Special Specification 3087
High Performance Permeable Friction Course

1. DESCRIPTION

Construct a high performance hot-mix asphalt (HMA) surface course composed of a compacted permeable mixture of aggregate, high performance-graded asphalt binder, and additives mixed hot in a mixing plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. Aggregate. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse aggregate. Do not use intermediate or fine aggregate in permeable friction course (PFC) mixtures. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. Coarse Aggregate. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials; however, Class B virgin (non-recycled) aggregate may be disallowed when shown on the plans. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion**. The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Geotechnical, Soils, and Aggregates Branch of the Construction Division, and additional testing may be required before granting approval.

Table 1
Coarse Aggregate Quality Requirements

Property	Test Method	Requirement
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.0
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note 1
Los Angeles abrasion, %, Max	Tex-410-A	30
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	20
Crushed face count,[2] %, Min	Tex-460-A, Part I	95
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 342.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

2.2. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.3. **Asphalt Binder**. Furnish the type and grade of binder specified on the plans that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.3.1. **High Performance-Graded (PG) Binder**. Provide a high performance-graded asphalt binder with a high-temperature grade of PG 76 and low-temperature grade as shown on the plans in accordance with Section 300.2.10., "Performance-Graded Binders," and Table 2.

Table 2
High Performance-Graded (HPG) Binder

Property and Test Method	HPG
Original Binder	
Flash Point, T 48, Min. °C	230
Viscosity, T316, Max. 5.0 Pa-s, test temperature, °C[1]	135
Separation, ASTM D7173, Dynamic Shear, T315, % G*/sinδ Difference[2], Max. 10%, temperature, °C	76
Polymer Content, Tex-533-C[2], Min. %	7.5
Rolling Thin-Film Oven (Tex-541-C)	
Mass change, Tex-541-C, Max. %	1.0
Multiple Stress Creep Recovery, T350, Jnr, 3.2, Max. 0.10 kPa-1, test temperature, °C	76
Multiple Stress Creep Recovery, T350, % recovery, Min. 90.0%, test temperature, °C	76
Pressure Aging Vessel (PAV) Residue (R 28)	
PAV aging temperature, °C	100
Dynamic shear, T315 G*sin(δ), Max, 4,000 kPa Test temperature @ 10 rad/sec., °C	25
Creep Stiffness, T313 @ 60 sec[3] S, Max. 300mPa, m-value, Min. 0.30, Test temperature, °C	-18

1. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. Use Spindle 21 when testing for rotational viscosity.
2. Determined as the absolute value of the percent difference in G*/sinδ measured on samples taken from the top and bottom:
   100*(G*/sinδ (top) - G*/sinδ (bottom))/ G*/sinδ (top)
3. In Tex-533-C, the SBS peak is changed to 699cm^{-1}, representing the polystyrene band.

2.4. **Tack Coat**. Furnish PG76-22 or CRS-2P tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized tack coat materials listed on the Department's MPL are allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will obtain the sample from the asphalt distributor immediately before use.

2.5. **Additives**. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.5.1. **Fibers**. Provide cellulose or mineral fibers when PG binder is specified. Submit written certification to the Engineer that the fibers proposed for use meet the requirements of DMS-9204, "Fiber Additives for Bituminous Mixtures." Fibers may be pre-blended into the binder at the asphalt supply terminal unless otherwise shown on the plans.

When at least 3% RAS is used in the mixture, the Contractor may reduce the amount of fibers as specified in Table 4, Note 3.

2.5.2. **Lime Mineral Filler**. Add lime as mineral filler at a rate of 1.0% by weight of the total dry aggregate in accordance with Item 301, "Asphalt Antistripping Agents," unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel test results. Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.5.3. **Lime and Liquid Antistripping Agent**. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum. When the plans require lime to be added as an antistripping agent, lime added as mineral filler will count towards the total quantity of lime specified.

2.5.4. **Warm Mix Asphalt (WMA)**. Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.6. **Recycled Materials**. Do not use RAP or RAS.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification**. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 3. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests. Provide Level AGG101 certified specialists for aggregate testing.

Table 3
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Parts I & III	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
Rice gravity	Tex-227-F	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F	✓	✓	2
Drain-down	Tex-235-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Overlay test	Tex-248-F		✓	TxDOT
Boil test	Tex-530-C	✓	✓	1A
Cantabro loss	Tex-245-F	✓	✓	1A
4. Production Testing				
Control charts	Tex-233-F	✓	✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Gradation & asphalt binder content[2]	Tex-236-F	✓	✓	1A
Moisture content	Tex-212-F	✓	✓	1A/AGG101
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Drain-down	Tex-235-F	✓	✓	1A
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Thermal profile	Tex-244-F	✓	✓	1B
Permeability	Tex-246-F	✓	✓	1B

1. Level 1A, 1B, AGG101 and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 342.4.5., "Production Operations," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. Reporting and Responsibilities. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement tests, control charts, and thermal profiles. Obtain the current version of the templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Use the procedures described in Tex-233-F to plot the results of all production and placement testing, when directed. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. Quality Control Plan (QCP). Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting when directed. Receive approval of the QCP before beginning production. Include the following items in the QCP:

4.3.1. Project Personnel. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. Material Delivery and Storage. For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. Production. For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, RAS, lime, liquid antistrip, WMA, fibers);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. Loading and Transporting. For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. Placement and Compaction. For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. Mixture Design.

4.4.1. Design Requirements. Use the PFC design procedure provided in Tex-204-F, unless otherwise shown on the plans. Design the mixture to meet the requirements listed in Tables 1, 2, and 4. Use a Superpave Gyratory Compactor (SGC) at 50 gyrations as the design number of gyrations (Ndesign).

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 4
Master Gradation Limits (% Passing by Weight or Volume) and Laboratory Mixture Design Properties

Sieve Size	PG 76 Mixtures				Test Procedure
	Fine (PFC-F)	Coarse (PFC-C)			
3/4"	–	100.0[1]			Tex-200-F
1/2"	100.0[1]	80.0-100.0			
3/8"	95.0-100.0	35.0-60.0			
#4	20.0-55.0	1.0-20.0			
#8	1.0-10.0	1.0-10.0			
#200	1.0-4.0	1.0-4.0			
Mixture Properties					
Asphalt binder content, %	6.0-7.0	6.0-7.0			–
Design gyrations (Ndesign)	50	50			Tex-241-F
Lab-molded density, %	78.0 Max	82.0 Max			Tex-207-F
Hamburg Wheel test,[2] passes at 12.5 mm rut depth	10,000 Min[3]	Note 2			Tex-242-F
Overlay tester,[2] number of cycles	200 Min	Note 2			Tex-248-F
Drain-down, %	0.10 Max	0.10 Max			Tex-235-F
Fiber content, % by wt. of total PG 76 mixture	0.20[4]-0.50	0.20[4]-0.50			Calculated
Lime content, % by wt. of total aggregate	1.0[5]	1.0[5]			Calculated
Boil test[6]	–	–			Tex-530-C
Cantabro loss, %	10.0 Max	10.0 Max			Tex-245-F

1. Defined as maximum sieve size. No tolerance allowed.
2. Mold test specimens to Ndesign at the optimum asphalt binder content (JMF1). Perform the test for informational purposes only when no minimum number is specified.
3. May be decreased when approved.
4. The Contractor may reduce the amount of fibers to no less than 0.10%, provided the mixture meets the drain-down requirement, when at least 3% RAS is used in the mixture.
5. Unless otherwise shown on the plans or waived by the Engineer based on Hamburg Wheel results.
6. Used to establish baseline for comparison to production results. May be waived when approved.

4.4.2. Job-Mix Formula Approval. The job-mix formula (JMF) is the combined aggregate gradation, Ndesign level, and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify

JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than 2 trial batches per design are required.

4.4.2.1. Contractor's Responsibilities.

4.4.2.1.1. Gyratory Compactor. Furnish an SGC calibrated in accordance with Tex-241-F for molding production samples. Locate the SGC at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. Gyratory Compactor Correlation Factors. Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different SGC. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. Hamburg and Overlay Testing. Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test and provide results with the mixture design, or provide 10,000 g of the laboratory mixture and request that the Department perform the Hamburg Wheel test.

Provide 25,000 g of the laboratory mixture and request that the Department perform the Overlay test.

The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel and Overlay test results on the laboratory mixture design.

4.4.2.1.4. Submitting JMF1. Furnish a mix design report (JMF1) including Hamburg and Overlay results. Provide representative samples of all component materials and request approval to produce the trial batch.

4.4.2.1.5. Supplying Aggregates. Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.6. Supplying Asphalt. Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.7. Ignition Oven Correction Factors. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F. Note that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for quality assurance (QA) testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used unless otherwise directed.

4.4.2.1.8. Boil Test. Perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test. Add lime or liquid antistripping agent, as directed, if signs of stripping exist.

4.4.2.1.9. Trial Batch Production. Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch including the WMA additive or process, if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in Table 5. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.10. Trial Batch Production Equipment. Use only equipment and materials proposed for use on the project to produce the trial batch. Provide documentation to verify the calibration or accuracy of the asphalt mass flow meter to measure the binder content. Verify that asphalt mass flow meter meets the requirements of 0.4% accuracy, when required, in accordance with Item 520, "Weighing and Measuring Equipment." The Engineer may require that the accuracy of the mass flow meter be verified based on quantities used.

4.4.2.1.11. **Trial Batch Quantity**. Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.12. **Number of Trial Batches**. Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.13. **Trial Batch Sampling**. Obtain a representative sample of the trial batch and split it into 3 equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.14. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 5. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.15. **Development of JMF2**. Evaluate the trial batch test results, determine the target mixture proportions, and submit as JMF2 after the Engineer grants full approval of JMF1 based on results from the trial batch.

4.4.2.1.16. **Mixture Production**. Use JMF2 to produce Lot 1 after receiving approval for JMF2.

4.4.2.1.17. **Development of JMF3**. Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.18. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the master gradation and binder content limits shown in Table 4; and
- be within the operational tolerances of JMF2 listed in Table 5.

4.4.2.1.19. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 342.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 5
Testing Frequency and Mixture Production Tolerances

Test Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency	Operational Tolerance from Current JMF
Individual % retained for sieve sized larger than #200	Tex-200-F	1 per sublot	1 per 12 sublots	±5.0[1]
% passing the #200 sieve				±2.0[1]
Laboratory-molded density, %	Tex-207-F, Part VIII	1 per sublot	1 per lot	Table 4
Asphalt binder content, %	Tex-236-F[2]	1 per sublot	1 per lot[3]	±0.3[4]
Drain-down, %	Tex-235-F	1 per sublot	1 per 12 sublots	Table 4
Boil test[5]	Tex-530-C	1 per project	1 per project	N/A
Cantabro loss, %	Tex-245-F	1 per project (sample only)	1 per project	Table 4
Asphalt binder sampling	Tex-500-C	1 per lot (sample only)	1 per project	N/A
Tack coat sampling and testing	Tex-500-C, Part III	N/A	1 per project	N/A
Thermal profile	Tex-244-F	1 per sublot	Optional	N/A

1. Only applies to mixture produced for Lot 1 and higher. Aggregate gradation is not allowed to be outside the limits shown in Table 4.
2. Ensure the binder content determination excludes fibers. Add the recycled binder content to the flow meter readout when the asphalt mass flow meter is used to determine binder content.
3. May be obtained from asphalt mass flow meter readouts.
4. Binder content is not allowed to be outside the limits shown in Table 4.
5. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. Gyratory Compactor. The Engineer will use a Department SGC calibrated in accordance with Tex-241-F to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location. The Engineer will make the Contractor-provided SGC in the Department field laboratory available to the Contractor for molding verification samples.

4.4.2.2.2. Hamburg Wheel and Overlay Testing. At the Contractor's request, the Department will perform the Hamburg Wheel test on the laboratory mixture in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 4. The Department will perform the Overlay test in accordance with Tex-248-F to verify compliance with the Overlay test requirements in Table 4. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel and Overlay test results on the laboratory mixture design.

4.4.2.2.3. Conditional Approval of JMF1 and Authorizing Trial Batch. The Engineer will review the Contractor's mix design report and verify specification conformance of the mixture and component materials. The Engineer will grant conditional approval of JMF1 within 2 working days of receiving the complete mixture design report (JMF1) and all required materials.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 342.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after 2 working days, conditional approval of JMF1 will still be granted within 2 working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

The Contractor is authorized to produce a trial batch after the Engineer grants conditional approval of JMF1.

4.4.2.2.4. Ignition Oven Correction Factors. The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F. The Engineer will verify that the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination.

4.4.2.2.5. Testing the Trial Batch. Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in Table 5.

The Engineer will have the option to perform the following tests on the trial batch:

- Tex-235-F, to verify that drain-down meets the requirements shown in Table 4;
- Tex-530-C, to retain and use for comparison purposes during production; and
- Tex-245-F, to verify the Cantabro loss meets the requirement shown in Table 4.

4.4.2.2.6. Full Approval of JMF1. The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in Table 5.

The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. Approval of JMF2. The Engineer will approve JMF2 within one working day if the mixture meets the master grading limits and binder content shown in Table 4.

4.4.2.2.8. Approval of Lot 1 Production. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2).

4.4.2.2.9. Approval of JMF3 and Subsequent JMF Changes. JMF3 and subsequent JMF changes are approved if they meet the master grading and binder content limits shown in Table 4, and are within the operational tolerances of JMF2 shown in Table 5.

4.4.2.2.10. Binder Content Adjustments. For JMF2 and above, the Engineer may require the Contractor to adjust the target binder content by no more than 0.3% from the current JMF.

4.5. Production Operations. Perform a new trial batch when the plant or plant location is changed. Perform QC at the frequency and within the tolerances listed in Table 5. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification.

At any time during production, the Engineer may require the Contractor to verify the following based on quantities used:

- lime content (within ±0.1% of JMF), when PG binder is specified;
- fiber content (within ±0.03% of JMF), when PG binder is specified; and

If the aggregate mineralogy is such that Tex-236-F does not yield reliable results, the Engineer may allow alternate methods for determining the asphalt content and aggregate gradation. The Engineer will require the Contractor to provide evidence that results from Tex-236-F are not reliable before permitting an alternate method unless otherwise allowed. Use the applicable test procedure as directed if an alternate test method is allowed.

4.5.1. Storage and Heating of Materials. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. Mixing and Discharge of Materials. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F (or 275°F for WMA). The Department will not pay for or allow placement of any mixture produced above 350°F.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

4.6. Hauling Operations. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent, when necessary, shown on the Department's MPL to coat the inside bed of the truck.

Use equipment for hauling as defined in Section 342.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. Placement Operations. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

4.7.1. Weather Conditions.

4.7.1.1. When Using a Thermal Imaging System. The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 60°F; however, the Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 342.4.7.3.1.2., "Thermal Imaging System."

4.7.1.2. When Not Using a Thermal Imaging System. Place mixture when the roadway surface temperature is at or above 70°F unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

4.7.2. Tack Coat.

4.7.2.1. Application. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.06 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply the tack coat to all surfaces the will come in contact with the subsequent HMA placement, unless otherwise directed. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

4.7.3. Lay-Down Operations.

4.7.3.1. Thermal Profile. Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 342.4.9.4., "Miscellaneous Areas."

4.7.3.1.1. Thermal Segregation.

4.7.3.1.1.1. Moderate. Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F, are deemed as having moderate thermal segregation.

4.7.3.1.1.2. Severe. Any areas that have a temperature differential greater than 50°F are deemed as having severe thermal segregation.

4.7.3.1.2. Thermal Imaging System. Review the output results when a thermal imaging system is used, and provide the automated report described in Tex-244-F to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system. The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots upon completion of the project or as requested by the Engineer.

4.7.3.1.3. Thermal Camera. Take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. When requested by the Engineer, provide the electronic files generated using the thermal camera. Report the results of each thermal profile in accordance with Section 342.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section.

4.7.3.2. Windrow Operations. Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. Hauling Equipment. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.4. Screed Heaters. Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 342.4.9.5., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. Compaction. Roll the freshly placed PFC with a steel-wheeled roller, operated in static mode, to seat the mixture without excessive breakage of the aggregate and to provide a smooth surface and uniform texture. Do not use pneumatic rollers. Moisten the roller drums thoroughly with a soap and water solution to prevent adhesion. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

The Engineer may use or require the Contractor to use Tex-246-F to test and verify that the compacted mixture has adequate permeability. Adjust the mixture design or construction methods if the compacted mixture does not exhibit adequate permeability.

Complete all compaction operations before the pavement temperature drops below 180°F unless otherwise allowed.

Allow the compacted pavement to cool to 180°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. Acceptance Plan. Sample and test the hot-mix on a lot and sublot basis. A production lot consists of 4 equal sublots. Lot 1 will be 2,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production. The lot size will be between 2,000 and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

4.9.1. Referee Testing. The Construction Division is the referee laboratory. The Contractor may request referee testing if the differences between Contractor and Engineer test results exceed the operational tolerances shown in Table 5 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within 5 working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than 3 referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

4.9.2. Asphalt Binder Sampling. Obtain a 1 qt. sample of the asphalt binder for each lot of mixture produced. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill in accordance with Tex-500-C, Part II.

Label the can with the corresponding lot and sublot numbers and deliver the sample to the Engineer. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample, the Engineer will split a sample of the asphalt binder with the Contractor. The Engineer will test at least one asphalt binder sample per project to verify compliance with Item 300, "Asphalts, Oils, and Emulsions."

4.9.3. Operational Tolerances. Control the production process within the operational tolerances listed in Table 5. Suspend production and placement operations when production or placement test results exceed the tolerances listed in Table 5 unless otherwise allowed. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.4. Miscellaneous Areas. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations such as driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. The specified layer thickness is based on the rate of 90 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. Miscellaneous areas are not subject to thermal profiles testing.

4.9.5. Recovered Asphalt Dynamic Shear Rheometer (DSR). The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Construction Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.6. Irregularities. Identify and correct irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities and areas where the mixture does not bond to the existing pavement. If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.7. Ride Quality. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

PFC will be measured by the ton of composite PFC. The composite PFC is defined as the asphalt, aggregate, and additives. The weights of asphalt and aggregate will be calculated based on the measured weight of PFC and the target percentage of asphalt and aggregate. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.1. Asphalt. The asphalt weight in tons will be determined from the total weight of PFC. Measured asphalt percentage will be obtained using Tex-236-F or asphalt mass flow meter readings for PG 76 mixtures, as determined by the Engineer.

5.1.1. Target Percentage. The JMF target asphalt percentage will be used to calculate the weight of asphalt binder unless the measured asphalt binder percentage is more than 0.3 percentage points below the JMF target asphalt percentage or less than the minimum percentage specified in Table 4. Volumetric meter readings will be adjusted to 140°F and converted to weight.

5.1.2. Measured Percentage. The averaged measured asphalt percentage from each sublot will be used for payment for that lot's production when the measured percentage for any sublot is more than 0.3 percentage points below the JMF target asphalt percentage or less than the minimum percentage specified in Table 4.

5.2. Aggregate. The aggregate weight in tons will be determined from the total weight of PFC less the weight of the asphalt.

5.3. Tack Coat. Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Article 342.5.1 and Article 342.5.2, "Measurement," will be paid for at the unit bid price for "PFC (Asphalt)" of the binder specified and for "PFC (Aggregate)" of the grade and SAC specified. These prices are full compensation for surface preparation, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Article 342.5.3, "Measurement," will be paid for at the unit bid price for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."