2006

2007 Project Special Provisions Bolded and Highlighted

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 which 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 %Gmm@Nini are within the applicable mix design criteria and the gradation, binder content, and %Gmm@Nini 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 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 which 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 tons of asphalt mix, furnish and maintain a Department certified laboratory at the plant site. A minimum of 320 square feet 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 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 which 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 the Engineer allows the mix to remain in place, payment will be made in accordance with Article 105-3**

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~~ **mix design** at the following minimum frequency during mix production:

Accumulative Production Increment	Number of Samples per Increment
750 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 tons and a regularly scheduled full test series random sample location for that mix design ~~is not reached~~ **does not occur** 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):
   1. Ignition Furnace (AASHTO T 308 Modified)
   2. 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 or ASTM 2041), 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. $P_{0.075}/P_{be}$ Ratio

I. % 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)

   1. Coarse Aggregates (Approved Standard Sizes)
      a. At beginning of production*
      b. Weekly thereafter*
   2. 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, which 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):

(1) Option 1:

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

(2) Option 2:

Mix sampled from truck at plant with one set of specimens prepared by the Contractor and then tested jointly by QA and QC at a mutually agreed upon lab site within the first seven (7) calendar days after beginning production of each new mix design.

~~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.~~

Test all TSR specimens required by either option noted above 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 which replace regularly scheduled random samples, on control charts the same day the ~~tests~~ **test results** 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:

1. Aggregate Gradation Test Results:
   a. For each mix type: one sieve size smaller than the mix nominal maximum size.
   b. For all mix types: 2.36 mm and 0.075 mm sieves
2. Binder Content, %, P_b
3. Bulk Specific Gravity of Compacted Specimens at N_{des} (measured)
4. Maximum Specific Gravity Determined by AASHTO T 209
5. Percent Voids in Total Mix at N_{des} Gyrations
6. Percent Voids in Mineral Aggregate at N_{des} Gyrations
7. $P_{0.075}/P_{be}$ Ratio
8. Percent Maximum Specific Gravity at N_{ini} Gyrations

Both the full test series individual test values and the moving average of the last four (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~~ **moving average** 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:

~~1. A change in the binder percentage or aggregate blend is made in the JMF, or,~~

1. A change in the binder percentage, aggregate blend, or Gmm is made on the JMF, or

2. When the Contractor elects to stop or is required to stop production after one or two moving average values, respectively, fall outside the ~~warning~~ **moving average** limits as outlined in Subarticle 609-5(C)6, or,
3. If failure to stop production after two consecutive moving averages exceed the ~~warning~~ **moving average** 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 which 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. **The individual limit shall apply to the individual test results.** Control limits for the ~~warning and~~ moving average limits are based on a moving average of the last four (4) data points. Apply all control limits to the applicable target source.

CONTROL LIMITS

Mix Control Criteria	Target Source	~~Warning Limit~~ **Moving Average 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~~ **1.0**	~~0.0~~ **±0.4**	~~N/A~~	~~+0.4%~~ **±0.8**
$\%G_{mm}$ @ 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)~~ (5) Corrective Actions:

Immediately notify the Engineer when moving averages exceed the ~~warning~~ **moving average** 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 which 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:

1. 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,
2. When two consecutive field TSR values fail to meet the minimum specification requirement, or,
3. 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 which 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~~ **moving average** 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~~ **moving average** limit. If two consecutive moving average values for any one of the mix control criteria fall outside the ~~warning~~ **moving average** 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~~ **moving average** 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~~ **moving average** 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~~ **is outside the moving average limits**, the mix will be ~~considered not to be within reasonably close conformity, but reasonably acceptable~~ **evaluated for acceptance in accordance with Article 105-3**. Reduced payment for **or removal of** 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~~ **moving average** limits. ~~in accordance with the following table~~. **In addition, any mix that is obviously unacceptable will be rejected for use in the work.**

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

~~Property~~	~~Pay Factor~~
~~2.36mm Sieve~~	~~90%~~
~~0.075mm 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 which 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 which 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~~ **moving average** 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~~ **moving average** 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)~~ (6) 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 which will be used on the project.

Establish acceptable control strips when required at locations approved by the Engineer. Construct control strips which are 300 feet 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 2000 linear feet 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 4.0 feet or greater,

C. Uniform width paved shoulders 2.0 feet 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 4.0 feet 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 which have irregular shapes which 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.~~**If the Engineer allows mix to remain in place, payment will be made in accordance with Article 105-3.**

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 three (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:

1. 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,
2. 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 ten feet 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 6 inch 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 6 inch 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 which 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 2000 linear feet 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 **(except as noted in the first paragraph below):**:

~~(1) Two consecutive failing lots, excluding lots representing an individual resurfacing map or portion thereof.~~

~~(2) Three consecutive failing lots, with each lot representing an individual resurfacing map or portion thereof.~~

(a) Two consecutive failing lots, except on resurfacing*

(b) Three consecutive failing lots on resurfacing*.

(c) Two consecutive failing nuclear control strips.

***Resurfacing is defined as the first new uniform layer placed on an existing pavement.**

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 300 foot control strip plus 100 feet 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 which 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, which 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:

1. 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;
2. By periodically observing sampling and testing procedures performed by the Contractor;
3. By monitoring required control charts exhibiting test results of control parameters;

4. 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);
5. 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
6. 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:

1. 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.
2. By periodically observing tests performed by the Contractor;
3. By testing randomly selected comparison core samples taken adjacent to the Contractor's quality control core samples (8 inches center-to-center) at a frequency equal to or greater than 5%of the frequency required of the Contractor; and
4. 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.
5. 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 which 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**
25.0mm sieve(Base Mix)	± 10.0%
19.0mm sieve(Base Mix)	± 10.0%
12.5mm sieve(Intermediate Mix)	± 6.0%
9.5mm sieve(Surface Mix)	± 5.0%
4.75mm sieve(Surface Mix)	± 5.0%
2.36mm sieve(All Mixes)	± 5.0%
0.075mm 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 :

1. QA test results of QC split sample does not meet above limits of precision, or
2. QA test results of QC split sample does not meet the individual test control limits or the specification requirements, or
3. 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:

1. Joint testing of any remaining split samples,
2. Review and observation of the QC technician's sampling and testing procedures,
3. Evaluation and calibration of QC testing equipment,
4. 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 COMPENSATION.

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.

See Division 10:

Coarse aggregate	Article 1012-1
Fine aggregate	Article 1012-1
Mineral filler	Article 1012-1
Stone screenings	Article 1012-1
Reclaimed asphalt pavement	Article 1012-1
Reclaimed asphalt shingles	Article 1012-1
Natural sand	Article 1012-1
Anti-strip additive (hydrated lime)	Article 1012-1
Anti-strip additive (chemical)	Article 1020-8
Asphalt Binder, Performance Grade	Article 1020-2
Silicone	Article 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 which 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) or Reclaimed Asphalt Shingles (RAS) may be incorporated into asphalt plant mixes in accordance with Article 1012-1 and the following applicable requirements.

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 six (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 20% 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 20% and shall be produced using virgin asphalt binder grade PG 76-22. For all other recycled mix types, when the percentage of RAP is 20% 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 20% 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 (G_{sb}), current apparent specific gravity (G_{sa}) 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 (G_{se}) 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 (No. 200) 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 (P_b) 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.

250 lb. (115 kg) of each coarse aggregate
150 lb. (70 kg) of each intermediate and fine aggregate
150 lb. (70 kg) RAP and / or RAS
1 gal. (4 liters) of mineral filler and/or baghouse fines
2 gal. (8 liters) of asphalt binder
1 gal. (4 liters) 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 which 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 which 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 which 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 265°F and 350°F or as approved. Unless otherwise requested, the JMF temperature will be established as follows:

Mixes with binder grade:	PG 64-22	300°F
	PG 70-22	315°F
	PG 76-22	335°F

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

	Design	Binder	Compaction Levels			Volumetric Properties (c)			
Mix	**ESALs**	**PG**							
Type	**millions**	**Grade**	**No. Gyrations @**		**Max. Rut Depth**	**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 which is to be the final layer of pavement between December 15 and March 16 of the next year if it is 1" or greater in thickness or between November 15 and April 1 of the next year if it is less than 1" 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 2" or greater in thickness has started, it may continue until the temperature drops to 32°F.

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	35°F	35°F
ACIC, Type I 19.0B, C, D	35°F	35°F
ACSC, Type S 4.75A, SF 9.5A, S 9.5B	40°F	50°F *
ACSC, Type S 9.5C, S 12.5C	**45°F**	**50°F**
ACSC, Type S 9.5D, S 12.5D	50°F	50°F

*** 35°F if surface is soil or aggregate base on a secondary road construction.**

610-5 ASPHALT MIXTURE PRODUCTION.

(A) General:

Utilize plants which 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 ±15°F of the temperature established on the JMF. Assure the temperature of the mix immediately prior to discharge from the hauling vehicle is within +15°F to -25°F 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 which is relocated, modified, or changes ownership shall be recertified prior to use.

Any completely automatically controlled asphalt plant which, 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, which 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 which 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 which is injected into the asphalt binder being introduced into the aggregate. Provide a system which 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 which is accurate to within ±10 percent of the specified amount. Provide a proportioning device with a convenient and accurate means of calibration and which is interlocked with the aggregate feed or weigh system so as to maintain the correct proportion. Provide a flow indicator or sensor which 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 which 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 which 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 which 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 50-pound weights for testing the plant scales.

(2) Screens:

Provide plant screens which 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 which close tightly so that no material is allowed to leak into the weigh hopper.

(4) Weigh Box or Hopper:

Use equipment which 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 which 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 which 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 which 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 which 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 3,000 pounds.

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 which have fully automated proportioning and mixing controls and a rated capacity of at least 90 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 which 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 which 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 which will permit rapid and complete discharge of the mixture. Provide paddles which 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 which 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 which 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 which 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 which 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 90 tons per hour when producing a finished mixture at 300°F 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 which 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 which are so constructed and secured as to prevent the entrance of moisture and the rapid loss of temperature. Provide a 3/8 inch diameter hole on each side of the vehicle body near the center of the body and 6 inches 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 tolernce of plus 15°F to minus 25°F 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 which 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 which 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 which 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 30 foot 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 24 feet. 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 25 feet for the finished pavement grade.

Use the 30 foot minimum length mobile grade reference system or the non-contacting laser or sonar type ski with at least four referencing stations on the paver at a minimum of 24 feet 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 6 inch 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, which 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 which 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 7 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 7 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 20°F difference between the highest and lowest temperatures when measured transversely across the width of the mat in a straight line at a distance of one foot to three feet from the screed while the paver is operating. Obtain the temperature measurements approximately one foot 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 10 tons, with additional rolling limited to one coverage with the roller where necessary to improve the riding surface.

Steel wheel tandem vibratory rollers which have been specifically designed for the compaction of asphalt pavements may be used on all layers 1 inch 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 which have variable amplitude and frequency capabilities and which are designed specifically for asphalt pavement compaction. Provide rollers equipped with controls which 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 which 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 which 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 which 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 which 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.

610-10 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 100 lbs/sy (55 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.

1. Full width travel lane pavements, including normal travel lanes, turn lanes, collector lanes, ramps and loops, and temporary pavements,
2. Pavement widening 4.0 feet (1.2 m) or greater,
3. Uniform width paved shoulders 2.0 feet (0.6 m) or greater,
4. 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 4.0 feet (1.2 meters) 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 6 inches. 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 2500 feet of pavement at the laydown width.

Remain on limited production until such time as satisfactory laydown results are obtained or until three consecutive 2500 foot sections have been attempted without achieving satisfactory laydown results. If the Contractor fails to achieve satisfactory laydown results after three consecutive 2500 foot 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 the Project Special Provision titled, "FINAL SURFACE TESTING - ASPHALT PAVEMENTS" is included in the contract. In that case, adhere to the project special provision.

Each pavement layer will be tested by the Contractor and the Engineer using a 10-foot 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 1/8 inch 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 (G_{mm}), 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 G_{mm} 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:

(1) 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.

(2) 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.

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

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

(5) 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:

(1) 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);

(2) pavement which is within a designated travel lane of the final traffic pattern; and

(3) pavement which is 4.0 feet or wider.

As an exception, when the first layer of mix **is a surface course** ~~is~~ placed **directly** on an unprimed aggregate **or soil** base ~~and is 2.0 inches 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 which 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.

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

where: 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. Payment at the contract unit prices for the various asphalt items will be full compensation for all 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.

The quantity of hot mix asphalt pavement to be paid for at the contract unit prices per ton will be the actual number of tons of each type of hot mix asphalt pavement which 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 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, which 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:

Asphalt Concrete Base Course, Type B 25.0B ..... Ton
Asphalt Concrete Base Course, Type B 25.0C ..... Ton
Asphalt Concrete Base Course, Type B 37.5C ..... Ton

Asphalt Concrete Intermediate Course, Type I 19.0B ..... Ton
Asphalt Concrete Intermediate Course, Type I 19.0C ..... Ton
Asphalt Concrete Intermediate Course, Type I 19.0D ..... Ton

Asphalt Concrete Surface Course, Type S 4.75A ..... Ton
Asphalt Concrete Surface Course, Type SF 9.5A Ton
Asphalt Concrete Surface Course, Type S 9.5B ..... Ton
Asphalt Concrete Surface Course, Type S 9.5C ..... Ton
Asphalt Concrete Surface Course, Type S 9.5D ..... Ton

Asphalt Concrete Surface Course, Type S 12.5C ..... Ton
Asphalt Concrete Surface Course, Type S 12.5D ..... Ton

THE FOLLOWING ARE ASPHALT RELATED CHANGES THAT ARE NOT INCLUDED IN SECTIONS 609 or 610.

Page 6-69, Table 660-1 **Material Application Rates and Temperatures**, add the following:

Type of Coat	Grade of Asphalt	Asphalt Rate gal/yd^2	Application Temperature ^oF	Aggregate Size	Aggregate Rate lb./sq. yd. Total
Sand Seal	CRS-2 or CRS-2P	0.22-0.30	150-175	Blotting Sand	12-15

Page 6-75, Subarticle 660-9(B), add the following as sub-item (5)

(5) Sand Seal

Place the fully required amount of asphalt material in one application and immediately cover with the seal coat aggregate. Uniformly spread the fully 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.

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

When the sand seal is to be constructed for temporary sealing purposes only and will not be used by traffic, other grades of asphalt material meeting the requirements of Articles 1020-6 and 1020-7 may be used in lieu of the grade of asphalt required by Table 660-1 when approved.

Article 661-1

Add the following paragraph at the end of this Subarticle:

Provide and conduct the quality control and required testing for acceptance of the UBWC in accordance with "Quality Management System for Asphalt Pavements (OGAFC, PADL, and Ultra-thin HMA Version)", included in the Contract.

Subarticle 661-3(A)

Add the following as the first paragraph in this Subarticle:

Utilize asphalt mixing plants in accordance with Article 610-5 of the Standard Specifications.

Article 661-4

add the following pay item to the list of Pay Items at the end of this Article.

Pay Item	Pay Unit
Asphalt Binder for Plant Mix, Grade PG 70-28	Ton

TABLE 1012-1
AGGREGATE CONSENSUS PROPERTIES [a]

Mix Type	Course Aggregate Angularity[b]	Fine Aggregate Angularity % Minimum	Sand Equivalent % Minimum	Flat &Elongated 5 : 1 Ratio % Maximum
	ASTM D 5821	AASHTO T304 Method A	AASHTO T 176	ASTM D 4791 Section 8.4
S.4.75		40	40	
SF9.5A S 9.5 , B				
S 12.5 B	75 / -	40	40	10[c]
I 19.0 B B 25.0 B				
S 9.5 C				
S 12.5 C	95 / 90	45	45	10
I 19.0 C B 25.0 C B 37.5 C				
S 12.5 D	100 / 100	45	50	10
I 19.0 D				
S 9.5 D	**100/100**	**45**	**50**	**10**
OGAFC	100/100	N/A	N/A	**10**
UBWC	**100/85**	**40**	**45**	**10**

Notes [a] Requirements apply to the coarse aggregate blend and/or fine aggregate blend

[b] 95/90 denotes that 95% of the coarse aggregate has one fractured face and 90% has two or more fractured faces.

(c) Does not apply to Mix Types SF 9.5A and S 9.5B.

Page 10-43 thru 10-45, Subarticle 1012-1(G): Delete this entire Subarticle and substitute the following:

(G) Reclaimed Asphalt Pavement (RAP)

(1) Mix Design RAP

Incorporate RAP from stockpiles or other sources that have been tested for uniformity of gradation and binder content prior to use in an asphalt mix design. Use reclaimed asphalt pavement that meets all requirements specified for *one of* the following *two* classifications.

(a) Millings

Existing reclaimed asphalt pavement (RAP) that is removed from its original location by a milling process as specified in Section 607. Millings should be such that all materials will pass a 2" sieve prior to introduction into the plant mixer unit.

(b) Processed RAP

RAP that is processed in some manner (possibly by crushing *and*/or use of a blending method) to produce a uniform gradation and binder content in the RAP prior to use in a

recycled mix. Process RAP so that all materials will pass a 2" sieve prior to introduction into the plant mixer unit.

(2) Mix Production RAP

During mix production use RAP that meets the criteria for one of the following categories:

(a) Mix Design RAP

RAP contained in the mix design stockpiles as described above may be used in all applicable JMFs. These stockpiles have been pretested: however, they are subject to required QC/QA testing in accordance with Subarticle 609-5(C)(2).

(b) New Source RAP

New Source RAP is defined as any acceptable material which was not included in the stockpile or other source when samples were taken for mix design purposes. Process new source RAP so that all materials will pass a 2" sieve prior to introduction into the plant mixer unit.

After a stockpile of processed RAP or millings has been sampled and mix designs made from these samples, do not add new source RAP to the original stockpile without prior field testing to insure gradation and binder uniformity. Sample and test new source RAP before blending with the existing stockpile.

Store new source RAP in a separate stockpile until the material can be sampled and tested for comparison with the original recycled mix design data. New source RAP may also be placed against the existing stockpile in a linear manner provided it is sampled for mix design conformity prior to its use in the recycled mix.

Unprocessed RAP is asphalt material that was not milled and/or has not been processed to obtain a uniform gradation and binder content and is not representative of the RAP used during the applicable mix design. Unprocessed RAP shall not be incorporated into any JMFs prior to processing. Different sources of unprocessed RAP may be stockpiled together provided it is generally free of contamination and will be processed prior to use in a recycled mix. RAP contamination in the form of excessive dirt, debris, clean stone, concrete, etc. will not be allowed. Incidental amounts of dirt, concrete, and clean stone may be acceptable. Unprocessed RAP may be processed and then classified as a new source RAP as described above.

Field approval of new source RAP will be based on Table 1012-2 below and volumetric mix properties on the mix with the new source RAP included. Provided the Table 1012-2 tolerances are met, volumetric properties of the new mix will then be performed. If all volumetric mix properties meet the mix design criteria for that mix type, the new source RAP may continue to be used.

If the gradation, binder content, or any of the volumetric mix properties are not within the allowable tolerances of Table 1012-2, do not use the new source RAP unless approved by

the Engineer. The Contractor may elect to either not use the stockpile, to request an adjustment to the JMF, or to redesign the mix.

TABLE 1012-2
NEW SOURCE RAP GRADATION and BINDER TOLERANCES
(Apply Tolerances to Mix Design Data)

Mix Type	0-20% RAP			20^{+}-25 % RAP			25^{+} % RAP		
Sieve (mm)	Base	Inter.	Surf.	Base	Inter.	Surf.	Base	Inter.	Surf.
P_b %		± 0.7%			± 0.4%			± 0.3%	
25.0	±10	-	-	±7	-	-	±5	-	-
19.0	±10	±10	-	±7	±7	-	±5	±5	-
12.5	-	±10	±6	-	±7	±3	-	±5	±2
9.5	-	-	±8	-	-	±5	-	-	±4
4.75	±10	-	±10	±7	-	±7	±5	-	±5
2.36	±8	±8	±8	±5	±5	±5	±4	±4	±4
1.18	±8	±8	±8	±5	±5	±5	±4	±4	±4
0.300	±8	±8	±8	±5	±5	±5	±4	±4	±4
0.150	-	-	±8	-	-	±5	-	-	±4
0.075	±4	±4	±4	±2	±2	±2	±1.5	±1.5	±1.5