# DIVISION 6
# ASPHALT PAVEMENTS

## SECTION 600
## PRIME COAT

### 600-1 DESCRIPTION

Perform the work covered by this section including but not limited to treating an existing non-asphalt base course with asphalt material by furnishing and applying the prime, furnishing and placing granular material to protect the prime, and maintaining the prime coat in accordance with these Specifications.

Treat all non-asphalt bases beneath an asphalt surface treatment with a prime coat.

### 600-2 MATERIALS

Use materials for prime coat application that are on the Department's Approved Product List for Materials used for Prime Coat Applications and meet the requirement shown below.

Refer to Division 10.

| Item | Section |
|---|---|
| Prime Coat Materials | 1020-3 |

These materials shall meet the manufacturer's specifications as submitted to and approved by the Department. This list is on file at the Materials and Tests Unit.

Where the grade of prime coat material is not established by the contract documents, the Contractor may select the grade to be used from the approved list. All prime coat materials shall be delivered to the project ready for use.

### 600-3 WEATHER LIMITATIONS

Apply prime coat only when the surface to be treated is sufficiently dry and the atmospheric temperature in the shade away from artificial heat is 4°C or above for plant mix, and 10°C or above for asphalt surface treatment.

Do not apply prime coat on a frozen surface or when the weather is foggy or rainy.

### 600-4 BASE PREPARATION

Clean the base of objectionable debris, excessive dust, and any other deleterious matter prior to placing the prime coat.

When directed, dampen the surface of the base prior to application of the prime coat.

### 600-5 APPLICATION EQUIPMENT

Provide, maintain, and operate a pressure distributor that is designed and equipped such that the asphalt material remains at a constant temperature and may be applied uniformly on variable widths of surface at predetermined and controlled rates. Use a distributor equipped with a tachometer or synchronizer, pressure gauges, accurate volume measuring devices or a calibrated tank, and a mounted thermometer for measuring temperature.

Utilize a distributor equipped with a power driven pump of sufficient capacity to distribute the required quantity of asphalt material at constant flow and uniform pressure. Provide a full circulation spray bar adjustable laterally and vertically and adjustable in length to conform to the required width of application without overlapping. Provide and maintain nozzles designed to provide equal and uniform application at all times. Provide a hand spray hose and nozzle to cover areas inaccessible to the spray bars. Equip the distributor with a positive shut-off control for the spray bar and hand hose.

### 600-6 APPLICATION RATES AND TEMPERATURES

Apply the prime coat at a rate from .90 to 2.3 l/m$^2$. The exact rate for each application will be established by the Engineer prior to application, in accordance with the limits shown in the approved products list referenced in Article 600-2.

The required rate of application of asphalt materials will be based on the volume of material measured at the application temperature. Apply the prime coat material at a temperature that is in accordance with the manufacturer's recommendations or as approved.

### 600-7 APPLICATION OF PRIME COAT

When the plans require the base course to be constructed with side slopes flatter than 1:1, apply prime to the full width of the base including the side slopes.

Apply the prime coat only when the base to be treated has been approved.

Place a string line to provide alignment control for the distributor during prime coat application unless waived by the Engineer.

Cover bridge floors, curbs, and handrails of structures and all other appurtenances to protect them from tracking or splattering of prime coat.

After the prime coat has penetrated sufficiently and when directed, roll the primed surface until all loose base material is thoroughly bonded.

### 600-8 MAINTENANCE AND PROTECTION

Allow the prime coat to thoroughly penetrate the base. When directed, apply blotting sand in accordance with the requirements of Section 818.

Maintain the prime coat in an acceptable condition until such time as the pavement is placed. Replace any damaged prime coat at no cost to the Department.

### 600-9 MEASUREMENT AND PAYMENT

Have the volume of the distributor tank calibrated by a commercial laboratory or the manufacturer prior to use. Provide a calibration chart with an accurately calibrated measuring stick graduated in increments of not more than 100 liters on the distributor at all times for use by the Engineer.

Prime will be determined by measuring the material at the actual application temperature and free from air bubbles. Deductions will be made from each measured tank of material for all material placed on the roadway that exceeds the application rate established by the Engineer by more than 0.14 l/m$^2$.

Prime Coat will be paid at the contract unit price per liters of prime coat material that has been satisfactorily placed on the roadway. Each distributor load of prime coat material delivered and utilized on the project will be measured.

Blotting sand will be paid for in accordance with Article 818-4.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Prime Coat | Liter |

## SECTION 605
## ASPHALT TACK COAT

### 605-1 DESCRIPTION

Apply tack coat material to existing asphalt or concrete surfaces in accordance with these Specifications.

Apply tack coat beneath each layer of asphalt plant mix to be placed, unless otherwise approved. Where a prime coat or a newly placed asphalt surface treatment mat coat has been applied, apply tack coat as directed.

## 605-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Asphalt Binder, Grade PG 64-22 | 1020-2 |
| Emulsified Asphalt, Grade RS-1H | 1020-6 |
| Emulsified Asphalt, Grade CRS-1H | 1020-7 |
| Emulsified Asphalt, Grade CRS-1 | 1020-7 |
| Emulsified Asphalt, Grade HFMS-1 | 1020-6 |
| Emulsified Asphalt, Grade CRS-2 | 1020-7 |

Do not dilute or mix the tack coat material with water, solvents, or other materials prior to application.

Unless otherwise specified in the contract, the Contractor may utilize any of the grades of tack coat material specified in this article.

When tack coat is required beneath an open-graded asphalt friction course, the asphalt grade and rate of application to be used on the project will be specified on the job mix formula in accordance with Section 650.

## 605-3 WEATHER LIMITATIONS

Apply tack coat only when the surface to be treated is sufficiently dry and when the atmospheric temperature in the shade away from artificial heat is 2°C or above.

Do not apply tack coat when the weather is foggy or rainy.

## 605-4 SURFACE PREPARATION

Clean the existing asphalt or concrete surface to that tack coat is to be applied of all dust and foreign material prior to placing the tack coat.

Remove grass, dirt, and other materials from the edge of the existing pavement prior to the placement of tack coat.

## 605-5 ACCEPTANCE OF ASPHALT MATERIALS

The acceptance of asphalt materials will be in accordance with the requirements of Article 1020-1.

## 605-6 APPLICATION EQUIPMENT

Provide equipment for heating and uniformly applying the asphalt material in accordance with the requirements of Article 600-5.

## 605-7 APPLICATION RATES AND TEMPERATURES

Apply tack coat uniformly at a rate from .0.18 to 0.36 l/m$^2$. The exact rate for each application will be established by the Engineer. A different rate of application for different layers or surfaces may be established.

The established rates of application will be based on the volume of material at the actual application temperature. Apply tack coat at a temperature within the ranges shown in Table 605-1.

**TABLE 605-1**
**APPLICATION TEMPERATURE FOR TACK COAT**

| Asphalt Material | Temperature Range |
|---|---|
| Asphalt Binder, Grade PG 64-22 | 191-218 °C |
| Emulsified Asphalt, Grade RS-1H | 32-66°C |
| Emulsified Asphalt, Grade CRS-1 | 32-66°C |
| Emulsified Asphalt, Grade CRS-1H | 32-66°C |
| Emulsified Asphalt, Grade HFMS-1 | 32-71°C |
| Emulsified Asphalt, Grade CRS-2 | 52-85°C |

## 605-8 APPLICATION OF TACK COAT

Apply only as much tack coat material as can be covered with base, intermediate, or surface course material during the next day's operation except where public traffic is being maintained.

Where public traffic is being maintained, apply only as much tack coat as can be covered during the same day's operation. In addition, the Engineer may limit the application of tack coat in advance of the paving operation depending on traffic conditions, project location, proximity to business or residential areas, or other reasons. In the event that tack coat material is not covered in the same day's operation, the Engineer may require the application of suitable granular material or other means to provide a safe traffic condition at no additional cost to the Department.

Take necessary precautions to limit the tracking and/or accumulation of tack coat material on either existing or newly constructed pavements. Excessive accumulation of tack may require corrective measures.

Apply tack coat material with a distributor spray bar that can be adjusted to uniformly coat the entire surface at the directed rate. Use a hand hose attachment only on irregular areas and areas inaccessible to the spray bar. Cover these areas uniformly and completely.

Apply tack coat as directed by and in the presence of the Engineer. Do not place any asphalt mixture until the tack coat has sufficiently cured.

Paint or spray contact surfaces of headers, curbs, gutters, manholes, vertical faces of old pavements, and all exposed transverse and longitudinal edges of each course with tack coat before mixture is placed adjacent to such surfaces.

Cover bridge floors, curbs, and handrails of structures, and all other appurtenances to protect them from tracking or splattering tack coat material.

## 605-9 PROTECTION OF TACK COAT

After the tack coat has been applied, protect it until it has cured for a sufficient length of time to prevent it from being picked up by traffic.

## 605-10 MEASUREMENT AND PAYMENT

There will be no direct payment for the work covered by this section.

Payment at the contract unit prices for the various mix items covered by Sections 610, 650, and 654 will be full compensation for all work covered by this section.

# SECTION 607
# MILLING ASPHALT PAVEMENT

## 607-1 DESCRIPTION

Perform the work covered by this section including but not limited to milling and re-milling the pavement at locations, depths, widths, and typical sections indicated in the contract documents, cleaning the milled surface, loading, hauling, stockpiling the milled material for use in recycled asphalt mixtures, and disposal of any excess milled material.

Except where the milled material is used in the work, provide areas outside the right of way to dispose of milled material, which becomes property of the Contractor.

## 607-2 EQUIPMENT

Use a self-propelled unit capable of removing the existing asphalt pavement to the depths, widths, and typical sections shown in the contract. Use milling machines designed and built exclusively for pavement milling operations and with sufficient power, traction, and stability to accurately maintain depth of cut and slope. Use milling machines equipped with an electronic control system that will automatically control the longitudinal profile and cross slope of the milled pavement surface through the use of either a mobile grade reference(s), an erected string line(s), joint matching shoe(s), slope control systems, or other methods or combination of approved methods. Use an erected fixed stringline when required by the contract; otherwise, use a mobile grade reference system capable of averaging the existing grade or pavement profile over a minimum 9.1 m distance or by non-contacting laser or sonar type ski systems with at least four referencing stations mounted on the milling machine at a minimum length of 7.3 m. Coordinate the position of the grade control system such that the grade sensor is at the approximate midpoint of the mobile reference system. Use a machine capable of leaving a uniform surface suitable for handling traffic without excessive damage to the underlying pavement structure. Use a milling machine and other loading equipment capable of loading milled material to be used in other parts of the work without excessive segregation.

Provide additional equipment necessary to satisfactorily remove the pavement in the area of manholes, water valves, curb and gutter, and other obstructions.

Equip the milling equipment with a means of effectively limiting the amount of dust escaping from the removal operation in accordance with local, State, and Federal air pollution control laws and regulations.

## 607-3 CONSTRUCTION REQUIREMENTS

Mill the existing pavement in a manner that will restore the pavement surface to a uniform longitudinal profile and cross section in accordance with typical sections shown in the plans. Where indicated in the contract, remove pavement to a specified depth and produce a specified cross slope. Mill intersections and other irregular areas as indicated in the contract.

The Contractor may elect to make multiple cuts to achieve the required depth of cut or cross slope required by the plans.

Establish the longitudinal profile of the milled surface by a mobile string line on the side of the cut nearest the centerline of the road. Establish the cross slope of the milled surface by an automatic cross slope control mechanism or by a second skid sensing device located on the opposite edge of the cut. The Engineer may waive the requirement for automatic grade and cross slope controls where conditions warrant.

Operate the milling equipment in such a manner as to prevent damage to the underlying pavement structure, utilities, drainage facilities, curb and gutter, paved surfaces outside the milled area, and any other appurtenances. Produce milled pavement surfaces that are reasonably smooth and free of excessive scarification marks, gouges, ridges, continuous grooves, or other damage. Repair any leveling or patching required as a result of negligence by the Contractor with hot asphalt plant mix at no cost to the

Department and in a manner acceptable to the Engineer. Coordinate the adjustment of manholes, meter boxes, and valve boxes with the milling operation.

The Engineer may require re-milling of any area exhibiting laminations or other defects. If the defects are determined to be the result of the Contractor's negligence, then measurement for the re-milling, as specified in Article 607-5, will not be made. If however, the Engineer directs the re-milling of an area that is not due to the Contractor's negligence, measurement of the re-milled area will be made under requirements of Article 607-5.

Thoroughly clean the milled pavement surface of all loose aggregate particles, dust, and other objectionable material. Disposing or wasting of oversize pieces of pavement or loose aggregate material will not be permitted within the right of way.

Conduct pavement removal operations in a manner that effectively minimizes the amount of dust being emitted. Plan and conduct the operation so it is safe for persons and property adjacent to the work including the traveling public.

## 607-4 TOLERANCE

Remove the existing pavement to the depth required by the contract. The Engineer may vary the depth of milling by not more than 25 mm. In the event the directed depth of milling per cut is altered by the Engineer more than 25 mm, either the Department or the Contractor may request an adjustment in unit price under the requirements of Article 104-3. In administering the requirements of Article 104-3 the Department will give no consideration to value given to reclaimed asphalt pavement.

The Department will give no consideration to value given to reclaimed asphalt material due to the deletion or reduction in quantity of milling.

The requirements of Article 104-3 will not apply to the item of Incidental Milling.

## 607-5 MEASUREMENT AND PAYMENT

### (A) General

Milled asphalt pavement to be paid for will be the actual number of square meters of pavement surface that has been milled in accordance with the requirements of this Section. In measuring this quantity, the length will be the actual length milled, measured along the pavement surface. The width will be the width required by the plans or directed, measured along the pavement surface.

Where the depth of milling varies from the required depth, no adjustment in the contract unit price for *Milling Asphalt Pavement, _____ mm Depth* will be made except as provided in Article 607-4.

### (B) Milling Asphalt Pavement, _____ mm Depth

For each and every square meter that the Engineer directs to be milled; including that requiring any additional equipment necessary to remove pavement in the area of manholes, water valves, curb and gutter, and other obstructions; measured as provided in Subarticle 607-5(A); compensation will be made at the contract unit price per square meter for *Milling Asphalt Pavement, _____ mm Depth*.

Where the Engineer directs multiple cuts to achieve the final depth, measurement will be made for each cut. Where the Contractor elects to make multiple cuts to achieve the final depth, no additional measurement will be made.

### (C) Incidental Milling

Where the Contractor is required by the plans to mill irregular areas and intersections or is directed to re-mill areas whose length is less than 30.5 m, measurement will be made as provided in Subarticle 607-5(A) for each cut he is directed to perform. Where the Contractor elects to make multiple cuts to achieve the final depth, no additional measurement will be made. Compensation will be made at the contract unit price per square meter for *Incidental Milling*.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Milling Asphalt Pavement, __mm to ___mm | Square Meter |
| Milling Asphalt Pavement, __mm Depth | Square Meter |
| Incidental Milling | Square Meter |

# SECTION 609
# QUALITY MANAGEMENT SYSTEM FOR ASPHALT PAVEMENTS

## 609-1 DESCRIPTION

Produce and construct asphalt mixtures and pavements in accordance with a quality management system as described in these Specifications. Apply these Specifications to all materials and work performed in accordance with Division 6. Perform all quality control activities in accordance with the Department's *Hot Mix Asphalt Quality Management System (HMA/QMS) Manual* in effect on the date of contract advertisement, unless otherwise approved.

## 609-2 DESCRIPTION OF RESPONSIBILITIES

### (A) Quality Control (QC)

Provide and conduct a quality control program in accordance with Article 609-5 and these Specifications. A quality control program is defined as all activities, including mix design, process control inspection, plant and equipment calibration, sampling and testing, and necessary adjustments in the process that are related to production of a pavement that meets all requirements of the Specifications.

### (B) Quality Assurance (QA)

The Department will conduct a quality assurance program in accordance with Article 609-6 and these Specifications. A quality assurance program is defined as all activities, including inspection, sampling, and testing related to determining that the quality of the completed pavement conforms to specification requirements.

## 609-3 MIX DESIGN/JOB MIX FORMULA REQUIREMENTS

Apply all requirements of Article 610-3.

## 609-4 FIELD VERIFICATION OF MIXTURE AND JOB MIX FORMULA ADJUSTMENTS

Conduct field verification of the mix at each plant within 30 calendar days prior to initial production of each mix design, when required by the Allowable Mix Adjustment Policy and when directed as deemed necessary.

Field verification testing consists of performing a minimum of one full test series on mix sampled and tested in accordance with Subarticle 609-5(C)2, Required Sampling and Testing Frequencies. Mix obtained from NCDOT or non-NCDOT work may be used for this purpose provided it is sampled, tested, and the test data handled in accordance with current procedures in the Department's HMA/QMS Manual and the following provisions.

Obtain the mix verification sample and split in accordance with current procedures in the Department's HMA/QMS Manual. Do not begin normal plant production until all field verification test results have been completed and the mix has been satisfactorily verified by the Contractor's Level II Technician. Verification is considered satisfactory when all volumetric properties except $\%G_{mm}@N_{ini}$ are within the applicable mix design criteria and the gradation, binder content, and $\%G_{mm}@N_{ini}$ are within the individual limits for the mix type being produced.

In addition to the required sampling and testing for field verification, perform all preliminary inspections and plant calibrations as outlined in the HMA/QMS Manual.

Retain records of these calibrations and mix verification tests, including Superpave Gyratory Compactor (SGC) printouts, at the QC laboratory. In addition, furnish copies, including SGC printouts, to the Engineer for review and approval within one working day after beginning production of the mix.

Conduct the initial mix verification of all new mix designs with the plant set up to produce the aggregate blend and binder content in accordance with the initially approved JMF. If the Contractor and/or the Engineer determine from results of quality control tests conducted during mix verification that adjustments to the JMF are necessary to achieve specified mix properties, adjustments to the JMF may be made within tolerances permitted by Specifications for the mix type being produced, subject to approval. No reduction of asphalt binder content will be made when the average production VMA computes below the minimum specification requirement. All JMF adjustments will be approved by the Engineer and documented in writing.

Failure by the Contractor to fully comply with the above mix verification requirements will result in immediate production stoppage by the Engineer. Do not resume normal production until all mix verification sampling, testing, calibrations, and plant inspections have been performed and approved. Any mix produced that is not verified may be assessed a price reduction at the Engineer's discretion in addition to any reduction in pay due to mix and/or density deficiencies.

## 609-5 CONTRACTOR'S QUALITY CONTROL SYSTEM

### (A) Personnel Requirements

Obtain all certifications in accordance with the Department's QMS Asphalt Technician Certification Program as outlined in the *HMA/QMS Manual*. Perform all sampling, testing, data analysis and data posting by or under the direct supervision of a certified QMS asphalt plant technician.

Provide a certified Asphalt Plant Technician Level I to perform quality control operations and activities at each plant site at all times during production of material for the project. A plant operator who is a certified Asphalt Plant Technician Level I may be utilized to meet this requirement when daily production for each mix design is less than 100 metric tons provided the randomly scheduled increment sample as defined in Article 609-5(C)2 is not within that tonnage. When performing in this capacity, the plant operator will be responsible for all quality control activities that are necessary and required. Absences of the Level I Technician, other than those for normal breaks and emergencies shall be pre-approved by the appropriate QA Supervisor or his designated representative. Any extended absence of the Technician that has not been approved will result in immediate suspension of production by the Engineer. All mix produced during this absence will be accepted in accordance with Article 105-3.

Provide and have readily available a certified Asphalt Plant Technician Level II to supervise, coordinate, and make any necessary adjustments in the mix quality control process in a timely manner. The Level II Technician may serve in a dual capacity and fulfill the Level I Technician requirements specified above.

Provide a certified QMS Roadway Technician with each paving operation at all times during placement of asphalt. This person is responsible for monitoring all roadway paving operations and all quality control processes and activities, to include stopping production or implementing corrective measures when warranted. Provide a certified nuclear gauge operator when nuclear density control is being used.

Post in the quality control laboratory an organizational chart, including names, telephone numbers and current certification numbers of all personnel responsible for the quality control program while asphalt paving work is in progress.

**(B) Field Laboratory Requirements**

For a contract with 5000 or more total metric tons of asphalt mix, furnish and maintain a Department certified laboratory at the plant site. A minimum of 30 $m^2$ of floor space (exclusive of toilet facilities), equipment, and supplies necessary for performing Contractor quality control testing is required. Provide convenient telephone and fax machine access for QMS personnel at the plant site.

For a contract with less than 5000 total metric tons of asphalt mix, the quality control testing may be conducted in a Department certified off-site laboratory. All other requirements in these Specifications still apply.

Provide testing equipment meeting the requirements of the test methods herein identified in Subarticle 609-5(C)2. Provide equipment that is properly calibrated and maintained. Allow all measuring and testing devices to be inspected to confirm both calibration and condition. If at any time the Engineer determines that the equipment is not operating properly or is not within the limits of dimensions or calibration described in the applicable test method, the Engineer may stop production until corrective action is taken. Maintain and have available a record of all calibration results at the laboratory.

**(C) Plant Mix Quality Control**

(1) General

Include in the quality control process the preliminary inspections, plant calibrations and field verification of the mix and JMF as described in Article 609-4. In addition, conduct at a minimum but not limited to, the sampling, testing, and determination of all parameters outlined in these provisions using test methods and minimum frequencies as specified herein. Perform additional sampling and testing when conditions dictate. Obtain all scheduled samples at randomly selected locations in accordance with the current edition of the Department's *HMA/QMS Manual*. Log all samples taken on forms provided by the Department. Split and retain all samples taken in accordance with prescribed procedures in the *Manual*. Provide documentation as required in Subarticle 609-5(E). Identify any additional quality control samples taken and tested at times other than the regularly scheduled random samples or directed samples that take the place of regularly scheduled as process control (PC) samples on the appropriate forms. Process Control test results should not be plotted on control charts nor reported to Quality Assurance Laboratory.

Retain the untested split portion of quality control aggregate and mix samples and the tested TSR specimens for 5 calendar days at the plant site, commencing the day the samples are tested. Retain the QC compacted volumetric test specimens for 5 calendar days, commencing the day the specimens are prepared. Permission for disposal may be given by Quality Assurance personnel prior to these minimum storage periods. Retain the split portion of the Contractor’s mix verification and referee mix samples until either procured by or permission for disposal is given by Quality Assurance personnel. Store all retained samples in a dry and protected location.

(2) Required Sampling and Testing Frequencies

Maintain minimum test frequencies as established in the schedule below. Complete all tests within 24 hours of the time the sample is taken, unless specified otherwise within these provisions. Should the specified tests not be completed within the required time frame, cease production at that point until such time the tests are completed.

Should the Contractor’s testing frequency fail to meet the minimum frequency requirements as specified, all mix without the specified test

representation will be considered unsatisfactory. If the Engineer allows the mix to remain in place, payment will be made at 50 percent of the contract unit bid price for the mixture.

If desired, innovative equipment or techniques not addressed by these Specifications to produce or monitor the production of mix may be utilized, subject to approval.

**Quality Control Minimum Sampling and Testing Schedule**

Sample and test the completed mixture from each job mix formula at the following minimum frequency during mix production:

| Accumulative Production Increment | Number of Samples per Increment |
|---|---|
| 750 metric tons | 1 |

If production is discontinued or interrupted before the accumulative production increment tonnage is completed, continue the increment on the next production day(s) until the increment tonnage is completed. Obtain a random sample within the specified increment at the location determined in accordance with the current edition of the Department's *HMA/QMS Manual*. Conduct quality control sampling and testing on each random sample as scheduled below. When daily production of each mix design exceeds 100 metric tons and a regularly scheduled full test series random sample location for that mix design is not reached during that day's production, perform at least one partial test series consisting of Items A and B in the schedule below. These partial test series and associated tests do not substitute for the regularly scheduled random sample for that increment.

Perform the following full test series on all regularly scheduled random samples:

Asphalt Mixture - Sampled From Truck at Plant (AASHTO T 168 Modified)(Split Sample Required)

(a) Binder Content, % (Contractor may select either option below):

  (i) Ignition Furnace (AASHTO T 308 Modified)

  (ii) Other (Contractor may request and use other means of determining percent asphalt binder, subject to approval).

(b) Gradation on Recovered Blended Aggregate from Mix Sample (AASHTO T 30 Modified) Grade on all sieves specified on JMF

(c) Maximum Specific Gravity (AASHTO T 209), optional (ASTM D 6857)

(d) Bulk Specific Gravity of Compacted Specimens (AASHTO T166), optional (ASTM D 6752), Average of 3 specimens at $N_{des}$ gyrations (AASHTO T 312)

(e) Air Voids (VTM) (AASHTO T 269), Average of 3 specimens at $N_{des}$ gyrations

(f) Voids in Mineral Aggregate (VMA) (calculation)

(g) Voids Filled with Asphalt (VFA) (calculation)

(h) P0.075/Pbe Ratio

(i) Percent Maximum Specific Gravity at $N_{ini}$ (calculation)

In addition to the above schedule, conduct the following sampling and testing as indicated:

(a) Aggregate Stockpile Gradations (AASHTO T 27 and T 11)

(Sampled from stockpiles or cold feed system as follows; split samples not required)

(i) Coarse Aggregates (Approved Standard Sizes)

a. At beginning of production*

b. Weekly thereafter*

(ii) Fine Aggregates (Stone Screenings, Natural Sands, Etc.)

a. At or within 1 week prior to mix verification (Gradations valid for multiple mix designs).

b. Weekly after mix verification*,

c. Anytime production is stopped due to plant mix gradation related problems.

*In lieu of the aggregate stockpile gradations performed by QC personnel, gradation quality control data conducted by the aggregate producer, that is representative of the Contractor's current stockpiles, may be furnished.

(b) Reclaimed Asphalt Pavement (RAP) Binder Content and Gradation (AASHTO T 308 Modified or T 164 and AASHTO T 30 Modified) (sampled from stockpiles or cold feed system at beginning of production and weekly thereafter). Have RAP approved for use in accordance with Subarticle 1012-1(G). (Split Sample Required)

(c) Reclaimed Asphalt Shingle Material (RAS) Binder Content and Gradation (AASHTO T 308 Modified or T 164 and AASHTO T 30 Modified) (sampled from stockpiles or cold feed system at beginning of production and weekly thereafter). Have RAS approved for use in accordance with Subarticle 1012-1(F). (Split Sample Required)

(d) Combined Aggregate Moisture Content (AASHTO T 255) Drum Plant Only (sampled from stockpiles or cold feed system a minimum of once daily).

(e) Retained Tensile Strength (TSR) - (AASHTO T 283 Modified):

Mix sampled from truck at plant, tested, and results furnished to the Engineer within 7 calendar days after beginning production of each new mix design. From the split sample, Quality Control personnel will prepare and submit within 5 calendar days of the sample date, an additional set of specimens to the QA Laboratory for TSR testing (Split Sample Required).

Specimens shall be tested on either a recording test press or a test press that maintains the peak load reading after the specimen has broken.

Additional TSR testing required prior to mix production in accordance with above procedures is required when a change is made in anti-strip additive dosage or when a new anti-strip additive source or grade is utilized, unless otherwise approved. Other TSR test(s) may be directed as deemed necessary. TSR testing is not required for mix verification, but may be performed at that time.

(3) Control Charts

Maintain standardized control charts furnished by the Department at the field laboratory. For mix incorporated into the project, record full test series data from all regularly scheduled random samples or directed samples that replace regularly scheduled random samples, on control charts the same day the tests are obtained.

In addition, partial test series results obtained due to reasons outlined in Subarticle 609-5(C)(2) will be reported to Quality Assurance personnel on the proper forms, but will not be plotted on the control charts.

Results of quality assurance tests performed by the Engineer will be posted on the Contractor's control charts as data becomes available.

Record the following data on the standardized control charts:

(a) Aggregate Gradation Test Results

  (i) For each mix type: one sieve size smaller than the mix nominal maximum size.

  (ii) For all mix types: 2.36 mm and 0.075 mm sieves

(b) Binder Content, %, Pb

(c) Bulk Specific Gravity of Compacted Specimens at $N_{des}$ (measured)

(d) Maximum Specific Gravity Determined by AASHTO T 209

(e) Percent Voids in Total Mix at $N_{des}$ Gyrations

(f) Percent Voids in Mineral Aggregate at $N_{des}$ Gyrations

(g) P0.075/Pbe Ratio

(h) Percent Maximum Specific Gravity at $N_{ini}$ Gyrations

Both the full test series individual test values and the moving average of the last 4 data points will be plotted on each chart. The Contractor's test data will be shown in black and the moving average in red. The Engineer's assurance data will be plotted in blue. Denote the warning control limits with a dash green line, the moving average control limits with a dash blue line, and individual test limits with a dash red line.

Maintain a continuous moving average with the following exceptions. Re-establish a new moving average only when:

(a) A change in the binder percentage or aggregate blend is made in the JMF, or,

(b) When the Contractor elects to stop or is required to stop production after one or two moving average values, respectively, fall outside the warning limits as outlined in Subarticle 609-5(C)6, or,

(c) If failure to stop production after two consecutive moving averages exceed the warning limits occurs, but production does stop at a subsequent time, re-establish a new moving average beginning at the actual production stop point.

In addition, re-establish the moving averages for all mix properties. Moving averages will not be re-established when production stoppage occurs due to an individual test result exceeding the individual test limits and/or Specifications.

All individual test results for regularly scheduled random samples or directed samples that replace regularly scheduled samples are part of the plant quality control record and shall be included in moving average calculations with the following exception. When the Contractor’s testing data has been proven incorrect, use the correct data as determined by the Engineer in lieu of the Contractor’s data to determine the appropriate pay factor in accordance with Subarticle 609-5(C)6. In this case, replace the data in question and any related data proven incorrect.

(4) Control Limits

The following are established as control limits for mix production. Control limits for the warning and moving average limits are based on a moving

average of the last 4 data points. Apply all control limits to the applicable target source.

**CONTROL LIMITS**

| Mix Control Criteria | Target Source | Warning Limit | Moving Average Limit | Individual Limit |
|---|---|---|---|---|
| 2.36mm Sieve | JMF | ±4.0 % | ±5.0 % | ±8.0 % |
| 0.075mm Sieve | JMF | ±1.5 % | ±2.0 % | ±2.5 % |
| Binder Content | JMF | ±0.3 % | ±0.5 % | ±0.7 % |
| VTM @ $N_{des}$ | JMF | ±1.0 % | ±1.5 % | ±2.0 % |
| VMA @ $N_{des}$ | Min. Spec. Limit | -0.5% | -0.8% | -1.0 % |
| $P_{0.075}$/ $P_{be}$ Ratio | Max. Spec. Limit | 0.0 | N/A | +0.4% |
| $\%G_{mm}$ @ $N_{ini}$ | Max. Spec. Limit | N/A | N/A | +2.0% |
| TSR | Min. Spec. Limit | N/A | N/A | -15.0% |

(5) Warning Bands

Warning bands are defined as the area between the warning limits and moving average limits.

(6) Corrective Actions

Immediately notify the Engineer when moving averages exceed the warning limits. All required corrective actions are based upon initial test results and shall be taken immediately upon obtaining those results. In the event situations occur that warrant more than one corrective action and/or adjustment, give precedence to the more severe of these actions. Stopping production when required takes precedence over all other corrective actions. Document all corrective actions.

Immediately cease production and immediately notify the Engineer when any of the following occur:

(a) When an individual test result for a mix control criteria (including results for required partial test series on mix) exceeds both the individual test control limits and the applicable specification design criteria, or,

(b) When two consecutive field TSR values fail to meet the minimum specification requirement, or,

(c) When two consecutive binder content test results exceed the individual limits.

Do not resume normal plant production until one of the following has occurred.

Option 1: Approval has been granted by the appropriate QA Supervisor.

Option 2: The mix in question has been satisfactorily verified in accordance with Article 609-4. Normal production may resume based on the approval of the contractor's Level II technician, provided notification and the verification test results have been furnished to the QA Laboratory.

Failure to fully comply with one of the above provisions will result in immediate production stoppage by the Engineer. Normal production shall not then resume until a complete verification process has been performed and approved by the Engineer.

Acceptance of all mix failing to meet the individual test control limits (including results for required partial test series on mix) or minimum TSR requirements as described above will be determined in accordance with Article 105-3. In addition, any mix that is obviously unacceptable will be rejected for use in the work.

Failure to stop production when required due to an individual mix test not meeting the specified requirements will subject all mix from the stop point tonnage to the point when the next individual test is back on or within the warning limits, or to the tonnage point when production is actually stopped, whichever occurs first, to being considered unacceptable.

Failure to stop production when required due to two consecutive TSR tests failing to meet the specification requirements will subject all mix from the stop point tonnage to the point when the next TSR test meets or exceeds the specification requirement, or to the tonnage point when production is actually stopped, whichever occurs first, to being considered unacceptable.

In either case, remove and replace this mix with materials that comply with the Specifications at no additional costs to the Department, unless otherwise approved. Payment will be made for the actual quantities of materials required to replace the removed quantities, not to exceed the original amounts.

Immediately notify the Engineer when any moving average value exceeds the warning limit. If two consecutive moving average values for any one of the mix control criteria fall outside the warning limits, cease production of that mix, immediately notify the Engineer of the stoppage, and make adjustments. The Contractor may elect to stop production after only one moving average value falls outside the warning limits. In either case, do not determine a new moving average until the fourth test after the elective or mandatory stop in production.

Do not resume normal plant production until one of the following has occurred.

Option 1: Approval has been granted by the appropriate QA Supervisor.

Option 2: The mix in question has been satisfactorily verified in accordance with Article 609-4. Normal production may resume based on the approval of the contractor's Level II technician, provided notification and the verification test results have been furnished to the QA Laboratory.

Failure to fully comply with one of the above provisions will result in immediate production stoppage by the Engineer. Normal production shall not then resume until a complete verification process has been performed and approved by the Engineer.

If the process adjustment improves the property in question such that the moving average after four additional tests is on or within the warning limits, the Contractor may continue production with no reduction in payment.

If the adjustment does not improve the property in question such that the moving average after four additional individual tests stays in the warning bands, the mix will be considered not to be within reasonably close conformity, but reasonably acceptable. Reduced payment for the mix in question will be applied starting from the plant sample tonnage at the stop point to the sample tonnage when the moving average is on or within the warning limits in accordance with the following table.

**Payment for Mix Produced in the Warning Bands***

| Property | Pay Factor |
|---|---|
| 2.36 mm Sieve | 90% |
| 0.075 mm Sieve | 90% |
| Binder Content | 85% |
| VTM @ $N_{des}$ | 70% |
| VMA @ $N_{des}$ | 90% |

* When two or more properties are in question, only the lower pay factor will be applied to the mix unit bid price.

If the adjustment does not improve the property in question such that the moving average after four additional tests exceeds the moving average control limits, the mix will be considered not to be within reasonably close conformity with Specifications. If the Engineer determines the mix is reasonably acceptable based on test data and an inspection of the completed pavement and allows it to remain in place, the mix will be accepted in accordance with Article 105-3. If the mix is determined to be unacceptable, the mix will be removed and replaced with materials that comply with the Specifications. In either case, the adjustment or removal, respectively, for the mix in question will be applied starting from the plant sample tonnage at the stop point to the sample tonnage when the moving average is on or within the warning limits. In addition, any mix that is obviously unacceptable will be rejected for use in the work.

Failure to stop production and make adjustments when required due to two consecutive moving average values falling outside the warning limits will subject all mix produced from the stop point tonnage to the tonnage point when the moving average is back on or within the warning limits or to the tonnage point when production is actually stopped, whichever occurs first, to being considered unacceptable. Remove this material and replaced with materials which comply with the Specifications at no additional costs to the Department, unless otherwise approved. Payment will be made for the actual quantities of materials required to replace the removed quantities, not to exceed the original amounts.

(7) Allowable Retesting for Mix Deficiencies

The Contractor may elect to resample and retest for plant mix deficiencies when individual QC test(s) exceed one or more mix property target(s) by more than the tolerances indicated below. Perform the retesting within 10 days after initial test results are determined. Retesting shall be approved prior to being performed and in accordance with the Department's GUIDELINES FOR RETESTS OF PLANT MIX DEFICIENCIES outlined in the HMA/QMS Manual. The Contractor, under the supervision of the Department's QA personnel, will perform these retests. Retests for any mix deficiency other than as listed below will not be allowed unless otherwise permitted. Acceptance of the mix in question will be based on the retest data in accordance with Article 105-3.

The Department reserves the right to require the Contractor to resample and retest at any time or location as directed.

- VTM -- by more than +/- 2.5%
- VMA -- by more than +/- 2.0%
- % Binder Content -- by more than +/- 1.0%
- 0.075 mm sieve -- by more than +/- 3.0%
- 2.36 mm sieve -- exceeds both the Specification mix design limits and one or more of the above tolerances
- TSR -- by more than -15% from Specification limit

**(D) Field Compaction Quality Control**

(1) General

Perform quality control of the compaction process in accordance with these provisions and applicable requirements of Article 610-9. The Contractor may elect to use either cored sample density procedures or nuclear gauge density procedures. Provide to the Department at the pre-construction conference the method of density quality control that will be used on the project.

Establish acceptable control strips when required at locations approved by the Engineer. Construct control strips that are 91.4 m in length at the paver laydown width being placed. When utilizing core sample control, place control strips anytime placement is proceeding on limited production due to failing densities. When utilizing nuclear density control, place control strips at the minimum frequencies specified in the Department's current Nuclear Gauge Operator's Manual. In addition, place control strips anytime deemed necessary by the Engineer.

Conduct density sampling and testing by either method based on test sections consisting of not more than 600 linear meters or fraction thereof per day on pavement placed at the paver laydown width. Perform density sampling and testing on all pavements listed below unless otherwise approved.

(a) All full width travel lane pavements, including normal travel lanes, turn lanes, collector lanes, ramps and loops, and temporary pavements,

(b) Pavement widening 1.2 m or greater,

(c) Uniform width paved shoulders 0.6 m or greater,

(d) And wedging as outlined in the *HMA/QMS Manual*.

Base and intermediate mix types (surface mixes not included) utilized for pavement widening of less than 1.2 m and all mix types used in tapers, irregular areas and intersections (excluding full width travel lanes of uniform thickness), will not be subject to the sampling and testing frequency specified above provided the pavement is compacted using approved equipment and procedures. However, the Engineer may require occasional density sampling and testing to evaluate the compaction process. Irregular areas are defined as areas that have irregular shapes that make them difficult to compact with conventional asphalt rollers.

Perform the sampling and testing at the minimum test frequencies as specified above. Should the density testing frequency fail to meet the minimum frequency as specified above, all mix without the required density test representation will be considered unsatisfactory and if allowed to remain in place, will be paid for at 50 percent of the contract unit bid price for the mixture.

Conduct all QC nuclear density testing the same day that the mix being tested is placed and compacted. Obtain all core samples no later than the beginning of the next production day, not to exceed 3 calendar days. Test QC core samples and submit test results within one working day of the time the samples are taken. Should the specified density tests not be completed within the allowable time cease production at that point until such time the required tests are completed. Failure to provide samples may result in suspension of all project operations.

Retain quality control density core samples at the plant site for 5 calendar days, commencing the day the samples are tested, or until permission for disposal is granted by the quality assurance personnel, whichever occurs first. Retain the Department's quality assurance comparison and verification core samples in a sealed container at the plant site until obtained by quality assurance personnel. Store all retained density samples on a smooth, flat surface in a cool, dry, and protected location.

Check core samples may be taken by the Contractor for any of the following reasons:

(a) When core sample control is being used and a test section core sample(s) is more than 2.0 percent below the average of all core samples from the same lot, that core(s) samples may be checked,

(b) When a control strip fails and a core sample(s) is more than 2.0 percent below the average of the control strip, that core(s) may be checked.

For each core sample that is to be checked, take 3 check samples as follows: one adjacent to the initial sample and one 3 m in each direction, longitudinally, of the initial sample. The results of these 3 check samples will be averaged and this average will be used in lieu of the initial core results in question. The initial core sample results will not be used if check samples are taken.

Check samples shall be taken within 2 calendar days of the date of the initial sample. Only one set of check samples per sample location will be allowed. If full depth cores are necessary at these check sample locations, separation of the layer to be tested will be the responsibility of the Contractor. Take all check samples in the presence of a representative of the Engineer. In addition, a QA comparison core sample(s) may be taken adjacent to one or more of these check samples.

(2) Pavement Samples (Cores)

When cored samples are required by either density method, obtain cores from the full layer depth of the compacted pavement at random locations determined in accordance with procedures in the Department's HMA/QMS Manual. If full depth cores are taken, the Contractor is responsible for separating the layer of mix to be tested in a manner such that it is not damaged. The use of a separator medium beneath the layer to be tested is prohibited.

Pavement layers may be cooled by approved artificial methods to allow cutting the core samples as quickly as possible. No additional compensation will be made for the costs of artificial cooling.

Take pavement specimens for density testing purposes utilizing a 152 mm core drill. Use approved coring equipment that is capable of taking a representative sample of the compacted pavement. In the event a malfunction of the coring equipment occurs, utilize other approved means to obtain the required samples. Repair the coring equipment and restore to use within three working days.

Where samples have been taken, clean the inside surfaces of the sample hole, dry, properly apply tack coat, place and compact new mix of the same type to

conform with the surrounding area within one working day of the sample being taken. Use a circular tamp or other approved device to achieve compaction.

(3) Core Sample Density Procedures

In addition to the above requirements, perform core sample density control procedures as noted herein. When cored sample control is being utilized, the testing frequency will be a minimum of one random 152 mm core sample taken from each test section, except take a minimum of at least three core samples from each mix type and/or lot placed on a given day.

An initial control strip is not required at the beginning of placement of each job mix formula but may be performed by the Contractor for use in determining the necessary compactive effort and roller patterns. Cored sample control strips will be required if production and placement is being performed under limited production procedures due to failing densities.

(4) Nuclear Gauge Density Procedures

In addition to the requirements in Subarticle 609-5(D)1, perform nuclear density control procedures in accordance with the Department's most current Nuclear Gauge Operator's Manual. This Manual may be obtained through the Department's M & T Soils Laboratory. Determine density by the backscatter method of testing using a thin-lift nuclear gauge, with printer, which has been approved by the Department. Furnish, maintain, and operate the nuclear gauge. Furnish an operator that has been certified by the Department.

Provide a gauge that has been calibrated within the previous 12 months by an approved calibration service. Maintain documentation of such calibration service for a 12 month period.

Conduct all QC nuclear density tests the same day the mix being tested is placed and compacted. Furnish summary of density results to the Engineer no later than the end of each day's production. Furnish a copy of the nuclear gauge printout(s) to the Engineer upon request.

Determine target density for testing by constructing control strip(s) in accordance with and at the frequencies prescribed in the Nuclear Gauge Operator's Manual. Core samples from the control strips may be checked in accordance with the criteria established in Subarticle 609-5(D)1.

Conduct sampling and testing as specified based on test sections consisting of not more than 600 linear meters or fraction thereof per day on pavement placed at the paver laydown width. The nuclear density testing frequency will consist of five random gauge readings (one random reading from each of five equally spaced increments) from each test section. In addition, take at least five gauge readings during any day's production of a given mix type. Random locations for gauge readings will be determined in accordance with the procedures in the Department's most current Nuclear Gauge Operator's Manual. Test section pavement shall be of the same mix design as the pavement utilized in the applicable control strip.

(5) Limited Production Procedure

Proceed on limited production when, for the same mix type and contract, one of the following conditions occur:

(a) Two consecutive failing lots, excluding lots representing an individual resurfacing map or portion thereof.

(b) Three consecutive failing lots, with each lot representing an individual resurfacing map or portion thereof.

(c) Two consecutive failing nuclear control strips.

As exceptions to the above, pavement within each construction category (New and Other), as defined in Article 610-13, and pavement placed simultaneously by multiple paving crews will be evaluated independently for limited production purposes.

Limited production is defined as being restricted to the production, placement, and compaction of a sufficient quantity of mix necessary to construct only a 100 m control strip plus 30 m of pavement adjacent to each end of the control strip.

Remain on limited production until such time as satisfactory density results are achieved or until two control strips have been attempted without achieving acceptable density test results. If the Contractor fails to achieve satisfactory density after two control strips have been attempted, cease production of that mix type until such time as the cause of the failing density test results can be determined. As an exception, the Engineer may grant approval to produce a different mix design of the same mix type if the cause is related to mix problem(s) rather than compaction related problems.

If the Contractor does not operate by the limited production procedures as specified above, the two consecutive failing density lots, three consecutive failing lots with each lot representing an individual resurfacing map or portion thereof, or two consecutive failing nuclear control strips, whichever is applicable, and all mix produced thereafter will be considered unacceptable. Remove this material and replace with material that complies with the Specifications at no cost to the Department, unless otherwise approved. Payment will be made for the actual quantities of materials required to replace the removed quantities, not to exceed the original amounts.

**(E) Documentation (Records)**

Document all quality control activities, records of inspection, samples taken, adjustments to the mix, and test results on a daily basis. Note the results of observations and records of inspection as they occur in a permanent field record. Record adjustment to mix production and test results on forms provided. Process control sample test results are for the Contractor’s informational purposes only.

Make all such records available to the Engineer, upon request, at any time during project construction. Complete all QC records and forms and distribute in accordance with the most current edition of the Department's *HMA/QMS Manual*. Maintain all QC records, forms and equipment calibrations for a minimum of 3 years from their completion date. Failure to maintain QC records and forms as required, or to provide these records and forms to the Engineer upon request, may result in production and/or placement stoppage until the problem is resolved.

Falsification of test results, documentation of observations, records of inspection, adjustments to the process, discarding of samples and/or test results, or any other deliberate misrepresentation of the facts will result in the revocation of the applicable person’s QMS certification. The Engineer will determine acceptability of the mix and/or pavement represented by the falsified results or documentation. If the mix and/or pavement in question is determined to be acceptable, the Engineer may allow the mix to remain in place at no pay for the mix, asphalt binder and other mix components. If the mix and/or pavement represented by the falsified results is determined not to be acceptable, remove and replace with mix, that complies with the Specifications. Payment will be made for the actual quantities of materials required to replace the falsified quantities, not to exceed the original amounts.

## 609-6 QUALITY ASSURANCE

The Department's quality assurance program will be conducted by a certified QMS technician(s) and will be accomplished in the following ways:

**Plant Mix Quality Assurance:**

**(A)** By conducting assurance testing of split samples obtained by the Contractor at a frequency equal to or greater than 5%of the frequency required of the Contractor;

**(B)** By periodically observing sampling and testing procedures performed by the Contractor;

**(C)** By monitoring required control charts exhibiting test results of control parameters;

**(D)** By directing the Contractor to take additional samples at any time and any location during production (in lieu of the next scheduled random sample for that increment);

**(E)** By conducting verification sampling and testing on samples taken independently of the Contractor's quality control samples; at a frequency equal to or greater than 10% of the QC sample frequency; or

**(F)** By any combination of the above

The Engineer will periodically obtain quality assurance and verification mix samples for testing independently of the Contractor's quality control process. The Engineer will conduct assurance tests on both split QC samples taken by the Contractor and verification samples taken by the Department. These samples may be the regular quality control samples or a sample selected by the Engineer from any location in the process, or verification samples taken at random by the Department. The Engineer may select any or all split samples for assurance testing.

**Density Quality Assurance**

**(A)** By retesting randomly selected quality control test sections (either cores or nuclear) at a frequency equal to or greater than 5% of the frequency required of the Contractor.

**(B)** By periodically observing tests performed by the Contractor;

**(C)** By testing randomly selected comparison core samples taken adjacent to the Contractor's quality control core samples (200 mm center-to-center) at a frequency equal to or greater than 5% of the frequency required of the Contractor; and

**(D)** By conducting verification sampling and testing on test sections (either core or nuclear) independently of the Contractor's quality control test sections at a frequency equal to or greater than 10% of the QC sample frequency.

**(E)** By periodically directing the recalculation of random locations for the Quality Control core or nuclear density test sites. The original QC test locations may be tested by QA personnel and evaluated as verification tests.

Comparison and verification core samples will be taken in the presence of a DOT technician, and either delivered directly to the appropriate QA Laboratory by a DOT technician or placed in a sealed container and delivered to the Contractor's QC Laboratory for Quality Assurance personnel to obtain.

Results of quality assurance tests for plant mix and density will be provided to the Contractor within 3 working days after the sample has been obtained, except for verification TSR test results that will be provided within 7 calendar days.

**Limits of Precision**

Differences between the Contractor's and the Department's split sample test results will be considered acceptable if within the following limits of precision:

| Mix Property | Limits of Precision |
|---|---|
| 25.0 mm sieve (Base Mix) | ± 10.0% |
| 19.0 mm sieve (Base Mix) | ± 10.0% |
| 12.5 mm sieve (Intermediate Mix) | ± 6.0% |
| 9.5 mm sieve (Surface Mix) | ± 5.0% |
| 4.75 mm sieve (Surface Mix) | ± 5.0% |
| 2.36 mm sieve (All Mixes) | ± 5.0% |
| 0.075 mm sieve (All Mixes) | ± 2.0% |
| Asphalt Binder Content | ± 0.5% |
| Maximum Specific Gravity ($G_{mm}$) | ± 0.020 |
| Bulk Specific Gravity ($G_{mb}$) | ± 0.030 |
| TSR | ± 15.0% |
| QA retest of prepared QC Gyratory Compacted Volumetric Specimens | ± 0.015 |
| Retest of QC Core Sample | ± 1.2% (% Compaction) |
| Comparison QA Core Sample | ± 2.0% (% Compaction) |
| QA Verification Core Sample | ± 2.0% (% Compaction) |
| Nuclear Comparison of QC Test | ± 2.0% (% Compaction) |
| QA Nuclear Verification Test | ± 2.0% (% Compaction) |

The Engineer will immediately investigate the reason for differences if any of the following occur:

**(A)** QA test results of QC split sample does not meet above limits of precision, or

**(B)** QA test results of QC split sample does not meet the individual test control limits or the specification requirements, or

**(C)** QA verification sample test results exceed the allowable retesting tolerances.

If the potential for a pavement failure exist, the Engineer may suspend production, wholly or in part, in accordance with Article 108-7 while the investigation is in progress. The Engineer's investigation may include, but not be limited to the following:

**(A)** Joint testing of any remaining split samples,

**(B)** Review and observation of the QC technician's sampling and testing procedures,

**(C)** Evaluation and calibration of QC testing equipment,

**(D)** Comparison testing of other retained quality control samples, and/or additional density core samples.

If additional mix samples or core samples are necessary to resolve the difference, these samples will be taken as directed and tested jointly by the Contractor's quality control and Department's quality assurance personnel. If reasons for the difference cannot be determined, payment for the mix in question will be determined in accordance with Article 105-3. If the reason for the difference is determined to be an error or other discrepancy in the quality control test results, the applicable quality assurance test results or verification test results will be used to determine compliance with the applicable mix or density specification requirements.

The Engineer will periodically witness the sampling and testing being performed by the Contractor. If the Engineer observes that the sampling and quality control tests are not being performed in accordance with the applicable test procedures, the Engineer may stop production until corrective action is taken. The Engineer will promptly notify the Contractor of observed deficiencies, both verbally and in writing. The Engineer will document all witnessed samples and tests.

## 609-7 ACCEPTANCE

Final acceptance of the asphalt pavement will be made by the Department in accordance with the following:

### Mix Acceptance

The Engineer will base final acceptance of the mix on the results of random testing made on split samples during the assurance process and validation of the Contractor's quality control process as outlined in Subarticle 609-5(C) and Article 609-6.

### Density Acceptance

The Department will evaluate the asphalt pavement for density compliance after the asphalt mix has been placed and compacted using the Contractor's quality control test results, the Department's quality assurance test results, and by observation of the Contractor's density quality control process as outlined in Subarticle 609-5(D), Article 609-6 and Article 610-13.

## 609-8 MEASUREMENT AND PAYMENT

Produce and construct all asphalt mixtures and pavements in accordance with these Specifications. There will be no direct payment for work covered by this Specification. Payment at the contract unit prices for the various asphalt items will be full compensation for all work covered by these specifications.

# SECTION 610
# ASPHALT CONCRETE PLANT MIX PAVEMENTS

## 610-1 DESCRIPTION

Perform the work covered by this section, including but not limited to the construction of one or more courses of asphalt mixture placed on a prepared surface in accordance with these Specifications and in reasonably close conformity with the lines, grades, thickness, and typical sections shown on the plans. This work includes producing, weighing, transporting, placing and compacting the plant mix; furnishing aggregate, asphalt binder, anti-strip additive, and all other materials for the plant mix; furnishing and applying tack coat as specified in Section 605; furnishing scales; maintaining the course until final acceptance of the project; making any repairs or corrections to the course that may become necessary; providing and conducting quality control as specified in Section 609; and surface testing of the completed pavement. The design requirements for the various mix types are given in Table 610-1 and Table 610-2 for Superpave mix types, Section 650 for OGAFC and Section 652 for PADC.

Provide and conduct the quality control and required testing for acceptance of the asphalt mixture in accordance with Section 609.

## 610-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Coarse aggregate | 1012-1 |
| Fine aggregate | 1012-1 |
| Mineral Filler | 1012-1 |
| Stone Screenings | 1012-1 |
| Reclaimed asphalt pavement | 1012-1 |
| Reclaimed asphalt shingles | 1012-1 |
| Natural sand | 1012-1 |
| Anti-strip additive (hydrated lime) | 1012-1 |
| Anti-strip additive (chemical) | 1020-8 |
| Asphalt Binder, Performance Grade | 1020-2 |
| Silicone | 1020-4 |

## 610-3 COMPOSITION OF MIXTURES (MIX DESIGN AND JOB MIX FORMULA)

### (A) Mix Design-General

Prepare the asphalt mix design utilizing a mixture of coarse and fine aggregate, asphalt binder, mineral filler, and other additives when required. Size, uniformly grade, and combine the several aggregate fractions in such proportions that the resulting mixture meets the grading and physical requirements of the Specifications for the specified mix type. Materials that will not produce a mixture within the design criteria required by the Specifications will be rejected, unless otherwise approved.

At least 10 days prior to start of asphalt mix production submit, in writing and in electronic form, the mix design and proposed job mix formula (JMF) targets for each required mix type and combination of aggregates to the Engineer for review and approval. Prepare the mix design using a Department certified mix design technician in an approved mix design laboratory. Perform the mix design in accordance with the Superpave mix design system as described in AASHTO R 35 Standard Practice for Designing Superpave HMA as modified by the Department. Perform, document and submit all mix designs in accordance with Department policies, procedures and computerized mix design programs. Submit the mix design and proposed job mix formula targets on approved forms and in the format required by the Department for the appropriate mix type. In addition, submit the mix design data in electronic format using the Department's latest mix design programs and procedures for the specified mix type. In addition, submit Superpave gyratory compactor printouts for all specimens compacted at $N_{des}$ during the mix design process.

For the final surface layer of the specified mix type, use a mix design with an aggregate blend gradation above the maximum density line on the 2.36 mm and larger sieves.

Reclaimed asphalt pavement (RAP) may constitute up to 50 percent of the total material used in recycled mixtures, except for mix Type S 12.5D, Type S 9.5D, and mixtures containing reclaimed asphalt shingle material (RAS). Reclaimed asphalt shingle (RAS) material may constitute up to 6 percent by weight of total mixture for any mix. When both RAP and RAS are used, do not use a combined percentage of RAS and RAP greater than 15% by weight of total mixture, unless otherwise approved. When the percent of binder contributed from RAS or a combination of RAS and RAP exceeds 20% of the total binder in the completed

mix, the virgin binder PG grade shall be one grade below (both high and low temperature grade) the binder grade specified in Table 610-2 for the mix type.

For Type S 12.5D and Type S 9.5D mixes, the maximum percentage of reclaimed asphalt material is limited to 15% and shall be produced using virgin asphalt binder grade PG 76-22. For all other recycled mix types, when the percentage of RAP is 15% or less of the total mixture, the virgin binder PG grade shall be as specified in Table 610-2 for the specified mix type. When the percentage of RAP is greater than 15% but not more than 25% of the total mixture, the virgin binder PG grade must be one grade below (both high and low temperature grade) the specified grade for the mix type detailed in Table 610-2. When the percentage of RAP is greater than 25% of the total mixture, the Engineer will establish and approve the asphalt binder grade.

Should a change in the source of RAP or RAS be made, a new mix design and/or job mix formula may be required in accordance with Article 1012-1. Samples of the completed recycled mixture may be taken by the Department on a random basis to determine the PG grading on the recovered asphalt binder in accordance with AASHTO M 320. If the grading is determined to be a value other than required for the specified mix type, the Engineer may require the Contractor to adjust the grade and/or percentage of additional asphalt binder, and/or the blend of reclaimed material to bring the grade to the specified value.

Prepare all proposed mix design data in accordance with Department policies and procedures including but not limited to, the following information:

(1) Source and percentage of each aggregate component to be used in the design aggregate blend gradation, including RAP and RAS.

(2) Percentage of asphalt binder in RAP and RAS.

(3) Gradation of each aggregates component, including RAP and RAS.

(4) The following aggregate properties: current bulk specific gravity (Gsb), current apparent specific gravity (Gsa) and absorption of the individual aggregate components to be used when tested in accordance with AASHTO T 84 and T 85, except report the effective bulk specific gravity (Gse) of RAP and RAS aggregate as determined by AASHTO T 209. Report coarse aggregate angularity, fine aggregate angularity, flat and elongated percentages, and sand equivalent for the total aggregate blend.

(5) Source(s), modification method, and percent of modifier by weight of asphalt binder, if modified.

(6) Supplier, source, grade, and equi-viscous mixing and compaction temperatures of the asphalt binder. Determine equi-viscous temperatures using the rotational viscometer in accordance with ASTM D 4402 corresponding to the following recommended viscosity ranges:

Range for mixing = 0.150 to 0.190 Pa-s

Range for compaction = 0.250 to 0.310 Pa-s

When PG 76-22 or other modified binders are used, base the temperatures on the documented supplier's recommendations.

(7) Brand name, manufacturer, shipping point, and percentage of anti-strip additive used in the mix design. Determine TSR data in accordance with AASHTO T 283 as modified by the Department.

(8) Target value for percent passing each standard sieve for the design aggregate gradation. Data will show the percent passing for all standard sieves listed in Table 610-1 for the specified mix type. Show the percentages in units of one percent of aggregate passing, except for the 0.075 mm sieve, show in units to one-tenth of one percent. Base

percentages on the dry weight of aggregate determined in accordance with AASHTO T 11 and T 27.

(9) Volumetric properties of the compacted mixture calculated on the basis of the mixture's maximum specific gravity as determined by AASHTO T 209. The mixture shall be aged in accordance with AASHTO R 30 and the bulk specific gravity of specimens determined by AASHTO T 166, Method A, for each asphalt content tested. Determine and report properties in accordance with the requirements of AASHTO R 35 except as modified herein, and Department Mix Design Policies and Procedures.

(10) Graphical plots of percent asphalt binder by total weight of mix (Pb) versus the following properties at the design number of gyrations, $N_{des}$, specified

(a) SGC bulk gravity, $G_{mb}$ @ $N_{des}$

(b) % $G_{mm}$ @ $N_{ini}$

(c) Voids in total Mix (VTM)

(d) Voids Filled With Asphalt (VFA)

(e) Voids in Mineral Aggregate (VMA)

(f) % Compaction vs. Log of Gyrations

(11) Graphical plot of the design aggregate gradation (design blend) on FHWA 0.45 power chart showing the applicable control points, and maximum density line. Plot all standard sieves for the applicable mix type.

(12) Proposed target value of asphalt binder content by weight of total mix and specification design properties at that percentage.

(13) TSR test data in accordance with AASHTO T 283(Modified)

In addition to the required mix design submittal forms, the Contractor shall deliver six (6) Superpave Gyratory Compactor specimens to the Department's Central Asphalt Laboratory for the following surface mix types: SF 9.5A, S 9.5B, S 9.5C, S 9.5D, S 12.5C and S 12.5D. The Contractor will prepare these specimens using lab produced mix in accordance with AASHTO T 312 (Modified). These specimens shall be compacted to a height of 75mm and to a void content (VTM) of 4.0% +/- 0.5%. These specimens will be tested for rutting susceptibility using the Asphalt Pavement Analyzer in the Materials and Test Central facility or other approved facility.

In addition, when requested by the Engineer, submit to the Department's Materials & Tests Asphalt Design Laboratory, representative samples of each mix component, including RAP, RAS, mineral filler, asphalt binder, chemical anti-strip additive and hydrated lime as noted below. Provide the samples at least 20 days prior to the anticipated beginning placement of mixture.

115 kg of each coarse aggregate

70 kg of each intermediate and fine aggregate

70 kg RAP and / or RAS

4 L of mineral filler and/or baghouse fines

8 L of asphalt binder

4 L of hydrated lime

When the submitted aggregate samples are combined according to the Contractor's proposed blend percentages, the combined gradation shall be within the gradation band defined by the design criteria specified in Table

610-1 for each sieve or the samples will not be considered representative and new samples may be required.

**(B) Mix Design Criteria**

Design and produce asphalt concrete mixtures that conform to the gradation requirements and design criteria in Table 610-1 and Table 610-2 for the mix type specified. The mix type designates the nominal maximum aggregate size and the design traffic level.

Surface mix designs will be tested by the Department for rutting susceptibility. Rut depth requirements for each surface mix type and traffic level are specified in Table 610-2. Mix designs that fail to meet these requirements will be considered unacceptable and must be redesigned by the Contractor such that rut depths are acceptable.

Table 610-1 provides gradation control points to be adhered to in the development of the design aggregate structure for each mix type. Aggregate gradations shall be equal to or pass between the control points, unless approved in writing. Table 610-2 provides the mix design criteria for the various mix types.

Use an anti-strip additive in all Superpave asphalt mixes. It may be hydrated lime or a chemical additive or a combination of both as needed to meet the retained strength requirements as specified in TABLE 610-2. When a chemical additive is used, add at a rate of not less than 0.25% by weight of binder in the mix. When hydrated lime is used, add at a rate of not less than 1.0 % by weight of the total dry aggregate.

**(C) Job Mix Formula**

Establish the job mix formula (JMF) gradation target values within the design criteria specified for the particular type of asphalt mixture to be produced. Establish the JMF asphalt binder content at the percentage that will produce voids in total mix (VTM) at the midpoint of the specification design range for VTM, unless otherwise approved. The formula for each mixture will establish the following: blend percentage of each aggregate fraction, the percentage of reclaimed aggregate, if applicable, a single percentage of combined aggregate passing each required sieve size, the total percentage and grade of asphalt binder required for the mixture (by weight of total mixture), the percentage and grade of asphalt binder to be added to the mixture (for recycled mixtures), the percentage of chemical anti-strip additive to be added to the asphalt binder or percentage of hydrated lime to be added to the aggregate, the temperature at that the mixture is to be discharged from the plant, the required field density, and other volumetric properties.

The mixing temperature at the asphalt plant will be established on the job mix formula. For mix types listed in Table 610-2, the mixing temperature will be established between 130°C and 175°C or as approved. Unless otherwise requested, the JMF temperature will be established as follows:

| | | |
|---|---|---|
| Mixes with binder grade | PG 64-22 | 149°C |
| | PG 70-22 | 157° C |
| | PG 76-22 | 168° C |

Have on hand at the asphalt plant the approved mix design and job mix formula issued by the Department, prior to beginning the work.

The job mix formula for each mixture will remain in effect until modified in writing, provided the results of QMS tests performed in accordance with Section 609 on material currently being produced conform with specification requirements. When a change in sources of aggregate materials is to be made, a new mix design and job mix formula will be required before the new mixture is produced, unless otherwise approved. When a change in sources of RAP or RAS

material is to be made, a new mix design and/or job mix formula may be required in accordance with Article 1012-1. When unsatisfactory results or other conditions make it necessary, the Engineer may revoke the existing job mix formula or establish a new job mix formula.

**TABLE 610-1**
**SUPERPAVE AGGREGATE GRADATION DESIGN CRITERIA**

| Standard | Percent Passing Criteria (Control Points) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sieves | Mix Type (Nominal Maximum Aggregate Size) | | | | | | | | | | | |
| | 4.75 mm (a) | | 9.5 mm (c) | | 12.5 mm (c) | | 19.0 mm | | 25.0 mm | | 37.5 mm | |
| (mm) | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| 50.0 | | | | | | | | | | | 100.0 | |
| 37.5 | | | | | | | | | 100.0 | | 90.0 | 100.0 |
| 25.0 | | | | | | | 100.0 | | 90.0 | 100.0 | | 90.0 |
| 19.0 | | | | | 100.0 | | 90.0 | 100.0 | | 90.0 | | |
| 12.5 | | | 100.0 | | 90.0 | 100.0 | | 90.0 | | | | |
| 9.5 | 100.0 | | 90.0 | 100.0 | | 90.0 | | | | | | |
| 4.75 | 90.0 | 100.0 | | 90.0 | | | | | | | | |
| 2.36 | 65.0 | 90.0 | 32.0(b) | 67.0(b) | 28.0 | 58.0 | 23.0 | 49.0 | 19.0 | 45.0 | 15.0 | 41.0 |
| 1.18 | | | | | | | | | | | | |
| 0.600 | | | | | | | | | | | | |
| 0.300 | | | | | | | | | | | | |
| 0.150 | | | | | | | | | | | | |
| 0.075 | 4.0 | 8.0 | 4.0 | 8.0 | 4.0 | 8.0 | 3.0 | 8.0 | 3.0 | 7.0 | 3.0 | 6.0 |

(a) For Type S 4.75A, a minimum of 50% of the aggregate components shall be material manufactured from the crushing of stone.

(b) For Type SF 9.5A, the percent passing the 2.36mm sieve shall be a minimum of 60% and a maximum of 70%.

(c) For the final surface layer of the specified mix type, use a mix design with an aggregate blend gradation above the maximum density line on the 2.36 mm and larger sieves.

**TABLE 610-2**
**SUPERPAVE MIX DESIGN CRITERIA**

| Mix Type | Design ESALs millions | Binder PG Grade | Compaction Levels No. Gyrations @ | | Max. Rut Depth | Volumetric Properties (c) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | VMA | VTM | VFA | %Gmm |
| (e) | (a) | (b) | $N_{ini}$ | $N_{des}$ | (mm) | % Min. | % | Min. - Max. | @ $N_{ini}$ |
| S-4.75A | <0.3 | 64 -22 | 6 | 50 | ------- | 20.0 | 7.0-15.0 | | ------- |
| SF-9.5A | <0.3 | 64 -22 | 6 | 50 | 11.5 | 16.0 | 3.0 - 5.0 | 70 - 80 | ≤ 91.5 |
| S-9.5B | 0.3 - 3 | 64 -22 | 7 | 75 | 9.5 | 15.0 | 3.0 - 5.0 | 65 - 80 | ≤ 90.5 |
| S-9.5C | 3 - 30 | 70 -22 | 8 | 100 | 6.5 | 15.0 | 3.0 - 5.0 | 65 - 76 | ≤ 90.0 |
| S 9.5D | > 30 | 76 -22 | 9 | 125 | 4.5 | 15.0 | 3.0 - 5.0 | 65 - 76 | ≤ 90.0 |
| S-12.5C | 3 - 30 | 70 -22 | 8 | 100 | 6.5 | 14.0 | 3.0 - 5.0 | 65 - 75 | ≤ 90.0 |
| S-12.5D | > 30 | 76 -22 | 9 | 125 | 4.5 | 14.0 | 3.0 - 5.0 | 65 - 75 | ≤ 90.0 |
| I-19.0B | < 3 | 64 -22 | 7 | 75 | --------- | 13.0 | 3.0 - 5.0 | 65 - 78 | ≤90.5 |
| I-19.0C | 3 - 30 | 64 -22 | 8 | 100 | --------- | 13.0 | 3.0 - 5.0 | 65 - 75 | ≤ 90.0 |
| I-19.0D | > 30 | 70 -22 | 9 | 125 | --------- | 13.0 | 3.0 - 5.0 | 65 - 75 | ≤ 90.0 |
| B-25.0B | < 3 | 64 -22 | 7 | 75 | --------- | 12.0 | 3.0 - 5.0 | 65 - 78 | ≤ 90.5 |
| B-25.0C | > 3 | 64 -22 | 8 | 100 | --------- | 12.0 | 3.0 - 5.0 | 65 - 75 | ≤ 90.0 |
| B-37.5C | > 3 | 64 -22 | 8 | 100 | --------- | 11.0 | 3.0 - 5.0 | 63 - 75 | ≤ 90.0 |
| | **Design Parameter** | | | | | **Design Criteria** | | | |
| All Mix | 1. Dust to Binder Ratio ($P_{0.075}$ / $P_{be}$) | | | | | 0.6 - 1.4 | | | |
| Types | 2. Retained Tensile Strength (TSR)(AASHTO T 283 Modified) | | | | | 85 % Min. **(d)** | | | |

Notes (a) Based on 20 year design traffic.

(b) When Recycled Mixes are used, select the binder grade to be added in accordance with Subarticle 610-3(A).

(c) Volumetric Properties based on specimens compacted to $N_{des}$ as modified by the Department.

(d) AASHTO T 283 Modified (No Freeze-Thaw cycle required). TSR for Type S 4.75A, Type B 25.0 and Type B 37.5 mixes is 80% minimum.

(e) Mix Design Criteria for Type S 4.75A may be modified subject to the approval of the Engineer

## 610-4 WEATHER, TEMPERATURE, AND SEASONAL LIMITATIONS FOR PRODUCING AND PLACING ASPHALT MIXTURES

Do not produce or place asphalt mixtures during rainy weather, when the subgrade or base course is frozen, or when the moisture on the surface to be paved would prevent proper bond. Do not place asphalt material when the air temperature, measured in the shade away from artificial heat at the location of the paving operation and the road surface temperature in the shade is less than the temperatures shown in Table 610-3.

Do not place surface course material that is to be the final layer of pavement between December 15 and March 16 of the next year if it is 25 mm or greater in thickness or between November 15 and April 1 of the next year if it is less than 25 mm in thickness, unless otherwise approved. Do not place open-graded asphalt friction course between October 31 and April 1 of the next year, unless otherwise approved.

As an exception to the above, when in any day's operations the placement of a layer of asphalt base course material or intermediate material 50 mm or greater in thickness has started, it may continue until the temperature drops to 0°C.

Do not place plant mix base course or intermediate course that will not be covered with surface course during the same calendar year or within 15 days of placement if the plant mix is placed in January or February. Failure by the Contractor to cover the plant mix as required above will result in the Engineer notifying the Contractor in writing to cover the plant mix with a sand seal. Apply the sand seal in accordance with the requirements of Section 660, except that Articles 660-3, 660-11, and 660-12 will not apply. Perform this work at no cost to the Department. In the event the Contractor fails to apply the sand seal within 72 hours of receipt of such notice, the Engineer may proceed to have such work performed with Department forces and equipment. The cost of such work performed by Department forces will be deducted from monies due or to become due to the Contractor.

**TABLE 610-3**
**ASPHALT PLACEMENT- MINIMUM TEMPERATURE REQUIREMENTS**

| Asphalt Concrete Mix Type | Minimum Air Temperature | Minimum Road Surface Temperature |
|---|---|---|
| ACBC, Type B 25.0B, C, B 37.5C | 2°C | 2°C |
| ACIC, Type I 19.0B, C, D | 2°C | 2°C |
| ACSC, Type S 9.5C, D, S 12.5C, D | 10°C | 10°C |
| ACSC, Type S 4.75A, SF 9.5A, S 9.5B | 4°C | 10°C |

## 610-5 ASPHALT MIXTURE PRODUCTION

### (A) General

Utilize plants that are either of the batch mixing, continuous mixing, or drum mixing type, and so designed, equipped, and operated that the weighing, proportioning, and mixing of the materials will result in a uniform and satisfactory asphalt mixture meeting the requirements of these Specifications. All plants shall conform to requirements of Subarticle 610-5(B) for the preparation of asphalt mixtures. In addition, batch mixing plants shall conform to the requirements of Subarticle 610-5(C), continuous mixing plants shall conform to the requirements of Subarticle 610-5(D), and drum mixing plants shall conform to the requirements of 610-5(E).

Prior to production of the mix, stockpile aggregates for a sufficient period of time to facilitate the drainage of free moisture. Keep the different aggregate sizes separated until they have been delivered to the cold feeders. Keep the separate stockpiles readily accessible for sampling.

When mineral filler is required in the mix, feed or weigh-in separately from the other aggregates.

Introduce the asphalt binder and other additives, when required, into the mixture at the amounts and percentages specified by the job mix formula. No working tolerance will be allowed. Introduce the dried and heated aggregates, and mineral filler, when required, in amounts and at temperatures such that the mixture produced is within the production control limits of Subarticle 609-5(C)(4). Provide a positive means of controlling mixing time so as to obtain complete and uniform coating of the aggregate particles and thorough distribution of the asphalt binder throughout the aggregate.

Produce the mixture at the asphalt plant within ±8°C of the temperature established on the JMF. Assure the temperature of the mix immediately prior to

discharge from the hauling vehicle is within +8°C to -14°C of the JMF temperature.

All asphalt plants shall be certified by the Department as meeting the requirements of these Specifications. Certification is effective from the date of issuance and is non-expiring subject to continued compliance. The Department will check the plant on an annual basis or as deemed necessary by the Engineer. Any plant that is relocated, modified, or changes ownership shall be recertified prior to use.

Any completely automatically controlled asphalt plant that, due to the basic design of the plant, does not meet all the requirements of these Specifications for conventional batch mixing, continuous mixing, or drum mixing may be utilized on a project by project basis provided a uniformly consistent mix meeting all mix requirements can be produced and the plant has been approved in writing.

**(B) Requirements for All Plants**

(1) Equipment for Preparation of Asphalt Binder

Equip tanks for the supplying of asphalt binder to the plant to uniformly heat and hold the material at the required temperature prior to introduction into the mixer unit. Provide a circulating system for asphalt materials, that is capable of the proper mixing of additives. Provide a system with adequate pump or pumps to charge the mixing unit and unload asphalt material simultaneously. Include provisions for measuring and sampling plant supply tanks.

(2) Anti-Strip Additive Equipment

When chemical anti-strip additive is to be added to the asphalt binder at the asphalt plant in lieu of at the terminal, equip the plant with an in-line blending system capable of metering the additive within plus or minus 10 percent of the amount specified. Provide a thermostatically controlled heating system capable of heating and maintaining the additive tanks, contents and distribution system at the additive supplier's recommended temperature for the additive being used. Interlock the additive metering system with the asphalt binder control equipment in such a manner as to automatically vary the additive feed rate to maintain the required proportions. Provide a system that will automatically indicate in the plant control room the amount or rate of flow, when flow is occurring, and when flow is obstructed or stops. Inject the additive into the asphalt binder feed line prior to introduction into the aggregate. Equip the feed line with an in-line blending device capable of thoroughly mixing the additive with the asphalt binder prior to mixing with the aggregate. Provide a metering system capable of being calibrated, checked, and monitored for accuracy and amount of additive used.

Equip the system with an in-line totalizing flow meter capable of measuring the actual quantity in gallons of anti-strip additive that is injected into the asphalt binder being introduced into the aggregate. Provide a system that is capable of being easily read but not capable of being reset. Install the totalizer meter in the anti-strip feedline beyond the calibration bypass and as close to the actual point of additive introduction into the feedline as practical.

When hydrated lime anti-strip additive is used, provide a separate bin or tank and feeder system to store and proportion the lime into the aggregate in either dry or slurry form. Mix the lime and aggregate by pugmill or other approved means to achieve a uniform lime coating of the aggregate prior to entering the drier. When the lime is added in dry form, the aggregate shall contain at least 3 percent free moisture. The stockpiling of lime treated aggregate will not be permitted. Control the lime feeder system by a proportioning device that is accurate to within ±10 percent of

the specified amount. Provide a proportioning device with a convenient and accurate means of calibration and that is interlocked with the aggregate feed or weigh system so as to maintain the correct proportion. Provide a flow indicator or sensor that is interlocked with the plant controls such that production of the mixture will be interrupted if there is a stoppage or reduction of the lime feed.

(3) Aggregate Cold Feed Equipment

Utilize cold bins and a feeder system to proportion the aggregates and feed them to the dryer. Use separate cold bins for each size aggregate and each natural sand being used to provide a uniform and continuous flow. Provide separate dry storage when mineral filler is required. Equip cold aggregate bins with feeder units having interlocking controls capable of maintaining a constant ratio between the relative quantities of each size aggregate at varying plant production rates.

Provide cold feeders that are capable of being easily and accurately calibrated to ensure full control of the mix gradation.

(4) Dryer

Use a plant with a dryer or dryers that continuously agitate the aggregate during the heating and drying process.

(5) Control Unit for Asphalt Binder

Provide satisfactory means, either by weighing or metering to introduce the proper amount of asphalt binder into the mix.

(6) Thermometric Equipment

(a) Asphalt Binder Thermometric Equipment

Provide a thermometric device of adequate temperature range fixed in the asphalt binder feed line.

(b) Dryer Thermometric Equipment:

Equip the dryer with an automatic burner control device that uses an approved thermometric instrument located in the discharge chute to actuate the automatic controls.

(7) Pollution Control Equipment

Equip all plants with such pollution control equipment as is necessary to meet all applicable local, State, and Federal pollution requirements. Register and certify all plants by applicable environmental regulatory agencies prior to being certified by the Department.

(8) Safety Requirements

Provide adequate safety devices at all points where accessibility to plant operations is required. Provide accessibility to the top of truck bodies by a platform or other suitable device to enable Quality Control and Quality Assurance personnel to obtain samples and mixture temperature data. Thoroughly guard and protect all gears, pulleys, chains, sprockets, and other dangerous moving parts. Provide ample and unobstructed space on the mixing platform. Maintain a clear and unobstructed passage at all times in and around the truck loading area. Keep all work areas free from asphalt drippings.

(9) Production Consistency

Any asphalt plant that cannot consistently produce a high quality mix meeting the requirements of these Specifications will be considered in non-compliance with these Specifications and may have its certification revoked.

Upon a malfunction of required automatic equipment on a batch mixing plant, the plant may continue to operate manually for the following 2 consecutive working days, provided acceptable mixture is being produced.

When a malfunction of required automatic equipment on a drum mixer or continuous plant occurs, manual operation of the plant will not be allowed except that if, in the opinion of the Engineer, an emergency traffic condition exists, the plant may be allowed to operate manually until the unsafe traffic condition is corrected. All mix produced by manual operation will be subject to the requirements of Section 609.

**(C) Requirements for Batch Mixing Plants**

(1) Plant Scales and/or Weighing Devices

Provide and keep scales accurate to 0.5 percent at anticipated scale settings that may be required.

Scales will be inspected and tested as described in the latest edition of the Department's *HMA/QMS Manual* or as the Engineer may deem necessary to assure their continued accuracy.

Provide not less than ten 22.68 kg weights for testing the plant scales.

(2) Screens

Provide plant screens that are capable of adequately screening aggregates to the specified sizes necessary to consistently produce a mixture meeting the requirements of the job mix formula. Provide screens for removing all oversize materials.

(3) Hot Bins

Include hot storage bins of sufficient capacity and number to supply the mixer with uniform material. Equip each compartment with adequate and convenient devices to provide for sampling. Provide each compartment with an overflow pipe of such sizes and at such locations as to prevent any backing up of the material into other bins or interference with the operations of screens. Provide gates that close tightly so that no material is allowed to leak into the weigh hopper.

(4) Weigh Box or Hopper

Use equipment that includes a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without running over. Provide a gate that closes tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

(5) Asphalt Binder Controls

Use equipment to measure the asphalt binder that is capable of an accuracy of plus or minus 0.5 percent by weight of the amount of asphalt binder required. Locate the flow indicator, whether scale or metering device is used, in full view of the operator.

Provide an asphalt binder bucket of the non-tilting type with a removable top.

Provide gates that close tightly such that no material is allowed to leak into the weigh hopper. Adequately heat the asphalt binder bucket, its discharge valve or valves, and distribution bar. Ensure heating connections are so constructed that they will not interfere with the efficient operation of the asphalt binder scales. Provide an asphalt binder bucket with a capacity of at least 15 percent in excess of the weight of asphalt binder required in any batch. Locate an adequately heated, quick-acting, non-drip, charging valve near the asphalt binder bucket.

When a metering device is substituted for an asphalt binder bucket, use a flow indicator with a capacity of at least 15 percent in excess of the quantity of asphalt binder used in a batch. Provide a valve and outlet for checking the meter in the section of asphalt feed line between the charging valve and distribution bar.

Provide a system capable of discharging all of the asphalt binder required for one batch in not more than 15 seconds after the flow has started. Make the size and spacing of the distribution bar openings capable of providing a uniform application of asphalt binder across the full length of the mixer.

(6) Mixer

Provide batch mixer of an approved type that is capable of producing a uniform mixture. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust. Provide a batch mixer with a rated capacity of not less than 1,361 kg.

Maintain the clearance of blades from all fixed and moving parts such as to insure complete coating and mixing of aggregates and asphalt binder.

(7) Control of Proportioning and Mixing

Utilize plants with fully automated controls for proportioning and mixing. Equip the mixer with an accurate interlocking timing device to control the operations of a complete mixing cycle.

Use a timing device capable of being set at intervals of 5 seconds or less throughout a total cycle.

Mixing time will be established by the Engineer. Provide means by lock, cover, or other methods to prevent unauthorized changes in mixing time.

**(D) Requirements for Continuous Mixing Plants**

(1) General

Utilize continuous mixing plants that have fully automated proportioning and mixing controls and a rated capacity of at least 82 metric tons per hour.

(2) Aggregate Proportioning

Equip the plant with a feeder system capable of being accurately calibrated to uniformly produce the specified mixture.

Include means for accurately proportioning each size of aggregate to consistently meet the requirements of the job mix formula.

(3) Screens

Provide plant screens that are capable of adequately screening aggregates to the specified sizes necessary to consistently produce a mixture meeting the requirements of the job mix formula. Use screens that are capable of removing all oversize materials.

(4) Hot Bins

Provide hot storage bins of sufficient capacity and number to supply the mixer with uniform material. Equip each compartment with adequate and convenient devices to allow for sampling. Equip each compartment with an overflow pipe of such sizes and at such locations as to prevent any backing up of material into other bins or interference with the operations of screens. Provide adjustable gates such that the rate of flow can be controlled.

(5) Synchronization of Aggregate Feed and Asphalt Binder Feed

Provide satisfactory means to afford positive interlocking control between the flow of aggregate from the bins and the flow of asphalt binder from the meter or other proportioning device. Accomplish this control by interlocking mechanical means or by other positive methods satisfactory to the Engineer.

(6) Mixer

Provide a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture. Equip the mixer with a discharge hopper with dump gates that will permit rapid and complete discharge of the mixture. Provide paddles that are adjustable for angular position on the shafts and reversible to retard the flow of the mix. Provide the manufacturer's plate giving the net volumetric contents of the mixer at several heights inscribed on a permanent gauge. Provide charts showing the rate of feed per revolution and per interval of time at the plant operating speed.

**(E) Requirements for Drum Mix Plants**

(1) Aggregate Feed Equipment

Equip each cold feeder with an automatic device that activates a warning alarm and/or flasher light when any bin becomes empty or when aggregate flow becomes restricted. Interlock the automatic device with the plant control system so as to automatically stop production if normal aggregate flow is not resumed within 60 seconds.

(2) Scalping Screen

Provide a vibratory screening system capable of removing all oversize materials for the particular mix being produced prior to entry of the aggregate into the dryer-drum mixer. Locate the screening system in the aggregate flow prior to the material passing over the aggregate weighing system.

(3) Weight Measurement of Aggregate

Provide a system that ensures positive weight measurement of the combined cold aggregate feed rate by the use of belt scales or other approved devices. Provide means to allow correction for variations in the moisture content of the cold aggregate. Provide a continuous readout or other means that can be monitored in the plant control room and that indicates the aggregate dry-weight equivalent feed rate. Interlock the aggregate weighing system and binder flow to automatically maintain the required proportions. Provide a weighing system capable of being easily and accurately calibrated.

(4) Dryer-Drum Mixer Unit

Provide a drum mixer that is specifically designed and constructed for the process and capable of producing a uniform mixture. Control heating to prevent damage to the aggregate and asphalt binder. Provide a dryer-drum mixer with a rated capacity of at least 82 metric tons per hour when producing a finished mixture at 149°C with removal of 5 percent moisture.

(5) Asphalt Binder Controls

Provide a metering system capable of introducing the required amount of asphalt binder in the mix, including a means of correcting the delivered asphalt binder flow rate for temperature and specific gravity variations. Connect the flow meter to the asphalt binder supply so as to measure and display only the asphalt binder being fed to the mixer unit. Position the meter readout for convenient observation by the plant operator.

Provide means for checking the rate of flow of asphalt binder into the mixing unit. Assure the rate of flow is accurate to 0.5 percent by weight of the amount of asphalt binder required.

(6) Synchronization of Aggregate Feed and Asphalt Binder Feed

Interlock the asphalt binder feed control with the total aggregate weight measurement device in such a manner as to automatically vary the asphalt binder feed rate as necessary to maintain required proportions. Interlock the controls in a manner that will automatically stop all feed components if either the aggregate or asphalt flow stops.

(7) Asphalt Mixture Storage Facilities

Provide hot mix surge storage facilities in accordance with Article 610-6 that are adequate to minimize production interruptions during operation and ensure the mixture meets the requirements of the job mix formula when discharged from the storage bin.

## 610-6 HOT MIX STORAGE SYSTEMS

When a storage system is used, provide a system capable of conveying the mix from the plant to the storage bin and storing the mix without a loss in temperature, segregation or oxidation of the mix. Limit storage time to the ability of the storage system to maintain the mix with in the specification requirements. Material may be stored in storage bins without an approved heating system for no more than 24 hours.

Provide a continuous type or skip bucket type conveyor system. Enclose continuous type conveyors so that the mix temperature is maintained within specification requirements. Provide a system designed in such manner as to prevent segregation of the mix during discharge from the conveyor into the bins and equipped with discharge gates that will not cause segregation of the mix while loading the mix into trucks.

## 610-7 HAULING OF ASPHALT MIXTURE

Transport the mixture from the mixing plant to the point of use in vehicles that have tight, clean, smooth beds approved by the Department, that have been sprayed with an approved release agent material, to prevent the mixture from adhering to the beds. Remove excess release agent prior to loading. Cover each load of mixture with a canvas or other suitable material. Use covers that are so constructed and secured as to prevent the entrance of moisture and the rapid loss of temperature. Provide a 9.5 mm diameter hole on each side of the vehicle body near the center of the body and 200 mm above the bed of the vehicle for the purpose of inserting a thermometer.

Assure temperature of the mixture immediately prior to discharge from the hauling vehicle is within a tolerance of plus 8°C to minus 14°C of the specified job mix formula temperature.

## 610-8 SPREADING AND FINISHING

Apply tack coat in accordance with the requirements of Section 605.

Mixtures produced simultaneously from different plant sources can not be intermingled by hauling to the same paver on the roadway unless the mixtures are being produced from the same material sources and same job mix formula.

Utilize a self-contained, power propelled paver capable of spreading and finishing the asphalt mixture to the required grades, cross sections, thicknesses, and widths shown on the plans and typical sections and to uniform density and texture. Equip and operate the paver with a fully activated screed plate that is designed to be preheated for the full length whenever necessary. Provide a screed of adequate length to spread and finish the full uniform width travel lane being placed, unless otherwise permitted. Do not use strike off devices, either mechanically or manually operated, in spreading and finishing mixture placed in the uniform width travel lane.

Utilize a paver with a receiving hopper and an automatically controlled distribution system that is capable of uniformly maintaining a proper head of material in front of the full length of the screed, including screed extensions. Equip the screed unit with a sliding shoe attachment that will form a slope on the edge of the mat to prevent edge raveling when the mixture is compacted.

Place a string line for the first lane of each layer of mixture placed to provide alignment control for the paver, except that a string line will not be required when the first layer is placed adjacent to a curb section.

Operate pavers at forward speeds consistent with plant production, material delivery, and satisfactory laying of the mixture so as to ensure a uniform and continuous laydown operation. Coordinate and adjust the paving operation and loading operation so as to maintain an adequate amount of asphalt mixture in the paver hopper between truck exchanges. Do not allow the paver hopper to become empty between loads. Take necessary precautions during production, loading of trucks, transportation, truck exchanges with paver, folding of the paver hopper wings, and conveying material in front of the screed to prevent segregation of the asphalt mixtures. Should unevenness of texture, tearing, segregation, or shoving occur during the paving operation due to unsatisfactory methods or equipment, immediately take such action as may be necessary to correct such unsatisfactory work. Excessively throwing back material will not be permitted.

Use pavers equipped with an electronic screed control that will automatically control the longitudinal profile and cross slope of the pavement. Control the longitudinal profile through the use of either a mobile grade reference(s), including mechanical, sonic and laser grade sensing and averaging devices, an erected string line(s) when specified, joint matching shoe(s), slope control devices or the approved methods or combination of methods. Unless otherwise specified, use a mobile grade reference system capable of averaging the existing grade or pavement profile over a minimum 9 m distance or by non-contacting laser or sonar type ski with at least four referencing stations mounted on the paver at a minimum length of 7.3 m. Establish the position of the reference system such that the average profile grade is established at the approximate midpoint of the system. The transverse cross-slope shall be controlled as directed by the Engineer.

Use an erected fixed stringline for both longitudinal profile and transverse cross slope control when required by the contract. When an erected fixed string line is required, furnish and erect the necessary guide line for the equipment. Support the stringline with grade stakes placed at maximum intervals of 7.6 m for the finished pavement grade.

Use the 9 m minimum length mobile grade reference system or the non-contacting laser or sonar type ski to control the longitudinal profile when placing the initial lanes and all adjacent lanes of all layers, including resurfacing and asphalt in-lays, unless other specified or approved. A joint matching device (short 152.4 mm shoes) may be used only when approved.

Utilize the automatic slope control system unless otherwise approved. The Engineer may waive the use of automatic slope controls in areas where the existing surface (subgrade, base, asphalt layer, etc.) exhibits the desired cross slope of the final surface. The Engineer may also waive the use of automatic slope controls in areas where the use of such equipment is impractical due to irregular shape or cross section (such as resurfacing). When the use of the automatic slope controls is waived, the Engineer may require the use of mobile grade references on either or both sides of the paver. Manual screed operation will be permitted in the construction of irregularly shaped and minor areas, subject to approval. Waiver of the use of automatic screed controls does not relieve the Contractor of achieving plan profile grades and cross-slopes.

In the case of malfunction of the automatic screed control equipment, the paver may be manually operated for the remainder of the workday provided this method of operation produces acceptable results. Do not resume work thereafter until the automatic system is functional.

The Engineer will waive the requirement for use of pavers for spreading and finishing where irregularities or obstacles make their use impractical. Spread, rake, and lute the mixture by hand methods or other approved methods in these areas.

Operate the paver as continuously as possible. Pave intersections, auxiliary lanes, and other irregular areas after the main line roadway has been paved, unless otherwise approved.

Repair any damage caused by hauling equipment across structures at no additional cost to the Department.

Use a Material Transfer Vehicle (MTV) when placing all asphalt concrete plant mix pavements, including open-graded asphalt friction course that requires the use of asphalt binder grade PG 76-22, unless otherwise approved. Utilize the MTV when placing all full width travel lanes, including shoulders, collector lanes, ramps, and loops that require PG 76-22.

Provide an MTV that receives mixture from the hauling equipment and independently delivers the mixture from the hauling equipment to the paving equipment. Provide an MTV capable of transferring the material from the haul vehicle to the paver hopper at a uniform and continuous rate to allow the continuous movement of the paver. Install a paver hopper insert with a minimum capacity of 6.4 metric tons in the hopper of conventional paving equipment when utilizing a MTV. Perform remixing of the material prior to discharge into the paver conveyor system by utilizing either a MTV with a remixing system contained within a minimum 6.4 metric ton capacity storage bin or a dual pugmill system with two full length transversely mounted paddle mixers located in the paver hopper insert.

Use an MTV that provides to the paver a homogeneous, non-segregated mixture that is of uniform temperature such that there is no more than 11°C difference between the highest and lowest temperatures when measured transversely across the width of the mat in a straight line at a distance of 0.3 m to 1 m from the screed while the paver is operating. Obtain the temperature measurements approximately 0.3 m from each edge and at least once in the middle of the mat.

Empty the MTV when crossing a bridge and move across without any other Contractor vehicles or equipment being on the bridge. Move the MTV across a bridge in a travel lane and not on the shoulder. While crossing a bridge move the MTV at a speed no greater than five miles per hour without any abrupt acceleration or deceleration.

In the event the MTV malfunctions during paving operations, immediately discontinue plant operations and do not resume operations until the MTV malfunctions have been remedied, unless otherwise directed due to safety concerns. The Contractor may continue placement of the mix until any additional mix in transit has been placed, provided satisfactory results are achieved. This procedure in no way alleviates the Contractor from meeting contract requirements.

## 610-9 COMPACTION

Immediately after the asphalt mixture has been spread, struck off, and surface and edge irregularities adjusted, thoroughly and uniformly compact the pavement. Compact the mix to the required degree of compaction for the type of mixture being placed.

Provide sufficient number and weight of rollers, except as noted, to compact the mixture to the required density while it is still in a workable condition. Obtain approval of equipment used in compaction from the Engineer prior to use. Where uniform density is not being obtained throughout the depth of the layer of material being tested, change the type and/or weight of the compaction equipment as necessary to achieve uniform density even though such equipment has been previously approved.

Compact all final wearing surfaces, except open-graded asphalt friction course, using a minimum of 2 steel wheel tandem rollers, unless otherwise approved. Pneumatic-tired rollers with 2 tandem axles and smooth tread tires may be used for intermediate rolling.

Limit rolling for open-graded asphalt friction course to one coverage with a tandem steel wheel roller weighing a maximum of 9.1 metric tons, with additional rolling limited to one coverage with the roller where necessary to improve the riding surface.

Steel wheel tandem vibratory rollers that have been specifically designed for the compaction of asphalt pavements may be used on all layers 25 mm or greater in thickness during the breakdown and intermediate rolling phase. Do not operate vibratory rollers in the vibratory mode during the finish rolling phase on any mix type or pavement course, open-graded asphalt friction course, or on permeable asphalt drainage course.

When vibratory rollers are used, use rollers that have variable amplitude and frequency capabilities and that are designed specifically for asphalt pavement compaction. Provide rollers equipped with controls that automatically disengage the vibration mechanism before the roller stops when being used in the vibratory mode.

The Engineer may prohibit or restrict the use of vibratory rollers where damage to the pavement being placed, the underlying pavement structure, drainage structures, utilities, or other facilities is likely to occur or is evident.

Do not use rolling equipment that results in excessive crushing of the aggregate or excessive displacement of the mixture.

In areas inaccessible to standard rolling equipment, thoroughly compact the mixture by the use of hand tampers, hand operated mechanical tampers, small rollers, or other approved methods.

Use rollers that are in good condition and capable of being reversed without backlash to compact the mixture. Operate rollers with the drive wheels nearest the paver and at uniform speeds slow enough to avoid displacement of the mixture. Equip steel wheel rollers with wetting devices that will prevent the mixture from sticking to the roller wheels.

Begin compaction of the material immediately after the material is spread and shaped to the required width and depth. Carry out compaction in such a manner as to obtain uniform density over the entire section. Perform compaction rolling at the maximum temperature at that the mix will support the rollers without moving horizontally. Complete the compaction (including both intermediate rolling) prior to the mixture cooling below a workable temperature. Perform finish rolling to remove roller marks resulting from the compaction rolling operations.

**DENSITY REQUIREMENTS**
**TABLE 610-4**
**MINIMUM DENSITY REQUIREMENTS**

| **Mix Type** | **Minimum % of $G_{mm}$** |
|---|---|
| **Superpave Mixes** | **(Maximum Specific Gravity)** |
| S 4.75A | 85.0[(a,b)] |
| SF 9.5A | 90.0 |
| S 9.5X, S 12.5X, I 19.0X, B 25.0X, B 37.5X | 92.0 |

(a) All S 4.75A pavement will be accepted for density in accordance with Article 105-3

(b) Compaction to the above specified density will be required when the S 4.75 A mix is applied at a rate of 54 kg/m$^2$ or greater

Compact the asphalt plant mix to at least the minimum percentage of the maximum specific gravity listed in Table 610-4, except as noted below. Perform density sampling and testing on all pavements listed below unless otherwise approved.

**(A)** Full width travel lane pavements, including normal travel lanes, turn lanes, collector lanes, ramps and loops, and temporary pavements,

**(B)** Pavement widening 1.2 m or greater,

**(C)** Uniform width paved shoulders 0.6 m or greater,

**(D)** and wedging as outlined in the HMA/QMS Manual

Compact base and intermediate mix types (surface mixes not included) utilized for pavement widening of less than 1.2 m and all mix types used in tapers, irregular areas and intersections (excluding full width travel lanes of uniform thickness), using equipment and procedures appropriate for the pavement area width and/or shape. Compaction with equipment other than conventional steel drum rollers may be necessary to achieve adequate compaction. Occasional density sampling and testing to evaluate the compaction process may be required. Densities lower than that specified in Table 610-4 may be accepted, in accordance with Article 105-3, for the specific mix types and areas listed directly above.

## 610-11 JOINTS

### (A) Transverse Joints

When the placing of the mixture is to be suspended long enough to permit the mixture to become chilled, construct a transverse joint.

If traffic will not pass over the end of the paving, a butt joint will be permitted, provided proper compaction is achieved. If traffic will pass over the joint, construct a sloped wedge ahead of the end of the full depth pavement to provide for proper compaction and protection of the full depth pavement. Construct the joint square to the lane alignment and discard all excess material. Place a paper parting strip beneath this wedge to facilitate joint construction unless waived by the Engineer.

Before paving operations are resumed, remove the sloped wedge and cut back into the previously constructed pavement to the point of full pavement depth. Coat the exposed edge of the previously constructed pavement with tack coat.

When laying of the mixture is resumed at the joint, complete and then test the construction of the joint in accordance with Article 610-12 while the mixture is still in a workable condition.

### (B) Longitudinal Joints

Tack the exposed edge of all longitudinal joints prior to placing the adjoining pavement.

Form longitudinal joints by allowing the paver to deposit the mixture adjacent to the joint to such depth that maximum compaction can be obtained along the joint. Pinch the joint by rolling immediately behind the paver.

When multi-lane multi-layer construction is required, offset the longitudinal joints in each layer from that in the layer immediately below by approximately 150 mm. Construct the joints in the final layer, where possible, between designated travel lanes of the final traffic pattern.

## 610-12 SURFACE REQUIREMENTS AND ACCEPTANCE

Construct pavements using quality-paving practices as detailed herein. Construct the pavement surface smooth and true to the plan grade and cross slope. Immediately correct any defective areas with satisfactory material compacted to conform with the surrounding area.

Pavement imperfections resulting from unsatisfactory workmanship such as segregation, improper longitudinal joint placement or alignment, and non-uniform edge alignment, or excessive pavement repairs will be considered unsatisfactory and if allowed to remain in place will be accepted in accordance with Article 105-3.

When directed due to unsatisfactory laydown or workmanship, operate under the limited production procedures. Limited production for unsatisfactory laydown is defined as being restricted to the production, placement, compaction, and final surface testing (if applicable) of a sufficient quantity of mix necessary to construct only 762 m of pavement at the laydown width.

Remain on limited production until such time as satisfactory laydown results are obtained or until three consecutive 762 m sections have been attempted without achieving satisfactory laydown results. If the Contractor fails to achieve satisfactory laydown results after three consecutive 762 m sections have been attempted, cease production of that mix type until such time as the cause of the unsatisfactory laydown results can be determined. As an exception, the Engineer may grant approval to produce a different mix design of the same mix type if the cause is related to mix problem(s) rather than laydown procedures.

Mix placed under the limited production procedures for unsatisfactory laydown or workmanship will be evaluated for acceptance in accordance with Article l05-3.

Provide a surface of the pavement after compaction that conforms to the requirements below, except in the case where FINAL SURFACE TESTING - ASPHALT PAVEMENTS is included in the contract.

Each pavement layer will be tested by the Contractor and the Engineer using a 3.05 m stationary straightedge furnished by the Contractor. Any location on the pavement selected by the Department shall be tested as well as all transverse joints. Apply the straightedge parallel to the centerline of the surface. Do not exceed 3.2 mm variation of the surface being tested from the edge of the straightedge between any 2 contact points. Correct areas found to exceed this tolerance by removal of the defective work and replacement with new material, unless other corrective measures are permitted. Provide the work and materials required in the correction of defective work at no cost to the Department.

## 610-13 DENSITY ACCEPTANCE

The Department will evaluate the asphalt pavement for density acceptance after the asphalt mix has been placed and compacted using the Contractor's quality control test results, the Department's quality assurance test results, including verification samples, and by observation of the Contractor's density quality control process conducted in accordance with Section 609. Minimum density requirements for all mixes will be as specified in Article 610-10, Table 610-4. Density acceptance will be as provided herein. Core sample densities will be determined by use of the average maximum specific gravity (Gmm), until a moving average of the last four maximum specific gravities is established. Once a moving average of the last four maximum specific gravities is established, the last Gmm moving average in effect at the end of the same day's production will then be used to determine density acceptance.

The pavement will be accepted for density on a lot by lot basis. A lot will consist of one day’s production of a given job mix formula on a contract. As an exception, separate lots will be established when the one of the following occurs:

**(A)** Portions of pavement are placed in both New and Other construction categories as defined below. A lot will be established for the portion of the pavement in the New construction category and a separate lot for the portion of pavement in the Other construction category.

**(B)** Pavement is placed on multiple resurfacing maps, unless otherwise approved prior to paving. A lot will be established for each individual resurfacing map or portion thereof.

**(C)** Pavement is placed by multiple paving crews. A lot will be established for the pavement placed by each paving crew.

**(D)** Pavement is placed in different layers. A lot will be established for each layer.

**(E)** Control strips are placed during limited production.

The Engineer will determine the final category and quantity of each lot for acceptance purposes.

The New construction category will be defined as pavements of uniform thickness, exclusive of irregular areas, meeting all three of the following criteria:

**(A)** pavement placed on a new aggregate or soil base compacted to the specified density or pavement placed on a new asphalt mix layer (excluding wedging and leveling);

**(B)** pavement that is within a designated travel lane of the final traffic pattern; and

**(C)** pavement that is 1.2 m or wider.

As an exception, when the first layer of mix is placed on an unprimed aggregate base and is 50 mm or less in thickness, the layer will be included in the Other construction category.

The Other construction category will include all pavements except as described above.

A failing lot for density acceptance purposes is defined as a lot for which the average of all test sections, and portions thereof, fails to meet the minimum specification requirement. If additional density sampling and testing, beyond the minimum requirement, is performed and additional test sections are thereby created, then all test results shall be included in the lot average. In addition, any lot or portion of a lot that is obviously unacceptable will be rejected for use in the work.

If the Engineer determines that a given lot of mix that falls in the New category does not meet the minimum specification requirements but the work is reasonably acceptable, the lot will be accepted at a reduced pay factor in accordance with the following formula. The reduced pay factor will apply only to the mix unit price.

where: $PF = 100 - 10(D)^{1.465}$

PF = Pay Factor (computed to 0.1%)

D = the deficiency of the lot average density not to exceed 3.0%

Acceptance of all failing lots in the Other category will be made under the requirements of Article 105-3.

Any density lot not meeting minimum density requirements detailed in Table 610-4 will be evaluated for acceptance by the Engineer. If the lot is determined to be reasonably acceptable, the mix will be paid at an adjusted contract price in accordance with Article 105-3. If the lot is determined not to be acceptable, the mix will be removed and replaced with mix meeting and compacted to the requirement of these Specifications.

Any reduction in pay due to failing density will be in addition to any reduction in pay due to failing mix property test results on the same mix.

Perform the production and construction of all asphalt mixtures and pavements in accordance with these provisions. There will be no direct payment for work covered by this provision.

## 610-14 MAINTENANCE

Maintain the plant mix pavement in an acceptable condition until final acceptance of the project. Immediately repair any defects or damage that may occur. Perform maintenance to damaged or defective pavement and repeat as often as may be necessary to keep the base or pavement in an acceptable condition at no cost to the Department.

## 610-15 MEASUREMENT AND PAYMENT

Hot Mix Asphalt Pavement will be paid for at the contract unit price per metric ton that will be the actual number of metric tons of each type of hot mix asphalt pavement that has been incorporated into the completed and accepted work pursuant to the requirements of Article 106-7.

No direct payment will be made for providing and using the materials transfer vehicle or any associated equipment, as the cost of providing same shall be included in the contract unit bid price per metric ton for the mix type to be placed.

A high frequency of asphalt plant mix, density, or mix and density deficiencies occurring over an extended duration of time may result in future asphalt, that is represented by mix and/or density test results not in compliance with minimum specification requirements, being excluded from acceptance at an adjusted contract unit price in accordance with Article 105-3. This acceptance process may apply to all asphalt produced and /or placed and may continue until the Engineer determines a history of quality asphalt production and placement is reestablished.

Furnishing asphalt binder will be paid for as provided in Article 620-5 for *Asphalt Binder for Plant Mix* for each grade required.

Payment will be made under:

| **Pay Item** | **Pay Unit** |
|---|---|
| Asphalt Concrete Base Course, Type B 25.0B | Metric Ton |
| Asphalt Concrete Base Course, Type B 25.0C | Metric Ton |
| Asphalt Concrete Base Course, Type B 37.5C | Metric Ton |
| Asphalt Concrete Intermediate Course, Type I 19.0B | Metric Ton |
| Asphalt Concrete Intermediate Course, Type I 19.0C | Metric Ton |
| Asphalt Concrete Intermediate Course, Type I 19.0D | Metric Ton |
| Asphalt Concrete Surface Course, Type S 4.75A | Metric Ton |
| Asphalt Concrete Surface Course, Type SF 9.5A | Metric Ton |
| Asphalt Concrete Surface Course, Type S 9.5B | Metric Ton |
| Asphalt Concrete Surface Course, Type S 9.5C | Metric Ton |
| Asphalt Concrete Surface Course, Type S 9.5D | Metric Ton |
| Asphalt Concrete Surface Course, Type S 12.5C | Metric Ton |
| Asphalt Concrete Surface Course, Type S 12.5D | Metric Ton |

# SECTION 620
# ASPHALT BINDER FOR PLANT MIX

## 620-1 DESCRIPTION

Perform the work covered by this section including but not limited to furnishing of asphalt binder, with anti-strip additive when required, at an asphalt plant and incorporating the asphalt binder and anti-strip additive into the asphalt plant mix.

## 620-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Asphalt Binder, All Grades | 1020-2 |
| Anti-strip Additive (Chemical) | 1020-8 |
| Anti-strip Additive (Hydrated Lime) | 1012-1 |
| Silicone | 1020-4 |

The asphalt binder for the mixture will be accepted at the source subject to the requirements of Article 1020-1.

## 620-3 GENERAL REQUIREMENTS

The requirements of Section 610 that pertain to handling of asphalt binder will be applicable to the work covered by this section.

Add silicone to all asphalt binder used in surface courses and open-graded asphalt friction course, unless otherwise directed. The amount of silicone added will range from 30 ml/7,570 liters to 30 ml/9,465 liters of asphalt binder. Add silicone to the asphalt binder at the plant site unless added at the source and it is so noted on the delivery ticket. Use a brand of silicone from the approved list published by the Materials and Tests Unit. Submit a sample and manufacturer's data to the Engineer for approval prior to use if proposing to use a brand not on the approved list.

When required, incorporate an anti-strip additive. It may be either chemical additive mixed with the asphalt binder or hydrated lime added to the aggregate or a combination of both.

Do not heat the asphalt binder to a temperature in excess of the supplier’s recommendation while stored or when being used in production of mix at the asphalt plant.

Introduce the actual quantity of asphalt binder at the established percentage shown on the applicable job mix formula into the mix by the plant weighing or metering system. No working tolerance for asphalt binder percentage will be allowed during production.

Furnish the brand name of the type (lime or chemical), supplier, and shipping point of anti-strip additive. Note on the asphalt binder delivery ticket the rate (or quantity), brand of chemical additive when added at the supplier’s terminal.

Introduce and mix chemical anti-strip additive into the asphalt binder at either the supplier's terminal or at the asphalt plant site at the dosage required by the JMF. Use in-line blending equipment at either location. When added at the asphalt plant, use equipment that meets the requirements of Subarticle 610-5(B). When added at the supplier's terminal, use equipment that in-line blends the additive for a minimum of 80% of the asphalt binder loading time.

When hydrated lime is used, use equipment to introduce the lime that meets the requirements of Subarticle 610-5(B).

Thoroughly mix chemical anti-strip additive and asphalt binder together before incorporating into the asphalt plant mix.

## 620-4 MEASUREMENT AND PAYMENT

*Asphalt Binder for Plant Mix, Grade PG* ___ will be measured and paid for as the theoretical number of metric tons of the grade of asphalt binder required by the applicable job mix formula based on the actual number of metric tons of plant mix completed and accepted on the job.

Where recycled plant mix is being produced, the grade of asphalt binder to be paid for will be the grade for the specified mix type as required in Table 610-2 unless otherwise approved. The theoretical number of metric tons of the grade of asphalt binder to be paid

for will include additional new asphalt binder, salvaged asphalt binder from the reclaimed asphalt pavement material, and salvaged asphalt from the reclaimed shingle material.

Such price and payment will be full compensation for all work covered by this section.

There will be no direct payment for anti-strip additive. Payment at the contract unit prices for the various asphalt plant mix items will be full compensation for the work.

Adjustments will be made to the payments due the Contractor for each grade of asphalt binder when it has been determined that the monthly average terminal F.O.B. Selling Price of asphalt binder, Grade PG 64-22, has fluctuated from the Base Price Index for Asphalt Binder included in the contract. The methods for calculating a base price index, for calculating the monthly average terminal F.O.B. selling price and for determining the terminals used are in accordance with procedures on file with the Department's Construction Unit.

When it is determined that the monthly selling price of asphalt binder on the first business day of the calendar month during which the last day of the partial payment period occurs varies either upward of downward from the base price index, the contract unit price for asphalt binder for plant mix will be adjusted. The adjusted contract unit price will be determined by adding the difference between the selling price and the base price index to the contract unit bid price for asphalt binder. If the selling price is less than the base price index, the adjusted contract unit price will be determined by subtracting the difference between the selling price and the base price index from the contract unit price for asphalt binder.

The adjusted contract unit price will then be applied to the total theoretical quantity of asphalt binder authorized for use in the plant mix placed during the partial payment period involved, including both additional new asphalt binder and salvaged asphalt binder from reclaimed asphalt materials required by the job mix formula.

Adjusted contract unit prices for all grades of asphalt binder, including additional asphalt binder materials in recycled mixtures, will be based on the average selling price and base price index for asphalt binder, Grade PG 64-22, regardless of the actual grade required by the job mix formula.

In determining the adjusted contract unit price for any material specified in this provision the following formula will be used:

Where $A = B + (D - C)$

$A$ = Adjusted Contract Unit Price

$B$ = Contract Unit Price

$C$ = Base Price Index

$D$ = Monthly Average Terminal F.O.B. Selling Price

In the event the Department is unable to secure an F.O.B. selling price from at least four terminals in a given month, payment will be at the contract unit price for each metric ton of asphalt binder used in the work during that month.

Payment will be made under:

| **Pay Item** | **Pay Unit** |
|---|---|
| Asphalt Binder for Plant Mix, Grade PG 64-22 | Metric Ton |
| Asphalt Binder for Plant Mix, Grade PG 70-22 | Metric Ton |
| Asphalt Binder for Plant Mix, Grade PG 76-22 | Metric Ton |

# SECTION 650
# OPEN-GRADED ASPHALT FRICTION COURSE, TYPES FC-1, FC-1 MODIFIED, AND FC-2 MODIFIED

## 650-1 DESCRIPTION

Perform the work covered by this section including but not limited to construction of a plant mixed open-graded asphalt friction course (OGAFC) properly laid upon a prepared surface in accordance with these Specifications and in conformity with the lines, grades, thickness, and typical sections shown on the plans; producing, weighing, transporting, placing, and rolling the plant mix as specified in Section 610; furnishing the asphalt binder, anti-strip additive, fiber stabilizing additive, and all other materials for the plant mix; furnishing and applying tack coat as specified in Section 605; providing quality control as specified in Section 609 as modified for OGAFC; surface testing of the completed pavement; furnishing scales; making any repairs or corrections to the friction course that may become necessary, and maintaining the friction course until final acceptance of the project.

## 650-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Asphalt Binder, Grade PG 64-22, PG 76-22 | 1020-2 |
| Anti-strip Additive (Chemical) | 1020-8 |
| Anti-strip Additive (Hydrated Lime) | 1012-1 |
| Coarse Aggregate | 1012-1 |
| Mineral Filler | 1012-1 |
| Stone Screenings | 1012-1 |

Fiber Stabilizing Additives:

Use fiber stabilizing additives that are capable of stabilizing the asphalt film surrounding the aggregate particles in order to reduce drain-down of the asphalt binder. A fiber stabilizer such as mineral fiber or cellulose may be used. The selected fiber shall meet the properties described below. Dosage rates given are typical ranges but the actual dosage rate used will be approved by the Engineer.

### (A) MINERAL FIBERS

Mineral fibers shall be made from virgin basalt, diabase, or slag and that have been treated with a cationic sizing agent to enhance disbursement of the fiber as well as increase adhesion of the fiber surface to the asphalt binder. Add the fiber at a dosage rate between 0.2% to 0.4% by weight of total mix, as approved.

| | | |
|---|---|---|
| (1) | Size Analysis | |
| | Average Fiber length | 6.4 mm maximum |
| | Average Fiber thickness | .005 mm maximum |
| (2) | Shot Content (ASTM C 612) | |
| | Passing .250 mm sieve | 90 - 100% |
| | Passing .063 mm sieve | 65 - 100% |
| (3) | Degradation (GDT-124/McNett Fractionation) | 30% (maximum) |

### (B) CELLULOSE FIBERS

Add cellulose fibers at a dosage rate between 0.2% and 0.4% by weight of total mix as approved. Fiber properties shall be as follows:

| | | |
|---|---|---|
| (1) | Fiber length | 6.4 mm maximum |
| (2) | Sieve Analysis | |
| (a) | Alpine Sieve Method | |
| | Passing .150 mm sieve | 60 - 80% |
| (b) | Ro-Tap Sieve Method | |
| | Passing .850 mm Sieve | 80 - 95% |
| | Passing .425 mm Sieve | 45 - 85% |
| | Passing .150 mm Sieve | 5 - 40% |
| (3) | Ash Content | 18% non-volatiles (±5%) |
| (4) | pH | 7.5 (±1) |
| (5) | Oil Absorption (times fiber weight) | 5.0 (±1) |
| (6) | Moisture Content | 5.0 (maximum) |

**(C) CELLULOSE PELLETS**

Cellulose pellets consist of a 50/50 blend of cellulose fiber and asphalt binder. Use cellulose that complies with Item (B), Cellulose Fibers, above. Add the cellulose pellets at a dosage rate between 0.4% and 0.8% by weight of total mix, as approved.

| | | |
|---|---|---|
| (1) | Pellet Size | 4.1 $cm^3$ (maximum) |
| (2) | Asphalt | 25 – 80 pen |

## 650-3 COMPOSITION OF MIXTURE (MIX DESIGN & JOB MIX FORMULA)

**(A) General**

Design the open-graded asphalt friction course utilizing a mixture of coarse and fine aggregate, asphalt binder, mineral filler, fiber stabilizing additive, and other additives as required to produce a mix meeting the requirements of Table 650-1.

Submit in writing a mix design and proposed job mix formula (JMF) targets for each required mix type and combination of aggregates to the Engineer for review and approval at least 10 days prior to start of asphalt mix production. The mix design shall be prepared by a mix design technician approved by the Department in an approved mix design laboratory. Perform the mix design in accordance with applicable requirements of Article 610-3 and the Department's mix design procedures titled *Determination Of Optimum Asphalt Content for Open-Graded Asphalt Friction Courses*. A copy of these procedures can be obtained through the Department's Materials and Tests Unit. Submit the mix design and proposed job mix formula targets on forms and in a format approved by the Department.

The mix design and job mix formula target values will be established within the mix design criteria specified in Table 650-1 for the particular type mixture to be produced. The formula for each mixture will indicate the blend percentage of each aggregate fraction to be used, a single percentage of combined aggregate passing each required sieve, the percentage and grade of asphalt binder (by weight of total mixture) to be incorporated into the mixture, the percentage of anti-strip additive to be added to the asphalt binder, the percentage of fiber stabilizing additive (by weight of total mix), and the temperature at that the mixture is to be discharged from the plant.

Have on hand at the asphalt plant the approved mix design and job mix formula issued by the Department, prior to beginning the work.

The job mix formula for each mixture shall remain in effect until modified in writing, provided the results of QMS tests performed on material currently being produced conform with specification requirements.

Should a change in sources of aggregate materials to be made, a new mix design and job mix formula will be required before the new mixture is produced.

When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new job mix formula.

**(B) Mix Design Criteria**

Design open-graded asphalt friction course mixtures conforming to the gradation requirements and other mix design criteria in Table 650-1 for the mix type specified.

Use the asphalt binder grade shown in Table 650-1 for the mix type specified.

Use an anti-strip additive in all OGAFC mixes. It may be hydrated lime or a chemical additive or both. Add chemical anti-strip additive at a rate of 0.5% by weight of asphalt binder. Add hydrated lime at a rate of 1.0% by weight of dry aggregate. Use approved source and grade.

Incorporate a fiber stabilizing additive into all OGAFC types. Add the fiber at a dosage rate by weight of the total mix as approved.

When requested, submit to the Materials & Tests Unit in Raleigh, samples of mix components. Submit sample sizes as noted below or as requested. Provide the samples at least 20 days prior to the anticipated beginning placement of OGAFC mixture.

| | |
|---|---|
| 115 kg | of each coarse aggregate |
| 70 kg | fine aggregate |
| 4 liters | of mineral filler and/or baghouse fines |
| 4 liters | of hydrated lime |
| 0.5 liters | of chemical anti-strip additive |
| 2 kg | of fiber stabilizing additive |

Aggregate samples when combined according to the Contractor's proposed aggregate blend percentages shall be within the gradation range defined by the target values of Table 650-1 for each sieve or the samples will not be considered representative.

The mixing temperature at the asphalt plant will be established on the job mix formula.

Add the anti-strip additive to the asphalt binder in accordance with Article 620-3.

**TABLE 650-1**
**OGAFC MIX DESIGN CRITERIA**

| **Grading Requirements** | **Total Percent Passing** | | |
|---|---|---|---|
| **Sieve Designations** | **Type FC-1** | **Type FC-1 Modified** | **Type FC-2 Modified** |
| 19 mm | | | 100 |
| 12.5 mm | 100 | 100 | 85-100 |
| 9.5 mm | 75-100 | 75-100 | 55-75 |
| 4.75 mm | 25-45 | 25-45 | 15-25 |
| 2.36 mm | 5-15 | 5-15 | 5-10 |
| .075 mm | 1.0-3.0 | 1.0-3.0 | 2.0-4.0 |
| **Design Requirements** | | | |
| Asphalt Binder, | | | |
| Performance Grade | PG 64-22 | PG 76-22 | PG 76-22 |
| Asphalt Binder, % Range | 5.0-8.0 | 5.0-8.0 | 5.0-8.0 |
| Mixing Temperature Range | 93-135 °C | 165-175 °C | 165-175 °C |
| (To be established by the Engineer) | | | |
| Draindown, Percent | 0.3 max. | 0.3 max. | 0.3 max. |
| (AASHTO T 305) | | | |

## 650-4 PLANT EQUIPMENT

Use plant equipment in accordance with Article 610-5 and the following requirements:

When fiber stabilizing additives are required as an ingredient of the mixture, utilize a separate feed system capable of accurately proportioning the required quantity into the mixture and in such a manner that uniform distribution will be obtained. Interlock the proportioning device with the aggregate feed or weigh system so as to maintain the correct proportions for all rates of production and batch sizes. Accurately control the proportion of fibers to within plus or minus 10 percent of the amount required. Provide flow indicators or sensing devices for the fiber system that are interlocked with plant controls such that mixture production will be interrupted if introduction of the fiber fails.

When a batch type plant is used, add the fiber to the aggregate in the weigh hopper or as approved. Increase the batch dry mixing time by 8 to 12 seconds, or as directed, to assure the fibers are uniformly distributed prior to the injection of asphalt binder into the mixer.

When a continuous mix or dryer-drum type plant is used, add the fiber to the aggregate and uniformly disperse at the point of injection of asphalt binder. Add the fiber in such a manner that it will not become entrained in the exhaust system of the drier or plant.

## 650-5 CONSTRUCTION REQUIREMENTS

Produce, transport to the site, and place the OGAFC in accordance with the applicable requirements of Section 610, except as otherwise provided below.

Do not place open-graded asphalt friction course between October 31 and April 1 of the next year, unless otherwise approved. Place friction course, Type FC-1 mixes, only when the road surface temperature is 10°C or higher and the air temperature measured in

the shade away from artificial heat is 10°C or higher. The minimum air and road surface temperature for placing Type FC-1 Modified and FC-2 Modified mixes will be 16°C.

Prior to starting production of the mix, stockpile all aggregates for a sufficient period of time to facilitate the drainage of free moisture.

Produce the mixture at the asphalt plant within ±8°C of the temperature established on the JMF. Assure the temperature of the mix immediately prior to discharge from the hauling vehicle is within +8°C to -14°C of the JMF temperature.

Add the anti-strip additive to the asphalt binder in accordance with Article 620-3.

Clean the existing surface in an acceptable manner prior to placement of any asphalt material.

Remove all existing raised pavement markers as directed and repair any damaged areas caused by the removal. Use an approved dense graded mixture of similar type material for the repair.

Apply tack coat in accordance with the requirements of Section 605 and the following

**(A)** Use Asphalt Binder, Grade PG 64-22 tack coat material or as approved.

**(B)** Uniformly apply the tack coat material at a rate of application .27 to .36 l/m$^2$, as directed.

Spread and finish the friction course as specified in Article 610-8.

Roll the friction course as specified in Article 610-9.

Use a Material Transfer Vehicle (MTV) when placing all asphalt concrete plant mix pavements, including open-graded asphalt friction course, that require the use of asphalt binder grade PG 76-22, unless otherwise approved. Utilize the MTV when placing all full width travel lanes, including shoulders, collector lanes, ramps, and loops that require PG 76-22.

Provide an MTV that receives mixture from the hauling equipment and independently delivers the mixture from the hauling equipment to the paving equipment. Provide an MTV capable of transferring the material from the haul vehicle to the paver hopper at a uniform and continuous rate to allow the continuous movement of the paver. Install a paver hopper insert with a minimum capacity of 6.4 metric tons in the hopper of conventional paving equipment when utilizing a MTV. Perform remixing of the material prior to discharge into the paver conveyor system by utilizing either a MTV with a remixing system contained within a minimum 6.4 metric ton capacity storage bin or a dual pugmill system with two full length transversely mounted paddle mixers located in the paver hopper insert.

Use an MTV that provides to the paver a homogeneous, non-segregated mixture that is of uniform temperature such that there is no more than 11°C difference between the highest and lowest temperatures when measured transversely across the width of the mat in a straight line at a distance of 0.3 m to 1 m from the screed while the paver is operating. Obtain the temperature measurements approximately 0.3 m from each edge and at least once in the middle of the mat.

Empty the MTV when crossing a bridge and move across without any other Contractor vehicles or equipment being on the bridge. Move the MTV across a bridge in a travel lane and not on the shoulder. While crossing a bridge move the MTV at a speed no greater than five miles per hour without any abrupt acceleration or deceleration.

In the event the MTV malfunctions during paving operations, immediately discontinue plant operations and do not resume operations until the MTV malfunctions have been remedied, unless otherwise directed due to safety concerns. The Contractor may continue placement of the mix until any additional mix in transit has been placed, provided satisfactory results are achieved. This procedure in no way alleviates the Contractor from meeting contract requirements.

Remove and replace any part of the finished friction course that shows non-uniform distribution of asphalt binder, aggregate or fiber at no additional cost to the Department.

Coordinate plant production, transportation, and paving operations such that uniform continuity of operation is maintained. If spreading operations are interrupted, the Engineer may require that a transverse joint be constructed any time the mixture immediately behind the paver screed cools to less than 121ºC.

When OGAFC, Type FC-2 Modified mixture is specified, use OGAFC, Type FC-1 Modified on entrance and exit ramps, gore areas, and at end of project construction joints. Adjust the thickness of placement as specified below.

For end of project joints, provide a transition area consisting of one load of mixture per lane, or as directed. Taper the mixture in thickness from 9.5 mm at the end of the project to the typical thickness (approximately 19 mm) within the maximum distance of spread for one load of mixture. For ramps and gore areas, taper the mixture in thickness from that at the edge of the mainline, approximately 19 mm to 9.5 mm at the point of the ramp transverse joint. Construct the ramp transverse joint at a point specified by the plans or as directed.

### 650-6 QUALITY MANAGEMENT SYSTEM

Produce the OGAFC in accordance with the applicable requirements of Section 609 and QMS for Asphalt Pavements: (OGAFC, PADC, and Ultrathin Version) as shown in the contract.

### 650-7 MEASUREMENT AND PAYMENT

Open-Graded Asphalt Friction Course, Type FC-1, Type FC-1 Modified, or Type FC-2 Modified will be measured and paid for as the actual number of metric tons of friction course that has been incorporated into the completed and accepted work. The friction course will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

Furnishing asphalt binder for the mix will be paid for as provided in Article 620-4 Asphalt Binder for Plant Mix, Grade PG XX-XX. Adjustments in contract unit price due to asphalt binder price fluctuation will be made in accordance with Section 620.

No direct payment will be made for providing and using the materials transfer vehicle or any associated equipment, as the cost of providing same shall be included in the contract unit bid price per metric ton for the mix type to be placed.

Providing QMS for asphalt pavements will be in accordance with QMS for Asphalt Plant Mix Pavements contained elsewhere in the contract.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Open-Graded Asphalt Friction Course, Type FC-1 | Metric Ton |
| Open-Graded Asphalt Friction Course, Type FC-1 Modified | Metric Ton |
| Open-Graded Asphalt Friction Course, Type FC-2 Modified | Metric Ton |

## SECTION 652
## PERMEABLE ASPHALT DRAINAGE COURSE
## TYPES P-78M AND P-57

### 652-1 DESCRIPTION

Perform the work covered by this section including but not limited to the construction of a plant mixed permeable asphalt drainage course (PADC) properly laid upon a prepared surface in accordance with these Specifications and in conformity with the lines, grades, thickness, and typical sections shown on the plans; producing, weighing, transporting, placing, and rolling the plant mix as specified in Section 610; furnishing the asphalt binder, anti-strip additive, and all other materials for the plant mix; furnishing and

applying tack coat as specified in Section 605; furnishing scales; providing quality control as specified in Section 609 as modified for PADC; making any repairs or corrections to the friction course that may become necessary; and maintaining the friction course until final acceptance of the project.

## 652-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Coarse Aggregate | 1012-1 |
| Fine Aggregate | 1012-1 |
| Asphalt Binder, Grade PG 64-22 | 1020-2 |
| Anti-strip Additive (Chemical) | 1020-8 |

The coarse aggregate shall meet the requirements of Article 1012-1 except that that portion of the coarse aggregate retained on the 4.75 mm sieve shall contain at least 60 percent by weight of crushed pieces having 2 or more mechanically induced fractured faces.

## 652-3 COMPOSITION OF MIXTURE

### (A) General

Formulate the permeable asphalt drainage course from a mixture of crushed aggregate, asphalt binder, anti-strip additive and other additives as required to produce a mix meeting the requirements of Table 652-1.

Submit in writing a mix design (M&T 601 only) and proposed job mix formula (JMF) targets for each required mix type and combination of aggregates to the Engineer for review and approval at least 10 days prior to start of asphalt mix production. The job mix formula (JMF) will be established in accordance with the applicable requirements of Article 610-3. Establish the asphalt binder content at the midpoint of the range specified in Table 652-1 or as approved. Submit the mix design and proposed job mix formula targets on forms and in a format approved by the Department.

The formula for each mixture will indicate the blend percentage of each aggregate fraction to be used, a single percentage of combined aggregate passing each required sieve, the percentage and grade of asphalt binder (by weight of total mixture) to be incorporated into the mixture, the percentage of anti-strip additive to be added to the asphalt binder, and the temperature at that the mixture is to be discharged from the plant.

Have on hand at the asphalt plant the approved mix design and job mix formula issued by the Department, prior to beginning the work.

The job mix formula for each mixture will remain in effect until modified in writing, provided the results of QMS tests performed on material currently being produced conform with specification requirements.

Should a change in sources of aggregate materials to be made, a new mix design and job mix formula will be required before the new mixture is produced.

When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new job mix formula.

### (B) Mix Design

Design PADC mixtures conforming to the gradation requirements and other mix design criteria in Table 652-1 for the mix type specified.

Use the asphalt binder grade shown in Table 652-1 for the mix type specified or as approved.

Use a chemical anti-strip additive at a rate of 0.5% by weight of asphalt binder in all PADC mixes

When requested, submit to the Materials & Tests Unit in Raleigh, samples of mix components. Submit sample sizes as noted below or as requested. Provide the samples at least 20 days prior to the anticipated beginning placement of PADC mixture.

| | |
|---|---|
| 115 kg | of each coarse aggregate |
| 70 kg | fine aggregate |
| 8 liters | of asphalt binder |
| 0.5 liters | of chemical anti-strip additive |

Aggregate samples when combined according to the Contractor's proposed aggregate blend percentages shall be within the gradation range defined by the target values of Table 652-1 for each sieve or the samples will not be considered representative.

The mixing temperature at the asphalt plant will be established on the job mix formula.

**TABLE 652-1**
**PERMEABLE ASPHALT DRAINAGE COURSE**

| Sieve Designation | Total Percent Passing | |
|---|---|---|
| | **Type P 78M** | **Type P 57** |
| 37.5 mm | | 100 |
| 25.0 mm | | 95 – 100 |
| 19.0 mm | 100 | |
| 12.5 mm | 95 - 100 | 25 – 60 |
| 9.5 mm | 75 - 100 | |
| 4.75 mm | 20 - 45 | 10 – 20 |
| 2.36 mm | 3 - 15 | 5 – 10 |
| .075 mm | 1.0 – 3.0 | 1.0 – 3.0 |
| Asphalt Binder Content, % | 2.5 - 3.5 | 2.0 - 3.0 |
| Mixing Temperature at Plant (Established by the Engineer) | 93-121°C | 127-143°C |

## 652-4 CONSTRUCTION REQUIREMENTS

Produce, transport to the site, and place the asphalt plant mix in accordance with the applicable requirements of Section 610, except as otherwise provided below.

Produce the mixture at the asphalt plant within ±8°C of the temperature established on the JMF. Assure the temperature of the mix immediately prior to discharge from the hauling vehicle is within +8°C to -14°C of the JMF temperature.

Incorporate the asphalt binder into the asphalt plant mix in accordance with Section 620. Add the anti-strip additive to the asphalt binder in accordance with Article 620-3.

A prime coat or tack coat will not be required.

When the PADC is placed in trench sections, the rolling equipment and rolling sequences required by Article 610-9 will not apply. Compact the PADC to a degree acceptable to the Engineer.

When the PADC is to be covered with a subsequent layer of pavement, following placement of the PADC mixture to the appropriate line, grade and thickness, begin rolling when the mat has cooled sufficiently to support the weight of an 7.3 to 10.9 ton steel wheel tandem roller. Mat temperature at the time of initial rolling should be approximately
80°C - 107°C. The number of roller passes will be 2 or 3, unless otherwise directed. Consolidate the drainage layer sufficiently with rolling so as to support the weight of equipment that will place the next layer of pavement. Do not compact the drainage layer to the extent that it is not free draining or that the aggregate is crushed.

No construction traffic will be allowed to travel on any permeable asphalt drainage course. Only equipment necessary to place the next layer of pavement will be allowed on the drainage layer.

Do not place PADC that will not be covered with the next layer of pavement during the same calendar year or within 15 days of placement if the PADC is placed in January or February.

### 652-5 QUALITY MANAGEMENT SYSTEM FOR ASPHALT PAVEMENTS

Produce the PADC in accordance with the applicable requirements in Section 609 and QMS for Asphalt Pavements: (OGAFC, PADC, and Ultrathin Version).

### 652-6 MEASUREMENT AND PAYMENT

Permeable Asphalt Drainage Course, Type ___ will be paid for as the actual number of metric tons of drainage course that has been incorporated into the completed and accepted work. The drainage course will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

*Asphalt Binder for Plant Mix, Grade PG 64-22* will paid for in accordance with Article 620-4.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Permeable Asphalt Drainage Course, Type P-78M | Metric Ton |
| Permeable Asphalt Drainage Course, Type P-57 | Metric Ton |

## SECTION 654
## ASPHALT PLANT MIX, PAVEMENT REPAIR

### 654-1 DESCRIPTION

Perform the work covered by this section including but not limited to repairing of existing pavement with asphalt plant mix in order to provide a safe, passable, and convenient condition for traffic, or to replace pavement that has been removed in order to remove or to place pipe lines.

Perform the work by cutting of the existing pavement to a neat vertical joint and uniform line; removing and disposing of pavement, base, and subgrade material as approved or directed; coating of the area to be repaired with a tack coat; furnishing, placing, and compacting of asphalt plant mix; furnishing of asphalt binder for the asphalt plant mix; furnishing scales; and replacement of the removed material with asphalt plant mix.

Make the repairs in accordance with the plans, or as approved or directed.

### 654-2 MATERIALS

Where a pavement repair detail is not shown in the plans, use a type of asphalt plant mix that has have been approved.

Where a pavement repair detail is shown in the plans, the type of plant mix shall be in accordance with the pavement repair detail except where the Specifications permit the substitution of another type of plant mix or where approved.

In areas where the existing pavement is not to be resurfaced, the Contractor will not be allowed to substitute a different type of surface course from that shown on the pavement repair detail.

### 654-3 CONSTRUCTION METHODS

**(A) General**

Perform repair of existing pavement as approved or directed. Coordinate the work with all other work and operations necessary to maintain traffic.

**(B) Pipe Removal or Installation**

Where traffic is to be maintained, perform the removal or installation of pipe in sections so that half the width of the roadway will be available to traffic. Immediately upon completion of the entire pipeline removal or installation, repair the pavement.

### 654-4 MEASUREMENT AND PAYMENT

*Asphalt Plant Mix, Pavement Repair* will be paid for as the actual number of metric tons of asphalt plant mix, complete in place, that has been used to make completed and accepted repairs, except for those repairs that have been made necessary by the contractor's negligence. The asphalt plant mixed material will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

Any requirements included in the contract that provide for adjustments in compensation due to variations in the price of asphalt cement will not be applicable to payment for the work covered by this section.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Asphalt Plant Mix, Pavement Repair | Metric Ton |

## SECTION 657
## SEALING EXISTING PAVEMENT CRACKS AND JOINTS

### 657-1 DESCRIPTION

The work consists of sealing existing longitudinal and transverse pavement cracks and joints with PS/AR (hot-poured rubber asphalt) at locations as directed by the Engineer. The Contractor will not be required to seal the existing edge joints.

### 657-2 MATERIALS

| Item | Section |
|---|---|
| PS/AR (Hot-Poured Rubber Asphalt | 1012-1 |

The sealant is to be packaged in polyethylene bags and placed in boxes that weigh approximately 27.2 kg. The sealant may be packed in 27.2 kg boxes containing two polyethylene bags of sealant that weigh approximately 13.6 kg each. Boxes of sealant are to be palletized for shipment. The pallets are to be protected with a weatherproof covering. The Contractor is responsible for storage.

### 657-3 CONSTRUCTION METHODS

Install the sealant so that it forms a complete watertight bond with a high degree of elasticity, with maximum flexibility and longevity under extreme temperature ranges.

Use a hot compressed air (HCA) lance at all times to blast out any vegetation, dirt, dampness and loose materials from the cracks and joints.

Use a concentrated hot air jet that is a minimum of 1649°C in temperature and that has a minimum air jet force of 0.9 km/sec of blasting.

Force open asphalt cracks and joints, clean warm and dry, and have ready for the application of the preheated sealant for maximum crack sealing potential.

Preheat the sealant to its application temperature, using the air jacketed flow method to prevent the burning of the modified rubber in the sealant. Perform this by means of a trailer mounted 720 liter safety tested crack sealant preheater melter kettle, with a horizontally mounted full sweep double paddle agitator.

Apply sealant in the prepared cracks and joints at a temperature range of 188°C minimum and 216°C maximum, using the pressure screed shoe to completely fill the crack and joint, leaving a sealed 50.8 mm overband. Excessive overbanding or waste of sealant materials will not be tolerated. Immediately squeegee the crack seal material to minimize the height of the overband.

Do not apply the PS/AR sealant when the surface temperature of the pavement is below 0°C. Follow manufacturer's recommendations.

All cracks and joints sealed must have a minimum of 3.2 mm depth of sealant installed.

After the crack and joint has been sealed, promptly remove any surplus sealer on the pavement. Do not permit traffic over the sealed cracks and joints without approval by the Engineer. Sand or manufacturer's recommended material may be applied on top of the sealant to prevent traffic pick-up.

### 657-4 MEASUREMENT AND PAYMENT

*Sealing existing pavement cracks and j*oints will be measured and paid for as the actual number of kilograms of material that has satisfactorily been used to seal pavement cracks and joints in the designated highway. Any material that has been spilled, used in excessive overbanding, wasted, misapplied, or unsatisfactorily used in any way will be deducted in determining quantities for payment. The Engineer will determine the quantity, if any, to be deducted. The Engineer's decision on the quantity to be deducted will be final and binding.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Sealing Existing Pavement Cracks and Joints | Kilogram |

## SECTION 660
## ASPHALT SURFACE TREATMENT

### 660-1 DESCRIPTION

Perform the work covered by this section including but not limited to furnishing, hauling, spreading, and rolling the asphalt material and aggregate consisting of one or more applications of liquid asphalt material and one or more applications of aggregate cover coat material on a prepared surface; furnishing and spreading blotting sand; and maintaining and repairing the asphalt surface treatment.

### 660-2 MATERIALS

Refer to Division 10.

Use one of the following grades of asphalt:

| Item | Section |
|---|---|
| Emulsified Asphalt, Grade CRS-2 | 1020-7 |
| Emulsified Asphalt, Grade CRS-2P | 1020-7 |

| | |
|---|---|
| Emulsified Asphalt, Grade CSS-1H | 1020-7 |
| Aggregate for Mat and Seal Coat | 1012-2 |
| Blotting Sand | 1012-3 |
| Fine Aggregate | 1014 |
| Mineral Filler | 1012-1(D) |
| Water | 1024-4 |

Before any asphalt surface treatment is placed, obtain from the asphalt supplier and furnish to the Engineer a certification of compatibility of the asphalt with the aggregate proposed for use.

## 660-3 WEATHER AND SEASONAL LIMITATIONS

Do not place any asphalt surface treatment between October 15 and March 16, except for asphalt surface treatment that is to be overlaid with asphalt plant mix.

Apply asphalt material only when the surface to be treated is dry and when the atmospheric temperature is above 16°C in the shade away from artificial heat.

When placing asphalt surface treatment that is to be subsequently overlaid with asphalt plant mix, the seasonal and temperature limitations of Article 610-4 will apply.

Do not apply asphalt material when the weather is foggy or rainy.

## 660-4 SURFACE PREPARATION

Clean the surface to be treated of all dust, dirt, clay, grass, sod, and any other deleterious matter prior to application of the asphalt surface treatment.

## 660-5 ACCEPTANCE OF ASPHALT MATERIALS

The acceptance of asphalt materials will be in accordance with the requirements of Section 1020-1.

## 660-6 APPLICATION EQUIPMENT

Use asphalt application equipment that meets the requirements of Article 600-5.

Apply aggregate by the use of a self-propelled, pneumatic tired aggregate spreader capable of maintaining a specified rate with a uniform application for the width of asphalt material being covered. Tailgate spreaders will not be permitted. Areas that are inaccessible to the aggregate spreader may be covered by hand spreading or other acceptable methods.

## 660-7 APPLICATION OF ASPHALT MATERIALS

The grades, rates of application, and the temperature at that the asphalt material is to be applied shall be within the limits shown in Table 660-1.

Base the required rates of application on the volume of material at the application temperature.

**TABLE 660-1**
**MATERIAL APPLICATION RATES AND TEMPERATURES**

| TYPE OF COAT | GRADE OF ASPHALT | ASPHALT RATE $L/M^2$ Total | APPLICATION TEMP. °C | AGGREGATE SIZE | AGGREGATE RATE $KG/M^2$ Total |
|---|---|---|---|---|---|
| Mat | CRS-2 or CRS-2P | 1.58-1.81 | 66-79 | No. 6* | 16-19 |
| | CRS-2 or CRS-2P | 1.36-1.58 | 66-79 | No. 67 | 19-24 |
| | CRS-2 or CRS-2P | 2.04-2.26 | 66-79 | No. 5* | 24-27 |
| | CRS-2 or CRS-2P | 1.36-1.81 | 66-79 | No. 78M* | 8-11 |
| Straight Seal | CRS-2 or CRS-2P | 1.58-1.81 | 66-79 | No. 78M | 9-12 |
| | CRS-2 or CRS-2P | 1.58-1.81 | 66-79 | Lightweight | 5-7 |
| Split Seal | CRS-2 or CRS-2P | 2.26-2.72 | 66-79 | No.78M | 16-19 |
| | CRS-2 or CRS-2P | 2.04-2.72 | 66-79 | Lightweight | 10-11 |
| Triple Seal | CRS-2 or CRS-2P | 2.72-3.40 | 66-79 | No. 78M | 24-28 |
| | CRS-2 or CRS-2P | 2.72-3.40 | 66-79 | Lightweight | 15-16 |

* Use No. 6 or No. 78M aggregate for retreatment prior to an overlay on existing pavement.

Use No. 5 aggregate for initial treatment on new construction.

The Construction Methods article, 660-9, includes more detailed information regarding variations of the types of coats.

## 660-8 APPLICATION OF AGGREGATES

The size of the aggregate shall be as shown in Table 660-1 for the mat coat or the type of seal coat to be constructed.

The rate of application for mat and seal aggregates shall be within the limits shown in Table 660-1.

When directed, weigh a sufficient number of truck loads of aggregate prior to spreading to verify that the rate of application is within the required limits.

## 660-9 CONSTRUCTION METHODS

### (A) Asphalt Mat Coat

The surface on that the mat coat is to be applied shall be approved by the Engineer before the mat coat liquid asphalt is applied.

Place a string line guide for application equipment unless otherwise permitted.

Place the mat coat in full-lane widths unless otherwise permitted.

Immediately follow the application of mat liquid asphalt with the spreading of the aggregate. No more than 5 minutes can elapse from the time the liquid asphalt is applied until the aggregate is spread.

Test the mat coat aggregate, have it approved, and make sure it is drained of free moisture prior to use. Spread the aggregate uniformly at the required rate and correct all non-uniform areas prior to rolling.

Roll immediately after the aggregate is uniformly spread. Initial rolling consists of one complete coverage with a 4.5-7.3 metric ton steel wheel roller followed by pneumatic tired rollers. Continue rolling until the aggregate is thoroughly keyed into the mat liquid asphalt. Use rollers that neither crush the aggregate excessively, nor pick up material. A combination steel wheel and pneumatic tired roller will not be permitted. Use two individual rollers.

At the beginning of each mat liquid asphalt application, spread a paper over the end of the previously completed mat coat and begin the asphalt application on the paper. After application, remove and dispose of the paper.

After the aggregate is thoroughly seated, broom all excess aggregate off of the surface of the mat coat as directed. Traffic may be permitted on the mat coat immediately after the rolling and brooming is complete.

Correct defects or damage to the mat coat prior to the application of seal coat or plant mix overlay.

The seal coat may be applied the same day the mat coat is placed provided the mat coat has been satisfactorily applied and rolled.

**(B) Asphalt Seal Coat**

Use the type of seal coat as required by the contract.

Test seal coat aggregates, have approved, and drained of free moisture prior to use.

Adjust the aggregate rates to provide a sufficient quantity of cover material to be spread over the surface of the seal coat preventing traffic damage, where it is necessary to permit traffic on sections of a completed seal coat.

Perform rolling immediately after the aggregate has been uniformly spread. Initial rolling will consist of one complete coverage with a 4.5-7.3 metric ton steel wheel roller after that pneumatic tired rollers shall be used. Continue rolling until the aggregate is thoroughly keyed into the liquid asphalt. A final coverage with the steel wheel roller may be required to provide a satisfactory finished surface. The use of rollers that result in excessive crushing of the aggregate will not be permitted. Use rollers designed to prevent picking up the material. The use of a combination steel wheel and pneumatic tired roller will not be permitted. Use two individual rollers.

The requirements of Subarticle 660-9(A) will apply to the width of seal coat construction, application of liquid asphalt and aggregate, and the construction of joints. When directed, apply blotting sand in accordance with the requirements of Section 818.

The construction of the various types of seal coats will be in accordance with the following additional requirements:

(1) Straight Seal

Using the quantities shown in Table 660-1, apply asphalt material to the existing surface followed by an application of No.78M or lightweight aggregate. Apply approximately 1.58 - 1.81 l/$m^2$ of asphalt material to the existing surface immediately followed by the application of 16 - 20 kg/$m^2$ (No. 78) or 9 - 10 kg/$m^2$ (Lightweight). Uniformly spread the full required

amount of aggregate in one application and correct all non-uniform areas prior to rolling.

Immediately after the aggregate has been uniformly spread, perform rolling as previously described.

When directed, broom excess aggregate material from the surface of the seal coat.

(2) Split Seal

Apply approximately 0.91 - 1.36 l/$m^2$ of asphalt material to the existing surface immediately followed by the application of approximately 11 - 12 kg/$m^2$ (No. 78) or 5 - 6 kg/$m^2$ (Lightweight) of seal coat aggregate spread uniformly over the treated surface.

Immediately after the first application of seal aggregate has been made uniform, apply the second application of the required amount of asphalt material and seal coat aggregate and roll the seal coat on each aggregate layer as previously described.

In lieu of the No. 78 or Lightweight stone, Blotting Material as defined in Article 1012-3 may be used for the top aggregate layer and the application rate should be approximately 4 - 7 kg/$m^2$.

(3) Triple Seal

Apply approximately 0.91 - 1.13 l/$m^2$ of the required liquid asphalt to the existing surface immediately followed by the application of approximately 8 - 11 kg/$m^2$ (No. 78) or 5 - 6 kg/$m^2$ (Lightweight) of the required amount of seal coat aggregate spread uniformly over the treated surface. Apply second and third layers and after the final application of each aggregate layer is applied, roll it as previously described.

In lieu of the No. 78 or Lightweight stone, Blotting Material as defined in Article 1012-3 may be used for the top aggregate layer and the application rate should be approximately 4 – 7 kg/$m^2$.

(4) Slurry Seal

(a) Mix Requirements

Submit to the Engineer a mix design and results of the wear loss by the Wet Track Abrasion Test as prepared by an approved testing laboratory. The Wet Track Abrasion Test (WTAT) will be performed in accordance with ASTM D 3910. The wear loss by the Wet Track Abrasion Test must not be greater than 1,076 g/$m^2$. Apply the wear loss to the asphalt content limits designated on the job mix formula.

Place a test strip for approval by the Engineer prior to beginning the work. Once the consistency of the mix has been approved by the Engineer, maintain the total water content within 3 percent of the approved blend during the course of operation.

Submit a mix design for each type slurry. The gradation of the mix produced must conform to the job mix range. The asphalt content (residual asphalt) must not vary by more than 1.5 percent from the approved mix design.

**TABLE 660-2**
**Slurry Seal Gradation**

| TYPE | PERCENTAGE OF TOTAL BY WEIGHT PASSING (mm) | | | | | | | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 3/8 " | #4 | #8 | #10 | #16 | #30 | #40 | #50 | #80 | #100 | #200 | |
| B | 100 | 90-100 | 65-90 | | 45-70 | 30-50 | | 18-33 | | 10-21 | 5-15 | Design Asphalt Content, Percent #: 8.5-13 |
| C | 100 | 90-100 | 70-90 | | 32-54 | 23-38 | | 16-29 | | 9-20 | 5-15 | Design Asphalt Content, Percent #: 8.5-11.5 |

(b) **Sampling Requirements**

Samples for gradation will be taken **from** aggregate stockpiles designated by the Contractor for use. Take samples for asphalt content and total water content from the completed mixture. Samples of aggregate, filler, and emulsion for wet track abrasion check test will be taken at the job site. The frequency of sampling and testing will be established by the Engineer based upon the Department's current acceptance program and local conditions encountered.

(c) **Equipment**

Combine the mixing and spreading equipment in a single mobile operating unit. Attach a burlap drag approximately 483 mm wide to the back of the unit for the purpose of smoothing the slurry seal. Equip the mobile unit with an approved feeder that will accurately meter or otherwise introduce a predetermined amount of material into the mixer simultaneously with the aggregate. Use the feeder whenever mineral filler is added to the mix. Equip the mobile unit with a water pressure system and fog type spray bar capable of completely fogging the surface to that slurry seal is to be applied. Use a mobile unit capable of an operative speed of at least 18 m per minute and that has sufficient storage capacity to mix and apply a minimum of 4.5 metric tons of slurry.

**Mixer** Use a continuous flow type mixer capable of delivering water and a predetermined proportion of aggregate and asphalt emulsion to a revolving multiblade mixer tank. Use a mixer that discharges the thoroughly mixed product on a continuous basis and in that the blades of the mixing unit are capable of thoroughly blending all ingredients.

**Spreader** Use a spreader equipped with a flexible type squeegee positioned in contact with the pavement surface and designed to apply a uniform spread with a minimum loss of slurry.

**Auxiliary Equipment** Provide hand squeegees, shovels, and other hand equipment as necessary to perform work in areas that are inaccessible to the unit.

(d) **Construction Methods**

**Preparation of Surface** Thoroughly clean the surface upon that slurry seal is to be applied of all loose material, vegetation, silt spots, and other objectionable materials immediately preceding application by either brooming or the use of compressed air.

**Application** Wet aggregate immediately prior to mixing with the emulsion. The Engineer may direct that the surface of the pavement be fogged with water (approximately .22 l/$m^2$) immediately preceding the pass of the spreader. Provide a slurry mixture of a consistency such that it rolls in the spreader box in a continuous mass. Slurry that segregates in the spreader box, so that flowing of liquids (water and emulsion) is evident, is not acceptable and shall not be applied. The liquid portion of slurry mixture must not flow from either the spreader box or the applied slurry. Evidence of such flow is sufficient cause for rejection of the applied material. Place the slurry on the road in full lane widths up to and including 3.6 m. Use a mechanical device such as an auger to distribute the slurry mix in the spreader box.

Correct excess buildup of slurry on longitudinal and transverse joints.

Do not open treated areas to traffic until such time as the slurry seal has cured to the extent that it will no longer be damaged by traffic. The applied slurry mixture must be uniform in texture and not flush under traffic. Correct any areas not considered satisfactory by the Engineer at no additional expense to the State. Nothing contained herein is intended to relieve the Contractor from sharing in the responsibility and performance of the treatments, should a failure occur prior to acceptance of the contract. Article 105-17 of the Specifications is amended accordingly.

Do not apply Slurry Seal surface course on surfaces containing ponding water and the minimum surface temperature must be 10°C.

The Engineer may require the surface area to that the slurry has been applied by hand to be rolled using a pneumatic-tire type roller. Operate the roller at an approximate tire pressure of 345 kPa and subject the paved area to a minimum of two coverages.

Should oversize aggregate be encountered in the stockpile, immediately cease operation and remove the oversize aggregate by screening.

**Thickness of Application** The average minimum thickness of application must be at least 4.8 mm for Type B and at least 7.9 mm for Type C unless otherwise specified.

In the event of a test failure on compatibility and/or WTAT (loss greater than 1,076 g/$m^2$) for a sample of material being applied to the road, take corrective action prior to start-up of another day's run. Should the sample taken following adjustment also fail the compatibility and/or WTAT, cease application on the road. Maintain responsibility for furnishing additional compatibility and/or WTAT results and field application site(s) and will not be permitted to return to the road until he clearly demonstrates the acceptability of seal.

Materials placed in stockpiles or on the road not meeting the required tolerances may be accepted at a reduced price if it is not considered detrimental to the life of the treatment by the Engineer in accordance with Article 105-3. The following price adjustment schedule will be used when appropriate:

(i) One percent reduction in the bid price per square meter for each one-tenth percent the asphalt content is out of tolerance.

(ii) One-quarter percent price adjustment in the bid price per square meter for each one percent that the aggregate gradation is out of the job mix range.

(iii) One-half percent reduction in the bid price per square meter for each gram per square meter of WTAT loss between 1,077 and2,153 grams. Material having a loss greater than 2,153 $g/m^2$ will not be accepted for payment.

(iv) One percent reduction in the bid price per square meter for each one percent water in excess of the approved water content plus three percent.

Price adjustments under i, ii, iii, and iv above shall apply concurrently; however, price adjustment will not apply in the event the material is rejected. The disposition of rejected material will be subject to the approval of the Engineer.

**(C) Asphalt Mat and Seal**

Construct the mat coat in accordance with Subarticle 660-9(A) using the size aggregate required by the contract.

Construct the seal coat in accordance with Subarticle 660-9(B) using the type seal required by the contract.

**(D) Cape Seal**

Construct the cape seal by applying a seal coat followed by applying a slurry seal as defined in Article 660-9(B).

## 660-10 MAINTENANCE AND PROTECTION

Maintain and protect the asphalt surface treatment until it is accepted by the Department. Make all necessary repairs in such a manner as to preserve the uniformity of the surface.

## 660-11 MEASUREMENT AND PAYMENT

Asphalt Surface Treatments will be measured and paid for at the contract unit price per square meter. These include *Asphalt Surface Treatment, Mat Coat, No. __ Stone, Asphalt Surface Treatment, ____ Seal, Asphalt Surface Treatment, Slurry Seal, Asphalt Surface Treatment, Cape Seal, or Asphalt Surface Treatment, Mat and Seal*. Payment at the above prices will be made for replacing any satisfactorily completed asphalt surface treatment when such replacement has been made necessary by defects in subgrade or base that has been constructed by others.

When the Engineer directs that the rate of application of asphalt material be decreased below the minimum rate shown in Table 660-1, no reduction in compensation will be made.

When the Engineer directs that the rate of application of asphalt material be increased above the maximum rate shown in Table 660-1, compensation to the Contractor will be made in the amount of 5 cents plus the verified cash cost to the Contractor at the point of delivery for each liter of asphalt material, measured at application temperature, necessitated by the increase.

Blotting sand will be paid for as provided in Article 818-5 for Blotting Sand.

Furnishing and applying prime will be paid for as provided in Article 600-10 for Prime C.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Asphalt Surface Treatment, Mat Coat, No. _____ Stone | Square Meter |
| Asphalt Surface Treatment, _____ Seal | Square Meter |
| Asphalt Surface Treatment, Mat and Seal | Square Meter |

# SECTION 661
# ULTRA-THIN BONDED WEARING COURSE

## 661-1 DESCRIPTION

Produce and place an Ultra-thin Bonded Wearing Course (UBWC), including an application of a warm Polymer-Modified Emulsion Membrane (PMEM) followed immediately with an Ultra-thin Bonded Wearing Course hot mix asphalt overlay. Spray polymer-modified emulsion membrane immediately before applying hot mix asphalt

## 661-2 MATERIALS

Refer to Division 10.

| Item | Section |
|---|---|
| Coarse Aggregate and Fine Aggregate | 1005 and 1012 |
| Mineral Filler | 1012 |
| Asphalt Binder, Grade 70-28 | 1020 |
| Anti-strip Additive (Hydrated Lime) | 1012-1(E) |
| Anti-strip Additive (Chemical) | 1020-8 |

Do not use crystalline limestone, crystalline-dolomitic limestone, or marble for aggregates and do not use reclaimed asphalt pavement. Reclaimed asphalt shingle material may be used up to 6 percent by weight of total mix. Provide documentation that the asphalt binder grade meets the above requirements.

### (A) Coarse Aggregate

Coarse aggregates, such as crushed gravel, limestone, dolomite, sandstone, granite, chert, traprock, ore tailings, slag, or other similar materials, or blends of two or more of the above may be acceptable. Proportion and blend coarse aggregates for these mixes if made from more than one source or of more than one type of material, to provide a uniform mixture. Use coarse aggregates typically used for high performance surfaces. Coarse aggregates shall meet the skid resistance criteria as set forth by the Department and have a history of successful use in surface mixes for the intended traffic level.

Coarse aggregate material retained above the 4.75 mm sieve shall be from approved sources and shall meet the requirements listed in Table 661-1.

**TABLE 661-1 - COARSE AGGREGATE – PROPERTIES**

| Tests | Method | Limit |
|---|---|---|
| Los Angeles abrasion value, % loss | AASHTO T 96 | 35 max |
| Soundness, % loss, Sodium Sulfate | AASHTO T 104 | 15 max |
| Flat & Elongated Ratio, 5:1, + No 4 | ASTM D 4791 | 10 % max |
| % Fractured Particles, single face | ASTM D 5821 | 100 min |
| % Fractured Particles, two or more mechanically crushed faces | ASTM D 5821 | 85 min |
| Micro-Deval, % loss | AASHTO TP 58-02 | 18 max |

**(B) Fine Aggregate**

The fine aggregate passing the No. 4.75 mm shall be from approved sources and shall meet the requirements of Table 661-2 below.

**TABLE 661-2 - FINE AGGREGATE – PROPERTIES**

| Tests | Method | Limit |
|---|---|---|
| Sand Equivalent | AASHTO T 176 | 45 min |
| Uncompacted Void Content | AASHTO T 304 (Method A) | 40 min |

**(C) Mineral Filler**

Use hydrated lime, certain classes of fly ash, baghouse fines and Type 1 Portland Cement if needed as mineral filler.

**(D) Polymer Modified Emulsion Membrane**

Use Polymer Modified Emulsion Membrane consisting of styrene butadiene block co-polymer modified asphalt emulsion to form a water impermeable seal and bond the new hot mix to the existing surface. Complete polymer modification of base asphalt prior to emulsification.

Conform to the following:

| TABLE 661-3 EMULSION AND RESIDUE TESTING | Method | Min. | Max |
|---|---|---|---|
| **EMULSION** | | | |
| Viscosity @ 25°C, SFS | AASHTO T 59 | 20 | 100 |
| Sieve Test, % | AASHTO T 59 | | 0.1 |
| 24-Hour Storage Stability, % (1) | AASHTO T 59 | | 1 |
| Residue from Distillation @ 204°C, % (2) | AASHTO T 59 | 63 | |
| Oil portion from distillation ml of oil per 100 g emulsion | | | 2 |
| Demulsibility 35 ml, 0.02 N $CaCl_2$ or 35 ml, 0.8 % dioctyl sodium sulfosuccinate | AASHTO T 59 | 60 | |
| **RESIDUE** | | | |
| Solubility in TCE, % (3) | AASHTO T 44 | 97.5 | |
| Elastic Recovery, 10°C | | | |
| 20 cm elongation % (4) | AASHTO T 301 | 60 | |
| Penetration @ 25°C, 100 g, 5 sec, dmm | AASHTO T 49 | 60 | 150 |

(1) After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.

(2) AASHTO T-59 with modifications to include a 204°C ± 6°C maximum temperature to be held for a period of 15 minutes.

(3) ASTM D 5546, Test Method for Solubility of Polymer-Modified Asphalt Materials in 1,1,1-Trichloroethane may be substituted where polymers block the filter in Method D 2042.

(4) ASTM D 6084, Standard Test Method for Elastic Recovery of Binder Materials by Ductilometer with exception that the elongation is 20 cm and the test temperature is 10°C.

**(E) Asphalt Binder For Plant Mix, Grade PG 70-28**

Conform to the requirements of Section 620. The asphalt binder shall be compatible with the PMEM and existing pavement. Modify the binder with SBS, SB, or SBR polymer. Air blown asphalt is not permitted. Modification, testing, and certification of the asphalt binder shall be performed prior to delivery to the asphalt plant. Make test results available to the Engineer prior to use.

Meet the requirements of the following criteria:

| **Test on Binder** | **Method** | | |
|---|---|---|---|
| Separation of Polymer, % | ASTM D5892 | Report | 10 |
| **Tests On Residue From RTFO Test** | | | |
| Elastic Recovery, % | ASTM D 6084 | Minimum | 60 |

**(F) Anti-Strip Additive**

Use anti-strip additive and in accordance with the requirements of Article 620-3.

**(G) Composition of Mix**

Use a mixture of coarse and fine aggregate, asphalt binder, mineral filler, and other additives when required. Size, uniformly grade, and combine in such proportions such that the resulting mixture meets the gradation and physical requirements of Table 661-4. Use the mix design and optimum asphalt content for *Ultra-thin Bonded Wearing Course Mix Design Guidelines* on file with the Department's Materials & Tests Unit and available upon request.

Submit in writing a mix design and proposed job mix formula (JMF) targets for each required mix type and combination of aggregates to the Engineer for review and approval at least 10 days prior to start of asphalt mix production. Submit the mix design and proposed job mix formula targets on forms and in a format approved by the Department and in accordance with applicable requirements of Article 610-3.

Establish the job mix formula target values within the mix design criteria specified in Table 661-4 for the particular type mixture.

Have on hand at the asphalt plant, the approved mix design and job mix formula issued by the Department, prior to beginning the work.

The job mix formula for each mixture shall remain in effect until modified in writing by the Engineer, provided the results of QMS tests performed on material currently being produced conform with specification requirements. Should a change in sources of aggregate materials be made, a new mix design and job mix formula will be required before the new mixture is produced. When unsatisfactory results or other conditions make it necessary, the Engineer may establish a new job mix formula.

Determine and certify compatibility of all asphalt emulsion, asphalt binder, and aggregate components.

| TABLE 661-4 – MIXTURE DESIGN CRITERIA<br>Gradation Design Criteria (% Passing by Weight) | | | | |
|---|---|---|---|---|
| **Standard** | **Sieves** | **12.7 mm Type A** | **9.5 mm Type B** | **6.4 mm Type C** |
| **ASTM** | **Mm** | **(% Passing by Weight)** | | |
| 3/4 inch | 19.0 | 100 | | |
| 1/2 inch | 12.5 | 85 - 100 | 100 | |
| 3/8 inch | 9.5 | 60 - 80 | 85 - 100 | 100 |
| #4 | 4.75 | 28 - 38 | 28 - 42 | 40 - 55 |
| #8 | 2.36 | 19 - 32 | 19 - 32 | 22 - 32 |
| #16 | 1.18 | 15 - 23 | 15 - 23 | 15 - 25 |
| #30 | 0.600 | 10 - 18 | 10 - 18 | 10 - 18 |
| #50 | 0.300 | 8 - 13 | 8 - 13 | 8 - 13 |
| #100 | 0.150 | 6 - 10 | 6 - 10 | 6 - 10 |
| #200 | 0.075 | 4.0 - 7.0 | 4.0 - 7.0 | 4.0 - 7.0 |
| **Mix Design Criteria** | | | | |
| Asphalt Content, % | | 4.6 - 5.6 | 4.6 - 5.8 | 5.0 – 5.8 |
| Draindown Test, AASHTO T 305 | | 0.1% max | | |
| Moisture Sensitivity, AASHTO T 283* | | 80% min | | |
| Application Rate, kg/m$^2$ | | 49 | 38 | 27 |
| Approximate Application Depth, mm | | 19.0 | 15.9 | 12.5 |
| Asphalt PG Grade, AASHTO M 320 | | PG 70-28 | PG 70-28 | PG 70-28 |

Note: *Specimens for T-283 testing are to be compacted using the SUPERPAVE gyratory compactor. The mixtures are to be compacted using 100 gyrations to achieve specimens approximately 95 mm in height. Mixture and compaction temperatures as recommended by the binder supplier.

## 661-3 CONSTRUCTION

### (A) Equipment

Furnish paving machine with the following capabilities:

(1) Self-priming paving machine capable of spraying the Polymer-Modified Emulsion Membrane, applying the hot asphalt concrete overlay and screeding the surface of the mat to the required profile and cross- section in one pass at any rate between 9 to 28 meters/minute.

(2) Receiving hopper, feed conveyor, storage tank for Polymer-Modified Emulsion Membrane material, PMEM emulsion single variable-width spray bar and a variable width, heated, vibratory-tamping bar screed.

(3) Screed with the ability to be crowned at the center both positively and negatively and have vertically and horizontally adjustable extensions to accommodate the desired pavement profile and widths.

(4) Sprayer system capable of accurately and continuously monitoring the rate of spray and providing a uniform application across the entire width to be overlaid.

(5) Use pavers equipped with an electronic screed control that will automatically control the longitudinal profile and cross slope of the pavement. Control the longitudinal profile through the use of either a mobile grade reference(s), including mechanical, sonic and laser grade sensing and averaging devices, an erected string line(s) when specified, joint matching shoe(s), slope control devices or the approved methods or combination of methods. Unless otherwise specified, use a mobile grade reference system capable of averaging the existing grade or pavement profile over a minimum 9 m distance or by non-contacting laser or sonar type ski with at least four referencing stations mounted on the paver at a minimum length of 7.3 m. Establish the position of the reference system such that the average profile grade is established at the approximate midpoint of the system. The transverse cross-slope shall be controlled as directed by the Engineer.

Use an erected fixed stringline for both and longitudinal profile and cross slope control when required by the contract. When an erected fixed string line is required, furnish and erect the necessary guide line for the equipment. Support the stringline with grade stakes placed at maximum intervals of 7.6 m for the finished pavement grade.

Use the 9 m minimum length mobile grade reference system or the non-contacting laser or sonar type ski with at least four referencing stations mounted on the paver at a minimum length of 7.3 m to control the longitudinal profile when placing the initial lanes and all adjacent lanes of all layers, including resurfacing and asphalt in-lays, unless other specified or approved. A joint matching device (short 152.4 mm shoes) may be used only when approved.

Utilize the automatic slope control system unless otherwise approved. The Engineer may waive the use of automatic slope controls in areas where the existing surface (subgrade, base, asphalt layer, etc.) exhibits the desired cross slope of the final surface. The Engineer may also waive the use of automatic slope controls in areas where the use of such equipment is impractical due to irregular shape or cross section (such as resurfacing). When the use of the automatic slope controls is waived, the Engineer may require the use of mobile grade references on either or both sides of the paver. Manual screed operation will be permitted in the construction of irregularly shaped and minor areas, subject to approval. Waiver of the use of automatic screed controls does not relieve the Contractor of achieving plan profile grades and cross-slopes.

In the case of malfunction of the automatic screed control equipment, the paver may be manually operated for the remainder of the workday provided this method of operation produces acceptable results. Do not resume work thereafter until the automatic system is functional.

The Engineer will waive the requirement for use of pavers for spreading and finishing where irregularities or obstacles make their use impractical. Spread, rake, and lute the mixture by hand methods or other approved methods in these areas.

Operate the paver as continuously as possible. Pave intersections, auxiliary lanes, and other irregular areas after the main line roadway has been paved, unless otherwise approved.

Compact the wearing course with a steel double drum asphalt roller(s) with a minimum weight of 9.1 metric tons. Maintain rollers in reliable operating condition and equip with functioning water system and scrapers to prevent

adhesion of the fresh mix onto the roller drums. Supply adequate roller units and compact promptly following the placement of the material.

Request approval of equipment prior to the start of any work. Maintain all equipment and tools in satisfactory working condition at all times.

**(B) Surface Preparation**

Perform the following items prior to the commencement of paving operations.

(1) Protect and cover manhole covers, drains, grates catch basins and other such utility structures with plastic or building felt prior to paving and reference for location and adjustment after paving.

(2) Remove thermoplastic traffic markings symbols, characters, or other markings greater than 6.4 mm in thickness on the existing pavement.

(3) Clean and completely fill pavement cracks and joints greater than 6.4 mm wide. Do not overband the existing cracks and joints. Apply sealant per manufacturer's recommendation.

(4) Fill surface irregularities greater than 25.4 mm deep with a material approved by the Engineer.

(5) Thoroughly clean the entire pavement surface, giving specific attention to accumulated mud and debris. Pressurized water and/or vacuum systems may be required to ensure a clean surface.

**(C) Application of Ultra-thin Bonded Wearing Course**

Do not place Ultra-thin Bonded Wearing Course between October 31 and April 1, when the pavement surface temperature is less than 10°C or on a wet pavement. A damp pavement surface is acceptable for placement if it is free of standing water and favorable weather conditions are imminent.

Apply the Ultra-thin Bonded Wearing Course mixture at the rate per square meter as shown in Table 661-4 for the mix type shown in the plans.

Spray the Polymer-Modified Emulsion Membrane at a temperature of 60 - 82°C. Provide a uniform application across the entire width. Determine the rate of application (typically 0.68 – 1.13 l/m$^2$) by the mix design and current pavement condition for the specified project. Have the rate of application approved by the Engineer prior to beginning work.

Do not allow wheels or other parts of the paving machine to touch the Polymer-Modified Emulsion Membrane before the hot mix asphalt concrete wearing course is applied.

Place the hot asphalt concrete wearing course over the full width of the polymer-modified emulsion membrane. Apply the hot mix asphalt concrete at a temperature of 149 - 166°C and within a maximum of 3 seconds immediately after the application of the membrane. The temperature of the mix at the asphalt plant shall be within ±8°C of the JMF temperature. The temperature of the mix immediately prior to discharge from the hauling vehicle shall be within +8°C to -14°C of the JMF temperature.

Before opening to traffic, allow the pavement to sufficiently cool after the rolling operation to resist damage to the pavement.

**(D) Compaction**

Compact the wearing course with at least two passes of a steel double drum asphalt roller before the material temperature has fallen below 82°C. Do not allow the rollers to remain stationary on the freshly placed asphalt concrete. Compact immediately following the placement of Ultra-thin Bonded Wearing Course. A release agent (added to the water system) may be required to prevent adhesion of the fresh mix to the roller drum and wheels. Compact in the static mode.

QUALITY MANAGEMENT SYSTEM FOR ASPHALT PAVEMENTS

Produce the Ultra-thin Hot Mix Asphalt in accordance with the applicable provisions of Section 609 of the contract documents.

## 661-4 MEASUREMENT AND PAYMENT

*Ultra-thin Hot Mix Asphalt, Type_____* will be measured and paid for by the actual number of metric tons of mixture that has been incorporated into the completed and accepted work. The hot mix asphalt pavement will be measured by being weighed in trucks on certified platform scales or other certified weighing devices.

*Ultra-thin Hot Mix Asphalt* will be measured and paid for at the contract unit price per square meter. In measuring this quantity, the length will be the actual length constructed, measured along the surface. The width will be the width required by the contract or directed by the Engineer.

*Asphalt Binder For Plant Mix, Grade PG 70-28* will be paid for in accordance with Section 620-4. Asphalt binder price adjustments when applicable will be based on Grade PG 64-22, regardless of the grade used.

The above prices and payments shall include but not be limited to all traffic control, labor, materials, including the polymer modified asphalt emulsion, equipment necessary to produce and deliver the mix, including anti-strip additive (if necessary), equipment necessary to apply and compact the mix, and maintaining the Ultra-thin bonded wearing course until final acceptance of the project.

Providing QMS for asphalt pavements will be in accordance with the contract documents included elsewhere in this proposal.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Ultra-thin Hot Mix Asphalt, Type A | Metric Ton |
| Ultra-thin Hot Mix Asphalt, Type B | Metric Ton |
| Ultra-thin Hot Mix Asphalt, Type C | Metric Ton |
| Application of Ultrathin Hot Mix Asphalt | Square Meter |

# SECTION 663
# HOT IN-PLACE RECYCLED ASPHALT CONCRETE

## 663-1 DESCRIPTION

This work shall consist of hot in-place recycling of the existing asphalt concrete surface by heating and softening the existing asphalt pavement with indirect heat, loosening the heated pavement by hot milling to the depth specified in the plans, adding a plant produced hot mix asphalt admixture, if required, applying a rejuvenating agent, thoroughly remixing the material in a pugmill, leveling, relaying and compaction of the hot-in-place recycled (HIR) asphalt mixture. Use a continuous, single train, single pass, multi-step process to accomplish this work.

Hot In-Place Recycled Asphalt Concrete production and placement, including all materials and equipment shall be in accordance with applicable provisions of Division 6 except as specifically noted or modified herein.

Provide and conduct the quality control and required testing for acceptance of the HIR mixture in accordance with Quality Management System For Asphalt Pavements (Hot In-Place Recycled Asphalt), included herein.

## 663-2 MATERIALS

### (A) Hot Mix Asphalt Admixture

Determine the type and amount of plant produced hot mix asphalt (HMA) admixture to be added to the recycled mixture, subject to the approval of the

Engineer. The HMA admixture shall be a plant mixture of asphalt binder and aggregate(s) meeting the applicable requirements of Division 10 as shown below. The aggregate in the admixture may be a single standard size aggregate or a combination of aggregate sizes as needed. Provide enough binder content for the admixture such that the aggregate particles are fully coated. Provide a gradation and binder content for the admixture such that when blended with the other mix components, the hot in-place recycled mix properties will meet the mix design criteria for the applicable mix type specified in the plans, unless otherwise approved by the Engineer. Produce the HMA admixture in accordance with applicable requirements of Division 6.

| Item | Section |
|---|---|
| Coarse Aggregate | Article 1012-1 |
| Fine Aggregate | Article 1012-1 |
| Stone Screenings | Article 1012-1 |
| Asphalt Binder | Article 1020-2 |
| Anti-strip Additive | Article 1020-8 |

**(B) Asphalt Rejuvenating Agent**

Use an asphalt rejuvenating agent meeting the following requirements:

| | Minimum | Maximum |
|---|---|---|
| Viscosity, 25$^{o}$ C, SFS, ASTM D-244 | 20 | 125 |
| Sieve, %, ASTM D-244 | ----- | 0.10 |
| Storage Stability, 24 hr, %, ASTM D-244 | ----- | 1 |
| Residue from distillation, % (1) | 60 | ----- |
| Oil Distillate, Volume % | ------ | 5 |
| Tests on Residue and Rolling Thin-film Oven Tests: (2)<br>Penetration @ 25°C, 5 sec. | 300 | ------ |
| Torsional Recovery 4.3°C, % | 20 | ------ |

Notes (1) ASTM D244 except that the maximum temperature shall be 177$^{o}$C held for 20 minutes.

(2) The residue from distillation shall be subject to the standard rolling thin film oven test.

## 663-3 COMPOSITION OF MIXTURE (MIX DESIGN /JOB MIX FORMULA)

**(A) Mix Design-General**

Prepare and submit a proposed HIR mix design and job mix formula to the Engineer at least 14 days prior to beginning work in accordance with all applicable requirements of Article 610-3 except as modified herein. In addition, submit a proposed mix design for the admixture if an admixture is required.

Sample the existing pavement by coring or other methods approved by the Engineer to determine representative characteristics and properties of the existing pavement for use in mix design preparation. Take these samples at a minimum of one sample every 600 linear meters of each lane. Provide samples for quality assurance testing when requested by the Engineer. Take these all samples in the presence of the Engineer and at locations approved by the Engineer.

Perform and document a mix design in accordance with the Department's most current accepted policies and procedures for the design of asphalt mixes. The Department's Asphalt Design Engineer at the Materials and Tests Unit may be

contacted for copies of these procedures. Establish the proposed HIR mix design such that the hot in-place recycled mix properties are within the design criteria for the type mix specified, unless otherwise approved by the Engineer. Submit the mix designs on forms and in the format approved by the Department. Once the proposed mix designs are approved, the Engineer will provide approved Job Mix Formulas.

In addition to applicable mix design data required in Sub-article 610-3 (A), the data shall include but not be limited to the proposed percent admixture, if needed, admixture components, gradation, binder grade, binder content, percent anti-strip additive in admixture, percent existing pavement (RAP), gradation and binder content of existing pavement, percent rejuvenating agent, penetration of recovered binder from total mix, and all mix design properties and calculations.

**(B) Mix Design Criteria**

The finished asphalt pavement shall be a uniform mixture composed of the existing in-place asphalt pavement, asphalt rejuvenating agent, and new hot mix asphalt admixture, if required. The hot in-place recycled asphalt mix shall meet applicable requirements of Section 610-3 (excluding maximum percentage of allowable RAP) for the mix type specified, except as modified herein.

The proposed HIR mix design shall be established such that the hot in-place recycled mix properties will meet applicable gradation and mix design requirements of Table 663-1 and Table 663- 2 for the mix type specified, except as modified herein, unless otherwise approved by the Engineer

Add an asphalt rejuvenating agent at a rate that yields a completed mixture with a minimum/maximum penetration value as specified in Table 663-2 below, unless otherwise approved by the Engineer.

**TABLE 663-1 AGGREGATE GRADATION DESIGN CRITERIA**

| Standard Sieves | Percent Passing Criteria (Control Points) | | | | | |
|---|---|---|---|---|---|---|
| | Mix Type (Nominal Maximum Aggregate Size) | | | | | |
| | 9.5 mm | | 12.5 mm | | 19.0 mm | |
| (mm) | Min. | Max. | Min. | Max. | Min. | Max. |
| 50.0 | | | | | | |
| 37.5 | | | | | | |
| 25.0 | | | | | 100.0 | |
| 19.0 | | | 100.0 | | 90.0 | 100.0 |
| 12.5 | 100.0 | | 90.0 | 100.0 | | 90.0 |
| 9.5 | 90.0 | 100.0 | | 90.0 | | |
| 4.75 | | 90.0 | | | | |
| 2.36** | 32.0** | 67.0** | 28.0 | 58.0 | 23.0 | 49.0 |
| 1.18 | | | | | | |
| 0.600 | | | | | | |
| 0.300 | | | | | | |
| 0.150 | | | | | | |
| 0.075 | 4.0 | 8.0 | 4.0 | 8.0 | 3.0 | 8.0 |

**Note: For Type SF 9.5A the percentage Passing the 2.36 mm sieve is 60% Minimum and a Maximum of 70%.

Aggregate Nominal Maximum Size is defined as one standard sieve size larger than the first sieve to retain more than 10 percent aggregate. Maximum Size is defined as one standard sieve size larger than the nominal maximum size.

**Table 663-2 MIX DESIGN CRITERIA**

| Mix Type | Design ESALs (millions) | Target Binder PG Grade | Compaction Levels No. Gyrations @ | | | Volumetric Properties (b) (AASHTO PP 28) VMA | VTM | VFA | %Gmm |
|---|---|---|---|---|---|---|---|---|---|
| | (a) | | $N_{ini}$ | $N_{des}$ | $N_{max}$ | % Min. | % | Min.-Max. | @ $N_{ini}$ |
| SF-9.5A | < 0.3 | 64 - 22 | 6 | 50 | 75 | 16.0 | 3.0 - 5.0 | 70 - 80 | ≤ 91.5 |
| S-9.5A | < 0.3 | 64 - 22 | 6 | 50 | 75 | 15.0 | 3.0 - 5.0 | 70 - 80 | ≤ 91.5 |
| S-9.5B | 0.3 - 3 | 64 - 22 | 7 | 75 | 115 | 15.0 | 3.0 - 5.0 | 65 - 80 | ≤ 90.5 |
| S-9.5C | 3 - 30 | 70 - 22 | 8 | 100 | 160 | 15.0 | 3.0 - 5.0 | 65 - 76 | ≤ 89.0 |
| S-12.5B | < 3 | 64 - 22 | 7 | 75 | 115 | 14.0 | 3.0 - 5.0 | 65 - 78 | ≤ 90.5 |
| S-12.5C | 3 - 30 | 70 - 22 | 8 | 100 | 160 | 14.0 | 3.0 - 5.0 | 65 - 75 | ≤ 89.0 |
| | | | | | | | | | |
| I-19.0B | < 3 | 64 - 22 | 7 | 75 | 115 | 13.0 | 3.0 - 5.0 | 65 - 78 | ≤90.5 |
| I-19.0C | 3 - 30 | 64 - 22 | 8 | 100 | 160 | 13.0 | 3.0 - 5.0 | 65 - 75 | ≤ 89.0 |

| | Design Parameter | Design Criteria |
|---|---|---|
| All Mix | 1. $\%G_{mm}$ @ $N_{max}$ | ≤ 98.0% (c) |
| | 2. Penetration(AASHTO T 49) from Absorption Recovery (AASHTO T 170) | 40 Min. 90 Max. |

Notes: (a) Based on 20 year design traffic.

(b) Volumetric Properties based on specimens compacted to $N_{des}$ as modified by the Department.

(c) Based on specimens compacted to Nmax at selected optimum asphalt content.

(d) Mix Design Criteria may be modified, subject to approval by the Engineer.

**(C) Job Mix Formula**

Once the proposed mix design is approved, the Engineer will provide a Job Mix Formula for the hot in-place recycled asphalt mix. The job mix formula will be established within the design criteria in Tables 663-1 and 663-2, unless otherwise approved by the Engineer.

Once the HIR mix design is approved, the Engineer will provide a Job Mix Formula for the admixture if admixture is required. The completed admixture shall be produced in accordance with the Job Mix Formula requirements for gradation and binder content as prescribed in Quality Management System for Asphalt Pavements (Hot In-Place Recycled Asphalt Concrete – Superpave Version) as shown in the contract.

Samples of the completed recycled mixture may be taken by the Department on a random basis to determine if the PG grading on the recovered asphalt binder is in accordance with AASHTO M 320 for the grade specified. If the grading is determined to be a value other than required for the specified mix type, the

Engineer may require the Contractor to adjust the grade and/or percentage of additional asphalt binder, asphalt rejuvenator, and/or the blend of reclaimed material and admixture to bring the PG grade to the specified value for the required mix type, in accordance with Table 663-2.

## 663-4 EQUIPMENT

### (A) General

Equipment used to recycle the existing asphalt surface shall be designed and built for this specific purpose. The equipment shall be capable of a single pass, multi-step operation that includes; multi-step heating, milling, introducing rejuvenating agent, introducing hot mix asphalt admixture, if required, mixing the new material with the reclaimed material in a separate on-board chamber, redistributing the recycled material, leveling, and compacting the mixture.

### (B) Heating Unit

Preheating mechanism(s) consisting of clusters of heaters capable of uniformly heating the asphalt pavement to a temperature high enough to remove excess moisture, to allow milling of the existing pavement material to the designated plan depth without excessive fracturing of aggregate particles, without charring the existing asphalt and without producing undesirable pollutants. The heating mechanism shall be so equipped that the heat application shall be completely under an enclosed or shielded hood. The unit shall be adjustable in width. The Contractor shall protect adjacent landscape from heat damage and shall be responsible for any damage that may occur.

### (C) Milling/Blending Unit

A self propelled processing unit containing the following:

(1) A recycling machine equipped with additional heaters conforming to the same requirements as the preheaters.

(2) A unit capable of uniformly loosening the existing asphalt pavement to the depth specified. Care must be taken to ensure that milling or pavement reclaiming does not degrade the aggregates but only loosens the heated existing pavement.

(3) A controlled system for adding and uniformly blending a rejuvenating agent at a predetermined rate with the reclaimed mix during the remixing and leveling operation. The metering equipment shall be capable of measuring in liters. The application rate in liters, for the added material, shall be synchronized with the machine ground speed to provide a uniform application. The actual rate used may be adjusted as determined.

(4) A blending unit consisting of a twin shafted pugmill capable of uniformly adding new hot mix asphalt admixture, if required, at a rate established by the mix design. The unit shall be capable of thoroughly mixing the loosened asphalt pavement, asphalt rejuvenating agent, and new hot mix asphalt admixture if required, at the pugmill to produce a uniform mixture.

(5) A unit capable of auguring the heated and loosened material into a windrow at the center of the machine prior to entry into the blending unit.

(6) A paving machine meeting the requirements of Article 610-8 of the *Standard Specifications*, except as modified herein, shall be utilized to redistribute the remixed material over the width being processed and finished, so as to produce a uniform cross section and surface. The paving machine must be capable of screeding the full width of the remixed material. Automatic screed controls meeting the requirements of this Article shall be provided and used unless otherwise approved by the Engineer.

(7) The recycling train shall be capable of maintaining an average production rate of a minimum of 1.6 lane kilometer per day.

(8) The reheating and remixing units shall meet all state and local air quality emission standards for mobile sources.

**(D) Compaction Equipment**

Rollers meeting the requirements of Section 610-9 of the *Standard Specifications* and capable of achieving the specified density and surface requirements shall be utilized.

## 663-5 CONSTRUCTION REQUIREMENTS

Hot In-place recycled mixtures shall not be produced or placed during rainy weather or when the air temperature measured in the shade away from artificial heat at the location of the paving operations is less than 10°C. Do not place surface course material that is to be the final layer of pavement between December 15 and March 16 of the next year.

Prior to heating and remixing operations, the pavement shall be cleaned of all loose material. Power brooms shall be used and supplemented when necessary by hand brooming or other cleaning operations, as required, to bring the surface to a clean, suitable condition free of deleterious material.

The pavement surface shall be evenly heated, loosened, and remixed to the lines, grades and depths shown on the plans. Heating shall be controlled to ensure uniform heat penetration without overheating, cooking, or sooting of the asphalt pavement. The milled material shall be picked up, mixed with an asphalt rejuvenator and asphalt admixture, if needed, in a pugmill and then distributed and leveled by a conventional paving machine. The temperature of the milled material shall not be more than 163°C when measured immediately behind the milling unit. The temperature of the remixed material shall not be less than 113°C directly behind the screed.

The heating operation shall extend at least 100 mm beyond the width of remixing on both sides. When a pass is made adjacent to a previously placed mat, the longitudinal joint shall extend at least 50 mm into the previously placed mat.

The layer thickness of the HIR specified in the Plans or Contract Proposal shall be the compacted in-place thickness of the rejuvenated recycled mixture layer including any admixture. The depth of milling of the existing surface shall be such that the depth as specified on the plans is within ±6.4 mm, unless otherwise approved by the Engineer.

The asphalt rejuvenator shall be applied uniformly to the mixed material prior to remixing in the pugmill. The rate of application of rejuvenator will be as specified on the Job Mix Formula approved by the Engineer based upon the Contractor’s proposed mix design.

The remixed asphalt pavement shall be compacted immediately after it has been spread and leveled, while it is still in a workable condition.

Density control may be by either core samples or nuclear density control in accordance with the Department's most current procedures. Density for HIR mixes shall be a minimum of 92.0 percent of Maximum Specific Gravity (Gmm), except for SF9.5A that will be 90.0 percent of the Maximum Specific Gravity (Gmm). The Maximum Specific Gravity (AASHTO T 209) will be determined by procedures specified in the Department’s most current edition of the HMA/QMS Manual.

The compacted surface of the completed and accepted pavement structure shall meet the requirements of Article 610-12 of the *Standard Specifications*.

The Contractor shall take precautions needed to protect the adjacent landscape from heat damage. Damaged landscape shall be repaired or replaced at no cost to the Department.

### 663-6 MEASUREMENT AND PAYMENT

*Hot In-Place Recycled Asphalt Concrete, Type___* will be measured and paid for by the square meter in the completed and accepted work.

*Emulsified Asphalt Rejuvenating Agent* to be paid for will be measured by the metered quantity in liters used in all completed and accepted work and will be paid for at the contract price per liter.

*Hot Mix Asphalt Admixture* will be measured and paid for, when required, will be measured by being weighed in trucks on a certified weighing device and documented on load tickets and will be paid for at the contract unit price per metric ton.

Asphalt binder to be paid for will be measured and paid for in accordance with Article 620.

The above prices and payments will be full compensation for all work covered by this section including but not limited to furnishing all materials, producing, weighing, transporting, placing, and compacting the recycled pavement; maintaining the finished course until final acceptance of the project, performing quality control as specified in the contract and making any repairs or corrections to the surface of the pavement that may become necessary.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Hot In-Place Recycled Asphalt Concrete, Type _____ | Square Meter |
| Emulsified Asphalt Rejuvenating Agent | Liter |
| Hot Mix Asphalt Admixture | Metric Ton |

## SECTION 665
## MILLED RUMBLE STRIPS ON ASPHALT CONCRETE SHOULDERS

### 665-1 DESCRIPTION

Construct rumble strips on asphalt concrete shoulders in accordance with the plans and as directed by the Engineer. Work includes but is not limited to furnishing all labor and equipment; disposing of milled material; and all incidentals necessary to complete the work satisfactorily.

### 665-2 EQUIPMENT

Provide equipment consisting of a rotary type cutting head with a maximum outside diameter of 610 mm and that is a minimum of 400 mm long. Provide a cutting head that has the cutting tips arranged in such a pattern as to provide a relatively smooth cut as well as a cutting head(s) that is on its own independent suspension from that of the power unit to allow the tool to self align with the slope of the shoulder and/or any irregularities in the shoulder surface.

Provide a cutting tool equipped with guides to provide consistent alignment of each cut in relation to the roadway and to provide uniformity and consistency throughout the project.

### 665-3 CONSTRUCTION METHODS

Demonstrate the ability to achieve desired surface inside each depression without tearing or snagging the asphalt prior to beginning the work.

Provide rumble strips that have finished dimensions of 178 mm (±13 mm) wide in the direction of travel and are at least 400 mm long measured perpendicular to the direction of travel. Provide rumble strips having depressions with a concave circular shape with a minimum 13 mm depth at center (no more than an allowable depth 16 mm). Place rumble strips in relation to the roadway according to the patterns shown in the plans.

Material resulting from the operation becomes the property of the Contractor. Remove and dispose of this material in accordance with the requirements of Section 802.

At the end of each working day remove all equipment to a location where it does not present a traffic hazard, clean pavement and reopen work area to traffic.

## 665-4 MEASUREMENT AND PAYMENT

Milled Rumble Strips (Asphalt Cement Concrete) will be measured and paid for at the contract unit price per linear meter for the actual number of linear meters of shoulder, measured longitudinally along the surface of each shoulder, where rumble strips have been constructed.

Payment will be made under:

| Pay Item | Pay Unit |
|---|---|
| Milled Rumble Strips (Asphalt Cement Concrete) | Linear Meter |