

**QUALITY MANAGEMENT SYSTEM FOR ASPHALT PAVEMENTS**  
**(Hot In-Place Recycled Asphalt Concrete)**

3-20-07

SPI

**(A) Description**

Produce and construct Hot In-Place Recycled (HIR) asphalt concrete pavements. Work and materials shall conform to Division 6 of the *2006 Standard Specifications*. Perform all quality control activities in accordance with the Department's *Hot Mix Asphalt Quality Management System (HMA/QMS) Manual*.

**(B) Description of Responsibilities**

**(1) Quality Control**

The Contractor shall provide and conduct a quality control program. A quality control program is defined as all activities, including mix design, process control inspection, sampling and testing, and necessary adjustments in the process that are related to production of a pavement which meets all requirements of the specifications.

**(2) Quality Assurance**

The Department will conduct a quality assurance program. 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.

**(C) Mix Design/Job Mix Formula Requirements**

All mix design and job mix formula requirements of Article 663-3 of the *2006 Standard Specifications* and the contract documents shall apply. In addition, submit Superpave gyratory compactor printouts for all specimens required to be compacted during the mix design process.

**(D) Field Verification of Mixture and Job Mix Formula Adjustments**

The Contractor shall conduct field verification of the hot in-place recycled mix at the beginning of production of each new mix design. Beginning production shall be limited to a maximum of 2500 linear feet of laydown width for the purpose of performing the field verification tests. In addition to the required sampling and testing, all preliminary checks and equipment calibrations shall be performed. Retain records of these calibrations and mix verification tests, including Superpave Gyratory Compactor (SGC) printouts at the QC laboratory. In addition, furnish copies of all calibrations and mix verification tests to the Engineer for review and approval before beginning normal production of the HIR mix.

Field verification testing shall consist of a minimum of 1 set of samples tested according to "Required Sampling and Testing" specified elsewhere in this provision. The field verification mix sample shall be obtained from the completed hot in-place recycled mix prior to laydown and compaction and split in accordance with current procedures in the *HMA/QMS Manual*. Normal production shall not begin until all field verification test results have been completed and approved by the Engineer. Verification is considered

satisfactory when all volumetric properties except  $\%G_{mm}@N_{ini}$  are within the applicable mix design criteria and the gradation, binder content, and  $\%G_{mm}@N_{ini}$  are within the individual limits for the mix type being produced, unless otherwise approved by the Engineer.

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. 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 shall result in immediate production stoppage by the Engineer. Normal production shall not resume until all mix verification sampling and testing, and calibrations have been performed and approved by the Engineer. 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.

## **(E) Contractor's Quality Control System**

### **(1) Personnel Requirements**

The Contractor shall provide a certified Hot-In-Place Recycling Asphalt Plant Technician Level I to perform quality control operations and activities at all times during production of hot in-place recycled mix on the project. The Contractor shall also have a certified Asphalt Plant Technician Level II readily available to supervise, coordinate, and make any necessary process adjustments in the HIR asphalt mixture.

In addition, a certified Plant Technician Level I shall be provided at the asphalt plant during production of the hot mix asphalt admixture, if required. A plant operator who is a certified Asphalt Plant Technician Level I may be used to meet this requirement when daily production for the admixture is less than 100 tons, provided the randomly scheduled increment sample as defined elsewhere in this provision, is not due. When performing in this capacity, the plant operator will be responsible for all quality control activities that are necessary and required. The Contractor producing the admixture shall also have a certified Asphalt Plant Technician Level II readily available to supervise, coordinate, and make any necessary process adjustments in the hot mix asphalt admixture.

Any absence of either 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. A plant technician may serve in more than one of the above capacities; however, all specification requirements shall still apply.

The Contractor shall provide a certified QMS Roadway Technician with each hot in-place recycling operation at all times during production and 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.

The Contractor shall provide a certified nuclear gauge operator when nuclear density control is being used.

All certifications shall be in accordance with the Department's current asphalt technician certification program.

**(2) Field Laboratory Requirements**

The Contractor shall furnish and maintain a Department certified laboratory for quality control testing of the hot in-place recycled mix. The laboratory shall be located either at or near the project site. In either case, all other requirements of these specifications shall apply. The laboratory may be either stationary or portable and shall include all necessary equipment and supplies for performing required Contractor quality control testing. The Contractor shall also furnish a certified laboratory for the quality control testing of the hot mix asphalt admixture, if required. This laboratory may be located at the plant site or may be the laboratory provided at the project site for testing of the hot in-place recycled mix. Convenient telephone and fax machine access for QMS personnel shall be provided by the Contractor at the plant laboratory site producing the admixture and the laboratory site testing the completed mix from the roadway.

**(3) Field Laboratory Equipment**

The laboratory testing equipment shall meet the requirements of the test methods identified as Required Sampling and Testing shown elsewhere in this provision.

Laboratory equipment furnished by the Contractor or his representative shall be properly calibrated and maintained. The Engineer shall be allowed to inspect measuring and testing devices 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. The Contractor shall maintain a record of calibration results at the laboratory.

**(4) Required Sampling and Testing (Mixtures)**

All mix sampling, testing, data analysis and data posting shall be performed or directly supervised by a certified HIR QMS Asphalt Plant Technician.

The Contractor's quality control process shall include, at a minimum but not limited to, the sampling and testing of all parameters outlined in these provisions using test methods and frequencies as specified herein. The Contractor shall obtain randomly selected samples of hot in-place recycled mix prior to the laydown and compaction processes. A minimum of one random mix sample of 200 pounds shall be taken from each 5000 linear foot section of roadway being remixed. The Contractor shall also obtain a minimum of one randomly selected 90 pound sample of the hot mix asphalt admixture, when required, from each 200

ton increment of admixture production. The admixture samples shall be taken from the truck at either the plant site or project site. The random samples shall be obtained in accordance with AASHTO T 168 Modified and at location(s) determined in accordance with procedures specified in ASTM D3665 Modified. All samples shall be split and retained in accordance with the procedures in the most current edition of the Department's "*HMA/QMS Manual*" and shall be logged on forms provided by the Engineer.

The untested split portions of the hot in-place recycled mix sample and hot mix asphalt admixture sample shall be retained for 5 calendar days at the appropriate laboratory site by the Contractor commencing the day the samples are tested. The QC Superpave Gyratory Compactor (SGC) specimens shall be retained for 5 calendar days commencing the day the specimens are prepared. Disposal permission may be given by Quality Assurance personnel prior to these maximum storage periods. The split portion of the Contractor's mix verification sample shall be retained until disposal permission is given by QA personnel. All retained samples shall be stored in a dry and protected location.

The Contractor shall maintain minimum test frequencies as established above. All tests shall be completed within 24 hours of the time the sample was taken, unless specified otherwise in these provisions. Should the specified tests not be completed within the required time frame, production will cease at that point until such time the tests are completed.

The Contractor may use innovative equipment or techniques not addressed by these specifications to produce and/or monitor the production of the mix, subject to approval by the Engineer.

Should the Contractor's testing frequency for hot in-place recycled mix fail to meet the minimum frequency requirement, all mix without the specified test representation shall 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 hot in-place recycling.

Should the Contractor's testing frequency for the hot mix asphalt admixture fail to meet the minimum requirements, all admixture without test representation shall be considered unsatisfactory and will be paid for at 50 percent of the contract unit bid price for the admixture.

**(5) Quality Control Sampling and Testing Schedule (Mixtures)**

Perform the following test series on all regularly scheduled random samples.

- (a) Hot In-Place Recycled Mix: Sampled from the paver at the roadway (AASHTO T 168 Modified) (split sample required)
  - (i) Blended aggregate recovered from hot in-place recycled mix sample (AASHTO T-30) shall be graded on all sieves specified on the job mix formula.)
  - (ii) Binder Content, % (Contractor may select any option below)
    - (a) Extraction (AASHTO T-164)

- (b) Ignition Furnace (AASHTO T 308 Modified)
- (c) OTHER: Contractor may request to use other means of checking Binder Content subject to approval by the Engineer.
- (iii) Maximum Specific Gravity (AASHTO T 209 or ASTM 2041), optional (ASTM 6857)
- (iv) Bulk Specific Gravity of Compacted Specimens (AASHTO T 312), (AASHTO T 166), (optional ASTM 6752)
- (v) Air Voids (VTM) (AASHTO T 269) Average of 3 specimens at  $N_{des}$  gyrations
- (vi) Voids in Mineral Aggregate (VMA) (calculation)
- (vii) Voids Filled with Asphalt (VFA) (calculation)
- (viii)  $P_{0.075}/P_{be}$  Ratio (calculation)
- (ix) % Maximum Specific Gravity at  $N_{ini}$  (calculation)

**(b) Hot Mix Asphalt Admixture (if required)**

1. Binder Content, % (Contractor may select any option below)
  - a. Extraction (AASHTO T-164)
  - b. Ignition Furnace (AASHTO T 308 Modified)
  - c. OTHER: Contractor may request to use other means of checking AC Content subject to approval by the Engineer
2. Blended aggregate recovered from admixture sample (AASHTO T-30) (Shall be graded on all sieves specified on the job mix formula.)

**(c) In addition to the above sampling and testing program, the following test shall be conducted as indicated:**

1. Penetration Test (AASHTO T 49) from Abson Recovery (AASHTO T 170).

Test performed on hot in-place mix sampled from roadway during field verification and at a minimum of weekly thereafter; however, penetration results are not required for approval of the field verification. Recovery and Penetration Test may be performed at an off-site laboratory. Results shall be furnished to the Engineer within 3 working days of obtaining the sample. Penetration test results should be within the range specified in Table 663-2.

2. Rut Test specimens in accordance with Article 610-3.

**(6) Documentation (Records)**

The Contractor shall document all activities, records of inspection, samples taken, adjustments to the mix, and test results on a daily basis. The results of observations and records of inspection shall be noted as they occur in a permanent field record. Adjustments to mix production and test results shall be recorded on forms provided.

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. Process control sample test results are for the Contractor's 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 mix processing, admixture, asphalt binder, rejuvenating agent and/or other mix components. If the mix and/or pavement represented by the falsified results are determined not to be acceptable, reprocess or remove and replace with mix that complies with the Specifications as approved by the Engineer. Payment will be made for the actual quantities of materials required to reprocess or replace the falsified quantities, not to exceed the original amounts.

**(7) Documentation (Control Charts)**

Standardized control charts furnished by the Department shall be maintained by the Contractor at the appropriate 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 are obtained. Process Control (PC) test results should not be plotted on control charts nor reported to Quality Assurance Laboratory.

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

The following data shall be recorded on standardized control charts:

**(8) Hot In-Place Recycled Mix**

(a) Aggregate Gradation Test Results:

1. For each mix type: one sieve size smaller than the mix nominal maximum size.

2. For all mix types: 2.36 mm and 0.075 mm sieves
- (b) Binder Content, %,  $P_b$
- (c) Bulk Specific Gravity of Compacted Specimens at  $N_{des}$  (measured)
- (d) Maximum Specific Gravity Determined by AASHTO T 209
- (e) Percent Voids in Total Mix at  $N_{des}$  Gyration
- (f) Percent Voids in Mineral Aggregate at  $N_{des}$  Gyration

**(9) Hot Mix Asphalt Admixture, if required**

- (a) Binder Content, %,  $P_b$
- (b) 0.075 mm sieve
- (c) 2.36 mm sieve

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

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

- (a) A change in the binder percentage or aggregate blend is made in the JMF, or,
- (b) When the Contractor elects to stop or is required to stop production after one or two moving average values, respectively, fall outside the warning limits as shown elsewhere in this provision, or
- (c) If failure to stop production after two consecutive moving averages exceed the warning limits occurs, but production does stop at a subsequent time, re-establish a new moving average beginning at the actual production stop point.

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

All individual test results for regularly scheduled random samples or directed samples 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 Article 105-3. In this case, replace the data in question and any related data proven incorrect.

**(10) Control Limits**

The following shall be considered control limits for mix production. For each criterion, the warning limits are based on a moving average of the last 4 data points. All control limits will be applied to target data as specified on the below tables.

### HIR Asphalt Mixture Control Limits

<u>Control Criteria</u>	<u>Target Source</u>	<u>Warning Limits</u>	<u>Individual Test Limits</u>
2.36 mm Sieve	JMF	± 4.0	± 8.0
0.075 mm Sieve	JMF	± 1.5	± 2.5
Binder Content, %	JMF	± 0.3	± 0.7
VTM, % @ N <sub>des</sub>	JMF	± 1.0	± 2.0
VMA, % @ N <sub>des</sub>	Min. Spec. Limit	- 0.5	- 1.0
%Gmm @ N <sub>ini</sub>	Max Spec. Limit	N/A	+2.0%

### HMA Admixture Control Limits (If Required)

<u>Control Criteria</u>	<u>Target Source</u>	<u>Warning Limits</u>	<u>Individual Test Limits</u>
Binder Content, %	JMF	± 0.3	± 0.7
0.075 mm Sieve	JMF	± 1.5	± 2.5
2.36 mm Sieve (If Applicable)	JMF	± 4.0	± 8.0

(g) Corrective Action

Immediately notify the Engineer when moving averages exceed the warning limits. All required corrective actions are based upon initial test results and shall be taken immediately upon obtaining those results. In the event situations occur 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 either of the following occurs:

1. When an individual test result for a mix control criteria exceeds both the individual test control limits and the applicable specification design criteria, or
2. When two consecutive binder content test results exceed the individual limits.
3. When two consecutive penetration test results exceed the range specified in Table 663-2.

Do not resume normal HIR asphalt production and/or HMA Admixture production until approval has been granted by the appropriate QA Supervisor.

Acceptance of all mix failing to meet the individual test control limits as described above will be determined in accordance with Article 105-3. In addition, any mix that is deemed unacceptable will be rejected for use in the work. All unacceptable HIR asphalt mixture shall be remilled and



reprocessed to comply with the Specifications, provided the quality of the HIR mixture is such that it can be reprocessed to meet specification requirements. Should the applicable HIR mixture not be of adequate quality such that it can be reprocessed to meet the specification requirements, remove and replace the unacceptable material with the appropriate thickness and type of HMA in accordance with Section 610 of the *2006 Standard Specifications*. In either case payment will be made only for the applicable original HIR quantities. There shall be no direct pay for any required corrective action(s) performed by the Contractor.

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

If two consecutive moving average values for any one of the mix control criteria fall outside the warning limits, the Contractor shall cease production of that mix and make adjustments. The Contractor may elect to stop production after only one moving average value falls outside the warning limits. In either case, a new moving average shall not be determined until the fourth test after the elective or mandatory stop in production.

Do not resume normal HIR asphalt production and/or HMA Admixture production until approval has been granted by the appropriate QA Supervisor.

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

If the adjustment does not improve the property in question such that the moving average after four additional tests is not on or within the warning limits, the applicable mix shall be accepted in accordance with Article 105-3. The quantity of mix in question will be determined by the Engineer. Any mix that is deemed unacceptable will be rejected for use in the work.

Failure to stop production and make adjustments as described above due to two consecutive moving average values falling outside the warning limits shall subject all mix produced from the stop point tonnage to the tonnage point when the moving average is back on or within the warning limits, or to the tonnage point when production is actually stopped, whichever occurs first, to be considered unacceptable.

**(11) Allowable Retesting for Mix Deficiencies**

The Contractor may elect to resample and retest for hot in-place recycled mix deficiencies when individual QC test(s) exceed one or more of the mix property target(s) by more than the tolerances indicated below. Perform retesting within 10 days after the initial test results are determined. Retesting shall be approved by the Engineer prior to being performed and in accordance with the Department's "Guidelines For Retests Of Plant Mix Deficiencies" as outlined in the HMA/QMS Manual, except sub-lots will be based on equivalent linear feet in lieu of tonnage. The Contractor will perform these tests under the supervision of the Department's QA personnel. Retests for any mix deficiency other than as listed below will not be allowed unless otherwise permitted by the Engineer. 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 direct the Contractor to resample and retest at any time or location as directed by the Engineer.

Air Voids (VTM)	by more than +/- 2.5%
Binder Content	by more than +/- 1.0%
VMA	by more than - 2.0%
0.075 mm sieve	by more than +/- 3.0%
2.36 mm sieve	exceeds Specification Mix Design Limits and one or more of the above tolerances are also exceeded

**(E) Quality Assurance of Mix**

The Department shall furnish certified plant technicians responsible for its' quality assurance of the HIR mix. Quality assurance will be accomplished in the following ways:

- (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) and;
- (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 required QC sample frequency; and
- (6) By any combination of the above

In all cases, the Engineer's quality assurance and verification testing will be independent of the Contractor's tests. The Department's quality assurance program will be conducted by a certified QMS technician(s).

The Engineer will conduct assurance tests on split samples taken by the Contractor for quality control testing. These samples may be the regular quality control samples or a sample selected by the Engineer from any location in the process. The frequency will be

equal to or greater than 10% of that required of the Contractor as stated in "Required Sampling and Testing". The Engineer may select any or all split samples for assurance testing. Results of quality assurance tests will be provided to the Contractor within 3 working days after the sample has been obtained. Differences between the Contractor's and the Department's split sample test results will be considered acceptable if within the following limits:

<u>Test Parameter</u>	<u>Acceptable Limits of Precision</u>
12.5 mm Sieve	±6.0
9.5 mm Sieve	±5.0
4.75 mm Sieve	±5.0
2.36 mm Sieve	±5.0
0.075 mm Sieve	±2.0
Binder Content, %	±0.5
Maximum Specific Gravity Mix, $G_{mm}$	±0.020
SGC Bulk Specific Gravity, $G_{mb}$	±0.030
QA Retest of QC Gyrotory Compacted Volumetric Specimens	±0.015

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,

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.

**(F) Acceptance of Mix**

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 shown elsewhere in this provision.

**(G) Thickness Quality Management**

**(1) Quality Control of Compacted HIR Mix Thickness**

The Contractor shall perform quality control of the compacted HIR mix thickness in accordance with these provisions.

The minimum frequency of checking the thickness shall be one randomly located 6 inch core for each 2000 linear feet or fraction thereof per day of completed HIR lane width pavement with a minimum of three cores per day. If core sample control is used for density control, the required density core samples shall also be used to determine thickness compliance. If the Contractor elects to use nuclear density control, the core samples for thickness shall be located and taken in accordance with the random sampling procedures for density core samples in the current HMA/QMS Manual and shall be logged on the QC-5 Form.

The thickness shall be determined by the average measurement of cores taken from the compacted HIR mix. Individual cores shall be measured at the approximate quarter points of the core and these four measurements averaged for the individual core thickness. Each average core thickness measurement shall be to the nearest 1/8 inch and reported on the QC-5 Form. The thickness of all cores for each day's placement shall be averaged to determine compliance with these specifications.

When the day's average thickness is less than the depth specified on the plans by more than 1/4 inch, corrective action shall be initiated. When two consecutive days' averages from the above sets of measurements exceed the tolerance specified, work shall be stopped until the process is corrected.

**(2) Quality Assurance of Compacted HIR Mix Thickness:**

**(a) Thickness Quality Assurance**

The Departments quality assurance program for compacted mix thickness will consist of the following:

1. By re-measuring randomly selected quality control core measurements at a frequency equal to or greater than 5% of the frequency required of the Contractor;
2. By measuring randomly selected comparison core samples taken adjacent to the Contractor's QC core samples (8 inches center-to-center) at a frequency equal to or greater than 5% of the frequency required of the Contractor,

3. By conducting verification core measurements independently of the Contractor's quality control measurements at a frequency equal to or greater than 10% of the required QC sample frequency; and
4. By periodically observing measurements performed by the Contractor.
5. Comparison and verification core samples will be taken in the presence of a DOT technician and immediately turned over to that technician for measurement.

(b) Limits of Precision

Differences between the Contractor's and the Department's thickness measurements will be considered acceptable if within the following limits of precision:

Remeasurement of QC Measurement	+/- 1/8 inch
Comparison QA Core Measurement	+/- 1/8 inch
QA Verification Core Measurement	+/- 1/4 inch

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

1. QA core sample measurement(s) does not meet the above limits of precision, or
2. QA comparison or verification core sample measurement(s) is less than the depth specified on the plans by more than 1/4 inch.

(3) Acceptance of Compacted HIR Mix Thickness

The Department will evaluate the finished asphalt pavement for thickness compliance using the Contractor's thickness quality control test results, the Department's quality assurance test results, and by observation of the Contractor's thickness quality control process as outlined in Subarticle 8.1. Any pavement found to be deficient in thickness by more than 1/4 inch shall be evaluated for acceptance in accordance with Article 105-3 of the *2006 Standard Specifications*.

**(H) Field Compaction Quality Management**

(1) Contractor Quality Control of Density

(a) General

Perform quality control of the compaction process in accordance with these provisions and applicable requirements of Article 610-9 and 610-10 of the *2006 Standard Specifications*. The Contractor may elect to use either cored sample density procedures or nuclear gauge density procedures. Provide to the Department at the pre-construction conference the method of density quality control that will be used on the project.

Establish acceptable control strips when required at locations approved by the Engineer. Construct control strips that are 300 feet in length at the paver laydown width being recycled and 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 recycled and placed at the paver laydown width.

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

Conduct all QC nuclear density testing the same day that the mix being tested is placed and compacted. Obtain all core samples no later than the beginning of the next production day, not to exceed 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 Contractor's QC laboratory located on or near the project 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 above laboratory 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.

(b) 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, use 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.

(c) 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 used, 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.

(d) Nuclear Gauge Density Procedures

Perform nuclear density control procedures in accordance with the Department's most current *Nuclear Gauge Operator's Manual*. This *Manual* may be obtained through the Department's M & T Soils Laboratory. Determine density by the backscatter method of testing using a thin-lift nuclear gauge, with printer, which has been approved by the Department. Furnish, maintain, and operate the nuclear gauge. Furnish an operator that has been certified by the Department.

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

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

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

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 recycled and 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 used in the applicable control strip.

(e) Limited Production Procedure

Proceed on limited production when three consecutive failing density lots occur, not to exceed two production days, or two consecutive failing nuclear control strips occur for the same mix type. A failing density lot is defined as one in which the average results of all density test sections fail to meet the minimum specification requirement for that applicable mix type. A failing nuclear control strip is defined as one in which the average of the 5 core samples results fail to meet the minimum specification requirement for that applicable mix type.



Limited production is defined as being restricted to the remixing, placement, and compaction of the quantity of HIR mix generated from the incorporation of one load of admixture or 1000 linear feet of remixed pavement at the laydown width, whichever is greater. A 300 foot density control strip shall be located at the approximate midpoint of this pavement.

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.

Should the Contractor not operate by the limited production procedures as specified above, the two consecutive failing production days and all mix produced thereafter will be considered unacceptable. This material shall either be reprocessed, or removed and replaced with material that complies with the Specifications, unless otherwise approved by the Engineer.

**(I) Quality Assurance of Density**

The Department shall furnish certified plant and roadway technicians responsible for its' quality assurance of density. The Departments quality assurance program for density will consist of the following:

- (1) By retesting randomly selected quality control test sections (either cores or nuclear);
- (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" center-to-center) at a frequency equal to or greater than 5% of the frequency required of the Contractor;
- (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 required QC sample frequency;
- (5) By periodically directing the recalculation of random locations for the Quality Control core or nuclear density test sites.

Comparison and verification core samples will be taken in the presence of a Department QA technician and either delivered directly to the appropriate QA Lab by a DOT technician or placed in a sealed container and delivered to the Contractor's QC Lab for QA testing.

Results of all density quality assurance tests will be provided to the Contractor within 3 working days after the samples have been obtained by the QA personnel.

Differences between the Contractor's quality control and the Department's quality assurance test results will be considered acceptable if within the following limits.

Test	Acceptable Limits of Precision
------	--------------------------------

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 Section (Average of 5 Tests in Test Section)	±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 does not meet above limits of precision, or
- (2) QA comparison test results does not meet the minimum specification requirements,
- (3) QA verification test results does not meet the minimum specification requirements

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) Review and observation of the QC technician's sampling and testing procedures,
- (2) Evaluation and calibration of QC testing equipment,
- (3) Joint comparison testing of other retained quality control core samples, and/or additional density core samples.
- (4) Joint comparison testing of random nuclear density test sections, if applicable

If additional 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.

**(J) Acceptance of Density**

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.

Minimum density requirements will be as specified for each mix type in Article 663-5 of the *2006 Standard Specifications*. Density compliance for nuclear gauge control will be as provided in the Department's Nuclear Gauge Operator's Manual. Density compliance for core samples will be determined by use of the average maximum specific gravity ( $G_{mm}$ ) until a moving average of four maximum specific gravities is attained. Once a moving average is established for the maximum specific gravity, the last moving average in effect at the end of the same day's production will then be used to determine density compliance.

The pavement will be accepted for density on a lot by lot basis. A lot will consist of 1 day's production of a given mix type on the project except that individual map sections will be evaluated as separate lots, unless otherwise approved by the Engineer. The Engineer will determine the final quantity of each lot.

A failing lot for density purposes is defined as a lot, for which the average of all test sections fails to meet the minimum specification requirement. In addition, any lot or portion of a lot that is obviously unacceptable will be rejected for use in the work.

Acceptance of all failing lots will be made under the provisions of Article 105-3 of the *2006 Standard Specifications*.

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

**(K) Measurement and Payment**

Produce and construct all hot in-place recycled (HIR) 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 related items will be full compensation for all work covered by these specifications.