Level 2 Mix Design Specialist

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HMAC CERTIFIED SPECIALIST & APPLICANTS FOR CERTIFICATION: RIGHTS AND RESPONSIBILITIES

This agreement (the "Agreement") affirms that, _____, the below Applicant for Certification or the current Certified Specialist (collectively, the "Specialist") seeks to meet or has successfully met the requirements for certification by the Texas Asphalt Pavement Association ("TXAPA"), a/k/a the Hot Mix Asphalt Center (HMAC) as a certified technician. In that connection, the Specialist agrees as follows:

RIGHTS AND RESPONSIBILITIES - HMAC certification includes the exclusive right to perform certified sampling, testing and reporting on Texas Department of Transportation (TxDOT) projects involving Hot Mix Asphalt (HMA) and Soils & Base (SB) in accordance with TxDOT specifications and test procedures (as may be amended by TxDOT from time to time) for the level of certification issued. Specialists are required to perform and report test results with the accuracy and precision required of a certificated HMA or SB Specialist. It is important that the Specialist fully understands the significance of performing these duties in accordance with the certification level received by the Specialist.

Each Specialist is responsible for performing their own independent sampling, testing and reporting in accordance with TxDOT specifications, test procedures and standard operating procedures. These duties must be performed in a diligent and professional manner to produce TxDOT projects of the highest possible quality.

CONTACT INFORMATION - It is the Specialist's responsibility to provide the HMAC with current contact information by logging into www.txhmac.org, Communications from the HMAC will primarily be sent electronically to the most recent contact information provided by the Specialist.

ANNUAL PROFICIENCY - Once certified, Specialists are required to complete annual proficiency testing and the reporting of results to the HMAC. The testing and reporting must be timely and independently performed by the Specialist and, where applicable, in conformance with the requirements of the Specialist's certifications. TxDOT will ship the annual proficiency samples to the Specialist's address of record. (If this address is not current, the Specialist may not timely receive a proficiency sample and his/her certification may be danger of lapsing.)

Failure to submit proficiency test results or to respond to low rating(s) by the appointed deadlines may result in a change of certification status from active to inactive. Specialists whose certifications are inactivated because their annual proficiency testing/reporting is not current or whose certifications have been revoked or inactivated are prohibited from performing the duties associated with all certifications held by that Specialist.

RECERTIFICATION - Certification(s) are valid for three (3) years from the date originally issued, after which the Specialist must be recertified by again passing the requirements for certification. Specialists may seek recertification up to one year prior to the expiration of their certificate(s).

Failure to timely obtain recertification will cause all dependent certifications held by a Specialist to be inactivated. It is the Specialist's responsibility to maintain an active certification(s). (The HMAC will not provide reminders of pending expiration dates.)

ALLEGATIONS OF MISCONDUCT - Allegations of misconduct should be submitted to the HMAC, P.O. Box 149, Buda, TX 78610 and must include the name, address and signature of the individual asserting the allegations as well as a brief description of the allegations.

If the allegations are properly submitted and appear to have merit, the HMAC Steering Committee (the "Committee") the individual asserting misfeasance and the person so accused will be asked to meet in person (but at separate dates/times) with members of the Committee. At the conclusion of the meeting(s), the Committee will issue its determination.

Misconduct generally consists of (i) neglect, (ii) abuse and/or (iii) breach of trust which are generally defined as:

1. Neglect: unintentional deviation(s) from specifications or testing procedures;

2. Abuse: careless or deliberate deviation from specifications or testing procedures; and

3. Breach of Trust: violation of the trust placed in Certified Specialists including, but not limited to, acts such as:

    a. Falsification of or deliberate omission from material records or information; or

    b. Awareness of improprieties in sampling, testing and/or production by others and the failure to timely report those improprieties to the appropriate project supervision.

The Committee may issue written reprimands (private or public) and/or revoke or inactivate a certification (if the Specialist has made a false representation or misstatement to the Committee or to the public or has engaged in misconduct) or take such other actions as the Committee, in its sole discretion, determines to be appropriate with respect to the Specialist's certification(s).

Specialists who do not achieve recertification or whose certification is revoked or inactivated by the Committee may appeal to a separate appeals committee comprised of industry members (the "Appeal Committee"). The exhaustion of this right of appeal to the Appeal Committee is a prerequisite to the exclusive remedy of administrative review by final and binding arbitration in Hays County, Texas, as administered by the American Arbitration Association by a single-member panel. Any and all other claims related in any way to this Agreement are exclusively subject to final and binding arbitration in Hays County, Texas as administered by the American Arbitration Association by a single-member panel.

In consideration for the HMAC certification/recertification process, Specialist hereby waives any and all claims of whatsoever kind or character related, directly or indirectly, to this Agreement, against the TXAPA, HMAC (including, but not limited to, the Committee and the Appeal Committee and their members), that s/he may have (including claims for attorney's fees) and further agrees to save, indemnify and hold TXAPA, the HMAC (including, but not limited to, the Committee and the Appeal Committee and their members) harmless from any claim, action or cause of action arising as a result of, or relating to this Agreement including, but not limited to, Specialist's certification, or any refusal, reprimand, revocation and/or suspension of certification or recertification of Specialist.

ACKNOWLEGED & AGREED:

SPECIALIST:

_____ _____

SIGNATURE **DATE**

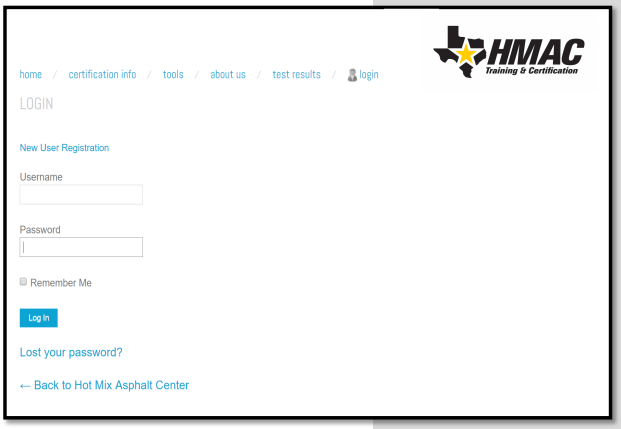
_____

PRINTED NAME

WEBSITE

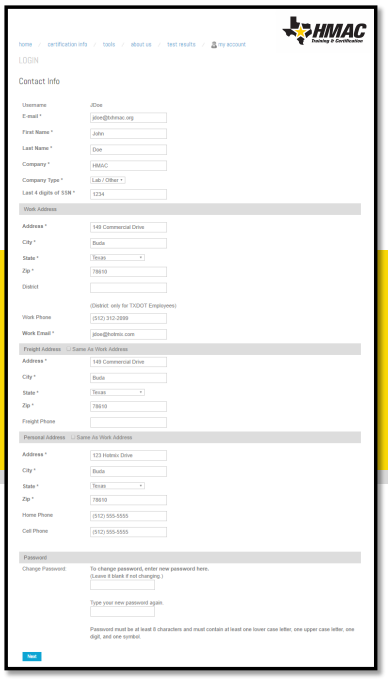
IT IS YOUR RESPONSIBILITY TO KEEP YOUR INFORMATION UP TO DATE

FIRST TIME LOGIN



- Username: Capitalize the **FIRST LETTER OF YOUR FIRST AND LAST NAME** then spell out the rest of your last name in lower case, followed by the last 4 digits of your SSN.
- Password: The same but add a "+" at the end.

Example: **John Doe**
Username: **JDoe1234**
Password: **JDoe1234+**



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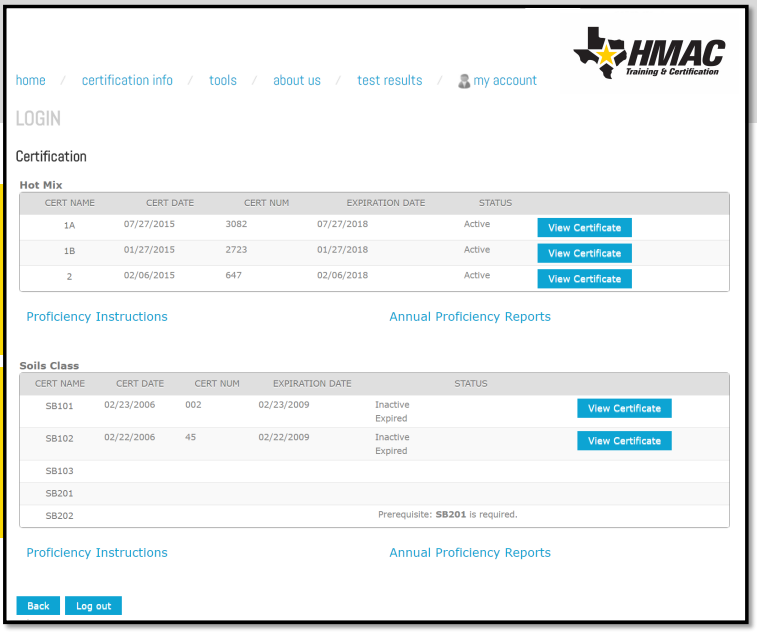
PROFICIENCY



Test Procedure for

DESIGN OF BITUMINOUS MIXTURES

TxDOT Designation: Tex-204-F

Effective Date: August 2016

1. SCOPE

1.1 Use the methods in this procedure to determine the proper proportions of approved aggregates, mineral filler, asphalt binder, additives, and recycled materials that, when combined, will produce a mixture that satisfies the specification requirements.

1.1.1 Refer to Part I for the mixture design method of Dense-Graded mixtures. See the example in Part I for a typical mixture design by weight. See Part II for a typical dense-graded design example by volume.

1.1.2 Refer to Part IV for the mixture design method of Superpave mixtures.

1.1.3 Refer to Part V for the mixture design method of Permeable Friction Course (PFC) mixtures.

1.1.4 Refer to Part VI for the mixture design method of Stone Matrix Asphalt (SMA) mixtures.

1.1.5 Refer to Part VIII for the mixture design method of Thin Bonded Wearing Course mixtures.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1—Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	**Superpave**	
G_a	G_{mb}	Bulk specific gravity of the compacted mixture
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified asphalt content
A_s	P_b	% by weight of asphalt binder in the mixture
A_g	P_s	% by weight of the aggregate in the mixture
G_e	G_{se}	Effective specific gravity of the combined aggregates
G_s	G_b	Specific gravity of the asphalt binder determined at 77°F (25°C)
G_r	G_{mm}	Theoretical maximum specific gravity

Nomenclatures		Definitions
Conventional	**Superpave**	
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test
SA	SA	Surface area in m^2/kg of combined aggregate gradation
F_T	F_T	Film thickness in microns of asphalt binder in mixture
% Density	% G_{mm}	Percentage of the ratio of the G_a to the G_t of the mixture
-	% Air Voids	% of air voids in the compacted mix
VMA	VMA	Voids in mineral aggregates
% Total CL_A	-	Total percentage retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_A	-	% retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_B	-	% retained of Class B aggregate on the 4.75 mm (#4) sieve
VCA_{CA}	-	Voids in coarse aggregate (coarse aggregate fraction only)
G_{CA}	-	Bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (#8) sieve)
γ_s	-	Unit weight of the coarse aggregate blend fraction in the dry-rodded condition
γ_w	-	Unit weight of water 1000 kg/m^3 (62.4 pcf)
P_{CA}	-	% coarse aggregate in the total mix
VCA_{CA}	-	Voids in the coarse aggregate in the dry-rodded condition
VCA_{Mix}	-	Voids in coarse aggregate for the compacted mixture

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. REPORT FORMAT

2.1 HMACP Mixture Design: Combined Gradation (2014) is an automated template containing the following worksheets:

- Instructions
- Combined Gradation
- Material Properties (Matl Properties)
- Aggregate Classification
- Weigh Up Sheet (Weigh Up)
- Weigh Up Sheet for Blank Samples (Blank Weigh Up)
- Bulk Gravity

- Film Thickness
- Summary Sheet (Summary)
- Grad Chart.

Note 1—The title in parentheses is the abbreviated title given on the tabs of the workbook.

2.2 Use the Sieve Analysis of Non-Surface Treatment Aggregates template to calculate the washed sieve analysis.

3. APPARATUS

Note 2—Each part of this test method incorporates the use of other test procedures. Each referenced procedure has its own list of apparatus in addition to those listed here.

3.1 *Drying oven*, capable of attaining the temperatures specified in the procedure.

3.2 *Balance*, Class G2 in accordance with Tex-901-K.

PART I—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES BY WEIGHT

4. SCOPE

4.1 Use this method to determine the proper proportions by weight of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the Texas gyratory compactor (TGC) and the Superpave gyratory compactor (SGC).

4.2 Use this method to determine the proper proportions by weight of approved materials to produce Thin Overlay Mixtures (TOM) that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC and the SGC.

5. PROCEDURE

5.1 *Selecting Aggregates:*

5.1.1 Select the aggregate per specification requirements.

Note 3—Use the Hot Mix Asphalt Concrete (HMAC) Rated Source Soundness Magnesium (RSSM) listed in the Bituminous Rated Source Quality Catalog (BRSQC) for approved stockpile sources from the Aggregate Quality Monitoring Program (AQMP) to determine compliance with soundness specifications.

Note 4—Enter any available aggregate testing results in the Material Properties worksheet and ensure all aggregate quality requirements are met.

5.1.2 Obtain representative samples consisting of a minimum of 50 lb. of each aggregate in accordance with Tex-221-F.

5.1.3 Dry the aggregate to constant weight at a temperature between 100 and 375°F (38 and 191°C).

5.1.4 When the aggregate stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet.

Note 5—Use the construction stockpile washed gradation when it is available.

5.1.5 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 6—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

Note 7—Proceed to Part II of this test procedure if the aggregate stockpile bulk specific gravities vary by 0.300 or more.

Note 8—Do not determine the specific gravity for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

5.2 *Selecting Asphalt Binder, Mineral Filler, and Additives:*

5.2.1 Select the asphalt binder per specification requirements.

5.2.2 When applicable, select mineral filler and additives per specification requirements.

5.2.3 Obtain a representative sample of the asphalt binder, mineral filler, and additives. Take asphalt samples in accordance with Tex-500-C. Ensure that you collect enough material for Section 5.2.4.

5.2.4 Confirm the asphalt binder, mineral filler, and additives meet applicable specifications.

Note 9—When using warm mix asphalt (WMA) additives in the mixture design, verify that the additive appears on the Department's Material Producer List (MPL).

5.3 *Selecting Recycled Materials (when applicable):*

5.3.1 Select reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) per specification requirements.

Note 10—Use RAS from shingle sources listed on the Department's MPL.

5.3.2 Obtain representative samples of recycled materials consisting of a minimum of 50 lb. of each material in accordance with Tex-221-F.

5.3.3 Dry RAS per manufacturer's recommendations.

5.3.4 Dry RAP to constant weight at a maximum temperature of 140°F (60°C).

5.3.5 When the recycled material gradation is unknown, extract the asphalt from RAP and RAS samples in accordance with Tex-236-F. Obtain the washed gradation of the burned sample in accordance with Tex-200-F, Part II. Enter the gradations on the Combined Gradation worksheet.

Note 11—Use the recycled material stockpile gradation when it is available.

Note 12—Do not determine the specific gravity for recycled materials.

5.3.6 Determine the asphalt content of the RAP and RAS materials from the average of a minimum of 4 samples (recycled material only) in accordance with Tex-236-F.

5.4 *Selecting the Combined Gradation:*

5.4.1 Enter the anticipated optimum asphalt content (OAC) in the Combined Gradation worksheet based on the mixture type and proposed materials.

5.4.2 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed materials so that the blended combination will fall within the required gradation limits for the specified mixture type. Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors for the bin percentages. Follow these instructions when applicable.

- Enter mineral filler or hydrated lime as an aggregate bin. The combined gradation should include the mineral filler and hydrated lime.
  - When using binder substitution, do not use more than 1% hydrated lime unless otherwise shown on the plans or allowed by the Engineer.
  - Enter RAP and RAS gradation and asphalt content in the "Recycled Materials" bin section. Enter their bin percentages by total mixture. (The worksheet calculates the bin percentages by total aggregate.)
  - Do not exceed the maximum percentage of recycled materials allowable per the specification.

5.4.3 When applicable, the worksheet calculates the ratio of the recycled asphalt binder to total binder. Adjust the recycled material and aggregate bins when the ratio exceeds the specification.

Note 13—After making adjustments to the bin percentages, ensure that the total bin is 100.0%.

5.4.4 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

5.4.5 Evaluate the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification or general note requirement.

Note 14—Consider the coarse aggregate from RAP and RAS as Class B aggregate.

5.5 *Preparing Laboratory-Mixed Samples:*

5.5.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

Note 15—Do not separate RAP or RAS larger than the No. 8 sieve into individual sieve sizes if the gradations are uniformly graded.

5.5.2 Separate the material passing the No. 8 sieve from each stockpile only when high gradation accuracy is needed.

5.5.2.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP, RAS, and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

5.5.3 Calculate the weights of the individual aggregates required to produce batches of mix for a minimum of 5 different asphalt contents using the Weigh Up worksheet.

Note 16—When using recycled materials and changing the asphalt content in the Combined Gradation worksheet, adjust a virgin aggregate bin percentage to ensure that the total bin is 100.0%.

Note 17—Batches of mix for a minimum of 3 different asphalt contents may be produced when using materials from a previous mix design.

Note 18—For designs with the TGC, a batch size of 5000 g is adequate to produce 3 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If hand mixing, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

Note 19—For designs with the SGC, a batch size of 11,500 g is adequate to produce 2 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If using a small mechanical mixer, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

5.5.4 Vary the asphalt contents in 0.5% increments around the anticipated optimum asphalt content (OAC). Enter the asphalt percentages in the asphalt content column of the Summary worksheet.

5.5.5 Produce a trial sample mixture in the laboratory to verify the height of a compacted specimen. Select the asphalt content closest to the expected OAC using previous mix design experience. Add any recycled materials and additives, such as RAP, RAS, or lime, before mixing the final bituminous mixture. Pre-blend asphalt additives such as liquid anti-stripping or WMA additives into the asphalt binder before laboratory mixing, similar to additive addition at the mixing plant.

5.5.6 Prepare a laboratory mix in accordance with Tex-205-F.

5.5.7 When using the TGC, mold 3 specimens in accordance with Tex-206-F.

Note 20—Use 1000 g of material per molded specimen for this trial mixture.

5.5.7.1 Determine the amount of material necessary to obtain a standard specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) Use the height adjustment formula in Tex-206-F, Part I, to determine the amount of material needed at this asphalt content.

5.5.8 When using the SGC, mold 2 specimens at the design number of gyrations (N_{design}) in accordance with Tex-241-F. Determine the N_{design} as shown on the plans or specification.

Note 21—Use 4500–4700 g of material per molded specimen for this trial mixture. Do not scalp out material larger than the 19.0-mm (3/4-in.) sieve size.

5.5.8.1 Determine the amount of material necessary to obtain a standard specimen height of 115 ± 5 mm (4.5 ± 0.2 in.)

5.5.9 Approximate the total weights for the compacted specimens containing other percentages of asphalt. Use the corrected weight of the trial specimen as a base value.

Note 22—When using the TGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 2.5 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by approximately 2.5 g.

Note 23—When using the SGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 10 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by 10 g.

5.5.10 Determine the G_r in accordance with Tex-227-F for the mixture produced at each asphalt content. Of these 3 mixtures, 2 should have asphalt contents above the optimum, and 1 mixture should have asphalt content below the optimum. Treat the mix used to perform this test the same as the mix used for molding. For mixtures designed on the TGC, remove the aggregate retained on the 19.0-mm (3/4-in.) sieve from the G_r sample before molding. Oven-cure the mixtures at the selected compaction temperature for 2 hr. Enter the G_r in the Summary worksheet.

5.5.11 Determine the G_a of the molded specimens in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

5.5.12 Use the Mix Design template to calculate the following:

- the average G_e of the blend, in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3, and
- the percent density of the molded specimens for each asphalt content, in accordance with Section 19.4.

5.6 *Determining the OAC:*

5.6.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

- Asphalt content versus VMA, G_a, and G_r—determine the VMA, G_a, and G_r at the OAC.

5.6.2 If the density or VMA is not within the allowable range, redesign by assuming another combination of aggregates or obtaining different materials.

5.7 *Evaluating the Mixture at the OAC:*

5.7.1 When required by the specification, determine the indirect tensile strength in accordance with Tex-226-F.

5.7.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

5.7.3 When required by the specification or requested by the Engineer, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

5.7.4 If the indirect tensile strength from Section 5.7.1 or the number of passes from Section 5.7.2 is not within specifications, redesign by adding an anti-stripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 24—The Engineer must approve any changes made to the N_{design} that results in a value different from what is shown on the plans or is allowed in the specification.

5.7.5 Report all data in the Mix Design Template.

6. MIX DESIGN EXAMPLE BY WEIGHT

6.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material weight is the primary consideration.

6.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by weight:

- aggregate A—a limestone dolomite Type D rock with a surface aggregate classification of class A;
- aggregate B—a limestone dolomite Type F rock with a surface aggregate classification of class B;
- limestone dolomite manufactured sand;
- hydrated lime;
- fractionated RAP;
- recycled asphalt shingles (RAS);
- warm mix additive treated as WMA;
- specified binder: PG 70-22; and
- substitute binder: PG 64-22.

6.2.1 Combine the six bins and asphalt in proportions that meet the requirements for a Type D hot-mix asphalt mixture under the applicable specification.

6.3 *Selecting Materials:*

6.3.1 Verify that all the materials comply with the project specifications.

6.3.2 Obtain the average washed sieve analysis of each of the proposed materials as shown in Figure 1 using the Sieve Analysis of Non-Surface Treatment Aggregates template. The example shown in Figure 1 shows the gradation of the crushed limestone dolomite aggregate used in this sample mix design.

6.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix design example will consist of 23% by weight of aggregate A, 35.4% by weight of aggregate B, 34% by weight of manufactured sand, 1% by weight of hydrated lime, 5.5% by total weight of mix of fractionated RAP, and 1.2% by weight of total mix of RAS.

6.3.4 Use the Combined Gradation worksheet to calculate the combined blend gradation in percent passing of each sieve size. Figure 2 shows an example of a completed worksheet. Use the bin percentages selected in Section 6.3.3. This worksheet also shows the individual and cumulative percent retained of the combined blend.

6.3.5 Use the Aggregate Classification worksheet to check the proposed bin percentages for compliance when blending Class A and B aggregates. At least 50% by weight of material retained on the 4.75 mm (No. 4) sieve from the Class A aggregate source is required, as shown in Figure 4.

6.4 *Preparing Laboratory-Mixed Samples:*

6.4.1 Calculate individual or cumulative aggregate weights with an asphalt weight. Figure 5 is an example weigh-up worksheet that shows the aggregate and asphalt weights for a 5000-g sample at 6% asphalt. A mixture size of 5000 g is adequate to produce 3 molds and 1 sample for G_r, when using a large mechanical mixer. If hand mixing, the mixture size must be the amount needed for one molded specimen or one G_r.

6.4.2 The asphalt contents for these test mixes are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight for this mix design example. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%. For this example, the total aggregate weight for a 5000-g batch at 6.0% asphalt will be 4700 g, and the weight of the asphalt will be 300 g.

6.4.3 Mix one batch using weights calculated in Section 6.4.1 in accordance with Tex-205-F. Use previous mix design experience or select the mixture at the midpoint of the design asphalt contents, which is 6.0% for this example.

Note 25—Select the batch expected to be closest to the OAC.

6.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding 3 samples of 1000 g each in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and

multiply by 1000 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

6.4.5 Subtract 5 g from the weight at each asphalt content above the trial specimen. Add 5 g to the weight at each asphalt content below the trial specimen. For this example, a 1000-g sample with 6.0% asphalt produced a molded specimen with a height of 53.8 mm (2.12 in.) Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51 mm/53.8 mm) × 1000 g or (2 in./2.11 in.) × 1000 g = 948 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% = 938 g
- asphalt content 5% = 943 g
- asphalt content 6% = 948 g
- asphalt content 7% = 953 g
- asphalt content 8% = 958 g.

6.4.6 Weigh the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

6.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample at the compaction temperature specified for the PG binder (PG 70-22 for this example) for 2 hr. in a manner similar to curing the hot-mix asphalt before molding. Enter G_r values in the worksheet as shown in Figure 6.

6.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F. Calculate the average of the 3 molds and enter the result in the Summary worksheet.

6.4.9 Use the Mix Design template to calculate the following, as shown in Figure 6:

- G_e for the blend at each of the 3 asphalt contents tested for G_r,
- the G_t,
- the percent density of the molded specimens, and
- the VMA of the molded specimens.

6.5 *Determining the OAC:*

6.5.1 Use Figure 6 to determine which asphalt content meets the target density. In this example, the OAC is 6.0%.

6.6 *Evaluating the Mixture at the OAC:*

6.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F. Enter the average strength as shown in Figure 6.

6.6.2 Determine the rut depth and number of passes on 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F. Enter the results as shown in Figure 6.

SIEVE ANALYSIS OF NON-SURFACE TREATMENT AGGREGATES
Tex-200-F

Refresh Workbook File Version: 10/15/15 13:26:06

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		GRADE:	D-Rock Limestone Dolom
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

SIEVE ANALYSIS
Tex-200-F: Part I

Original Dry Weight, (g):	2,000.0
Dry Weight After Washing, (g):	1,975.0

Sieve Size	Individual Weight Retained, (g)	Cumulative Weight Retained, (g)	Cumulative Percent Retained, (%)	Cumulative Percent Passing, (%)	Limits as Percent: Lower Limit of Grading (%)	Upper Limit of Grading (%)	Within Grading Limits
3/4"	0.0	0.0	0.0	100.0			
1/2"	20.0	20.0	1.0	99.0			
3/8"	572.0	592.0	29.6	70.4			
No. 4	1,345.0	1,937.0	96.9	3.1			
No. 8	30.0	1,967.0	98.4	1.6			
No. 16	3.0	1,970.0	98.5	1.5			
No. 30	0.0	1,970.0	98.5	1.5			
No. 50	0.0	1,970.0	98.5	1.5			
No. 200	0.0	1,970.0	98.5	1.5			
-No. 200	5.0						
	0.0	Sieving Loss, (g) from 'Dry Weight After Washing' weight					
	25.0	Washing Loss, (g)					
Total -No. 200	30.0	2,000.0	100.0				
Total Weight:	2,000.0						

Figure 1—Sieve Analysis of Fine and Coarse Aggregates

HMACP MIXTURE DESIGN : COMBINED GRADATION

Refresh Workbook — File Version: 10/12/15 10:00:39

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	
COURSE\LIFT:	Surface	STATION:	
		DIST. FROM CL:	

WMA Additive in Design?	Yes		
Target Discharge Temp., °F:	250		
WMA TECHNOLOGY:			
WMA RATE:		UNITS:	
CONTRACTOR DESIGN # :			

Use this value in the QC/QA template>>

Maximum Allowable, %	
Frac RAP:	20.0
Unfrac RAF	10.0
RAS:	5.0
RB Ratio:	30.0

Recycled Binder, %	
Bin No.8 :	0.3
Bin No.9 :	0.2
Bin No.10 :	0.0
Total	***0.500***

Ratio of Recycled to Total Binder, %
(based on binder percent (%) entered below in this worksheet)
8.3

Aggregate	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10	
	AGGREGATE BIN FRACTIONS							"RECYCLED MATERIALS"			
Source:	nestone_Dolom	nestone_Dolom	nestone_Dolom					Fractionated RAP	RAS		Material Type
Pit:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		Material Source
Number:	TxDOT	TxDOT	TxDOT								RAS Type
Producer:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		RAP/RAS Producer
Sample ID:	D-Rock	F-Rock	Manufactured Sand								Sample ID

																	Recycled Asphalt Binder (%)														
																	5.0		20.0												
Hydrated Lime?:							Yes										5.5	% of Tot. Mix	1.2	% of Tot. Mix		% of Tot. Mix									
Individual Bin (%):	23.0	Percent	35.4	Percent	34.0	Percent	1.0	Percent		Percent		Percent		Percent			5.6	% of Agg.Ag	1.0	% of Agg.Ag		% of Agg.Ag									
Sieve Size:	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %			Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %									
3/4"	100.0	23.0	100.0	35.4	100.0	34.0	100.0	1.0									100.0	5.6	100.0	1.0											
1/2"	99.0	22.8	100.0	35.4	100.0	34.0	100.0	1.0									100.0	5.6	100.0	1.0											
3/8"	70.4	16.2	99.9	35.4	100.0	34.0	100.0	1.0									100.0	5.6	100.0	1.0											
No. 4	3.1	0.7	75.2	26.6	99.6	33.9	100.0	1.0									98.6	5.5	100.0	1.0											
No. 8	1.6	0.4	15.3	5.4	86.6	29.4	100.0	1.0									85.5	4.8	100.0	1.0											
No. 16	1.5	0.3	5.2	1.8	55.8	19.0	100.0	1.0									70.2	3.9	99.8	1.0											
No. 30	1.5	0.3	2.8	1.0	35.7	12.1	100.0	1.0									51.2	2.9	99.2	1.0											
No. 50	1.5	0.3	2.3	0.8	20.8	7.1	100.0	1.0									14.5	0.8	97.6	1.0											
No. 200	1.5	0.3	1.9	0.7	7.3	2.5	100.0	1.0									1.0	0.1	62.8	0.6											

	Combined Gradation									
	Total Bin	Lower & Upper Specification Limits			Restricted Zone					
	100.0%									
Sieve Size	Cum. % Passing	Lower	Upper	Within Spec's	Lower	Upper	Within Spec's	Individual % Retained	Cumulative % Retained	Sieve Size
3/4"	100.0	100.0	100.0	Yes				0.0	0.0	3/4"
1/2"	99.8	98.0	100.0	Yes				0.2	0.2	1/2"
3/8"	93.2	90.0	100.0	Yes				6.6	6.8	3/8"
No. 4	68.7	32.0	90.0	Yes				24.4	31.3	No. 4
No. 8	42.0	32.0	67.0	Yes	47.2	47.2	Yes	26.7	58.0	No. 8
No. 16	27.1	2.0	67.0	Yes	31.6	37.6	Yes	14.9	72.9	No. 16
No. 30	18.3	2.0	67.0	Yes	23.5	27.5	Yes	8.8	81.7	No. 30
No. 50	11.0	2.0	67.0	Yes	18.7	18.7	Yes	7.3	89.0	No. 50
No. 200	5.2	2.0	10.0	Yes				5.8	94.8	No. 200

(Bold Italic) Not within specifications ***(Bold Italic)*** Not within specificaitons- Restricted Zone *(Italic)* Not cumulative

Lift Thickness, in:		Binder Substitution?	Yes	Binder Originally Specified:	PG 70-22	Substitute Binder:	PG 64-22
Asphalt Source:		Binder Percent, (%):	6.0	Asphalt Spec. Grav.:	1.029		
Antistripping Agent:		Percent, (%):					

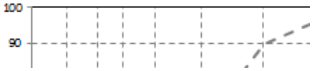


Figure 2—Combined Gradation

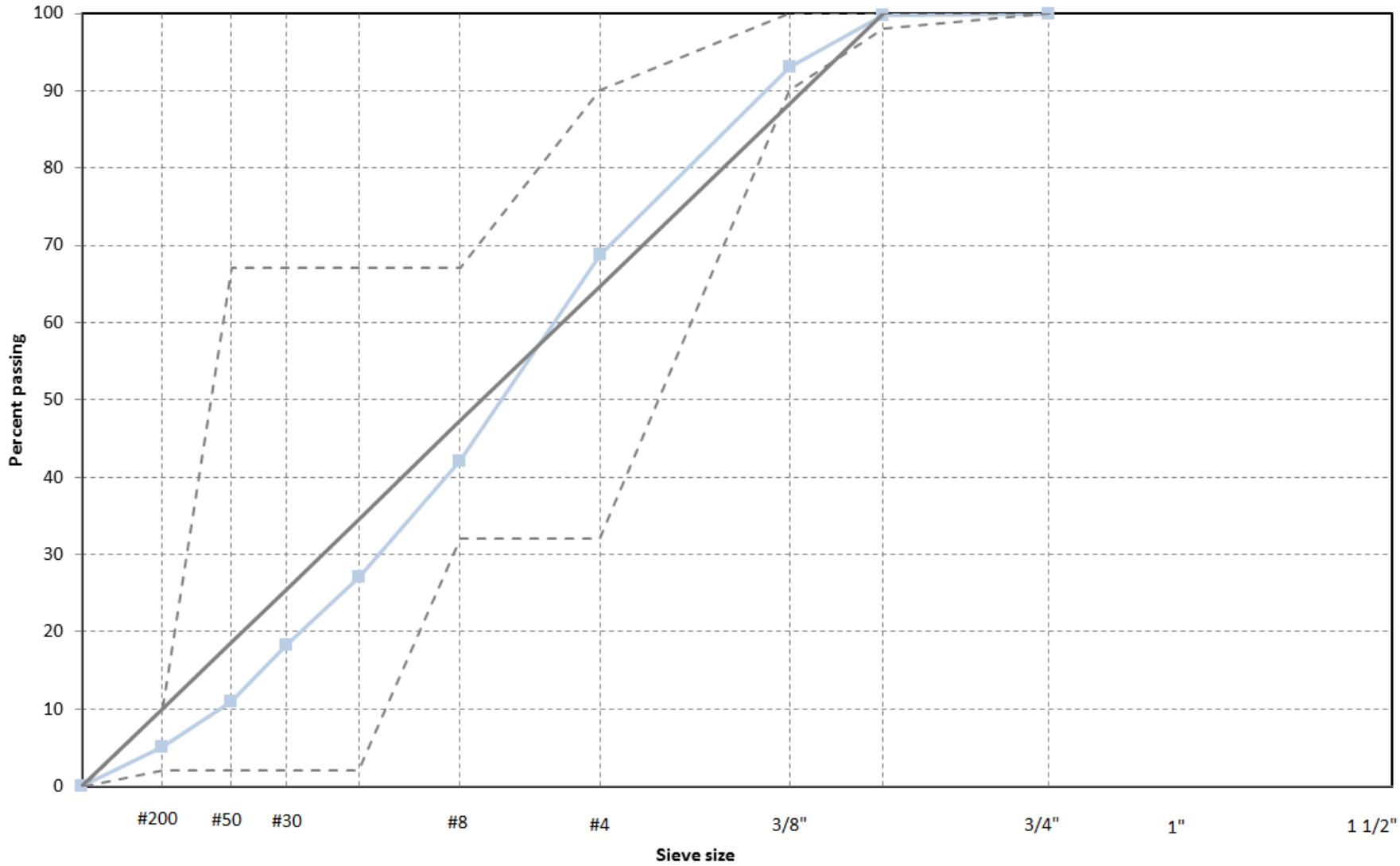


Figure 3—Power 0.45 Curve

HMACP MIXTURE DESIGN : Aggregate Classification

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	

Aggregate Classification

		Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10
Individual Bin (%):		Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.6 %	Bin No.9 = 1 %	
Aggregate Source:		Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS	
Aggregate Number:		TxDOT	TxDOT	TxDOT							
Class (A) Rock (Y/N):		Yes									
Sieve Size:		Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %
Passing	Retained										
-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0	
3/4"	1/2"	0.2	0.0	0.0	0.0				0.0	0.0	
1/2"	3/8"	6.6	0.0	0.0	0.0				0.0	0.0	
3/8"	No. 4	15.5	8.7	0.1	0.0				0.1	0.0	
No. 4	No. 8	0.3	21.2	4.4	0.0				0.7	0.0	
No. 8	No. 16	0.0	3.6	10.5	0.0				0.9	0.0	
No. 16	No. 30	0.0	0.8	6.8	0.0				1.1	0.0	
No. 30	No. 50	0.0	0.2	5.1	0.0				2.1	0.0	
No. 50	No. 200	0.0	0.1	4.6	0.0				0.8	0.3	
No. 200	Pan	0.3	0.7	2.5	1.0				0.1	0.6	
Total:		23.0	35.4	34.0	1.0				5.6	1.0	
Percent of plus No. 4		22.3	8.8	0.1	0.0				0.1	0.0	
Percent of plus No. 8		22.6	30.0	4.6	0.0				0.8	0.0	

Percent of plus No. 4 from class (A) Rock:	22.3
Total Percent of plus No. 4	31.3
Percent of plus No. 4 from class (A) Rock:	**71.2**

Percent of plus No. 8 from class (A) Rock:	22.6
Total Percent of plus No. 8	58.0
Percent of plus No. 8 from class (A) Rock:	39.0

Figure 4—Aggregate Classification

Aggregate Weight, g:	4,700.0
6% Asphalt by Total Weight, g:	300.0
Total Weight, g:	5000.0

6% Asphalt by Total Weight, g:	300.0
Less Asphalt by Weight of Recycled Material, g:	25.6
() Asphalt to Add, g:	**274.4**

			Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10			
	Individual Bin (%):		Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.5 %	Bin No.9 = 1.2 %				
	Aggregate Source:		Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS				
	Aggregate Number:		TxDOT	TxDOT	TxDOT					TxDOT	TxDOT				
	Sample ID:		D-Rock	F-Rock	Manufactured Sand								Total Weights	Individual Retained, %	Cumulative Retained, %
	Sieve Size: Passing	Sieve Size: Retained	Aggregate Weight	Aggregate Weight	Aggregate Weight	Hydrated Lime Weight				Fractionated RAP Weight	RAS Weight				
INDIVIDUAL	-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0		0.0	0.0	0.0
	3/4"	1/2"	10.8	0.0	0.0	0.0				0.0	0.0		10.8	0.2	0.2
	1/2"	3/8"	309.2	1.7	0.0	0.0				0.0	0.0		310.8	6.6	6.8
	3/8"	No. 4	727.5	411.0	6.4	0.0				3.9	0.0		1,148.7	24.3	31.1
	No. 4	No. 8	16.2	996.6	207.7	0.0				36.3	0.0		1,256.9	26.6	57.7
	No. 8	No. 16	1.1	168.0	492.2	0.0				42.4	0.1		703.8	14.9	72.6
	No. 16	No. 30	0.0	39.9	321.2	0.0				52.6	0.4		414.1	8.8	81.4
	No. 30	No. 50	0.0	8.3	238.1	0.0				101.7	0.9		349.0	7.4	88.8
	No. 50	No. 200	0.0	6.7	215.7	0.0				37.4	20.4		280.2	5.9	94.7
	No. 200	Pan	16.2	31.6	116.7	47.0				2.8	36.9		251.1	5.3	100.0
	Totals		1,081.0	1,663.8	1,598.0	47.0				277.1	58.8		**4,725.6**	Total includes asphalt from the recycled material	
Running Total:															
CUMULATIVE	-	3/4"	0.0	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		0.0		
	3/4"	1/2"	10.8	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		10.8		
	1/2"	3/8"	320.0	1,082.7	2,744.8	4,342.8				4,389.8	4,666.9		321.6		
	3/8"	No. 4	1,047.5	1,493.6	2,751.2	4,342.8				4,393.7	4,666.9		1,470.4		
	No. 4	No. 8	1,063.7	2,490.2	2,958.9	4,342.8				4,430.0	4,666.9		2,727.2		
	No. 8	No. 16	1,064.8	2,658.3	3,451.1	4,342.8				4,472.4	4,667.0		3,431.1		
	No. 16	No. 30	1,064.8	2,698.2	3,772.3	4,342.8				4,525.0	4,667.3		3,845.2		
	No. 30	No. 50	1,064.8	2,706.5	4,010.4	4,342.8				4,626.7	4,668.3		4,194.2		
	No. 50	No. 200	1,064.8	2,713.2	4,226.1	4,342.8				4,664.1	4,688.7		4,474.5	Total includes asphalt from the recycled material	
	No. 200	Pan	1,081.0	2,744.8	4,342.8	4,389.8				4,666.9	4,725.6		4,725.6		

Figure 5—Weigh Up Sheet

HMACP MIXTURE DESIGN : SUMMARY SHEET

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	

Target Density, %:	**96.0**
Number of Gyrations:	**50**

CRM* Content, %:

Note: This mix design requires an asphalt content of at least 1.7% to meet the Maximum Ratio of Recycled to Total Binder requirement.

	TEST SPECIMENS								Mixture Evaluation @ Optimum Asphalt Content			
										Hamburg Wheel Tracking Test		
	Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)	Indirect Tensile Strength (psi)	Number of cycles	Rut depth (mm)	Overlay Tester Min. Number of Cycles
1	4.0	12.5	2.241			2.454	91.3	17.4	126.4	20,000	8.2	
2	5.0	10.0	2.262	2.415	2.599	2.419	93.5	17.5				
3	6.0	8.3	2.292	2.380	2.598	2.385	96.1	17.3				
4	7.0	7.1	2.312	2.360	2.615	2.352	98.3	17.4				
5	8.0	6.3	2.307			2.320	99.4	18.5				

Effective Specific Gravity:	2.604
Optimum Asphalt Content :	**6.0**
Binder Ratio @ OAC:	8.3
VMA @ Optimum AC:	17.3
VFA @ Optimum AC:	**76.8**
Interpolated Values	
Specific Gravity (Ga):	*2.291*
Max. Specific Gravity (Gr):	*2.381*
Theo. Max. Specific Gravity (Gt):	*2.386*
Dust/Asphalt Ratio:	**0.9**

<Not meeting VFA requirement

Estimated Percent of Stripping, %:	

STONE-ON-STONE CONTACT	
VCA(CA, calc.)	
VCA(MIX, calc.)	

Mixing Temp,°F:	
Molding Temp,°F:	

Figure 6—Summary Sheet

PART II—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE TEXAS GYRATORY COMPACTOR (TGC) BY VOLUME

7. SCOPE

7.1 Use this method to determine the proper proportion by volume of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC for dense-graded mixtures, such as Type A, B, C, D, and F.

7.2 Determine the proper proportions volumetrically when the aggregate stockpile bulk specific gravities vary by 0.300 or more. Volumetric proportioning is always the most correct method; however, when aggregate specific gravities are similar, consider the error introduced by designing by weight as inconsequential.

8. MIX DESIGN EXAMPLE BY VOLUME

8.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material volume is the primary consideration.

8.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by volume:

- aggregate A—a lightweight aggregate with 12.5 mm (1/2 in.) maximum size and surface aggregate classification of class A;
- aggregate B—a crushed limestone with 9.5 mm (3/8 in.) maximum size and surface aggregate classification of class B;
- limestone screenings;
- field sand; and
- PG 64-22.

8.2.1 Combine the 4 aggregates and asphalt in proportions that meet the requirements for a dense-graded Type D hot-mix asphalt mixture under the applicable specification.

8.3 *Selecting Materials:*

8.3.1 Verify that all the materials comply with the project specifications.

8.3.2 Obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II, using the Sieve Analysis of Fine and Coarse Aggregates template. Figure 1 shows the hypothetical sample gradations of the proposed aggregates.

8.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix

design example will consist of 39% by volume of aggregate A, 23% by volume of aggregate B, 26% by volume of stone screening, and 12% by volume of field sand.

8.3.4 Determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity for the individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Test the proposed lightweight aggregate in accordance with Tex-433-A.

8.3.4.1 Normally, specific gravities are not determined for RAP aggregate size fractions consisting of less than 15% of the individual aggregate.

8.3.5 Calculate the average water absorption, average stockpile bulk gravities, and the bulk specific gravity of the combined gradation. Design the mix by volume, since the stockpile specific gravities vary by as much as 1.119, which exceeds 0.300.

8.3.5.1 Assume the differences in the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning of actual materials. This allows the use of the average bulk specific gravity for each stockpile in later calculations.

8.3.6 Calculate the combined volumetric job-mix formula using the assumption that the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning. Table 4 shows the volumetric combined gradation, which results from combining 39% by volume lightweight aggregate A, 23% by volume aggregate B, 26% by volume screenings, and 12% by volume sand. The resulting combined gradation meets the specification master gradation limits, which are identical for volumetric and weight proportioning.

8.3.7 Check the proposed aggregate proportioning for compliance with blending requirements. Check aggregate classification in accordance with Section 5.4.4.

8.3.8 Plot the proposed combined volumetric gradation and specification master limits on a 0.45 power curve.

8.4 *Preparing Laboratory-Mixed Samples:*

8.4.1 Calculate individual aggregate and asphalt weights for the test mixtures. Since all of the calculations to this point have been volumetric, convert to weight percentages so that the necessary weights of individual materials can be determined. Refer to Table 2 for conversion of the stockpile percentages.

8.4.1.1 This is the second application of the assumption that the differences in specific gravities of individual size aggregates within a stockpile will not have a significant effect on the proportioning for the combined gradation.

8.4.1.2 Use the values in the last column of Table 2 to calculate the weight percentage of each aggregate size fraction. See the example shown in Table 5.

8.4.2 Calculate individual aggregate and asphalt weights for the test mixtures as shown in Table 6. The presence of lightweight aggregate in this example means a specimen with a height of 51 mm (2 in.) will weigh less than if all natural aggregate were used.

8.4.2.1 The asphalt contents for the test mixes chosen are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%.

8.4.3 Mix one of the batches calculated in Section 8.4.2 in accordance with Tex-205-F.

8.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding a 900-g sample in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and multiply by 900 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

8.4.5 Subtract 5 g from the weight of the mix at each asphalt content above that of the trial specimen. Add 5 g to the weight of the mix at each asphalt content below that of the trial specimen. For this example, a 900-g sample with 4.0% asphalt produced a molded specimen with a height of 55.9 mm (2.20 in.). Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51.0 mm/ 55.9 mm) × [900 g or (2.00 in./2.19 in.) × 900 g] = 821 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% ≥ 821 g
- asphalt content 5% ≥ 826 g
- asphalt content 6% ≥ 831 g
- asphalt content 7% ≥ 836 g
- asphalt content 8% ≥ 841 g.

8.4.6 Weigh up the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

8.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Two of the 3 mixtures should have asphalt contents above the optimum, and one mixture should have asphalt content below the optimum.

8.4.7.1 Perform the dry-back procedure to determine if water absorption has introduced error in the initial G_r result when testing mixtures containing lightweight aggregate.

8.4.7.2 Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample for 2 hr. at the compaction temperature for the PG binder used (PG 64-22 for this example) similar to curing the mix before molding.

8.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F.

8.4.9 Calculate the average G_e of the blend in accordance with Section 19.2.

8.4.10 Calculate the G_t in accordance with Section 19.3.

8.4.11 Calculate the percent density of the molded specimens in accordance with Section 19.4.

8.4.12 Calculate the VMA of the specimens to the nearest 0.1% in accordance with Section 19.5.

8.5 *Determining the OAC:*

8.5.1 Plot densities on the vertical axis, versus asphalt content on the horizontal axis for each set of molded specimens. Draw a line at the target laboratory-molded density to where it intersects with the density curve. Draw a vertical line down from this point to where it intersects the horizontal axis to determine the OAC. Alternatively, calculate the OAC by interpolating between the asphalt contents above and below the target density.

8.5.2 Plot asphalt content versus VMA, G_a, and G_r. Report and verify all properties of the combined blend at the determined OAC.

8.6 *Evaluating the Mixture at the OAC*:

8.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F.

8.6.2 Determine the rut depth and number of passes of 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F.

Table 2—Stockpile Conversion Percentages (Volume to Weight)

Stockpile	Proportions % by Volume		Bulk Specific Gravity		Weight, g	Proportions % by Weight
Lightweight	39.0	×	1.502	=	58.578	27.4
Aggregate B	23.0	×	2.539	=	58.397	27.3
Screenings	26.0	×	2.524	=	65.624	30.6
Sand	12.0	×	2.621	=	31.452	14.7
TOTAL	**100.0**		—		**214.051**	**100.0**

Table 3—Sieve Analysis Worksheet (No. 2)

Project:									**Highway:**
County:									**Item No.:**
	Sieve Size								
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**	**Pass #200**	**TOTAL**
Lightweight									
Weight (g)	0	21.2	622.7	71.9	3.3	0.7	0.8	2.3	**722.9**
Ind. % Ret.	0	2.9	86.2	9.9	0.5	0.1	0.1	0.3	**100.0**
Cum. % Ret.	0	2.9	89.1	99.0	99.5	99.6	99.7	---	---
Cum. % Pass.	100.0	97.1	10.9	1	0.5	0.4	0.3	---	---
Aggregate B									
Weight (g)	0	0	2.4	1145.9	37.0	12.4	8.1	11.9	**1217.7**
Ind. % Ret.	0	0	0.2	94.1	3.0	1.0	0.7	1.0	**100.0**
Cum. % Ret.	0	0	0.2	94.3	97.3	98.3	99.0	---	---
Cum. % Pass.	100.0	100.0	99.8	5.7	2.7	1.7	1.0	---	---
Screenings									
Weight (g)	0	0	0	194.2	471.1	367.0	144.1	65.6	**1242.0**
Ind. % Ret.	0	0	0	15.6	37.9	29.6	11.6	5.3	**100.0**
Cum. % Ret.	0	0	0	15.6	53.5	83.1	94.7	---	---
Cum. % Pass.	100.0	100.0	100.0	84.4	46.5	16.9	5.3	---	---
Sand									
Weight (g)	0	0	0	0	480.0	468.1	172.0	74.0	**1194.1**
Ind. % Ret.	0	0	0	0	40.2	39.2	14.4	6.2	**100.0**
Cum. % Ret.	0	0	0	0	40.2	79.4	93.8	---	---
Cum. % Pass.	100.0	100.0	100.0	100.0	59.8	20.6	6.2	---	---

Table 4—Job-Mix Formula Gradation Worksheet (Volumetric % Passing)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	7.9	0.4	0.3	0.2	0.1
39%	39.0	37.8	3.1	0.2	0.1	0.1	0.0
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
23%	23.0	23.0	23.0	1.3	0.6	0.4	0.2
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
26%	26.0	26.0	26.0	21.9	12.1	4.4	1.4
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	98.8	64.1	35.4	20.0	7.4	2.3
Specification	100	85-100	50-70	32-42	11-26	4-14	1-6[1]

1. Dry sieve analysis

Table 5—Job-Mix Formula Gradation Worksheet (Volumetric Converted to Weight)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	10.9	1.0	0.5	0.4	0.3
27.4%	27.4	26.6	3.0	0.3	0.1	0.1	0.1
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
27.3%	27.3	27.3	27.2	1.6	0.7	0.5	0.3
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
30.6%	30.6	30.6	30.6	25.8	14.1	5.2	1.6
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	99.2	75.5	42.4	23.8	8.8	2.9
Specification[1]	100	85-100	50-70	32-42	11-26	4-14	1-6

1. Volumetric specification limits are not applicable to converted weight percentages.

Table 6—Weigh-Up for 4000g Batch at 4% Asphalt

Material ID	% of Aggregate	% of Mix	Cumulative %	1000 g Cumulative Wt.	4000 g Cumulative Batch Weigh-Up
Lightweight					
1/2" - 3/8"	0.8	0.8	0.8	8	32
3/8" - #4	23.6	22.7	23.5	235	940
#4 - #8	2.7	2.5	26.0	260	1040
Pass #8	0.3	0.3	26.3	263	1052
Aggregate B					
1/2" - 3/8"	0	0	---	---	---
3/8" - #4	0.1	0.1	26.4	264	1056
#4 - #8	25.6	24.6	51.0	510	2040
Pass #8	1.6	1.5	52.5	525	2100
Screenings					
Plus + #8	4.8	4.6	57.1	571	2284
Pass - #8	25.8	24.8	81.9	819	3276
Sand					
Pass - #8	14.7	14.1	96.0	960	3840
Asphalt					
%	---	4.0	(4.0)	(40)	(160)
TOTAL	**100.0**	**100.0**	**100.0**	**1000**	**4000**

PART III—MIX DESIGN FOR LARGE STONE DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE SUPERPAVE GYRATORY COMPACTOR (SGC)

9. SCOPE

9.1 Part III has been removed from this test procedure. Refer to Part I, “Mix Design for Dense-Graded Hot-Mix Asphalt Mixtures by Weight.”

PART IV—MIX DESIGN FOR SUPERPAVE MIXTURES

10. SCOPE

10.1 Use this method to determine the proper proportions by weight of approved materials to produce a Superpave mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

11. PROCEDURE

11.1 *Selecting Materials:*

11.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

11.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

11.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

11.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

11.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance to Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

11.1.6 Check the aggregate gradations for compliance with the applicable specifications.

11.1.7 Check the asphalt and additives for compliance with the applicable specifications.

11.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 26—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

11.1.8.1 Normally, specific gravities are not determined for RAP or aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

11.1.9 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact when shown on the plans.

11.1.10 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified hot-mix asphalt type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

11.1.11 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 11.1.5.

11.1.12 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

11.1.13 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

11.2 *Preparing Laboratory Mixed Samples:*

11.2.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

11.2.1.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

11.2.2 Combine the aggregates to create a trial blend that falls within the master gradation band required in the specification.

Note 27—Mix designs typically use 3–5 stockpiles to produce a combined gradation meeting gradation specifications.

11.2.3 Plot the combined gradation and specification limits on the Grad Chart worksheet.

11.2.4 Select and vary asphalt contents in 0.5% increments. Enter the asphalt percentages in the Summary worksheet.

Note 28—Select 3 or 5 asphalt contents to determine the OAC depending on experience and knowledge of materials used.

11.2.5 Calculate the weights of individual aggregates required to produce batches of mix at each chosen asphalt content from Section 11.2.4. Calculate weights for 2 laboratory-molded specimens and one G_r sample for each asphalt content. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement. 1900–2000 g of aggregate are required for a sample for the G_r.

11.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F.

11.2.7 Mold 2 specimens for each asphalt content at the design number of gyrations, N_{design}, in accordance with Tex-241-F. Determine the N_{design} according to the specification or as shown on the plans.

11.2.8 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

11.2.9 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

11.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

11.3 *Determining the OAC:*

11.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

11.3.2 If the VMA is not within the allowable specification range, redesign by assuming another combination of aggregates or by obtaining different materials.

11.4 *Evaluating the Stone-on-Stone Contact (when required by general note):*

11.4.1 Verify stone-on-stone contact when shown on the plans. Calculate the VCA_{CA} in accordance with Section 19.7.

11.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

11.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

11.5 *Evaluating the Mixture at the OAC:*

11.5.1 Calculate the weights of individual aggregates for laboratory molded specimens at the OAC determined in Section 11.3.1.

11.5.2 Determine the indirect tensile strength in accordance with Tex-226-F.

11.5.3 Determine the rut depth and number of passes in accordance with Tex-242-F.

11.5.4 When requested by the Engineer or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

11.5.5 If the rut depth or indirect tensile strength is not within specification, redesign by adding an antistripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 29—The Engineer must approve any changes made to the N_{design} that results in a value different from that shown on the plans or allowed in the specification.

PART V—MIX DESIGN FOR PERMEABLE FRICTION COURSE (PFC) AND THIN BONDED PERMEABLE FRICTION COURSE (TBPFC) MIXTURES

12. SCOPE

12.1 Use this method to determine the proper proportions by weight of approved materials to produce PFC and PFC-R mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

13. PROCEDURE

13.1 *Selecting Materials:*

13.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

13.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 30—Polymer-modified asphalt binder with a PG of 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

13.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

13.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile

gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available.

13.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

13.1.6 Check the asphalt and additives for compliance with the applicable specifications.

13.1.7 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 31—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, bulk specific gravity, and apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

13.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

13.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 32—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

13.1.9 Add 1% hydrated lime as a mineral filler for mixes with PG 76-XX. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime for mixes with PG 76-XX.

13.1.10 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

13.1.11 Plot the combined gradation and specification limits on the Grad Chart worksheet.

13.2 *Preparing Laboratory-Mixed Samples:*

13.2.1 Separate the material larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

13.2.2 Start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

13.2.3 Select a minimum of 3 asphalt binder contents in increments of 0.5% for the laboratory-molded specimens. Start at an asphalt content of 6.0% or greater for PFC mixtures with

PG 76-XX. Start at an asphalt content of 8.0% or greater for PFC mixtures with A-R binder. Lower asphalt contents are allowed when using an aggregate with a bulk specific gravity greater than 2.750.

13.2.4 Select 3 asphalt binder contents in increments of 0.5% for the G_r samples. Start at an asphalt content of 2.0–3.0%. Ensure all samples are thoroughly coated with asphalt binder.

Note 33—Perform this Section to determine accurate G_r values at the higher asphalt contents selected in Section 13.2.3 for the laboratory-molded specimens. The G_r values for the mixtures with the higher asphalt contents are back-calculated using the equation in Section 19.2.

13.2.5 Calculate the weights of individual aggregates required to produce the specimens and samples specified in Sections 13.2.3 and 13.2.4. Generally, 3500–3700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.); however, this may vary. It may be necessary to produce a trial specimen to achieve this height requirement.

13.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

13.2.7 Mold 2 specimens at each asphalt content selected in Section 13.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

13.2.8 Determine the G_r at the asphalt contents selected in Section 13.2.4 in accordance with Tex-227-F. Enter the G_r in the Summary worksheet.

13.2.9 Determine the G_a of the specimens using dimensional analysis in accordance with Tex-207-F, Part VIII. Enter the G_a in the Summary worksheet.

13.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2 (Use the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for the mixtures with the higher asphalt contents used for the laboratory-molded specimens.);
- the G_t in accordance with Section 19.3; and
- the percent density of the molded specimens in accordance with Section 19.4.

13.3 *Determining the OAC:*

13.3.1 Use the Mix Design template to plot densities versus asphalt content for the molded specimens. Determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

13.3.2 When applicable, adjust the percentage of coarse aggregate or fibers to achieve an OAC that meets the minimum asphalt binder content requirement according to the specification.

13.4 *Evaluating the Mixture at the OAC:*

13.4.1 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

13.4.2 Evaluate moisture resistance of the optimum mixture in accordance with Tex-530-C.

13.4.3 When required, requested by the Engineer, or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and the rut depth and number of passes in accordance with Tex-242-F.

13.4.4 Evaluate the durability of the optimum mixture in accordance with Tex-245-F.

13.4.5 Report all data in the Mix Design Template.

PART VI—MIX DESIGN FOR STONE MATRIX ASPHALT (SMA) MIXTURES

14. SCOPE

14.1 Use this method to determine the proper proportions by weight of approved materials to produce SMA and SMAR mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

15. PROCEDURE

15.1 *Selecting Materials:*

15.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

15.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 34—Polymer-modified asphalt binder with a PG 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

15.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

15.1.4 If the stockpile gradation in unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

15.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance with Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

15.1.6 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable aggregate specifications.

15.1.7 Check the asphalt and additives for compliance with the applicable specifications.

15.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 35—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-210-F and Tex-202-F.

15.1.8.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

15.1.8.2 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact.

15.1.9 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate such that the blended combination will fall within the specified gradation ranges for the specified mixture type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

Note 36—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

15.1.10 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 15.1.5.

15.1.11 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet**.**

15.1.12 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

15.2 *Preparing Laboratory Mixed Samples:*

15.2.1 Separate aggregate larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

15.2.2 For SMA, start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

15.2.3 Select 3 asphalt contents in increments of 0.5%. Start at the minimum asphalt content based on the bulk specific gravity of the aggregate. Locate the table in the specification that lists the minimum asphalt content based on the bulk specific gravity of the aggregate.

15.2.4 Calculate the weights of individual aggregates required to produce 2 laboratory-molded specimens and one G_r sample for each asphalt content selected in Section 15.2.3. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement.

15.2.5 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

15.2.6 Mold 2 specimens at each asphalt content selected in Section 15.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

15.2.7 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

15.2.8 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

15.2.9 Use the Mix Design template to calculate the following:

- average G_e of the blend in accordance with Section 19.2,
- the G_t in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

15.3 *Determining the OAC:*

15.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

15.3.2 Redesign by assuming another combination of aggregates or by obtaining different materials if the VMA is not within the allowable specification range.

15.4 *Evaluating the Stone-on-Stone Contact:*

15.4.1 Calculate the VCA_{CA} in accordance with Section 19.7.

15.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

15.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

15.5 *Evaluating the Mixture at the OAC:*

15.5.1 Determine the number of cycles to failure in accordance with Tex-248-F.

15.5.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

15.5.3 If the rut depth or number of cycles is not within specification, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different PG grade.

15.5.4 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

15.5.5 Evaluate the moisture resistance of the optimum mixture in accordance with Tex-530-F.

15.5.6 Report all data in the Mix Design template.

PART VII—MIX DESIGN FOR STONE-MATRIX ASPHALT RUBBER (SMAR) MIXTURES

16. SCOPE

16.1 Part VII has been combined with Part VI of the test procedure. Refer to Part VI, "Mix Design for Stone-Matrix Asphalt (SMA) Mixtures."

PART VIII—MIX DESIGN FOR THIN BONDED WEARING COURSE MIXTURES

17. SCOPE

17.1 Use this method to determine the proper proportions by weight of approved aggregates and asphalt, which, when combined, will produce a thin bonded wearing course mixture that will satisfy the specification requirements.

17.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

18. PROCEDURE

18.1 *Selecting Materials:*

18.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Sample the aggregates in accordance with Tex-221-F.

18.1.2 Obtain an adequate quantity of the asphalt and additives in accordance with Tex-500-C.

18.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

18.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile washed gradation when it is available.

18.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

18.1.6 Check asphalt and additives for compliance with the applicable specifications.

18.1.7 If the specific gravity values for the aggregate sources are unknown, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Enter the results or the known values from previous history on the Bulk Gravity worksheet.

18.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values are determined.

18.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 37—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

18.1.9 Consider the use of hydrated lime when necessary. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

18.1.10 Calculate the sand equivalent value of the combined virgin aggregate in accordance with Tex-203-F. Enter the value on the Material Properties worksheet.

Note 38—Perform the test on the combined aggregates not including lime.

18.1.11 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

18.1.12 Plot the combined gradation and specification limits using the Grad Chart worksheet. Confirm that the blend meets the specification requirements.

18.2 *Preparing Laboratory Mixed Samples:*

18.2.1 Separate the material larger than the 2.36 mm (No. 8) sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the 2.36-mm (No. 8) sieve into individual sizes if it is prone to segregation.

18.2.2 Select 2 asphalt contents around the anticipated OAC. Select the asphalt contents within the allowed tolerances in accordance with specifications.

Note 39—Select the asphalt contents to determine the OAC depending on experience and knowledge of materials used.

18.2.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample for each asphalt content selected in Section 18.2.2.

18.2.4 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.2.5 Determine the G_r of the 2 mixtures in accordance with Tex-227-F. Enter the asphalt content and the G_r values in the appropriate column of the Summary worksheet.

18.2.6 Mold 2 specimens at each asphalt content selected in Section 18.2.2 in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown in plans.

18.2.7 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the height and dry weight for each asphalt content in the appropriate column of the Summary worksheet to calculate the G_a.

18.2.8 Use the Summary worksheet to calculate G_e and G_t for each asphalt content in accordance with Sections 19.2 and 19.3.

Note 40—The worksheet uses the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for all other laboratory-molded specimens.

18.2.9 Use the Summary worksheet to calculate the density of the molded samples in accordance with Sections 19.4 and 19.5.

18.3 *Determining the OAC:*

18.3.1 Use the Film Thickness worksheet to calculate the SA and F_T of the mixtures in accordance with Sections 19.9 and 19.10.

18.3.2 Use the graphs in the Film Thickness worksheet to determine the OAC. The mixture at the OAC must meet the density and film thickness requirements, while staying within the

limits for asphalt content as outlined in the specification. If this is not possible according to the predicted estimates, redesign by assuming another combination of aggregates or by obtaining different materials.

18.3.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample at the OAC.

18.3.4 Prepare the asphalt mixture in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.3.5 Mold 2 specimens at the OAC in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown on the plans.

18.3.6 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the heights and dry weights in the appropriate column of the Summary worksheet.

18.3.7 Use the Summary worksheet to backcalculate the G_r, and calculate the density of the molded samples and the F_T for the combined aggregate at the OAC. The calculated density and F_T must meet the specifications.

18.3.8 If the density or F_T does not meet the specifications, modify the OAC and repeat the procedure, starting with Section 18.3.3.

18.4 *Evaluating the Mixture at the OAC:*

18.4.1 Evaluate the draindown of the mixture in accordance with Tex-235-F. Use 350 ± 5°F (177 ± 3°C) for testing temperature.

18.4.2 Evaluate the moisture resistance of the mixture in accordance with Tex-530-C.

18.4.3 Evaluate the durability of the mixture in accordance with Tex-245-F. Mold 2 specimens at the OAC to 50 gyrations. The density of the specimens must meet the specifications.

18.4.4 Report all test results in the Summary worksheet.

18.4.5 If any of the test results does not meet specifications, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different OAC.

19. CALCULATIONS

19.1 Calculate %Total CL_A:

$$\%\ \text{Total CL}_A = \frac{\%\ CL_A}{(\%\ CL_A + \%\ CL_B)}$$

Where:

% Total CL_A = total percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve

% CL_A = percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve
% CL_B = percentage retained of Class B aggregate on the 4.75 mm (No. 4) sieve.

19.2 Calculate G_e:

$$G_e = \frac{(100 - A_s)}{\left[\left(\frac{100}{G_r}\right) - \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
G_e = effective specific gravity
A_s = asphalt content, %
G_r = theoretical maximum specific gravity
G_s = specific gravity of the asphalt binder.

19.3 Calculate the G_t:

$$G_t = \frac{100}{\left[\left(\frac{A_g}{G_{e(avg)}}\right) + \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
$G_{e(avg)}$ = average of the effective specific gravities obtained
G_t = calculated theoretical maximum specific gravity
A_g = percentage of aggregate in the mixture.

19.4 Calculate the percent density of the molded samples:

$$\%\ \text{Density} = \left(\frac{G_a}{G_t}\right) \times 100$$

Where:
% Density = percentage of the ratio of G_a to G_t
G_a = bulk specific gravity.

19.5 Calculate the design VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_t}\right) \times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

Where:
VMA = voids in mineral aggregates.

19.6 Calculate the production VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_r}\right) \times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

19.7 Calculate the VCA_{CA}:

$$VCA_{CA} = \left\{\frac{\left[(G_{CA} \times \gamma_w) - \gamma_s\right]}{(G_{CA} \times \gamma_w)}\right\} \times 100$$

Where:

VCA_{CA} = voids in the coarse aggregate in the dry-rodded condition

G_{CA} = bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (No.8) sieve)

γ_w = unit weight of water

γ_s = unit weight of the coarse aggregate blend fraction in the dry-rodded condition.

19.8 Calculate the VCA_{Mix}:

$$VCA_{Mix} = 100 - \left[\left(\frac{G_a}{G_{CA}}\right) \times P_{CA}\right]$$

Where:

VCA_{Mix} = voids in coarse aggregate for the compacted mixture

P_{CA} = percentage coarse aggregate in the total mix.

19.9 Calculate SA:

$$SA = \frac{0.41 + (\%P\#4)0.41 + (\%P\#8)0.82 + (\%P\#16)1.64 + (\%P\#30)2.87 + (\%P\#50)6.14 + (\%P\#100)12.29 + (\%P\#200)32.77}{100}$$

Where:

SA = surface area, m^2/kg

$\%Pi$ = Aggregate passing sieve # i, %.

Note 41—*%P#30* and *%P#100* are automatically interpolated in the DATA_Film Thickness worksheet by using the *%P#16–%P#50* and *%P#50–%P#200*, respectively.

19.10 Calculate F_T:

$$P_{ba} = 100 * G_s \left(\frac{G_e - G_{sb}}{G_{sb} * G_e}\right)$$

$$P_{be} = A_s - P_{ba}\left(\frac{100 - A_s}{100}\right)$$

$$F_T = \frac{\left(\frac{P_{be}/100}{1 - P_{be}/100}\right)}{SA * G_s * 1000} * 10^6$$

Where:
P_{ba} = absorbed asphalt in mixture, %
G_{sb} = bulk specific gravity of combined aggregates
P_{be} = effective asphalt in mixture, %
F_T = film thickness of asphalt binder in mixture, microns.

20. ARCHIVED VERSIONS

20.1 Archived versions are available.

Tex-204-F, Aggregate & Liquid Asphalt Class Exercise

Washed Sieve Analysis (Percent Passing)

Aggregate	Class A		Class B		Class B		Class B		
	C Rock		D Rock		Screenings		Sand		Total
Bin %	24.0%		36.0%		25.0%		15.0%		100.0
Sieve	Cum. % Passing	Wtd. Cum %	Cum. % Passing	Wtd. Cum %	Cum. % Passing	Wtd. Cum %	Cum. % Passing	Wtd. Cum %	Cum. % Passing
1”	100.0		100.0		100.0		100.0		
¾”	100.0		100.0		100.0		100.0		
⅜”	9.8		96.3		100.0		100.0		
#4	3.3		40.5		100.0		100.0		
#8	2.0		8.8		68.1		100.0		
#30	2.0		4.7		27.2		88.5		
#50	1.5		3.3		16.3		22.5		
#200	1.0		2.8		5.7		2.6		

Calculation

$$\% \text{ Total } CL_A = \frac{\% \ CL_A}{(\% \ CL_A + \% \ CL_B)} \times 100$$

% Total CL_A = Total percentage retained of Class A aggregate on the #4 sieve
% CL_A = Percentage retained of Class A aggregate on the #4 sieve
% CL_B = Percentage retained of Class B aggregate on the #4 sieve

Tex-204-F, G_e & G_t Class Exercise

Calculations

Calculation of the Effective Specific Gravity

$$G_e = \frac{100 - A_S}{(100 / G_r) - (A_s / G_s)}$$

Calculation of the Theoretical Specific Gravity

Note: once the average effective specific gravity of the aggregate (Ge) is determined, the theoretical specific gravities for each asphalt content can be calculated with the below formula.

$$G_t = \frac{100}{(A_g / G_{e\,(Avg)}) + (A_s / G_s)}$$

Calculation for the Percent Density of the Molded Specimens

$$\%\ \text{Density} = \frac{Ga}{Gt} \times 100$$

Where:

G_e	=	Effective specific gravity
$G_{e\,(Avg)}$	=	Average of the effective specific gravities obtained
G_t	=	Calculated theoretical maximum specific gravity
A_g	=	Percentage of aggregate in the mixture
A_s	=	Asphalt content, %
Ga	=	Bulk specific gravity
G_r	=	Theoretical maximum specific gravity
G_s	=	Specific gravity of the asphalt binder

Tex-204-F, Mix Design Class Exercise

% Asphalt	G_a	G_r	G_e	G_t	Density

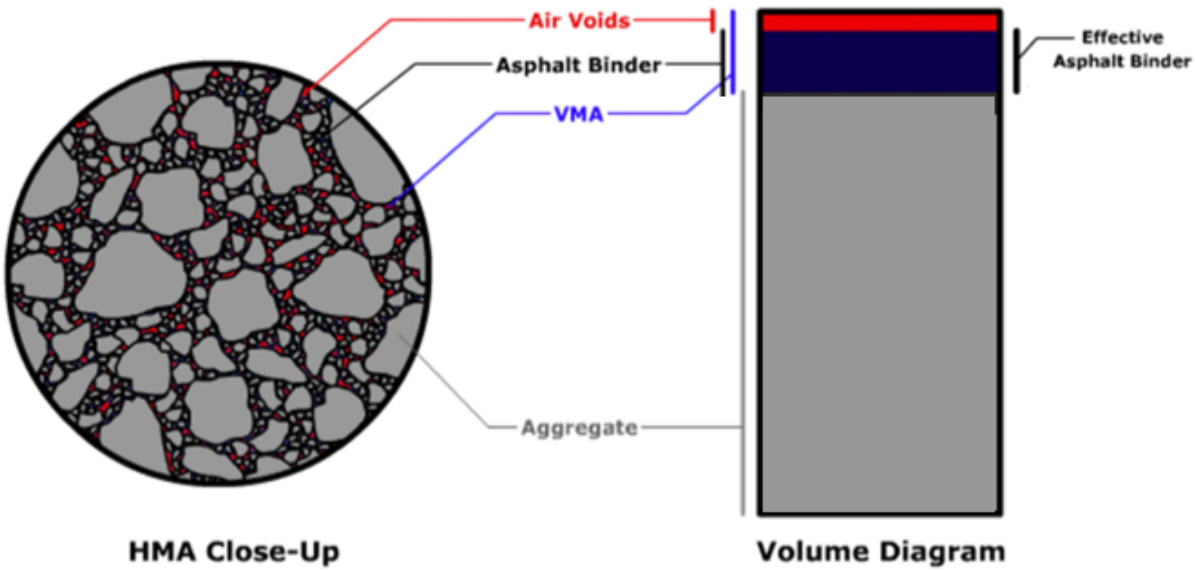
Average G_e =	

Where:

G_a = Bulk specific gravity
G_r = Theoretical maximum specific gravity
G_e = Effective specific gravity
G_t = Calculated theoretical maximum specific gravity

Voids in Mineral Aggregate (VMA)

Voids in the mineral aggregate (VMA) is the space occupied by asphalt and air in a compacted asphalt specimen.



Calculation

Design VMA = $[100 - (G_a / G_t) \times 100] + [(G_a \times A_S) / G_S]$

Production VMA = $[100 - (G_a / G_r) \times 100] + [(G_a \times A_S) / G_S]$

G_s = Specific gravity of asphalt
G_a = Bulk specific gravity of compacted specimens
G_r = Theoretical maximum specific gravity
G_t = Calculated theoretical maximum specific gravity
A_S = Asphalt content, %

Practice Problem

Design VMA = $[100 – (G_a / G_t) \times 100] + [(G_a \times A_S) / G_S]$

Production VMA = $[100 – (G_a / G_r) \times 100] + [(G_a \times A_S) / G_S]$

G_s = 1.030
G_a = 2.345
G_r = 2.460
G_t = 2.448
A_s = 5.0

Steps to Calculate Voids in Mineral Aggregates

Design VMA	Production VMA
Step One: Calculate Density $(G_a / G_t) \times 100$	Step One: Calculate Density $(G_a / G_r) \times 100$
Step Two: Calculate Air Voids 100 – Step One	Step Two: Calculate Air Voids 100 – Step One
Step Three: Calculate Volume of Asphalt $(G_a \times A_s) / G_s$	Step Three: Calculate Volume of Asphalt $(G_a \times A_s) / G_s$
Step Four: Calculate VMA Step Two + Step Three	Step Four: Calculate VMA Step Two + Step Three

Mix Design Worksheet

	Sample ID	1	2	3	4	5
	% Asphalt					
Rice Gravity	Material					
	Calibrated Pyc					
	Material in H20					
	Gr					

		A	B	A	B	A	B	A	B	A	B
Bulk Gravity	Height										
	Air										
	Water										
	SSD										
	Ga										
	Avg. Ga										

Test Procedure for

LABORATORY METHOD OF MIXING BITUMINOUS MIXTURES

TxDOT Designation: Tex-205-F

Effective Date: August 2016

1. SCOPE

1.1 Use this test method to combine various sizes of aggregates and blend them with asphalt to obtain uniform bituminous mixtures.

1.2 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Balance*, Class G2 in accordance with Tex-901-K, with a minimum capacity of 10,000 g and electronic tare feature.

2.2 *Heating oven,* capable of attaining a temperature of at least 325 ± 5°F (163 ± 3°C).

2.3 *Hot plate.*

2.4 *Mechanical mixer and bowl or round pans*, 8 in. (200 mm) in diameter and 3 in. (80 mm) deep.

2.5 *Small, pointed masonry trowels.*

2.6 *Small bowl or round pan*, less than 8 in. (200 mm) in diameter.

2.7 *Mercury thermometer,* marked in 5°F (3°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

2.8 *Angled pliers.*

2.9 *Insulating gloves*.

3. MATERIALS

3.1 *Asphalt cement.*

3.2 *Graded aggregate*.

3.3 *Additives,* if applicable.

3.4 *Recycled materials*, such as Reclaimed Asphalt Pavement (RAP) or Recycled Asphalt Shingles (RAS), if applicable.

4. PROCEDURE

4.1 Design the bituminous mixture as described in Tex-204-F. Use the calculated amounts of aggregate and asphalt, (including additives and recycled materials, when applicable,) to satisfy the requirements of the specifications.

4.2 Separate the material retained on the No.8 (2.36 mm) sieve for each stockpile into individual sieve sizes as required by the specification.

Note 1—Do not divide the material passing the No.8 (2.36 mm) sieve into smaller sieve sizes unless segregation is apparent or absolute control is necessary, since a minimum amount of segregation occurs in this material.

4.3 Place the pan, with or without a trowel, or small bowl on the balance and tare the balance.

Note 2—It is recommended, but not mandatory, to use a trowel or small bowl. Use the trowel to separate the aggregate sizes as they are added. This aids in the removal of excess material if too much is accidentally added.

4.4 Use the individual or cumulative weight for each sieve size calculated.

Note 3—Weigh the fine aggregate passing the No.8 (2.36 mm) sieve last. Adjust the weight of the aggregate batch by adding or removing very small amounts of fines to equal the total weight if necessary.

4.5 Add the calculated amount of aggregate for the largest sieve size from the first stockpile into the pan. Place the blade of the trowel or the small bowl in a flat position on top of this layer as noted in Section 4.3, if desired, and add the calculated amount of the aggregate for the next smaller sieve size on the trowel or to the side of the previous aggregate added. Add all the aggregate sizes for all the stockpiles, mineral filler, and hydrated lime to the pan by repeating this process.

Note 4—The blade of the trowel or the small bowl momentarily separates the aggregate being weighed from the portion that was previously placed in the pan or bowl. Use the trowel to retrieve any excess aggregate.

4.6 Mix the dry aggregate weighed in Section 4.5 until all sizes and materials are blended thoroughly.

Note 5—It is important to blend the dry aggregate thoroughly when adding hydrated lime as an anti-stripping additive.

4.7 Select a mixing temperature from Table 1 based on the asphalt binder specified on the plans. When adding warm mix asphalt (WMA) additives or using WMA processes in the laboratory, select the mixing temperature based on the asphalt binder specified on the plans.

Note 6—If using RAP or RAS and a substitute PG binder in lieu of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the mixing temperature.

4.8 Place a thermometer into the aggregate and set the aggregate in an oven maintained at or slightly above the mixing temperature selected in Section 4.7.

Note 7—Do not leave the trowel in the pan when heating materials.

4.9 Place the calculated quantity of asphalt and any required liquid additives into a small can to facilitate handling. Heat this material in an oven slowly to the temperature selected in Section 4.7.

Note 8—Do not allow the asphalt to heat to a temperature above the maximum temperature allowed for storage in the Department's *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges,* Item 300, or the recommended temperature obtained from the Construction Division's Materials and Pavements Section (CST/M&P), Flexible Pavements Branch.

Note 9—Incorporate and mix WMA additives into the laboratory mixture or use WMA processes according to the WMA supplier's recommendations, when applicable.

4.10 Place the calculated quantity of RAP or RAS in a separate pan, when applicable. Heat the material in an oven at the mixing temperature selected in Section 4.7.

Note 10—Keep heating time for recycled materials to a minimum to avoid further hardening of the recycled material asphalt binder.

4.11 Remove the aggregate from the oven after the aggregate has reached the required mixing temperatures. Remove the thermometer.

4.12 Slowly place the heated aggregate into a mixing bowl. When applicable, add the heated recycled materials to the heated aggregate and thoroughly blend the materials.

4.13 Make a small depression in the center of the aggregate using a trowel, without exposing the bottom of the mixing bowl, to receive the asphalt material.

4.14 Place the mixing bowl with the heated aggregate on the scale and tare. Add the required amount of preheated asphalt material.

Note 11—Use gloves or a pair of side angle pliers to avoid burning hands. Remove excess asphalt, if necessary.

4.15 Thoroughly mix to blend the asphalt material and the aggregate, either by hand or with a mechanical mixer. Use a trowel to blend the aggregate around the side of the pan when mixing by hand. Take care to prevent free asphalt material from coming in contact with the side or bottom of the mixing pan.

4.16 Mix the aggregate and asphalt material continuously until the materials are coated thoroughly.

Note 12—It may be necessary to adjust the mixing time or temperature for some mixtures to coat the aggregate particles thoroughly. Carefully consider and calculate the speed and time of mixing and the clearance between the mixing device and the bowl to prevent abnormal degradation of the aggregate, when using a mechanical mixer.

4.17 Split the mixture into the appropriate size, as need it, and place the samples in the oven.

4.18 Identify each mixture with a laboratory number and indicate the percentage of asphalt.

5. MIXING TEMPERATURE

5.1 Mixtures containing asphalt materials not listed in Table 1, or those containing viscosity-modifying additives, may require considerably varied mixing temperatures from those listed. For guidance, consult the binder supplier or the Flexible Pavements Branch of the Materials and Pavements Section of the Construction Division.

5.2 The Engineer must approve the use of asphalt material and mixing temperatures different from those listed in Table 1.

Table 1—Asphaltic Material Mixing Temperatures by Grade and Type

Type-Grade[1]	Asphalt Material Temp. °F (°C)	Mixing Temp. °F (°C)[2]
PG 70-28, PG 76-22	325 (163)	325 (163)
PG 64-28, PG 70-22	300 (149)	300 (149)
PG 64-22, PG 64-16	290 (143)	290 (143)
AC-3,5,10; PG 58-28, PG 58-22	275 (135)	275 (135)
RC-250	100 (38)	165 (74)
MC-250	100 (38)	165 (74)
MC-800	140 (60)	190 (88)
CMS-2	140 (60)	235 (113)
AES-300	140 (60)	235 (113)
Asphalt-Rubber (A-R) Binder	325 (163)	325 (163)

1. If using RAP or RAS and a substitute PG binder in lieu of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the mixing temperature.
2. When using RAP or RAS, mixing temperature may be increased up to 325°F to achieve adequate coating.

6. ARCHIVED VERSIONS

6.1 Archived versions are available.

Test Procedure for

DETERMINING DENSITY OF COMPACTED BITUMINOUS MIXTURES

TxDOT Designation: Tex-207-F

Effective Date: January 2020

1. SCOPE

1.1 This test method determines the bulk specific gravity (G_a) of compacted bituminous mixture specimens. Use the G_a of the specimens to calculate the degree of densification or percent compaction of the bituminous mixture.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with the Superpave nomenclature when required.

Table 1
Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	Superpave	
AC	-	Asphalt Content
A_g	P_s	Percent by weight of aggregate in the mixture
A_s	P_b	Percent by weight of asphalt binder in the mixture
G_a	G_{mb}	Bulk specific gravity of compacted specimens
G_e	G_{se}	Effective specific gravity of the combined aggregates
G_r	G_{mm}	Theoretical maximum specific gravity
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test
G_s	G_b	Specific gravity of the asphalt binder determined at 77°F (25°C)
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified AC

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. DEFINITIONS

2.1 *Bulk Specific Gravity (G_a)*—the ratio of the weight of the compacted bituminous mixture specimen to the bulk volume of the specimen.

2.2 *Percent Density or Percent Compaction*—the ratio of the actual G_a of the compacted bituminous mixture specimen to the theoretical maximum specific gravity of the combined aggregate and asphalt contained in the specimen expressed as a percentage.

PART I—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES

3. SCOPE

3.1 Use this procedure for all compacted bituminous mixtures, except use Part VI for mixtures with more than 2.0% water absorption.

4. APPARATUS

4.1 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g, equipped with suitable apparatus to permit weighing the specimen while suspended in water.

4.2 *Suspension Apparatus, Non-Absorptive String, Metal Bucket, or a Cage*, attached to the balance with a metal wire or a non-absorptive string.

4.3 *Mercury Thermometer,* marked in 2°F (1°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

4.4 *Water Bath with a Tank Heater and Circulator,* for immersing the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level.

4.5 *Towel,* suitable for surface drying the specimen.

4.6 *Vacuum Device,* such as Coredryer (optional).

4.7 *Measuring Device,* such as a ruler, calipers, or measuring tape.

4.8 *Drying Oven,* capable of attaining the temperature specified in the test procedure.

5. TEST SPECIMENS

5.1 Test specimens may be laboratory-molded mixtures or pavement cores.

5.2 Avoid distorting, bending, or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

5.3 Obtain cores in accordance with Tex-251-F, Part I.

5.4 *Laboratory-Molded Specimens:*

5.4.1 Measure and record the specimen height to the nearest 1/16 in.

5.5 *Pavement Cores*

5.5.1 Prepare pavement cores for testing in accordance with Tex-251-F, Part II.

6. PROCEDURES

6.1 For specimens containing moisture, follow the instructions in Sections 6.2–6.9. For laboratory-molded specimens, perform the instructions in Sections 6.3–6.9.

6.2 Place the specimen in an oven with the flat side of the specimen on a flat surface to complete the drying process. Oven-dry the specimen for a minimum of two hr. at a temperature of 115 ± 5°F (46 ± 3°C) to constant weight. "Constant weight" is the weight at which further oven drying does not alter the weight by more than 0.05% in a two hr. or longer drying interval when calculated in accordance with Section 7.1.

Note 1—The oven drying temperature can be reduced to a temperature no lower than 100°F (38°C) provided that the specimen remains in the oven for a minimum of eight hr.

Note 2—As an option, for specimens not subject to further testing and evaluation, rapid dry in an oven at a temperature of 140°F (60°C), for a maximum of 12 hr. to constant weight.

Note 3—As an option, use a Coredryer in conjunction with or instead of a drying oven. Dry all samples to a constant weight as defined in Section 6.2.

6.3 Allow the specimen to cool, and then weigh in air to the nearest 0.1 g.

6.4 Record and designate this weight as *A* in Section 7.2.

6.5 Unplug or turn off the water circulator in the water bath while obtaining the submerged sample weight. Attach the suspension apparatus to the scale and submerge in water. Tare the scale with the suspension apparatus submerged in water.

6.6 Immerse the specimen in a water bath at 77 ± 3°F (25 ± 2°C).

6.7 Leave the sample in the water for three min. ± 15 sec. When the scale readings stabilize, record the specimen weight and designate as *C* in Section 7.2.

6.8 Remove the specimen from water. Dry the surface of the specimen by blotting gently with a damp towel for no longer than 20 sec. To facilitate drying, gently rotate the specimen while blotting, if necessary; however do not shake, sling, or perform any action that removes water from within the specimen.

6.9 Weigh the specimen in air. Record as the saturated surface dry weight (SSD) and designate as *B* in Section 7.2.

7. CALCULATIONS

7.1 Calculate the percent difference in weight:

$$PercentDifference = \left(\frac{InitialWeight - FinalWeight}{InitialWeight} \right) * 100$$

7.2 Calculate G_a and percent of water absorbed by the specimen:

$$G_a = \frac{A}{B - C}$$

Where:
G_a = bulk specific gravity,
A = weight of dry specimen in air, g,
B = weight of the SSD specimen in air, g, and
C = weight of the specimen in water, g.

$$Percent\ absorption = \frac{B - A}{B - C} \times 100$$

Where:
A = weight of dry specimen in air, g,
B = weight of the SSD specimen in air, g, and
C = weight of the specimen in water, g.
Note 4—If the percent absorption exceeds 2.0%, use Part VI.

PART II—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING PARAFFIN

8. SCOPE

8.1 The paraffin method is no longer an accepted process.

8.2 Refer to Part VI of this test procedure for absorptive mixtures (those with more than 2.0% water absorption).

PART III—DETERMINING IN-PLACE DENSITY OF COMPACTED BITUMINOUS MIXTURES (NUCLEAR METHOD)

9. SCOPE

9.1 Use this procedure to determine the in-place density of compacted bituminous mixtures using a nuclear density gauge.

10. APPARATUS

10.1 *Nuclear Density Gauge.*

10.2 *Portable Reference Standard.*

10.3 *Calibration Curves for the Nuclear Gauge.*

10.4 *Scraper Plate and Drill Rod Guide.*

10.5 *Drill Rod and Driver or Hammer.*

10.6 *Shovel, Sieve, Trowel, or Straightedge and Miscellaneous Hand Tools.*

10.7 *Gauge Logbook.*

11. STANDARDIZATION

11.1 To standardize the nuclear density gauge, turn on the apparatus and allow it to stabilize.

Note 5—Follow the manufacturer's recommendations to ascertain the most stable and consistent results.

11.2 Perform standardization with the apparatus located at least 25 ft. (8 m) away from other sources of radioactivity. Clear the area of large masses or other items that may affect the reference count rate.

Note 6—The preferred location for standardization checking is the pavement location tested. This is the best method for determining day-to-day variability in the equipment.

11.3 Take a minimum of four repetitive readings using Table 2 at the normal measurement period, and determine the average of these readings.

Note 7—One measurement period of four or more times the normal period is acceptable if available on the apparatus. This constitutes one standardization check.

11.4 Detect the total number of gammas during the period by determining the count per measurement period. Correct the displayed value for any prescaling built into the instrument. Record this corrected value as N_s.

Note 8—The prescale value (F) is a divisor, which reduces the actual value for the purpose of display. The manufacturer will supply this value if other than 1.0.

11.5 Use the value of N_s to determine the count ratios for the current day's use of the instrument.

Note 9—Perform another standardization check if for any reason the measured density becomes suspect during the day's use.

11.6 Table 2 lists the required actions to take based on the results from Section 11.3.

Table 2
Reference Standard

If . . .	Then. . .
the value obtained is within the limits stated in limits calculation	the apparatus is considered to be in satisfactory operating condition and the value may be used to determine the count ratios for the day of use.
the value is outside these limits	allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference, then conduct another standardization check.
the second standardization check is within the limits	the apparatus may be used.
the second standardization check also fails the test	the apparatus must be adjusted or repaired as recommended by the manufacturer.

12. CALCULATIONS

12.1 Use the test results from Section 11.3 and the following calculations to determine the limit:

$$(N_s - N_o) \leq 2.0\sqrt{N_o / F}$$

Where:

N_s = value of current standardization count

N_o = average of the past four values of N_s taken previously

F = value of any prescale.

13. PROCEDURE

13.1 To determine the in-place density using a nuclear density gauge, select an area that is relatively free of loose material, voids, or depressions. Avoid elevating the gauge above the surface of the material to be tested.

Note 10—Select an area at least 12 in. (0.3 m) away from surface obstructions such as curbing, etc. It is optional to use fine sand to fill any voids or minor depressions.

13.2 Measure the density of the selected area in either the backscatter or direct transmission mode.

Note 11—The direct transmission method is only applicable for lifts greater than two in. (50 mm) thick.

13.3 Follow the instructions in Sections 13.3.1–13.3.2 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the backscatter mode.

13.3.1 Firmly seat the density gauge on the selected area so it is in full contact with the surface.

13.3.2 Record the readings that are required at each location with the probe in the backscatter position. Do not leave the gauge in one position on the compacted bituminous pavement for a long time, as erratic readings may result from the hot surface. Proceed to Section 13.5.

13.4 Follow the instructions in Sections 13.4.1–13.4.4 to measure the in-place density of compacted bituminous pavements using a nuclear density gauge in the direct transmission mode.

13.4.1 Make a hole two in. (50 mm) deeper than the transmission depth used with the drive pin and guide plate.

Note 12—The hole must be as close as possible to 90° from the plane surface.

13.4.2 Firmly seat the density gauge on the prepared area so it is in full contact with the surface.

13.4.3 Adjust the probe to the desired transmission depth. Pull the gauge so that the probe is in contact with the side of the hole nearest the detector tubes.

13.4.4 Measure and record the readings required for each location for the particular type of gauge used. Proceed to Section 13.5.

13.5 Use one of the following methods to determine the in-place density.

13.5.1 Divide the field counts by the standard counts.

OR

13.5.2 Use the appropriate calibration curves, if necessary.

Note 13—Most models are now programmable to provide direct reading of the nuclear density or percent compaction.

13.6 Take cores or sections of the pavement from the same area selected for the nuclear tests when correlating the nuclear density to the actual density of the compacted material.

13.7 Measure the G_a of the cores or samples taken from the selected area tested for density as described in Part I or Part VI. Establish a correlation factor using a minimum of seven core densities and seven nuclear

densities. Adjust the nuclear density readings using this correlation factor to correlate with the actual G_a determined through laboratory testing.

Note 14—When testing thin lifts in the backscatter mode, the influence of underlying strata with varying densities may render this procedure impractical without special planning. Most manuals for the nuclear gauge describe the various methods to use with thin lifts.

13.8 Make correlations as described in Section 13.6 and compare the correlated nuclear density to the G_r or G_{rc} of the mixture when controlling in-place density with the nuclear gauge. Calculate the percent density or directly read from programmable models to determine air-void content.

PART IV—ESTABLISHING ROLLER PATTERNS (CONTROL STRIP METHOD)

14. SCOPE

14.1 Use this procedure to establish roller patterns for bituminous pavement.

15. APPARATUS

15.1 *Nuclear Density Gauge.*

15.2 *Electrical Impedance (Nonnuclear) Density Measurement Gauge* (Optional).

15.3 *Portable Reference Standard.*

15.4 *Calibration Curves for the Nuclear Gauge.*

15.5 *Scraper Plate and Drill Rod Guide.*

15.6 *Drill Rod and Driver or Hammer.*

15.7 *Shovel, Sieve, Trowel, or Straightedge and Miscellaneous Hand Tools.*

15.8 *Gauge Logbook.*

16. PROCEDURE

16.1 To establish roller patterns (control strip method), refer to the gauge manufacturer's instructions for operating the density gauge.

Note 15—Standardize the equipment at the start of each day's use as described in Part III when using a nuclear density gauge.

Note 16—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

16.2 Establish a control strip approximately 300 ft. (90 m) long and at least 12 ft. (3.5 m) wide or the width of the paving machine. Select three test sites.

Note 17—Avoid areas near edges or overlap of successive passes of the rollers.

16.3 Allow the roller to complete a minimum of two coverages of the entire control strip before checking the density. Perform density tests at the three test sites selected. Record the results. Mark each test site very

carefully so that subsequent tests made are in the same position and location. Use a colored marker keel to outline the gauge before taking the readings. Take the tests as quickly as possible and release rollers to complete additional coverage to prevent cooling of unrolled areas.

16.4 Repeat the density tests at the previously marked test sites. Continue this process of rolling and testing until there is no significant increase in density. Try several different combinations of equipment, and numbers of passes with each combination, to determine the most effective rolling pattern.

Note 18—In-place density determined with roadway cores is the final measure of rolling pattern effectiveness.

16.5 Construct another section, without interruption, using the roller patterns and number of coverages determined by the control strip after completion of the control strip tests. Take random density tests on this section to verify the results from the control strip.

Note 19—It may be possible to reduce the required coverages based on these tests.

16.6 Make density tests for job control in accordance with the *Guide Schedule of Sampling and Testing* or as often as necessary, when some changes in the compacted material indicate the need.

17. NOTES

17.1 Visual observation of the surface being compacted is a very important part of this procedure. Cease rolling and get an evaluation of the roller pattern if obvious signs of distress develop, such as cracking, shoving, etc. Structural failures due to over-compaction will cause the density tests to indicate the need for more compaction. Observe closely and take particular care when using vibratory rollers, since they are more likely to produce over-compaction in the material.

17.2 Use the minimum test time allowed by the particular gauge when measuring density on hot material, since the gauge may display erratic results if overheated.

17.3 Exercise particular care to clean the bottom of the gauge after using it on asphalt pavement.

17.4 Use the correlation procedures outlined in Part III, Section 13.7 when using specified density and rolling patterns with a nuclear density gauge.

17.5 This procedure provides a general guide to establish roller patterns. Follow the manufacturer's instruction manual furnished with the particular density gauge for specific operation of that gauge. This is essential, since several different models and different brands are in standard use by the Department.

17.6 Nuclear gauges and the user of the nuclear gauges must meet all requirements of the Department's radioactive material license, "Nuclear Gauge Operating Procedures," and the *Texas Rules for Control of Radiation*.

PART V—DETERMINING MAT SEGREGATION USING A DENSITY-TESTING GAUGE

18. SCOPE

18.1 Use this procedure to identify segregation in bituminous pavements after placement on the roadway using a density-testing gauge.

19. APPARATUS

19.1 *Nuclear Density Gauge.*

19.2 *Thin Lift Density Gauge* (Optional).

19.3 *Electrical Impedance (Nonnuclear) Measurement Gauge* (Optional).

19.4 *Measuring Tape* (Optional).

20. REPORT FORMS

20.1 Use Segregation Density Profile Form to identify segregation in a pavement section.

21. PROCEDURE

21.1 Refer to the manufacturer's instructions for operating the density gauge.

Note 20—It is not necessary to calibrate the gauge to the mix.

Note 21—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

21.2 Profile a 50 ft. (15 m) section of the bituminous pavement.

21.3 When profiling a location where the paver stopped for more than 60 sec., perform the instructions in Sections 21.3.1–21.3.3.

21.3.1 Identify the location where the paver stopped paving, such as sporadic mix delivery.

21.3.2 Move approximately 10 ft. (3 m) behind the location where the paver stopped paving, and mark and record this location as the beginning of the profile section.

21.3.3 Proceed to Section 21.6.

21.4 When profiling a random location, randomly select an area, and then choose an area with visible segregation, if possible. Proceed to Section 21.6.

21.5 When profiling an area with segregation of longitudinal streaking greater than the profile length, perform the instructions in Sections 21.5.1–21.5.5.

21.5.1 Profile the area at an angle in a diagonal direction.

21.5.2 Start the profile with a transverse offset of 2 ft. (0.6 m) from the center of the longitudinal streak.

21.5.3 End profile with a transverse offset of 2 ft. (0.6 m) on the opposite side of the longitudinal streak.

21.5.4 Do not start or end a profile less than 1 ft. (0.3 m) from the pavement edge.

21.5.5 Proceed to Section 21.7.

21.6 Determine the transverse offset 2 ft. (0.6 m) or more from the pavement edge. Take density readings in a longitudinal direction and do not vary from this line. Visually observe the mat and note the surface texture in

the section and the location of any visible segregated areas. Take additional readings along the transverse offset in areas with visible segregation. Include any visually segregated areas in the profile.

21.7 After completion of the final rolling patterns, position the density gauge at the identified location.

21.7.1 *Use of a Nuclear Density Gauge:*

21.7.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge at each random sample location.

21.7.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

21.7.2 *Use of an Electrical Impedance Gauge:*

21.7.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 22—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

21.8 Record the in-place density gauge readings.

21.9 Average the readings before moving the density gauge. Compare each individual reading to the average. Discard any single readings that vary more than 1 pcf (16 kg/m^3) from the average. Take additional readings to replace the discarded readings until all the readings are within 1 pcf (16 kg/m^3) of the average.

21.10 Move the density gauge approximately 5 ft. (1.5 m) forward in the direction of the paving operation. Take an additional set of readings at any location with visible segregation in between the 5 ft. (1.5 m) distance.

21.11 Repeat the instructions in Sections 21.7–21.10. Complete a minimum of 10 sets of readings.

Note 23—Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.

21.12 Determine the average density from all locations.

21.13 Determine the difference between the highest and lowest average density.

21.14 Determine the difference between the average and lowest average density.

21.15 Record the data using the Example Segregation Profile Worksheet.

PART VI—BULK SPECIFIC GRAVITY OF COMPACTED BITUMINOUS MIXTURES USING THE VACUUM METHOD

22. SCOPE

22.1 Use this procedure to determine the G_a of compacted bituminous mixtures using the vacuum device. This procedure is applicable for mixtures with more than 2.0% water absorption.

23. APPARATUS

23.1 *Specialized Vacuum Sealing Device.*

23.2 *Balance,* Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g, equipped with suitable apparatus to permit weighing of the specimen while suspended in water.

23.3 *Suspension Apparatus, Non-Absorptive String, Metal Bucket, or Cage,* attached to the balance with a metal wire or a non-absorptive string.

23.4 *Mercury Thermometer,* marked in 2°F (1°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

23.5 *Water Bath with a Tank Heater and Circulator,* for immersing the specimen in water while suspended from a scale, equipped with an overflow outlet for maintaining a constant water level.

23.6 *Vacuum Device,* such as Coredryer (optional).

23.7 *Measuring Device,* such as a ruler, calipers, or measuring tape.

24. TEST SPECIMENS

24.1 Test specimens may be laboratory-molded mixtures or pavement cores.

24.2 Avoid distorting, bending or cracking the specimens during and after removal from pavements or molds. Store the specimens in a cool place.

24.3 Obtain cores in accordance with Tex-251-F, Part I.

24.4 *Laboratory-Molded Specimens:*

24.4.1 Measure and record the specimen height to the nearest 1/16 in.

24.5 *Pavement Cores:*

24.5.1 Prepare pavement cores for testing in accordance with Tex-251-F, Part II.

25. MATERIALS

25.1 Use a supply of large and small-specialized polymer bags as recommended by the manufacturer.

26. PROCEDURES

26.1 *Vacuum Sealing Device Setup:*

26.1.1 Set the vacuum timer.

Note 24—The manufacturer calibrates the vacuum pump timer setting and exhaust at the factory to eliminate drift and variability due to the sealing process. The vacuum pump operates for approximately one min. Contact the manufacturer for adjustments if the vacuum pump stops before this time has elapsed.

26.1.2 Set the sealing bar timer in accordance with the vacuum device manufacturer's recommendations.

Note 25—Inspect the seal quality after the first sealing operation. Reduce the setting if the polymer bag stretches or burns. Increase the setting if the seal is not complete or the bag easily separates.

26.2 *Determine the G_a of Compacted Bituminous Mixtures:*

26.2.1 Perform the instructions in Sections 26.2.2–26.2.3 for specimens containing moisture. Proceed to Section 26.2.4 for laboratory-molded specimens.

26.2.2 Proceed to Section 26.2.3 or, as an option, pre-dry the specimen using a Coredryer or air dry to remove excess moisture.

26.2.3 Place the specimen in an oven with the flat side of the specimen on a flat surface. Oven-dry the specimen for a minimum of two hr. at a temperature of 115 ± 5°F (46 ± 3°C) to a constant weight. "Constant weight" is the weight at which further oven drying does not alter the weight by more than 0.05% in a two hr. or longer drying interval in accordance with Section 7.1. Refer to Part I, Notes 3 and 4.

26.2.4 Allow the specimen to cool to room temperature, and then weigh in air to the nearest 0.1 g. Record and designate this weight as *A* in Section 27.1.

26.2.5 Open the lid of the vacuum device. Stack or remove rectangular spacer plates in the vacuum chamber of the vacuum device so there is adequate space for the test specimen.

26.2.6 Place a sliding plate in the vacuum chamber on top of the spacer plates away from the seal bar.

Note 26—Place the sliding plate in the chamber to reduce friction during the sealing operation.

26.2.7 Select and use a large or small polymer bag, as recommended by the manufacturer, to seal the specimen.

26.2.8 Weigh the selected polymer bag and record and designate this weight as *B* in Section 27.1.

26.2.9 *Determine the Polymer Bag Correction Factor (CF):*

26.2.9.1 Calculate the ratio, R, by dividing the weight of the specimen by the weight of the bag.

26.2.9.2 Use the CF Table provided in the manufacturer's operator guide.

26.2.9.3 Look up the calculated R-value and record and designate the corresponding correction factor from the table as *CF* in Section 27.1.

26.2.10 *Vacuum Seal the Specimens:*

26.2.10.1 Place the bag inside the chamber.

26.2.10.2 Place the specimen in the polymer bag, carefully avoiding puncturing or tearing the bag.

26.2.10.3 Center the core in the bag, leaving approximately 1 in. (25.4 mm) of slack on the backside.

26.2.10.4 Position the bag so that approximately 1 in. (25.4 mm) of the open end is evenly against the sealing bar.

26.2.10.5 Close the lid of the vacuum device and hold firmly for two to three sec.

Note 27—The vacuum pump will start, and the lid will stay closed on its own. The vacuum gauge will read less than 28 in. (50 mm) Hg.

26.2.10.6 The lid of the vacuum device will automatically open upon completion of the sealing process. Carefully remove the sealed specimen from the chamber. Gently pull on the polymer bag to ensure the seal is tightly conformed to the specimen. Return to the instructions in Section 26.2.8 if the seal is not tightly conformed to the specimen.

Note 28—A loose seal may be an indication of a leak.

26.2.11 Determine the type of apparatus to use to weigh the samples suspended in water.

26.2.12 Unplug or turn off the water circulator in the water bath while obtaining the submerged sample weight. Attach the apparatus to the scale and submerge in water. Tare the scale with the apparatus submerged in water.

26.2.13 Completely submerge the sealed specimen in water at 77 ± 3°F (25 ± 2°C) and record the weight of the specimen in the bag. Weigh the sealed specimen in water. Record the weight to the nearest 0.1 g when the scale reading stabilizes. Designate this weight as *C* in Section 27.1.

Note 29—Do not allow the polymer bag to touch the sides of the water bath.

26.2.14 Remove the specimen from the polymer bag and reweigh the specimen in air. Compare this weight to the weight recorded for *A* in Section 26.2.4. If the difference in weight is greater than 5 g, a leak may have occurred. Dry the sample to a constant weight and repeat the procedure using a new polymer bag.

26.3 Do not use the test results calculated in this test procedure using the vacuum device if this method produces a G_a that is higher than the G_a calculated in Part I.

Note 30—Use the results calculated in Part I of this method in this case.

27. CALCULATIONS

27.1 Calculate the G_a of the compacted specimen:

$$G_a = \frac{A}{\left[\left(A+B\right)-C\right]-\frac{B}{CF}}$$

Where:

G_a = bulk specific gravity,

A = weight of specimen in air, g,

B = weight of the polymer bag in air, g,

C = weight of sealed specimen in water, g, and

CF = correction factor.

PART VII—DETERMINING LONGITUDINAL JOINT DENSITY USING A DENSITY-TESTING GAUGE

28. SCOPE

28.1 Use this procedure to perform a longitudinal joint density evaluation on bituminous pavement using a density-testing gauge.

29. APPARATUS

29.1 *Nuclear Density Gauge.*

29.2 *Thin Lift Density Gauge* (Optional).

29.3 *Electrical Impedance (Nonnuclear) Density Measurement Gauge* (Optional).

29.4 *Measuring Tape* (Optional).

30. FORMS

30.1 Longitudinal Joint Density Profile Form.

31. PROCEDURES

31.1 *Perform a Longitudinal Joint Density Using a Density-Testing Gauge:*

31.1.1 Refer to the manufacturer's instructions for operating the density gauge.

31.1.2 Identify the random sample location selected for in-place air void testing. Mark and record this location as the reference point to perform the joint evaluation.

Note 31—This point must be more than 2 ft. (0.6 m) from the pavement edge.

31.1.3 Position the gauge at the random sample location selected for in-place air void testing identified in Section 36.1.2 after completion of the final rolling pattern.

31.1.3.1 *Use of a Nuclear Density Gauge:*

31.1.3.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge.

31.1.3.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

31.1.3.2 *Use of an Electrical Impedance Gauge:*

31.1.3.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 32—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

31.1.4 Record the density measurements from the density gauge at the random sample location selected for in-place air void testing.

31.1.5 Measure the longitudinal joint density at the right and left edge of the mat, which is or will become a longitudinal joint.

Note 33—Select a location that is perpendicular to the random sample location selected for in-place air void testing.

Identify the joint type as "Confined" or "Unconfined."

Note 34—Take additional readings along the longitudinal joint at areas with visible irregularities or segregation.

31.1.6 Position the gauge with the center placed 8 in. (200 mm) from the pavement edge that is or will become a longitudinal joint. Orient the gauge so the longer dimension of the gauge is parallel to the longitudinal joint.

31.1.6.1 *Use of a Nuclear Density Gauge:*

31.1.6.1.1 Take three one min. readings (minimum time length, longer readings can be used) in backscatter mode when using a nuclear density gauge.

31.1.6.1.2 It is optional to use fine sand passing the No. 40 sieve size to fill any voids without elevating the gauge above the rest of the mat.

31.1.6.2 *Use of an Electrical Impedance Gauge:*

31.1.6.2.1 Take two readings; it is not necessary to move the gauge between readings.

Note 35—Operate electrical impedance (nonnuclear) gauges in continuous mode to ensure all data is from the location in question.

31.1.7 Record the density measurements from the density gauge at the longitudinal joint.

31.1.8 Determine the difference in density between the readings taken at the random sample location selected for in-place air void testing and the readings taken at the longitudinal joint.

Note 36—Use a nuclear density gauge to verify impedance gauge readings whenever readings from an impedance gauge may not be accurate.

31.1.9 Record and report the data using the Example Longitudinal Joint Density Worksheet.

31.2 *Determine a Correlated Joint Density:*

31.2.1 Record the average G_a of the cores taken at the random sample location selected for in-place air voids (*A*).

31.2.2 Record the G_r for each sublot evaluated for joint density (*B*).

31.2.3 Record the average density gauge reading in pcf (kg/m^3) at the longitudinal joint sample location for in-place air voids (*C*).

31.2.4 Record the average density gauge reading in pcf (kg/m^3) at the interior mat random sample location for in-place air voids (*D*).

31.2.5 Record and report the data using the Example Longitudinal Joint Density Worksheet.

32. CALCULATIONS

32.1 Calculate the correlated joint density, CJD (%) of the compacted specimen:

$$CJD(\%) = \frac{A}{B} \times \frac{C}{D} \times 100$$

Where:

A = Average G_a of cores at random sample location,

B = Rice gravity, G_r, for each sublot,

C = Average density gauge reading at the longitudinal joint, pcf (kg/m^3), and

D = Average density gauge reading at the interior mat sample location, pcf (kg/m^3).

PART VIII—DETERMINING DENSITY OF PERMEABLE FRICTION COURSE (PFC) AND THIN BONDED WEARING COURSE (TBWC) MIXTURES

33. SCOPE

33.1 Use this procedure to back-calculate the G_r of loose PFC and TBWC mixtures, to calculate the G_a of laboratory-molded specimens for PFC and TBWC mixtures using dimensional analysis, and to calculate density of compacted PFC and TBWC mixtures.

34. APPARATUS

34.1 *Measuring Device,* such as a ruler, calipers, or measuring tape.

35. PROCEDURE

35.1 Back calculate G_r.

35.1.1 Obtain the G_e of the combined aggregate blend.

Note 37—Obtain the G_e from the Summary worksheet of the Mix Design Template.

35.1.2 Record and designate this as G_e in Section 36.1.

35.1.3 Determine the AC of the PFC or TBWC mixture.

Note 38—Determine the AC of PFC-Asphalt Rubber (AR) mixtures by using the asphalt flow meter. Determine the AC of PFC PG 76 mixtures using an ignition oven in accordance with Tex-236-F or by using the asphalt flow meter

35.1.4 Record and designate this as A_s in Section 36.1.

35.1.5 Determine the specific gravity of the asphalt binder. Round to three decimal places (0.001).

35.1.6 Record and designate this as G_s in Section 36.1.

35.1.7 Calculate G_r as noted in Section 36.1.

35.2 Calculate G_a using dimensional analysis.

35.2.1 Measure the weight of the laboratory molded specimen in air, to the nearest 0.1 g.

35.2.2 Record and designate this weight as W in Section 36.2.

35.2.3 Measure the height of the laboratory-molded specimen, to the nearest 0.1 mm.

35.2.4 Record and designate this height as h in Section 36.2.

35.2.5 Measure the diameter of the laboratory-molded specimen, to the nearest 0.1 mm.

Note 39—The diameter for specimens molded with a Superpave Gyratory Compactor is 150 mm.

35.2.6 Calculate the radius of the laboratory-molded specimen by dividing the diameter, as determined in Section 34.2.5, by 2.

Note 40—The radius for specimens molded with a Superpave Gyratory Compactor is 75 mm.

35.2.7 Record and designate this as *r* in Section 36.2.

35.2.8 Calculate G_a as noted in Section 36.2.

Note 41—Numerical value for π is 3.14.

35.3 Calculate density of compacted PFC or TBWC mixture.

35.3.1 Divide the G_a determined in Section 35.2.8 by the G_r determined in Section 35.1.7.

35.3.2 Multiply the results from Section 35.3.1 by 100.

Note 42—Round this calculated value to the tenth decimal place (0.1).

36. CALCULATIONS

36.1 Calculate the G_r of the loose PFC or TBWC mixture:

$$G_r = \frac{100}{\left[\left(\frac{100 - A_s}{G_e}\right) + \left(\frac{A_s}{G_s}\right)\right]}$$

Where:

G_r = theoretical maximum specific gravity,

G_e = effective specific gravity, %,

A_s = AC, %,and

G_s = asphalt binder specific gravity, 0.001.

36.2 Calculate the G_a of the compacted specimen:

$$G_a = \frac{\left[\frac{W}{\pi r^2 h}\right]}{\gamma}$$

Where:

G_a = bulk specific gravity,

W = weight of specimen, 0.1 g,

π = pi, 3.14,

r = radius of specimen, 1 mm,

h = height of specimen, 0.1 mm, and

γ = density of water, 0.001 g/mm^3.

37. REPORT FORMAT

37.1 Use the following Excel programs to calculate and report density test results.

37.1.1 Quality Control/Quality Assurance (QC/QA), used in conjunction with the hot mix specification and test data worksheets. Refer to the "Help" tab for detailed instructions on how to use the program.

37.1.2 Segregation Density Profile Form.

37.1.3 Longitudinal Joint Density Profile Form.

38. ARCHIVED VERSIONS

38.1 Archived versions are available.

Test Procedure for

THEORETICAL MAXIMUM SPECIFIC GRAVITY OF BITUMINOUS MIXTURES

TxDOT Designation: Tex-227-F

Effective Date: July 2019

1. SCOPE

1.1 Use this test method to determine the theoretical maximum specific gravity (commonly referred to as "Rice gravity") of a bituminous mixture. The theoretical maximum specific gravity of a bituminous mixture is the bulk specific gravity of that mixture when compacted to the point of zero air voids. Use the specific gravity obtained to calculate the percent air voids and percent voids in mineral aggregates (VMA) contained in compacted samples as described in Tex-207-F. The theoretical maximum specific gravity is also used to calculate the effective specific gravity (G_e) of aggregates as described in Tex-204-F.

1.1.1 Part I is no longer an approved method. Refer to Part II of the test procedure.

1.1.2 Use Part II to perform the test using the 4,500 mL metal vacuum pycnometer and vibrating table.

1.1.3 Part III is no longer an approved method. Refer to Part II of the test procedure.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1
Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	**Superpave**	
G_e	G_{se}	Effective Specific Gravity of Aggregates
G_r	G_{mm}	Theoretical maximum specific gravity
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test

1.3 Use Table 2 to achieve sample size requirements.

Table 2
Sample Size

Nominal Maximum Size of Aggregate in Mixture, in. (mm)[1]	Minimum Weight of Sample, g (lb.)
1 (25.0)	2,500 (5.5)
3/4 (19.0)	2,000 (4.4)
1/2 (12.5)	1,500 (3.3)
3/8 (9.5)	1,000 (2.2)
#4 (4.75)	500 (1.1)

1. Nominal maximum aggregate size is one sieve size larger than the first sieve that retains more than 10% of the total aggregate.

1.4 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

PART I—USING HAND-HELD GLASS PYCNOMETER

2. SCOPE

2.1 The hand-held glass pycnometer is no longer an accepted process.

2.2 Refer to Part II of this test procedure.

PART II—USING A METAL VIBRATORY PYCNOMETER

3. SCOPE

3.1 This procedure measures the theoretical maximum specific gravity of bituminous mixtures using a metal vibratory pycnometer.

4. APPARATUS

4.1 *Metal vacuum pycnometer*, 150 fl. oz. (4,500 mL), with a clear poly (methyl methacrylate) (PMMA) lid for applying vacuum (Humbolt H-1750, Gilson SG-16A, or equal).

4.2 *Vibrating table*, Humbolt H-1755, Gilson SGA-5RT, or equal.

4.3 *Vacuum hoses, connections, tapered stoppers, and valves*, suitable to apply and control the specified vacuum level within the assembly. A vacuum flask or moisture trap needs to be inline between the vacuum pump and the metal vacuum pycnometer to prevent water vapor from entering the vacuum pump.

4.4 *Manometer or vacuum gauge*, able to determine the level of pressure (vacuum) within the assembly.

4.4.1 Do not keep a manometer in the system during routine testing, as a sudden vacuum loss can break it.

4.4.2 Use the manometer to qualify vacuum pumps and water aspirators and check the accuracy of vacuum gauges.

4.5 *Vacuum pump or water aspirator*, to evacuate air from the assembly.

4.5.1 It must be able to reduce residual pressure to 2.0 in. (50 mm) Hg or less before completion of the evacuation process of the procedure. (See Section 10.)

4.5.2 A quick check to determine the adequacy of a vacuum source is possible without the use of a manometer, should the vacuum gauge reading be suspect.

4.5.2.1 Place water in the vacuum flask at slightly above 102°F (39°C) so that the water will be at 102°F (39°C) at the time the maximum degree of evacuation is achieved by the vacuum source.

4.5.2.2 Begin applying vacuum.

4.5.2.3 If the vacuum source is capable of causing a vigorous boil to occur in water at 102°F (39°C) or less, the residual pressure within the system is 2.0 in. (50 mm) Hg or less and the vacuum source meets the requirements for this test method.

4.6 *Balance*, Class G2 in accordance with Tex-901-K, with a minimum capacity of 2,500 g.

4.7 *Masonry trowel and flat scoop.*

4.8 *Sample splitter or quartering machine.*

4.9 *Mercury thermometer*, marked in 2°F (1°C) divisions or less, or digital thermometer capable of measuring the temperature specified in the test procedure.

4.10 *Air circulating fan.*

4.11 *Large, flat-bottom pans.*

4.12 *Vacuum flasks*, of any capacity found suitable to condense water vapor and trap moisture to protect vacuum pump (optional).

4.13 *Stopwatch or timer.*

4.14 *Gloves.*

4.15 *Water bath with a Tank Heater and Circulator*, for calibration of metal pycnometer and for immersing the metal pycnometer and sample in water, while suspended. It should be equipped with an overflow outlet for maintaining a constant water level.

4.16 *Standard U.S. sieves,* as specified in procedure, meeting the requirements of Tex-907-K.

5. CALIBRATING METAL VACUUM PYCNOMETER

5.1 Perform this calibration procedure each day that the pycnometer is used.

5.2 Prepare and calibrate the metal pycnometer as follows, to assure that it is of definite and constant volume.

5.3 Determine the water temperature.

5.3.1 A water temperature of 77 ± 3°F (25 ± 2°C) is a standard calibration and test temperature.

5.3.2 The water temperatures used during the pycnometer calibration and the final weighing of the pycnometer containing evacuated mixture must be within 2°F (1°C).

5.4 Unplug or turn off the water circulator in the water bath while obtaining the submerged pycnometer weight. Tare the scale with the weighing apparatus suspended in water.

Note 1—Equip the scale with a suitable apparatus to permit weighing the metal pycnometer with sample while suspended in water.

5.5 Submerge the metal pycnometer in water by placing it into the water bath at an angle. This will prevent any air from remaining under the bottom of the metal pycnometer. Hang the metal pycnometer from the weighing apparatus and allow the scale to stabilize.

5.6 Weigh and record the weight to the nearest 0.1 g. Record weight as *D* in Section 7.

6. PROCEDURE

6.1 Obtain a representative sample. Minimum sample size requirements are given in Table 2.

6.2 Place sample in a large flat pan and warm in an oven until it becomes workable.

6.3 Heat sample to the minimum temperature and for the least amount of time necessary to separate the mix into individual aggregate particles. If using the theoretical maximum specific gravity in the calculation of laboratory molded density, cure the sample at the same temperature and for the same length of time as the sample used for molding.

6.4 Use a circular motion with a masonry trowel while exerting downward pressure to roll the aggregate and effectively break apart individual coated aggregates. It is important to separate the aggregates, particularly the fine material, to the greatest extent possible without fracturing particles in the process.

6.5 If the aggregate larger than 3/4 in. (19.0 mm) was removed from the laboratory-molded specimens, then sieve aggregate larger than 3/4 in. (19.0 mm) out of the sample.

Note 2−If a Rice gravity is needed to calculate the percent density of road cores for mixes that contain aggregate larger than 3/4 in. (19.0 mm), then perform an additional Rice gravity without removing the aggregate larger than 3/4 in. (19.0 mm).

6.6 Reduce the mix using a quartering machine or by thoroughly blending the material and taking small portions from several places from the entire area of the pan to achieve a sample size conforming to the requirements in Table 2.

6.7 *Alternative One for Determining the Weight of the Sample:*

6.7.1 Weigh the prepared sample at room temperature to the nearest 0.1g

6.7.2 Record the weight as *A* in Section 7.

6.7.3 Transfer the weighed sample into the metal pycnometer.

6.7.4 Take care not to lose any of the material

6.7.5 Proceed to Section 6.9.

6.8 *Alternative Two for Determining the Weight of the Sample:*

6.8.1 Fill the metal pycnometer approximately one third full with water at approximately the temperature used for calibration.

6.8.2 Place the metal pycnometer on the scale.

6.8.3 Zero out or tare the scale.

6.8.4 After the sample has cooled to room temperature, pour the sample into the metal pycnometer.

6.8.5 Record the weight as *A* in Section 7.

6.8.6 Remove the metal pycnometer from the scale and proceed to Section 6.9.

6.9 Cover the sample with water at approximately the temperature used for calibration.

6.9.1 As some cooling can occur during the evacuation procedure, a water temperature a few degrees above that used for calibration may help provide the desired water temperature at the time of weighing the evacuated pycnometer.

6.9.2 The water level must be adequate to submerge the entire sample (by approximately 1 in. [25 mm]) yet not be so high as to cause water to siphon into the vacuum lines during the test.

6.10 Place the flat plexiglass vacuum lid with O-ring on the metal pycnometer and place on vibrating table. Clamp to hold in place. Turn on the vacuum pump or water aspirator and lower the residual pressure within the system to 2.0 in. (50 mm) Hg pressure. This equates to a vacuum gauge reading of 27.9 in. (710 mm) Hg at normal sea level atmospheric pressure.

6.11 Turn the vibrating table on and maintain the residual pressure and agitation for 10 to 15 minutes.

Note 3—Water can suck into the aggregate, so the minimum time required to remove air from the sample is best.

6.11.1 If the mix looks lightly coated or the aggregate is absorptive, use 10 min.

6.11.2 If the mix looks well coated and has a thick film of asphalt, use 15 min.

6.12 After the 10 to 15 min. of agitation and evacuation, turn the vibrating table off, turn the vacuum or water aspirator off, and gently release the vacuum. Remove the metal pycnometer from the vibrating table and then remove the flat plexiglass vacuum lid.

6.13 Check the water temperature. It must be within 2°F (1°C) of the calibration temperature.

6.14 Unplug or turn off the water circulator in the water bath while obtaining the submerged sample weight. Tare the scale with the weighing apparatus suspended in water.

6.15 Submerge the metal pycnometer with sample in water by placing it into the water bath at an angle. This will prevent any air from remaining under the bottom of the metal pycnometer. Hang the metal pycnometer from the weighing apparatus and allow the scale to stabilize.

6.16 Weigh and record the weight to the nearest 0.1 g. Record weight as *E* in Section 7.

6.17 Perform the instructions in Sections 6.18–6.26 if the aggregate absorbs water during the test. This can occur when the surfaces of any absorptive aggregate are not completely coated or are coated very thinly with asphalt. This problem may increase when highly effective vacuum pumps are used and if the samples

remain exposed to this vacuum for an excessive time. Very porous aggregates, such as lightweight aggregates, are particularly prone to absorb water during this test.

6.18 Tare a large flat pan.

6.19 Pour the contents of the pycnometer into the pan. Rinse particles clinging to the wall of the pycnometer into the pan.

6.20 Decant the water from the pan over a No. 200 (75 µm) sieve, taking care to avoid loss of any of the sample.

6.21 Tilt the sample pan to further drain water to the bottom and place in front of an electric fan to remove surface moisture. Set the fan so that it will not cause movement of the fine particles of the mixture.

6.22 Remove water draining to the bottom of the pan with a suction bulb.

6.23 Stir the sample intermittently with a trowel until the sample is almost surface dry.

6.24 Increase the drying cycle to 15min. intervals, stirring for two min. every interval. Weigh after every other stirring. When the loss in mass is 0.5 g or less, the sample is surface dry. Record this weight as A_{sd} in Section 7.

6.25 Verify the validity of the end-point by drying for an additional 30min. period when practical.

6.26 If a loss greater than 0.5 g occurs, continue drying until the new endpoint is reached. Record this new value as A_{sd} in Section 7.

6.27 See notes in Section 10 for additional information.

7. CALCULATIONS

7.1 Calculate theoretical maximum specific gravity:

$$G_r = \frac{A}{D + A - E}$$

Where:

G_r = theoretical maximum specific gravity

A = weight of dry sample in air, g

D = weight of calibrated pycnometer submerged in water, g

E = weight of pycnometer containing sample while submerged in water, g

7.2 Calculate theoretical maximum specific gravity (corrected for water absorption during test):

$$G_{rc} = \frac{A}{D + A_{sd} - E}$$

Where:

G_{rc} = theoretical maximum specific gravity corrected for water absorption during test

A = weight of dry sample in air, g

A_{sd} = weight of surface dry sample in air, g

D = weight of calibrated pycnometer submerged in water, g

E = weight of pycnometer containing sample while submerged in water, g

PART III—USING A WIDE-MOUTH HAND-HELD GLASS PYCNOMETER

8. SCOPE

8.1 The wide-mouth hand-held glass pycnometer is no longer an accepted process.

8.2 Refer to Part II of this test procedure.

9. TEST RECORD FORMS

9.1 Use the following Excel forms (in conjunction with hot mix specifications) to calculate and report theoretical maximum specific gravity results:

- HMAC Properties and Gradation,
- HMAC Mixture Design,
- HMAC Mix Properties, and
- Quality Control/Quality Assurance (QC/QA) test data worksheets for 2004 Specifications or for 2014 Specifications.

10. NOTES

10.1 Values for G_r and G_{rc} are rarely equal, even when no water absorption occurs. The determination of the surface dry condition is usually, to some degree, inaccurate because moisture commonly contained inside fine aggregate conglomerates. For this reason, some values will tend to indicate more correction than is justified. The decision on which value to use must be based on the following factors:

10.1.1 *Aggregate Potential for Water Absorption:*

Other factors being equal, if the average aggregate water absorption is lower than accepted parameters during mixture design, the probability for absorption during this test diminishes.

10.1.2 *Asphalt Film Thickness:*

10.1.2.1 Mixtures with high asphalt contents will rarely require absorption correction.

10.1.2.2 High vacuum levels applied to highly absorptive aggregates may overcome this factor.

10.1.2.3 Lean mixtures will often require correction.

10.1.3 *Number of Fractured Aggregates:*

10.1.3.1 Some absorption will always occur when uncoated aggregate remains exposed to vacuum saturation procedures.

10.1.3.2 Consider both the number of these particles and their potential for absorption.

10.1.4 *Vacuum Level applied:*

10.1.4.1 Other factors being equal, highly effective vacuum pumps will cause more water absorption than less effective pumps or water aspirators.

10.1.5 *Difference Between G_r and G_{rc} Values:*

10.1.5.1 As the difference between G_r and G_{rc} values increases, confidence that significant water absorption has occurred also increases.

10.1.5.2 Make corrections when values vary by more than 1.0%.

10.1.5.3 Corrections of less than 0.3% are usually insignificant and exist only because of the inadequacy of the correction procedure.

10.1.5.4 Base decisions concerning variations between G_r and G_{rc} ranging from 0.3–1.0% on the first four factors.

10.1.5.5 Calculate the percentage difference:

$$\frac{G_r - G_{rc}}{G_{rc}} \times 100 = \%$$

10.2 When using a vacuum pump to create a partial vacuum on the sample contained in the pycnometer, close the system for periods during the test by closing the valve in the line leading from the vacuum pump. This will protect the pump from water vapors and it can be turned off if necessary. Restart the pump and reopen the valve when leaks in the system cause the absolute pressure to rise above 2.0 in. (50 mm) Hg.

10.3 Vacuum sources applying absolute pressure considerably below 2.0 in. (50 mm) Hg may reach the end-point more quickly than less effective pumps.

10.4 Treat mix used to perform Rice gravity calculations identically to mix used for molding for density.

10.5 The vacuum pump or water aspirator must be able to reduce the residual (absolute) pressure in the system to 2.0 in. (50 mm) Hg or less before the completion of the air evacuation process of the procedure. This equates to a vacuum gauge reading of 27.9 in. (710 mm) Hg or more at normal sea level atmospheric pressure. When a gauge is used, it is necessary to use a mercury manometer to establish the point on a vacuum gauge that equates to 2.0 in. (50 mm) Hg of residual (absolute) pressure.

10.5.1 This can be accomplished by pulling a residual (absolute) vacuum of 2.0 in. (50 mm) Hg as read on a mercury manometer that is placed in line with the vacuum gauge.

10.5.2 At this point, make a mark on the vacuum gauge and use this point as the minimum vacuum that must be pulled.

10.5.2.1 Vacuum gauges are not as precise as manometers and as such, the vacuum gauge should be calibrated with a manometer on a regular basis.

Table 3
Pressure Conversions

% Vacuum	Absolute Pressure (mmHg)	Absolute Pressure (inHg)	Gauge Pressure (inHg)
0.0	760.0	29.92	0.00
7.9	700.0	27.56	2.36
21.1	600.0	23.62	6.30
34.2	500.0	19.68	10.24
47.4	400.0	15.75	14.17
60.5	300.0	11.81	18.11
73.7	200.0	7.87	22.05
86.8	100.0	3.94	25.98
88.2	90.0	3.54	26.38
89.5	80.0	3.15	26.77
90.8	70.0	2.76	27.16
92.1	60.0	2.36	27.56
93.3	51.3	2.02	27.90
94.7	40.0	1.57	28.35
96.1	30.0	1.18	28.74
97.4	20.0	0.79	29.13
98.7	10.0	0.39	29.53
99.3	5.0	0.20	29.72
99.7	2.5	0.10	29.82
99.9	1.0	0.04	29.88
100.0	0.0	0.00	29.92

11. ARCHIVED VERSIONS

11.1 Archived versions are available.

Test Procedure for

DETERMINING ASPHALT CONTENT FROM ASPHALT PAVING MIXTURES BY THE IGNITION METHOD

TxDOT Designation: Tex-236-F

Effective Date: July 2019

1. SCOPE

1.1 Use Part I of this test method to determine the asphalt content of hot mix asphalt (HMA) paving mixtures, reclaimed asphalt pavement (RAP) stockpiles, and recycled asphalt shingles (RAS) stockpiles using an ignition oven. Use the remaining aggregate for sieve analysis in accordance with Tex-200-F.

1.2 Use Part II of this test method to determine aggregate gradation and asphalt content correction factors before the start of production. The type of aggregate in the mixture may affect the ignition procedure. Establish correction factors by testing a set of samples for each mix type produced to optimize accuracy.

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Ignition oven,* capable of:

2.1.1 Maintaining a temperature to cause combustion with an internal balance thermally isolated from the chamber accurate to 0.1 g. The balance must be capable of weighing a 4,000 g sample in addition to the sample baskets.

2.1.2 Providing an audible alarm and indicator light when the sample reaches constant weight.

Note 1—The oven door must automatically lock when the test procedure begins and must remain locked until the test procedure is completed.

2.1.3 Providing initial sample weight, sample weight loss, correction factor, corrected asphalt content (percent), and test time.

2.2 *Tempered stainless steel No. 8 (2.36 mm) mesh basket,* otherwise perforated basket, or combination of baskets. The basket must incorporate a design that confines the sample during testing.

2.3 *Tempered stainless steel catch pan*, to fit under the basket assembly.

2.4 *Oven*, capable of maintaining a minimum temperature of 325 ± 5°F (163 ± 3°C).

2.5 *Balance,* Class G2, in accordance with Tex-901-K, with a minimum capacity of 17.6 lb. (8 kg) for weighing sample in baskets.

3. SAFETY EQUIPMENT

3.1 *Safety glasses or face shield.*

3.2 *High temperature gloves.*

3.3 *Long sleeve jacket.*

3.4 *Heat-resistant surface,* capable of withstanding heat from the sample baskets.

3.5 *Protective cage,* capable of surrounding the sample baskets.

4. MISCELLANEOUS EQUIPMENT

4.1 *Pan for transferring samples after ignition.*

4.2 *Spatulas.*

4.3 *Bowls.*

4.4 *Wire brushes.*

5. REPORT FORMAT

5.1 The Correction Factor Calculation Report is an Excel template containing the following worksheets:

- Asphalt Content and Combined Aggregate Gradation (Tx236) and
- Summary Sheet (Summary).

5.2 For hot-mix asphalt (HMA) mixtures, use the QC/QA Excel template for the Ignition Oven Method in conjunction with the HMA specification. Refer to the Instructions tab for guidelines on how to use the template.

5.3 Use the Mix Design Excel template to prepare blank samples when establishing correction factors.

6. SAMPLE PREPARATION

6.1 *Asphalt Paving Mixtures:*

6.1.1 Produce a sample in accordance with Tex-205-F or quarter a sample in accordance with Tex-222-F.

6.1.1.1 When the mixture is not sufficiently workable to separate the mix with a spatula or trowel, place it in a large flat pan and warm to 250 ± 5°F (121 ± 3°C) for 30 min.

Note 2—Do not heat sample for more than one hr.

6.1.1.2 For microsurfacing production mix, place the mixture in a large flat pan and dry to constant weight at 230 ± 10°F.

6.1.1.3 The mixture type controls the required sample size, as shown in Table 1.

Table 1
Required Weight of Sample

Mixture Type	Required Weight of Sample, g
Type A, SP-A	3,000–4,000
Type B, SP-B	2,000–3,000
Type C, PFC (PG 76), SP-C, CMHB-C, SMA-C, SMA-D, SMAR-C, UTBWC-C, TBPFC (PG 76)	1,000–2,000
Type D, PFC (A-R), SP-D, CMHB-F, SMA-F, UTBWC-B, TBPFC (A-R)	1,200–1,500
Type F, SMAR-F, Microsurfacing, CAM, UTBWC-A, TOM-C, TOM-F	1,000–1,200

6.1.2 Sample sizes should not be more than 400 g greater than the maximum required sample mass as shown in Table 1. Large samples of fine mixes tend to result in incomplete ignition of the asphalt.

Note 3—When the mass of the sample exceeds the capacity of the equipment used, divide the sample into suitable increments. Appropriately combine the results for calculating the asphalt content (weighted average).

6.1.3 Verify that the mixture contains no more than 0.2% of moisture by weight in accordance with Tex-212-F, Part II. Do not use the same sample used for moisture determination as used for asphalt content determination.

6.2 *Recycled Materials Samples:*

6.2.1 Take a representative sample from the recycled material stockpile in accordance with Tex-222-F.

6.2.2 Oven-dry the sample to constant weight at 140 ± 5°F (60 ± 3°C).

6.2.3 Quarter a test sample to the required size shown in Table 2.

6.2.4 Verify that the mixture contains no more than 0.2% of moisture by weight in accordance with Tex-212-F, Part II. Do not use the same sample used for moisture determination as used for asphalt content determination.

Table 2
Required Weight of Recycled Material Sample

Recycled Material Type	Required Weight of Sample, g
Reclaimed Asphalt Pavement (RAP)[1]	1,000–4,000
Recycled Asphalt Shingles (RAS)[2]	500–700

1. Refer to Table 1 for required sample weights.
2. Sample size exceeding the required weight above may not completely ignite the asphalt.

PART I—DETERMINE ASPHALT CONTENT BY IGNITION METHOD

7. SCOPE

7.1 Use this procedure to determine the asphalt content of hot mix asphalt (HMA) paving mixtures using an ignition oven. Use the remaining aggregate for sieve analysis in accordance with Tex-200-F.

8. PROCEDURE

8.1 Pre-heat the ignition oven according to the manufacturer's recommendations.

8.2 Determine and record the weight of the basket assembly to the nearest 0.1 g.

8.3 Place the loose mixture directly into the sample baskets.

Note 4—Reheat the sample in a 250°F (121°C) oven for 30 min. if it gets cold. Do not reheat microsurfacing, limestone rock asphalt (LRA), or hot-mix cold-laid samples. Do not preheat the sample baskets.

8.4 Evenly distribute the sample in the basket assembly, keeping the material away from the edges of the basket.

8.5 Weigh and record the sample and basket assembly to the nearest 0.1 g.

8.6 Calculate and record the initial weight of the sample (total weight minus the weight of the sample basket assembly) and designate as W_S in Section 11.1.

8.7 Input W_S into the ignition oven controller. Verify entry of the correct weight.

8.8 Open the chamber door and place the sample and basket assembly in the ignition oven.

Note 5—Failure of the oven scale to stabilize may indicate that the sample basket assembly is contacting the oven wall. If this occurs, adjust the sample basket inside the oven.

8.9 Close the chamber door and start the test.

Note 6—This should lock the oven chamber for the duration of the test.

8.10 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete.

8.11 Press the start/stop button.

Note 7—This should unlock the oven chamber.

8.12 Open the chamber door, remove the sample, and allow it to cool to room temperature (approximately 45 min.)

Note 8—Do not use a fan to assist in cooling the sample to room temperature due to the possibility of losing fines.

8.13 Weigh the sample and basket assembly after ignition to the nearest 0.1 g.

8.14 Calculate and record the final weight of the sample (total weight from Section 8.13 minus the weight of the sample basket assembly) and designate this weight as W_A in Section 11.1.

8.15 Calculate the asphalt content of the sample according to Section 11.1.

Note 9—Asphalt content reported by the ignition oven may be used if proven accurate.

8.16 Empty the contents of the basket into a flat pan. Use a small wire sieve brush to ensure removal of any residual fines from the basket. Add those fines to the contents in the flat pan.

8.17 Use the remaining aggregate for the sieve analysis in accordance with Tex-200-F.

PART II—DETERMINE CORRECTION FACTORS

9. SCOPE

9.1 Use this test method to determine aggregate gradation and asphalt content correction factors before the start of production. The type of aggregate in the mixture may affect the ignition procedure. Establish correction factors by testing a set of samples for each mix type produced to optimize accuracy.

10. PROCEDURE

10.1 A Level 2-certified technician must prepare one blank sample in the laboratory in accordance with Tex-205-F, using the Blank Weigh Up worksheet in the Mix Design Excel template. Determine the sample size for the blank sample in accordance with Tex-200-F, Table 1.

Note 10—Do not add any asphalt binder, fibers, or any recycled materials to the blank sample. Do not perform the ignition oven procedure with the blank sample.

10.2 Perform a washed sieve analysis on the blank sample in accordance with Tex-200-F, Part II.

Note 11—Enter the individual or cumulative weight of aggregate retained on each sieve on the Asphalt Content and Combine Aggregate Gradation worksheet.

10.3 When applicable, enter the gradation of any recycled material used in the mixture design, such as RAP or RAS, in the Asphalt Content and Combined Aggregate Gradation worksheet, under the Recycled Materials Section. Use the gradation of the recycled material determined for the mixture design in accordance with Tex-204-F.

Note 12—The Asphalt Content and Combined Aggregate Gradation worksheet calculates the combined gradation of the blank sample and recycled materials, when applicable.

Note 13—The combined gradation, including the use of any recycled materials, must fall within the master gradation band of the specification used for the project.

10.4 Prepare a "butter batch mix" at the design optimum asphalt content and discard before mixing any other samples for determining correction factors.

Note 14—A "butter batch mix" is a trial batch of asphalt and aggregate design mixture used to coat the mixing bowl and whips with asphalt. This helps prevent a loss of asphalt due to adhesion on the bare walls of the bowl or in the mixing whips to ensure an accurate asphalt content of the samples used to determine correction factors.

10.5 Use the Weigh Up worksheet in the Mix Design Report to prepare two samples in the laboratory in accordance with Tex-205-F. Determine the sample size in accordance with Section 6.1.1.3.

- two at the design optimum asphalt content

Note 15— Add the recycled material when preparing the samples if applicable.

10.6 Perform the ignition oven procedure as described under Section 8 with the samples prepared in Section 10.5.

10.7 Perform a dry gradation sieve analysis in accordance with Tex-200-F, Part I, on the residual aggregate for each ignited sample from Section 10.6.

Note 16—Enter the individual or cumulative weight of aggregate retained on each sieve on the Asphalt Content and Combine Aggregate Gradation worksheet.

10.8 *Determining Asphalt Content Correction Factor:*

10.8.1 Determine the asphalt content for each ignited sample in Section 10.6 in accordance with Section 11.1.

10.8.2 Use the Asphalt Content and Combined Aggregate Gradation worksheet to subtract the measured asphalt content for each ignited sample determined in Section 10.8.1 from the actual asphalt content. Average the two measured differences to determine the asphalt content correction factor.

Note 17—When fibers are added to the mixture, 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.

10.8.3 If Section 10.8 yielded an asphalt correction factor that was greater than 0.3%, use the Back Calculated Rice Method in Section 10.9 to verify the asphalt content.

Note 18—The type of aggregate in the mixture may affect the ignition procedure. Establish standard Rice values by testing a set of known asphalt contents from a laboratory produced sample. Compare production samples to these standards for verification.

10.9 *Verifying Asphalt Content using the Back Calculated Rice Method:*

10.9.1 Using the current design, produce a laboratory mixture at the design optimum asphalt content in accordance with Tex-205-F. Prepare enough material to test three G_r samples in accordance with Tex-227-F.

10.9.2 During production, compare the production G_r to the average G_r obtained in part 10.9.1.

10.9.3 Use the Tex236 template to enter these values and verify asphalt contents.

10.10 *Determining Aggregate Gradation Correction Factors:*

10.10.1 Use the Asphalt Content and Combined Aggregate Gradation worksheet to subtract the gradation determined in Section 10.7 (ignited samples) for each sieve size from each corresponding sieve size of the combined gradation determined in Section 10.3 (blank samples and recycled material).

10.10.2 Average the two measured differences for each sieve size to determine the aggregate gradation correction factor for each sieve size. Report the correction factors in percent passing.

10.11 Use the Summary worksheet to report the asphalt content and aggregate gradation correction factors.

Note 19—If the aggregate correction factor for a sieve is historically less than 0.5%, a zero correction factor can be used.

11. CALCULATIONS

11.1 Calculate the asphalt binder content of the sample.

11.1.1 For hot-mix asphalt (HMA), LRA, hot-mix cold-laid, and recycled materials:

$$AC\% = \left[\frac{W_S - W_A}{W_S}\right] * 100$$

11.1.2 For microsurfacing mixtures:

$$AC\% = \left[\frac{W_S - W_A}{W_A} \right] * 100$$

Where:

AC% = measured asphalt content

W_A = total weight of aggregate remaining after ignition, g

W_S = total weight of the HMA sample before ignition, g

11.2 Report ignition oven test results to the nearest 0.1%.

12. ARCHIVED VERSIONS

12.1 Archived versions are available.

TEXAS DEPARTMENT OF TRANSPORTATION

ASPHALT CONTENT AND COMBINED AGGREGATE GRADATION CORRECTION FACTORS
Tex-236-F

Refresh Workbook

File Version: 08/23/19 14:30:50

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	Superpave_D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

Fiber Content:

SIEVE ANALYSIS WORKSHEET FOR CALIBRATION SAMPLES

Original Sample Weight:	1175.9				1202.4	1211.6		
Dry Weight after Washing:	1103.6		Ignited Sample 1	Ignited Sample 2	Ignited Sample 1	Ignited Sample 2	Ignited Sample 5	Ignited Sample 6
Cumulative?	Blank Sample	Blank Sample 2	@OAC-0.5%AC	@OAC-0.5%AC	@OAC	@OAC	@OAC+0.5%AC	@OAC+0.5%AC

Sieve Size	Individual Weight Retained							
3/4"	0.0			0.0	0.0	0.0		
1/2"	0.0				0.0	0.0		
3/8"	80.5				88.6	89.0		
No. 4	277.7				286.0	291.1		
No. 8	336.7				363.1	355.4		
No. 16	50.0				83.9	77.0		
No. 30	142.6				156.2	158.0		
No. 50	126.3				130.7	141.9		
No. 200	87.2				90.4	92.6		
PAN	3.4				4.0	6.6		
Sieving Loss(+) or Gain(-):	-0.8							
Wash Loss(+):	72.3							
Total Pan:	74.9							
Total Weight:	1175.9							

AGGREGATE GRADATION CORRECTION FACTOR CALCULATIONS

			Total Percent Passing, %						
Sieve Size	Combined Gradation	Meets Master Grading Limits	Ignited Sample 1 @OAC-0.5%AC	Ignited Sample 2 @OAC-0.5%AC	Ignited Sample 1 @OAC	Ignited Sample 2 @OAC	Ignited Sample 5 @OAC+0.5%AC	Ignited Sample 6 @OAC+0.5%AC	
3/4"	100.0	☑			100.0	100.0			
1/2"	100.0	☑			100.0	100.0			
3/8"	93.2	☑			92.6	92.7			
No. 4	69.5	☑			68.8	68.6			
No. 8	40.9	☑			38.6	39.3			
No. 16	36.7	☑			31.7	32.9			
No. 30	24.5	☑			18.7	19.9			
No. 50	13.8	☑			7.8	8.2			
No. 200	6.4	☑			0.3	0.5			

ASPHALT CONTENT CORRECTION FACTOR CALCULATIONS

	@OAC-0.5%AC		@OAC		@OAC+0.5%AC		AVG Difference Target-Measured
Target AC %			4.8	4.8			
Measured AC %			4.9	4.9			

Test Procedure for

COMPACTING BITUMINOUS SPECIMENS USING THE SUPERPAVE GYRATORY COMPACTOR (SGC)

TxDOT Designation: Tex-241-F

Effective Date: July 2019

1. SCOPE

1.1 Use this test method to:

- compact cylindrical specimens of hot-mix asphalt (HMA) using the Superpave gyratory compactor;
- prepare specimens for determining the mechanical and volumetric properties of HMA; and

  Note 1—The specimens simulate density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.
- monitor the density of test specimens during their preparation and for field control of an HMA production process.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1
Nomencablatures and Definitions

Nomenclatures		Definitions
Conventional	Superpave	
G_a	G_{mb}	Bulk specific gravity of the compacted mixture
G_r	G_{mm}	Theoretical maximum specific gravity

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Superpave gyratory compactor (SGC).*

2.1.1 The compactor is an electrohydraulic or electromechanical compactor with ram and ram heads that are restrained from revolving during compaction.

2.1.2 The axis of the ram is perpendicular to the platen of the compactor.

2.1.3 The compactor tilts the specimen molds at an internal angle of 1.16 ± 0.02° (20.2 ± 0.35 mrad) and gyrates specimen molds at a rate or 30.0 ± 0.5 gyrations per minute throughout compaction.

2.1.4 The compactor is designed to permit the specimen mold to revolve freely on its tilted axis during gyration.

2.1.5 The ram applies and maintains a pressure of 600 ± 18 kPa (87 ± 2 psi) perpendicular to the cylindrical axis of the specimen during compaction.

Note 2 —This stress calculates to 10,600 ± 310 N (2,383 ± 70 lbf) total force for 150 mm (5.912 in.) specimens.

2.2 *Specimen height measurement and recording device.*

2.2.1 When monitoring specimen density during compaction, provide a means to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction, once per gyration.

Note 3 —Specimen height monitoring is for informational purposes only during design.

2.2.2 The system should be capable of downloading or printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

2.3 *Specimen molds.*

2.3.1 Specimen molds must have steel walls that are at least 7.5 mm (0.3 in.) thick and have a minimum Rockwell hardness HR-C 48.

2.3.2 Molds must have an inside diameter of 149.90–150.00 mm (5.901–5.912 in.) and be at least 250 mm (10 in.) high.

2.3.3 The inside finish of the molds must have a root mean square (rms) of 1.60 µm or smoother.

Note 4 —Measure smoothness according to ANSI B46.1. One source of supply for a surface compactor, which is used to verify the rms value of 1.60 µm, is GAR Electroforming, Danbury, Connecticut.

2.4 *Ram heads and mold bottoms.*

2.4.1 Ram heads and mold bottoms must be fabricated from steel with a minimum Rockwell hardness of C48.

2.4.2 The ram heads must be perpendicular to its axis.

2.4.3 The platen side of each mold bottom must be flat and parallel to its face.

2.4.4 All ram and base plate faces (the sides presented to the specimen) must be ground flat to meet smoothness the requirements of ANSI B 46.1 and must have a diameter of 149.50–149.75 mm (5.885–5.896 in.)

2.5 *Mercury thermometer,* marked in 5°F (3°C) divisions or less, or a digital thermometer capable of measuring the temperature specified in this test procedure.

2.6 *Balance,* Class G2 in accordance with Tex-901K, with a minimum capacity of 10,000 g.

2.7 *Oven,* capable of maintaining a temperature of at least 325 ± 5°F (163 ± 3°C).

2.8 *Pans,* metal, with flat bottom.

2.9 *Scoop, spatula, trowel.*

2.10 *Paper disks.*

2.11 *Insulating gloves.*

2.12 *Lubricating materials.*

3. SAFETY PRECAUTIONS

3.1 Use standard safety precautions and protective clothing when handling hot asphalt mixtures, molds, and equipment.

4. CALIBRATION

4.1 Items requiring periodic verification of calibration include:

- ram pressure,
- angle of gyration,
- gyration frequency,
- LVDT (or other means used to continuously record the specimen height), and
- oven temperature.

4.2 Verification of the mold and platen dimensions and the inside finish of the mold are also required.

4.3 When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes.

4.4 The manufacturer, other agencies providing such services, or in-house personnel may perform the verification of the calibration system standardization and quality checks. Frequency of verification must follow manufacturer's recommendations.

5. PREPARATION OF THE SGC

5.1 Turn on the compactor and allow it to warm up before the asphalt concrete mixture is ready for placement in the mold.

5.2 Verify settings for angle and pressure.

5.3 Select gyration or height mode. Enter the design number of gyrations or required specimen height according to the specification or test procedure.

Note 5 —Gyration mode is normally used when molding samples for volumetric properties. Height mode is normally used when molding samples for performance testing such as Hamburg, Overlay, Cantabro, and IDT.

5.4 Lubricate bearing surfaces as needed.

5.5 Lubricate the surface of the rotating base and the surface of the four rollers.

5.6 Follow the instructions in Sections 5.6.1–5.6.2 when monitoring the specimen height.

5.6.1 Before placing the material in the mold, turn on the device for measuring and recording the height of the specimen. Verify that the readout is in the proper units (mm) and that the recording device is ready.

5.6.2 If using a computer, prepare it to record the height data and enter the header information for the specimen.

6. MIXTURE PREPARATION

6.1 For laboratory-produced mixtures, proceed to Section 6.2. For plant-produced mixtures, proceed to Section 6.3. For mixtures requiring re-heating, proceed to Section 6.4.

Note 6 —Mixtures requiring re-heating are defined as plant or lab mixtures that will be cooled to ambient temperature and transported to another laboratory for testing.

6.2 *Laboratory-Produced Mixtures:*

6.2.1 Combine aggregates and prepare the laboratory mixture as described in Tex-205-F.

6.2.2 Split the mixture into the appropriate sample size.

Note 7 —The sample weight of test specimens will vary based on the selected compaction method and the test to be performed. If a target density is desired for performance testing, adjust the sample weight to create a given density for a specified height. If the specimens are to be used for determining volumetric properties, adjust the sample weight to yield results based on gyration control.

6.2.3 Proceed to Section 6.5.

6.3 *Plant-Produced Mixtures:*

6.3.1 Sample the plant-produced mixture in accordance with Tex-222-F.

6.3.2 Split the mixture into the appropriate sample size. Refer to Note 7.

6.3.3 Proceed to Section 6.5.

6.4 *Plant-Produced or Lab-Produced Mixtures Requiring Re-Heating:*

6.4.1 For plant-produced mixtures, sample the mixture in accordance with Tex-222-F. For lab-produced mixtures, combine aggregates and prepare the laboratory mixture as described in Tex-205-F.

6.4.2 Transfer the sample to a suitable container for shipping and labeling. The sample thickness in the container must not exceed 3 in.

Note 8 —Recommended sampling containers are paper bags or cardboard boxes.

6.5 Select the compaction temperature from Table 2 based on the asphalt binder specified on the plans. Use the target discharge temperature as the compaction temperature when it is less than the temperature shown in Table 2.

Note 9 —If using reclaimed asphalt pavement (RAP) or recycled asphalt shingles (RAS) and a substitute PG binder instead of the PG binder originally specified, defer to the originally specified binder grade when selecting the compaction temperature.

6.6 Place the compaction mold, base, and the top plate in an oven at the selected compaction temperature for a minimum of 60 min. before compaction.

6.7 Place the material into an oven at the selected compaction temperature. For pre-weighed lab or plant mix samples, proceed to Section 6.7.1. For shipped lab or plant mix that requires reheating, proceed to Section 6.7.2.

6.7.1 For pre-weighed lab or plant mix samples, cure the mix in the oven for 2 hr. ± 5 min. Monitor the sample mixture until it reaches the specified compaction temperature, mold the specimen, and proceed to Section 7.

6.7.2 When receiving shipped lab or plant mix that requires reheating, cure the mix in the oven for 1.5 hr. ± 5 min. Remove the sampled material from the containers and place it into a large pan. Thoroughly mix the sample and split into the appropriate sample size. Place the split samples back into the oven. Refer to Note 7. Monitor the sample mixture until it reaches the specified compaction temperature, mold the specimen, and proceed to Section 7.

7. COMPACTION TEMPERATURES

7.1 Use the compaction temperatures in Table 2 when molding samples. Use the same temperature for both curing and compaction of these mixtures.

7.2 Compaction temperatures not listed in Table 2 may be used when shown on the plans or approved by the Engineer. For guidance on materials not listed in Table 2 or materials containing modifying additives, RAP, or RAS, consult the Flexible Pavements Section of the Materials and Tests Division.

Table 2
Curing and Compaction Temperatures

Binder[1]	Temperature, °F[2]
PG 58 - 28	250
PG 64 - 22	250
PG 64 - 28	275
PG 70 - 22	275
PG 70 - 28	300
PG 76 - 22	300
PG 76 - 28	300
Asphalt Rubber (A-R)	300

Note: Mixtures must be compacted at the selected compaction temperature within a tolerance of ± 5°F (± 3°C).

1. If using RAP or RAS and a substitute PG binder instead of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the compaction temperature.
2. Use the target discharge temperature when it is less than the compaction temperature shown.

8. PROCEDURES

8.1 *Compaction:*

8.1.1 Use the design number of gyrations (N_{des}) or height for compaction according to the specification or as shown on the plans.

Note 10 —When the mixture appears dry and lacking asphalt, lower the N_{des} value to increase the optimum asphalt content of the mixture.

8.1.2 Following oven curing, remove the heated mold and base plate from the oven and place a paper disk on the bottom of the mold.

8.1.3 Place the mixture into the mold in one lift. Take care to avoid segregation in the mold.

8.1.4 After all the mix is in the mold, level the mix with a spatula and place another paper disk and the top plate on the leveled material.

8.1.5 Load the specimen mold into the compactor and center the mold under the loading ram.

8.1.6 Press the start button to lower the ram. The pressure on the specimen should reach 600 ± 18 kPa (87 ± 2 psi).

8.1.7 The compactor should then apply a 1.16 ± 0.02° (20.2 ± 0.35 mrad) internal angle to the mold assembly and begin the gyratory compaction.

8.1.8 Allow compaction to proceed until completion of the specified number of gyrations or height and until the gyratory mechanism shuts, off.

8.1.8.1 When monitoring the specimen height, record the specimen height to the nearest 0.1 mm (0.004 in.) after each revolution.

8.1.9 Once the machine removes the angle from the mold assembly and raises the loading ram, remove the mold from the compactor, and extrude the specimen from the mold.

Note 11 —Do not immediately extrude the specimen from the mold for lean, rich, and tender mixtures, for mixtures containing asphalt rubber binder, or for mixtures compacted to a density less than 82% to prevent deformation of the specimen. Allow the mold to cool for approximately 10 min. or more in front of a fan.

8.1.10 Remove the paper disks from the top and bottom of the specimens.

Note 12 —When molding multiple specimens, place the mold in the oven for at least 5 min. before reusing. The use of multiple molds will expedite the compaction process.

8.2 *Density:*

8.2.1 Use the maximum specific gravity (G_r) of the loose mix determined in accordance with Tex-227-F using a companion sample. For permeable friction course (PFC) mixtures, use a back-calculated G_r in accordance with Tex-207-F.

Note 13 —Oven-cure the companion sample at the same temperature and for the same length of time as the compaction sample.

8.2.2 Record the mass of the extruded specimen to the nearest tenth gram and determine the bulk specific gravity (G_a) of the extruded specimen in accordance with Tex-207-F.

8.2.3 Calculate the relative density of the extruded specimen ($\%G_{mm}$) in accordance with Section 9.1.

Note 14 —Estimations of the relative density of the specimen can be made at any point in the compaction process based on the specimen height accordance with Section 9.2.

9. CALCULATIONS

9.1 Calculate $\%G_{mm}$:

$$\%G_{mm} = \frac{G_a}{G_r} * 100$$

Where:

$\%G_{mm}$ = relative density of the extruded specimen expressed as a percent of the theoretical maximum specific gravity

G_a = bulk specific gravity of the extruded specimen

G_r = theoretical maximum specific gravity of the mix

9.2 Estimate the percent compaction ($\%G_{mmx}$) at any point in the compaction process:

$$\%G_{mmx} = \frac{G_a h_m}{G_r h_x} \times 100$$

Where:

$\%G_{mmx}$ = relative density expressed as a percentage of the theoretical maximum specific gravity

G_a = bulk specific gravity of the extruded specimen

G_r = theoretical maximum specific gravity of the mix

h_m = height of the extruded specimen, mm

h_x = height of the specimen after "x" gyrations, mm

10. ARCHIVED VERSIONS

10.1 Archived versions are available.

Special Specification 3076
Dense-Graded Hot-Mix Asphalt

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. Payment adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 3076.4.9.4., "Exempt Production."

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, intermediate, or fine aggregate. 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, unless otherwise 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 unless otherwise shown on the plans. 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 Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Unless otherwise shown on the plans, up to 10% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note 1
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30
Crushed face count,[2] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

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

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for 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.

2.6. **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.

2.6.1. **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.

2.6.2. **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.

2.6.3. **Compaction Aid.** Compaction Aid is defined as a chemical warm mix additive that is used to produce an asphalt mixture at a discharge temperature greater than 275°F.

Compaction Aid is allowed for use on all projects and is required when shown on the plans.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Use of RAS is restricted to only intermediate and base mixes unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine the asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F, Part I. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface**. The final HMA lift placed at the top of the pavement structure or placed directly below mixtures produced in accordance with Items 316, 342, 347, or 348;
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base**. Mixtures placed greater than 8.0 in. from the riding surface. Unless otherwise shown on the plans, mixtures used for bond breaker are defined as base mixtures.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Fractionated RAP is defined as a stockpile that contains RAP material with a minimum of 95.0% passing the 3/8-in. or 1/2-in. sieve, before burning in the ignition oven, unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

Maximum Allowable Fractionated RAP (%)		
Surface	**Intermediate**	**Base**
15.0	25.0	30.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.

2.7.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is not permitted in surface mixtures unless otherwise shown on the plans. RAS may be used in intermediate and base mixtures unless otherwise shown on the plans. Up to 3% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 3.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if using recycled materials, and if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders;" and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder for Surface Mixes	Allowable Substitute PG Binder for Intermediate and Base Mixes	Maximum Ratio of Recycled Binder[1] to Total Binder (%)		
			Surface	Intermediate	Base
76-22[4,5]	70-22	70-22	10.0	20.0	25.0
70-22[2,5]	N/A	64-22	10.0	20.0	25.0
64-22[2,3]	N/A	N/A	10.0	20.0	25.0
76-28[4,5]	70-28	70-28	10.0	20.0	25.0
70-28[2,5]	N/A	64-28	10.0	20.0	25.0
64-28[2,3]	N/A	N/A	10.0	20.0	25.0

1. Combined recycled binder from RAP and RAS. RAS is not permitted in surface mixtures unless otherwise shown on the plans.
2. Binder substitution is not allowed for surface mixtures.
3. Binder substitution is not allowed for intermediate and base mixtures.
4. Use no more than 10.0% recycled binder in surface mixtures when using this originally specified PG binder.
5. Use no more than 20.0% recycled binder when using this originally specified PG binder for intermediate mixtures. Use no more than 25.0% recycled binder when using this originally specified PG binder for base mixtures.

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 6. 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 AGG101 certified specialists for aggregate testing.

Table 6
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
Linear shrinkage	Tex-107-E	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	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 (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1B
Trimming roadway cores	Tex-251-F, Parts I & II	✓	✓	1A/1B
In-place air voids	Tex-207-F, Parts I & VI	✓	✓	1A
In-place density (nuclear method)	Tex-207-F, Part III	✓		1B
Establish rolling pattern	Tex-207-F, Part IV	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B
Shear Bond Strength Test	Tex-249-F		✓	TxDOT

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3076.4.9.2.3., "Production Testing," 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 QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. 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 maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment adjustment less than 1.000, 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."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[3]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[4]			
Boil test[3]			
Binder tests[4]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day after receiving the trimmed cores[5]
Segregation[3]			1 working day of completion of the lot
Longitudinal joint density[3]			
Thermal profile[3]			
Aging ratio[4]			
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency specified in Table 16 or as shown on the plans.
4. To be reported as soon as the results become available.
5. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the payment adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. 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. 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);
- 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**. The Contractor will design the mixture using a Superpave Gyratory Compactor (SGC). A Texas Gyratory Compactor (TGC) may be used when shown on the plans. Use the dense-graded design procedure provided in Tex-204-F. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

4.4.1.1. **Design Number of Gyrations (Ndesign) When The SGC Is Used**. Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to at least 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

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;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- 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 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	–	–	–	–
1-1/2"	100.0[1]	–	–	–
1"	98.0–100.0	100.0[1]	–	–
3/4"	84.0–98.0	95.0–100.0	100.0[1]	–
1/2"	–	–	98.0–100.0	100.0[1]
3/8"	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA, % Minimum				
–	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum				
–	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (SGC)	Tex-207-F	96.0
Design gyrations (Ndesign for SGC)	Tex-241-F	50[1]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[2]
Boil test[3]	Tex-530-C	–

1. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
2. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
3. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to at least 35 gyrations.
2. May be decreased to at least 5,000 passes when shown on the plans.
3. May be decreased to at least 10,000 passes when shown on the plans.

4.4.1.2. **Target Laboratory-Molded Density When The TGC Is Used**. Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

4.4.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or 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. **Providing Gyratory Compactor**. Use a SGC calibrated in accordance with Tex-241-F to design the mixture in accordance with Tex-204-F, Part IV, for molding production samples. Locate the SGC, if used, at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples. Furnish a TGC calibrated in accordance with Tex-914-K when shown on the plans to design the mixture in accordance with Tex-204-F, Part I, for 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 gyratory compactor. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

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

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

4.4.2.1.6. **Ignition Oven Correction Factors**. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 months old. 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 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.

4.4.2.1.7. **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.

4.4.2.1.8. **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 4, Table 5, and Table 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

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

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

4.4.2.1.12. **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.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel requirement in Table 10. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2**. Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 3076.4.9.3.1.1., “Lot 1 Placement,” after receiving approval for JMF2 and a passing result from the Department’s or a Department-approved

laboratory's Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor's risk without receiving the results from the Department's Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

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

4.4.2.1.17. **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 mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 11.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 3076.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer[1]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0[2,3]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[2,3]	±3.0
% passing the #200 sieve			±2.0[2,3]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[3]	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, %, min	Tex-204-F	Note[4]	Note[4]	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Test and verify that Table 8 requirements are met.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. **Gyratory Compactor**. For SGC mixtures designed in accordance with Tex-204-F, Part IV, 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.

For TGC mixtures designed in accordance with Tex-204-F, Part I, the Engineer will use a Department TGC, calibrated in accordance with Tex-914-K, to mold samples for trial batch and production testing. The Engineer will make the Department TGC and the Department field laboratory available to the Contractor for molding verification samples, if requested by the Contractor.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance of the following information within 2 working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 3076.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two working days, conditional approval of JMF1 will still be granted within two working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

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, Part II. Provide correction factors that are not more than 12 months old.

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 11. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

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

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- Tex-530-C, to retain and use for comparison purposes during production.

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 11. 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 requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 11.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

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 the maximum production temperatures listed in Table 12 (or 275°F for WMA). The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures listed in Table 12.

Table 12
Maximum Production Temperature

High-Temperature Binder Grade[1]	Maximum Production Temperature
PG 64	325°F
PG 70	335°F
PG 76	345°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

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 shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 3076.4.7.3.3., "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 and are not placed in the wheel path, or as directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 13 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 13
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. Place mixture when the roadway surface is dry and the roadway surface temperature is at or above the temperatures listed in Table 14A. The Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3076.4.7.3.1.2., "Thermal Imaging System."

Table 14A
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	35	40
PG 70	45[2]	50[2]
PG 76	45[2]	50[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture or when using WMA.

4.7.1.2. **When Not Using a Thermal Imaging System**. When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above the temperatures listed in Table 14B 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.

Table 14B
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	45	50
PG 70	55[2]	60[2]
PG 76	60[2]	60[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture, when using WMA, or utilizing a paving process with equipment that eliminates thermal segregation. In such cases, for each sublot and in the presence of the Engineer, use a hand-held thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

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 0.04 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 that 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.

4.7.2.2. **Sampling.** 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 notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use.

For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

4.7.3. **Lay-Down Operations**. Use the placement temperatures in Table 15 to establish the minimum placement temperature of the mixture delivered to the paver.

Table 15
Minimum Mixture Placement Temperature

High-Temperature Binder Grade[1]	Minimum Placement Temperature (Before Entering Paver)[2,3]
PG 64	260˚F
PG 70	270˚F
PG 76	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Minimum placement temperatures may be reduced 10°F if using a chemical WMA additive as a compaction aid.
3. When using WMA, the minimum placement temperature is 215°F.

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 3076.4.9.3.1.4., "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 moderate thermal segregation.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F are deemed as 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. Density profiles are not required and not applicable when using a thermal imaging system. 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 daily or upon completion of the project or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." 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 thermal images generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3076.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains severe thermal segregation. 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. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 3076.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

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 3076.4.9.3.3.4., "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**. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids. Take immediate corrective action to bring the operation within 3.8% and 8.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.9%. Areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°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**. Payment adjustments for the material will be in accordance with Article 3076.6., "Payment."

Sample and test the hot-mix on a lot and sublot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in payment factors of at least 1.000, if the production payment factor given in Section 3076.6.1., "Production Payment Adjustment Factors," for two consecutive lots or the placement pay factor given in Section 3076.6.2., "Placement Payment Adjustment Factors," for two consecutive lots is below 1.000.

4.9.1. **Referee Testing**. The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 11 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 five 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 three 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.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 3076.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three to four sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 3076.6.1., "Production Payment Adjustment Factors." Close all lots within five working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Shear Bond Strength Testing.** Select one random sublot from Lot 2 or higher for shear bond strength testing. Obtain full depth cores in accordance with Tex-249-F. Label the cores with the Control Section Job (CSJ), producer of the tack coat, mix type, shot rate, lot, and sublot number and provide to the

Engineer. The Engineer will ship the cores to the Materials and Tests Division or district laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. sample of the asphalt binder witnessed by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. 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 and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility location, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to MTD to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for one year.

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests in accordance with Table 16. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 11 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 97.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results. Provide evidence that results from Tex-236-F, Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 16
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)[2]	Tex-207-F, Part V	1 per sublot	1 per project
Longitudinal joint density	Tex-207-F, Part VII		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per sublot[1]
Asphalt binder content	Tex-236-F	1 per sublot	1 per lot[1]
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS)[3]	Tex-217-F, Part III	N/A	
Thermal profile[2]	Tex-244-F	1 per sublot	
Asphalt binder sampling and testing	Tex-500-C, Part II	1 per lot (sample only)[4]	
Tack coat sampling and testing	Tex-500-C, Part III	N/A	
Boil test[5]	Tex-530-C	1 per lot	
Shear Bond Strength Test[6]	Tex-249-F	1 per project (sample only)	

1. For production defined in Section 3076.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. Not required when a thermal imaging system is used.
3. Testing performed by the Materials and Tests Division or designated laboratory.
4. Obtain witnessed by the Engineer. The Engineer will retain these samples for one year.
5. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
6. Testing performed by the Materials and Tests Division or District for informational purposes only.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances listed in Table 11. 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.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances in Table 11 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 11. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA)**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on two consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that does not

meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Materials and Tests Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 3076.6.2., "Placement Payment Adjustment Factors"; however, no placement adjustment less than 1.000 will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.9%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.9%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 3076.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 13. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of

pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article 3076.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 3076.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores on site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement sublot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-251-F if the core heights meet the minimum untrimmed value listed in Table 13. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after witnessing the trimming of the cores and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value shown in Table 13. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores

immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 16. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 11.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a CoreDry or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Segregation (Density Profile)**. Test for segregation using density profiles in accordance with Tex-207-F, Part V when using a thermal camera insead of the thermal imaging system. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas."

Perform a minimum of one density profile per sublot. Perform additional density profiles when any of the following conditions occur, unless otherwise approved:

- the paver stops due to lack of material being delivered to the paving operations and the temperature of the uncompacted mat before the initial break down rolling is less than the temperatures shown in Table 17;
- areas that are identified by either the Contractor or the Engineer with thermal segregation;,
- any visibly segregated areas that exist.

Table 17
Mimimum Uncompacted Mat Temperature Requiring a Segregation Profile

High-Temperature Binder Grade[1]	Minimum Temperature of the Uncompacted Mat Allowed Before Initial Break Down Rolling[2,3,4]
PG 64	<250˚F
PG 70	<260˚F
PG 76	<270˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Segregation profiles are required in areas with moderate and severe thermal segregation as described in Section 3076.4.7.3.1.3.
3. Minimum uncompacted mat temperature requiring a segregation profile may be reduced 10°F if using a chemical WMA additive as a compaction aid.
4. When using WMA, the minimum uncompacted mat temperature requiring a segregation profile is 215°F.

Provide the Engineer with the density profile of every sublot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 3076.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 18. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 3076.4.9.3.3.5., "Irregularities." The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if 2 consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 18
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
Type B	8.0 pcf	5.0 pcf
Type C, Type D & Type F	6.0 pcf	3.0 pcf

4.9.3.3.3. **Longitudinal Joint Density**.

4.9.3.3.3.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations, at least once per sublot, unless otherwise directed.

4.9.3.3.3.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 3076.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on two consecutive sublots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.4. **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 Materials and Tests 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.

4.9.3.3.5. **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. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) 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.

4.9.4. **Exempt Production**. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 500 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements, except for coring operations when required by the Engineer. The production and placement pay factors are 1.000 if the specification requirements listed below are met, all other specification requirements are met, and the Engineer performs acceptance tests for production and placement listed in Table 16 when 100 tons or more per day are produced.

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 3076.4.8., "Compaction;" and
- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

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

5. MEASUREMENT

5.1. **Dense Graded Hot-Mix Asphalt.** Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **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 Section 3076.5.1, "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt" of the mixture type, SAC, and binder 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 3076.5.2, "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. Payment adjustments will be applied as determined in this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code, and all testing requirements are met.

Payment for each sublot, including applicable payment adjustments greater than 1.000, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 3076.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in Tex-244-F are required.

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."

6.1. **Production Payment Adjustment Factors**. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. The bulk specific gravities of the samples from each sublot will be divided by the Engineer's maximum theoretical specific gravity for the sublot. The individual sample densities for the sublot will be averaged to determine the production payment adjustment factor in accordance with Table 19 for each sublot, using the deviation from the target laboratory-molded density defined in Table 9. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the four sublots sampled within that lot.

Table 19
Production Payment Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production payment adjustments for incomplete lots, described under Section 3076.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production payment factors from all sublots sampled.

A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples within the first sublot.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing, the laboratory-molded density for any sublot results in a "remove and replace" condition as listed in Table 19, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3076.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Payment Adjustment Factors**. The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. The bulk specific gravities of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the placement payment adjustment factor in accordance with Table 20 for each sublot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 3076.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to four sublots within that lot.

Table 20
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.710	6.5	1.040
2.8	0.740	6.6	1.038
2.9	0.770	6.7	1.036
3.0	0.800	6.8	1.034
3.1	0.830	6.9	1.032
3.2	0.860	7.0	1.030
3.3	0.890	7.1	1.028
3.4	0.920	7.2	1.026
3.5	0.950	7.3	1.024
3.6	0.980	7.4	1.022
3.7	0.998	7.5	1.020
3.8	1.002	7.6	1.018
3.9	1.006	7.7	1.016
4.0	1.010	7.8	1.014
4.1	1.014	7.9	1.012
4.2	1.018	8.0	1.010
4.3	1.022	8.1	1.008
4.4	1.026	8.2	1.006
4.5	1.030	8.3	1.004
4.6	1.034	8.4	1.002
4.7	1.038	8.5	1.000
4.8	1.042	8.6	0.998
4.9	1.046	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

6.2.1. **Payment for Incomplete Placement Lots**. Payment adjustments for incomplete placement lots described under Section 3076.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement payment factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination.

If the random sampling plan results in production samples, but not in placement samples, the random core location and placement adjustment factor for the sublot will be determined by applying the placement random number to the length of the sublot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that sublot placed.

A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any production samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing, the placement payment adjustment factor for any sublot results in a "remove and replace" condition as listed in Table 20, the Engineer will choose the location of two cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Materials and Tests Division, where they will be trimmed if necessary and tested for bulk specific gravity within 10 working days of receipt.

The bulk specific gravity of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the new payment adjustment factor of the sublot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that sublot. If the new payment adjustment factor is less than 0.700, no payment will be made for the sublot. Remove and replace the failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3076.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay Calculation**. Total adjusted pay (TAP) will be based on the applicable payment adjustment factors for production and placement for each lot.

$TAP = (A+B)/2$

where:
A = Bid price × production lot quantity × average payment adjustment factor for the production lot
B = Bid price × placement lot quantity × average payment adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas

Special Specification 3077
Superpave Mixtures

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, Superpave (SP) mixture of aggregate and asphalt binder mixed hot in a mixing plant. Payment adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 3077.4.9.4., "Exempt Production."

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, intermediate, or fine aggregate. 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, unless otherwise 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 unless otherwise shown on the plans. 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 Soils and Aggregates Section of the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Unless otherwise shown on the plans, up to 10% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
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	35[2]
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	25[3]
Crushed face count,[4] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 3077.2.1.1.2., "Micro-Deval Abrasion."
2. For base mixtures defined in Section 3077.2.7., "Recycled Materials," the Los Angeles abrasion may be increased to a maximum of 40%.
3. For base mixtures defined in Section 3077.2.7., "Recycled Materials," the magnesium sulfate soundness, five cycles, may be increased to a maximum of 30%.
4. Only applies to crushed gravel.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

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

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for 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.

2.6. **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.

2.6.1. **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.

2.6.2. **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.

2.6.3. **Compaction Aid.** Compaction Aid is defined as a chemical warm mix additive that is used to produce an asphalt mixture at a discharge temperature greater than 275°F.

Compaction Aid is allowed for use on all projects and is required when shown on the plans.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Use of RAS is restricted to only intermediate and base mixes unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine the asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F, Part I. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface**. The final HMA lift placed at the top of the pavement structure or placed directly below mixtures produced in accordance with Items 316, 342, 347, or 348;
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base**. Mixtures placed greater than 8.0 in. from the riding surface. Unless otherwise shown on the plans, mixtures used for bond breaker are defined as base mixtures.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Fractionated RAP is defined as a stockpile that contains RAP material with a minimum of 95.0% passing the 3/8-in. or 1/2-in.

sieve, before burning in the ignition oven, unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than eight. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

Maximum Allowable Fractionated RAP (%)		
Surface	**Intermediate**	**Base**
20.0	30.0	35.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.

2.7.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is not permitted in surface mixtures unless otherwise shown on the plans. RAS may be used in intermediate and base mixtures unless otherwise shown on the plans. Up to 3% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 3.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless

otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified if using recycled materials, and if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders;" and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder for Surface Mixes	Allowable Substitute PG Binder for Intermediate and Base Mixes	Maximum Ratio of Recycled Binder[1] to Total Binder (%)		
			Surface	Intermediate	Base
76-22[4,5]	70-22	70-22	15.0	25.0	30.0
70-22[2,5]	N/A	64-22	15.0	25.0	30.0
64-22[2,3]	N/A	N/A	15.0	25.0	30.0
76-28[4,5]	70-28	70-28	15.0	25.0	30.0
70-28[2,5]	N/A	64-28	15.0	25.0	30.0
64-28[2,3]	N/A	N/A	15.0	25.0	30.0

1. Combined recycled binder from RAP and RAS. RAS is not permitted in surface mixtures unless otherwise shown on the plans.
2. Binder substitution is not allowed for surface mixtures.
3. Binder substitution is not allowed for intermediate and base mixtures.
4. Use no more than 15.0% recycled binder in surface mixtures when using this originally specified PG binder.
5. Use no more than 25.0% recycled binder when using this originally specified PG binder for intermediate mixtures. Use no more than 30.0% recycled binder when using this originally specified PG binder for base mixtures.

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 6. 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 AGG101 certified specialists for aggregate testing.

Table 6
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
Linear shrinkage	Tex-107-E	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Bulk specific gravity	Tex-201-F	✓	✓	AGG101
Unit weight	Tex-404-A	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	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, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Parts I & VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Gradation & asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Hamburg Wheel test	Tex-242-F	✓	✓	1A
Micro-Deval abrasion	Tex-461-A		✓	AGG101
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1B
Trimming roadway cores	Tex-251-F, Parts I & II	✓	✓	1A/1B
In-place air voids	Tex-207-F, Parts I & VI	✓	✓	1A
In-place density (nuclear method)	Tex-207-F, Part III	✓		1B
Establish rolling pattern	Tex-207-F, Part IV	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 3
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B
Shear Bond Strength Test	Tex-249-F		✓	TxDOT

1. Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 3077.4.9.2.3., "Production Testing," 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 QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. 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 maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment adjustment less than 1.000, 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."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[3]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[4]			
Boil test[3]			
Binder tests[4]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day after receiving the trimmed cores[5]
Segregation[3]			1 working day of completion of the lot
Longitudinal joint density[3]			
Thermal profile[3]			
Aging ratio[4]			
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency specified in Table 17 or as shown on the plans.
4. To be reported as soon as the results become available.
5. Two days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the payment adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. 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. 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);
- 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 SP 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, 3, 4, 5, 8, 9, 10, and 11.

Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 10. The Ndesign level may be reduced to at least 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

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.

The aggregate gradation may pass below or through the reference zone shown in Table 9 unless otherwise shown on the plans. Design a mixture with a gradation that has stone-on-stone contact and passes below the reference zone shown in Table 9 when shown on the plans. Verify stone-on-stone contact using the method given in the SP design procedure in Tex-204-F, Part IV.

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;
- the Ndesign level used;
- 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 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture
2"	–	–	–
1-1/2"	100.0[1]	–	–
1"	98.0–100.0	100.0[1]	–
3/4"	90.0–100.0	98.0–100.0	100.0[1]
1/2"	Note[2]	90.0–100.0	98.0–100.0
3/8"	–	Note[2]	90.0–100.0
#4	23.0–90.0	28.0–90.0	32.0–90.0
#8	23.0–34.6	28.0–37.0	32.0–40.0
#16	2.0–28.3	2.0–31.6	2.0–37.6
#30	2.0–20.7	2.0–23.1	2.0–27.5
#50	2.0–13.7	2.0–15.5	2.0–18.7
#200	2.0–8.0	2.0–10.0	2.0–10.0
Design VMA, % Minimum			
–	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum			
–	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.
2. Must retain at least 10% cumulative.

Table 9
Reference Zones (% Passing by Weight or Volume)

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture
2"	–	–	–
1-1/2"	–	–	–
1"	–	–	–
3/4"	–	–	–
1/2"	–	–	–
3/8"	–	–	–
#4	–	–	–
#8	34.6–34.6	39.1–39.1	47.2–47.2
#16	22.3–28.3	25.6–31.6	31.6–37.6
#30	16.7–20.7	19.1–23.1	23.5–27.5
#50	13.7–13.7	15.5–15.5	18.7–18.7
#200	–	–	–

Table 10
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, %	Tex-207-F	96.0
Design gyrations (Ndesign)	Tex-241-F	50[1]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[2]
Dust/asphalt binder ratio[3]	–	0.6–1.4
Boil test[4]	Tex-530-C	–

1. Adjust within a range of 35–100 gyrations when shown on the plans or specification or mutually agreed between the Engineer and Contractor.
2. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
3. Defined as % passing #200 sieve divided by asphalt binder content.
4. Used to establish baseline for comparison to production results. May be waived when approved.

Table 11
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to lower the Ndesign level to at least 35 gyrations.
2. May be decreased to at least 5,000 passes when shown on the plans.
3. May be decreased to at least 10,000 passes when shown on the plans.

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 two trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities**.

4.4.2.1.1. **Providing Superpave Gyratory Compactor (SGC)**. 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. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

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

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

4.4.2.1.6. **Ignition Oven Correction Factors**. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II. Provide correction factors that are not more than 12 months old. 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 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.

4.4.2.1.7. **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.

4.4.2.1.8. **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 4, Table 5, and Table 12. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

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

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

4.4.2.1.12. **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.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 12. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel-requirement in Table 11. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test.

The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

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

Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 4 and Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 3077.4.9.3.1.1., "Lot 1 Placement," after receiving approval for JMF2 and a passing result from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor's risk without receiving the results from the Department's Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

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

4.4.2.1.17. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustment 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 mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 12.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 3077.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 12
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer[1]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0[2,3]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[2,3]	±3.0
% passing the #200 sieve			±2.0[2,3]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[3]	±0.3
Dust/asphalt binder ratio[4]	–	Note 5	Note 5	N/A
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±0.5
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, % min	Tex-204-F	Note 6	Note 6	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Defined as % passing #200 sieve divided by asphalt binder content.
5. Verify that Table 10 requirement is met.
6. Verify that Table 8 requirements are met.

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. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance of the following information within two working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 3077.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after two 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.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 11.

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, Part II. Provide correction factors that are not more than 12 months old.

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 12. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 11.

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

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 10; and
- Tex-530-C, to retain and use for comparison purposes during production.

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 12. 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 requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 12.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

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 the maximum production temperatures listed in Table 13 (or 275°F for WMA). The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures listed in Table 13.

Table 13
Maximum Production Temperature

High-Temperature Binder Grade[1]	Maximum Production Temperature
PG 64	325°F
PG 70	335°F
PG 76	345°F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.

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 shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 3077.4.7.3.3., "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 and are not placed in the wheel path, or as directed. Ensure that all finished surfaces will drain properly. Place the

mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 14 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 14
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
SP-B	2.50	4.0	2.00
SP-C	2.00	3.0	1.25
SP-D	1.25	2.0	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. Place mixture when the roadway is dry and the roadway surface temperature is at or above the temperatures listed in Table 15A.The Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 3077.4.7.3.1.2., "Thermal Imaging System."

Table 15A
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	35	40
PG 70	45[2]	50[2]
PG 76	45[2]	50[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture or when using WMA.

4.7.1.2. **When Not Using a Thermal Imaging System**. When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above the temperatures listed in Table 15B 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.

Table 15B
Minimum Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64	45	50
PG 70	55[2]	60[2]
PG 76	60[2]	60[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture, when using WMA, or utilizing a paving process with equipment that eliminates thermal segregation. In such cases, for each sublot and in the presence of the Engineer, use a hand-held thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

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 0.04 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 that 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.

4.7.2.2. **Sampling.** 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 notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use.

For emulsions, the Engineer may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in Item 300, "Asphalts, Oils, and Emulsions."

4.7.3. **Lay-Down Operations**. Use the placement temperatures in Table 16 to establish the minimum placement temperature of mixture delivered to the paver.

Table 16
Minimum Mixture Placement Temperature

High-Temperature Binder Grade[1]	Minimum Placement Temperature (Before Entering Paver)[2,3]
PG 64	260˚F
PG 70	270˚F
PG 76	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Minimum placement temperatures may be reduced 10°F if using a chemical WMA additive as a compaction aid.
3. When using WMA, the minimum placement temperature is 215°F.

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 3077.4.9.3.1.4., "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 moderate thermal segregation.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F are deemed as 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. Density profiles are not required and not applicable when using a thermal imaging system. 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 daily or upon completion of the project or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. When using a thermal camera instead of the thermal imaging system, take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 3077.4.9.3.3.2., "Segregation (Density Profile)." 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 thermal images generated using the thermal camera. Report the results of each thermal profile in accordance with Section 3077.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains severe thermal segregation. 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. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 3077.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

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 3077.4.9.3.3.4., "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**. Compact the pavement uniformly to contain between 3.7% and 7.5% in-place air voids. Take immediate corrective action to bring the operation within 3.7% and 7.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.7% and 7.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.0%. Areas defined in Section 3077.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°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**. Payment adjustments for the material will be in accordance with Article 3077.6., "Payment."

Sample and test the hot-mix on a lot and sublot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in pay factors of at least 1.000 if the production pay factor given in Section 3077.6.1., "Production Payment Adjustment Factors," for two consecutive lots or the placement pay factor given in Section 3077.6.2., "Placement Payment Adjustment Factors," for two consecutive lots is below 1.000.

4.9.1. **Referee Testing**. The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 12 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 three 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.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 3077.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such

that approximately three to four sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 3077.6.1., "Production Payment Adjustment Factors." Close all lots within five working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Shear Bond Strength Testing.** Select one random sublot from Lot 2 or higher for shear bond strength testing. Obtain full depth cores in accordance with Tex-249-F. Label the cores with the Control Section Job (CSJ), producer of the tack coat, mix type, shot rate, lot, and sublot number and provide to the Engineer. The Engineer will ship the cores to the Materials and Tests Division or district laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. sample of the asphalt binder witnessed by the Engineer for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. 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 and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer, producer facility location, grade, district, date sampled, and project information including highway and CSJ. The Engineer will retain these samples for one year. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to MTD to verify compliance with Item 300, "Asphalts, Oils, and Emulsions" and will retain the other split sample for one year.

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests in accordance with Table 17. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 12 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 97.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results. Provide evidence that results from Tex-236-F, Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 17
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)	Tex-207-F, Part V	1 per sublot[2]	1 per project
Longitudinal joint density	Tex-207-F, Part VII		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per sublot[1]
Asphalt binder content	Tex-236-F	1 per sublot	1 per lot[1]
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS)[3]	Tex-217-F, Part III	N/A	
Thermal profile	Tex-244-F	1 per sublot[2]	
Asphalt binder sampling and testing	Tex-500-C, Part II	1 per lot (sample only)[4]	
Tack coat sampling and testing	Tex-500-C, Part III	N/A	
Boil test[5]	Tex-530-C	1 per lot	
Shear Bond Strength Test[6]	Tex-249-F	1 per project (sample only)	

1. For production defined in Section 3077.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. To be performed in the presence of the Engineer, unless otherwise approved. Not required when a thermal imaging system is used.
3. Testing performed by the Materials and Tests Division or designated laboratory.
4. Obtain samples witnessed by the Engineer. The Engineer will retain these samples for one year.
5. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
6. Testing performed by the Materials and Tests Division or District for informational purposes only.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances listed in Table 12. 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.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances in Table 12 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 12. No production or placement payment

adjustments greater than 1.000 will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA)**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on two consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that does not meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 11. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Materials and Tests Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 12, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 3077.6.2., "Placement Payment Adjustment Factors;" however, no placement adjustment less than 1.000 will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.0%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.0%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 3077.4.9.2.1.1., "Incomplete Production Lot," excluding areas defined in Section 3077.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 14. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article3077.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 3077.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores on-site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement sublot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. For SP-C and SP-D mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-251-F if the core heights meet the minimum untrimmed value listed in Table 14. Trim the cores on-site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after witnessing the trimming of the coresand will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value shown in Table 14. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on-site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 17. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 12.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a CoreDry or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Segregation (Density Profile**). Test for segregation using density profiles in accordance with Tex-207-F, Part V when using a thermal camera instead of the thermal imaging system. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 3077.4.9.3.1.4., "Miscellaneous Areas."

Perform a minimum of one density profile per sublot. Perform additional density profiles when any of the following conditions occur, unless otherwise approved:

- the paver stops due to lack of material being delivered to the paving operations and the temperature of the uncompacted mat before the initial break down rolling is less than the temperatures shown in Table 18;
- areas that are identified by either the Contractor or the Engineer with thermal segregation;
- any visibly segregated areas that exist.

Table 18
Minimum Uncompacted Mat Temperature Requiring a Segregation Profile

High-Temperature Binder Grade[1]	Minimum Temperature of the Uncompacted Mat Allowed Before Initial Break Down Rolling[2,3,4]
PG 64	<250˚F
PG 70	<260˚F
PG 76	<270˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Segregation profiles are required in areas with moderate and severe thermal segregation as described in Section 3077.4.7.3.1.3.
3. Minimum uncompacted mat temperature requiring a segregation profile may be reduced 10°F if using a chemical WMA additive as a compaction aid.
4. When using WMA, the minimum uncompacted mat temperature requiring a segregation profile is 215°F.

Provide the Engineer with the density profile of every sublot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 3077.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 19. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 3077.4.9.3.3.5., "Irregularities." The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if two consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 19
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
SP-B	8.0 pcf	5.0 pcf
SP-C & SP-D	6.0 pcf	3.0 pcf

4.9.3.3.3. **Longitudinal Joint Density**.

4.9.3.3.3.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations at least once per sublot unless otherwise directed.

4.9.3.3.3.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 3077.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density

verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 3077.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on two consecutive sublots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.4. **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 Materials and Tests 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.

4.9.3.3.5. **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. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) 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.

4.9.4. **Exempt Production**. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 500 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement QC/QA sampling and testing requirements, except for coring operations when required by the Engineer. The production and placement pay factors are 1.000 if the specification requirements listed below are met, all other specification requirements are met, and the Engineer performs acceptance tests for production and placement listed in Table 17 when 100 tons or more per day are produced:

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 3077.4.8., "Compaction"; and
- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

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

5. MEASUREMENT

5.1. **Superpave Mixtures.** Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **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 measure by the gallon applied.

The Engineer may allow the use of a metering device to determine the 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 3077.5.1, "Measurement," will be paid for at the unit bid price for "Superpave Mixtures" of the mixture type, SAC, and binder 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 3077.5.2, "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. Payment adjustments will be applied as determined in this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code, and all testing requirements are met.

Payment for each sublot, including applicable payment adjustments greater than 1.000, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 3077.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in Tex-244-F are required.

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."

6.1. **Production Payment Adjustment Factors**. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. The bulk specific gravities of the samples from each sublot will be divided by the Engineer's maximum theoretical specific gravity for the sublot. The individual sample densities for the sublot will be averaged to determine the production payment adjustment factor in accordance with Table 20 for each sublot using the deviation from the target laboratory-molded density defined in Table 10. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the four sublots sampled within that lot.

Table 20
Production Payment Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.075
0.1	1.075
0.2	1.075
0.3	1.066
0.4	1.057
0.5	1.047
0.6	1.038
0.7	1.029
0.8	1.019
0.9	1.010
1.0	1.000
1.1	0.900
1.2	0.800
1.3	0.700
> 1.3	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 97.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production payment adjustments for incomplete lots, described under Section 3077.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production pay factors from all sublots sampled.

A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples within the first sublot.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing, the laboratory-molded density for any sublot results in a "remove and replace" condition as listed in Table 20, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3077.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Payment Adjustment Factors**. The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. The bulk specific gravities of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the placement payment adjustment factor in accordance with Table 21 for each sublot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 3077.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to four sublots within that lot.

Table 21
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Payment Adjustment Factor	In-Place Air Voids	Placement Payment Adjustment Factor
< 2.7	Remove and Replace	5.9	1.048
2.7	0.710	6.0	1.045
2.8	0.740	6.1	1.042
2.9	0.770	6.2	1.039
3.0	0.800	6.3	1.036
3.1	0.830	6.4	1.033
3.2	0.860	6.5	1.030
3.3	0.890	6.6	1.027
3.4	0.920	6.7	1.024
3.5	0.950	6.8	1.021
3.6	0.980	6.9	1.018
3.7	1.000	7.0	1.015
3.8	1.015	7.1	1.012
3.9	1.030	7.2	1.009
4.0	1.045	7.3	1.006
4.1	1.060	7.4	1.003
4.2	1.075	7.5	1.000
4.3	1.075	7.6	0.980
4.4	1.075	7.7	0.960
4.5	1.075	7.8	0.940
4.6	1.075	7.9	0.920
4.7	1.075	8.0	0.900
4.8	1.075	8.1	0.880
4.9	1.075	8.2	0.860
5.0	1.075	8.3	0.840
5.1	1.072	8.4	0.820
5.2	1.069	8.5	0.800
5.3	1.066	8.6	0.780
5.4	1.063	8.7	0.760
5.5	1.060	8.8	0.740
5.6	1.057	8.9	0.720
5.7	1.054	9.0	0.700
5.8	1.051	> 9.0	Remove and Replace

6.2.1. **Payment for Incomplete Placement Lots**. Payment adjustments for incomplete placement lots described under Section 3077.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement pay factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination.

If the random sampling plan results in production samples, but not in placement samples, the random core location and placement adjustment factor for the sublot will be determined by applying the placement random number to the length of the sublot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that sublot placed.

A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any production samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing, the placement payment adjustment factor for any sublot results in a "remove and replace" condition as listed in Table 21, the Engineer will choose the location of two cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Materials and Tests Division,

where they will be trimmed, if necessary, and tested for bulk specific gravity within 10 working days of receipt.

The bulk specific gravity of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the new payment adjustment factor of the sublot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that sublot. If the new payment adjustment factor is less than 0.700, no payment will be made for the sublot. Remove and replace the failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 3077.5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay Calculation**. Total adjusted pay (TAP) will be based on the applicable payment adjustment factors for production and placement for each lot.

$TAP = (A+B)/2$

where:
A = Bid price × production lot quantity × average payment adjustment factor for the production lot
B = Bid price × placement lot quantity × average payment adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas