume, and Forb Seed

Grass, legume, and Forb seed in the quantities and varieties required shall be furnished full-tagged and delivered in properly designated packages or bags as directed. Seeds shall be in accordance with the following requirements.

Native grass and forb seed shall be purchased from lots for which test results are provided. Testing will not be required for aquatic species. When normal germination testing is not practical for forb species, a tetrazolium test shall be conducted to determine seed viability.

Seeds shall contain none of the prohibited noxious weeds listed in 360 IAC 1-1-5 or any that are listed in the Acts of the General Assembly of the State. Restricted noxious weed seed listed in 360 IAC 1-1-6 shall not exceed 0.25% by weight in accordance with IC 15-15-1-32.

Clover shall be free from dodder with no tolerance allowed.

Requirements noted above are minimum and trade allowances will not be allowed.

Seed shall be purchased from sources of supply that have been accepted and reported by the State Seed Commissioner, Purdue University, West Lafayette, Indiana, and found to be satisfactory. Seed of native grasses shall be tested by the State Seed Commissioner or by an independent laboratory. Seed of forbs shall be tested by an independent laboratory. Test results by independent laboratories shall be signed by a

Registered Seed Technologist and shall be submitted to the State Seed Commissioner. This report is required before seed is installed.

Seed will be considered to be expired 15 months after the date it was tested. Expired seed shall not be installed.

Each bag or container of seed shall have a printed tag or label providing all of the information required by IC 15-15-1-32. Seed from bags with no labels, illegible labels, or with labels not giving all of the required information will not be accepted.

The seed supplier shall provide certification in accordance with 916.02 and 916.03(g) that lists the seed lots used in the mixture and shall indicate that the seed mixture supplied meets the contract requirements for the specific contract that the particular seed mixture is supplied. Also, as part of the certification, the seed supplier shall provide a copy of the State Seed Commissioner's letter for the seed mixture that shows that each seed lot has been tested and found to be satisfactory. The specific test results for each seed lot shall also be attached to the certification.

Seed which meets the weed seed tolerance, but does not comply with the purity or germination requirements, or both, may be used provided the percentage of purity or the percentage of germination is not more than 10% below the minimum specified and that the result obtained from the following formulae does not exceed the maximum percent of weed seeds allowed.

$$M = W \times P \times G$$

where:

M = Maximum percent of weed seeds allowed

W = Actual percent of weed seeds

$$P = \text{Purity Factor} = \frac{\text{Minimum Specified Purity}}{\text{Actual Purity}}$$

$$G = \text{Germination Factor} = \frac{\text{Minimum Specified Germination}}{\text{Actual Germination}}$$

If such seeds are selected for use, the amount to be used shall be increased in accordance with the following formula except the amount used shall not be less than that specified.

Amount to be used = Amount specified x P x G

914.04

Percentages of Weed Seed Content		
Variety		% (not more than)
Alkaligrass	Puccinellia distans	0.5
Alsike Clover	Trifolium hybridum	0.5
Chewings Fescue	Festuca rubra (var. fallax)	0.5
Creeping Red Fescue	Festuca rubra spp. rubra	0.5
Illinois Bundleflower	Desmanthus illinoensis	0.5
Kentucky Bluegrass	Poa pratensis	0.5
Ladino Clover	Trifolium repens (var. latum)	0.5
Lemons Alkali Grass	Puccinellia airoides (Lemons)	0.5
Orchard Grass	Dactylis glomerata	0.5
Perennial Rye Grass	Lolium perenne	0.5
Purple Prairie Clover	Dalea purpurea	0.5
Red Fescue	Festuca rubra	0.5
Red top	Agrostis gigantea	0.75
Rye, Agricultural	Secale cereale	0.5
Rye, Annual	Lolium multiforum	0.5
Smooth Brome Grass	Bromus inermis	0.95
Tall Fescue	Festuca arundinacea	0.5
White Dutch Clover	Trifolium repens	0.75

Percentages of Purity		
Variety		% (not less than)
Alkaligrass	Puccinellia distans	90
Alsike Clover	Trifolium hybridum	97
Chewings Fescue	Festuca rubra (var. fallax)	97
Creeping Red Fescue	Festuca rubra spp. rubra	95
Illinois Bundleflower	Desmanthus illinoensis	98
Kentucky Bluegrass	Poa pratensis	85
Ladino Clover	Trifolium repens (var. latum)	98
Lemons Alkali Grass	Puccinellia airoides (Lemons)	85
Orchard Grass	Dactylis glomerata	85
Perennial Rye Grass	Lolium perenne	95
Purple Prairie Clover	Dalea purpurea	99
Red Fescue	Festuca rubra	95
Red top	Agrostis gigantea	90
Rye, Agricultural	Secale cereale	99
Rye, Annual	Lolium multiforum	95
Smooth Brome Grass	Bromus inermis	85
Tall Fescue	Festuca arundinacea	98
White Dutch Clover	Trifolium repens	97

100

Percentages Actual Germination		
Variety		% (not less than)
Alkaligrass	Puccinellia distans	80
Alsike Clover	Trifolium hybridum	85*
Chewings Fescue	Festuca rubra (var. fallax)	75
Creeping Red Fescue	Festuca rubra spp. rubra	80
Illinois Bundleflower	Desmanthus illinoensis	85
Kentucky Bluegrass	Poa pratensis	80
Ladino Clover	Trifolium repens (var. latum)	85*
Lemons Alkali Grass	Puccinellia airoides (Lemons)	80
Orchard Grass	Dactylis glomerata	80
Perennial Rye Grass	Lolium perenne	90
Purple Prairie Clover	Dalea purpurea	75
Red Fescue	Festuca rubra	85
Red top	Agrostis gigantea	80
Rye, Agricultural	Secale cereale	80
Rye, Annual	Lolium multiforum	90
Smooth Brome Grass	Bromus inermis	80
Tall Fescue	Festuca arundinacea	85
White Dutch Clover	Trifolium repens	90*
* including not more than 25% hard seeds.		

For all other seed indicated to be used but not shown in the charts above, that seed shall be placed at the indicated rate and be 100% pure live seed.

914.05 Mulch

(a) Mulch for Seeding

Mulch for seeding may consist of straw; excelsior mulch; wood cellulose fiber mulch; excelsior blanket; paper mat; or straw mat. All mulch shall be reasonably free from primary noxious weeds in accordance with 914.04.

1. Excelsior Mulch

Excelsior mulch shall consist of wood fibers cut from sound green timber. The average length of the fibers shall be 4 in. to 6 in. The cut shall be made in such a manner as to provide maximum strength of fiber, but at a slight angle to the natural grain of the wood so as to cause splintering of the fibers when weathering in order to provide adherence to each other and to the soil.

2. Wood Cellulose Fiber

Wood cellulose fiber mulch shall be made from wood chip particles manufactured particularly for discharging uniformly on the ground surface when disbursed by a hydraulic water sprayer. It shall remain in uniform suspension in water under agitation and blend with grass seed, and fertilizer when allowed, to form a homogeneous slurry. The mulch fibers shall intertwine physically to form a strong moisture holding mat on the ground surface. The mulch shall be heat processed so as to contain no germination

or growth inhibiting factors. It shall be non-toxic and colored green. The percent of moisture content shall be determined in accordance with 621.14(c), except material containing more than 15% will be rejected. The ash content shall not exceed 1.5%. One hundred grams of oven dried material saturated in water, drained, and weighed shall hold a minimum of 1,000 grams of water.

3. Excelsior Blanket

Excelsior blanket shall consist of a machine produced mat of wood excelsior with 80% of the fibers to be 6 in. or longer. The wood from which the excelsior is cut shall be properly cured to achieve curled and barbed fibers. The blanket shall have a consistent thickness, with the fibers evenly distributed over the entire area of the blanket. The excelsior blanket shall be covered on the top side with a 3 by 1 in. leno weave, twisted kraft paper yarn netting having a high wet strength, or a biodegradable extruded plastic mesh netting having an approximate minimum opening of 5/8 by 5/8 in. to an approximate maximum opening of 2 in. by 1 in. The netting shall be entwined with the excelsior mat for maximum strength and ease of handling. The minimum roll width shall be 4 ft. The mass of the material shall be not less than 0.7 lb/sq yd, constant mass, air dry. The rolls shall be packaged with suitable protection for outdoor storage on the project site in a manner which protects them from biodegradation prior to use.

4. Paper Mat

Paper mat shall consist of a knitted construction of photodegradable, polypropylene yarn with uniform openings interwoven with strips of biodegradable paper. The rolls shall be packaged with suitable protection for outdoor storage at a construction site in a manner which protects them from biodegradation prior to use. The mass of the paper shall be a minimum of 0.125 lb/sq yd. Roll sizes shall have a minimum width of 5 ft.

5. Straw Mat

Straw mat shall consist of a machine produced mat consisting of at least 90% of the total dry mass being clean straw from agricultural crops, with the exception that up to 30% of the total dry mass may be coconut fibers in lieu of an equal percentage of straw. Paper or paper related products shall not be allowed as component in the straw mat. The straw shall be evenly distributed throughout the mat to form a thickness of 1/2 in. ±1/8 in. The top side of the mat shall be covered with a photo-degradable/biodegradable plastic mesh which shall be substantially adhered to the straw by a knitting process using photodegradable/biodegradable thread. The rolls shall be packaged with suitable protection for outdoor storage at a construction site in a manner which protects them from biodegradation prior to use. The average dry mass of the straw shall not be less than 0.7 lb/sq yd. The minimum roll width shall be 6 ft.

6. Compost Mulch

Compost mulch shall consist of well-composted vegetable matter, leaves, yard trimmings, food scraps, composted manures, paper fiber, wood bark, class A bio-solids as defined in Title 40 of the Code of Federal Regulations at 40 CFR Part 503, or any combination thereof. Compost shall be produced using an aerobic composting process

in accordance with 40 CFR Part 503 regulations, including time and temperature data indicating effective weed seed pathogen, and insect larvae kill. Compost shall be well decomposed, stable, and weed free. Compost shall be refuse free by less than 1% by weight. Compost shall be free of any contaminants and materials toxic to plant growth. Inert materials shall not exceed 1% by dry weight, pH of 5.5 to 8.0. Carbon-nitrogen ratio shall not exceed 100. Moisture content shall not exceed 45% by dry weight. Variable particle size of the compost shall be a maximum dimension of 3 in. in length 1/2 in. in width, and 1/2 in. in depth. Compost mulch shall not be used in storm water runoff channels or where concentrated flow is anticipated.

(b) Mulch for Plants

Mulch for plants shall consist of broken corncobs, wood chips, chopped bark, size No. 5 gravel, or crushed stone in accordance with 904.02(e), except 0% to 5% may pass the No. 200 (75 µm) sieve, or other approved materials. The particles of wood chips, chopped bark, and corncobs shall contain no more than 10% passing the 1/2 in. screen and 100% shall pass the 3 in. screen. Wood chips shall be from green, hardened, deciduous trees. Broken corncobs shall be no longer than 4 in.

914.06 Leguminous Inoculants

The inoculants for treating leguminous seeds shall be standard pure culture of nitrogen fixing bacteria. They shall be no more than one year old at the time of use and shall be subject to approval. Directions of the manufacturer on containers of inoculants shall be followed when inoculating seed.

914.07 Sod

Sod shall consist of fibrous, well rooted, bluegrass, fescue, or other approved grass cut to a height of 2 to 3 in. Edges of sod shall be cut cleanly, either by hand or machine, to a uniform minimum thickness of 3/4 in. or more. The roots shall be exposed in the sod strip to allow the sod to be handled without undue tearing or breaking. The sod strip shall be of a uniform width of no less than 16 in. and no less than 2 ft in length. Sod shall be free from all primary noxious weeds in accordance with 914.04. Acceptance in the field before cutting shall not preclude rejection when delivered to the work if such contamination is found.

Nursery sod shall meet applicable requirements as set out above and shall be a variety or blend of Kentucky bluegrass or fescue. It shall comply with nursery inspections and plant quarantine regulations of the states of origin and destination as well as with Federal regulations governing interstate movement of nursery stock. A type C certification in accordance with 916 shall be provided for the sod.

914.08 Plant Materials

If the plant material is shown on the Schedule of Pay Items as plant, the Contractor shall submit its source of supply for each plant material for approval prior to delivery to the project site. This plant list shall include the name of the source of supply and the location where the plants were grown. A certification that the plants are available at this source, that the plants were grown at the prescribed location, and that there is a

firm commitment for their purchase at the time of certification shall be provided. These procedures shall be followed for approval of alternate sources when the originally approved source is unable to furnish plants at the time when needed. Plants shall be in accordance with the requirements set out herein. Unless otherwise specified, all plant material shall be acquired from zones 4, 5, or 6. However, plant material shall be acquired from zones no further than 1/2 zone south of the zone in which the project is located. Hardiness zones shall be determined from the Plant Hardiness Zone Map, Miscellaneous Publications No. 1475, Agricultural Research Service, United States Department of Agriculture, published by the U. S. Government Printing Office, Washington, D.C. The Contractor shall have a copy of this map.

If the plant material is shown on the Schedule of Pay Items as seedlings, the Contractor shall choose a source which is shown on the QPL of Seeding Sources. The QPL will specify the sources that are currently on an immediate use basis. If the source is not on the QPL, then the same procedure shall be followed as stated above for plants to obtain approval.

(a) Quality of Plant Material

All plants shall be first class and representative of the normal species or varieties, true to type, and standard form. Unless otherwise specified, all plants shall be nursery grown stock that had been transplanted or rootpruned two or more times according to the kind and size of plant. The root system shall be vigorous and well developed. The branch system shall be developed normally. All plants shall be free from disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.

(b) Plant Names

Plants shall be true to name, following standard botanical and common nomenclature as adopted by the American Joint Committee on Horticultural Nomenclature given in the current edition of Standardized Plant Names. All trees delivered shall be tagged legibly with the names and sizes of the trees.

All delivered shrubs shall be tagged legibly with the name and size of the shrub when “Tag Each” is indicated on the summary list. Otherwise, each bundle shall be tagged. If shrubs are separated individually when delivered, 20% of each species shall be tagged. A tag with the name and size of the shrub printed thereon shall be used for each species. A 1 in. band of non-toxic paint shall be applied to the stem of seedlings or “whips”, prior to delivery, in lieu of tags. If tags are required, they shall remain attached to shrubs for the duration of the contract.

(c) Substitutions

Substitutions of plants in size and kind shall be made only after proper execution of a change order in accordance with 109.05 and then only when sufficient evidence has been shown that the specified stock could not be secured.

(d) Grading Standards

Grading of plants shall be in accordance with the American Association of Nursery Horticultural Standards of the current ASNS, ANSI Z 60.1 as revised herein and on the plans.

(e) Nursery Inspection and Plant Quarantine

All plants shall be free from plant diseases and insect pests. Shipments of plants shall be in accordance with nursery inspection and plant quarantine regulations of the states of origin and destination as well as with Federal regulations governing interstate movement of nursery stock. A valid copy of the certification of inspection shall accompany each package, box, bale, or carload shipped or otherwise delivered.

(f) Balled and Burlapped Plants

Balled and burlapped plants shall be dug so as to retain as many fibrous roots as possible and shall come from soil which forms a firm ball. The soil in the ball shall be the original and undisturbed soil in which the plant was grown and shall be free of noxious weeds and weed seeds. The plant shall be dug, wrapped, transported, and handled in such a manner that the soil in the ball will not be loosened enough to cause stripping of the small and fine feeding roots or cause the soil to drop away from such roots. Any indication of manufactured earth balls or mishandling of the plant will be cause for rejection. The shape and size of the ball shall be as specified in the ASNS as revised herein and shown on the plans.

(g) Container Grown Plants

Plants which are furnished in containers shall be well rooted and established in the container in which they were shipped. An established container grown plant shall be a plant transplanted into a container and grown in that container sufficiently long for the new fibrous roots to have developed so that the root mass retains its shape and holds together when removed from the container.

(h) Bare Rooted Plants

The minimum root system of bare rooted trees or shrubs shall be in accordance with the standards stated in the ASNS. Bare rooted plants shall be dug only when the air temperature exceeds 35°F. Particular attention shall be given to the fibrous roots. The maximum time lapse between loading for shipment and delivery to the work or approved storage site shall be four days unless other shipping arrangements are approved.

(i) Collected Plants

Collected plants, when specified in connection with any species or variety, shall not be nursery grown, but shall have been grown under natural conditions at the location from which they were procured. They may be balled and burlapped or bare roots as specified in the plant list on the plans. In either case, the collected material shall be in accordance with the applicable requirements given in the current issue of ASNS for quality, size, ball, and grade.

(j) Forms, Shapes, and Condition of Plants

Vines and groundcover plants shall be in accordance with grades and specifications shown in the ASNS unless otherwise specified.

Plants which have been cut back from larger grades to meet specifications will not be acceptable. Plants designated on the plans as street trees, specimen, extra heavy, clump, or of other like import shall be in accordance with the standards as given in the ASNS for the special type specified.

Trees shall have straight trunks, be well branched, and have symmetrical tops. There shall be no cuts of limbs over 3/4 in. in diameter which have not completely healed over. Each tree shall have the top and root characteristics of its variety and growth that are typical of such trees in this region. Deciduous trees, unless otherwise specified, shall have branching between 1/4 and 1/2 of the distance of their height from the ground. Street trees, if so specified, shall be of uniform branching height. Bush form, when specified, shall be branching at the base of the plant or within 12 in. of the base. Clumps, when specified, shall have three or more main leaders or trunks starting at the ground. At least two of these shall be of the caliber specified.

(k) Inspection

Plant materials shall be subject to inspection at any time during the life of the contract. Such inspection shall not be construed as final acceptance of the plants involved. Any stock which is not in accordance with these specifications will be rejected and shall be removed from the project.

Balled and burlapped plants may have the ball opened for inspection, at the option of the Department, to determine if the root system is sufficient to ensure plant growth. If after breaking open, the ball is found to be acceptable, payment for the destroyed plant will be made at 50% of the contract price for the plant involved.

Nursery stock may be inspected at the nursery before digging or shipping and sealed with Department seals. If not inspected and sealed at the nursery, it shall be done at a final collecting point at or adjacent to the project and prior to planting, unless otherwise specified in writing. Notification shall be made a minimum of three days in advance of delivery of unsealed plants. Large quantities of small plant material such as shrubs, seedlings, vines, and groundcovers shall be sealed in a satisfactory manner. Sealing of plants shall not be considered as final acceptance and shall not waive the responsibility to furnish, plant, and maintain material that complies with the specifications.

(l) Shipment

All precautions that are customary in good trade practice shall be taken to ensure the arrival of the plants in good condition. Plants shall be packed or covered in such a manner as to ensure adequate protection against damage while in transit. The roots of bare root plants shall be protected with wet straw or other suitable material to ensure the arrival at destination with the roots in a moist condition. When shipment is made

in an enclosed vehicle, the vehicle shall be adequately ventilated to prevent over heating of the plants in transit.

(m) Certification

Certifications from all plant supply sources shall be furnished certifying that all plants furnished are in accordance with 914.08. These certifications shall be submitted monthly and shall contain the information as indicated on the suggested form in ITM 804.

914.09 Miscellaneous Material

(a) Water

Water used in the planting or care of vegetation shall be free from oil, acids, alkalis, salts, or any substance injurious to plant life. Water from streams, lakes, ponds, or similar sources shall not be used unless approved.

(b) Stakes for Bracing and Anchoring

Wood stakes for bracing or supporting trees shall be of rough cypress, cedar, locust, oak, or other approved wood free from knots, rot, cross grain, or other defects that would impair the strength of the stake for which it is to be used. Wood stakes shall be a minimum of 2 in. by 2 in. square in cross section and of adequate length. The wood bracing stakes shall be painted or stained dark green. Delineator posts in accordance with 910.15 may be used except they shall be painted dark green.

An alternate staking and bracing method using a solid rubber support cord with metal hooks and stakes, and plastic stake disk system, may be used.

(c) Tree Wound Dressing

Dressing for treating tree wounds or cuts shall be either:

1. an approved black asphaltum base antiseptic paint;

2. an approved black paint consisting of Bordeaux Mixture, raw linseed oil, and lampblack; or

3. an approved black paint consisting of zinc oxide, raw linseed oil, and lampblack.

(d) Porous Material

Porous material for tree root protection may be gravel, crushed stone, slag, or other porous material varying in size from 1 to 3 in. and shall be approved before being used.

(e) Pipe

Pipe for underdrains shall be in accordance with 907 or 908. The size and type shall be as specified.

(f) Staples

Wire staples shall be made from No. 11 gauge (3 mm) or heavier wire, 1 or 2 in. wide at the throat and 6 in. from top to bottom after bending. Biodegradable staples shall be in accordance with ASTM D6400 and be 4 in. or longer with a head suitable for securing the fabric in place. The staples shall be packaged in cartons.

(g) Plastic Net

Plastic net shall consist of photodegradable, longchain synthetic polymer plastic yarn, either extruded oriented or woven into a net with the yarns fixed at each intersection such that they retain their relative positions with respect to each other. The plastic net shall have a square mesh opening of approximately 3/4 in. by 3/4 in. The plastic net shall have a minimum tensile strength of 20 lb over a 3 in. width in the machine direction and 15 lb over a 3 in. width in the transverse direction. The plastic net shall have a nominal mass of 2.8 ±0.4 lb per 1,000 sq ft. The plastic net shall be furnished in rolls which can be easily handled and the rolls shall be packaged in a suitable protection for outdoor storage at a construction site, which protects the material from degradation prior to use. Roll sizes shall have a minimum width of 6 ft.

A type C certification in accordance with 916 shall be provided for the plastic net.

(h) Filter Sock

Filter socks for sediment control applications shall use a continuous tubular knitted mesh netting with 3/8 in. openings and constructed of 500 denier polypropylene. They shall be set in place using hardwood stakes of 1 by 2 in. or stakes of equivalent strength.

Where using socks with compost soil bark mixture as a filler, the Contractor shall use a continuous knitted mesh netting with 3/8 in. openings and constructed of 5 mil thickness of photodegradable HDPE.

Filler particle size shall not be greater than 3 by 1/2 by 1/2 in. and shall be capable of staying within the sock.

SECTION 915 – BRIDGE PILES AND BEARINGS

915.01 Steel Pipe Piles and Epoxy Coated Steel Pipe Piles

(a) General Requirements

Steel pipe piles and epoxy coated steel pipe piles, as designated herein, shall consist of fluted steel, or rounded straight seamed, spiral seamed, or seamless steel pipes which, after being driven are filled with class A concrete. The steel pipe shall be uncoated unless an epoxy coating, in accordance with 915.01(d) is specified.

Pipe piles shall be of the diameter and minimum wall thickness shown on the

plans. All sections shall be one cylindrical integral piece except as otherwise required for end sections of the outside diameter specified. All pipe piles shall be of sufficient strength to withstand driving to the required penetration depth and nominal driving resistance.

If necessary to facilitate handling, pipe piles may be furnished in sections to be welded in the field to form the final integral lengths required.

The manufacturer shall provide a mill certification showing heat numbers and test results for the specified tests. Each pipe pile shall be stenciled to show the diameter, wall thickness, and heat numbers for the verification of the certifications. The certifications shall be delivered before the pipe piles are driven.

The end of pipe piles shall be equipped with conical pile tips or flat end plates. The welding used to attach the conical pile tips or flat end plates to the end of pipe piles shall be done by a welder qualified in accordance with 711.32.

1. End Plates

If end plates are used, they shall be flat, non-reinforced and a minimum thickness of 3/4 in. for pipe piles 12 in. outside diameter or smaller, and 1 in. thick for pipe piles greater than 12 in. outside diameter up to and including 14 in. For pipe piles larger than 14 in. outside diameter, the end plates shall be designed to complement the size of the pipe pile. End plates shall have a diameter approximately 1/2 in. greater than the outside diameter of the pipe pile and be fillet welded to the pipe pile, using two passes or beads.

2. Conical Pile Tips

Conical pile tips shall be of sufficient dimensions to ensure adequate joint and driving strength. The end of the pipe pile shall have full bearing on the face of the pile tip or against a shoulder inside the pile tip. Unless otherwise approved, the pile tip shall be conical with a 60 to 90° angle between faces. The pile tip shall be substantially of the same diameter as the end of the pipe pile and butt welded to the end of the lowest section.

(b) Fluted Steel Pipe Piles

Fluted steel pipe piles shall have a minimum tensile strength of 50,000 psi when tested in accordance with ASTM A370. Test specimens for determination of tensile strength shall be taken longitudinally adjacent to the crest of the flute. The diameter of fluted steel pipe piles shall be measured from crest to crest of flutes.

A sufficient taper will be allowed to enable no less than 6 in. telescoping at the joints. The lowest section shall taper approximately 1 in. in 4 ft from an 8 in. tip to the specified diameter of the upper end. Fluted steel pipe piles with a taper of 1 in. in 7 ft on the lowest section of long piles may be used provided a minimum of approximately 5 ft of the top of the pile below cutoff elevation is the full diameter as shown on the plans.

(c) Rounded Steel Pipe Piles

Rounded steel pipe piles, except for end finish, shall be in accordance with ASTM A252, grade 3. Welded pipe may be welded with straight or spiral seams.

(d) Epoxy Coating for Piles

Only powdered epoxy resin from the QPL of Epoxy Coating Materials shall be used for the epoxy coating of steel pipe piles and steel H piles.

The patching or repair material shall be compatible with the coating and shall be made available by the coating manufacturer. The material shall be suitable for repairs made to coated areas damaged during fabrication or handling.

The coating color shall contrast with the color of iron oxide. All coated piles furnished for a structure shall be the same color. The patching or repair material shall also be the same color as the original coating material.

1. Prequalification of Organic Coatings for Steel Piles

The coating product shall be a 100% solids, heat curable, thermosetting, dry powdered epoxy coating. Coating manufacturers who request to have their product added to the QPL of Epoxy Coating Materials shall supply the information as follows.

a. Product Data Sheet

A product data sheet which shall specify the method of surface preparation, the thermal treatments before and after coating application, the coating application procedure, and the product name and description of the patching material shall be provided.

b. Fingerprint

The fingerprint shall include the method of test, such as infrared spectroscopy or thermal analysis, and a generic description of the product.

c. Materials Safety Data Sheet

Current materials safety data sheets shall be supplied for the product and the patching material.

d. Laboratory Report

A dated laboratory report shall be provided which substantiates full compliance with the following test requirements.

(1) Tensile Strength and Elongation

The tensile strength and elongation of the coating material shall be tested in accordance with ASTM D2370 with a rate of elongation of 10% to 20% per minute. The minimum tensile strength shall be 8,000 psi. The minimum elongation shall be 5%.

(2) Impact Resistance

The impact resistance of the coating shall be tested in accordance with ASTM G14 using a 0.03 mm minimum coating thickness of a 3.2 mm thick panel at 23°C. Three tests shall be performed. The minimum acceptable value shall be9.0 N m. of impact with no visible breaks in the coating.

(3) Abrasion Resistance

The abrasion resistance of the coating shall be tested in accordance with the Annex to ASTM A972.

(4) Salt Fog

The weathering resistance of the coating shall be tested by means of a salt spray cabinet following ASTM B117 for 1,000 h. The coating shall not blister or exhibit corrosion, discoloration, or loss of adhesion away from the scribed area.

2. Application

The application of the epoxy coating shall be at an enclosed plant, equipped with environmental controls and automated blasting equipment. This equipment shall facilitate surface preparation and coating application in accordance with the manufacturer's recommendations and in accordance with additional requirements set out herein. The application process shall be performed by a continuous, balanced system where cleaning of the surface and application of the coating are performed at the same rate.

a. Surface Preparation

The pile surface shall be blast cleaned in conformance with SSPC-SP-10, Near White Metal Blast. The cleaning media shall produce an anchor pattern profile of 2 mils minimum. All raised slivers, scabs, laminations or bristles of steel remaining on the newly cleaned surface shall be removed by means of abrasive sanders. All traces of grit and dust from the blasting shall be removed.

b. Coating Application

The coating shall be applied immediately to the cleaned surface and before visible oxidation of the surface occurs. The coating shall be applied in accordance with the manufacturer's recommendations. The recommendations shall address the equipment required for proper application, the number of coats of epoxy, cure time between coats, cure time before placing in service, and all other information needed by the Department to ensure proper performance of the material.

(1) Thickness

Thickness of the cured coating shall be measured on a representative number of piles from each production lot by the same method required by ASTM G12 for measurement of film thickness of pipeline coatings on steel. The minimum coating thickness for fusion bonded epoxy shall be 8.0 mils for individual measurements and 12 mils for the average.

(2) Cure

The coating film shall be cured and post cured in accordance with the manufacturer's recommendations. A representative proportion of each production lot shall be checked by the coating applicator using a method found most effective for measuring cure to ensure that the entire production lot is in a fully cured condition.

(3) Continuity of Coating

After cure, the epoxy coating shall be checked by the applicator for continuity of coating and shall be free from holes, voids, contamination, cracks, and damaged areas. There shall not be more than two holidays, which are pinholes not visually discernable, in any linear foot of the coated pile. A holiday detector in accordance with ASTM A972 shall be used in accordance with the manufacturer's instructions to check the coatings for holidays.

3. Certification

A type C certification in accordance with 916 shall be provided for the epoxy coating. In addition, a certificate of compliance prepared by the applicator shall be provided for each shipment of coated piles. The certificate of compliance shall state that the piles have been coated in accordance with the manufacturer's requirements; that thickness, continuity, and flexibility tests of the coating have been performed; and that the test results are in accordance with the requirements outlined herein. Test results shall be retained by the applicator and made available for inspection upon request for a period of seven years.

915.02 Steel H Piles and Epoxy Coated Steel H Piles

Steel H piles and epoxy coated steel H piles shall be of the shape and dimensions shown on the plans or as otherwise specified. The steel shall be in accordance with ASTM A572, grade 50. Steel H piling shall be handled in the same manner as required in 711.56. The piles shall be uncoated unless an epoxy coating, in accordance with 915.01(d), is specified.

The manufacturer shall provide a mill certification showing heat numbers and test results for the specified tests. Each H pile shall be stenciled to show the manufacturer's name, the specifications, size and mass of section, and heat numbers for verification of the certification. The certification shall be submitted at the time of delivery of the piles.

915.03 Pile Shoes

A type C certification in accordance with 916 shall be provided for the steel H pile shoes. Pile shoes shall be cast-in-one-piece steel in accordance with ASTM A148, grade 80-50 and shall be fastened to the piles by welding in accordance with the manufacturer's recommendations. They shall have sufficient flange and continuous web vertical back-ups to assure proper alignment and fitting to the pile. Either the pile shoe or the outside of each flange of the pile shall be beveled 45°. E70XX welding rods shall be used. All welds shall be made in the flat position and the welder shall be qualified in accordance with 711.32.

A type C certification in accordance with 916 shall be provided for the timber pile shoes. Pile shoes shall be cast-in-one-piece steel in accordance with ASTM A27, grade 65-35, class 2 or grade 70-36, class 2 and shall be fastened to the piles in accordance with the manufacturer's recommendations.

The soil or rock bearing surfaces of the shoes shall be sloped downward towards the web a minimum of 15° but not to exceed 45° to the horizontal under the flanges. The sloped surfaces of the shoes shall terminate so as to form a flat surface not exceeding 1/3 of the flange width. The surfaces may have individual or continuous cutting teeth.

915.04 Elastomeric Bearings

(a) Description

Elastomeric bearings as herein specified shall include plain bearings, consisting of elastomer only, and laminated bearings, consisting of layers of elastomer restrained at their interfaces by bonded laminates. The bearing type shall be as shown on the plans.

(b) Materials

1. Elastomer

Elastomeric bearing pads shall be made from elastomeric materials and shall be steel reinforced as shown on the plans. They shall be in accordance with Articles 18.1 and 18.2 of the AASHTO LRFD Bridge Construction Specifications and AASHTO M 251 with the exception that Table X1 is not applicable. The elastomer portion of the elastomeric compound shall be 100% virgin natural polyisoprene known as natural rubber, or 100% virgin polychloroprene known as neoprene. The cured compound shall be in accordance with Table A for natural rubber, or Table B for neoprene, depending on which type is furnished.

TABLE A

230 **POLYISOPRENE, OR NATURAL RUBBER, QUALITY CONTROL TESTS**

PHYSICAL PROPERTIES		
ASTM D2240	Hardness (Durometer type A)	55 ±5
ASTM D412	Tensile Strength, Min., ksi	2.25
	Ultimate Elongation, Min. %	425
HEAT RESISTANCE		
ASTM D573, 70 h, @ 158ºF	Change in Durometer Hardness, Max. Points	10
	Change in Tensile Strength, Max. %	-25
	Change in Ultimate Elongation, Max. %	-25
COMPRESSION SET		
ASTM D395, Method B	22 h @ 158ºF, Max. %	25
OZONE		
ASTM D1149	25 ppm ozone in air by volume, 20% strain, 100ºF ±2ºF, 48 h mounting procedure, D 518, Procedure A	No Cracks
LOW-TEMPERATURE BRITTLENESS		
ASTM D746, Procedure 9.1.2	Grades 0 and 2	
	Grade 3, Brittleness @ -40ºF	No Failure
INSTANTANEOUS THERMAL STIFFENING		
ASTM D1043	Grades 0 and 2, Tested @ -32ºC	Stiffness at test temperature shall not exceed four times the stiffness measured at 74ºF.
	Grade 3, Tested @ -40ºF	
LOW-TEMPERATURE CRYSTALLIZATION		
Quad Shear Test as Described	Grade 3, 14 Days @ -15ºF	Stiffness at test time and temperature shall not exceed four times the stiffness measured at 74ºF with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ±25% strain cycle shall be used. A complete cycle of strain shall be applied within a period of 100 s. The first 0.75 cycle of strain shall be discarded. The stiffness shall be determined by the slope of the force deflection curve for the next 0.50 cycle of loading.

TABLE B
POLYCHLOROPRENE, OR NEOPRENE, QUALITY CONTROL TESTS

PHYSICAL PROPERTIES		
ASTM D2240	Hardness (Durometer type A)	55 ±5
ASTM D412	Tensile Strength, Min., ksi	2.25
	Ultimate Elongation, Min. %	375
HEAT RESISTANCE		
ASTM D573, 70 h, @ 212ºF	Change in Durometer Hardness, Max. Points	15
	Change in Tensile Strength, Max. %	-15
	Change in Ultimate Elongation, Max. %	-40
COMPRESSION SET		
ASTM D395, Method B	22 h @ 212ºF, Max. %	35
OZONE		
ASTM D1149	25 ppm ozone in air by volume, 20% strain, 100ºF ±2ºF, 48 h mounting procedure, D 518, Procedure A	No Cracks
LOW-TEMPERATURE BRITTLENESS		
ASTM D746, Procedure 9.1.2	Grade 3, Brittleness @ -40ºF	No Failure
INSTANTANEOUS THERMAL STIFFENING		
ASTM D1043	Grade 3, Tested @ -40ºF	Stiffness at test temperature shall not exceed four times the stiffness measured at 74ºF.
LOW-TEMPERATURE CRYSTALLIZATION		
Quad Shear Test as Described	Grade 3, 14 Days @ -15ºF	Stiffness at test time and temperature shall not exceed four times the stiffness measured at 74ºF with no time delay. The stiffness shall be measured with a quad shear test rig in an enclosed freezer unit. The test specimens shall be taken from a randomly selected bearing. A ±25% strain cycle shall be used. A complete cycle of strain shall be applied within a period of 100 s. The first 0.75 cycle of strain shall be discarded. The stiffness shall be determined by the slope of the force deflection curve for the next 0.50 cycle of loading.

The bond strength, determined in accordance with ASTM D429, Method B, shall be at least 40 lb/in.

The adhesion failure, determined in accordance with ASTM D429, Method B, shall be at least R-80. The adhesion-failure requirement will be waived if the bond strength is at least 80 lb/in.

2. Structural Steel

Structural steel spacer plates, top and bottom load plates, and other steel components, including anchor bolts, exposed to the environment shall be galvanized in accordance with AASHTO M 111, zinc metallized with a coating of 7 mils in accordance with SSPC-CS 23.00, or painted with the structural steel coating system in accordance with 619.09(a). The finish coat for painted steel shall be in accordance with 909.02(d). The color shall be in accordance with SAE-AMS-STD-595, color No. 20045.

When stainless steel load plates are specified, the material shall be in accordance with ASTM A240, type 304.

3. Internal Steel Shims

Internal steel shims shall be rolled hot and cold steel and shall be in accordance with AISI 1015 through 1025, ASTM A1008, or ASTM A1011 grade 36 or higher. Shims shall be of the thickness specified with a tolerance of ±0.015 in.

4. Threaded Stud

Threaded studs, where required, shall be in accordance with ASTM A307 and mechanically zinc coated in accordance with ASTM B695, class 50.

5. Side Retainer

Side retainers shall be made from plates or rolled mild steel in accordance with ASTM A36.

(c) Manufacturing Requirements

Plain bearings may be molded individually, cut from previously molded strips or slabs, or extruded and cut to length. Cut edges shall be at least as smooth as ANSI B 46.1 No. 250 finish. Unless otherwise shown on the plans, all components of a laminated bearing shall be molded together into an integral unit. Air bubbles within the elastomeric material shall be cause for rejection.

Laminated elastomeric bearings shall be individually molded to the required size. Corners and edges may be rounded with a radius at the corners not exceeding 3/8 in. and a radius at the edges not exceeding 1/4 in.

Steel shims shall be sandblasted and cleaned and protected against contaminants until fabrication is completed.

Bearings designed as a single unit shall be built as a single unit.

Each reinforced bearing shall be marked with indelible ink or flexible paint. The

marking shall consist of the orientation, the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, the marking shall be on a face that is visible after erection of the bridge.

Where load plates are shown on the plans, the bearing shall be vulcanized to the steel load plate during the primary molding process.

(d) Appearance and Dimensions

The edges of the embedded steel laminates, including around holes, shall be covered with 1/8 to 1/4 in. of elastomer. All other dimension tolerances shall be in accordance with AASHTO M 251.

(e) Quality Assurance

The mechanical properties of the materials and of the finished bearing shall be in accordance with the AASHTO LRFD Bridge Construction Specifications, Article 18.2.5, and AASHTO M 251, with the exception that the tables in 915.04(b)1 shall be used.

1. Compressive strain of any layer of an elastomeric bearing shall not exceed 7% at 800 psi average unit pressure or at the design dead load plus live load pressure if so indicated on the plans.
2. The shear resistance of the bearing shall not exceed 40 psi for 55 durometer, table A compounds; or 75 psi for 55 durometer, table B compounds at 25% strain of the total effective rubber thickness after an extended four-day ambient temperature of -20°F.

(f) Certification

A type B certification in accordance with 916 shall be provided for the elastomeric bearings. The limits of the following shall be shown on the certification.

TEST	ASTM, or INDOT Standard Specifications
Ultimate Tensile Strength	D412
Ultimate Elongation	D412
Hardness (Durometer)	D2240
Tensile Strength and Elongation on Oven-aged Material	D573 and D412
Hardness on Oven-aged Material	D573 and D2240
Compression Set	D395, Method B
Ozone Resistance	D1149
Adhesion	D429, Method B
Brittleness	D746, Procedure 9.1.2
Compressive Strain	915.04(e)1
Shear Resistance	915.04(e)2

When steel components are incorporated into elastomeric bearings, a mill certification, galvanization certification, if applicable, and a Buy America Certification in accordance with 106.01(c) will be required.

In addition, one bearing pad from each type to be furnished for the structure will be required for laboratory testing. A type of bearing is defined by the length, width, and thickness of elastomer, and the number and thickness of internal shims. Bearings that differ by the dimensions of load plates vulcanized to similar elastomeric pads will also be considered different types. The material may be sampled prior to shipment to the project, provided suitable arrangements can be made through the Department's Division of Materials and Tests. Materials not previously sampled and approved for use shall be sampled after delivery to the project site. Samples shall be furnished at least 30 days before date of use.

915.05 Bearing Assemblies with Polytetrafluoroethylene, PTFE, Sliding Surfaces

A copy of the manufacturer's design manual shall be submitted for approval when directed.

All steel components shall be in accordance with ASTM A709, grade 36 unless otherwise shown on the plans. Where these assemblies are to be used in conjunction with a self-weathering steel bridges, the steel components shall be in accordance with ASTM A709, grade 50W. Stainless steel mating surfaces shall be 14 gauge minimum ASTM A240, type 304 sheets with a maximum surface roughness of 20 Rms.

The PTFE shall be 100% virgin unfilled polymer or 15% glass filled and etched on the bonding side. The properties of the PTFE shall be in accordance with the following:

Requirement	Test Method	Value
Tensile Strength, minimum	ASTM D638	2,500 psi
Elongation, %, minimum	ASTM D638	200
Specific Gravity	ASTM D792	2.1 to 2.3

PTFE, where required, shall be virgin material, etched on the bonding face and in accordance with ASTM D 4894. The PTFE shall be bonded to grit blasted steel in accordance with Federal Specification MMM-A-134, Type 1. The elastomeric pad shall be vulcanized to the steel load plate during the primary molding process. The stainless steel sliding plate shall be seal welded to the steel load plate.

All steel surfaces exposed to the environment shall be zinc metalized and shall be 7 mils thick in accordance with SSPC-CS 23.00, or painted in accordance with 619.09(a). The finish coat for painted steel shall be in accordance with 909.02(d). The color shall be in accordance with SAE-AMS-STD-595, color No. 20045.

A type B certification in accordance with 916 shall be provided for the bearing assemblies. The limits of the above shall be shown on the certification.

SECTION 916 – MATERIALS CERTIFICATIONS

916.01 General

Materials certifications will be required for certain materials in accordance with various sections of these specifications and other contract documents. Unless otherwise specified or directed, one copy of each certification shall be submitted prior to use of the material. All certifications shall be signed by a person having legal authority to bind the company preparing the certification.

The contract number, name of the Contractor, destination to which the material covered by the certification is consigned, and name and quantity of material represented shall be shown on all copies of the certification. Identifying information such as alloy, grade, type, class, or other similar designation shall also be shown when applicable.

Any material received on the project for which certification has been furnished may be sampled and tested. If the results of the tests are in disagreement with the certification, the test results shall prevail and further acceptance by certification from the manufacturer of the material concerned may be suspended.

916.02 Types of Certifications

Certifications shall be type A, type B, type C, type D, or as required under other types. When specified, the type of certification provided for a material shall be in accordance with the Frequency Manual except as otherwise specified. Specific information and test results required in type A, type B, and other types of certifications will be listed in the material specifications. Sample forms for type A, type B, type C, and type D certifications are shown in 916.03. Sample forms for other type certifications are shown in 916.03 or ITM 804.

(a) Type A

Type A certification shall be prepared by the manufacturer. It shall consist of a certified copy of a laboratory report which lists results of the specified tests and shall certify that the materials furnished comply with the specifications. The applicable specification shall be referred to in the certification. The tests may be conducted in the laboratory of the manufacturer or in another qualified laboratory. Such tests shall have been conducted on samples obtained from the lot or lots of material in the shipment.

(b) Type B

Type B certification shall be prepared by the manufacturer. It shall show the limits of test values for the specified tests and shall certify that the materials furnished comply with the specifications. The applicable specification shall be referred to in the

certification. The tests may be conducted in the laboratory of the manufacturer or in another qualified laboratory.

(c) Type C

Type C certification shall be prepared by the manufacturer and shall certify that the materials furnished are in accordance with the specifications. The applicable specification shall be referred to in the certification.

(d) Type D

Type D certification shall be prepared by the Contractor and shall certify that the materials furnished are in accordance with the specifications. The applicable specification shall be referred to in the certification. A type D certification shall be used for product identification. It may be required to certify that the material is in accordance with minimum trade standards.

(e) Other Types

Types of certifications other than type A, B, C, and D are specified for selected materials. The requirements for a certification, other are described in the respective material's specification. A sample is shown in ITM 804.

(f) Requirements for Small Quantities of Materials

Where circumstances warrant and previously approved material is not available, small quantities may be accepted either by a type D certification or by an affidavit from the supplier stating that the material offered is equal to that specified.

(g) Buy America Requirement

All steel and cast iron materials and products used in the contract shall be certified to be in accordance with 106.01(c).

916.03 Sample Forms

(a) For Buy America Requirement

BUY AMERICA CERTIFICATION

In accordance with Indiana Department of Transportation Specification 106.01(c), I hereby certify that all steel and cast iron materials and products were produced and manufactured in the United States of America or territories subject to its jurisdiction.

CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

This is to certify that for the contract described above, the materials supplied are as follows:

** Material Name	Quantity
_____	_____
_____	_____

_____ Date

_____ Company of Manufacture

_____
* Signature of Company Official/Title

_____ Date

_____ Contractor

_____
Signature of Contractor Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

(b) Sample Type A Certification Form

INDIANA DEPARTMENT OF TRANSPORTATION

TYPE A CERTIFICATION OF COMPLIANCE

CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

This is to certify that for the contract described above, the materials supplied are as follows:

** Material Name Quantity

_____ _____

_____ _____

*** Conform to: _____

The materials listed above comply with the following Test Methods and are within the acceptable limits of said Test Methods:

TEST METHOD	LIMITS OF TEST VALUE	ACTUAL TEST RESULTS
_____	_____	_____
_____	_____	_____
_____	_____	_____

_____ _____

Date Company of Manufacture

_____

* Signature of Company Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed.

(c) Sample Type B Certification Form

INDIANA DEPARTMENT OF TRANSPORTATION

TYPE B CERTIFICATE OF COMPLIANCE

CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

This is to certify that for the contract described above, the materials supplied are as follows:

180

** Material Name Quantity

_____ _____

_____ _____

*** Conform to: _____

The materials listed above comply with the following Test Methods and are within the acceptable limits of said Test Methods.

190

TEST METHOD LIMITS OF TEST VALUE

_____ _____

_____ _____

_____ _____

_____ _____

Date Company of Manufacture

_____

* Signature of Company Official/Title

200

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.

** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.

*** Applicable material specification reference shall be listed.

(d) Sample Type C Certification Form

210 CONTRACT NUMBER _____

PROJECT NUMBER _____

CONTRACTOR'S NAME _____

MANUFACTURER'S NAME _____

B/L or INVOICE NUMBER _____

220 This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name Quantity

_____ _____

_____ _____

*** Conform to: _____

230 _____ _____
Date Company of Manufacture

_____
* Signature of Company Official/Title

* This Certification shall be prepared by the manufacturer of the material being supplied for this contract.
** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.
*** Applicable material specification reference shall be listed.

240

(e) Sample Type D Certification Form

CONTRACT NUMBER _____

PROJECT NUMBER _____

MANUFACTURER'S NAME _____

250 This is to certify that for the contract described above, the materials supplied are as follows:

**Material Name Quantity

_____ _____
_____ _____

*** Is in accordance with: _____

_____ _____
260 Date Contractor

_____
* Signature of Contractor Official/Title

* This Certification shall be prepared by the Contractor.
** Identifying information such as Alloy, Grade, Type, Class, or other similar designation shall also be shown when appropriate.
*** Applicable material specification reference shall be listed. Otherwise, a statement shall be provided that the material supplied is in accordance with minimum trade standards.

270

(f) Sample Asbestos Exclusion Letter

Prior to acceptance of work and final payment, the Contractor shall submit to the Engineer for each building or bridge, on the Contractor's letterhead, a signed, dated copy of the following letter. The Engineer will be responsible for the distribution of the letter.

ASBESTOS EXCLUSION LETTER

_____
Date

_____
work address of Engineer for Indiana Department of Transportation

ATT: _____
Name, Project Engineer/Supervisor

Re: Asbestos Exclusion
Location/Description _____
Contract Number _____
Bridge Structure Number _____
Contractor's Name _____

Dear Engineer:

I hereby certify that to the best of my knowledge no asbestos containing material was used as a building material in this project.

Very truly yours,

_____
Signature of Contractor official

_____
Title of Contractor official

cc: District Bridge Inspection Engineer
Environment, Planning and Engineering Division Chief
Project File

(g) Sample Type Other Certification Form

SEED CERTIFICATION

This is to certify that the seed mixture supplied, _____, by
(name of seed mixture)

_____ _____
(Manufacturer's Name) (source code)

located in _____, _____
(City) (State)

manufactured at _____
(Location of Manufacturing Plant)

and has Case Review Number _____ meets INDOT Standard Specifications.

Attached are copies of the State Seed Commissioner's Letter and test reports for each lot of seed used in the above-mentioned seed mixture.

Seed Species	Lot No.	Seed Expiration Date
<<All seed species contained in the seed mixture shall be listed in this space. >>		

I understand that State and/or Federal funds are involved in the work in which this material will be used and that any misrepresentation on my part constitutes fraud.

_____ _____
(Date) (Signature of Company Official)

This _____ pounds of seed mixture._____ is being provided by
(name of seed mixture)

_____., for INDOT Contract No. _____
(Name of Contractor)

_____ _____
(Date) (Signature of Contractor)

SECTION 917 – QUALITY ASSURANCE AGGREGATE CERTIFICATION

917.01 General Requirements

An aggregate source will be authorized to ship products in the status of a Certified Aggregate Producer who is in accordance with the required standards of ITM 211. This will consist of a program which will require the aggregate source to make a commitment to product quality management. Approval to participate in the program will be based on the following criteria.

(a) existence of suitable materials in the deposit being mined;

(b) facilities capable of consistently processing uniform materials in accordance with the specification requirements; and

(c) a source Quality Control Plan which will ensure that the mineral aggregates have a 95% assurance of being in accordance with the Department's quality and uniformity requirements.

Specific details of the CAPP are contained in ITM 211. Additional details about the program are included in the CAPP Training Manual for Producer Technicians. A Certified Aggregate Producer shall operate in accordance with both of these publications.

917.02 Quality Control Plan

An aggregate source will not be included on the QPL of Certified Aggregate Producers until it has prepared a Quality Control Plan and the plan has been approved. The plan shall encompass all details of production starting with the extraction of the indigenous raw materials and concluding with material shipped from the plant. The Quality Control Plan shall be prepared in accordance with the requirements of ITM 211.

917.03 Source Approval Requirements

The Department's Division of Materials and Tests shall be notified in writing that the aggregate source wants to become a Certified Aggregate Producer. The aggregate source shall identify the specific products for which approval is sought. Such list shall include all of the products to be produced at the source regardless of whether the products are for Department or other uses.

An aggregate source may not be considered for entry into the certification program until the preliminary source investigation has been completed in accordance with ITM 203.

The following procedure will be used to establish an aggregate source as a Certified Aggregate Producer.

(a) Step 1

The source shall enter the coordinated testing phase of ITM 211. Coordinated

testing shall be performed in accordance with ITM 211. During this phase, the producer shall be required to develop a Quality Control Plan to establish demonstrated mean test values and standard deviations.

(b) Step 2

The aggregate source shall enter the trial phase. The producer shall also operate in accordance with ITM 211 and the Quality Control Plan. The Quality Control Plan shall be refined as may be necessary.

(c) Step 3

The aggregate source will be included on the QPL of Certified Aggregate Producers following satisfactory performance during the trial phase. Achieving such status shall be accompanied by the inherent responsibility to operate within the tenets of ITM 211. The Certified Aggregate Producer shall produce material at a compliance requirement of effectively 95% of the appropriate specifications. The Department will monitor such compliance through the use of periodic in-depth inspections of the production site. Continuing approval is contingent upon the effectiveness of the producer's Quality Control Plan as evidenced by the quality and uniformity of the products which are prepared in accordance with the appropriated specifications and ITM 211.

917.04 Removal from Certified Producer Status

The Department's Division of Materials and Tests will be responsible for the review and removal of an aggregate source from being an approved Certified Aggregate Producer. A Certified Aggregate Producer shall operate so as to avoid a need for the Department to exercise this action. However, removal from Certified Aggregate Producer status may be necessary for situations such as:

(a) the statistical probability of the product compliance has fallen below 90%;

(b) the product has a 90% to 95% probability of compliance but the producer has failed to take corrective action to restore 95% probability;

(c) the Certified Aggregate Producer has failed to take immediate corrective action relative to deficiencies in the performance of the approved Quality Control Plan;

(d) evaluation of data has demonstrated an inability of the Certified Aggregate Producer to consistently be in accordance with Department requirements;

(e) the Certified Aggregate Producer has deliberately shipped aggregate material which is not in accordance with the specifications, or has falsified records; or

(f) the production site has not been operated in accordance with the Summary of Production or Ledge Quality Results letter.

Notice of removal from Certified status will be in written form, will be issued by the Department's Division of Materials and Tests, and will identify the reasons for the removal. Effective immediately upon receipt of such notification, no further aggregate shipments shall be made on a certified basis.

917.05 Appeals

The producer shall have the right to appeal removal from Certified Producer status to the Engineer. The appeal shall be in written form, shall state the reason or reasons on which the appeal is based, and shall be received within 14 calendar days of receipt of the removal notice.

SECTION 918 – GEOSYNTHETIC MATERIALS

918.01 General Requirements

Geosynthetics are polymer based products used for separation, filtration, reinforcement, liquid containment, soil and aggregate confinement, and many other soil related purposes within many conventional civil engineering structures. When appropriate, the Department will require the use of geosynthetics meeting the categories and characteristics indicated below.

A manufacturer requesting that a geosynthetic be added to the QPL shall submit the required documents in accordance with ITM 806 to the Department's Division of Materials and Tests.

918.02 Geotextile

The geotextile shall be either non-woven or woven and consist of at least 85% long-chain synthetic polymers. The geotextile shall contain stabilizers or inhibitors added to the base polymer mix to make the filaments and yarns resistant to deterioration caused by ultraviolet radiation exposure. The geotextile shall be produced such that the yarns and fibers retain their relative positions. The non-woven geotextile shall be needle punched, heat bonded or resin bonded.

All damaged geotextile shall be replaced for the entire width of the roll. The Contractor shall furnish the product labeled that clearly indicates the manufacturer's or supplier's name, product identification, lot number, manufactured date, and roll dimensions. Geotextiles used for Department projects shall be NTPEP listed and shall be in accordance with AASHTO M 288 and the QPL of Geosynthetic Materials. Geotextiles will be placed and maintained on the QPL in accordance with ITM 806.

The geotextile shall meet the following requirements:

(a) Geotextile Properties for Riprap and Revetment Applications

		Requirements[1]				
Test	Method, ASTM	Type 1A	Type 1B	Type 2A	Type 2B	Type 3
Grab Tensile Strength, min.	D4632	200 lb	200 lb	250 lb	300 lb	250 lb
Grab Elongation	D4632	> 50%	< 50%	> 50%	< 50%	< 50%
CBR Puncture Strength, min.	D6241	500 lb	600 lb	625 lb	1,000 lb	875 lb
Trapezoid Tearing Strength, min.	D4533	80 lb	75 lb	100 lb	150 lb	60 lb
Deterioration in Tensile Strength due to UV Degradation 500 hrs, min.	D4355 D6637	70% strength retained	70% strength retained	70% strength retained	70% strength retained	90% strength retained
Apparent Opening Size, AOS	D4751	≤ No. 80 sieve, for soils ≥ 40% passing the No. 200 sieve	≤ No. 40 sieve, for soils < 40% passing the No. 200 sieve	≤ No. 100 sieve, for soils ≥ 40% passing the No. 200 sieve	≤ No. 40 sieve, for soils < 40% passing the No. 200 sieve	≤ No. 70 sieve
Permittivity	D4491	≥ 1.2 sec^{-1}	≥ 2.1 sec^{-1}	≥ 0.80 sec^{-1}	≥ 0.90 sec^{-1}	0.28 sec^{-1}

Note:
[1] All values are minimum average roll values (MARV) as determined in accordance with ASTM D4354 in the weaker principal direction, except AOS size is based on maximum average roll value.

(b) Geotextile Properties for Underdrains and Drainage Applications

		Requirements[1] [2]				
Test	Method, ASTM	Type 1A	Type 1B	Type 2A	Type 2B	Type 3
Grab Tensile Strength, min.	D4632	80 lb	200 lb	160 lb	200 lb	200 lb
Grab Elongation	D4632	> 50%	< 50%	> 50%	< 50%	< 50%
CBR Puncture Strength, min.	D6241	175 lb	600 lb	410 lb	750 lb	1,100 lb
Deterioration in Tensile Strength due to UV Degradation 500 hrs, min.	D4355 D6637	70% strength retained	70% strength retained	70% strength retained	70% strength retained	90% strength retained
Apparent Opening Size, AOS	D4751	≤ No. 50 sieve, for soils ≥ 40% passing the No. 200 sieve	≤ No. 40 sieve, for soils < 40% passing the No. 200 sieve	≤ No. 70 sieve, for soils ≥ 40% passing the No. 200 sieve	≤ No. 30 sieve, for soils < 40% passing the No. 200 sieve	≤ No. 40 sieve
Permittivity	D4491	≥ 1.2 sec^{-1}	≥ 2.1 sec^{-1}	≥ 0.8 sec^{-1}	≥ 0.9 sec^{-1}	0.90 sec^{-1}

Notes:

[1] All values are minimum average roll values (MARV) as determined in accordance with ASTM D4354 in the weaker principal direction, except AOS size is based on maximum average roll value.

[2] Type 3 value is a maximum average roll value (Max ARV) as determined in accordance with ASTM D4354.

(c) Geotextile Properties for Pavement or Subgrade Stabilizations

		Requirements[1]			
Test	Method, ASTM	Type 1A	Type 1B	Type 2A	Type 2B
Grab Tensile Strength, min.	D4632	200 lb	300 lb	290 lb	400 lb
Wide Width Tensile , @ 5% Strain, min.	D4595	n/a	n/a	1,200 lb/ft	2,400 lb/ft
Grab Elongation	D4632	≤ 50%	< 50%	≤ 50%	< 50%
CBR Puncture Strength, min.	D6241	175 lb	600 lb	410 lb	750 lb
Trapezoid Tearing Strength, min.	D4533	75 lb	110 lb	n/a	n/a
Deterioration in Tensile Strength due to UV Degradation 500 hrs, min.	D4355 D6637	70% strength retained	70% strength retained	70% strength retained	70% strength retained
Apparent Opening Size, AOS, min.	D4751	No. 50 sieve	No. 40 sieve	No. 30 sieve	No. 30 sieve
Soil Retention, Pore Size, O_{50}/O_{95}, min.	D6767	n/a	n/a	290/380	100/350
Permittivity, min.	D4491	0.05 sec^{-1}	0.050 sec^{-1}	0.50 sec^{-1}	0.40 sec^{-1}

[1] All values are minimum average roll values (MARV) as determined in accordance with ASTM D4354 in the weaker principal direction, except AOS size is based on maximum average roll value.

(d) Geotextile Properties for Silt Fence

		Requirements[1]	
Test	Method, ASTM	Wire Fence Supported	Self Supported
Grab Strength	D4632	90 lb	90 lb
Elongation @ 45 lb	D4632		50% max.
Apparent Opening Size [2]	D4751	No. 20 sieve	No. 20 sieve
Permittivity [2]	D4491	0.01 sec^{-1}	0.01 sec^{-1}
Ultraviolet Degradation at 500 hrs	D4355	70% strength retained	70% strength retained

[1] The value in the weaker principal direction shall be used. All numerical values will represent the minimum average roll value. Test results from a sampled roll in a lot shall be in accordance with or shall exceed the minimum values shown in the above table. The stated values are for non-critical, non-severe conditions. Lots shall be sampled in accordance with ASTM D4354.

[2] The values reflect the minimum criteria currently used. Performance tests may be used to evaluate silt fence performance if deemed necessary by the Engineer.

Note: All values are minimum average roll values (MARV) as determined in accordance with ASTM D4354.

918.03 Geomembrane

This material shall consist of a geomembrane fabricated from high density polyethylene, HDPE, consisting of strong, rot resistant, chemically stable long-chain synthetic polymer materials, dimensionally stable with distinct and measurable openings. The manufactures shall submit the tests for the intended use to the Department.

Geomembrane shall be selected from the QPL of Geosynthetic Materials. Geomembrane will be placed and maintained on the QPL in accordance with ITM 806.

The geomembrane shall meet the following requirements:

Test	Method	Requirement
Density @ 23°C, min.	ASTM D1505	0.88 g/cm^3
Sheet Thickness	ASTM D5199	0.75 mm
Tear Resistance	ASTM D1004	98 N
Resistance to Soil Burial	ASTM D6134	min. of 90% of original value retained
pH	AASHTO T 289	Durability between 3 to 12
Roll Width	Calibered	20 ft

918.04 Geocell Confinement System

Geocell confinement system is a lightweight, flexible mat that consists of high density polyethylene strips. The mat shall be perforated and the strips shall be ultrasonic bonded together to form a strong configuration. Cell seam strength shall be uniform over full depth.

Geocell shall be selected from the QPL of Geosynthetic Materials. Geocell will be placed and maintained on the QPL in accordance with ITM 806.

The geocell shall meet the following requirements:

Properties	Material/Test Method	Unit	Value
Sheet Thickness	ASTM D5199	mils	50
Environmental Stress Crack Reduction, min.	ASTM D1693	hours	3,500
Short-Term Seam Peel Strength for 4 in. depth	ASTM D6392	lb/ft	350
Percent Open Area	COE-02215	%	12.6
Nominal Expanded Cell Size	Calibered	in.	12.6 x 11.3
Note: Carbon Black shall be minimum 1.5% by weight in accordance with ASTM D5199.			

918.05 Geogrid

Geogrid shall be biaxial or multi axial of a regular network of connected polymer tensile elements with aperture geometry sufficient to enable significant mechanical interlock with the surrounding material. The material shall be polypropylene, ASTM

D4101 (97% minimum) and Carbon Black, ASTM D1603 (0.5% minimum). The geogrid structure shall be dimensionally stable and shall be able to retain its geometry under construction stresses. The geogrid structure shall have a resistance to damage during construction, ultraviolet degradation, and all forms of chemical and biological degradation encountered in the soil being placed.

Geogrid shall be in accordance with the property requirements as specified in the Geosynthetic Research Institute, GRI, Standard Test Methods GG1, GG3, GG4, ASTM D5262, and ASTM D6637.

During periods of shipment and storage, the geogrid shall be protected from temperatures greater than 140°F, mud, dirt, dust, and debris. Each geogrid roll shall be labeled or tagged to provide product identification. The manufacturer's recommendations shall be followed with regard to protection from direct sunlight. At the time of installation, the geogrid will be rejected if it has defects, tears, punctures, flaws, deterioration, or damage incurred during manufacture, transportation, or storage. All damaged portions of geogrid shall be replaced for the entire width of the roll. All of the geogrid shall be identified, stored, and handled in accordance with ASTM D4873. The Contractor shall furnish the product labels that clearly show the manufacturer's or supplier's name, product identification, lot number, manufactured date, roll dimension, and provide a document that the material is in accordance with manufacturer's or supplier's certificate.

Only geogrids selected from the QPL of Geosynthetic Materials shall be used. Geogrids will be placed and maintained on the QPL in accordance with ITM 806, Procedure S.

The geogrid shall be in accordance with the property requirements for the type specified as follows:

(a) Type IA and Type IB

Property	Test Method	Unit	Type IA Value, Min.	Type IB Value, Min.
Aperture Area	Calibered	Sq. in.	1.3	1.3
Open Area	COE, CW02215	%	> 50.0 ≤ 80.0	> 50.0 ≤ 80.0
Junction Strength	ASTM D7737	lb/ft	-----	788
Tensile Modulus,	ASTM D6637[1,2,3]			
machine direction		lb/ft	10,000	10,000
cross machine direction		lb/ft	10,000	10,000
Ultimate Strength,	ASTM D6637[2,3]			
machine direction		lb/ft	800	800
cross machine direction		lb/ft	800	800
Ultraviolet Stability	ASTM D4355	-----	-----	70% at 500 hrs

[1] Secant modulus at 5% elongation.
[2] Results for machine direction, MD, and cross machine direction, CMD, are required.
[3] Minimum average roll values shall be in accordance with ASTM D4759.

(b) Type II

Property	Test Method	Unit	Value, Min.
Open Area	COE, CW02215	%	> 50.0 ≤ 80.0
Tensile Modulus, machine direction	ASTM D6637[1,2]	lb/ft	49,300
Ultraviolet Stability	ASTM D4355	70% at 500 hrs	
Creep Limited Strength, machine direction at 5% strain	ASTM D5262	lb/ft	1,090

[1] Secant modulus at 2% elongation.
[2] Minimum average roll values shall be in accordance with ASTM D4759.

(c) Type III

Geogrid material shall be of high-density polyethylene, HDPE; polypropylene, PP; or polyester, PET, polymers and have the following properties:

Property	Test Method	Unit	Value, Min.
Open Area	COE, CW02215	%	> 50.0 ≤ 80.0
Ultraviolet Stability	ASTM D4355	70% at 500 hrs	
Ultimate Strength, machine direction	ASTM D6637	lb/ft	1,500
Long-Term Design Strength, Allowable, LTDS, machine direction	GRI-GG4	lb/ft	1,000*

* Minimum Average Roll Value, MARV: Property value calculated as average minus two standard deviations.

$$\text{LTDS} = \frac{T_{ult}}{(RF_{CR})(RF_{IR})(RF_D)}$$

where:

T_{ult} = Ultimate strength
RF_{CR} = Reduction factor for creep
RF_{IR} = Reduction factor for installation damage
RF_D = Reduction factor for durability

The minimum reduction factors are as follows:

RF_{CR} = 2.6 for HDPE, 4.0 for PP, 1.6 for PET
RF_{IR} = 1.10
RF_D = 1.10

918.06 Fabric for Waterproofing

Fabric for waterproofing shall be treated cotton in accordance with ASTM D173, woven glass in accordance with ASTM D1668, or glass fiber mat in accordance with ASTM D2178. A type C certification in accordance with 916 shall be provided for the fabric.

SECTION 919 – TRAFFIC SIGNS

919.01 Traffic Signs

Traffic signs shall be in accordance with the MUTCD.

Panel sign fabrication shall not utilize overlapping or butt splicing of reflective sheeting. Roll splices, as supplied on the roll of sheeting by the sheeting manufacturer, are allowed subject to the following conditions.

(a) a maximum of one roll splice per panel, and
(b) a maximum of three roll splices per sign.

Exit panels are considered a part of the signs to which they are attached when fabricated under the same contract. If the exit panels are made for separate installation, only one roll splice is allowed on the entire sign.

Overlap splices on sheet signs will be allowed only because of insufficient sheeting width on signs whose smaller dimension exceeds 48 in. The overlap splice shall be installed in a shingle type manner using a horizontal lap. The lap width shall be a minimum of 1/4 in. Butt splices shall not be used. Roll splices are allowed on sheet signs but shall not exceed one splice per sign.

All signs shall be packed for shipment and handled during construction in accordance with the manufacturer's recommendations. All sign or sign face damaged prior to acceptance shall be replaced or repaired. Damaged sheet signs shall be replaced in their entirety. Damaged panel signs shall have the affected panels replaced or repaired in accordance with the manufacturer's recommendations.

Repaired areas on panel signs shall not be larger than 3 in. by 3 in. Repaired areas 1 in. by 1 in. or less shall be limited to a maximum of three per panel and a maximum of six per panel sign. Repaired areas larger than 1 in. by 1 in. shall be limited to one per panel and a maximum of three per panel sign. The maximum number of repaired areas shall be three on a panel or six on a panel sign. No more than 20% of the total number of panel signs may be patched. Panels with sheeting cracked at the bend around the panel edge shall be replaced.

A sign with the metal face damaged greater than superficial deformation shall be replaced.

Digital printed signs shall have transparent and opaque durable ink as recommended by the manufacturer. Digital printed colors shall have a warranty life of the base reflective sign sheeting. Digital applied colors shall present a smooth surface, free from the foreign material, bubbles, blemishes, streaks or spotted areas, and all messages and borders shall be clear and sharp. Digital printed signs shall meet the

daytime color and luminance, and night time color requirements of ASTM D4956. Overlapping of colors will not be allowed.

All digital printed signs shall be from an integrated system including reflective sheeting, durable inks, and clear overlay film all from the same manufacturer applied to aluminum substrate in accordance with 919.01(a)1. Only digital printers recommended by the manufacturer of the reflective sheeting shall be used.

Finished digital printed signs shall have a UV-protective clear overlay applied to the entire face of the signs. Overlay shall be part of an integrated component system as recommended by the reflective sheeting manufacturer. On temporary construction signs digitally printed with black ink only, the protective overlay film is optional.

(a) Backing Material

Fabrication, including cutting and punching of holes but excluding holes for demountable copy, shall be completed prior to surface treatment. Material shall be cut to size and shape and shall be free from buckles, warp, dents, cockles, burrs, and defects resulting from fabrication. The surface shall be a plane surface.

Metal sign base material shall be cleaned and prepared to receive the sheeting material in accordance with the sheeting manufacturer's recommendation.

1. Sheet Signs

The backing material for permanent sheet signs shall be sheet aluminum in accordance with ASTM B209, alloy 5052H38, or alloy 6061-T6.

The minimum thickness of the sheet shall be as shown for the appropriate sign width.

Width, in.	Thickness, in.
Up to 30	0.080
31 to 60	0.100
61 and Over	0.125

Backing material for temporary ground mounted signs shall be aluminum, steel, fiberglass, reinforced plastic, or plywood, unless otherwise approved.

2. Panel Signs

Extruded aluminum panels shall be in accordance with ASTM B221, alloy 6063-T6, and be 12 in. in width. Extruded aluminum panels shall be flat and straight within tolerances established by the aluminum industry. The weight for panels shall be 2.48 lb/ft.

Trim molding shall be of the same material and thickness as the panels to which it is attached.

Panel bolts, flat washers, and lock-nuts shall be in accordance with ASTM B211, alloy 2024-T4. Panel bolts shall be 3/8 in. by 3/4 in. standard hex head. Lock-nuts shall be standard hex head.

3. Demountable Letters, Numbers, and Symbols

If demountable letters, numbers, or symbols are used, the backing material shall be 0.040 in. thick aluminum sheets in accordance with ASTM B209, alloy 3003-H14. Borders shall be 0.032 in. thick aluminum sheet in accordance with ASTM B209, alloy 6061-T6.

(b) Sheeting Material

Only sheeting materials from the QPL of Reflective Sheeting shall be used for Type IV through Type X sheeting. Type IV or higher sheeting shall be used for all sheet signs except as specified herein. For contracts let on or after September 1, 2020, Type VIII or higher reflective sheeting shall be used for sheet signs with a red background color and Type XI sheeting shall be used for all panel signs. Type XI highway sheeting shall be from the QPL of Reflective Sheeting or from a manufacturer that has complete test results from the NTPEP showing that the ASTM D4956 minimum requirements have been met. A type C certification in accordance with 916 shall be provided for Type XI sheeting. The sheeting type for the sign copy and border shall be the same type or higher than the sheeting type used for the background. Reflective sheeting materials will be placed and maintained on the QPL in accordance with ITM 806, Procedure H.

A non-prorated manufacturer's written warranty, against delamination, blistering, discoloration, or 15% or greater loss of retro-reflectivity compared with the minimum initial ASTM D4956 value, shall be provided to, and in favor of, the Department by the reflective sheeting manufacturer. The warranty shall cover a period of 10 years.

1. Reflective Sheeting

Reflective sheeting used for signs, channelizing and delineation devices shall be in accordance with ASTM D4956.

For contracts let on or after September 1, 2019, type IV or higher white and fluorescent orange reflective sheeting shall be used for drums utilized on interstate routes and ramps.

For contracts let on or after September 1, 2020, Type IV or higher white and fluorescent orange reflective sheeting shall be used on all drums, tubular markers, vertical panels, and 42 in. cones.

Type V or higher reflective sheeting shall be used on delineators, except for barrier delineators which shall be Type III or higher.

Reboundable reflective sheeting shall be used on plastic drums, flexible delineator posts, and other flexible channelizers.

The reflective sheeting shall include an adhesive backing Class 1 or Class 2 in accordance with ASTM D4956.

2. Non-reflective Sheeting

Non-reflective sheeting shall be in accordance with ASTM D4956 except that the sheeting shall not incorporate optical elements. The color shall be black in accordance with SAE-AMS-STD-595, color No. 17038.

3. Transparent Sheeting

Transparent sheeting shall be a material recommended by the background sheeting manufacturer.

(c) Letters, Numbers, and Symbols

Letters, numbers, and symbols may be demountable.

The reflective sheeting shall be of the same type as used on the background and mechanically applied to the properly prepared aluminum in a manner prescribed by the sheeting manufacturer.

Each demountable legend unit, supplemental panel, and border frame shall be supplied with mounting holes and shall be secured to the sign face with aluminum rivets with aluminum mandrels. Adhesives that, when removed, may damage the sign face, legend unit, or border shall not be used to hold the unit in place.

(d) Fasteners

1. Sheet Signs

The bolts, steel flat washers, and lock-nuts used to attach sheet signs to posts shall be stainless steel in accordance with ASTM A276, or type 304 carbon steel in accordance with ASTM A307, grade A. Carbon steel hardware shall be galvanized in accordance with ASTM F2329. Lock washers and hex nuts shall be used in lieu of the lock-nuts when carbon steel hardware is furnished.

The bolts shall be 5/16 in. by 3 in. hex head, full threaded. The steel flat washers shall be size no. 1/4, 0.738 in. outside diameter, 0.317 in. inside diameter, and 0.051 to 0.08 in. thick and in accordance with Military Specifications MS 15795-811. Nylon flat washers shall be 7/8 in. outside diameter, 0.317 in. inside diameter, and shall be 0.032 in. thick.

2. Panel Signs and Temporary Panel Signs

The aluminum post clips shall be in accordance with ASTM B26 or ASTM B108, alloy 356.0-T6 and as shown on the plans. Aluminum post clip bolts shall be as shown on the plans and in accordance with ASTM B211, alloy 2024-T4. Lock-nuts shall be in accordance with ASTM B211, alloy 2017-T4. Flat washers shall be in accordance with ASTM B209, alloy Alclad 2024-T4.

3. Aluminum Rivets

Aluminum rivets shall be determined by character size and shape but shall not be more than 8 in. on center. All rivets shall be color matched to the legend or supplemental panel being installed.

(e) Basis for Use

A type C certification in accordance with 916 shall be provided for the traffic signs and components except those used for temporary construction signs, temporary traffic signs, and temporary panel signs.

SECTION 920 – HIGHWAY ILLUMINATION MATERIALS

920.01 Highway Illumination Materials

All luminaires, lamps, fuse kits, wire and cable, and major equipment shall be approved new material bearing the UL seal of approval or meet their standards.

Descriptive and technical literature shall be furnished for approval on all equipment prior to purchase and incorporation into the work.

Warranties for all major equipment shall be in accordance with 807.02.

(a) Light Poles s and Mast Arms, under 45 ft

1. General Requirements

Conventional light poles shall be aluminum or steel and shall be in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

For conventional light poles, design wind velocity shall be 120 mph. The maximum horizontal deflection of the pole under maximum loading conditions shall not exceed a deflection angle of 1° 40" from the vertical axis of the pole for any 1 ft section of the pole along the entire length of the pole. Poles shall be designed for the Service I, Service II, Extreme I, and Strength I load combination states. The light pole shall be designed to support an ice load of 3 lb/sq ft applied to the full perimeter of all members. Vibration dampers shall be furnished as recommended by the manufacturer. The manufacturer may use drag coefficients based on actual wind tunnel tests; otherwise, they shall use the drag coefficients in Table 3.8.7-1. The pole shall also be designed for the Fatigue I load combination state should signs or other appurtenances be specified for mounting on the pole.

Conventional light poles shall be designed to support a 53 lb luminaire with an effective projected area of 2.4 sq ft. When larger luminaires are specified, the light poles shall be designed to support the larger luminaires and this shall be shown on the light pole working drawings.

Conventional light poles shall have a 4 in. by 8 in. reinforced handhole centered 18 in. above the base of the pole, unless installed with a transformer base, and a cover attached with a minimum of two stainless steel hex head bolts. The pole shall have a removable pole cap and a wire support hook to support the vertical drop of the wire by a service drop clamp attached to the cable. A wiring hole with a 1 in. inside diameter grommet shall be provided where the mast arm is attached. Pole bases shall be designed for mounting on anchor bolts equally spaced on an 11 1/2 in. or 14 1/2 in. diameter anchor bolt circle. Anchor bolt covers shall be furnished.

Hardware shall be type 304 or 305 stainless steel in accordance with ASTM A276, except where otherwise specified.

For conventional light poles, a 1/2 in. by 13 UNC threaded grounding nut or other approved method shall be provided near the bottom of and shall be accessible through the handhole for attaching the ground wire. The ground wire shall be No. 6 AWG soft-drawn, solid copper in accordance with ASTM B3.

Mast arms less than 8 ft in length shall either be single member or truss type, except that mast arms for poles on bridge deck shall be truss type. Single member arms shall be a tapered tube, oval shaped, at the pole end with the long dimension in the vertical plane, welded to a pole plate and bolted, or clamped, to the shaft with a minimum of four 1/2 in. bolts. Mast arms 8 ft and over in length shall be truss type. The upper member shall be a tapered tube, oval shaped, at the pole with the long dimension in the horizontal plane. The lower member may be standard pipe. Both members shall be welded to a pole plate and bolted or clamped to the pole. A minimum of four 1/2 in. bolts at the upper member and a minimum of two 3/8 in. bolts at the lower member shall be used if a pole plate configuration is used to attach the mast arm to the pole. Mast arms that are clamped to the pole shall have a minimum of four 1/2 in. bolts per clamp. Mast arms shall provide an enclosed raceway for the wiring and shall be free of burrs and rough edges. Each arm shall be furnished with a 2 in. nominal pipe size slipfitter. The maximum rise of the truss style arm shall be as set out in the table and shall be measured vertically from the centerline of the free end of the truss to a plane through the centerline of the upper arm bracket after loading.

Mast Arm Length, ft	Maximum Rise, ft
9 or less	4
10 to 14	5
15 to 19	5.5
20 to 25	6
26 to 30	8

Light poles shall be constructed to provide a nominal luminaire mounting height above the roadway pavement as shown on the drawings. The elevations of foundations above or below the edge of the pavement shall be controlled by existing roadside

conditions. The effective mounting height shall be determined by field measurement prior to placing an order for the poles.

A variation in the nominal mounting height of ±1 ft is allowed so that the "Effective Mounting Height", foundation to luminaire, of the light standards may be supplied for 40 ft nominal mounting height.

Elevation of Foundation Top with Respect to the Near Road Edge, ft	Effective Mounting Height, Foundation to Luminaire, ft
+7.00 to +5.01	34
+5.00 to +3.01	36
+3.00 to +1.01	38
+1.00 to -1.00	40
-1.01 to -3.0	42
-3.01 to -5.00	44
-5.01 to -7.00	46

The effective mounting heights for other nominal mounting heights deviate from the table by the difference in nominal height and 40 ft..

2. Aluminum Light Poles

a. Round Seamless

The pole and mast arm shall be in accordance with ASTM B221, alloy 6063-T6, and of sufficient diameter and wall thickness to withstand the design loads. The pole shall be tapered full length or tapered in the middle with the top or bottom approximately 1/3 of the pole of constant cross section. The minimum wall thickness for poles on breakaway couplings and steel slip bases shall be 0.219 in. Poles on transformer bases or shoe anchor bases installed without breakaway devices are exempted from this minimum wall thickness requirement. An inner tube extension, or sleeve, fitted inside the main tube shaft, is permissible to increase the wall thickness of the shaft starting at the bottom of the shoe base and extending upward towards the top of the pole. The sleeve or tube extension shall be no less than 3 ft in length, fabricated from aluminum alloy 6063-T4 and heat treated to produce a T6 temper after placing in the shaft. The minimum wall thickness of the combination of shaft and sleeve shall be 0.219 in. Attaching plates or clamps for aluminum mast arms shall be in accordance with ASTM B241, alloys 6061-T6, 6063-T6, 356.0-T6, or 5052-H32. The bottom end of the shaft shall be welded to a one-piece cast aluminum shoe anchor base of 356.0-T6 aluminum alloy in accordance with ASTM B26 for sand castings or ASTM B108 for permanent mold castings or equal and provided with four slotted holes for anchor bolts and the shaft's full length shall be heat treated to produce a T6 temper. The top of the shaft shall be provided with a removable aluminum pole cap. The shaft shall have no longitudinal welds. After fabrication, the shaft shall be cleaned to a satin finish and wrapped for protection during shipping and handling.

b. Single Longitudinal Welded

The material for these light poles shall be round, tapered structural marine aluminum sheet in accordance with ASTM B209, alloy 5086-H34, and of sufficient diameter and wall thickness to withstand the design loads. The minimum wall thickness for poles on breakaway couplings and steel slip bases shall be 0.219 in. Poles on transformer bases or shoe anchor bases installed with no breakaway devices are exempted from the minimum wall thickness requirement. The anchor base shall be one-piece cast aluminum in accordance with ASTM B26, alloy 356.0-T6. The base casting for the formed and welded shaft shall be designed to be inserted a minimum of 12 in. into the shaft and bonded to the shaft with a weatherproof structural epoxy adhesive that fully develops the required strength as specified by the design criteria. After fabrication, the shaft shall be cleaned to a satin finish and wrapped for protection during shipping and handling.

3. Galvanized Steel Light Poles

The pole and base plate shall be fabricated from steel in accordance with ASTM A572, A595, or A1011 with a minimum yield strength of 50,000 psi. Single member mast arms and the upper members of truss type mast arms shall be fabricated from steel in accordance with ASTM A572 or A595 with a minimum yield strength of 50,000 psi. The lower member of truss type arms may be fabricated from standard steel pipe in accordance with ASTM A53 with a minimum yield strength of 36,000 psi. After fabrication, the pole and mast arm shall be thoroughly cleaned and galvanized in accordance with ASTM A123.

Steel poles shall be tapered 0.14 in./ft and shall be round, octagonal, or dodecagonal. The design load shall be used to determine the pole diameter and wall thickness. Design calculations stamped by an Indiana registered professional engineer shall be submitted with the working drawings. The pole shall have one longitudinal electrically welded joint. A steel base plate shall be welded to each pole and provided with four slotted holes for the anchor bolts.

All welds on steel poles shall be performed at the factory. Base plate welds shall be 100% penetration. Circumferential welds shall be backed-up welds with 100% penetration. Longitudinal welds shall be a minimum of 60% penetration. The 100% penetration welds shall be ultrasonically inspected and all other welds shall be inspected by magnetic particle. Welding shall be performed in accordance with 711.32.

4. Timber Light Poles

Timber poles for highway light pole shall be in accordance with 922.10(b).

5. Frangible Breakaway Bases

All light poles, except high mast towers, those protected by bridge end bents or retaining walls, and those placed along sidewalks, pedestrian pathways, and bicycle pathways shall be installed on breakaway devices. All breakaway devices on a contract shall be of the same type and manufacturer.

Breakaway devices shall be in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals as modified in 920.01(a)1.

A certification from the manufacturer shall be furnished with the shop drawings stating the breakaway devices conform to the breakaway criteria of the AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

a. Cast Aluminum Transformer Base

The anchor bolts for transformer bases shall be in accordance with 920.01(a)7. The anchor bolt circle for transformer bases shall be 15 in. The bolt holes in the transformer base may be slotted. The pole shall be bolted to the transformer base with four 1 in. diameter galvanized steel bolts.

An approved handhole in the transformer base may be substituted for the 4 in. by 8 in. handhole specified in 920.01(a)1.

b. Breakaway Coupling

Breakaway couplings may be used with aluminum poles with mounting heights up to 50 ft and with steel poles that weigh 600 lb or less. The couplings shall be furnished with necessary hardware including a two-piece cover. Couplings shall be installed in accordance with the manufacturer's instructions and recommended clearance between the top of the foundation and the bottom of the breakaway coupling.

6. Anchor Bolts

Anchor bolts shall be 1 in. with 8NC rolled threads in accordance with ASTM A307. The minimum length of threads shall be 6 in. Mean diameter of rod stock shall be 0.918 in. ±0.011 in. and out-of-round tolerance shall be ±0.012 in. The top 10 in. of the bolt shall be galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. Anchor bolts shall be in accordance with 910.19(b). The bolts shall be a minimum of 36 in. in length for poles 8 in. outside diameter or less and 48 in. in length for poles 9 in. or 10 in. outside diameter. In addition to the minimum length, the bolt shall have a 4 in. right angle bend at the unthreaded end. The anchor bolts in bridge structures shall be as shown on the plans.

(b) High Mast Towers 60 ft and Over

The high mast pole, base, anchor bolts, lowering device, installed fixtures, and associated appurtenances shall be designed to withstand a minimum wind speed of 120 mph using applicable design criteria in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals. Minimum design criteria for high mast tower heights from 60 ft to 120 ft shall be an effective projected area of 14.70 sq ft and a weight of 740 lb to account for 6 luminaires and a 6 place lowering ring. Criteria for high mast tower height from 125

ft to 200 ft shall be an effective projected area of 26.70 sq ft and a weight of 1,065 lb to account for 12 luminaires and a 12 place lowering ring. If larger fixtures are used, the actual size and weight shall be used in the design of the pole.

The Contractor shall be responsible for the accuracy of the dimensions and the proper fit of all material and equipment furnished with the pole. The Contractor shall provide all applicable manufacturers' warranties for material and workmanship. External lowering devices shall be designed to attach to the pole as shown on the plans. The pole shall include the mounting accommodations as shown on the plans.

1. High Mast Poles

The poles shall be tapered shafts having poly-sided or circular cross sections. The pole shaft sections shall be slip fitted and shall provide at least 1 in. radial clearance from all interior devices.

All tower shaft components shall be fabricated from high strength, low alloy, steel in accordance with AASHTO M 270; ASTM A595, grade A or B; ASTM A572, grade 55; ASTM A1011; ASTM A606, or ASTM A656, with a minimum yield strength of 50,000 psi.

Sections which are slip fitted shall have slip joints with a minimum overlap of 1.5 times the diameter of the bottom of the upper section at the slip joint. Towers having slip joint construction shall be match marked at the factory and shall be shipped disassembled for assembly at the work site. Slip joints shall be marked to ensure that the 1.5 times diameter insertion is provided.

All steel used in the base plate and shaft shall meet an impact property of 15 ft·lb at 40°F in the longitudinal direction using the Charpy V-Notch test. This shall be an average of three tests per mill heat with no test below 10 ft·lb. A copy of the certified mill test reports for this steel and the Charpy V-Notch test results shall be submitted. Sufficient information shall be furnished to demonstrate that this material is traceable to the mill heat number shown on the test report.

All tower shaft hardware including hardware for the handhole door, and the latch mechanism shall be stainless steel in accordance with ASTM A276, type 304 or 305, except where otherwise specified.

After fabrication, the pole shall be cleaned and galvanized. Galvanized steel towers, including the handhole, handhole door, base plate, mounting plate, and all other elements welded to the shaft shall be hot-dip galvanized in accordance with AASHTO M 111 or ASTM A123.

2. Welding

The welding symbols and all information regarding location, type, size, welding sequence, and welding procedure specifications shall be shown on the working drawings.

Welds shall be smooth and cleaned of flux and spatter in accordance with AWS procedure. Minimum preheats for welds shall be 100°F for seams, and 225°F for circumferential welds.

All welds shall be performed at the factory. Circumferential welds shall be backed-up welds with 100% penetration. Longitudinal welds shall have a minimum of 60% penetration except within 2 ft of either side of the circumferential joint, the welds shall be backed-up and of 100% penetration. Base plate welds shall be 100% penetration. Circumferential welds and 100% penetration longitudinal welds shall be 100% ultrasonically inspected. The 60% penetration longitudinal welds shall be 100% ultrasonically or radiographically inspected for soundness. Welding shall be performed in accordance with 711.32. Weld filler shall provide Charpy V Notch equal to or greater than 20 ft·lb at 0°F.

a. Inspection

The manufacturer shall provide quality control, QC, inspection. The inspector shall be an AWS CWI, in accordance with AWS D1.1. The NDT inspector shall be an independent non-destructive-testing inspector, certified as level II in RT, UT, or MT, or all as applicable. Copies of the inspection reports and NDT reports shall be provided to the Engineer.

The method for testing full penetration and partial penetration welds by the independent welding inspector shall be the same as specified above.

b. Blank

3. Handholes

Openings for handholes shall be reinforced to maintain the design strength of the pole. The handhole shall have a weatherproof gasket made of neoprene or silicone rubber. The gasket shall be formed for a forced fit around the handhole or be attached by mechanical means. The door and hinges shall be the same type steel as the poles. The hinge pins and other securing hardware shall be stainless steel and tamperproof. The door shall be fabricated to allow for a padlock, which is not included in the hardware. The hasp used for padlocking shall be fabricated from stainless steel. Provisions shall be made to bolt the door securely shut. The door shall include a bugproof and weatherproof aperture with a minimum opening of 4 sq in. Nylon or non-corrosive screens, or other approved methods of bug proofing shall be furnished. Two bonding plates shall be furnished which are accessible through the pole handhole for connecting the ground wires. A connection shall be furnished for an additional ground wire on the outside of the pole near the base plate.

4. Luminaire Ring Assembly

The ring shall be fabricated from ASTM A666, type 304 stainless steel and shall have a removable raceway cover. The ring shall be fabricated as an enclosed wire

raceway to provide for the symmetrical mounting of the luminaires. All structural connections shall be made with bolts and nuts.

The luminaire ring shall be supported by means of stainless steel aircraft cables of seven strands with 19 wires per strand with a minimum breaking strength of 3,700 lb.

Luminaire rings shall be provided with either 6 or 12 - 2 in. diameter pipe fittings for luminaire attachment. The number of luminaires and their positions on the ring will be shown on the plans. Counterweights that provide an even weight distribution shall be installed on pipe fittings where luminaires are not shown.

5. Head Frame Assembly

The head frame shall be made of ASTM A666, type 304 stainless steel. All required pulleys, rollers, or sheaves and shafts shall be constructed from non-corrosive metallic materials. No component shall be used in the lowering device in excess of its rating or in violation of the component manufacturer's recommendation. This requirement shall be applicable, but not limited to, the compatibility of the cables and sheaves. There shall be three supports for the suspension cables. A roller system or one compatible sheave for the power cable shall be located mid-point between two of the suspension supports. To prevent the cables from riding out of the grooves, cable guides shall be provided. The suspension cable sheaves shall have a minimum pitch diameter of 3 1/2 in. and the power cable sheave or individual rollers in a roller assembly shall have a minimum pitch diameter of 18 1/2 in. and shall be grooved to fit the power cable.

All components at the top of the pole shall be protected from the weather by a dome fabricated from steel in accordance with 920.01(b)1, fiberglass, or spun aluminum.

The dome shall be secured to the head frame assembly with at least eight fasteners around the perimeter of the dome. The dome shall be reinforced at the points of attachment and it shall be fitted to the head frame assembly so that no visible distortion occurs to the dome when it is properly installed. The dome attachment shall be designed to withstand pole vibration, other pole movement, and the design windload. The fiberglass dome shall be made of material that is not subject to cracking or other deterioration because of aging.

6. Winch Assembly

The winch cable shall be 5/16 in. diameter galvanized steel aircraft cable of seven strands with 19 wires each strand with a minimum breaking strength of 9,800 lb.

The winch shall have a drum with a minimum diameter of 4 in. and drum flanges with a minimum diameter of 8 in. The drum shall be supported at each end by a rigidly mounted, permanently lubricated, bearing capable of carrying the design load. The winch drum shall be designed to allow the cable to lay in even consecutive layers.

The winch shall be driven by a self locking, worm gear reducer. The gear reducer shall be permanently lubricated and totally enclosed in a cast aluminum or cast iron housing. The winch assembly shall be powered by an external drive system.

7. External Drive System

The external drive system shall be powered by a heavy duty reversing NEMA frame motor with an electromagnetic friction breaking mechanism rated at a minimum of 6 ft·lb of torque per motor horsepower (746 W). The brake shall be actuated each time the power to the motor is interrupted. The breaking mechanism shall be an integral part of the motor housing. The motor operated drive shall have a factory set torque limiter or clutch. This clutch assembly shall be calibrated to position the ring at the top of the pole and not exceed 80% of yield strength of the cable.

The external drive system shall operate with the 240/480 AC volt power available at the pole or incorporate a transformer into the system. The external drive system may use either the luminaire power plug or a separate outlet with a 600 volt, 30 ampere rating. The external drive system shall be operated from a minimum distance of 25 ft from the pole. The control voltage for any handheld control equipment shall not exceed 120 volts. The handheld control equipment shall be shock proof.

The external drive system shall be capable of operating all high mast pole installations. Working drawings shall be furnished in accordance with 105.02 and shall include the dimensions and the wiring diagram of the standard connections of the external drive system. The external drive system shall be mounted on a two-wheel cart with wheels at least 12 in. in diameter and the weight shall be distributed so that it presents a balance load.

8. Cable Terminator

The three luminaire ring support cables shall be attached to three stainless steel helical compression springs incorporated into the cable terminating device. These springs shall be designed to compensate for inequalities in the cable lengths and to maintain adequate tension on the support cables through pole and cable thermal expansion and contraction.

The cable terminator shall incorporate a separate eye bolt on the bottom of the device for the attachment of a cable or chain to hold the luminaire ring in a raised position while the winch cable or winch assembly is being inspected or repaired. The cable terminating device shall be designed to prevent the device from catching on the slip joint of the structure.

9. Lightning Rod Assembly and Grounding System

The lightning rod, air terminal, shall shield the head frame assembly cover and the outer edge of the luminaires within a 45° electrostatic shielded cone. The grounding system shall include bonding plates, grounding clamps, four copper weld grounding rods, a grounding conductor, air terminal, lightening rod, and other

incidental connectors. All hardware shall be stainless steel, brass, copper, copper alloy, or equally corrosion-resistant metal.

Bonding plates, with a minimum contact surface area of 8 sq in., shall be installed at locations shown on the plans. The bonding plates shall be welded to the tower shaft during the time of manufacturing. The grounding conductor shall be secured to the bonding plates by a two-bolt pressure plate clamp connector having a minimum of 4 in. of contact with the copper. At the point of termination, the grounding conductor shall extend beyond the bonding plate a minimum of 3 in.

Each ground rod clamp shall have a minimum of 1 1/2 in. of contact between the grounding conductor and the ground rod. The grounding conductor shall be continuous between the bonding plates inside the tower shaft handhole and the grounding rod termination point.

Bends of conductors shall form an angle of 90° or more. Unsupported conductors shall have a radius of bend 8 in. or greater.

10. Anchor Bolts

Anchor bolts for high mast poles shall be furnished in a pre-clustered form and shall be a hooked deformed reinforcing bar or a hooked smooth bar. The bolts shall be in accordance with ASTM A615 modified to a minimum yield strength of 75,000 psi. The top 12 in. of each anchor bolt, nut, and washer shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM B695, class 55.

(c) Wire and Cable

Lighting circuit cables for direct burial shall be enclosed in polyethylene conduit.

1. Polyethylene Conduit

This conduit shall be in accordance with ASTM D3485 either medium density type II, class C or high density type III, class C smooth wall, coilable polyethylene conduit for preassembled wire and cable. The diameter of the conduit shall be 1 1/4 in for the standard 4-No. 4 conductor cable.

2. Conductors in Cable-Duct

The cable shall consist of four separate electrically insulated conductors installed in the duct so any one conductor may be easily removed without damage to the other two. The conductors shall not be cabled or twisted together. The conductors shall be stranded copper of the No. 4 AWG size. Conductors shall be stranded in accordance with ASTM B8, class B.

Each conductor shall be insulated with crosslinked polyethylene manufactured in accordance with Insulated Power Cable Engineer Association standard WC 70/ICEA S-95-658-1999, Nonshielded 0-2kV Cables. Each conductor shall have the following

characteristics: a 600 volt rating; UL listed; an XHHW conductor temperature rating not to exceed 90°C in dry locations; and not to exceed 75°C in wet locations.

Each of the four conductors shall be imprinted at regular intervals with the following description: Type XHHW; 600 volt; UL; the conductor's AWG size and metal or alloy; the manufacturer's name, trademark, or other distinctive marking by which the product can be readily identified.

Identification coding of the conductors shall be accomplished by complete color coding. Color coding of the insulation shall be homogeneous throughout the entire depth and length of the jacket. The colors shall include one black, one white, one red, and one green.

3. Light Pole Circuit Wiring

This wiring shall consist of two 1/C No. 10 AWG, 600 volt, THWN or MTW insulation, stranded copper wire.

4. Sign and Underpass Wiring

The wiring from the switch box to the last luminaire shall be 3/C copper stranded No. 10 AWG conductors and shall have imprinted at regular intervals along the length of the insulation jacket the following designation: No. 10 AWG, type MTW or THWN, or Gasoline and Oil Resistant II or AWM, 600 volt, UL. The conductor classifications shall be UL listed and have the following minimum temperature ratings: MTW 90°C; THWN 75°C; and AWM 105°C. It shall be installed in 3/4 in. conduit between the breaker box and luminaires.

5. Aerial Cable

This cable shall be triplex secondary distribution cable consisting of two insulated conductors and a steel reinforced bare copper messenger neutral. The insulated conductor shall be No. 6 AWG stranded copper with 600 volt, XHHW-XLP type insulation.

6. High Mast Tower Luminaire Ring Conductors

The wiring from the terminal box on the ring through the last luminaire shall be in accordance with 920.01(c)4.

7. Power Cable-High Mast Tower Poles

The power cable shall be a 4/C No. 10 AWG copper insulated electrical cable type "SO" modified for a repetitive reeling operation. It shall be in accordance with ASTM B3, ASTM B173, and IPCEA S-19-83. Conductor insulation shall be in accordance with ASTM D1693 and IPCEA S-19-81, Paragraph 3.12. The sheath or jacket shall meet or exceed IPCEA S-19-81, Paragraph 7.6.20.1.1. Conductors shall be color coded.

The power cable shall have a heavy-duty 600 volt, AC 30 amp rated electrical plug capable of disconnection in a safe manner under load conditions. The electrical

plug shall be moisture resistant and waterproof at both transition points.

8. Electrical Connectors

Connectors shall be a compression type of the proper size with only one conductor per groove in the fitting. They shall be designed specifically for use on aluminum and copper conductors, prefilled with an oxide inhibitor and installed with a hydraulic tool according to the manufacturer's specifications. After installation, the connectors shall be fully insulated and weatherproofed. The connectors installed in underground handhole shall be taped and then waterproofed as shown on the plans.

(d) Luminaires

Underpass, Roadway, and High Mast models shall be selected from the QPL of Luminaires.

1. General Requirements

Luminaires shall be compatible with the lighting materials specified in this section and in the plans. Luminaires, including primary fuse protection, surge protection devices, power drivers, and other major components, shall be rated for a minimum operational life of 50,000 hours at 77°F.

Luminaires shall be a single, self-contained device, not requiring on-site assembly for installation. Connectors shall be crimp or cage-clamp type.

All internal components shall be adequately supported to withstand mechanical shock and vibration. Luminaires shall be tested in accordance with ANSI C136.31, 2G loading or ANSI C136.31, 3G loading for luminaires on bridges. Testing about all axes shall be accomplished with a single luminaire.

Luminaires shall include gasketing that will completely seal out dust, moisture, and insects from the interior of the optical assembly and retard the formation of an undesirable film from gaseous vapors on the interior of the optical assembly. The optical assembly shall be rated at IP 66 or better in accordance with ANSI/IEC 60529 while power drivers, and surge protection devices shall be rated at IP 65 or better.

Light sources supplied for luminaires shall be electrically compatible with the luminaires. Luminaires shall include an integrally built in power driver. The luminaire shall operate satisfactorily in temperatures from -40°F to 122°F with an input voltage variation of ±10% of the rated operating voltage specified. Power consumption, wattage, shall not exceed that which is shown on the plans. The luminaire power factor shall be 0.9 or greater. The power driver, or combination of power drivers if more than one is used in the luminaire, shall have a Mean Time To Failure, MTTF, of 1,000,000 hrs as determined by Telcordia SR 332, Issue 3 or MIL-HDBK-217F methodology. The MTTF estimate shall be of the driver as a complete and functioning unit. Total Harmonic Distortion, THD, of the power driver shall not exceed 20% as verified by ANSI C82.77.

Roadway lighting luminaires shall have a precision-cast aluminum housing with weatherproof finish.

Refractors or lenses shall be scratch resistant and made from high impact, heat-resistant, glass or UV inhibited, high impact polycarbonate plastic. If utilized, reflectors shall be detachable and made of highly specular aluminum.

Luminaires shall have seven wire photocontrol receptacle in accordance with ANSI C136.41 with shorting cap for adaptive lighting control.

Luminaires shall exhibit a color temperature in the range of 3500K to 4500K per ANSI C78.377 and a minimum Color Rendering Index of 70 as verified by the IESNA LM-79 test.

A Surge Protection Device, SPD, shall be included to protect the luminaire from damage and failure from transient voltage and currents. The SPD shall conform to UL 1449 and shall be tested in accordance with, and survive, the procedure in ANSI/IEEE C62.41.2 definitions for standard and optional waveform for location category C-High. Once the surge current has subsided, the SPD shall automatically restore normal operation and reset to a state ready to receive the next surge.

Luminaires shall comply with Title 47 CFR Part 15, Class A on unlicensed transmissions in a business, commercial, or industrial environment.

Underpass and post top mounted luminaires shall be protected against salt spray and conform to ASTM B117, 2,000 hrs time horizon.

Luminaires shall include vandal shields when installed on an underpass or signs on bridge brackets and when otherwise specified. The vandal shield shall be made of a tough durable plastic, such as Lexan, mounted in a rugged galvanized steel or aluminum frame, and shall withstand severe impact without being damaged or allowing the refractor to be damaged. It shall be fastened securely to the luminaire so it cannot be removed from the outside and shall not interfere with the light distribution pattern. It shall protect the face of the refractor and if ventilation is necessary, the ventilating apertures shall be arranged so that they do not admit a probe of a diameter greater than 1/4 in.

Luminaire shall be aimable toward the required direction.

a. LED Luminaires

LEDs shall be connected so that the loss of one LED will not result in the loss of the entire luminaire. LED circuitry shall prevent flickering to the unaided eye at the voltage specified on the plans and the range indicated herein.

LEDs shall deliver a minimum of 85% of the initial rated lumens after 50,000 hours of operation at 130°F ambient temperature as indicated by LM-80 lumen

maintenance test of the light source as calculated by IESNA TM-21, L85 > 50,000 hrs.

A passive thermal management system to dissipate the heat generated by operation shall be provided. Fans or other mechanical cooling systems shall not be used. The thermal management system shall maintain temperatures during the operation of the luminaire to be within the limits established by the Power Driver Lifetime and LM-80 testing.

b. Light Emitting Plasma Luminaires

Plasma emitters shall deliver a minimum of 70% of the initial lumens after 50,000 hrs of operation.

c. Metal Halide Luminaires

Metal halide luminaires shall utilize a power driver; external capacitors or igniters shall not be used. Metal Halide lamps used in high mast luminaires shall be supported at both ends with mechanical spring grips or other means to hold the lamp secure against vibration.

2. Roadway Lighting Luminaires

Roadway luminaires shall have a strong, easily operated, positive latch on the street side of the housing with a hinge and a safety catch that prevents accidental unhinging on the house side of the refractor or lens holder. They shall include a four bolt slipfitter capable of adapting to a 2 in. mounting bracket that is adjustable ±5° for leveling.

Luminaires shall be adjustable in the horizontal and vertical directions to meet the specified IESNA light distribution pattern. Luminaire weight shall not exceed 53 lb and its projected area shall not exceed 2.4 sq ft.

3. Sign and Underpass Luminaires

Sign and underpass luminaires shall be LED and operate on no more than 150W of power. Sign luminaires shall have a shield that blocks the view of the refractor from an approaching motorist. This shall be accomplished by the design of the housing or by a shield fabricated from sheet aluminum, approximately 0.05 in. thick, and of sufficient size to be fastened onto the horizontal edge of the refractor holder with self tapping screws and placed between the refractor and approaching traffic.

Aluminum and steel structural members for luminaire supports shall include aluminum conduit, conduit clamps, fittings, and stainless steel screws.

(e) Circuit Breakers and Enclosure

All circuit breaker enclosures shall be NEMA 4/5.

1. Circuit Breakers for Type II Service Point

The cabinet and hardware shall be weatherproof and rain tight. The enclosure shall have provisions for pad locking. The fastener and mounting hardware shall be plated

brass, stainless steel, or aluminum. The enclosure shall be made of 14 gauge aluminum or 14 or 16 gauge stainless steel. The circuit breaker operating handles for manual tripping shall be concealed inside the enclosure. Computation of branch circuits shall be based on the National Electrical Code Standard Limitation of loading breakers to 80% of their rated current. Additional details shall be as shown on the plans.

2. Circuit Breakers for Sign and Underpass Circuits

Sign and underpass circuit protection shall be provided by two single pole, 240 volt AC, 120 volt for 120/240 volt service, circuit breakers with ampere rating of 200% of the normal load. The circuit breakers shall have provisions for padlocking externally. The circuit breaker operating handles for manual tripping shall be concealed inside the enclosure. The enclosure shall be made of aluminum or stainless steel. Additional details shall be as shown on the plans.

3. Circuit Breakers for High Mast Towers

The enclosure shall be furnished with two single pole, 30 ampere, 480 volt AC circuit breakers with a minimum symmetrical RMS interrupting capacity of 14,000 amperes. The breakers shall be accessible through the pole handhole. The circuit breaker operating handles for manual tripping shall be external to the enclosure. The enclosure shall be made of aluminum or stainless steel. Additional details shall be as shown on the plans.

4. E-Series Magnetic Circuit Breakers

These breakers shall have the following features.

a. capable of 10,000 on-off operations;

b. interrupting capacity of 7,500 amperes;

c. temperature stable so as not to be adversely affected by temperature changes over their operating environment of -40°F to 185°F;

d. lug range 1/0 - 14 copper and 1/0 - 12 aluminum; and

e. trip on overload, even when handle is forcibly held in the ON position.

(f) Multiple Relay Switches with Photocell Receptacles

Multiple relay switches with photocell receptacles shall have a two-pole relay for connection to a 120/240 or 240/480 volt, three-wire, single phase, 60 Hz power supply. The relay switch components shall match the service voltage being supplied. The unit shall contain two single pole circuit breakers with a minimum rated capacity to withstand 100% of the rated ampere load. The circuit breakers shall trip at not less than 125% of the rated load capacity. Control circuit arresters for lighting protection and a manual control selector switch shall be included within the unit. The enclosure

shall be a cast aluminum weatherproof case, with a hinged cover, having provisions for padlocking and a hanger for pole or wall mounting.

(g) Materials Certification

A type C certification in accordance with 916 shall be provided for the materials in this section unless otherwise specified.

(h) Junction Box

The junction box shall be polymer concrete, of concrete-gray color, with a cover rating of 20,000 lb.

(i) Handholes

Handholes shall be in accordance with 922.17 except the cover shall be with the logo imprint of "LIGHTING".

SECTION 921 – PAVEMENT MARKING MATERIALS

921.01 Blank

921.02 Durable Marking Material

Durable marking material shall be thermoplastic, preformed plastic, or multi-component pavement markings. The materials shall not contain any toxic heavy metals above the limits of the regulatory levels of 40 CFR 261.24, table 1, when tested in accordance with EPA TCLP, or contain any other material which will require characterization as a hazardous waste when removed from the pavement surface.

(a) Thermoplastic

This material shall be in solid form in accordance with AASHTO M 249 or supplied in a preformed state and shall not contain lead chromate pigments.

Heat bonded preformed thermoplastic shall be in accordance with AASHTO M 249 with the exception of the application properties outlined in section 5 of AASHTO M 249 shall not apply. Drying time and short term and long term flowability requirements are not applicable at time of installation. The material shall be capable of fusing to itself and previously applied thermoplastic pavement markings when heated. The material shall contain a minimum of 30% beads by weight. The beads shall be homogeneously blended throughout the material. The marking thickness throughout its width, before the material is heated, shall be supplied at a minimum average thickness of 90 mils.

(b) Preformed Plastic

This material shall consist of a homogeneous preformed plastic film with a width as specified. Dimensional requirements shall meet one of the following:

1. Preformed plastic material shall have a smooth plane surface,

with a minimum thickness of 60 mils throughout the entire cross section, or

2. Preformed plastic material shall have an embossed patterned surface with 35% to 65% of the surface area raised. The edges of the raised areas shall present a near vertical face to traffic from any direction. The minimum thickness of the raised area shall be 60 mils. The area between the raised areas shall be a minimum of 20 mils measured at the thinnest section of the cross section.

The material shall have a precoated adhesive. The adhesive shall allow the preformed plastic material to be repositioned on the pavement surface to which it is applied before permanently fixing it in its final position with downward pressure.

The material shall be capable of being affixed to either HMA or PCCP by means of the precoated adhesive and, following the initial application of pressure, shall mold itself to pavement contours, breaks, and faults by traffic action at normal pavement temperatures.

The near vertical faces of patterned preformed plastic shall be coated with a layer of beads.

A type C certification in accordance with 916 shall be provided for the marking materials except materials used for temporary pavement markings.

1. Packaging

Each package shall be marked to indicate the color of the material, specific symbol or word message, the batch number, the manufacturer's name, address, and the date of manufacture.

2. Basis For Use

A type C certification in accordance with 916 shall be provided for the performed plastic material.

(c) Multi-Component

The material shall be for use on both HMA and PCC pavements. The material shall consist of a pigmented resin system of epoxy. The multi-component pavement markings shall be ultra-violet light resistant and shall not darken during the heating conditions of application, chalk, crack, show appreciable degradation or discoloration due to sunlight exposure and aging of the markings. The cured multi-component pavement markings shall be impervious to salts, grease, oil, fuels, acids, alkalies, and other common chemicals that may be found in or on HMA and PCC pavements. The pigment in the white material shall contain titanium dioxide in accordance with ASTM D476.

The material shall be provided in containers, which are in accordance with current Federal DOT regulations. Each container shall be labeled in accordance with 29 CFR 1910.1200 and include the trade name or trade mark, formulation or product identification, date of manufacturer, color, batch or lot number, component identification, and mixing instructions.

A type C certification in accordance with 916 shall be provided for the multi-component pavement marking material.

(d) Snowplowable Raised Pavement Marker and Cast Metal Base

Snowplowable raised pavement marker shall consist of a cast metal base to which is attached a replaceable prismatic reflector for reflecting light longitudinally along the pavement from a single or from opposite directions. Both ends of the casting shall be shaped to deflect a snowplow blade upward.

The prismatic reflectors and cast metal bases shall be in accordance with ASTM D4383. Only prismatic reflectors and cast metal bases from the QPL of Snowplowable Raised Pavement Markers shall be used.

1. Epoxy Adhesive

The epoxy adhesive shall be in accordance with AASHTO M 237, type IV, Table 3 with respect to composition and performance. A type B certification in accordance with 916 shall be provided for the epoxy material. The limits of the following shall be shown on the certification.

Property	Test Standard
Chemical composition	AASHTO M 237
Density	AASHTO M 237
Gel time	AASHTO M 237
Percent air	AASHTO M 237
Bond strength	AASHTO M 237

2. Blank

(e) Pavement Marking Beads

A type C certification in accordance with 916 shall be provided for the pavement marking beads.

1. Standard Beads

Beads shall be glass in accordance with AASHTO M 247, Type 1. The beads shall have a moisture resistant coating.

2. Modified Standard Beads

The modified standard beads shall be glass in accordance with AASHTO M 247, Type 2. These beads shall have a moisture resistant coating and may have an adhesion

promoting coating.

3. Supplemental Beads

The supplemental beads shall be glass in accordance with AASHTO M 247, Type 4 except the beads shall have a minimum roundness of 80% by weight.

These beads shall a have a moisture resistant coating and may have an adhesion promoting coating.

4. Supplemental Elements

These shall be for color, skid resistance, or wet weather retro-reflectivity and may be used provided they do not exhibit a characteristic of toxicity referenced in AASHTO M 247. A type D certification in accordance with 916 shall be provided for the supplemental elements.

SECTION 922 – TRAFFIC SIGNAL MATERIALS AND EQUIPMENT

922.01 Description

Unless otherwise specified, traffic signal materials and equipment shall be in accordance with the NEMA TS2 2003 Standards Publication, and be compatible with the Department's current inventory of signal equipment.

922.02 Traffic Signal Control Equipment

Models shall be selected from the QPL of Traffic Signal and ITS Devices, unless otherwise specified.

(a) Model Approval

Each model of controller assembly, CA, and all major units, as defined in NEMA TS2-2.1.1, will be tested and evaluated by the Department's Traffic Management Division, and approved prior to use. The CA, as defined by NEMA TS2-1.1.7, as being a complete electrical unit, shall include major units operational in a TS2 environment. Major units of the CA are defined as controller unit, CU; malfunction management unit, MMU; bus interface unit, BIU; cabinet power supply; load switches; vehicle detector equipment; cellular modems; radio modems, and flasher. The evaluation of a product will be considered when the Department receives the preliminary product evaluation submittal form. The Department will advise the manufacturer or vendor of the date of delivery. At the time of delivery, a presentation of the product will be required accompanied by the product brochure, the operational manual containing procedures for all features incorporated in the CU's design, and the maintenance manual containing all schematics, pictorial parts layouts, components parts listings, and documented theory of operation. Certification in accordance with 922.02(d) shall also accompany the preliminary product evaluation form. If a product has TS2 communicative capabilities, then a data analysis interpretation offered in a decimal form expressing frames by an SDLC protocol analyzer shall accompany the initial documentation as well. When accuracy of documentation is validated, the evaluation

period may commence. In addition, all computer system software applicable to a manufacturer's product shall work with the Department's current operating systems so that upgrades will not be needed to recognize the full potential of the product. Any product under evaluation that has an operational failure occurring during the bench test procedure will be rejected and returned to the submitter. The product will not be considered for future evaluation without a cover letter documenting failures encountered and changes to the design to correct the failures. A presentation by the manufacturer of the product in question and explanation of why the product failed will be required. Resubmittal of the original product will be expected for testing, evaluation, and approval. Furthermore, two more rejections of a product submitted for evaluation will be cause to deny approval of that model permanently.

The controller model shall be fully NTCIP 1202 compliant, and be capable of logging time-stamped controller event data at 100 ms resolution. The events collected shall be logged in the Department specified data file format and shall include but are not limited to, start and termination of all phase green, amber, and red, pattern changes, and all detector actuations and terminations. Data log file shall be accessible for standard FTP retrieval directly from the controller model's internal FTP server via the IP addressable RJ-45 Ethernet port.

Continued failures indicative of a trend, repeated random malfunctions, or NEMA non-compliance of a qualified product shall be cause to remove that model from the QPL of Traffic Signal and ITS Devices. If the manufacturer makes any changes to a qualified model of a major unit or controller cabinet terminal/facilities to correct a non-NEMA compliant or safety issue, the Department shall be notified immediately. The manufacturer shall correct all existing equipment purchased by the Department either directly, by contract, or through agreement prior to the change being incorporated at the manufacturer's production level.

A design change to a qualified model of a CA or any major unit shall require a submittal of documented changes. At the discretion of the Department, resubmission of the model for testing, evaluation, and approval may be required. The permanent addition or removal of component parts or wires, printed circuit board modifications, or revisions to memory or processor software, are examples of items that are considered to be design changes.

(b) Controller Assemblies or Major Units Furnished and Installed by the Contractor

A CA, as defined by NEMA TS2-1.1.7, shall be provided by the Contractor and shall be built to the specifications of the intersection design.

Each CA shall be supplied with three documentation packets. The documentation shall be provided in both paper hard copy and electronically as specified for each document. Each packet shall consist of:

1. One complete set of wiring and schematic diagrams for all of

the CA's panels, racks and wiring. The electronic document shall have a minimum of one indexed page for each paper sheet.

2. A parts list indicating contract number, vendor, category, manufacturer, model, serial number, software/firmware version as applicable, and inventory number of all major units incorporated in the CA. The electronic document format and the blank worksheet shall be obtained from the Department's Traffic Management Division.

3. An 11 by 17 in. intersection design plan.

4. A completed Department approved loop tagging table. The electronic document format and the blank worksheet shall be obtained from the Department's Traffic Management Division.

5. Packet number 2 shall also include a paper hard copy and an indexed and searchable electronic format file of the instructional programming manual identical in nature to that approved for use during the evaluation of each product and shall include a TS2 type 2 to TS2 type 1 adapter harness.

All electronic documents shall be submitted to the Asset Manager in the Department's Traffic Management Division. Each packet shall be labeled with the name of the intersection, the contract number, the commission number and the date of installation. Packet destinations shall be as per 805.08.

A 60-day burn-in period of traffic control equipment shall be required prior to acceptance of the contract. The Contractor shall be responsible for all costs associated with vendor or manufacturer warranty service until acceptance of the contract, or acceptance of that portion of the contract where the traffic control equipment is installed.

(c) Warranty

The manufacturer's or vendor's warranty shall be provided for the following components: all major units operating in a TS2 environment, light emitting diode, LED, signal indications, load switches, and flashers. Warranty periods shall commence from the date of field placement of the device or on the date of signal turn-on as shown on the IC 636A form if purchased through a contracting agent.

(d) Certification of NEMA TS2 Traffic Control Equipment

The following certifications shall be provided.

1. Certification of a Production Run Model

A certification representing each model of approved major unit of a CA shall be on file with the Department. A certification of a production run model for a CU will

be valid for a maximum period of five years from the date of approval or unless a significant change is made in the CU. If a significant change is made, a new certification shall be submitted. A significant change shall be the addition or deletion of any function or feature in the control unit, or any other change as defined in 922.02(a) to the circuitry in the product.

2. Certification of Environmental Testing

A certification shall be provided with each major unit approval request indicating it has been tested and is in accordance with the tests from NEMA TS2-2. The certification shall specify the model and serial number of the product being tested. A complete log of each test shall be provided to the Department and will be maintained by the Department. The log shall show which, if any, controller component failed during the test, when it failed, and what steps were taken to repair the controller. The log shall include the date of testing, name and title of person conducting the tests, a record of conditions throughout the tests, and a temperature and humidity verses time chart. The maximum report interval of any chart shall be 24 h. The chart shall be from a recording machine used to monitor the status of the environmental chamber during testing.

(e) NEMA TS2 Fully Actuated Solid State Controller Unit, CU

The following requirements are the minimum for the design and operation of a 16 channel fully actuated solid state CU. The NEMA TS2 configuration will consist of 2 types of CU's, type A1 and type A2, as defined in NEMA TS2-3.2.

The CU shall be in accordance with NEMA TS2 Standards, all provisions contained herein, and the Department's specifications. Manufacturer specific enhancements are acceptable. No function or device shall preclude the interchangeability of a CU with another CU of like NEMA specification within a controller assembly.

1. General Requirements

The CU shall be microprocessor based and both versions shall contain a three-port configuration and shall operate in the NEMA TS2 type A1 environment.

The CU shall include provisions for time-of-day programming. The CU shall be capable of a minimum of 50 programmed events and be in accordance with NEMA TS2-3.8.

A removable nonvolatile EEPROM module or removable serial, flash-based, non-volatile data module shall be utilized in each CU to maintain all programmed data. A real-time clock shall be either battery-backed or powered by a super capacitor and active during a power outage so as to provide complete time keeping functions and leap year corrections. A switch or other means shall be provided to turn off or disconnect battery power during storage. This shall be accomplished without physical removal of the battery. Batteries within the CU shall be turned off or disconnected during storage and shipment.

Programming and maintenance manuals for approved CU's shall be identical in nature to that approved for use during the evaluation period of the CU. The Department shall be notified of any changes to the manuals.

Serial number and model numbers shall be permanently applied on or near the front of circuit boards of the CU and viewable without removing or disconnecting the board. Serial number and model number of the main frame shall be permanently applied externally on top or on the front panel.

2. CU Requirements

The requirements set forth herein refer to a type A1 and A2 CU. Where differences occur between types, it will be designated.

The CU shall have, as a minimum, the internal diagnostics defined by NEMA TS2-3.9.3.

The CU shall monitor and log the status of events as specified in NEMA TS2-3.9.3.1.5 in non-volatile memory and shall be selectable via program entry and be retrievable by the system computer via NEMA port 2 or 3. In addition, the CU shall have the ability to log an MMU fault as it occurs. A minimum of 16 entries shall be stored in non-volatile memory. When capacity is exceeded, the oldest entry will be replaced by the newest. Logged entries shall at minimum contain the date and time denoted in military style with minute resolution, description of the fault as it would appear on the MMU, and the status of each of the channel inputs at the time the fault occurred, clearly denoting the presence of activity on a channel.

The CU shall be capable of all inputs and outputs listed by controller type in NEMA TS2-3. Pedestrian timing shall be provided on all phases of a CU. The CU shall be keyboard programmable to enable initialization in any color and phase. Initialization shall occur after a recognized power interruption, upon MMU reset, or upon return from manual or time-of-day flash. The CU shall be programmable from a closed loop computer system, a laptop computer using the RS232 port, front panel programming, and by downloading from another like CU through the RS232 port.

Keystroke buttons shall be clearly marked as to function. All programming buttons and indicators pertinent to the operation of a phase shall be on the front of the CU and shall have programmable phase omitting and phase skipping capabilities.

The TS2 type A2 CU shall be in accordance with all applicable requirements for a type A2 CU as defined by NEMA TS2-3 and shall contain a full complement of connectors.

The CU shall have an RJ-45 ethernet port on the front panel and ethernet module that provide 10/100 base T interface in half or full duplex and which supports auto-configuration of the link parameters.

3. Internal Modules

All plug-in modules shall be equipped for easy removal or installation without the use of tools and shall be readily accessible for maintenance. All internal module plugs and edge card plugs shall have the corresponding pin connector position labeled with the first and last numbers or the first and last letters.

4. CU Enclosure

The enclosure shall be of adequate strength to protect the components during normal handling. The keypad, liquid crystal display and all interface connectors required for the operation and standard field adjustments shall be mounted on the front panel. Fusing shall be on the front panel of the CU and shall provide protection from internal or external overload.

The front panel of the controller shall be fastened to the frame such that no special tools shall be required to remove or replace printed circuit board modules or to gain access through the front panel. All hinges shall have stainless steel pins.

5. Firmware and Software Revisions

The Department's Traffic Management Division shall be notified each time an update or revision of the firmware or software is released and be provided with an explanation of the changes and the benefits of the change. The Department will determine if and to what extent a revision is to be placed into field operation and may fully re-evaluate the CU with the revision.

(f) NEMA TS2 Cabinet, Auxiliary Equipment, and Terminal and Facilities, TF, Requirements

These standards define the minimum requirements for a TS2 type A1 cabinet, both inside and out. The performance and construction of the cabinet shall be in accordance with the applicable requirements of NEMA TS2 sections 4, 5, 6, and 7. The serial number and model number of the auxiliary equipment shall be permanently applied externally on or near the front of the product. Programming and maintenance manuals for approved products shall be identical in nature to that approved for use during the evaluation period of the product. The Department shall be notified of all changes to the documentation. Manufacturer specific enhancements are acceptable, however no function or device shall preclude the interchangeability of an auxiliary product with another product of like NEMA specification within a controller assembly.

1. Controller Cabinet Requirements

The NEMA TS2 type A1 controller cabinet shall be in accordance with the following requirements.

a. General

The cabinet and the shelves shall be fabricated of aluminum. The cabinet shall be 1/8 in. minimum thickness sheet aluminum or 1/4 in. minimum thickness die-cast

aluminum. The cabinet exterior and interior including shelves shall have a sandblasted, roughened, or chemically etched finish that reduces gloss, reflection, and glare.

The main cabinet door shall use a Corbin lock No. 2 and each cabinet shall be furnished with two No. 2 keys. The lock shall open in a counterclockwise motion only. The door shall be capable of being opened and stopped in at least the following two ranges of degree opening as measured from the face of the cabinet door on the hinged side: 80 to 100°, and 170 to 190°. The door shall be hinged on the right side of the cabinet. The main door and the police panel door shall close against a weatherproof and dustproof gasket seal, which shall be permanently bonded to the cabinet. A standard police panel key shall be provided with each cabinet.

A rain channel shall be incorporated into the design of the main door panel to prevent liquids from entering the enclosure. A 1 1/2 in. deep drawer shall be provided in the cabinet, mounted directly beneath the controller support shelf. The drawer shall have a hinged top cover and shall be capable of accommodating one complete set of cabinet prints and manuals. This drawer shall support 50 lb in weight when fully extended. The drawer shall open and close smoothly. Drawer dimensions shall make maximum use of available depth offered by the controller shelf and be a minimum of 24 in. wide.

b. Switches, Auxiliary, and Environmental Feature Requirements

The cabinet shall have a police door and a police control panel within the main door. The police panel shall have three different switches, one switch for field indication cutoff, one switch for flashing operation, and one switch for Auto and Manual with a manual control jack to accept a 1/4 in. monaural phone plug jack. The switches shall be protected from water when the cabinet door is open.

A test switch panel shall be mounted on the inside of the main door. The test switch panel shall include, as a minimum, the following switches. An auto/flash switch shall be installed so that when in the flash position, power shall be maintained to the controller and the intersection shall be placed in flash. A stop time switch shall be installed so that when in the ‘On’ position the controller shall be stop-timed in the current interval. A controller equipment power On/Off switch shall be installed which shall control AC power to the CU, MMU, and cabinet power supply. All switches mounted on the switch panel on the inside of the main door shall have in place a mechanism to prevent accidental activation of the switch. “Locking bat” type switches or side switch guards are acceptable.

Switch guards, if used, shall be in place for each switch, shall be made of the same material as the cabinet, and shall enable the operation of the switch without the use of tools.

All switch functions shall be permanently and clearly labeled. Handwritten labeling will not be allowed.

The cabinet shall include all required wiring, connectors, and adapters to provide full compatibility and interchangeability with either a TS2 type A1 or type A2 controller.

c. Receptacle

The cabinet shall contain one duplex convenience outlet and a lamp receptacle that is actuated and turns on when the door is open and goes off upon closing of the door and an internal On/Off switch which can override the preceding. The convenience outlet shall be duplex, three-prong, NEMA type 5-15R grounding outlet in accordance with NEMA WD - 6, with ground-fault circuit interruption as defined by the National Electric Code. These units shall be protected with a 15-ampere cartridge fuse wired ahead of the multi breakers. An additional outlet shall be provided in each cabinet and shall be a duplex, three-prong, NEMA type 5-15R grounding outlet wired after the cabinet surge protection. This unit shall be protected with a 10-ampere cartridge fuse. The additional outlet in master cabinets shall be powered by the 10-ampere circuit breaker and through a separate power interrupt switch providing separate control of the master CU power supply.

d. Fan and Filter

The cabinet shall contain a thermostatically controlled ventilating fan and a vent with a commercially classified uniform 1 in. thick filter. The thermostat shall be manually adjustable from 90 to 115°F. The fan shall be mounted internally at the top and toward the front of the cabinet to exhaust out the front top lip of the cabinet. The fan shall be rated at a minimum of 100 cu ft per minute as designated by NEMA TS2-7.9.1. The thermostat shall be located within 6 in. of the fan.

The filter size shall be in accordance with the provisions for the type of cabinet as stated in NEMA TS2-7.9.2.3 and shall be a replaceable pleated air filter with a minimum efficiency reporting value, MERV, rating of 5 or higher as defined by the ASHRAE 52.2-2007 specification. The cabinet ventilation shall be in accordance with NEMA TS2-7.9. The diameter of circular openings for cabinet ventilation shall not exceed 3/8 in. The short dimension for slotted openings shall not exceed 3/8 in.

Each inductive device, including the fan, shall have a separate power surge protection.

2. Load Switch and Flasher Requirements

The cabinet shall contain a jack mounted type 3 solid state non-repairable flasher in accordance with NEMA TS2-6.3 electrical and physical dimensions.

The pedestrian load switch and the signal load switch shall be an approved unit meeting all electrical and physical dimension requirements in accordance with NEMA TS2-6. The load switch shall not use a printed circuit board to transmit the 115V AC line input or signal buss output. Each load switch shall offer three indicators, one for each circuit indicating the status of the input to the load switch.

The load switch signal outputs shall be brought to a separate terminal strip for hook-up of the signal displays. Load switches inputs shall be capable of being programmed for flash, overlap, vehicular, or pedestrian phases with the use of a standard slotted or phillips screwdriver via the cabinet terminal strip. The load switch input programming of the TS2 type A1 CU shall be accomplished through front panel data entry of a TS2 type A1 or a TS2 type A2 CU.

3. Terminal and Facilities Requirements

a. General Requirements

The TF layout shall be in accordance with NEMA TS2-5.2.7. The cabinet shall contain a main TF panel complying with NEMA TS2-5 standards. The model number of the main panel shall be permanently applied to the front of the panel, where it is easily readable, without removing or disconnecting the panel. Each controller input and output circuit shall terminate on the main TF panel or on a supplementary panel. The phase arrangement of the controller shall coincide with the channel arrangement of the load switches and MMU. All outputs on channels 9 through 12 field connections shall have a 1μF capacitor placed at each output terminal on the front of the TF panel. All TFs within the cabinet shall be readily accessible for field connection without removing the controller or associated equipment and for maintenance in the cabinet. All stranded wiring shall be tinned. A 24 volt relay shall be used on the TF to remove 24V DC from the common side of the load switches, effectively taking the mercury relay out of the circuit when the signal is put in mechanical flash. The TF panel shall be hinged at the bottom and capable of swinging down to allow accessibility of the wiring and terminals at the rear of the panel. The backpanel shall be attached to the cabinet such that access to the backside of the backpanel, for maintenance purposes, shall be accomplished without the use of special tools or removal of auxiliary panels, shelving, or other cabinet appurtenances. A bracket extending at least half the length of the NEMA load switch shall support all load switches.

Terminals shall be consecutively numbered on both sides of the TF panel and shall be in compliance with the appropriate schematic diagrams. All positions for load switches, flasher, and mechanical relays shall have reference designators on both sides of the TF panel. All nomenclature shall be on or adjacent to the component or terminal. All nomenclature shall be machine produced and not handwritten. Cabinet prints shall identify the function of each terminal position.

CU and MMU harness cables shall be of sufficient length to allow units to be placed on either shelf or on top of the cabinet while remaining in operational mode. RS485 port 1 communications cable shall also be of sufficient length to allow any port 1 cable to be utilized with any TS2 unit within the CA. The RS485 harness shall be constructed of a high quality shielded communications cable. The TF panel shall contain a resistor/capacitor network circuit which will provide an external restart pulse to initiate the startup sequence upon initialization from flash.

Remote flashing shall be provided for all signal circuits. Unless otherwise indicated on the plans, phases 2 and 6 shall be wired to flash yellow. All other phases shall be wired to flash red. Flashing for signal circuits shall be activated on one circuit for odd numbered phases and on the other circuit for even numbered phases.

b. Power Panel Requirements

A transparent plexiglass cover shall be provided over the CA power supply panel. The cover shall leave the switches on the breakers exposed as well as leave access to terminals at the bottom of the panel for wiring purposes. No terminals on the power panel shall have silicon protectant on them in lieu of the plexiglass cover. The panel shall contain a multi-breaker with one 10A circuit breaker to provide overload protection to the CU, MMU, BIU, +12/24V DC cabinet power supply, and detection devices. It shall also contain one main circuit breaker of 35 or 40A, to provide overload protection to the signal and flash bus load. All breakers shall have line and load terminals clearly labeled. The signal bus shall be connected to the incoming AC line through a mercury contact switch or a solid state control device functionally equivalent to the NEMA 5.4.2.3 specified contact switch. The terminals for AC + and − input to the cabinet shall be capable of accepting a No. 6 wire.

With the CA 10A and main 35 or 40A circuit breakers 'Off' (tripped), all units inside the cabinet and the intersection display shall be 'Off'. With the 10A breaker 'On' and main 35 or 40A circuit breaker 'Off', the signal output shall be 'Off' and the major units within the cabinet shall function. With the 10A breaker 'Off' and main 35 or 40A circuit breaker 'On', the intersection shall be in flash mode and all units within the cabinet will be 'Off'.

The cabinet shall contain a 50kA, 8x20µs surge suppressor. The surge suppressor shall be a 120V AC, 15A, minimum 2-stage parallel/series type device and protect lines: line-neutral, line-ground and neutral-ground, have a maximum continuous operating voltage of 140V AC, maximum clamp voltage of 350 volts and device status indicators of green/good and red/failed. The device shall plug into a NEMA 12 position terminal base wired before and in parallel with the 35 or 40A main signal buss circuit breaker and in series with the 10A circuit breaker for the solid state equipment and provide for a tool-free replacement of the device. There shall be a minimum of two electrical receptacles on the equipment side of the device for future auxiliary equipment. The surge suppressor shall operate between -30 to 165°F. The dimensions of the unit shall not exceed 4 1/2 in. wide by 7 in. long by 3 1/2 in. deep.

All equipment capable of operating at 12 or 24V DC typically powered by an individual receptacle type power supply shall have a power cable permanently wired into the cabinet and the device shall be powered by the cabinet TS2 power supply.

4. MMU Requirements

The cabinet shall contain a MMU and shall be in accordance with the standards of NEMA TS2- 4. The MMU shall be wired to monitor each load switch output.

5. BIU Requirements

All BIU's shall be in accordance with NEMA TS2 2008, Section 8. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length. BIU's shall be supplied with each cabinet to allow for maximum phase and function utilization for which the cabinet is designed.

6. Loop Amplifier Units and Rack Requirements

a. General

All loop amplifier units shall be in accordance with NEMA TS2-6 and shall follow type C, two-channel with delay and extend, as stated in NEMA TS2-6.5.2.2.1. All amplifiers shall be selected from the QPL of Traffic Signal and ITS Devices for each type of amplifier. In addition, loop amplifiers shall have an LCD display or a RS232 serial data connection and software interface capable of displaying loop status including but not limited to operating frequency and -ΔL/L, diagnostics, and all amplifier settings and operating parameters. Edge mounted printed circuit boards and rack cards shall not have jumper wire modifications unless the jumper wires are permanently bonded to the PCB over its entire length.

All detection components including amplifiers, racks, auxiliary BIU, interface panels, lead-ins, and all connecting harnesses shall provide one count output channel per lane of each approach within project limits.

All loop amplifiers designated for counting shall meet all requirements as above and shall additionally transmit channel 1 and 2 count pulses on the edge connection assigned to channels 3 and 4 respectively. Counting amplifiers shall be configured with count outputs mapped to and recorded in the CU detector logs. The status output of each active counting channel, 3 and 4, shall be set to logic ground by software configuration within the amplifier or externally by use of jumper card in the adjacent slot.

An auxiliary BIU panel may be used strictly for count outputs, channels 3 and 4 only, in this configuration, the status outputs for those count output channels may be wired to logic ground on the BIU panel. The status outputs for all standard output channels shall provide accurate status data at all times. All detector input data to the CU shall remain accurate at all times.

All M and P-1 cabinets shall incorporate a 16 channel detector rack, configuration No. 2, in accordance with NEMA TS2-5.3.4, and shall allow operation of a two-channel detector in each slot and the capability of operation of a two-channel counting amplifier in each even-numbered slot with the respective count outputs in each odd numbered slot. The number of detector racks provided shall be determined by the loop tagging table. All G cabinets shall incorporate an eight-channel detector rack, configuration No. 1, in accordance with NEMA TS2-5.3.4.

All detector loop panels and detector racks shall be labeled according to the loop tagging table and as follows.

All detection shall be labeled in such a way that the numbering for any loop is consistent throughout the cabinet; the loop terminated as Loop or Detector 17 shall be Detector Channel 17 in the detector rack and Detector Input 17 to the controller.

b. Loop Termination Panel

Each loop lead-in panel shall be labeled on the upper left corner with the loop numbers that are terminated on that panel as follows: (1-16), (17-32), (33-48), (49-64). Each loop termination point shall be labeled with the corresponding loop number. Example: For panel 17-32: loops terminated on this panel will start with 17 and end with 32.

c. Detector Rack

Each detector rack shall be labeled at the bottom of the rack with a continuous label. The label shall be 1 in. wide, thermal printed black on clear, white or matte polyester tape with permanent adhesive, water, chemical and scratch resistant printed with 4 lines of Arial, size 10 font. Below the BIU shall be the BIU number and detector channel numbers that are contained within the rack as follows: (1-16), (17-32), (33-48), (49-64). This area shall also contain the intersection for diamond interchanges controlled from one cabinet. Each slot shall be labeled below the module with the corresponding loop tag information; the count output number portion of the information shall be under the first part of the tag information. For each two-channel module, channel 2's label shall be below channel 1's label.

7. Cabinet Power Supply Requirements

The TS2 cabinet power supply shall adhere to the guidelines of NEMA TS2-5.3.5. The power supply shall be encased on all sides so that no circuitry is exposed to the user.

(g) Cabinets

1. G Cabinet (Size 3)

The G cabinet shall be pedestal-mounted or pole-mounted. As per NEMA TS2-5.3, the TS2 type 1 G cabinet, at minimum, shall house an eight-load switch bay (configuration 2) terminal and facilities panel and shall have 1 adjustable shelf located 12 in. below the top of the cabinet. The bottom of the cabinet shall be reinforced to ensure a secure pedestal mounting. The G cabinet shall have dimensions of 25 in. wide, 38 in. high, 18 in. deep with a tolerance of + 4 in. in any or all dimensions.

A cabinet slipfitter shall be used to attach the cabinet to the pedestal. The slipfitter shall fit a 4 1/2 in. outside diameter pipe and shall have a minimum of three set screws equally spaced around the slipfitter.

A vent of adequate size shall be provided. The size of the vent and the filter requirements shall be in accordance with the manufacturer's recommendations.

2. M Cabinet (Size 5)

As per NEMA TS2-5.3, the TS2 type 1 M cabinet, at minimum, shall house an eight-load switch bay (configuration 2) terminal and facilities panel and shall have two adjustable shelves with the first shelf located 15 in. below the top of the cabinet and the second located 7 in. below the first shelf.

The M cabinet shall be ground-mounted on a concrete foundation at locations and dimensions as shown on the plans.

The M cabinet shall have dimensions of 30 in. wide, 48 in. high, and 16 in. deep with a tolerance of ±2 in. in any or all dimensions.

Anchor bolts shall be steel in accordance with ASTM A36. Diameter of the bolt shall be 1/2 in. or 5/8 in. and the minimum length shall be 15 in. plus 3 in. right angle hook on the unthreaded end.

The top 6 in. of the bolt shall be threaded with 13 NC threads on 1/2 in. bolts and 11 NC threads on 5/8 in. bolts. The hexagon nut, the flat washer, and the threaded end of the bolt shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM B695, class 55.

The cabinet shall include one loop detector rack.

3. P-1 Cabinet (Size 6)

The P-1 cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 P-1 cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have two adjustable shelves with the first shelf a minimum of 30 in. above the bottom of the cabinet, the second shelf having a minimum clear opening of 11 in. above the first shelf.

The cabinet shall be 44 in. wide, 52 in. high, and 24 in. deep with a tolerance of ±3 in. in any or all dimensions.

The cabinet shall include two loop detector racks.

4. R Cabinet (Size 7)

The R cabinet shall be ground mounted on a concrete foundation at locations and dimensions as shown on the plans with anchor bolts in accordance with 922.02(g)2. As per NEMA TS2-5.3, the TS2 type 1 R cabinet, at minimum, shall house a 16-load switch bay (configuration 3) terminal and facilities panel and shall have three

adjustable shelves with the first shelf located a minimum of 30 in. above the bottom of the cabinet, the second shelf having a minimum clear opening of 11 in. above the first shelf and the third shelf having a minimum clear opening of 11 in. above the second shelf.

The cabinet shall be 44 in. wide, 72 in. high, and 24 in. deep with a tolerance of ±3 in. in any or all dimensions.

The cabinet shall include three loop detector racks.

5. Flasher - Two Circuit Alternating Flasher

Two circuit alternating flasher shall be solid state.

a. General

The solid state flasher shall periodically interrupt a source of alternating current line power. Solid state shall mean electrical circuits, the active components of which are semi-conductors, to the exclusion of electromechanical devices or tubes.

The flasher shall be a type 3 solid state flasher conforming to NEMA TS1-1989. The flasher output circuit carrying the signal load shall consist of opto or photo isolated solid state power relays and shall be hard wired to the flasher connector.

Three schematic diagrams and three descriptive parts lists shall be furnished with each flasher.

Two circuit flashers shall be plug-in design. The flasher design shall not allow the unit to be inserted improperly into the plug-in base. The flasher shall have heavy-duty plugs and jacks capable of handling the rated load current. The rate of flash shall be 50 to 60 flashes per minute.

The flasher shall operate between 95V and 135V AC 60 Hz. No degradation of performance shall be experienced in environmental changes from -20 to 165°F and 0 to 90% relative humidity.

b. Cabinet Requirements

The cabinet shall be weatherproof and fabricated from cast aluminum or aluminum sheeting with a minimum thickness of 1/8 in. The cabinet door shall be the entire front of the cabinet and shall be hinged on the right or left side of the cabinet. A Corbin No. 2 lock and two No. 2 keys shall be furnished. The lock shall be located near the center of the door on the side opposite the hinge.

Minimum dimensions for the cabinet shall be 12 in. deep, 12 in. wide and 12 in. high. The maximum dimensions shall be 18 in. deep, 15 in. wide and 18 in. high.

The cabinet shall have two pole plates for stainless steel band mounting of the cabinet on a pole with a minimum diameter of 4 in. and a maximum diameter of 18 in.

Two blank cover plates shall be provided. Two hub plates for 1 in. diameter conduit shall be provided with gaskets, eight bolts at four bolts per plate, nuts, and washers for attaching the hub plates to the cabinet. The cabinet shall be drilled for the mounting of the pole plates or hub plates as shown on the plans.

It shall have a screened vent in the bottom with a minimum size of 1 3/4 sq in., and a minimum of one louvered and screened vent towards the top of the cabinet.

The panel in the cabinet shall be capable of being removed and reinstalled with simple hand tools. A 25 ampere radio interference filter and surge arrestor wired ahead of a 15 ampere circuit breaker shall be mounted on the panel. A terminal block capable of the following electrical connections shall be mounted on the panel:

Circuit 1 - for connection of field signals (flash circuit 1)
Circuit 2 - for connection of field signals (flash circuit 2)
Circuit 3 - for connection of field signals (field neutral)
AC plus - capable of accepting a No. 6 wire
AC minus - capable of accepting a No. 6 wire
Ground lug - capable of accepting a No. 6 wire.

922.03 Signal Head Components

The components shall be in accordance with the Institute of Transportation Engineers for Adjustable Face Vehicular Traffic Control Signal Heads. All new traffic signal and flasher installations that include new indications shall be fitted with LED modules. All LED indications shall be selected from the QPL of Traffic Signal and ITS Devices.

(a) General

The signal faces shall be sectional in construction, requiring one section for each lens and furnished in the nominal size of 12 in. Each section of a face shall have a rectangular silhouette when viewed from the front or the rear.

(b) Housing, Door, and Visor

The top and bottom of each housing shall have an integral locking ring with 72 serrations to enable rotation of the signal housing in 5° increments. Hub openings in the top and bottom of the signal housing shall accommodate standard 1 1/2 in. bracket arms. The thickness of the hub at the top and bottom of the housing shall be a maximum of 1 in. and a minimum of 3/8 in. The 12 in. door shall have two simple locking devices. The door on the hinged side shall be attached with hinge pins. Each lens shall have the standard cap type visor. All screws, latching bolts, locking devices, and hinge pins shall be stainless steel.

(c) Signal Indications

1. LED Signal Indications

All LED indications shall be selected from the QPL of Traffic Signal and ITS Devices.

All LED indications shall have a permanent indelible sticker affixed to the back of the module indicating month and year of initial installation.

All LED indications provided shall be individually listed on a parts list indicating the contract number, vendor, category, manufacturer, model, serial number, and inventory number. Hard copy and electronic copies shall be provided. The electronic document format and the blank worksheet shall be obtained from the Department's Traffic Management Division.

2. Incandescent Signal Indications

All new traffic signal and flasher installations that include new indications shall be fitted with LED's. The minimum design requirements for replacement incandescent light bulbs to be used in a traffic signal face shall be in accordance with the Institute of Transportation Engineers standard for traffic signal bulbs.

(d) Wiring

The field wiring leads shall be terminated with screw spade lug type connectors. The LED module wiring leads shall be terminated with 1/4 in. female type connectors for ease of connection to the terminal block.

(e) Section Coupling

Any method to connect two or more sections together may be used, if the following requirements are met:

1. Two or more sections, when jointed together, shall maintain structural integrity when loaded in accordance with Institute of Transportation Engineers Standards.

2. The opening between joined sections shall accommodate two 1/2 in. cables.

3. The maximum length of bolts used to connect sections together shall be 4 in.

Nuts, bolts, and lock washers shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and be in accordance with the coating thickness, adherence, and quality requirements of ASTM B695, class 55.

(f) Terminal Block

The center section of the three-section signal head, both center sections of the four-section head, one section of the two-section signal head, and each one-section signal head shall be equipped with a five-position terminal block for termination of field wiring. Each section shall have provisions for two five-position terminal blocks. Each terminal screw shall have a 1/4 in. corresponding spade tab. The terminal block shall have a minimum spacing between screw connections of 1/2 in. The height of the

insulating ridge between screw connections shall be a minimum of 19/32 in. from the base of the terminal blocks.

(g) Material Requirements

1. Polycarbonate Signal Head

The housing, door, and visor of the section shall be made of ultraviolet and heat stabilized polycarbonate. The black color shall be permanently molded into the components.

2. Die-Cast Aluminum Signal Head

The housing, door, and visor of the section shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B85. All surfaces of the housing, doors, and visor shall be shop painted or powder coated. The finish shall be nonreflecting flat black, color No. 37038, in accordance with SAE-AMS-STD-595.

(h) Signal Backplates

The traffic signal backplate shall be one piece and made of sheet aluminum. The sheet aluminum shall have a nominal thickness of 0.063 in. and shall be according to ASTM B209, alloy 5052. The backplate shall be designed to be attached to a signal face without interfering with the opening and closing of the traffic signal door. It shall be rectangular in shape with round corners and shall be of such dimensions as to give an exposed margin of 5 in. on each side.

The backplate shall have a 2 in. wide yellow retroreflective strip applied to the outside perimeter of the backplate. The sheeting shall be Type IV in accordance with 919.01(b) and applied in the orientation for the maximum angularity according to the manufacturer's recommendations.

The aluminum backplates shall be shop painted or powder coated. The finish shall be nonreflecting flat black, color No. 37038, in accordance with SAE-AMS-STD-595.

(i) Certification

A material certification shall accompany each order certifying that a signal head from a normal production run within the past 12 months, passed the Institute of Transportation Engineers criteria for breaking strength and deflection. Deflection testing is not required in the certification for polycarbonate signal heads.

922.04 Pedestrian Signal Components

(a) Pedestrian Signal Head

A pedestrian signal shall be one section and rectangular in shape. The dimensions of each side may vary from 18 to 19 in., including the visor and the hinges. The signal shall contain two figures with two different colored messages. The first figure shall transmit an upraised hand symbol message, and the second figure shall transmit a

walking person symbol message. All new installations including new pedestrian indications shall use Light Emitting Diodes with countdown displays. All pedestrian LED indications shall be selected from the QPL of Traffic Signal and ITS Devices. The pedestrian signal shall be in accordance with the standard of the Institute of Transportation Engineers for Pedestrian Traffic Control Signal Indications.

1. Housing, Door, and Visor

The housing shall be equipped with mounting device hardware, such as a clamshell, with round openings at the top and bottom for mounting with brackets made of iron pipe standard, to fit the 1 1/2 in. pipe. The round openings shall have a common vertical centerline through the housing to allow for rotation. The round openings shall have a serrated ring, with 72 serrations, which enables locking of the housing in 5° increments. The brackets or the clamshell shall serve as the electrical conduit for the pedestrian signal. The housing shall be black and made of die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B85.

The door on the front of the housing may be hinged from any side. The door shall be gasketed to maintain a weather-tight enclosure when secured to the housing. The door and the visor shall be made of the same material as the housing or of polycarbonate. All materials shall be clean, smooth, and free from flaws, cracks, blowholes, or other imperfections.

The polycarbonate components shall be black in color. The metal components shall be painted or powder coated. The finish shall be nonreflecting flat black, color No. 37038, in accordance with SAE-AMS-STD-595.

2. Message

The upraised hand and walking person symbols shall each be a minimum of 11 in. in height. The width of the upraised hand symbol shall be a minimum of 7 in. The width of the walking person symbol shall be a minimum of 6 in. Message configuration, color, and size shall be in accordance with the standard of the Institute of Traffic Engineers for Pedestrian Traffic Control Signal Indications.

Each pedestrian signal shall be completely wired internally, and ready for connection of the field wiring. A suitable terminal block for connection of the internal wiring and the incoming field wires to the pedestrian signal head shall be provided in the signal housing.

The light source shall be designed and constructed so that if an electrical or mechanical failure occurs, the upraised hand and walking person symbols shall also remain dark.

(b) Pedestrian Push-Button

Pedestrian push-button assemblies shall meet the standards of the MUTCD and Americans with Disabilities Act, ADA. Pedestrian push-button assemblies shall be vandal and weather resistant, be pressure activated with minimal movement, and

cannot be stuck in a closed or constant call position. A red latching LED and audible tone shall be provided for confirmation of an actuation call.

A type D certification in accordance with 916 shall be provided for the pedestrian push-button. Such certification shall contain the contract number, manufacturer's name, model name, supplier's name, location or intersection name, and for a type APS pedestrian push button, the sound level measurement of the audible features of the device.

1. Housing

The pedestrian push-button housing shall be constructed of cast aluminum, cast zinc alloy, or stainless steel and powder coated yellow, and furnished with suitable mounting hardware.

2. Latching LED

The normal state of the LED shall be off. When the push button is pressure activated, the LED shall be lighted and remain on until the beginning of the walk phase. The latching relay shall be mounted in the signal cabinet, controlling two pedestrian phases.

3. Actuator

The actuator shall be stainless steel or aluminum with a minimum diameter of 2 in. and a solid state electronic Piezo switch rated for a minimum of 20 million cycles with no moving plunger or moving electrical contacts. The operating voltage shall be 12-24V. The actuator’s nominal operating force shall not exceed 5 lb.

4. Sign

The pedestrian sign shall be the R10-3e in accordance with the MUTCD, unless a different MUTCD sign code is indicated on the plans. The sign base shall be sheet aluminum in accordance with 919.01(b).

5. Accessible Pedestrian Push Buttons

When accessible pedestrian signals, APS, are specified, the push-button shall have audible and tactile features. The push-button shall activate both the Walk interval and the APS. The color of the actuator shall contrast visually with the housing or mounting. A standard manufacturer’s warranty shall be provided.

a. Audible Features

The pedestrian push-button assembly shall include an audible indication of the Walk interval by either tone or voice and shall be audible from the near side of the associated crosswalk. If the tone for the Walk interval is the same as the locator tone of the push-button, it shall have a faster repetition rate than the associated locator tone. The volume of the audible features shall have automatic volume adjustment based on the ambient noise levels. Audible features shall be at least 2 dB but no more than 5 dB louder than ambient sound, up to a maximum volume of 89 dB measured at 36 in. from

the device. Audible features may be integral to the pedestrian push-button assembly or through a separate speaker housing.

When push buttons are separated by 10 ft or more, the audible indication shall be a tone.

When push buttons are separated by less than 10 ft, the indication shall be a voice message. When voice messages are used, they shall include a clear message that the walk interval is in effect and shall indicate to which crossing it applies.

The pedestrian push button shall have an audible locator tone feature. The locator tone shall have a duration of 0.15 seconds or less and shall repeat at 1 second intervals.

b. Tactile Features

The push button assembly shall incorporate a raised arrow. The arrow shall be raised 0.03125 in. minimum and shall be 1.5 in. minimum in length. The arrow color shall contrast with the background. The raised arrow shall vibrate to indicate that the walk interval is in effect.

922.05 Blank

922.06 Disconnect Hanger Junction Box

Traffic signal disconnect hanger junction boxes shall consist of a span hanger, a balance adjuster, a disconnect hanger clevis, and a housing with a hinged door with a positive latching device. The span hanger, balance adjuster, and all related hardware shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM B695, class 55. The housing shall be made of a die-cast, corrosion resistant, copper free, non-ferrous metal which shall be in accordance with ASTM B85. The balance adjuster fitting shall be made of ferrous or non-ferrous metal. When made of ferrous metal it shall be galvanized in accordance with the requirements for the components and related hardware as set out above.

The disconnect hanger shall be designed so that the maximum allowable space or play between the span hanger and the eye-bolt of the balance adjuster and between the balance adjuster and the disconnect hanger clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. The span hanger bolt where the eye-bolt or the balance adjuster is attached shall be 5/8 in. diameter.

When serrated locking rings are not integrally cast in the components, the component and locking ring shall be designed so that when the locking ring is placed flush against the component, the component and locking ring shall not rotate or slide when torque is applied. The serrated components shall have 72 serrations to enable rotation of the disconnect hanger clevis, hub plate, or signal head in 5° increments.

There shall be no thread in contact with a wearing surface. Locking rings shall be a minimum thickness of 3/16 in. and a maximum thickness of 1/4 in. from the base of the ring to the serration peaks. The inside diameter shall be 2 in. and the outside diameter shall be 2 7/8 in.

The terminal block shall have an 18-point terminal block permanently engraved or etched with sequential numbers indicating the circuits. The terminal block shall not have a method of connection which allows a screw point to damage wires when the wires are securely connected. Each point of connection shall accommodate a minimum of four No. 14 gauge wires.

The disconnect hanger shall have two side entrance holes on opposite sides capable of receiving a 1 1/2 in. plastic or rubber insert to reduce water infiltration. It shall be capable of supporting signal faces in the ambient temperature range of -35 to 120°F without failure.

The balance adjuster shall have hex head bolts, lock washers, and nuts for securing the main body of the balance adjuster firmly onto and around the eye-bolt to prevent any twisting or turning of the head suspended below it. The span hanger shall have two J-bolts, lock washers, and hex head nuts adequate in size to securely fasten the hanger to a messenger cable up to 1/2 in. in diameter.

A type C certification in accordance with 916 shall be provided for the disconnect hanger junction box.

922.07 Signal Support Assemblies

(a) Clearance

The maximum allowable space or play between the hanger assembly and the eyebolt of the balance adjuster and between the balance adjuster and the weatherhead clevis, at points where they are attached to each other by rivet pins or hex head bolts and nuts with lock washers, shall be 0.062 in. No bushings or shims will be allowed in this assembly.

(b) Balance Adjuster

The balance adjuster shall consist of a hex head bolt, a lock washer, and nuts for securing the main body of the balance adjuster onto and around the threads of the eye-bolt to prevent any twisting or turning of the adjuster.

(c) Span Hanger

The span hanger, balance adjuster, weatherhead, and all related hardware shall be made of a non-corrosive metal or shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM B695, class 55. The weatherhead shall have a minimum of 2 1/2 in. of exposed threads. The weatherhead shall have two set screws to fasten the nipple to the weatherhead. If the weatherhead and threaded pipe

has a slip-in connection, the locking device shall be a double nut assembly. If the weatherhead and threaded pipe has a screw-in connection, the locking device shall be a double set screw assembly.

The span hanger shall be furnished with two each of J-bolts, lock washers, and hex head nuts. The J-bolt shall be a minimum of 1/4 in. diameter and shall have sufficient threads to be able to secure the hanger to a 1/4 in. or to a 1/2 in. span cable.

(d) Tether Bracket

The tether bracket shall attach to a 1/4 in. tether and prevent the bottom of the head from moving side-to-side on the tether. Where backplates are installed on the signal heads, the tether bracket shall be of the proper length for the backplate so that the cable is mounted below the bottom of the backplate to avoid interference with head alignment and damage to the backplate. Three bolts, nuts, and washers, shall be used to secure the tether bracket to a three-section or four-section signal head. A wire rope clamp in accordance with 922.10(e)4c, shall be used to secure the tether bracket to the tether. The tether bracket shall have predrilled 1/2 in. diameter holes. In lieu of the wire rope clamp and 1/2 in. diameter holes, a beveled tether plate that completely fills in the extruded portion of the tether bracket may be used to secure the tether bracket to the tether. The tether bracket shall not extend more than 2 in. below the tether.

(e) Pipe Arm Assemblies

The multiple pipe arm assembly shall consist of a span hanger assembly, a balance adjuster, a signal weatherhead, a two, three, or four- way pipe arm, 1 1/2 in. pipe, a lower arm assembly, and all related hardware necessary for a complete assembly.

The two, three, or four-way pipe arms shall have a minimum of 2 in. of exposed thread. Each arm of the pipe arm shall be furnished with two 72 serration locking rings. One locking ring shall have a 3 in. outside diameter and one locking ring shall have a 2 3/8 in. outside diameter.

Assembly	Maximum Allowable Weight
Two-way	19 lb
Three-way	25 lb
Four-way	28 lb

922.08 Signal Cantilever Mount Signal Bracket

The bracket shall allow the following four adjustments:

(a) rotational adjustment about bracket axis;
(b) vertical adjustment;
(c) rotational adjustment about signal cantilever arm; and
(d) rotational adjustment right and left from vertical plane

The bracket shall be fastened to the supporting arm or structure with stainless steel bands. The bracket shall adjust to fit all sizes of round, octagonal, elliptical, or other shape structure without special tools or equipment.

The bracket shall attach to the signal by clamping the signal head both top and bottom and shall be designed to accommodate the specified signal configuration. Each bracket shall be complete with all necessary hardware to attach the traffic signal to the bracket and the bracket to the support.

All electrical wiring shall be concealed within the bracket, except that which runs from the bracket to the signal cantilever arm.

Upper and lower arms shall be cast from aluminum in accordance with ASTM B26, alloy 713.0-T5 or 356.0-T6. The vertical support tube shall be extruded from aluminum in accordance with to ASTM B241, alloy 6061-T6 or 6063-T6, and the strapping to attach the bracket to the arm shall be stainless steel. All steel or malleable iron parts shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM A153, B695, class 55.

922.09 Pedestal Poles and Cast Aluminum Pedestal Bases

The pedestal base used for mounting pedestrian signal heads or control cabinets shall be in accordance with 922.09(a). The length of the pedestal pole shall be as shown on the plans.

(a) Cast Aluminum Pedestal Base

A pedestal mounted G cabinet shall have a cast aluminum pedestal base. The cabinet and pedestal base shall be ground mounted on a concrete type A foundation at locations and dimensions as shown on the plans.

The cast aluminum base shall be made of aluminum in accordance with ASTM B179, alloy ANSI 319.1 or 319.2, or in accordance with ASTM B26, alloy ANSI 356.0 - T6. The square base shall include an access door and anchor bolts with nuts and washers. The base shall be 13 3/8 in. square and 15 in. in height ±1/4 in. The weight shall be 22 lb ±5%.

The base shall be designed to support a 150 lb axial load and 11 sq ft of signal head area rigidly mounted. For design purposes, the distance from the bottom of the base to the center of the signal head area is 18 ft. In addition to the dead load, the base shall be designed to withstand wind and ice loads on the specified signal head area and on all surfaces of the support, in accordance with the AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Wind speeds used for design shall be based on a 10 year mean recurrence interval and a wind drag coefficient of 1.2 or as shown on the plans. The base shall contain an access door, which is 8 by 8 1/4 in. ±1/4 in. with a stainless steel hex head bolt for attaching the door.

The base shall be attached to a foundation by four anchor bolts, with an anchor bolt circle of 12 3/4 in. Slotted lugs shall be integrally cast into the four corners of the base for attachment of the anchor bolts. The anchor bolts shall be steel in accordance to ASTM F1554, Grade 36. The diameter of the anchor bolt shall be 3/4 in. with a minimum length of 18 in. ±1/2 in., plus 2 1/2 to 3 in. right angle hook on the unthreaded end. The top 4 in. of the bolt shall be threaded with 10 NC threads. The threads, plus 3 in., shall be hot-dip galvanized in accordance with ASTM F2329 or be mechanically galvanized and in accordance with the coating thickness, adherence, and quality requirements of ASTM B695, Class 55. Each anchor bolt shall be provided with two high strength heavy hex head nuts in accordance with ASTM A563 and three washers. Two of the washers shall have a minimum 2 in. and maximum 2 1/8 in. outside diameter and be in accordance to ANSI B 27, type B regular series and one shall be a nominal 3/4 in. series W washer, in accordance with ASTM F436.

The cast aluminum pedestal base shall be in accordance with the dimensions and requirements shown on the plans. The casting shall be true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, and blowholes; and free from other defects in positions affecting the strength and value of the intended use for the casting. The base shall not have sharp unfilleted angles or corners. The surface shall have a workmanlike finish.

The door and bolt for the door shall be interchangeable on cast bases from the same manufacturer.

(b) Pedestal Pole

The top of the base shall accommodate a pole having a 4 1/2 in. outside diameter. The threads inside the top of the base shall be 4 in. national standard pipe threads. The pole shall be either a steel pedestal pole or an aluminum pedestal pole.

A steel pedestal pole shall be a seamless Schedule 40 carbon steel pipe in accordance with ASTM A53, grade B. The pole shall have an outside diameter of 4 1/2 in. The pole shall weigh approximately 10.8 lb/ft. The length of the pole shall be as shown on the plans. The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. The pole shall be galvanized, after threading, in accordance with ASTM A123. The threads shall be cleaned of all excess galvanizing and protected by a suitable shield.

An aluminum pedestal pole shall be in accordance with ASTM B241 for seamless aluminum alloy, Schedule 40, 6061-T6. The outside diameter of the pole shall be 4 1/2 in. The length of the pole shall be as shown on the plans. The pole shall weigh approximately 3.7 lb/ft. The pole shall have full depth national standard pipe threads on one end of the pole. The length of threads shall be 2 1/2 in. and protected by a suitable shield. The pole shall have a spun finish.

(c) Pole Cap

A pole cap shall be supplied for the top of the pole if the pole is used for the mounting of pedestrian signal faces or side mounted signal control cabinets. The pole cap shall be either a cast pole cap of aluminum or a pole cap of spun aluminum.

A cast pole cap shall be made of aluminum, in accordance with ASTM B179, alloy ANSI 319.1 or 319.2. The cap shall fit freely on the 4 1/2 in. outside diameter pole. A set screw using a 3/4 in. No. 12 hex head machine screw shall be supplied to hold the cap on the pole. A standard foundry draft will be allowed on the casting.

A pole cap made from spun aluminum shall be in accordance with ASTM B209, alloy 1100-0. The cap shall fit tightly when placed on the end of the pole.

922.10 Signal Supports

All welding shall be in accordance with 711.32. Welds shall generate the full strength of the shaft. Only longitudinal continuous welding will be allowed on the pole shaft. Contacting joint surfaces shall be cleaned before fabrication then sealed by means of welding. Working drawings shall be submitted in accordance with 105.02.

(a) Steel Strain Pole

The steel strain pole shall be an anchor base type pole and shall include a handhole and a pole top or cap. The poles shall be furnished in lengths specified.

The pole shall have a handhole within 18 in. of the base. The pole shall have a top or cap with a set screw that can be removed with small hand tools.

The pole material shall be in accordance with ASTM A595 or A572 with a minimum yield strength of 50,000 psi. The pole shall be galvanized after fabrication in accordance with ASTM A123.

All hardware, handhole cover and latching device, and band-type steel polebands shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized and conform to the coating thickness, adherence, and quality requirements of ASTM B695, Class 55. All nuts and bolts, except anchor bolts, shall be in accordance with ASTM A307, and shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. If a cast pole top or cap is used it shall be in accordance with ASTM A126 and shall be galvanized with a minimum coating of 2 oz/sq ft.

The polebands shall fit the pole as planned. The wire rope shall not be in contact with any 90° edges or with any threads on the band. The pole band material shall be in accordance with ASTM A572, grade 50; ASTM A606; or ASTM A36 with minimum yield of 50,000 psi. The minimum width of the bands shall be 3 in. and the bands shall be capable of supporting the pole design load. Each half of the band shall be stamped with the corresponding size number.

The pipe coupling for the weatherhead and base plate shall be installed prior to galvanizing. The threads shall be cleaned of all excess galvanizing. An internal J-hook shall be installed near the top of the pole for wire support.

The steel strain pole shall be capable of supporting an 8,000 lb load applied horizontally 18 in. below the top of the pole with a maximum allowable deflection of 0.16 in. per 100 lb of load. The pole shall be tapered 0.14 in./ft of length.

A one-piece base plate shall be secured to the base of the pole and shall develop the full strength of the pole. The base plate material shall be in accordance with ASTM A36, ASTM A572, or ASTM A588. The base plate shall have four holes of adequate size to accommodate 2 1/4 in. anchor bolts. The bolt circle shall have a 22 in. diameter and bolt square of 15 1/2 in.

Four high strength steel anchor bolts, 2 1/4 in. in diameter and 96 in. long, including the hook, shall be furnished with each pole. Each bolt shall have two heavy hex nuts and two washers in accordance with ASTM A563 and F436 respectively. The anchor bolt material shall be in accordance with ASTM A576 or ASTM A675 with a minimum yield strength of 55,000 psi or ASTM A36, special quality, modified to 55,000 psi or approved equal. The threaded end of the anchor bolt shall have 12 in. of 4 1/2 NC threads and shall be galvanized the length of the threads, plus 3 in. The threaded end shall be hot-dip galvanized in accordance with ASTM A153 or be mechanically galvanized in accordance with ASTM B695, Class 55. The unthreaded end of the anchor bolt shall have a standard L bend for a distance of 9 in. from the centerline of the anchor bolt to the end of the L. In lieu of the standard bend a steel plate 4 1/2 sq in. and 1 1/4 in. thick may be welded to the embedded end of the anchor bolt.

(b) Timber Strain Pole

Timber strain poles shall be made from southern yellow pine and shall be in accordance with the current ANSI Specifications and Dimensions for Wood Poles No. 05.1. They shall be of the length and class specified.

All poles shall be full length pressure treated by the full cell process in accordance with current specifications as set forth in the AWPA Standards T1 and U1, Commodity Specification D: Poles, use category UC4B using preservative as outlined in 911.02(h).

Treatment, handling, and storage methods shall be in accordance with the current AWPA Standards.

(c) Signal Cantilever Structures

1. General

All traffic signal cantilever structures, with or without combination arm, shall be as shown on the plans.

There shall be no threads in the wearing surface plane at the point of connection between the clevis clamp and the signal face assembly. The clevis clamp shall have an 11/16 in. diameter bolt hole to receive the signal face assembly.

The signal cantilever structure pole, sections 1 and 2, signal arm, and combination arm shall be a round or multi-sided tapered tube, except the upper 4 to 6 ft of a signal pole may be non-tapered. The pole and arms taper rate shall be 0.14 in./ft. A 1/2 in. 13 NC threaded grounding nut or approved equivalent shall be provided and be accessible through the handhole. The pole cap shall be secured in place with setscrews. The pole shall be provided with a removable pole cap and integral wire support hook for the luminaire electrical cable. The cable shall be attached to the hook by a service drop clamp.

The signal cantilever arm and combination arm, if required, shall be attached to the pole as shown on the plans. The arms shall have cable inlets as shown on the plans. All signal heads on the arm shall be attached as shown on the plans and installed parallel to the horizontal plane and centered to the cantilever arm. The cantilever arms shall be used as an enclosed raceway for wiring and shall be free of burs or rough edges.

The pole top luminaire for roadway lighting, if required, shall be installed on these structures as shown on the plans.

2. Base Plate

A one-piece anchor base shall be supplied as shown on the plans. Four removable bolt covers shall be provided with each base and each cover shall attach to the upright portion of the body of the base by means of one-hex head cap screw.

3. Materials

The signal cantilever pole, arms, base plates, arm flange plates, gusset plates, ring stiffeners, and pole splice plates shall be in accordance with ASTM A595 or A572 with a minimum yield strength of 50,000 psi.

4. Hardware

High strength heavy hex bolts for the pole splice shall be in accordance with ASTM F3125, grade A490 and shall be coated in accordance with ASTM F1136, Grade 3, ASTM F2833, Grade 1, or ASTM F3019, Grade 4, as shown in ASTM F3125. The contact area for both pole splice plates shall be class B in accordance with AASHTO Standard Specifications for Highway Bridges, Table 10.32.3C with a minimum slip coefficient of 0.5. The surfaces shall be blast cleaned with class B coatings. The arm flange plate connection bolts shall be in accordance with ASTM F3125, grade A325. All other hardware shall be in accordance with ASTM A307 and by either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. A cast pole cap shall be in accordance with ASTM A126 and shall be galvanized with a minimum coating of 2 oz/sq ft.

5. Anchor Bolts

Four steel anchor bolts, each fitted with two high strength heavy hex nuts and two flat washers, shall be furnished with each pole. The anchor bolt shall be as shown on the plans with a minimum of 15 in. of seven NC threads on the upper end. The threads, nuts, and washers shall be either hot dip galvanized in accordance with ASTM F2329 or mechanically galvanized in accordance with ASTM B695, Class 55. The steel for the bolt shall be in accordance with ASTM F1554, with a yield strength of 36,000 or 55,000 psi.

6. Finish

All steel material shall be fully galvanized. Galvanizing shall take place after all welding is accomplished and holes cut.

7. Working Drawings

Working drawings and design calculations shall be submitted in accordance with 105.02.

(d) Downguys, Anchors, Rods, and Guards

Pole anchors shall be eight way expanding with a minimum area of 135 sq in. when expanded or a 10 in. diameter screw anchor. They shall have a minimum holding strength of 10,000 lb. They shall be painted and in accordance with ASTM A575. Anchor rods for expanded anchors shall be 3/4 in. diameter steel and for screw anchors shall be 1 1/4 in. diameter steel, 8 ft long, in accordance with ASTM A659, and be galvanized in accordance with ASTM A153.

Guy guards shall be made of 18 gauge galvanized steel, polyethylene, polyvinyl chloride, or melamine phenolic, and shall be 7 ft long. The steel guy guard shall have a tight gripping, non-scarring hook for quick attachment to the guy wire. The bottom shall have a clamp that fits over the anchor rod and securely grips by tightening the bolt. Steel guy guards shall be in accordance with ASTM A659. The nonmetallic guy guard shall be a helical pigtail which shall resist upward movement, a lock strap to secure the lower end, and a guy guard sleeve. Non-metallic guy guards shall be gray or yellow.

(e) Support Cable

1. Messenger Cable

Messenger cable shall be zinc-coated steel wire strand, contain seven wires, and have a nominal diameter of 3/8 in. The cable shall be in accordance with ASTM A475, Siemens-Martin Grade.

2. Span, Catenary, and Downguy Cable

Span, catenary, and downguy cable, shall be aircraft cable for non-aircraft use, and shall be 3/8 in. nominal diameter, made of stainless steel wire, and consist of seven, 19-wire flexible steel strands. The 3/8 in. cable shall have a minimum breaking

strength of 12,000 lb. It shall be in accordance with Military Specifications MIL-W-83420D.

3. Tether and Support Cable

Tether and support cable shall be aircraft cable, for non-aircraft, and shall be 1/4 in. nominal diameter, made of stainless steel wire, and consist of seven, 19-wire flexible steel strands. The 1/4 in. cable shall have a minimum breaking strength of 6,400 lb. It shall be in accordance with Military Specifications MIL-W-83420D.

4. Cable Hardware

a. Messenger Hangers

Messenger hangers shall be either a 3-bolt clamp or a 3/8 by 1 3/4 in. steel hanger with a 90° bend extending from the pole 3 3/4 in. The hanger shall have a curved groove and clamp capable of receiving a 5/16 to 1/2 in. cable.

The messenger shall be clamped by two 1/2 in. high carbon steel bolts. The angle hanger shall be mounted with a 5/8 in. through bolt and a 1/2 in. lag screw. The three-bolt clamp shall be mounted with a 5/8 in. through bolt. The angle hanger shall be in accordance with ASTM A575. The bolts shall be in accordance with NEMA PH 23.

b. Cable Ring

Cable rings shall be galvanized steel in accordance with IMSA 51-1.

c. Clamps

Clamps shall be made of 3/8 in. steel and in accordance with ASTM A575.

Two bolt clamps shall be a minimum of 3 3/4 in. long and 1 1/4 in. wide with two 1/2 in. bolts which shall clamp cable of 1/8 to 1/2 in. diameter.

Three bolt clamps shall be a minimum of 6 in. long and 1 5/8 in. wide with three 5/8 in. bolts which shall clamp cable of 5/16 to 1/2 in. diameter.

The bolt heads shall be large enough to provide maximum clamping area and shall have oval shoulders to prevent the bolts from turning while tightening. The bolts shall be in accordance with NEMA PH 23.

d. Servi-Sleeves

Servi-sleeves shall be 1 1/4 to 2 1/4 in. in length and shall hold the size of the cable specified. The sleeves shall be in accordance with ASTM A659.

e. Straight Eye-Bolts

Straight eye-bolts shall be 3/4 in. diameter drop forged steel, a minimum of 14 in. long, and have 6 in. of thread. The steel washers shall be 2 1/4 by 2 1/4 by 3/16 in. in size with a 13/16 in. hole in the center. All parts shall be in accordance with ASTM A575 and shall be galvanized in accordance with ASTM A123.

f. Hub-Eyes

Hub-eyes shall be made of drop forged steel and in accordance with ASTM A575. They shall receive a 3/4 in. mounting bolt and have a full rounded thimble eye for protection of the guy cable.

922.11 Signal Cable

(a) Hook-up Wire

Signal hook-up wire shall be stranded one conductor wire, type THW seven strand No. 14 AWG, with a thermoplastic sheath 3/64 in. thick and a 600 volt rating. Insulation shall be color-coded, as required, and labeled with gauge, voltage rating, and insulation type.

(b) Signal Control Cable

Signal control cable shall be in accordance with IMSA 19-1 or 20-1 and shall be stranded No. 14 AWG wire.

(c) Service Cable

Traffic signal service cable shall be color coded, stranded copper No. 8 AWG wire, three conductor cable, type THWN.

922.12 Signal Interconnect

(a) Integral Messenger Interconnect Cable

Integral aerial interconnect cable shall be figure “8” self-supporting type cable consisting of a messenger cable and seven conductors No. 14 AWG signal cable in accordance with IMSA 20-3.

(b) 6 Pair/19 Telemetry Cable

Six pair telemetry cable shall contain six twisted pairs of 19 gauge conductors and shall be in accordance with IMSA 40-2 for underground application and IMSA 40-4, integral messenger, for aerial application.

(c) Fiber Optic Interconnect Cable

Fiber optic cable shall contain 12-strand multimode, graded index, optic fibers with a minimum of one non-metallic central strength member. The cable shall be gel-free design, loose tube, all dielectric construction, suitable for outdoor use in conduit or on aerial supports. Each length of fiber optic cable in nonmetallic conduit shall include a No. 14 AWG aluminum or No. 6 AWG copper tracer wire.

Each individual fiber shall be 2.5/5 mils (62.5/125 µm) diameter, core/color-coded clad, and each color-coded set of fibers shall be encased in a loose tube buffer with water blocking tape on the outside and fully water blocked inside using craft-friendly, water-swellable yarns. The fiber optic cable shall be constructed with Kevlar braid and outer polyethylene jackets as a minimum. If an inner jacket is used it shall

be PVC. Maximum attenuation of the cable shall be 4.0 dB/km nominal, measured at room temperature at 850 nm. The bandwidth shall not be less than 160 MHz/km, also at 850 nm. Each fiber shall be continuous with no factory splices except for joining standard length cables to form longer, continuous jacketed cable to fit installation requirements. The cable shall have standard nylon rip cords. Kevlar rip cords will not be accepted.

The cable shall be in accordance with the generic requirements for optical fiber and optical fiber cable per ANSI/ICEA S-104-696 design and test criteria.

The exterior of the polyethylene outer cable jacket shall be stenciled so that every 16.4 ft on each reel is marked with a number. The 16.4 ft of each reel shall be marked with a 5, the 32.8 ft marked with a 10, and so on until the end of the reel. The stencil shall be applied to the outer jacket using permanent ink and shall be permanently engraved into the jacket to provide long lasting readability.

(d) Radio Interconnect Using Spread Spectrum Radio Modems

Spread spectrum radio modems for communications between local controllers and the system master controller shall be on the QPL of Traffic Signal and ITS Devices.

922.13 Detection Components

(a) Loop Detector Lead-in Cable

Runs 700 ft and less of loop detector lead-in cable shall be in accordance with IMSA 50-2 and shall be stranded two conductor No. 16 AWG, 19 strands of No. 29 wire.

Runs greater than 700 ft shall use 14 AWG wire. The nominal capacitance between conductors shall be 57 pF/ft and 98 pF/ft between one conductor and the other conductor connected to the shield.

(b) Roadway Loop Wire

Roadway loop wire shall be 14 AWG gauge IMSA 51-7 duct-loop wire with polyvinyl chloride or polyethylene outer jacket of 1/4 in. diameter.

(c) Other Vehicle Detection Systems

Other vehicle detection systems shall be selected from the QPL of Traffic Signal and ITS Devices.

922.14 Ground Wire

The ground wire shall be copper wire No. 6, AWG soft-drawn, solid copper in accordance with ASTM B3.

922.15 Splicing Kit

Splicing kits shall contain a two-piece, transparent snap-together mold body and include an epoxy and sealing compound contained in a unipak. It shall be capable of

insulating and splicing nonshielded cables rated up to 5 kilovolts and multi-conductor cables rated up to 600 volts.

922.16 Ground Rod and Connections

Ground rods shall be 1/2 in. in diameter by 8 ft long with a machined point and chamfered top. They shall be made of steel with a molecularly bonded outer layer of electrolytically applied copper. A single electrode shall have a maximum resistance to ground of 25 ohms. Single electrodes that do not have resistance to ground of 25 ohms or less shall be augmented by additional electrodes, grids, or plates until resistance to ground of 25 ohms or less is achieved. Resistance shall be measured using a three-point ground tester using the fall of potential method. Data, graphs, resistance in ohms, date of test, make and model of ground tester, and the individual's initials performing the test shall be recorded and submitted to the District Office. Resistance in ohms shall be tagged at the ground connection.

The finished rod shall be cold-drawn and shall have the following minimum physical properties:

Physical Property	Value
Tensile strength, min.	97,000 psi
Yield strength, 0.2% offset, min.	85,000 psi
% of elongation	13 - 40

The ground rod and wire connection shall be made by a thermo weld process or approved equal. The welding material shall cover and secure the conductor to the rod and shall be porous free.

An acceptable alternate shall be a ground grid connection properly sized and shall consist of a shear head bolt, a "C" shaped body, nest, and wedge. The connector components shall be fabricated from an aluminum-bronze alloy, silicone-bronze alloy, or copper.

922.17 Handholes

(a) Type I (Concrete Handhole)

A Type I handhole shall be made of class III reinforced concrete pipe with a cast iron ring and cover. The concrete shall be in accordance with section 907.02. Reinforcement shall be provided as shown on the plans or in accordance with the manufacturer's design. If reinforcement deviates from the plans, provide calculations showing that the modified design supports HS-20-44 loading. The ring and cover for handholes shall be in accordance with 910.05(b).

(b) Type II (Alternative Handhole)

A Type II handhole shall be made of polymer concrete or other material that is certified to be in accordance with ANSI/SCTE 77 and meet or exceed Tier 22 loading requirements. The handhole shall be stackable.

1. Handhole Box

The handhole box shall be heavy duty. The inner surface of the handhole shall be smooth and free from cracks and imperfections.

2. Handhole Cover

The cover shall be marked with logo imprints of "TRAFFIC SIGNAL" and the ANSI/SCTE Tier rating - "TIER XX". The cover shall be secured with stainless steel, 300 series, 3/8 in., 16 NC hex bolts and washers. The cover shall have a friction coefficient of at least 0.5.

(c) Type III (Handhole located in the Roadway)

A type III handhole shall be AASHTO HS-20 rated. The handhole box shall be concrete. The ring and cover shall be steel and shall be secured to the handhole box.

922.18 Entrance Switch

The entrance switch shall be a double pole, 50A, 120V AC circuit breaker in a NEMA type 3R enclosure in accordance with NEMA 250-2008. The minimum dimensions of the enclosure shall be 5 in. wide, 3 3/4 in. deep and 9 1/4 in. high. A 1 in. rain-tight detachable hub shall be supplied in the top of the enclosure. The enclosure shall have knockouts on the sides, bottom and back with diameters of 7/8 in. to 1 3/4 in. The enclosure shall contain the circuit breaker, an insulated solid bar for connection of AC neutral, a separate lug for attachment of earth ground, have provisions for a padlock, and shall be surface mounted.

The enclosure shall be made of galvanized steel with a rust inhibiting treatment and finished in the manufacturer's standard color of baked enamel.

All wire terminations and breaker to buss-bar contact points inside the enclosure shall be coated with an anti-oxidant to prevent oxidizing and corrosion of components.

922.19 Conduit and Fittings

(a) Steel Conduit

Steel conduit, couplings, and elbows shall be galvanized rigid steel conduit in accordance with UL 6. The conduit shall be galvanized by the hot dip method on the interior and exterior surfaces. Conduit threads shall be cut after galvanizing. The conduit shall be supplied with a threaded coupling attached to one end and the other threaded end protected by a suitable shield.

The various conduit fittings such as bands, bodies, straps, lock nuts, and threadless connectors, shall be in accordance with Federal Specifications A-A-50553 and shall be galvanized if not stainless steel. Conduit straps shall be two hole straps with a minimum thickness of 1/8 in. Conduit lock nuts 3/8 to 1 1/2 in. in size shall be made of steel. Other sizes shall be made of either steel or malleable iron. All conduit lock nuts shall be galvanized. Other nuts shall be either stainless steel or galvanized steel.

(b) PVC Schedule 40 or 80 Conduit

Conduit, fittings, and accessories shall be manufactured from PVC meeting ASTM D1784 and shall comply with all the applicable requirements of NEMA TC2 and UL 651. Each length of pipe shall include a coupling.

(c) Fiberglass Conduit

Rigid fiberglass conduit and fittings shall be filament wound consisting of E-glass and corrosion resistant epoxy resin manufactured for use at temperatures from -40 to 230°F. Rigid fiberglass conduit shall be pigmented with carbon black for ultraviolet protection and fire resistant per UL 94. All rigid fiberglass conduit shall have tracer wire, be heavy walled, HW, and meet the specifications, labeling and testing of ANSI/NEMA TC9.

(d) HDPE Schedule 40 or 80 Conduit

Conduit shall be smooth wall, Type III, Grade P-33, Category 5, Class C, coilable, HDPE. Standard dimension ratio, SDR, 13.5 may be used for Schedule 40 HDPE and SDR 11 may be used for Schedule 80. Conduit and fittings shall meet the applicable requirements of ASTM D1248, ASTM D3350, ASTM F2160 and UL 651.

Schedule 40 or 80 HDPE conduit shall be marked in accordance with ASTM D3485 with the producer code and designation type indicated. HDPE conduit shall be produced from material with an orange color and ultraviolet stabilization code of C, D, or E in accordance with ASTM D3350. Schedule 40 HDPE conduit for use above ground shall be black.

922.20 Detector Housing

The entire housing casting shall be made from aluminum alloy in accordance with ANSI 320.

922.21 Certification

A type C certification in accordance with 916 shall be provided for traffic signal materials and equipment unless otherwise specified.

SECTION 923 – TEMPORARY TRAFFIC CONTROL DEVICES

923.01 Temporary Pavement Marking Tape

Temporary pavement marking tape shall be furnished in three colors and two types. It shall consist of a white or yellow film that provides both dry and wet retro-reflectivity on a conformable backing which is a minimum of 4 in. wide, and is designed for marking either asphalt or concrete pavements. Black temporary pavement marking tape shall consist of a matte film on a conformable backing which is designed for marking asphalt pavement. White and yellow temporary pavement marking tape shall be in accordance with ASTM D4592.

Type I tape shall be selected from the QPL of Temporary Pavement Marking Tape, Type I. Temporary pavement marking tape type I will be placed and maintained on the QPL in accordance with ITM 806, Procedure H.

A type C certification in accordance with 916 shall be provided for the Type I temporary pavement marking tape.

923.02 Temporary Raised Pavement Marker

Temporary pavement markers shall be designed to be affixed with adhesive to the pavement surface and shall be in accordance with ASTM D4280. Adhesive shall be in accordance with the manufacturer's recommendations.

Markers shall be selected from the QPL of Temporary Raised Pavement Markers. Temporary raised pavement markers will be placed and maintained on the QPL in accordance with ITM 806.

923.03 Construction Warning Lights

Construction warning lights shall be self-illuminated by means of an electric lamp behind the lens. Types A and C shall also be externally illuminated by reflex-reflective elements built into the lens to enable it to be seen by the light from the headlights of oncoming traffic.

The batteries shall be entirely enclosed in a case. The case shall be secured by a locking device which can be opened with a special tool.

(a) Flash Requirements

1. Flash Rate

The light from types A and B shall have a flash rate of 65 ±10 pulsations per minute from -20°F to 150°F.

2. On-Time

On-time is defined as the period of the flash when instantaneous intensity is equal to or greater than the effective intensity as specified in 923.03(b)1.

a. Type A

The light shall have an on-time of no less than 10% of the flash cycle.

b. Type B

The light shall have an on-time of no less than 8% of the flash cycle.

(b) Optical Requirements

1. Effective Intensity

The light beam projected upon a surface perpendicular to the axis of the light beam shall produce a lighted area within the solid angle bounded by the two vertical

planes 9° from the vertical plane through the axis of the optical system and two planes 5° above and below the horizontal plane through the optical axis of the system.

For type A, the effective intensity shall not drop below 4.0 candles within the area specified herein during the first 336 h of continuous flashing.

For type B, the effective intensity shall not drop below 35 candles within the area specified herein during the first 168 h of continuous flashing.

For type C, the effective intensity shall not drop below 2.0 candles within the area specified herein during the first 168 h of continuous burning.

2. Lens Illumination

The illuminated lens shall be uniformly bright in appearance over its entire illuminated surface when viewed from any point within the angle defined in 923.03(b).

3. Reflex-Reflective Performance

For types A and C the specific intensity of the lens when acting as a reflex-reflector at an observation angle of 0.2 of a degree shall be no less than the following.

Entrance Angle degrees	Specific Intensity Candles per Footcandle
0	18
10	14
20	7

4. Testing Procedure

The effective intensity of types A and B lights shall be calculated using the Guide for Calculating the Effective Intensity of Flashing Signal Lights as approved by the Illuminating Engineering Society, June, 1961. The intensity of the type C light shall be tested in accordance with SAE Standard J 575d, Lighting Equipment and Photometric Tests. Reflex-reflection shall be tested in accordance with SAE Standard J 594d.

(c) Lens Requirements

1. Size of Lens

The lens shall be no less than 7 in. in diameter including for a reflex-reflector ring of 1/2 in. minimum width around the periphery for types A and C.

2. Directional Lenses

Unless otherwise directed, types A, B, and C shall have uni-directional lenses.

3. Lens Chromaticity

If the light uses an incandescent lamp, the chromaticity of the lens color shall be

defined by the tri-stimulus coordinates of the Commission International d'Eclairage Standards. When tested with illuminants from 2856 K to 2366 K, the lens color shall fall within the area of the chromaticity diagram in accordance with the 1931 Commission International d'Eclairage Standard Observer as defined by the following coordinates.

X	Y	Z
0.543	0.452	0.005
0.548	0.452	0.000
0.584	0.411	0.005
0.589	0.411	0.000

If the light uses other than an incandescent lamp, the light output shall be in the same range as the light obtained with the incandescent lamp and the specific lens.

4. Lens Luminous Transmittance

The minimum relative luminous transmittance of the lens with illuminant at 2856 K shall be 0.440.

5. Lens Material

The lens shall be plastic of one-piece construction and shall meet the test requirements in accordance with SAE J 576b, except that the exposure time and condition, paragraph 3.4.3, for the purposes of this standard shall be one year.

(d) Head and Case

1. Swivel Head

If swivel capabilities as described herein are not incorporated in the device used to mount a type A or C light on a barricade or sign, the head shall be mounted on the housing in a manner allowing it to be swiveled through a minimum 90° arc in a horizontal plane. If swiveling is accomplished by rotation of the head, construction shall be such that the head rotation shall not damage the wiring.

2. Case

The case shall be so constructed and closed as to exclude moisture that would affect the specified operation of the light. The case shall have a weephole to allow the escape of moisture from condensation.

(e) Photoelectric Controls

Photoelectric controls, if provided on types A or C lights, shall keep the light operating whenever the ambient light falls below 20 footcandles.

923.04 Flashing Arrow Sign

The flashing arrow sign shall be an all weather, self-contained, flashing sign designed to display the required flashing messages continuously for a minimum of 24 h without servicing. A reserve storage battery shall be provided to automatically

operate the flashing arrow sign for a minimum period of 8 h if there is a power failure of the primary source.

The flashing arrow sign shall have a control unit which incorporates a photo-controlled transfer relay for automatic lamp intensity settings. The highest photo-controlled setting shall be full intensity for daylight operation. The lowest photo-controlled setting shall be for night-time operation and shall be 50% of full intensity when the ambient light level drops below five footcandles. A minimum of two interim photo-controlled settings shall automatically increase or decrease the lamp intensity in direct proportion to the ambient light level.

The flashing arrow sign shall have a manual control unit for adjusting lamp intensity when automatic operation becomes unsatisfactory. The manual control shall be fully adjustable between the minimum limit of 30% of full lamp voltage and maximum limit of full lamp voltage.

An indicator light shall be provided on the back of the sign to provide confirmation that the flashing arrow sign is operating. The indicator light shall be visible for 500 ft.

(a) Solar Powered

Solar power assisted units shall incorporate a target sight device and leveling mechanism to aid the user for positioning of the unit prior to use. The device shall be attached to the elevated portion of the flashing arrow sign and not to the fixed support frame.

The lamps shall be electronically operated by means of a solid state controller. An automatic lamp intensity regulator shall hold the lamp output constant with varying battery voltage. The control system shall incorporate a full time tracking system designed to track ambient light for 24 h a day. The control system shall adjust lamp intensity to provide maximum system efficiency. The controller shall be in a weatherproof, ventilated, lockable enclosure.

The lamps shall provide amber beams with a minimum of 20° horizontal and 6° vertical field of view. The minimum effective luminance within the required beam shall not be less than one-half the effective luminance at the beam center.

The battery bank shall consist of 12V, deep cycle, batteries. The battery bank shall be of sufficient capacity to power the unit for 15 days with no assistance from the sun. A battery condition indicator and a test switch shall be provided to monitor the system's battery charge. The batteries shall be secured in a well ventilated, weatherproof lockable housing. A low battery charge indicator which shall be visible to maintenance personnel driving past the sign shall be provided to indicate the need to recharge the batteries. The battery bank shall be at full charge when delivered to the project site.

The unit shall be equipped with a sign/solar panel lifting mechanism. The lifting mechanism shall be designed to safely carry the capacity of the sign's load. The lifting mechanism shall incorporate a positive locking device to secure the panel in a raised or lowered position.

Solar power assisted flashing arrow signs to be used shall be selected from the QPL of Solar Power Traffic Control Devices.

(b) Diesel Powered

Flashing arrow sign shall be fueled by diesel fuel only.

(c) AC Powered

When connected to an AC electrical power source, provisions shall be made to prevent electrocution.

FLASHING ARROW SIGN GENERAL SPECIFICATIONS

	Type A	Type B	Type C	SOLAR POWER ASSISTED
Minimum Board Size	2 ft high by 4 ft wide**	2.5 ft high by 5 ft wide	4 ft high by 8 ft wide	4 ft high by 8 ft wide
Minimum No. of Lamps Flashing Arrow Flashing Double Arrow Sequential Chevron (3 heads minimum)	5 in. head, 5 in. shaft* 5 in. head, 4 in. shaft* 5 in. head	(See Note)	Same as Type A	5 in. head, 5 in. shaft* 5 in. head, 3 in. shaft* 7 in. shaft
Lamp Type	Sealed Beam: 12.8V, not to exceed 3A Average rated life: 300 h minimum Candlepower: 1000 candles minimum 9700 candles maximum	(See Note)	Same as Type A	Sealed Beam: 12.8V, not to exceed 3A Average rated life: 300 h minimum Candlepower: 600 candles at normal voltage and >250 candles at low voltage
Lens Color	Amber	Amber	Amber	Amber
Board Color	Flat Black	Flat Black	Flat Black	Flat Black
Flashing Rate	30-50 F.P.M. (50% on time)	25-40 F.P.M. (50% on time)	30-50 F.P.M. (50% on time)	25-40 F.P.M. (50% on time)
Message (Left or Right)	Flashing Arrow, Flashing Double Arrow, or Sequential Chevron	Flashing Arrow, Flashing Double Arrow	Flashing Arrow, Flashing Double Arrow	Flashing Arrow, Flashing Double Arrow, or Warning Bar
Minimum mounting height (to bottom of board)	7 ft	7 ft	7 ft	7 ft
Where Allowed	Where normal speed limit is <40 mph	(See Note)	All rural and urban locations	Stationary Operations Tangent Sections (See 801.15(a))
Required minimum Visibility	0.5 mi	0.75 mi	1 mi	1 mi

* When flashing a single or double arrow(s), the lamp(s) nearest the arrow points shall not be illuminated.
** Either rectangular or arrow shaped black background sign will be allowed.
Note: General specifications for a type B flashing arrow sign are shown in the MUTCD.

923.05 Portable Changeable Message Sign

Portable changeable message signs shall be capable of displaying 3 lines with of 8 characters per line. Letter height shall be a minimum of 18 in. The sign shall have automatic dimming capability for nighttime operation.

Portable changeable message signs shall be selected from the QPL of Solar Power Traffic Control Devices.

923.06 Temporary Worksite Speed Limit Sign Assembly

The temporary worksite speed limit sign assembly shall be an all weather, self-contained unit designed to display speed limit signs in accordance with the MUTCD and as shown on the plans. The signs shall be installed on frangible posts or mounted on movable stands or trailers in accordance with 910.14(f). The power source shall be capable of operating the strobe lights, without service, for the period which the sign is in effect. An on/off switch will be required.

923.07 Tubular Marker

The vertically placed portion of this device shall consist of high density polyethylene plastic in accordance with ASTM D5203. The base material shall be butyl rubber in accordance with ASTM D5900 or high impact polystyrene in accordance with ASTM D4549. Epoxy material used to attach the base to the roadway surface shall be in accordance with the manufacturer's recommendations. The tubular portion shall be reflectorized with high intensity reflective sheeting in accordance with 919.01(b)1 as shown on the plans.

923.08 Automated Flagger Assistance Device

The Automated Flagger Assistance Device, AFAD, shall alternately display either a STOP sign and a SLOW sign or a steadily illuminated CIRCULAR RED and a flashing CIRCULAR YELLOW lens to control traffic while being operated by a handheld remote control. AFADs shall meet the requirements of the Indiana Manual on Uniform Control Devices, Chapter 6E. Each AFAD shall be equipped with two handheld remote controls. Trailer mounted AFAD's shall be equipped with a gate arm.

Only automated flagger assistance devices from the QPL of Solar Powered Traffic Control Devices shall be used. Automated flagger assistance devices will be placed and maintained on the QPL in accordance with ITM 955.

(a) Signs

1. STOP/SLOW AFAD

The STOP and SLOW signs shall have a minimum width of 24 in. with lettering that is at least 8 in. in height. The WAIT ON STOP sign shall be visible along the same line of view of the STOP sign face.

2. RED/YELLOW Lens AFAD

A "STOP HERE ON RED", R10-6 or R10-6a, sign shall be installed on the right-

hand side of the approach at the point at which drivers are expected to stop when the CIRCULAR RED lens is illuminated.

(b) Signals

Red/Yellow lens AFAD shall have at least one set of CIRCULAR RED and CIRCULAR YELLOW lenses that are 12 in. in diameter and in accordance with the Institute of Transportation Engineers, ITE, Purchase Specification for Vehicle Traffic Control Signal Heads.

(c) Supplemental Conspicuity Devices

The STOP sign face in STOP/SLOW AFAD shall be supplemented by a circular, red stop beacon. The SLOW sign face shall be supplemented by either: a circular, yellow warning beacon, or Type B warning lights with a minimum viewing distance of 1,000 ft.

(d) Gate Arm

Gate arms shall be made of reinforced thermoplastic or tubular aluminum. When in the horizontal positions the arm shall have a 2 ft to 4 ft mounting height above the pavement surface.

(e) Cabinets and Controller

The battery and controller cabinets shall be in accordance with NEMA Standard 250 Enclosure 3R requirements and be provided with a hasp and lock. The AFAD shall include a manual override of the handheld remote at the device. The AFAD shall not have any means by which it can operate on a pre-set or pre-timed basis.

(f) Remote Control Device

Two handheld, cordless remote controls shall be provided with each AFAD. The remote control shall be waterproof and display signal receipt confirmation. The remote shall use a frequency hopping, spread spectrum radio signal with frequencies outside the 700 MHz band, 698 MHz to 806 MHz. The remote control device shall be programmable to control either one unit or two units simultaneously and shall control the units over a one-mile range.

(g) Batteries and Charging System

Batteries shall be deep cycle type and be capable of operating the AFAD continuously for two days, 24 hrs per day without a need of re-charging. An audible low battery voltage alarm sound system shall be provided. The battery charging system shall consist of a solar panel. Solar panels shall be UL 1703 certified.

(h) Trailer

The trailer, if used, shall be designed to withstand a 60 mph wind loading with a 1.3 gust factor when the AFAD is set up in operating position. The trailer shall be painted safety orange, SAE-AMS-STD-595, color No. 12300. The trailer shall be provided with a minimum of two leveling jacks, each operated by a crank which locks in place.

923.09 Acceptance of Temporary Traffic Control Devices

Temporary traffic control devices will be accepted by visual inspection unless otherwise indicated.

SECTION 924 – WELDING SUPPLIES

924.01 Welding Supplies

(a) Aluminum Alloy Base Metals

1. Bare Wire Electrodes and Welding Rods

Bare wire electrodes for use with the gas metal arc welding process and welding rods for use with the gas tungsten-arc welding process shall be in accordance with AWS A5.10. Tungsten electrodes for the gas tungsten-arc welding process shall be in accordance with the Specifications for Tungsten-Arc Welding Electrodes, AWS A5.12.

2. Filler Metal

Filler metals to be used with particular base metals shall be as shown in the table below. Other filler metals may be used if approved.

Base Metal	Filler Metal
3003 to 3003	ER1100
3004 to 3004	ER4043
5052 to 5052	ER5356*
5083 to 5083	ER5183
5086 to 5086	ER5356*
5456 to 5456	ER5556
6061 to 6061	ER5356*
6063 to 6063	ER5356*
356.0 to 6061	ER4043
356.0 to 6063	ER4043
*ER5183, ER5356, and ER5556 may be used interchangeably for these base metals.	

Filler metals shall be kept covered and stored in a dry place at relatively uniform temperatures. Original rod and wire containers shall not be opened until time to be used. Rod and wire shall be free of moisture, lubricant, or other contaminants. Spools of wire temporarily left unused on the welding machine shall be kept covered to avoid contamination by dirt and grease collecting on the wire. If a spool of wire is to be unused for more than a short length of time, it shall be returned to the carton and the carton tightly sealed.

3. Shielding Gases

Shielding gases shall be welding grade or better. Shielding gas for gas metal-arc

welding shall be argon, helium, or an approximate 75% helium and 25% argon mixture. Shielding gas for gas tungsten-arc welding done with alternating current shall be argon. Shielding gas for gas tungsten-arc welding done with direct current, straight-polarity, shall be helium.

Hose used for shielding gases shall be made of synthetic rubber or plastic. Hose which has been previously used for acetylene or other gases shall not be used.

(b) Blank

SECTION 925 – ITS CONTROLLER CABINET

925.01 General Requirements

ITS controller cabinets shall be constructed such that it has a NEMA 3R rating. The cabinet shall be a rainproof cabinet with dimensions of 66 in. by 24 in. by 30 in. in depth. The cabinet top shall be crowned or slanted to the sides to prevent standing water.

The cabinet, sunshields, doors, and all panels shall be fabricated of 1/8 in. minimum thickness aluminum. The only exception to this aluminum thickness is the detector rack, which shall be fabricated of 0.090 in. thickness aluminum. All exterior seams for the cabinets and doors shall be continuously welded. All exterior welds shall be ground smooth. All edges shall be filed to a radius of 5/16 in. minimum.

The cabinet, sunshields, doors, and all panels shall be fabricated from aluminum sheet in accordance with ASTM B209, 5052-H32 aluminum sheet.

Welding on aluminum shall be done by the gas metal arc welding process using bare aluminum welding electrodes. Electrodes shall be in accordance with AWS A5.10 for ER5356 aluminum alloy bare welding electrodes.

Procedures, welders, and welding operators for welding on aluminum shall be qualified in accordance with the requirements of AWS B2.1 “Specification for Welding Procedure and Performance Qualification” or AWS D9.1M/D9.1 Sheet Metal Welding Code.

Each aluminum surface shall be finished in accordance with Military Specification MIL-A-8625F(1), “Anodic Coatings for Aluminum and Aluminum Alloys”, type II, class I coating, except that the anodic coating shall have a minimum thickness of 0.0008 in. and a minimum coating weight of 0.04 mg/sq mm. The anodic coating shall be sealed in a 5% aqueous solution of nickel acetate (pH 5.0 to 6.5) for 15 minutes at 206°F. The anodized coating shall be silver in color. Prior to applying the anodic coating, the cabinets shall be cleaned and etched as follows:

(a) Clean by immersion in inhibited alkaline cleaner such as Oakite 61A or Diversey 909, or equivalent, 45 to 60 g per liter, 160°F for 5 minutes.

(b) Rinse in cold water.

(c) Etch in a solution of 11 g of sodium fluoride, plus 30 to 45 g of sodium hydroxide per liter of distilled water at 140 to 150°F for 5 minutes.

(d) Rinse in cold water.

(e) Dissolve in a 50% by volume nitric acid solution at room temperature for 2 minutes.

(f) Rinse in cold water.

The cabinet shall have single front and rear doors equipped with a lock. The doors shall use a Corbin lock No. 2, and each cabinet shall be equipped with two No. 2 keys. When each door is closed and latched, the door shall be locked. Keys shall be removable in both the locked and unlocked positions. The door handles shall have provision for padlocking in the closed position. The handle shall have a minimum length of 7 in. and shall be provided with a 5/8 in., minimum, steel shank. The handle shall be fabricated of cast aluminum or stainless steel. The cabinet door frame shall be designed so that the latching mechanism shall hold tension on and form a firm seal between the door gasket and the door frame.

The cabinet shall not include a police door or have provisions for a police door.

The latching mechanism shall be a three-point cabinet latch with nylon rollers. The center catch and pushrods shall be zinc-plated or cadmium-platted steel. Pushrods shall be turned edgewise at the outer supports and shall be 1/4 by 3/4 in, minimum. The nylon rollers shall have a minimum diameter of 3/4 in. and shall be equipped with ball bearings.

All cadmium plating shall be in accordance with the Society of Automotive Engineers, SAE-AMSQQP416. All zinc plating shall be in accordance with ASTM B633.

The door's hinging shall be three or four bolt butt hinges. Each hinge shall have a fixed pin. Doors larger than 22 in. in width or 6 sq ft in area shall be provided with catches to hold the door open at both 90° and 180°, ±10°. The catches shall be 1/3 in. diameter, minimum, plated steel rods. The catches shall be capable of holding the door open at 90° in a 56 mi/h wind at an angle perpendicular to the plane of the door. Door hinges, pins, and bolts shall be made of stainless steel. The hinges shall be bolted to the cabinet. The hinge pins and bolts shall not be accessible when the door is closed.

Door gaskets shall be provided on all door openings and shall be dust tight. Gaskets shall be permanently bonded to the metal. The mating surface of the gasket shall be covered with a silicone lubricant to prevent sticking to the mating surface.

Both cabinet doors shall have louvered openings and shall provide ventilation. A filter shall be provided over the louvers and shall include an aluminum filter cover secured with a spring loaded latch as shown on the plans. The filter shall be 12 by 16 by 1 in. Two spare filters shall be provided with each cabinet.

The cabinet shall be provided with two metal lifting eyes to be used when placing the cabinet on the foundation. Each eye shall have a minimum diameter of 3/4 in. and shall be capable of lifting 990 lb.

Machine screws and bolts shall not protrude beyond the outside wall of the cabinet.

925.02 Model Approval

Each cabinet model shall be approved prior to use. A period of evaluation will commence when the Department receives a preliminary product evaluation form accompanied by the product brochure, detailed electrical schematics, and cabinet assembly drawings. The Operations Support Division will advise the manufacturer or vendor, in writing, of the date and location to deliver the cabinet for which model approval is requested. Electrical schematics for the cabinet, cabinet assembly drawings, and parts lists shall be furnished with the controller when it is submitted to the Operations Support Division for evaluation and testing.

Only models from the QPL of Traffic Signal and ITS Devices in effect as of the date of letting, or as otherwise specified, shall be used on the contract. Continued failure and repeated malfunctions of a qualified controller or control equipment shall be cause to remove that model from the QPL. A design change to a qualified model or cabinet will require re-submittal of the model for testing, evaluation, and approval. Permanent addition or removal of component parts or wires will be considered to be a design change.

925.03 Warranty

The cabinet, sunshields, doors, and all other exterior surfaces shall carry a five year warranty against all material imperfections. All other electrical components and wiring shall carry a three year warranty against all imperfections in workmanship or materials.

925.04 Cabinet Accessories

The following accessories shall be furnished and installed with each ITS cabinet.

(a) Rack Frame Assembly

The cabinet shall come equipped with standard Electronic Industries Alliance

19 in. rack frame assembly. The rack frame assembly shall have standard Electronic Industries Alliance vertically spaced threaded holes for attachment of equipment, mounting angles, and shelves. Frame mounting of equipment and shelves shall be available on both door sides of the cabinet.

(b) Equipment Shelves

The equipment rack shall be furnished with two adjustable equipment shelves. A 3 in. hole shall be provided in each shelf. The hole shall be fitted with a nylon snap bushing liner with an outside diameter of 3.16 in., inside diameter of 2 1/2 in. and a height of 0.72 in. The shelves shall be constructed of an aluminum screen tack welded between the shelf bottom and upper ribs. The shelves shall be capable of being moved in any location.

(c) Sunshield

An aluminum panel sunshield shall be mounted on standoffs on the top and each side of each cabinet.

(d) Side Panels

Two aluminum side panels shall be provided and mounted on the Electronic Industries Alliance rack parallel to the cabinet sides. One panel shall be designated as the “power distribution panel” and the other panel shall be designated the “heater panel”.

(e) Data Pocket

The data pocket is to be large enough to hold several drawings, a maintenance log notebook, and several pieces of reference material but not so large as to contact any of the installed equipment.

(f) Equipment Labels

The labels shall have a non-reflective, exterior grade, low glare matte surface finish applied to flexible ABS plastic. The labels shall be black with white lettering and have an engraving depth of 0.002 to 0.003 in. Labels shall conform to the designations on the cabinet diagrams.

(g) Primary Power Terminal Block

A power distribution terminal block shall be mounted on the power distribution panel. The power distribution block shall be a mechanical three-pole connector. The connectors for the incoming power shall be able to accept wire sizes between 12 AWG and 2/0 AWG. The load side connectors shall be able to accept wire sizes between 14 AWG and 4 AWG. The rating of the connector shall be 195 amps per pole. The connector elements shall be made from a tin plated, high conductivity aluminum alloy and insulated with high strength thermoplastic housing with a relative temperature index of 260°F. It shall be rated 600 volt, AL9CU. The dimensions shall be 4 by 5.2 by 3.23 in. high. The block shall come with one polycarbonate safety cover per pole. Mounting screws shall be No. 10, 0.19 in. diameter. The block shall be UL Listed. The terminal block shall be a Burndy Model BDB-11-2/0-3.

(h) Ground Lug

The ground lug mounted on the power distribution panel shall be a heavy-duty one-hole ground lug, manufactured from electrolytic copper tubing and strip stock. UL Listed and CSA certified for stranded CU wire and for 600 volts. Wire range: 6 AWG to 14 AWG. Bolt size: #10. Tang length shall be 1/2 in. Width shall be 5/16 in. The lug shall be an Ilsco Model SLUH-35.

(i) Ground Bus

The ground bus shall be rated to 600 volts. A maximum of 12 taps per ground bar suitable for wire ranging from 6 AWG to 14 AWG will be allowed. The main ground connection wire shall have a range from 4 AWG to 14 AWG. The ground bar shall be 5 15/16 in. by 3/4 in. by 11/32 in. and shall be UL Listed. The ground bus shall be an Ilsco Model D167-12.

(j) Transient Voltage Surge Suppression

The transient voltage surge suppression, TVSS, shall have individually fused suppression modes, thermal cutout, LED operational indicators to indicate loss of protection or circuit fully operational, including neutral-to-ground, AC tracking filter with EMI/RFI filtering up to -50dB from 100 kHz to 100 MHz, and a short circuit current rating of 200,000 rms symmetrical amperes. Surge suppression shall be provided for each mode (L-N or L-L, L-G, N-G). The TVSS shall be UL 1449 Second Edition Listed and UL 1283 Recognized. The TVSS shall have 120/240 volt split phase service voltage and dry contacts for each phase providing a summary alarm. The contacts shall be terminated in a DB-9 connector.

The surge capacity shall be 80 kA/phase. The response time shall be less than 1/2 nanosecond. The unit shall withstand 5000 category C3 impulses with less than 10% drift. It shall be suitable for use under non-condensing relative humidity range of 0 - 95%. The suppressed voltage rating shall be 330 volts L-N, L-G, N-G and 700 volts L-L. Operating frequency: 47 - 63 Hz. Operating temperature: -40°F to 140°F. External mount NEMA 1 standard enclosure. Standard size: 6 in. by 6 in. by 4 in. depth. Weight: 8 lb. The unit shall be an Advanced Protection Technologies Model TE/1XF.

(k) Load Center Main Breaker

The load center main breaker shall be an enclosed, two-pole, 240/240V AC, 60 amp breaker. It shall have a 10,000 rms symmetrical ampere short circuit current rating. The circuit breaker enclosure shall be a Square D, Model QO2TR.

(l) Load Center Panelboard

The panelboard shall be a 120/240V AC, 600 volt, eight pole panelboard. The panelboard shall have a neutral bus bar with three 10 amp breakers, four 15 amp breakers and one spare. The load center shall be main lug only Square D, Model QO. The circuit breakers shall be Square D, Model QO.

(m) GFI Duplex Receptacle

The convenience receptacle shall be a duplex, three-prong, NEMA type 5-15R grounding type outlet and shall be in accordance with UL 943.

(n) Duplex Receptacle

A standard three-prong, NEMA type 5-15R grounding type outlet shall be mounted on the power distribution panel.

(o) Terminal Strip Surge Protector

One 48 in. surge protected terminal strip with ten 15A outlets shall be furnished and installed.

The terminal strip shall have a low profile aluminum housing measuring 1 1/2 by 1 3/16 in. and have a 14/3 SJT cord and a NEMA 5-15P plug. The spacing between the outlets shall be 4 in. and the grounding pin shall be positioned so that it is oriented toward the bottom of the cabinet. The unit shall be in accordance with UL 1449 with a 330 volt clamping level. The unit shall be a Wiremold Model 4810BCS with a 6 ft cord.

(p) Door Open Switches

Four dry-contact, one-pole-form-C (single-pole, double throw), switches shall be provided and installed. Switch poles are to be electrically isolated. One set of switches shall be rated for 5 amp at 120 volt AC to be used to automatically turn the lights off when both cabinet doors are closed. The other set shall be rated for 1 amp at 5 volt DC and are to be used to send a door open alarm. The switches shall be Omron part No. Z-15GQ-B.

(q) Light Switch

A toggle switch 20 amp, DPDT with 1/8 in. diameter hole in solder lugs shall be provided and installed that will manually switch on the lights regardless of the door switch position. The switch shall be McGill Mfg. Co., part No. 0121-7013 or Eaton part No. 7803K13.

(r) Lamp Holders

Each cabinet shall be furnished with two lamp holders. The UL Listed device shall have a medium phenolic base measuring 1.9 by 1.9 by 1.5 in. and rating 660 watt and 250 volt. The lamp holder shall be a Leviton Model 9063.

(s) Lamps

Each lamp holder shall be provided with a 100 watt rugged service incandescent bulb.

(t) Circulating Fans

Three 110 cu ft/min, 4.7 by 4.7 by 1.5 in. cooling fans shall be installed within the cabinet to circulate internal air. The fans shall have an allowable ambient temperature range of 14°F to 158°F and a voltage rating of 115 volt. The fan casings shall be

aluminum alloy. The impeller shall be UL94V-O reinforced plastic. The fans shall have ball bearings and an impedance protected, shaded pole induction motor. The fans shall not be exposed or routed to the external environment. The environmental controller shall control fan operation. The fans shall activate at 80°F. The fans shall be NMB Model 4715FS-12T-B50-D00.

(u) Enclosure Heaters

Two 250 watt ceramic insulated strip heaters shall be furnished and installed in the cabinet to protect against condensation damage and to keep the electronic components above freezing in the winter. The strip heaters shall have a seamless stainless steel sheath with ceramic element support and magnesium oxide packing. The environmental controller shall control enclosure heater operation. Heating strips shall not be installed on either door. The heaters shall be 8 in. long by 1 1/2 in. wide and shall have two wire terminals. The strip heaters shall be UL Recognized. The heaters shall be Hotwatt Model CS-8.

(v) Heater Relays

Two solid state SPST-NO heater relays shall be installed on the power distribution side panel. Load current range 0.04 to 25 amp, one-cycle surge 250 amp peak. Rated for 120 volt AC and UL Recognized.

(w) Thermostats

The cabinet shall be furnished with two thermostats installed. One thermostat shall activate the enclosure heaters and circulating fan with the internal cabinet temperature goes below 35°F. The other thermostat shall activate the two circulating fans at the top of the cabinet when the internal cabinet temperature goes above 80°F. The thermostats shall be Thermodisc, Type AL-1.

(x) Detector Card DIN Rail Terminal Blocks

Double-deck compression clamp DIN rail terminal blocks shall be hard wired to the Canoga Card Racks. A total of 64 terminal blocks shall be mounted to an aluminum panel that is secured to the Electronic Industries Alliance rack. The terminal blocks shall allow wires between 24 AWG and 10 AWG. Each measures 2.5 in. by 0.2 in. The terminal blocks shall be the Entretec part number 011527122 type M 4/6 D2.

(y) I/O Module

An isolated 8-Bit digital input module shall be provided and installed. It shall have six fully isolated inputs and two share common ground inputs. High voltage inputs. Logic levels: LOW +1.0 volt DC max, HIGH +3.5 to +30 volt DC. Input impedance: 3 kohm. Input isolation: 3000 vrms. Power consumption: 0.4 watt. Operating temperature: 14°F to 158°F. The I/O module shall be a Measurement Computing, Model CB-7052.

(z) Detector Card Rack

The detector card rack shall be as shown on the plans.

(aa) Padlocks

Padlocks shall be classified as a high security padlock with hardened shackles, laminated body, a minimum four-pin cylinder, and come complete with a weather cover to protect the lock body and cylinder from sand, dirt, water, and ice. A wafer cylinder shall not be used. Keys shall not be provided with each padlock supplied. All padlocks shall be keyed alike and shall be keyed identical to the keys currently in use by the Department. The main body width of the padlock shall not exceed 3 in. and shall have a shackle length of 2 1/4 to 3 3/4 in. and a shackle diameter of 5/16 in. For padlock information, contact the ITS Operations Engineer.

(bb) Other Cabinet Equipment

In addition to the equipment specified above, the cabinet shall be furnished with all ancillary equipment, brackets, wiring ducts, and hardware as is necessary to provide a neat and finished appearance. These items along with all associated cables, connectors, wiring, and other incidental items shall be labeled on the required submittal drawings.

925.05 Cabinet Wiring

All conductors used in ITS cabinet wiring shall be in accordance with the following color-code requirements.

(a) The AC neutral conductor of a circuit shall be identified by a continuous white or natural gray color.

(b) The equipment grounding conductor shall be identified by a continuous green color or by a continuous green color with one or more yellow stripes.

(c) The ungrounded conductors shall be identified by any color not specified in (a) or (b) above.

All wire shall be type THHN with color and gauge as shown on the plans with the exception of the microloop card rack wiring which will be two-pair twisted with a shield and plenum rated.

Connectors used for interconnecting various portions of circuits together shall be designed and constructed for the application involved. Connectors shall be designed to provide positive connection of all circuits, and easy insertion and removal of mating contacts. Connections shall be permanently keyed to prevent improper connection of circuits.

925.06 Drawings

The Contractor shall provide three sets of cabinet wiring diagrams. The diagrams shall be non-proprietary and shall identify all circuits, as installed, in such a manner as to be readily interpreted. In addition, three cabinet drawings shall be provided with each cabinet to show the component layout in elevation views from the front and rear.

An elevation of both aluminum side panels shall also be shown. Elevation views are to be detailed down to the level showing mounting brackets and wiring ducts. All other mounting hardware and cable ties need not be shown. All cables and connectors shall be clearly labeled. Any data sheets for internal cabinet components that have been made available by the manufacturer shall also be provided. One set of the wiring diagram and cabinet drawing shall be placed in a heavy-duty side-opening clear plastic pouch and inserted into the data pocket. The pouch shall be of such design and material that it provides adequate storage and access to the drawings. The other two sets of drawings shall be delivered to the attention of the ITS Field Engineer.

SECTION 926 – MISCELLANEOUS MATERIALS

926.01 Flexible Delineator Posts

Flexible delineator posts shall be made of impact resistant thermoplastics. The post shall be straight along its center line and have a smooth surface free from cracks, flaws, seams, laps, blisters, and edges affecting the strength, durability, or appearance. The cross section width shall not exceed 6 in.

The reflective sheeting on all posts shall be in accordance with 919.01(b)1 and shall have minimum dimensions of 3 by 8 in. Reflective sheeting shall be applied directly to the post and protected in a manner that minimizes damage to the sheeting upon impact.

The color of the post and the reflective sheeting shall match the color of the adjacent edgeline.

Only flexible delineator posts from the QPL of Flexible Delineator Posts shall be used. Flexible delineator posts will be placed and maintained on the QPL in accordance with ITM 806, Procedure H.

(a) Type I. Ground Mounted Flexible Delineator Post

Roadside delineator post shall use an anchor sufficient to keep the post securely embedded in the soil.

(b) Type II. Surface Mounted Flexible Delineator Post

Surface-mounted post shall have either a surface-mounted base capable of bolting or adhering to the pavement or an anchor cup embedded in the pavement. Bases shall be made of materials suitable for securely mounting the vertical portion to the roadway. Materials used to attach the base or in-pavement anchor cup to the roadway surface shall be in accordance with the manufacturer's recommendations.

The reflective sheeting on surface-mounted posts shall consist of two 3 in. wide wraps around the post separated by a 3 in. gap beginning 1 in. down from the top, or as shown on the plans.

926.02 Delineators

(a) Acrylic Plastic Delineators

Acrylic plastic delineators shall consist of a hermetically sealed optical system with a circular plastic face and prismatic molded rear surface. The optical system shall have a minimum diameter of 3 in. with a minimum area of approximately 7 sq in. The trademark of the manufacturer shall be molded legibly into the face of the lens. Color shall be clear, red, or yellow in daylight as well as when viewed by reflected light at night. Photometric or optical requirements shall equal or exceed the following minimum values.

Observation Angle, Degrees	Entrance Angle, Degrees	Specific Intensity, Candlepower/Footcandle		
		Clear	Yellow	Red
0.1	0	119	79	28
0.1	20	47	28	11

Note: The observation angle is the angle at reflector between the observer's line of sight and direction of light incident on reflector. The entrance angle is the angle at the reflector between the direction of light incident on it and the direction of reflector axis. The specific intensity is the candlepower returned at the chosen observation angle by a reflector or reflective surface for each footcandle of illumination at the reflector.

The opaque backing shall be made from aluminum sheet having a minimum thickness of 0.02 in. The backing shall form an integral part of the delineator and shall retain the optical system securely. A single aluminum grommeted hole in the center of the reflector shall be provided for mounting. The inside diameter of the grommet hole shall be 3/16 in.

Only acrylic plastic delineator models and colors from the QPL of Delineators shall be used. Acrylic plastic delineators will be placed and maintained on the QPL in accordance with ITM 806, Procedure G.

(b) Reflective Sheeting Delineators

Reflective sheeting delineators shall consist of reflective sheeting affixed to an aluminum backing material. The white delineator shall be 3 by 8 in. ±1/8 in. The yellow delineator shall be 5 by 5 in. ±1/8 in. The backing material shall be in accordance with 919.01(a) except the minimum thickness shall be 0.064 in. Reflective sheeting shall be in accordance with 919.01(b)1.

There shall be two mounting holes, 3/16 in. in diameter, with one at the top and one at the bottom. The holes shall be 6 in. ±1/16 in. center to center and in the corners of the square units. Completed delineators shall be dip coated with a high gloss clear finish coat as specified and supplied by the sheeting manufacturer. The finished units shall be clean cut, sharp, and have essentially a plane surface.

A type C certification in accordance with 916 shall be provided for the reflective sheeting delineators.

(c) Barrier Delineators

The delineators shall consist of a transparent acrylic plastic face, herein referred to as the lens, and an opaque back fused to the lens under heat and pressure around the entire perimeter to form a unit permanently sealed against dust, water, and water vapor. The reflector lens shall be colorless.

The lens shall consist of a smooth front surface free from projection or indentations other than for purposes of identification or orientation of the reflector. The rear surface shall have a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

The reflector lens, having a minimum effective reflex area of 6.5 sq in., shall be methyl methacrylate in accordance with Federal Specification LP-380C, type 1, Class 3. Photometric or optical requirements shall equal or exceed the minimum values in 926.02(a).

Only barrier delineator models and colors from the QPL of Delineators shall be used. Barrier delineators will be placed and maintained on the QPL in accordance with ITM 806, Procedure G.

(d) Temporary Barrier Delineator

Temporary barrier delineators shall consist of a type III or higher sheeting in accordance with 919.01(b)1 affixed to a reboundable substrate. The delineator shall be 8 by 12 in. vertically mounted. The mounting bracket used to affix the delineator to the barrier shall not be more than 3 in. vertical.

926.03 Alternate Material Guardrail Blockouts

Non-timber blockouts shall be dimensioned as tested and shall be used with the type of guardrail as tested in accordance with NCHRP 350 or MASH. Blockouts shall be accompanied by a copy of the FHWA eligibility letter stating that the product complies with the requirements of NCHRP 350 or MASH test level 3.

Alternate material blockouts meeting the criteria may be used interchangeably with timber blockouts as long as the line and grade of the face of the guardrail is true to that shown on the plans.