

AGG 101

Aggregate Properties Specialist

CERTIFICATION MANUAL



**Partners
in Quality**





The Hot Mix Asphalt Center exists to certify, train, and equip specialists with the knowledge and skills needed to inspect, test, and design construction materials. Through education and support that continue beyond certification, the HMAC seeks to help people realize their potential to contribute to the future of Texas' infrastructure.

To execute our mission, we constantly aim to:

EDUCATE

Through hands-on learning, training, and testing, our instructors ensure specialists not only have a thorough understanding of the subject, but will be able to apply what they've learned in a real-world setting. We believe our role as an educational resource doesn't stop at the door – it continues throughout a specialist's career.

INNOVATE

From installing the latest, cutting-edge equipment in our labs to streamlining processes and developing new educational tools, we strive to continuously set a higher bar for ourselves and those around us.

EMPOWER

We believe in the potential of every specialist who comes through the center and do all we can to help them be successful before, during, and after certification. Our mantra is that what you do matters. If you put in the work to be the best you can be, we'll be here to cheer you on and support you along the way.

SERVE

Service is at the core of everything we do. Whether it be for individuals, companies, TxDOT, or the traveling public, the goal is for every certification to result in improved quality of asphalt pavements across the state of Texas.



AGG101 Aggregate Properites Specialist

TABLE OF CONTENTS

Rights and Responsibilities

Website

Tex-107-F Linear Bar Shrinkage of Soils and Base Materials

Tex-200-F Sieve Analysis of Fine and Coarse Aggregates (Parts 1 & 2)

Tex-201-F Bulk Specific Gravity and Water Absorption of Aggregates

Tex-203-F Sand Equivalent Test

Tex-212-F Determining Moisture Content of Bituminous Mixtures (Part 2)

Tex-217-F Determining Deleterious Material and Decantation Test For Coarse Aggregates

Tex-221-F Sampling Aggregate for Bituminous Mixtures, Surface Treatments, and Limestone Rock Asphalt

Tex-224-F Flakiness Index

Tex-280-F Determining Flat and Elongated Particles

Tex-400-A Sampling Aggregate and Stone Riprap

Tex-401-A Sieve Analysis of Fine and Coarse Aggregate

Tex-402-A Fineness Modulus of Fine Aggregate

Tex-403-A Saturated Surface-Dry Specific Gravity and Absorption of Aggregates

Tex-404-A Determining Unit Mass (Weight) of Aggregates

Tex-406-A Decantation Test for Concrete Aggregate (Part 1)

Tex-408-A Organic Impurities in Fine Aggregate

Tex-413-A Determining Deleterious Material In Mineral Aggregate

Tex-460-A Determining Crushed Face Particle Count (Part 1)

Tex-461-A Degradation of Coarse Aggregate by Micro-Deval Abrasion

Item 302 Aggregates for Surface Treatments

SS3077 Superpave Mixtures

©2023 HMAC - All Rights Reserved

No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, mechanical, electronic, photocopying, recording or otherwise without the prior written permission of the Texas Asphalt Pavement Association.



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 1468, 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.

ACKNOWLEDGED & AGREED:

SPECIALIST:

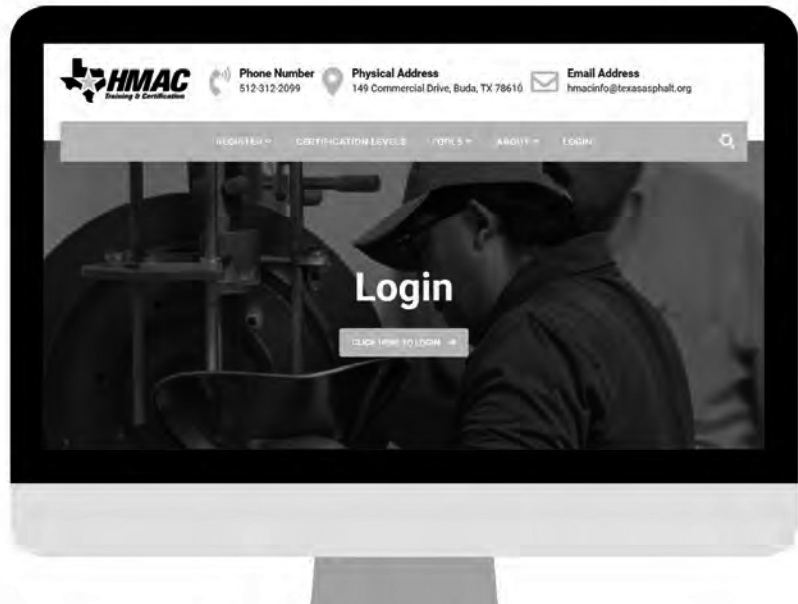
SIGNATURE

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

Same as your username, but add a "+" at the end.

Example

If your name is John Doe and your SSN ends in 1234:

Username: JDoe1234

Password: JDoe1234+





UPDATE INFORMATION

Contact Info

Username: J0041234

E-Mail: Joe.Smith@hmac.com

Work Email: j004@hmac.com

First Name: John

Last Name: Doe

Company: HMAC

Company Type: JAC - Other

Last 4 digits of SSN: 1234

Cell Phone: (512) 555-0000

Personal:

Change Password: To change password, enter new password here. (Leave it blank if not changing.)

Enter your new password again

Verify that all information is correct.



UPDATE INFORMATION

**VIEW/PRINT
CERTIFICATIONS
PROFICIENCY**

Certification

Test Results

Test Name	Test Date	Test Score	Expiration Date	Status	Actions
1A	07/27/2018	9982	07/27/2021	Active	View Summary
1B	07/27/2018	2723	07/27/2021	Active	View Summary
2	02/06/2015	647	02/06/2018	Active	View Summary
A00101	06/06/2018	9985	06/06/2021	Active	View Summary

[Proficiency Instructions](#) [Annual Proficiency Reports](#)

Beta Class

Test Name	Test Date	Test Score	Expiration Date	Status
SB101	03/23/2008	002	03/23/2009	Inactive
SB102	03/23/2008	001	03/23/2009	Inactive
SB103				
SB104				
SB105				

Prerequisite: SB201 is required

Test Procedure for

LINEAR BAR SHRINKAGE OF SOILS AND BASE MATERIALS



TxDOT Designation: Tex-107-E

Effective Date: July 2024

1. SCOPE

- 1.1 Use this test procedure to determine the linear bar shrinkage of material passing the No. 40 sieve. It provides an indication of the presence of clay material that may impact the performance of pavements.
 - 1.2 This test is required for embankment (soils), and for fine aggregate and mineral filler used to produce hot mix asphalt. It is also required when it is not possible to measure the liquid limit. This is when a groove closure before 20 blows cannot be obtained, such as for non-plastic, sand material having a low plasticity index.
 - 1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

2. APPARATUS AND MATERIALS

- 2.1 Balance, Class G1 in accordance with Tex-901-K, minimum capacity of 200 g.
 - 2.2 Distilled or deionized water.
 - 2.3 Flexible spatula, with a blade approximately 4 in. long and 0.75 in. wide.
 - 2.4 Grooving tool, ASTM grooving tool as shown in Tex-104-E.
 - 2.5 Linear bar shrinkage mold, stainless steel or aluminum, with section $0.75 \pm 0.02 \times 0.75 \pm 0.02 \times 5 \pm 0.02$ in.
 - 2.6 Number 20 scale.
 - 2.7 Oven, capable of maintaining a temperature of $230 \pm 9^\circ\text{F}$.
 - 2.8 Petroleum Jelly
 - 2.9 Porcelain evaporating dish, with a diameter of 4.5–5.5 in.
 - 2.10 Straight edge.
 - 2.11 Water, approved drinking source.
-

3. PREPARING SAMPLE

- 3.1 Sample embankment (soils) or flexible base in accordance with Tex-100-E.
 - 3.2 Sample a fine aggregate stockpile in accordance with Tex-221-F or Tex-400-A.
 - 3.3 Prepare the sample in accordance with Tex-101-E, Part I to provide a minimum of 200 g.
 - 3.3.1 When testing material for the liquid limit (Tex-104-E) and it is not possible to produce a groove closure before 20 blows, use the remaining wet sample for this test. Proceed to Section 4.4.
-

4. PROCEDURE

- 4.1 Grease the inside walls of the linear bar shrinkage mold with a thin layer of petroleum jelly to prevent any adhesion of the material to the mold.
- 4.2 Place a minimum of 100 g of material from the dry sample prepared in Section 3 in an evaporating dish.
- 4.3 Add water and thoroughly mix the material to a uniform consistency.
- 4.4 Shape the sample into a smooth layer about 0.5 in. thick on the bottom of the dish and make a groove with the grooving tool.
 - 4.4.1 The sample is ready for testing when the material immediately flows on its own and just closes the groove at the bottom. Proceed to Section 4.5.
 - 4.4.2 When it's necessary to tap the dish to close the groove, add more water and mix the material thoroughly. Verify the groove closure and proceed to Section 4.4.
 - 4.4.3 When the material is too wet, add dry material and mix it thoroughly. Verify the groove closure and proceed to Section 4.5.
- 4.5 Use a spatula and place the wet material into the greased mold.
 - 4.5.1 Hold the dish approximately 1 in. above the mold and slowly push the material out of the dish into the mold.
 - 4.5.2 Alternatively, pick up material from the dish using a spatula and gently tap the bottom of the mold to slide the material off the spatula and into the mold.
- 4.6 Gently tap the mold to cause the material to flow and to assist in the removal of entrapped air bubbles.
- 4.7 Continue to fill and remove entrapped air until the mold is filled with excess material.
- 4.8 Use a straightedge to smooth the surface level with the top of the mold.
 - 4.8.1 Discard or return any excess material to the dish to be used for another bar.
- 4.9 Wipe excess material from the top edges surrounding the bar.
- 4.10 Allow the mold and material to air dry until the color or the appearance changes slightly. This is to prevent excessive cracking or heaving of the bar during oven drying.

- 4.11 Place the mold in the drying oven at $230 \pm 9^{\circ}\text{F}$ and dry to a constant weight.
- 4.11.1 Constant weight is achieved when the weight loss is less than 0.1% of the sample weight after 4 hr. of drying.
- 4.12 Remove the mold from the oven and allow it to cool to room temperature or until it can be handled with bare hands.
- 4.13 Measure the length of the dry bar.
- 4.13.1 Do not remove the bar from the mold because this may damage the bar.
- 4.13.2 When there is shrinkage from both ends of the mold, use your finger or spatula and gently push the bar to one side of the mold.
- 4.13.3 Use a number 20 scale and measure to the whole percent.

5. CALCULATIONS

- 5.1 Use the following equation to determine the linear bar shrinkage.

$$LS = 100 - S_{20}$$

Where:

100 = Length of the wet soil bar, 100%.

S_{20} = Length of the dry soil bar, % (Section 4.13.3).

6. REPORT

- 6.1 Report to the nearest whole percent.

7. ARCHIVED VERSION

- 7.1 An archived version is available.

Test Procedure for**SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES****TxDOT Designation: Tex-200-F****Effective Date: April 2025**

1. SCOPE

- 1.1 Use this test method to determine the particle size distribution of aggregate samples, using standard U.S. sieves with square openings.
 - 1.2 Use Part I to determine a weight-based dry-sieve analysis for an aggregate sample.
 - 1.3 Use Part II to determine a weight-based sieve analysis for an aggregate sample requiring a washed sieve analysis.
 - 1.4 Use Part III to determine a volume-based sieve analysis for an aggregate sample. Perform a volumetric sieve analysis when aggregates with differences in bulk specific gravity greater than 0.3 are blended.
 - 1.5 Use Part IV to determine the precise data relating to aggregate compounds in which some percentage of the total volume includes material that is lighter than water or the usual suspension medium.
 - 1.6 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 *Sample splitter, quartering machine, quartering cloth, or shovel and a smooth surface.*
- 2.2 *Set of standard U.S. sieves, meeting the requirements of Tex-907-K.*
- 2.3 *Mechanical sieve shaker.*
- 2.4 *Balance, Class G2 in accordance with Tex-901-K, minimum capacity of 10000 g.*
- 2.5 *Drying oven, capable of attaining a temperature of at least $230 \pm 9^{\circ}\text{F}$ ($110 \pm 5^{\circ}\text{C}$).*
- 2.6 *Various pans.*
- 2.7 *Scoop.*
- 2.8 *Brass wire brush.*
- 2.9 *Bristle brush.*

3. PREPARING MATERIAL SAMPLE

- 3.1 Follow this method to prepare aggregate that has been sampled from a stockpile.
Note 1—This sample preparation method is not applicable when performing a sieve analysis on material obtained from an ignition oven or extraction sample.
- 3.2 Place a representative sample of processed aggregate in oven and dry to constant weight at a minimum temperature of $230 \pm 9^{\circ}\text{F}$ ($110 \pm 5^{\circ}\text{C}$).
- 3.2.1 For field testing of Portland cement concrete aggregate, it is not necessary to completely dry, but merely to surface dry, the coarse aggregate.
- 3.2.2 Dry limestone rock asphalt (LRA) samples at $140 \pm 9^{\circ}\text{F}$ ($60 \pm 5^{\circ}\text{C}$).
Note 2—For control testing, where rapid results are desired, it is not necessary to dry LRA aggregate.
- 3.3 For coarse materials (major portion retained on the No. 8 [2.36 mm] sieve), quarter the sample to the required size as shown in Table 1 using one of the following methods:
- sample splitter,
 - quartering cloth,
 - quartering machine, or
 - mix on a smooth clean surface with a large flat scoop or shovel until blended, and quarter with a straight edge.
- 3.4 For fine materials (major portion passing No. 8 [2.36 mm] sieve) thoroughly blend sample and take small portions from several places in the pan to make up a test sample with the required size as shown in Table 1.
- 3.5 For control testing, create a test sample for all size aggregates by blending small portions taken from several places in the pan.
- 3.6 For plant control testing, weigh aggregates in the same proportions as used in the bituminous mixture being produced, then combine and sieve to yield the combined aggregate gradation.
- 3.7 Reverse Sections 3.2 – 3.6 when this proves more practical.

Table 1
Min Size of Samples

Nominal Max Aggregate Size ¹	Min Weight of Field Sample, g (lb.)	Min Weight of Sample for Test, g (lb.)
Fine Aggregate		
No. 8 (2.36 mm)	4500 (10)	500 (1.1)
No. 4 (4.75 mm)	4500 (10)	500 (1.1)
Coarse Aggregate		
3/8 in. (9.75 mm)	4500 (10)	1000 (2)
1/2 in. (12.5 mm)	4500 (10)	1500 (3)
3/4 in. (19.0 mm)	4500 (10)	2000 (4)
1 in. (25.0 mm)	6800 (15)	3000 (6)
1-1/2 in. (37.5 mm)	9000 (20)	4000 (8)

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

PART I—DRY SIEVE ANALYSIS (BASED ON WEIGHT)

4. PROCEDURE

- 4.1 Prepare the material sample in accordance with Section 3.
- 4.2 Determine the mass of the total sample and record to the nearest 0.1 g as W_T in Section 6.
- 4.3 Using the sieve sizes required by the specification, arrange the set of sieves in descending order with the largest size on top.
- 4.4 *Method A—Follow these steps when using a mechanical shaker:*
 - 4.4.1 Place the set of sieves onto a pan and place into the shaker.
 - 4.4.2 Pour the prepared aggregate into the top sieve.
 - 4.4.3 Cover the stack of sieves and pan, then shake the sample for at least 5 min.
 - 4.4.4 It may be necessary to establish a shaking time for different types of aggregates to assure proper sieving of the material without degradation.
 - 4.4.5 Remove the stack of sieves from the shaker and sieve each sieve-size by hand to refusal.
 - 4.4.6 Starting with the largest sieve size, remove the material from the sieve and measure the weight to the nearest 0.1 g. This is the material retained on the individual sieve.
 - 4.4.7 Calculate 1% of this weight by multiplying it with 0.01.
 - 4.4.8 Place the empty sieve into an empty, clean bowl or pan such that it is beneath the sieve to catch material that passes during hand sieving.

- 4.4.9 Return the material from Section 4.4.6 to the empty sieve and hand sieve it for approximately 1 min. with lateral and vertical motion with a jarring action that keeps the material moving continuously over the surface of the sieve.
- 4.4.10 Remove the sieve and weigh the material in the bowl or pan.
- 4.4.10.1 When this measured weight is less than the weight calculated in Section 4.4.7, add the material from the bowl to the material in the next smaller sieve size.
- 4.4.10.2 Weigh the material retained on the individual sieve to the nearest 0.1 g and record.
- 4.4.10.3 Proceed to the next sieve size and repeat Sections 4.4.6 – 4.4.10.2. Continue hand sieving until all the sieves have been shaken to refusal.
- 4.4.10.4 When the weight in the bowl or pan is more than 1% (Section 4.4.7), add the material from the bowl to the material in the next smaller sieve size and repeat Sections 4.4.6 – 4.4.10.2.
- 4.4.11 Proceed to Section 4.6.
- 4.5 *Method B—Follow these steps when no mechanical shaker is available and hand sieving only:*
- 4.5.1 Begin with the largest sieve size and progress toward the smaller sieve sizes following the method described in Section 4.4.5 – 4.4.10.
- 4.6 Calculate and report the percentages to the nearest 0.1% for each sieve size as shown in Section 6 and Section 7.
- 4.7 Take care to prevent loss of material during the sieving operation. When there is a discrepancy of equal to or less than 0.2% between the original dry weight of the sample and the sum of the weights of the various sizes, assume this amount is particles passing the smallest size sieve and use the original weight. When the discrepancy is greater than 0.2%, check the weights of the various sizes or rerun the analysis with a new sample to correct the error.

PART II—WASHED SIEVE ANALYSIS (WHEN SPECIFIED BASED ON WEIGHT)

5. PROCEDURE

- 5.1 Prepare the material sample in accordance with Section 3.
Note 3—Test a minimum of two samples from each stockpile when developing a mixture design in accordance with Tex-204-F.
- 5.2 Determine the mass of the total dry sample and record to the nearest 0.1 g as W_T in Section 6.
- 5.3 Place the sample in a wash pan and completely cover with clean potable water.
- 5.4 Gently mix the sample with the hands to break up clay lumps and friable particles and loosen the coating of fines on the coarse aggregate.
- 5.5 Rinse any sample particles clinging to the hands back into the wash pan.
- 5.6 Soak the sample for a minimum of 10 min. A sample that contains very high clay content may require overnight soaking. After soaking, remix the sample with the hands as noted in Section 5.4 and repeat Section 5.5.

- 5.7 Stack a No. 8 (2.36 mm) on a No. 200 (75 μ m) sieve and place in a pan or over an open sink.
- 5.8 Flush the wetted sample over the stacked sieves in small batches to prevent overloading and damage to the No. 200 (75 μ m) sieve.
- 5.9 When the material retained on the No. 8 (2.36 mm) sieve is adequately washed, remove it, and place in a clean drying pan.
- 5.10 Continue to wash the material retained on the No. 200 (75 μ m) sieve until the wash water runs clear. Then place it in the drying pan with the previously cleaned No. 8 (2.36 mm) material.
- 5.11 Repeat Section 5.8 – 5.10 until the entire sample is washed over the set of sieves. After the final wash, rinse the sieves over the drying pan.
- 5.12 After the fines have settled, decant excess water from the drying pan and dry the washed sample to a constant weight.
- 5.13 Determine the mass of the dried washed sample and record as W_w in Section 6.
- 5.14 Determine the sieve analysis of the dried washed sample as described in Section 4.
- 5.15 Calculate and report the percentages to the nearest 0.1% for each sieve size as shown in Sections 6 and 7.
- 5.16 Take care to prevent loss of material during the sieving operation. When there is a discrepancy of equal to or less than 0.2% between the original dry weight of sample and the sum of the weights of the various sizes, assume this amount is particles passing the smallest size sieve and use the original weight. When the discrepancy is greater than 0.2%, check the weights of the various sizes or rerun the analysis with a new sample to correct the error.

6. CALCULATIONS

- 6.1 *Dry Sieve Analysis*—calculate the individual percent retained for each consecutive sieve using the following equation:

$$W = \left(\frac{X_1}{W_T} \right) \times 100$$

Where:

W = Individual percent retained

X_1 = Weight of oven dry aggregate retained on individual sieve or pan

W_T = Total weight of original dry sample.

- 6.2 *Washed Sieve Analysis*—the calculations are the same as for dry sieve analysis, except use the following equation to determine the percent finer than the No. 200 (75 μ m) sieve:

$$\text{Passing No. 200 (75}\mu\text{m)} = \frac{(W_T - W_w)}{W_T} \times 100$$

Where:

W_w = Total weight of the washed dry sample

W_T = Total weight of the original dry sample.

Note 4—When a small amount of additional material passing the No. 200 (75 μm) sieve is produced during the dry sieve analysis performed after washing, add this weight to the passing No. 200 (75 μm) sieve before calculating the percentage passing the No. 200 (75 μm) sieve.

7. REPORT FORMS

- 7.1 Use Sieve Analysis of Non-Surface Treatment Aggregates in Excel to calculate both a dry or washed sieve analyses.
- 7.2 Use Sieve Analysis of Surface Treatment Aggregate in Excel to calculate the sieve analysis of aggregates for surface treatment applications.

PART III—VOLUMETRIC SIEVE ANALYSIS

8. APPARATUS

- 8.1 Apparatus listed in Section 2, with the addition of the following items.
- 8.1.1 *Glass graduates, 2,000 mL, with 20-mL graduations; and 250 mL, with 2-mL graduations.*
- 8.1.2 *Wide-mouth funnel.*
- 8.1.3 *Water or other appropriate liquids.*

9. PROCEDURE

- 9.1 Prepare the material sample in accordance with Section 3.
- 9.2 Perform the sieve analysis in accordance with Section 4.
- 9.3 Fill the glass graduate with water or other appropriate liquid, enough to cover entire sample.
- 9.4 Make an initial reading of the liquid level and record on Form CST-M-2, "Volumetric Sieve Analysis Worksheet."
- 9.5 Place the aggregate retained on the largest sieve size into the graduate.
Note 5—Begin with the finest size when preparing more absorptive materials.
- 9.6 Eliminate entrapped air from the graduate, particularly after adding the fine aggregate, by gently rolling the graduate or stirring the aggregate before taking a reading.
- 9.7 Read the liquid level within 20 sec. and record on the worksheet.
- 9.8 Before adding each aggregate size, re-check the liquid level reading. When it differs from the liquid level recorded for the previous aggregate size, use the new reading as the initial liquid level before adding the next aggregate size. The procedure's objective is to measure the volume change of the liquid for each size aggregate.
- 9.9 Determine the volume of each size of aggregate by subtracting the liquid reading before the addition of each size of aggregate from the liquid reading after the addition of each size of aggregate. Enter the result in

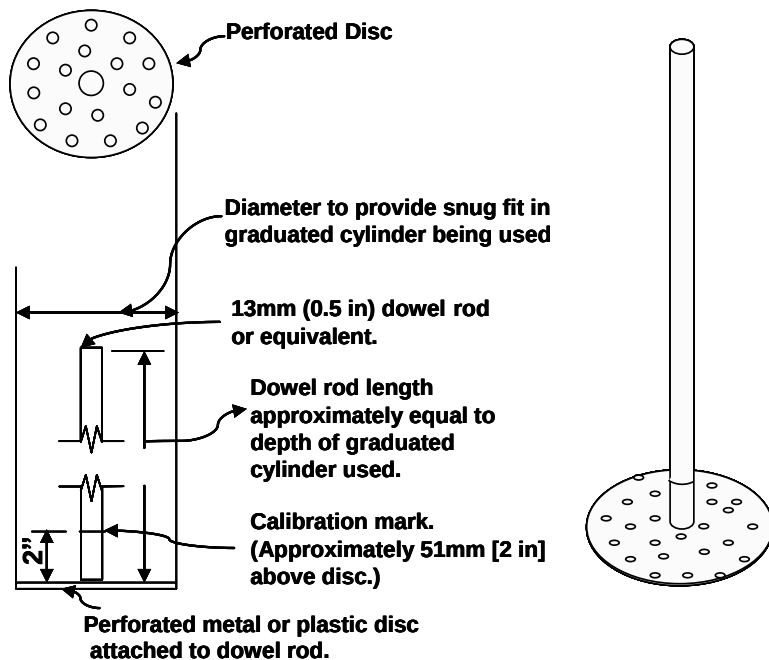
Column 3 of the worksheet. The difference in initial and final readings will be the total volume of the aggregate.

- 9.10 Divide the volume of each aggregate fraction by the total aggregate volume to determine the percent retained on each sieve and enter in Column 4. This percent will be an expression of each size as a portion of the total aggregate.
- 9.11 Calculate the total percent retained and percent passing from the values calculated in Section 9.10.

PART IV—VOLUMETRIC SIEVE ANALYSIS OF LIGHTWEIGHT AGGREGATE (WITH SPECIFIC GRAVITIES LIGHTER THAN WATER)

10. APPARATUS

- 10.1 Same apparatus as listed for Part III with the addition of a plunger. (See Figure 1.)



Note: The perforation in the disc should be small enough to permit the passage of any small floating particle.

Figure 1—Volumetric Sieve Analysis-Plunger—Diagram

11. PROCEDURE

- 11.1 Prepare the material sample in accordance with Section 3.
- 11.2 Perform the sieve analysis in accordance with Section 4.
- 11.3 Fill the graduate with enough water or other appropriate liquid to cover entire sample plus at least an additional 2 in. (51 mm).

Note 6—The additional 2 in. (51 mm) is required to ensure that the calibration mark on the plunger is submerged when taking a reading.

- 11.4 Slowly lower the plunger into the liquid, permitting air and liquid to percolate through the holes in the perforated disc, until the liquid level reaches the calibration mark on the plunger handle.
- 11.5 Trap all material beneath the plunger disc, eliminating any air before making readings.
- 11.6 With the liquid level on the calibration mark of the plunger handle, read and record the liquid level from the scale on the graduated cylinder. This is the “zero” or “initial” reading.
- 11.7 Remove the plunger and place the aggregate retained on the largest sieve into the graduate. Begin with the finest size when preparing more absorptive materials.
- 11.8 Slowly lower the plunger into the liquid until the level rises to the calibration mark on the plunger handle.
- 11.9 Read and record the liquid level from the calibrated scale on the graduated cylinder within 20 sec. of the aggregate being added.
- 11.10 Check the liquid level when ready to add the next aggregate size.
- 11.11 Record this as the initial reading and pour in the next sieve-size material. Make this reading within 20 sec., in the same manner described above.
- 11.12 Continue this procedure for each sieve size material.
- Note 7**—Take care when lowering the plunger into the liquid so that floating particles do not slip by the edge of the plunger disc.
- 11.13 Make calculations in the same manner described previously under Part III, Sections 9.9 – 9.11.
- 11.14 Improve the precision of this procedure by using two graduates.
- 250-mL graduate with 2-mL graduations—The volumes of small amounts of aggregate of any given size can be measured with a greater precision in the 250-mL graduate.
 - 2,000-mL graduate with 20-mL graduations—The volumes of the larger amounts of aggregate of any given size can be measured in the 2,000-mL graduate.

12. ARCHIVED VERSIONS

- 12.1 Archived versions are available.

Test Procedure for**BULK SPECIFIC GRAVITY AND WATER ABSORPTION OF AGGREGATE****TxDOT Designation: Tex-201-F****Effective Date: April 2025**

1. SCOPE

- 1.1 Use this method to determine the bulk specific gravity and water absorption of aggregate retained on the No. 200 (75 μm) sieve. The bulk specific gravity may be used in calculating the maximum theoretical specific gravity (G_t) or the voids in the mineral aggregate (VMA) of a bituminous mixture. Water absorption may be used to determine the amount of free moisture within the aggregate.
-

2. STANDARD TEST METHOD

- 2.1 Refer to [Tex-403-A](#) for the definitions, apparatuses, calibrations, and calculations.
- 2.1.1 Sample aggregates in accordance with [Tex-221-F](#). Prepare aggregates for testing in accordance with [Tex-403-A](#), Section 5.
- 2.1.2 For fine aggregate passing the No.4 sieve, refer to [Tex-403-A](#), Sections 6.2 and 6.3
- 2.1.3 For coarse aggregate, refer to [Tex-403-A](#), Section 6.4
-

3. REPORT FORMS

- 3.1 [Bulk Specific Gravity and Water Absorption of Aggregate](#)
- 3.2 Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1%.
-

4. ARCHIVED VERSIONS

- 4.1 Archived versions are available.

Test Procedure for

SAND EQUIVALENT TEST

TxDOT Designation: Tex-203-F

Effective Date: April 2025



1. SCOPE

- 1.1 Use this method to determine the relative proportion of detrimental fine dust or clay-like particles in soils or fine aggregates.
 - 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.
 - 1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

2. APPARATUS

- 2.1 *Transparent plastic graduated cylinder, 1.25-in. inside diameter, approximate 17-in. height, graduated up to 15 in. in intervals of 0.1 in., starting at the base.*
 - 2.2 *Rubber stopper, to fit the mouth of the graduated cylinder.*
 - 2.3 *Agitator tube, brass, stainless steel, or copper; 0.25-in. outside diameter; approximately 20 in. long; one end closed to form a wedge-shaped tip; two holes (drill size 60) drilled laterally through the flat side of the wedge.*
 - 2.4 *Weighted foot assembly, consisting of a metal rod connected to a foot with a flat, smooth surface at the lower end and a weight at the upper end to give the total assembly a weight of $1000 \pm 5\text{g}$. Use one of the assembly models described in Sections 2.4.1 and 2.4.2.*
 - 2.4.1 *Assembly with sand reading indicator, sand reading indicator attached on the rod 10 in. above the base of the foot.*
 - 2.4.2 *Assembly with no sand reading indicator, the foot has three small screws to center it loosely in the cylinder. A bored cap fits loosely around the rod at the top of the cylinder to center the weighted foot assembly in the cylinder. The weight of this cap is not part of the total weight of the assembly.*
 - 2.5 *Glass bottle, 1 gal., equipped with a siphon assembly consisting of a two-hole rubber stopper and pieces of glass or copper tubing, sits $3\text{ ft.} \pm 1\text{ in.}$ above the work surface.*
 - 2.6 *Tubing, 4 ft. long, plastic or rubber, with pinch clamp to connect the open end of the agitator tube with the siphon assembly.*
 - 2.7 *Standard U.S. sieve, No. 4, meeting the requirements of [Tex-907-K](#).*
-

- 2.8 *Measuring can, 85 ± 5 mL capacity*
 - 2.9 *Wide mouth funnel.*
 - 2.10 *Stopwatch, watch, or clock, reading in minutes and seconds.*
 - 2.11 *Glass cylinder, 100 mL, graduated in increments of 2 mL or less.*
 - 2.12 *Drying oven, capable of maintaining 140 ± 5°F and 230 ± 9°F.*
 - 2.13 *Motor-driven mechanical sand equivalent shaker.*
 - 2.14 *Straight edge or spatula.*
 - 2.15 *Splitter or quartering device.*
-

3. **MATERIALS**

- 3.1 *Stock solution, prepared either according to AASHTO T176, Section 4.8 or the method in Sections 3.1.1 – 3.1.3.*
 - 3.1.1 Dissolve 577 g of ACS grade calcium chloride dihydrate in 1.9 L of distilled or demineralized water.
 - 3.1.2 Cool the solution.
 - 3.1.3 Add 1,640 mL of U.S.P. glycerin and 53 mL of 50% 1,5-Pentanedial (Glutaraldehyde) in water to the solution and mix well; 1,5-Pentanedial is also known as glutaraldehyde, glutaric dialdehyde, and trade name UCARCIDE. It may also be found as “Glutaraldehyde Solution 50%.”
 - 3.2 *Working calcium chloride solution, prepared either according to AASHTO T176, Section 4.9 or the method in Sections 3.2.1 – 3.2.2.*
 - 3.2.1 Dilute 88 mL of the stock calcium chloride solution to 3.8 L of distilled or demineralized water. After the addition of the stock solution, shake thoroughly. Use a good quality tap water if the purity does not affect the test results.
 - 3.2.2 Maintain a working solution temperature of 72 ± 5°F during the test. If this is not possible in a field laboratory, send samples to the referee laboratory for testing under proper temperature control conditions.
-

4. **PROCEDURES**

- 4.1 *Preparing Sample:*
- 4.1.1 Select a representative sample of material in accordance with the applicable specification.
- 4.1.2 Oven-dry the test sample to constant weight at 230 ± 9°F. Oven-dry limestone rock asphalt aggregates at 140 ± 5°F.
Note 1—Constant weight is defined as oven drying the material at the specified temperature until the material will not lose more than 0.1% moisture after 2 hr. of drying. Verify by measuring the moisture content from weighing the mass of a sample before and after consecutive 2 hr. drying periods.

Note 2—Tests on damp samples will generally give lower sand equivalent values than tests on oven-dried samples. It is permissible not to dry the sample to save time, but if the test values are near or below the specified minimum, retest the sample in the oven-dry condition.

- 4.1.3 Remove sample from oven and allow it to cool to room temperature.
- 4.1.4 Using the No. 4 sieve, separate the sample into two portions, breaking up lumps that consist of particles obviously finer than the No. 4 sieve.
- 4.1.5 Using the material passing the No. 4 sieve, carefully reduce the amount of material to a laboratory test size of at least 500-grams.
- 4.2 *Performing the Sand Equivalent Test:*
 - 4.2.1 Set up the workstation so that the glass bottle containing the working calcium chloride solution sits 3 ft. $\pm$ 1 in. above the work surface.
 - 4.2.2 Siphon 4 ± 0.1 in. of the working calcium chloride solution into the plastic cylinder. Check the agitator tube to be certain that the solution flows freely.
 - 4.2.3 Secure the test sample by passing the measuring can through the thoroughly mixed sample of the prepared material in a pan.
 - 4.2.4 Strike off the excess material using a straight edge or spatula.

Note 3—Do not compact the sample before striking it off.
 - 4.2.5 Transfer the sample from the measuring can into the plastic cylinder using the small funnel.
 - 4.2.6 Stopper the cylinder.
 - 4.2.7 Tap the bottom of the cylinder on the heel of the hand several times to remove air bubbles and promote thorough wetting of the sample.
 - 4.2.8 Remove stopper.
 - 4.2.9 Wash particles clinging to wall of cylinder into the mixture, using a minimum amount of solution.
 - 4.2.10 Allow the cylinder with contents to stand undisturbed, free of any vibration, for 10 ± 1 min.
 - 4.2.11 Replace stopper in the end of cylinder.
 - 4.2.12 Partially invert cylinder and shake to dislodge material from the bottom.
 - 4.2.13 Place stoppered cylinder in the mechanical sand equivalent shaker and set the timer.
 - 4.2.14 Allow machine to shake the cylinder and contents for 45 ± 1 sec.
 - 4.2.15 Following the mixing operation, place the cylinder on the worktable.
 - 4.2.16 Remove stopper.
 - 4.2.17 Wash down the cylinder wall with the agitator tube.

- 4.2.18 Force the agitator through the material to the bottom of the cylinder by gently twisting and shoving while the solution flows from the tip of the tube.
- 4.2.19 Continue smoothly jabbing the agitator tube up and down with a gentle twisting motion while slowly rotating the cylinder in a vertical position to flush the fine clay-like material into suspension above the coarse sand particles. Continue the operation until the cylinder is filled to the 15 in. mark.
- 4.2.20 Slowly remove the agitator tube without shutting off the flow, so the level of the liquid is maintained at 15 in.
- 4.2.21 Regulate the flow of the solution and adjust the level of solution to 15 in. when the agitator tube is entirely withdrawn.
- 4.2.22 Allow the cylinder and contents to stand undisturbed for 20 min. $\pm$ 15 sec. Start the timing immediately after the removal of the agitator tube.
- 4.2.23 After the 20-min. sedimentation period, read the level of the top of the clay suspension and record as the clay reading.
- 4.2.24 If there is no clear line of demarcation or clay meniscus at the end of the 20-min. sedimentation period, allow the material to stand undisturbed until the division is clear.
- 4.2.25 Read and record the level of the clay meniscus and the total sedimentation time.
Note 4—If the total sedimentation time exceeds 30 min., rerun the test using three more samples of the same material. Use the clay reading obtained from sample with the shortest sedimentation time.
- 4.2.26 Determine the sand reading by following the instructions in Sections 4.2.25 or 4.2.26.
- 4.2.27 When using the weighted foot assembly with sand reading indicator, gently lower the foot assembly into the cylinder until it comes to rest on the sand. Very gently tilt the assembly until the indicator touches the graduation marks on the cylinder. Tilt assembly back to vertical before taking reading. Read the level indicated by the top edge of the indicator and subtract 10 in. Record this reading as the sand reading.
- 4.2.28 When using the weighted foot assembly with no sand reading indicator, gently lower the weighted foot assembly in the cylinder until it comes to rest on top of the sand. Keep one of the centering screws in contact with the cylinder wall near the graduation marks while lowering the foot assembly so that the centering screw remains visible. Read the middle of the centering screw and record this reading as the sand reading.
- 4.3 If the clay or sand readings fall between two divisions on the graduated cylinder, round up to the nearest marked interval (e.g., 8.68 = 8.7 in., 6.21 = 6.3 in.)
- 4.4 Calculate the sand equivalent in accordance with Section 5.1.
Note 5—If running the test in pairs, the two values should not differ by more than four points. If the two values are different by more than four points repeat the test until two results are within four points of each other.

5. CALCULATIONS

- 5.1 Calculate the sand equivalent value to the nearest 0.1 in.:

$$\text{Sand Equivalent Value (SE)} = 100 * (\text{Sand Reading} / \text{Clay Reading})$$

6. REPORTING TEST RESULTS

- 6.1 Report sand equivalent test result rounded up to the next highest whole number.

EXAMPLE:

$$SE = 100 * (3.2/6.9) = 46.4$$

Report the value as 47.

- 6.2 If it is desired to average a series of sand equivalent values (such as for pairs), average the whole number values determined as described above. If the average of these values is not a whole number, raise it to the next higher whole number. Examples of this calculation can be found below.

EXAMPLE for two SE results: 45, 44

$$\text{Average SE Value} = (45+44)/2 = 44.5$$

This is then raised and reported as 45.

EXAMPLE for three SE results: 62, 63, 65

$$\text{Average SE Value} = (62+63+65)/3 = 63.3$$

This is then raised and reported as 64.

- 6.3 If the calculated SE value exceeds 100, report the value as 100.
-

7. ARCHIVED VERSIONS

- 7.1 Archived versions are available.

Test Procedure for**DETERMINING MOISTURE CONTENT OF BITUMINOUS MIXTURES****TxDOT Designation: Tex-212-F****Effective Date: April 2025**

1. SCOPE

- 1.1 Use this test method to determine the moisture content of any type of bituminous paving mixtures by direct measurement and to determine the moisture in aggregates for bituminous mixtures and in completed bituminous mixtures that have no significant amounts of hydrocarbon volatiles.
 - 1.1.1 Use Part I to determine the moisture content of any type of bituminous paving mixtures by direct measurement.
 - 1.1.2 Use Part II to determine the moisture (free and absorbed) in aggregates for bituminous mixtures and in completed bituminous mixtures that have no significant amounts of hydrocarbon volatiles.
- 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.

PART I—MOISTURE CONTENT BY DISTILLATION

2. SCOPE

- 2.1 Use this procedure to determine the moisture content of any type of bituminous paving mixtures by direct measurement.

3. APPARATUS

- 3.1 *Metal still*, consisting of a vertical cylindrical container, approximately 5 in. (127 mm) in diameter and 6 in. (152 mm) deep, with removable lid, heavy fiber gasket or O-ring, and a clamping system. There should be two holes in the lid, each approximately 1 in. (25 mm) in diameter, to provide for entrance of the water trap-condenser assembly and a safety valve.
- 3.2 *Moisture trap*, of 25 mL capacity, graduated in 0.1-mL divisions and equipped with cork stoppers.
- 3.3 *Condenser*, Liebig glass-tube type, with a condenser jacket approximately 16 in. (400 mm) long.
- 3.4 *System of tubing*, for passing water continuously through condenser.
- 3.5 *Loose, clean cotton*, for plugging the top of the condenser.
- 3.6 *Balance*, Class G2 in accordance with Tex-901-K.

- 3.7 Hot plate or other satisfactory heating device.
- 3.8 Ring stand, with base and clamp.
- 3.9 Pipette, with 1–10 mL capacity.
- 3.10 Bucket, 1 gal. (4 L), with airtight lid or plastic bag.

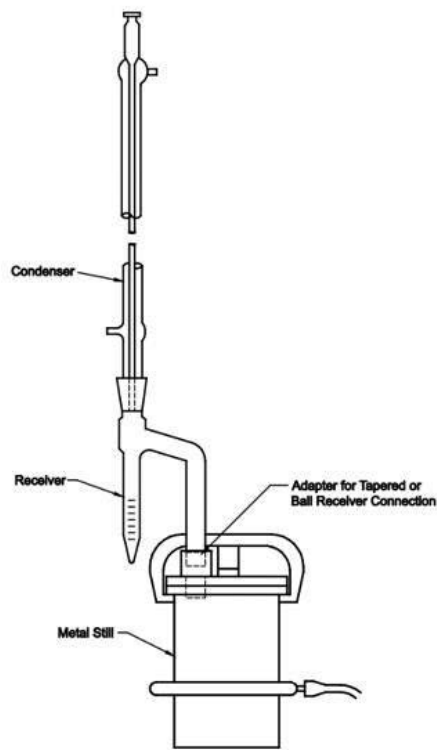


Figure 1—Typical Assembly for Determining Moisture Content by Distillation

4. MATERIALS

- 4.1 Water-free gasoline.

5. PROCEDURE

- 5.1 Obtain a representative sample of the bituminous mixture in accordance with [Tex-222-F](#). Thoroughly mix, breaking up large lumps.
- 5.2 Reduce the mixture to laboratory test size by quartering, or by thoroughly blending the material and taking small portions from several places in the pan.
Note 1—Keep samples in moisture-tight containers from the time of sampling to the time of testing.
- 5.3 Weigh a 500–600 g sample and record to the nearest 0.1 g as X under Section 6.

- 5.4 Immediately pour the weighed sample into the still.
- 5.5 Add gasoline until the sample is covered to a depth of about 1 in. (25 mm).
- 5.6 Place gasket or O-ring on rim of still and firmly fasten the lid with the clamping system.
- 5.7 Insert the moisture trap through a rubber stopper in the still lid, making sure the tip extends away from the source of heat, and assemble the condenser.
- 5.8 Place a cork or rubber stopper in the other hole as a safety valve. Minimize evaporation loss by inserting a loose cotton plug in the top of the glass condenser. Inspect all stoppers regularly to be certain they do not leak.
- 5.9 Circulate plenty of cool water continuously through the condenser. Apply heat at such rate that refluxing will start within 20 min. after the heat has been applied and solvent will drip from the condenser at a rate of 60–120 drops per minute.
- 5.10 Continue distillation until three consecutive readings of the trap at 15-min. intervals show no increase in the condensed water.
- 5.11 If the volume of moisture exceeds the capacity of the trap, stop the distillation, allow the still and trap to cool, record meniscus reading and withdraw 10–20 mL of water from the bottom of the trap with pipette. Record the volume of water removed.
- 5.12 Cool the moisture trap and contents to room temperature.
- 5.13 Rinse the condenser tube with gasoline to remove any trace of moisture and read the meniscus between the gasoline and water.
- 5.14 The meniscus value, in addition to any water withdrawn from the trap, is the volume of moisture removed from the bituminous mixture.
- 5.15 Record the total volume of moisture as V (under Section 6), which is also the weight of the moisture, since the assumption is made that 1 mL of water weighs 1 g at room temperature.

6. CALCULATIONS

- 6.1 Calculate percent by weight of moisture in the mixture:

$$\text{Percent Moisture} = \frac{100V}{X}$$

Where:

X = Weight of total sample, g

V = Volume of moisture, mL.

- 6.2 Report moisture content test results to the nearest 0.1%.

7. PRECAUTIONS

- 7.1 To maintain a safe working condition:

- 7.1.1 Use care in handling and heating the solvent and avoid inhaling fumes.
- 7.1.2 Fumes should not escape the still. Escaping fumes indicate a possible fire hazard.
- 7.1.3 Verify that all connections and the lid on the still are fastened tightly.

PART II—MOISTURE CONTENT BY OVEN DRYING

8. SCOPE

- 8.1 Use this procedure to determine the moisture in aggregates for bituminous mixtures and in completed bituminous mixtures that have no significant amounts of hydrocarbon volatiles.

9. APPARATUS

- 9.1 *Balance*, Class G2 in accordance with [Tex-901-K](#).
- 9.2 *Drying oven*, capable of attaining a temperature of 200°F (93°C), or suitable microwave oven.
- 9.3 *Pans*, suitable for drying aggregates.

10. PROCEDURE

- 10.1 Obtain a representative sample of the bituminous mixture in accordance with [Tex-222-F](#).
- 10.2 Thoroughly mix, breaking up large lumps, and reduce to laboratory test size by quartering the material, or by thoroughly blending the material and taking small portions from several places from the entire area of the pan.
Note 2—Keep samples in moisture-tight containers from the time of sampling to the time of testing.
- 10.3 Weigh a pan and record this weight to the nearest 0.1 g as *A* under Section 11.
- 10.4 Quickly place approximately 2000 g of mix in the pan and weigh to the nearest 0.1 g. Record the combined weight of the pan and sample as *B* under Section 11.
- 10.5 Immediately place material in pre-heated oven and allow sample to dry at 200–300°F (93–150°C). Stir sample periodically to facilitate drying.
- 10.6 Remove pan of material at 30-min. intervals and weigh to the nearest 0.1 g. Record the combined weight of the pan and sample.
- 10.7 Place pan back in oven immediately and continue drying.
- 10.8 Continue the drying and weighing procedure until a constant weight is reached. Record final weight of the pan and sample to the nearest 0.1 g as *C* under Section 11.
Note 3—Constant weight is defined as the weight at which further drying does not alter the weight by more than 0.05% in a 2-hr. or longer drying interval in accordance with Section 11.

11. CALCULATIONS

11.1 Calculate the percent by weight of moisture in the sample:

11.1.1 For Aggregates:

$$\text{Moisture Content} = \frac{B - C}{C - A} \times 100$$

11.1.2 For Bituminous Mixtures:

$$\text{Moisture Content} = \frac{B - C}{B - A} \times 100$$

Where:

A = Tare weight of pan

B = Original sample weight plus pan

C = Final sample weight plus pan.

Note 4—Other methods of moisture determination that correlate satisfactorily with Part I or Part II may be used.

11.2 Calculate the percent difference in weight:

$$\text{Percent Difference} = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \times 100$$

11.3 Report moisture content test results to the nearest 0.1%.

12. ARCHIVED VERSIONS

12.1 Archived versions are available.

Test Procedure for

DETERMINING DELETERIOUS MATERIAL AND DECANTATION TEST FOR COARSE AGGREGATES (BITUMINOUS MIXTURES)



TxDOT Designation: Tex-217-F

Effective Date: April 2025

1. SCOPE

- 1.1 Use Part I to determine the percent by weight of deleterious material in coarse aggregate.
 - 1.2 Use Part II to determine the percent by weight of detrimental fine dust, clay-like particles, and silt present as a coating in coarse aggregate.
 - 1.3 Use Part III to determine the percent by weight of deleterious material contained in processed recycled asphalt shingles.
 - 1.4 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

PART I—DETERMINING DELETERIOUS MATERIAL IN COARSE AGGREGATES

2. SCOPE

- 2.1 Use this procedure to determine the percent by weight of deleterious material in coarse aggregate.
-

3. APPARATUS

- 3.1 *Balance*, class G2 in accordance with Tex-901-K, with a minimum capacity of 4000 g.
 - 3.2 *Drying Oven*, capable of maintaining temperature at $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$ or $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$
 - 3.3 *Sample splitter*, *quartering cloth*, *quartering machine*, or *shovel* and a smooth surface.
 - 3.4 *Set of standard U. S. sieves*, meeting the requirements of Tex-907-K. Must include the following sieve size.
 - No. 8.
 - 3.5 *Dishpan*, or similar container.
 - 3.6 *Pans*, *scoops*, *trowels*, and other normal laboratory supplies and equipment.
-

4. PROCEDURE

- 4.1 Obtain a representative sample of aggregate for testing in accordance with [Tex-221-F](#).
Note 1—Select samples of crushed limestone rock asphalt from the processing plant before addition of the flux oil.
- 4.1.1 Oven-dry the test sample to constant weight at $230 \pm 9^{\circ}\text{F}$. Oven-dry limestone rock asphalt aggregates at $140 \pm 5^{\circ}\text{F}$.
Note 2—Constant weight is defined as oven drying the material at the specified temperature until the material will not lose more than 0.1% moisture after 2 hr. of drying. Verify by measuring the moisture content from weighing the mass of a sample before and after consecutive 2-hr. drying periods.
- 4.2 Remove the sample from the oven and allow to cool to room temperature.
- 4.3 Obtain a minimum laboratory size sample of 2000 g using one of the following methods.
- Sample splitter
 - Quartering cloth
 - Quartering machine
 - Mix on a smooth clean surface with a large flat scoop or shovel until blended, and quarter with a straightedge
- Note 3**—When testing aggregates from the hot bins, the sample should consist of aggregates combined in the same proportions used in the mixture being produced.
- 4.4 Sieve the dried test sample over the No. 8 sieve. Use additional sieves as necessary to limit the amount of material on a given sieve.
- 4.5 Weigh the aggregate particles retained on the No. 8 sieve to the nearest 0.1 g. If additional sieves are used, determine the total mass retained on the No. 8 sieve by adding the weights retained on each sieve. Only the No. 8 and larger sieves weights should be added together. Record this weight as *W* in Section 5.
- 4.6 Discard the portion of material passing the No. 8 sieve.
- 4.7 Spread the aggregate sample portion retained on the No. 8 sieve out on an area of the worktable large enough to examine the individual particles carefully.
- 4.8 Separate and classify each type of deleterious matter from the remainder of the sample by visual inspection. Material may be wetted, or other suitable methods may be used to aid in identification.
- 4.9 Dry and weigh all deleterious material removed from the aggregate sample to the nearest 0.1 g and record the weight as *D* in Section 5.

5. CALCULATIONS

- 5.1 Calculate the percentage of each or a combination of deleterious materials.

$$P = \frac{D}{W} \times 100$$

Where:

P = Percentage of deleterious matter by weight

D = Weight of deleterious material, g

W = Weight of total sample (retained on No. 8), g

5.2 Report deleterious material content test results to the nearest 0.1%.

PART II—DECANTATION TEST FOR COARSE AGGREGATE

6. SCOPE

6.1 Use this procedure to determine the percent by weight of fine material adhering to the coarse aggregate due to handling or contamination by silt or clay.

7. APPARATUS

7.1 Balance, class G2 in accordance with Tex-901-K, with a minimum capacity of 4000 g.

7.2 Drying Oven, capable of maintaining temperature at $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$ or $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$

7.3 Sample splitter, quartering cloth, quartering machine, or shovel and a smooth surface.

7.4 Mechanical sieve shaker.

7.5 Set of standard U.S. sieves, meeting the requirements of Tex-907-K. Must include the following sieve sizes.

- No. 8
- No. 200

7.6 Dishpan, or similar container.

7.7 Pans, scoops, trowels, and other normal laboratory supplies and equipment.

8. PROCEDURE

8.1 Obtain a representative sample of aggregate for testing in accordance with Tex-221-F.

Note 4—Select the sample of crushed limestone rock asphalt from the processing plant before addition of the flux oil.

8.2 Oven-dry the aggregate to a constant weight at a temperature of $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$. Oven-dry limestone rock asphalt aggregates, when used, to a constant weight at a maximum temperature of $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$.

Note 5—Constant weight is defined as oven drying the material at the specified temperature until the material will not lose more than 0.1% moisture after 2 hr. of drying. Verify by measuring the moisture content from weighing the mass of a sample before and after consecutive 2-hr. drying periods.

8.3 Remove the sample from the oven and allow it to cool to room temperature.

8.4 Obtain a minimum laboratory size sample of 1500 g using one of the following methods.

- Sample splitter
-

- Quartering cloth
- Quartering machine
- Mix on a smooth clean surface with a large flat scoop or shovel until blended, and quarter with a straightedge

Note 6—When testing aggregates from the hot bins, the sample should consist of aggregates combined in the same proportions used in the mixture being produced.

- 8.5 Sieve the test sample over the No. 8 sieve. Use additional sieves as necessary to limit the amount of material on a given sieve.
- 8.6 Remove any material other than coated particles of aggregate that will slake down during the test.
Note 7—The remaining material constitutes the decantation test sample.
- 8.7 Remove the stack of sieves and empty each into a dry pan, discarding the material passing the No. 8 sieve.
- 8.8 Weigh the material retained on the No. 8 sieve to the nearest 0.1 g. If additional sieves were used, determine the total mass retained on the No. 8 sieve by adding the weights retained on each sieve. Only the No. 8 and larger sieves weights should be added together. Record this weight as *B* in Section 9.
- 8.9 Place the test sample in the dishpan, cover with water, and let sample soak for at least 12 hr.
- 8.10 Agitate the contents of the pan vigorously with the hands, and immediately pour the wash water over the No. 200 sieve. Agitate vigorously to completely separate all particles finer than the No. 200 sieve from the coarse particles and to bring the fine material into suspension so that it will be removed by decantation.
- 8.11 Repeat until the wash water is clear.
- 8.12 Return all the material retained on the No. 200 sieve to the washed sample.
- 8.13 Dry the washed aggregate to a constant weight, as indicated in Section 8.2.
- 8.14 Weigh the dried aggregate to the nearest 0.1 g and record the weight as *C* in Section 9.

9. CALCULATIONS

- 9.1 Calculate the percent loss by decantation.

$$\text{Percent Loss} = \frac{B - C}{B} \times 100$$

Where:

B = original dry weight, g

C = dry weight after washing, g

- 9.2 Report decantation test results to the nearest 0.1%.

PART III—DETERMINING DELETERIOUS MATERIAL IN RECYCLED ASPHALT SHINGLES (RAS)

10. SCOPE

- 10.1 Use this procedure to determine the percent by weight of deleterious material in processed recycled asphalt shingles (RAS).

11. APPARATUS

- 11.1 *Balance*, class G2 in accordance with Tex-901-K, with a minimum capacity of 5000 g.
- 11.2 *Drying oven*, capable of attaining a temperature of at least $140 \pm 5^{\circ}\text{F}$.
- 11.3 *Mechanical sieve shaker*.
- 11.4 *Standard U.S. sieves*, meeting the requirements of Tex-907-K, in the following sizes.
- 3/8 in.
 - No. 4
 - No. 8
 - No. 30
- 11.5 *Rectangular pan*, at least 14 in. wide.
- 11.6 *Sample splitter or quartering device*.
- 11.7 *Small scoop*.
- 11.8 *Metal collection device*, a rectangular, nonferrous tray, 12 in. wide, at least 20 in. long, with walls at the two long sides and both short ends open, with a 12 × 2-in. magnet fixed under the tray perpendicular to the walls, as shown in Figure 1.

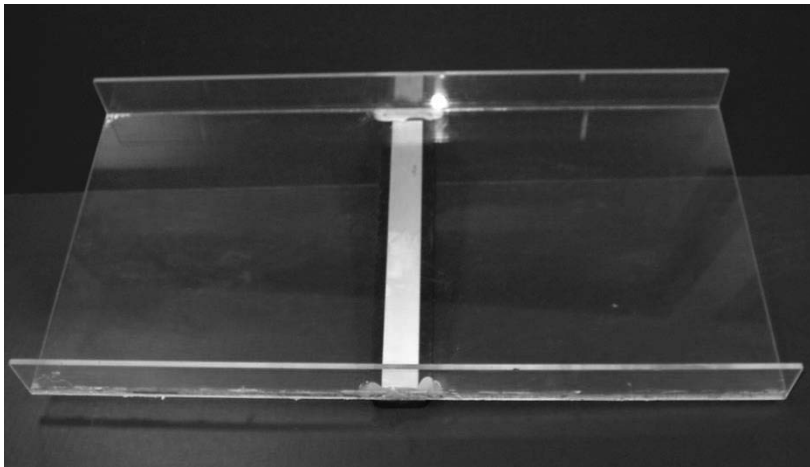


Figure 1—Metal Collection Device

12. SAFETY CONSIDERATIONS

- 12.1 Always use the appropriate personal protective equipment (PPE) when handling RAS.
- 12.1.1 Wear a long-sleeved lab coat.
- 12.1.2 Use a cartridge respirator or disposable paper mask to prevent inhalation of particulate.
- 12.1.3 Wear disposable gloves.
- 12.1.4 Use safety glasses.
- 12.2 Discard all excess RAS in a secured plastic bag.

13. PROCEDURE

- 13.1 Obtain a representative sample from the RAS stockpile in accordance with [Tex-222-F](#).
- 13.2 Oven-dry the sample to constant weight at $140 \pm 5^\circ\text{F}$.
Note 8—Constant weight is defined as oven drying the material at the specified temperature until the material will not lose more than 0.1% moisture after 2 hr. of drying. Verify by measuring the moisture content from weighing the mass of a sample before and after consecutive 2-hr. drying periods.
- 13.3 Remove the sample from the oven and allow to cool to room temperature.
- 13.4 Obtain a representative test sample of 1000 g using one of the following methods.
 - Sample splitter
 - Quartering cloth
 - Quartering machine
- 13.5 Weigh the sample to the nearest 0.1 g. Record the weight as W_T in Section 14.1.
- 13.6 Place a pan on the scale and tare its weight.

- 13.7 Place the metal collection device on the pan and angle one of the open ends down into the pan.
- 13.8 Tilt the metal collection device to an angle of 45° or more and pour the sample over the device. Ensure the sample particles pass over the magnet before falling into the pan.
- 13.9 Gently shake the metal collection device to remove material not retained by the magnet. Remove the device from the pan and discard the metal fragments retained by the magnet.
- 13.10 Weigh the material in the pan on the tared scale to the nearest 0.1 g. Record as *A* in Section 14.1. Save this material for future testing described in Section 13.12.
- 13.11 Calculate the weight of metal fragments in the sample in accordance with Section 14.1.
- 13.12 Sieve the sample through the sieves listed in Section 11.4.
- 13.13 Discard the portion of material passing the No. 30 sieve.
- 13.14 Test the material retained on each sieve for all deleterious content including, but not limited to, wood, paper, plastic, and felt paper.
- 13.14.1 Spread the portion of the sample retained on the 3/8 in. sieve out in a pan large enough to examine the individual particles carefully.
- 13.14.2 Separate and remove the deleterious matter from the remainder of the sample by visual inspection.
- 13.14.3 Weigh all objectionable material removed from the RAS sample retained on the 3/8-in. sieve to the nearest 0.1 g and record the weight as $N_{3/8}$ in Section 14.2.
- 13.15 Repeat Sections 13.15.1–13.15.3 for the material retained on the No. 4, the No. 8, and the No. 30 sieves.
- 13.16 Record these weights as N_4 , N_8 , and N_{30} respectively in Section 14.2.
-

14. CALCULATIONS

- 14.1 Calculate the weight of the metal fragments in the original sample.

$$M = W_T - A$$

Where:

M = weight of material retained by the magnet, g

W_T = total weight of sample, g

A = weight of material not retained by the magnet, g

- 14.1.1 Report weight of metal fragment test results to the nearest 0.1 g.

- 14.2 Calculate the percent by weight of deleterious material in the sample.

$$P = \frac{M + N_{3/8} + N_4 + N_8 + N_{30}}{W_T} \times 100$$

Where:

P = percent of deleterious matter by weight

M = weight of material retained by the magnet, g

$N_{3/8}$ = weight of deleterious substance retained on the 3/8-in. sieve, g

N_4 = weight of deleterious substance retained on the No. 4 sieve, g

N_8 = weight of deleterious substance retained on the No. 8 sieve, g

N_{30} = weight of deleterious substance retained on the No. 30 sieve, g

- 14.2.1 Report deleterious matter test results to the nearest 0.1%.

15. REPORT FORMS

- 15.1 Deleterious Materials and Decantation for Coarse Aggregate
-

16. ARCHIVED VERSIONS

- 16.1 Archived versions are available.

Test Procedure for

SAMPLING AGGREGATE AND LIMESTONE ROCK ASPHALT (LRA)



TxDOT Designation: Tex-221-F

Effective Date: October 2022

1. SCOPE

- 1.1 Use this test procedure for sampling completed stockpiles of coarse and fine aggregate used to produce hot-mix asphalt (HMA), hot-mix cold-laid asphalt, Limestone Rock Asphalt (LRA), microsurfacing, and for the placement of surface treatments.
- 1.2 Use this test procedure to sample completed coarse or fine aggregate and LRA stockpiles using a front-end loader or shovel. The preference for sampling is to use a front-end loader. Only use a shovel where a front-end loader is not available.

2. SAMPLE SIZE

- 2.1 Use Table 1 to determine the minimum sample size to perform the required tests listed in the applicable specification.
- 2.2 Obtain samples from completed stockpiles that show the true nature and condition of the materials they represent. Do not combine materials that apparently differ in property or character to make a composite sample. Differences may be indicated by color or texture.
- 2.3 Use a sample splitter or quartering cloth to reduce the field sample to laboratory test size.

Table 1—Min Size of Samples

Nominal Max Size of Aggregate ¹	Min Weight of Field Samples ² (pounds)
No. 8	10
No. 4	25
3/8 in.	25
1/2 in.	35
3/4 in.	55
1 in.	110
1-1/2 in.	165

1. Nominal maximum size is one sieve size larger than the first sieve that retains more than 10% of the aggregate.
2. The minimum sample mass depends on the nominal maximum aggregate size as well as the number and type of test required.

3. SAMPLING PROCEDURES

- 3.1 This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.
- 3.2 *Sampling procedure for aggregate from completed stockpiles using a front-end loader.*
- 3.2.1 Use this procedure to sample completed stockpiles of coarse or fine aggregate and LRA using a front-end loader.
- 3.2.2 Determine the minimum number of samples required for approval based on the Department's Guide Schedule frequency for HMA, hot-mix cold-laid asphalt, seal coat, and LRA.
- 3.2.3 Identify the sampling locations by dividing the stockpile in approximately equal sectors based on the number of samples determined from Section 3.2.2. Stockpiles must be sampled from a minimum of two sectors or locations for acceptance.
- 3.2.4 Clean and level the ground at the sampling location to prevent contamination of the sampling pile.
- 3.2.5 Cut approximately at the ground level to the top edge of the stockpile until a clean face is exposed. This represents the full height of the stockpile.
Note 1-The exposed vertical face should be perpendicular to the top edge of the stockpile, but this may not be possible with stockpiles of dry, coarse aggregates.
- 3.2.6 Discard the material cut away while exposing the clean face.
- 3.2.7 Build a sample pad by cutting into the vertical face at the ground level to the full height of the stockpile to obtain material.
- 3.2.8 Lower the bucket as close as possible to the ground to avoid segregation and empty the entire contents of the bucket in one motion onto the ground.
- 3.2.9 Using the loader bucket, strike and level the sample pad at mid-height in the direction the bucket was emptied to create a flat surface for sampling. Back-drag the sampling pad only once.
- 3.2.10 Using a shovel or straightedge, visibly trace lines on top of the sample pad to outline four evenly sized quarters.
- 3.2.11 Place clean sample bags or containers near the center of the sampling pad and obtain the sample across the flat area staying more than 1 ft. away from the edges.
- 3.2.11.1 Sample equal amounts of aggregate or LRA evenly across each quadrant. Fully insert the shovel as near as vertical as possible and then slowly roll the shovel back and lift slowly to avoid coarse aggregate rolling off the sides of the shovel.
Note 2-Spade-tip shovels are not recommended for sampling. Square-tip shovels work well preventing aggregate from rolling from the side.
- 3.2.11.2 Obtain additional shovelfuls from different quadrants of the sampling pad, and in areas avoiding previous shovel holes.
- 3.2.12 Place the material into the clean sample bags or containers.

- 3.2.13 Seal and label the sample bags or containers.
- 3.2.14 Repeat Section 3.2.4 to 3.2.13 for each additional location as determined from Section 3.2.3.
- 3.3 *Sampling procedure for aggregate from completed stockpiles using a shovel.*
- 3.3.1 Use this procedure to sample completed stockpiles of coarse or fine aggregate and LRA using a shovel where a front-end loader is not available. The preference for sampling is to use a front-end loader.
- 3.3.2 Determine the minimum number of samples required for approval based on the Department's Guide Schedule frequency for HMA, hot-mix cold-laid asphalt, seal coat, and LRA.
- 3.3.3 Identify the sampling locations by dividing the stockpile in approximately equal sectors based on the number of samples determined from Section 3.3.2. Stockpiles must be sampled from a minimum of two sectors or locations for acceptance.
- 3.3.4 Identify locations within each sector from the top third, at the mid-point, and bottom third of the stockpile. Sampling must be performed in no less than these three increments.
- 3.3.5 Dig a small trench into the stockpile at each location approximately 1 ft. deep and 3 ft. in diameter. Note 3-A board may be shoved vertically into the stockpile just above the point of sampling to prevent segregation from coarser aggregate rolling down during sampling.
- 3.3.6 Do not use the aggregate or LRA removed from the trenched area as a part of the sample.
- 3.3.7 Shovel material from the stockpile into clean sample bags or containers from the innermost part of the trench. Minimize larger sized aggregate falling back into the trench. Note 4-When sampling sands, sampling tubes of at least 1-1/4 in. diameter may be used where experience has indicated representative samples cannot be obtained otherwise.
- 3.3.8 Seal and label the sample bags or containers.
- 3.3.9 Repeat Section 3.3.4 to 3.3.8 for each additional location as determined from Section 3.3.3.
-

4. ARCHIVED VERSIONS

- 4.1 Archived versions are available.

Test Procedure for

FLAKINESS INDEX

TxDOT Designation: Tex-224-F

Effective Date: January 2025



1. SCOPE

- 1.1 Use this test method to determine the percentage of coarse aggregate that are flat with a thickness of less than approximately 2/3 of its nominal size. Flakiness Index is only required for seal coat surface treatment in accordance with Item 316, "Seal Coat."
- 1.2 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

2. APPARATUS

- 2.1 Oven, capable of maintaining a minimum temperature of $140 \pm 9^{\circ}\text{F}$.
- 2.2 Metal thickness gauge, metal plate with dimensions as shown in Figure 1.
- 2.3 Miscellaneous laboratory equipment, including a scoop, brass wire brush, bristle brush, metal pan, and gloves.
- 2.4 Sample splitter, quartering machine or quartering cloth.
- 2.5 Standard U.S. sieves, meeting the requirements of Tex-907-K, in the following sizes:
- 7/8 in.
 - 5/8 in.
 - 3/8 in.
 - 1/4 in.

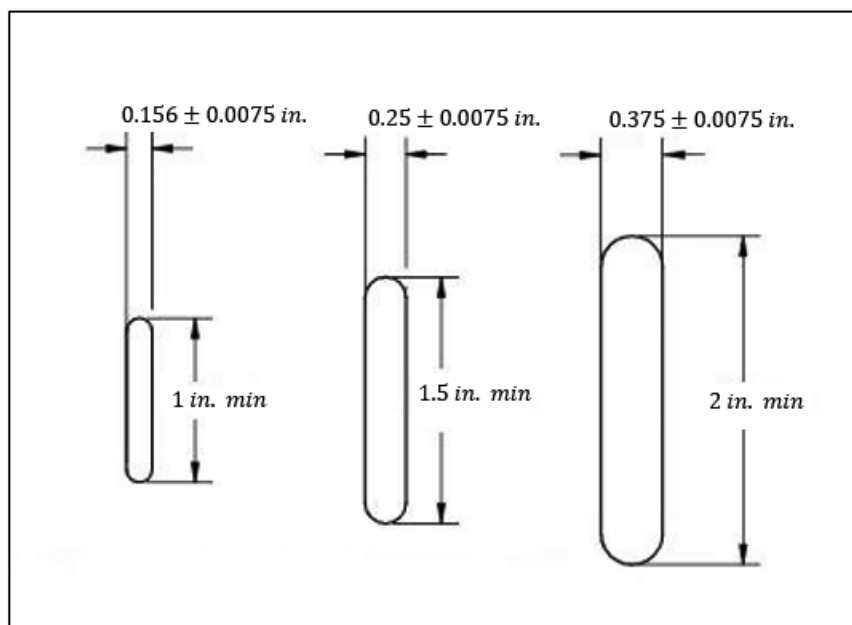


Figure 1
Flakiness Index Metal Gauge Plate.

3. SAMPLE PREPARATION

- 3.1 Obtain a representative sample of processed aggregates in accordance with Tex-221-F.
- 3.2 Oven dry the sample to a constant weight at $230 \pm 9^\circ\text{F}$. Oven dry Limestone Rock Asphalt (LRA) at $140 \pm 9^\circ\text{F}$.
- 3.3 Allow the sample to cool to room temperature.
- 3.4 Quarter the sample using a quartering machine or cloth.
- 3.5 Sieve the quartered sample through the 7/8-in., 5/8-in., 3/8-in., and 1/4-in. sieves to obtain a minimum of 200 particles passing the 7/8-in. sieve and retained on the 1/4-in. sieve.
- 3.6 Count the particles. If less than 200 particles are counted, sample or sieve more aggregate to have at least this many particles for testing.
- 3.7 Discard the aggregate retained on the 7/8-in. sieve and passing the 1/4-in. sieve.

4. PROCEDURE

- 4.1 Test each particle retained on the 5/8-in. sieve by attempting to pass it through the 3/8-in. slot of the thickness gauge.
 - 4.1.1 Create two piles of tested particles that do not pass through the 3/8 in. slot and those that pass through the 3/8 in. slot.
 - 4.1.2 Count the number of particles in each pile.

- 4.2 Test each particle retained on the 3/8-in. sieve by attempting to pass it through the 1/4-in. slot of the thickness gauge.
- 4.2.1 Create two piles of tested particles that do not pass through the slot and those that pass through the slot.
- 4.2.2 Count the number of particles in each pile.
- 4.3 Test each particle retained on the 1/4-in. sieve by attempting to pass it through the 5/32-in. slot of the thickness gauge.
- 4.3.1 Create two piles of tested particles that do not pass through the slot and those that pass through the slot.
- 4.3.2 Count the number of particles in each pile.
-

5. CALCULATIONS

- 5.1 Calculate Flakiness Index:

$$\text{Flakiness Index} = \left\lfloor \frac{\text{Total Passing Particles}}{\text{Total Particles}} \right\rfloor \times 100$$

Where: *Total Passing Particles* = Total number of particles that pass through the slot openings.

6. REPORT

- 6.1 Report the Flakiness Index to the nearest whole number.
-

7. ARCHIVED VERSIONS

- 7.1 Archived versions are available.

Test Procedure for**DETERMINING FLAT AND ELONGATED PARTICLES****TxDOT Designation: Tex-280-F****Effective Date: November 2024**



1. SCOPE

- 1.1 Use this test method to determine the percentage of flat and elongated particles in coarse aggregates. Flat and elongated aggregate particles interfere with compaction and can result in harsh, difficult to place materials. They also break under load and prevent development of an adequate aggregate skeleton.
 - 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.
 - 1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

2. DEFINITIONS

- 2.1 *Flat and Elongated Particles*—aggregate particles having a ratio of length to thickness (L/T) greater than a specified value.
 - 2.2 *Length (L)*—maximum dimension of the particle.
 - 2.3 *Width (W)*—maximum dimension in the plane perpendicular to the length.
 - 2.4 *Thickness (T)*—maximum dimension perpendicular to the length and width.
-

3. APPARATUS

- 3.1 Apparatus used in Tex-200-F.
 - 3.2 *Proportional caliper device*, consisting of a base plate with two fixed vertical posts and a swinging arm mounted between them so that the openings between the arms and the posts maintain a constant ratio.
 - 3.2.1 Adjustable axis position to provide the desired ratio of opening dimensions for the ratios of 2:1, 3:1, 4:1, and 5:1. Verify the ratio settings on the proportional caliper device using a machined block, micrometer, or other appropriate device.
-

4. SAMPLING

- 4.1 Sample a representative amount of coarse aggregate in accordance with Tex-221-F.
-

- 4.2 Reduce the sample to an amount suitable for testing in accordance with Tex-200-F.

5. PROCEDURE

- 5.1 Oven-dry the sample to constant weight, at a temperature of $230 \pm 9^{\circ}\text{F}$ ($110 \pm 5^{\circ}\text{C}$). Dry the limestone rock asphalt to constant weight at a temperature of $140 \pm 5^{\circ}\text{F}$ ($60 \pm 3^{\circ}\text{C}$).
- 5.2 Sieve the sample in accordance with Tex-200-F, Part I, using a 7/8 in., 5/8 in., 1/2 in., 3/8 in., and a No.4 sieve.
- 5.3 Calculate the individual percent retained for each sieve listed in Section 5.2.
- 5.4 Reduce each size fraction with 10% or more retained by quartering in accordance with Tex-200-F, until obtaining a minimum of 100 particles for each size.
- 5.5 Test each of the particles in each size fraction as follows:
- 5.5.1 Set the proportional caliper device to the 5:1 ratio.
- 5.5.2 Set the larger opening equal to the particle length. The particle is flat and elongated if the maximum dimension perpendicular to the length and width (thickness) can be placed through the smaller opening.
- 5.6 Place the tested particles into one of two groups:
- flat and elongated or
 - not flat and elongated.
- 5.7 After classifying the particles into one of the groups described in Section 5.6, count and record the number of particles in each group.
- 5.7.1 Divide the total number of flat and elongated particles by the total number of particles tested.
- 5.7.2 Multiply by 100 and record to the nearest 0.1 percentage point.

6. CALCULATIONS

- 6.1 Using the sieve analysis determined in Section 5.2, add the percentages of the sieve sizes with 10% or more retained to determine an accumulative weighted total based on the sample tested. Divide the individual percentage of each sieve size by the accumulative weighted total. This is the adjusted sieve analysis of the sample tested for flat and elongated particles. See Table 1.
- 6.2 Calculate the percentage of flat and elongated particles for each sieve size as described in Section 5.7.
- 6.3 Multiply the adjusted sieve percentage by the corresponding percentage of flat and elongated particles for each sieve size. Divide this number by 100. See Table 1.

Table 1
Calculation Example

Sieve	%	%	%	%	adjusted %
7/8 in.	4.8 →	0.0	0.0	88.5 =	0.0
5/8 in.	17.8 →	17.8	17.8 ÷	88.5 =	20.1

Sieve	%	%	%	%	adjusted %
1/2 in.	42.1 →	42.1	42.1 ÷	88.5 =	47.6
3/8 in.	28.6 →	28.6	28.6 ÷	88.5 =	32.3
No. 4	6.7 →	0.0	0.0 ÷	88.5 =	0.0
		88.5			100.0

6.4 Suppose the 5/8 in. sieve has a flat and elongated percentage of 5.2 for the ratio 5:1, then:

$$\frac{\text{Adjusted \%} \times \text{flat and elongated \%}}{100} = \text{weighted percentage}$$

$$\frac{20.1\% \times 5.2\%}{100} = 1.05\%$$

6.5 Add the percentages of flat and elongated particles measured on each sieve size and report to the nearest whole number.

7. REPORT

7.1 Identification of the coarse aggregate tested, producer, pit location, date, and person performing the test.

7.2 Grading of the aggregate sample, showing percentage retained on each sieve.

7.3 Weighted percentages for the sieve sizes that weigh 10% or more of the original sample weight.

7.4 Number of particles of each sieve size tested, in respective columns:

- flat and elongated particles, referred to as failing particles and
- total particles not considered as flat and elongated, referred to as passing particles.

7.5 Percentages calculated for failing particles for each sieve size and ratio.

8. ARCHIVED VERSIONS

8.1 Archived versions available.

Test Procedure for**SAMPLING AGGREGATE AND STONE RIPRAP**

TxDOT Designation: Tex-400-A

Effective Date: December 2023

1. SCOPE

- 1.1 Use this test procedure for sampling completed stockpiles of coarse and fine aggregate used to produce concrete and retaining wall select backfill, and stone riprap. This procedure may also be used to sample concrete aggregate during production when stored in bays or stockpiles that are not accessible in three directions.
 - 1.2 Use this test procedure to sample completed coarse or fine aggregate stockpiles and materials using a front-end loader or shovel. The preference for sampling is to use a front-end loader. Only use a shovel where a front-end loader is not available.
 - 1.3 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
-

2. APPARATUS

- 2.1 Sample bags or buckets with lids.
 - 2.2 Square-Tip Shovel.
-

3. SAMPLE SIZE

- 3.1 Use Table 1 from Section 3.3 to determine the minimum sample size to perform the required tests listed in the applicable specification.
- 3.2 Obtain samples that show the true nature and condition of the materials that they represent. Do not combine materials that apparently differ in property or character to make a composite sample. Differences may be indicated by color or texture.
- 3.3 Use a sample splitter or quartering cloth to reduce the field sample to laboratory test size.

Table 1
Minimum Field Sample Size

Nominal Max Size of Aggregate¹	Mini Weight of Field Samples² (lbs.)
3 in.	330
2-1/2 in.	275
2 in.	220
1-1/2 in.	165
1 in.	110
3/4 in.	55
1/2 in.	35
3/8 in.	25
No. 4	25
No. 8	25

1. The Max aggregate size is the largest sieve size listed in the applicable specification upon which any material can be retained.
2. The Min sample weight depends on the Max aggregate size and the type and number of tests required.

4. SAMPLING AGGREGATE STOCKPILES USING A FRONT-END LOADER

- 4.1 Determine the minimum number of samples required for acceptance based on TxDOT's Guide Schedule frequency for concrete or retaining wall select backfill.
 - 4.1.1 There is no minimum number of samples required for quality control testing.
- 4.2 Identify the sampling locations by dividing the stockpile in approximately equal sectors based on the number of samples determined from Section 4.1. Aggregate must be sampled from a minimum of two sectors or different locations for acceptance.
- 4.3 Clean and level the ground at the sampling location to prevent contamination of the sampling pile.
- 4.4 Cut approximately at the ground level to the top edge of the stockpile until a clean face is exposed. This represents the full height of the stockpile.
 - 4.4.1 The exposed vertical face should be perpendicular to the top edge of the stockpile, but this may not be entirely possible with stockpiles of dry, coarse aggregates.
- 4.5 Discard the aggregate cut away while exposing the clean face.
- 4.6 Build a sample pad by cutting into the vertical face at the ground level to the full height of the stockpile to obtain aggregate.
- 4.7 Lower the bucket as close as possible to the ground to avoid segregation and empty the entire contents of the bucket in one motion onto the ground.
- 4.8 Using the loader bucket, strike and level the sample pad at mid-height in the direction the bucket was emptied to create a flat surface for sampling. Back-drag the sampling pad only once.
- 4.9 Divide the sample pad into four quadrants of similar size.
- 4.10 Place clean sample bags or containers near the center of the sampling pad and obtain the sample across the flat area staying more than 1 ft. away from the edges.
- 4.11 Sample equal amounts of aggregate from each quadrant.

- 4.11.1 Fully insert a square-tip shovel as near as vertical as possible and then slowly roll the shovel back and lift slowly to avoid coarse aggregate rolling off the sides of the shovel.
 - 4.11.2 Spade-tip shovels are not allowed for sampling because they will not prevent aggregate from rolling off the side of the shovel.
 - 4.12 Place the aggregate into the clean sample bags or containers.
 - 4.13 Seal and label the sample bags or containers.
 - 4.14 Repeat Section 4.4 – 4.13 for each additional location as determined from Section 4.2.
-

5. SAMPLING AGGREGATE FROM STOCKPILES USING A SHOVEL

- 5.1 Use this procedure to sample completed stockpiles of coarse or fine aggregate using a shovel where a front-end loader is not available. The preference for sampling is to use a front-end loader.
 - 5.2 Determine the minimum number of samples required for acceptance based on TxDOT's Guide Schedule frequency for concrete or retaining wall select backfill.
 - 5.2.1 There is no minimum number of samples required for quality control testing.
 - 5.3 Identify the sampling locations by dividing the stockpile in approximately equal sectors based on the number of samples determined from Section 5.2. Aggregate must be sampled from a minimum of two sectors or different locations for acceptance.
 - 5.4 Identify locations within each sector from the top third, at the mid-point, and bottom third of the stockpile. Sampling must be performed in no less than these three increments.
 - 5.5 Dig a small trench into the stockpile at each location approximately 1 ft. deep and 3 ft. in diameter.
 - 5.6 A board may be shoved vertically into the stockpile just above the point of sampling to prevent segregation from coarser aggregate rolling down during sampling.
 - 5.7 Do not use the aggregate removed from the trenched area as a part of the sample.
 - 5.8 Shovel aggregate from the stockpile into clean sample bags or containers from the innermost part of the trench. Minimize larger sized aggregate falling back into the trench.
 - 5.8.1 When sampling sands, sampling tubes of at least 1-1/4 in. diameter may be used where experience has indicated representative samples cannot be obtained otherwise.
 - 5.9 Seal and label the sample bags or containers.
 - 5.10 Repeat Section 5.4 – 5.9 for each additional location as determined from Section 5.2.
-

6. SAMPLING AGGREGATE DURING CONCRETE PRODUCTION AT MIXING PLANT AND SITE.

- 6.1 Use this procedure to sample coarse or fine aggregate at concrete mixing plants and sites during production from bays or stockpiles that are not accessible in three directions and for Optimized Aggregate Gradation

(OAG) concrete. The preference for sampling is to use a front-end loader. Only use a shovel when a front-end loader is not available.

- 6.2 Identify the center of the open face of the aggregate bay.
- 6.3 Sample at this location using a front-end loader according to Section 4.
- 6.4 Sample at this location using a shovel when a front-end loader is not available according to Sections 5.
- 6.5 Sample at additional locations when the face of the open bay or face of the stockpile is significantly wide. Chose a minimum of two locations approximately equal offset from the center.

7. SAMPLING FLEXIBLE BASE STOCKPILES

- 7.1 Refer to Tex-100-E, Section 4.

8. PREPARING FLEXIBLE BASE SAMPLES FOR TESTING

- 8.1 Refer to Tex-100-E, Section 6.

9. SAMPLING STONE RIPRAP

- 9.1 Obtain six to eight pieces of the stone riprap that is representative of the size of the riprap.
- 9.2 Crush or break down the entire sample to a maximum particle size of 6 in.
- 9.3 Select approximately 275 lbs. of the riprap and place into sample bags or containers.
- 9.4 Seal and label the sample.

10. ARCHIVED VERSIONS

- 10.1 Archived versions are available.

Test Procedure for**SIEVE ANALYSIS OF FINE AND COARSE
AGGREGATE****TxDOT Designation: Tex-401-A*****Effective Date: August 1999***

1. SCOPE

- 1.1 Use this method to determine the particle size distribution of mineral fillers and coarse and fine aggregates for portland cement concrete.
- 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 *Standard U.S. sieves and pans*, meeting the requirements of Tex-907-K, in the following sizes:
- 75 mm (3 in.)
 - 63 mm (2-1/2 in.)
 - 50 mm (2 in.)
 - 37.5 mm (1-1/2 in.)
 - 25.0 mm (1 in.)
 - 19.0 mm (3/4 in.)
 - 12.5 mm (1/2 in.)
 - 9.5 mm (3/8 in.)
 - 4.75 mm (No. 4)
 - 2.36 mm (No. 8)
 - 1.18 mm (No. 16)
 - 600 μm (No. 30)
 - 300 μm (No. 50)
 - 150 μm (No. 100)
 - 75 μm (No. 200).
-

- 2.2 *Quartering machine, sample splitter, or quartering cloth.*
- 2.3 *Mechanical sieve shaker.*
- 2.4 *Balance, Class G2 in accordance with Tex-901-K.*
- 2.5 *Drying oven, maintained at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).*
- 2.6 *Round pans, to fit sieves.*
- 2.7 *Small scoop, brushes, etc.*

3. SAMPLING AND SIEVING FINE AND COARSE AGGREGATE

- 3.1 Sample the aggregate in accordance with Tex-400-A.
- 3.2 When material is a combination of coarse and fine aggregate, sieve sample over a 4.75 mm (No. 4) sieve to separate coarse and fine aggregates.

4. PREPARING SAMPLE

- 4.1 *Coarse Aggregate Method:*
 - 4.1.1 Reduce the sample into the test sample sizes shown in Table 1.
 - 4.1.2 Dry the sample in an oven to a constant mass and cool to room temperature.
 - 4.1.2.1 For rapid check of the gradation in the field, but not for project acceptance, it is not necessary to dry the coarse aggregates before the test.
 - 4.1.2.2 Sample size may be in accordance with Tex-406-A, Part I.
 - 4.1.3 Record the total dry mass of the sample to the nearest gram.

Table 1—Test Sample Sizes (Coarse Aggregate)

Nominal Maximum Size	Minimum Mass
9.5 mm (3/8 in.)	1 kg (2 lb.)
12.5 mm (1/2 in.)	2 kg (4 lb.)
19.0 mm (3/4 in.)	5 kg (11 lb.)
25.0 mm (1 in.)	10 kg (22 lb.)
37.5 mm (1-1/2 in.)	15 kg (33 lb.)
50.0 mm (2 in.)	20 kg (44 lb.)
63.0 mm (2-1/2 in.)	35 kg (77 lb.)
75.0 mm (3 in.)	60 kg (130 lb.)

4.2 *Fine Aggregate—Laboratory Method:*

- 4.2.1 Select a representative sample of approximately 500 g from material that has been thoroughly dried at a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$). Where the fine aggregate is a combination of sands, the sample should contain these sands in the proportion by dry mass in which they will be used.

Note 1—Do not include mineral filler in the sieve analysis.

- 4.2.2 Record the total dry mass of the sample.

- 4.2.3 Determine the amount of material finer than the $75\ \mu\text{m}$ (No. 200) sieve in accordance with Tex-406-A, Part I.

- 4.2.4 Weigh the sample and record its mass to the nearest 0.1 g.

4.3 *Fine Aggregate—Field Method:*

- 4.3.1 Secure a representative sample of approximately 500 g of the sand to be tested. Where the fine aggregate is a combination of sands, the sample should contain these sands in the proportion by mass in which they will be used.

- 4.3.2 Dry the sample to below saturated surface-dry condition either in the sun or by artificial heat.

- 4.3.3 Record the total mass of the sample to the nearest 0.1 g.

4.4 *Mineral Filler:*

- 4.4.1 Oven-dry the mineral filler to a constant mass.

- 4.4.2 Quarter material into a test sample of approximately 200 g.

- 4.4.3 Perform the sieve analysis immediately after removing the sample from the oven.

5. PROCEDURE

- 5.1 Using the sieve sizes required by the specification, arrange sieves in descending order with the largest size on top.

- 5.2 If using a mechanical sieve shaker, place the set of sieves onto a pan and pour the prepared aggregate onto the top sieve, cover the stack of sieves and pan, turn on the machine, and set it to shake for at least 5 minutes.

- 5.2.1 If hand sieving, start with the largest size, and progress toward the smaller sieve sizes; move the sieves in lateral and vertical motions accompanied by a jarring action to keep the material moving continuously over the surface of the sieves. Hand manipulation without forcing particles through the sieve is permitted.

- 5.3 For either mechanical or hand sieving, sieve the material until not more than 1% by mass of the residue on any individual sieve will pass that sieve during 1 minute of continuous hand sieving.
- 5.4 Using a scale with a capacity large enough to obtain the mass of the total sample, determine the mass of the fine aggregate to the nearest 0.1 g and coarse aggregate to the nearest 1 g.
- 5.4.1 First, determine the mass of the aggregate retained on the largest sieve size and record the value.
- 5.4.2 Add the contents of the next largest sieve size on the scale, obtain the cumulative mass of the two sizes and record this mass.
- 5.4.3 Finally, add the contents of the next size, and repeat this operation until the contents of the smallest sieve size used is empty, and cumulative mass has been obtained and recorded.
- 5.4.4 When the specifications require percent passing, record the weights retained on each sieve individually.
- Note 2**—For sieves with openings smaller than the 4.75 mm (No. 4), the mass retained on any sieve at the completion of the sieving operation should not exceed 6 kg/m^2 (4 g/in.^2) of sieving surface. No more than 200 g of material should be retained on any single 203 mm (8 in.) diameter sieve.
-

6. CALCULATIONS

- 6.1 Calculate percent retained:

$$PR = 100(MR / MTS)$$

Where:

PR = Percent Retained

MR = Mass Retained

MTS = Mass of Total Sample.

Note 3—For both the coarse and fine aggregate laboratory methods, use the total dry mass prior to washing as the basis for calculating all the percentages.

- 6.2 When the specifications require percent passing, record the weights retained on each sieve individually and calculate the weight passing each sieve. Then calculate the percent passing each sieve.
-

7. REPORTING TEST RESULTS

- 7.1 Report the cumulative percent retained on each sieve to the nearest whole percent, beginning with the largest sieve size.
-

- 7.2 In performing this analysis, use caution not to lose any of the sample during the shaking or weighing operations. If there is an insignificant discrepancy between the original total dry mass of the sample and the sum of the masses of the various parts, assume this difference to have passed the smallest sieve size and use the original total mass.
- 7.3 When the specifications require percent passing, report the percent passing each sieve according to the specifications.

Test Procedure for**FINENESS MODULUS OF FINE AGGREGATE****TxDOT Designation: Tex-402-A****Effective Date: August 1999**



1. SCOPE

- 1.1 This method determines the fineness modulus of concrete fine aggregate used in evaluation of natural and manufactured sands for portland cement concrete.
- 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 *Apparatus*, specified in Tex-401-A.
- 2.2 *Standard U.S. sieves*, meeting the requirements of Tex-907-K, in the following sizes:
- 4.75 mm (No. 4)
 - 2.36 mm (No. 8)
 - 1.18 mm (No. 16)
 - 600 μm (No. 30)
 - 300 μm (No. 50)
 - 150 μm (No.100).
-

3. PROCEDURE

- 3.1 Determine particle size distribution in accordance with Tex-401-A.
-

4. CALCULATIONS

- 4.1 Calculate Cumulative Percent Retained:

$$\text{Cumulative Percent Retained} = 100 (\text{Cumulative Mass Retained} / \text{Mass of Total Sample})$$

- 4.2 Calculate the Fineness Modulus (*FM*):

$$FM = (\sum \text{Cumulative percent retained}) / 100$$

- 4.3 Table 1 lists example amounts for discussion purposes.

Table 1—Amounts for Example Calculations

Sieve Size	Cum. Mass Retained	Cum. % Retained
4.75 mm (No. 4)	31.5 g	6.3
2.36 mm (No. 8)	99.1 g	19.8
1.18 mm (No. 16)	195.6 g	39.1
600 µm (No. 30)	306.7 g	61.3
300 µm (No. 50)	367.2 g	73.4
150 µm (No. 100)	482.8 g	96.5

(Dry Weight of Original Sample = 500.3 g)

Fineness Modulus = $(6.3 + 19.8 + 39.1 + 61.3 + 73.4 + 96.5) / 100 = 2.964$

Fineness Modulus = 2.96

5. REPORT

- 5.1 Report Fineness Modulus to the nearest 0.01.

Test Procedure for

SATURATED SURFACE-DRY SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATES



TxDOT Designation: Tex-403-A

Effective Date: April 2022

1. SCOPE

- 1.1 This method determines the saturated surface-dry (SSD) specific gravity and water absorption of fine aggregates, coarse aggregates, and coarse aggregates greater than 2 in. of nominal maximum size. This procedure does not include the testing of mineral fillers.
-

2. DEFINITIONS

- 2.1 *Absorption moisture content*—the moisture content at SSD condition in contrast to its oven-dry condition.
- 2.2 *Apparent relative density (specific density)*—the solid material making up the constituent particles, not including the pore space within the particles that is accessible to water.
- 2.3 *Bulk specific gravity*—the ratio of the oven-dry weight of the aggregate to the bulk volume of the aggregate particles.
- 2.4 *Bulk volume (of an aggregate)*—the volume of water displaced by aggregate in a SSD condition, including both the volume of the impermeable portion of the aggregate particles and the volume of the permeable voids in the particles.
- 2.5 *Constant weight*—oven dry at a temperature of $230 \pm 9^{\circ}\text{F}$ such that it will not lose more than 0.1% moisture after 2 hr. of drying. Verify by measuring the moisture content from weighing the mass of a sample before and after consecutive 2 hr. drying periods.
- 2.6 *Nominal maximum aggregate size*—the largest sieve size listed in the applicable specification upon which any material is retained.
- 2.7 *Saturated surface-dry*—the condition of the aggregate when all permeable pores of each particle are completely saturated with water and its surface has no free moisture.
- 2.8 *Saturated surface-dry specific gravity*—the ratio of the mass of SSD aggregate to the mass of an equal volume of water.
-

3. APPARATUS

- 3.1 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g, with the capability to weigh by hanging the sample under the balance.

- 3.2 *Cultivator*, hand tool with three metal tines.
- 3.3 *Drying oven*, maintained at $230 \pm 9^{\circ}\text{F}$.
- 3.4 *Electric fan*.
- 3.5 *Funnel*, wide-mouthed.
- 3.6 *Lint-free cloth or towel*.
- 3.7 *Mercury thermometer*, marked in 1°F divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.
- 3.8 *Metal cone*, with:
 - inside top diameter of 40 ± 3 mm (1.5 ± 0.125 in.),
 - inside bottom diameter of 90 ± 3 mm (3.5 ± 0.125 in.),
 - height of 75 ± 3 mm (3.0 ± 0.125 in.), and
 - minimum thickness of 0.8 mm (0.0313 in.).
- 3.9 *Pycnometer*, threaded glass jar, 2 L (0.5 gal.), with metal pycnometer cap.
- 3.10 *Quartering machine, sample splitter, or quartering cloth*.
- 3.11 *Round pans*, 12 in. in diameter.
- 3.12 *Sample container*, wire basket of No. 8 or finer mesh, or a bucket of approximately equal breadth and height, with a capacity of 4–7 L (1–1-3/4 gal.) for 1-1/2 in. nominal maximum size or smaller, and a larger container as needed for testing larger maximum size aggregate. The container should be constructed to prevent trapping air when the container is submerged.
- 3.13 *Standard U.S. sieves*, meeting requirements of Tex-907-K, in the following sizes:
 - No. 4 and
 - No. 30.
- 3.14 *Small trowel*, with a rectangular blade.
- 3.15 *Suspended apparatus*, wire suspending the sample container should be the smallest practical size to minimize any possible effects of a variable immersed length.
- 3.16 *Syringe or rubber bulb*.
- 3.17 *Tamper*, face diameter of 25 ± 3 mm (1.0 ± 0.125 in.) and mass of 340 ± 15 g.
- 3.18 *Water tank*, into which the sample and container are placed for complete immersion while suspended below the balance, equipped with an overflow outlet for maintaining a constant water level.
- 3.19 *Clear, potable tap water*, at $73 \pm 3^{\circ}\text{F}$.
- 3.20 *Fine Carborundum cloth*.

4. REPORTING AND DOCUMENTATION

- 4.1 Report all data and pertinent information using SiteManager form '[tx403-5.9.xlsm](#).'
- 4.2 This form is available from the Materials and Tests Division and online at the following link
<http://www.txdot.gov/insidetxdot/forms-publications/consultants-contractors/forms/site-manager.html>.

5. MATERIAL SAMPLING AND PREPARATION

- 5.1 When testing fine aggregate, sample a minimum of 25 lb. in accordance with [Tex-400-A](#).
- 5.1.1 Use a sample splitter or quartering cloth to reduce the sample to approximately 3,000 g.
- 5.2 When testing coarse aggregate, sample a minimum of 50 lb. in accordance with [Tex-400-A](#).
- 5.2.1 Use a sample splitter or quartering cloth to reduce the sample to the minimum mass in accordance with Table 1.

Table 1
Minimum Size of Test Sample

Nominal Max Aggregate Size ¹	Min Mass of Test Sample, g (lb.)
1/2 in. or less	2,000 (4.4)
3/4 in.	3,000 (6.6)
1 in.	4,000 (8.8)
1-1/2 in.	5,000 (11)
2 in.	8,000 (18)

1. Nominal Maximum Aggregate Size is the largest sieve size listed in the applicable specification, upon which any material is specified to be retained.

- 5.2.2 Sieve the sample over the No. 4 sieve and discard the material passing this sieve. The test sample after sieving over the No. 4 sieve must maintain the minimum mass in accordance with Table 1.
- 5.2.3 Thoroughly wash the aggregate sample.
- 5.2.4 Dry the sample to constant weight and allow to cool to room temperature.
- 5.3 When testing aggregate or Rip Rap Stone greater than 2 in. in diameter, sample the material in accordance with [Tex-400-A](#).
- 5.3.1 Use a sample splitter or quartering cloth to reduce the sample to the minimum mass listed in Table 2.

Table 2
Minimum Size of Test Sample

Nominal Max Size ¹	Min Mass of Test Sample, g (lb.)
3 in.	18,000 (40)
5 in.	27,250 (60)
6 in.	30,000 (66)
8 in.	35,000 (77)

1. Nominal Maximum Aggregate Size is the largest sieve size listed in the applicable specification, upon which any material is specified to be retained.

- 5.3.2 When testing Rip Rap Stone greater than 8 in. in diameter, use a crusher, hammer, or hydraulic hammer to reduce the sample to a size of 5 to 8 in. with a minimum mass of 35,000 g.
- 5.3.3 Sieve the sample over the 2 in. sieve and discard all material passing the sieve. The test sample after sieving over the No. 4 sieve must maintain the minimum mass in accordance with Table 2.
- 5.3.4 Thoroughly wash the aggregate sample.
- 5.3.5 Dry the sample in the oven to constant weight and cool in air at room temperature.

6. PROCEDURES

- 6.1 *This test procedure does not claim to address the safety concerns associated with its use. It is the responsibility of the user of this test procedure to establish the appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations before use.*
- 6.2 *Calibration of Pycnometer:*
- 6.2.1 Select a pycnometer with a rim that is free of cracks or chips to determine its volume.
- 6.2.2 When the pycnometer leaks water, place a piece of fine-grain Carborundum cloth on a smooth, solid plane surface. Hold the empty glass jar upside down with the rim against the Carborundum cloth and smooth the rim by rotating it over the cloth. Apply force and continue the grinding action until the rim is smooth.
- 6.2.3 Clean the glass jar and fill it to 90% capacity with clean tap water. Water temperature must be $73 \pm 3^{\circ}\text{F}$.
- 6.2.4 Seat the gasket flush within the cap and tighten the cap onto the glass jar. Do not overtighten the cap, only enough to prevent leaking.
- 6.2.5 Use a syringe to add additional water to the pycnometer until there is overflowing to remove the air bubbles through the top opening of the cap.
- 6.2.6 Pick up the pycnometer and place a finger covering the hole of the cap and vigorously twist the pycnometer back and forth to remove entrapped air. Do not invert the pycnometer.
- 6.2.7 Repeat Section 6.2.6 until all entrapped air has been removed.
- 6.2.8 Dry the outside of the pycnometer thoroughly.
- 6.2.9 Use a syringe to completely fill the pycnometer with water until a stable, rounded bead of water is established at the top opening of the cap.

- 6.2.10 Determine the mass of the pycnometer filled with water to the nearest 0.5 g.
- 6.2.11 Measure the temperature of the water to verify it is $73 \pm 3^{\circ}\text{F}$.
- 6.2.12 When the water temperature is not $73 \pm 3^{\circ}\text{F}$, it must be within 3°F of the temperature measured at the final weighing of the pycnometer containing the test sample in Section 6.3.18.
- 6.2.13 When the water temperature requirement is not achieved, repeat this calibration procedure.
- 6.3 *Testing Fine Aggregate:*
 - 6.3.1 Place the test sample into a pan and cover with water. Allow to soak for a minimum of 24 hr. Avoid using metal pans, which react with aggregates.
 - 6.3.1.1 Use Tex-409-A, Part II for field determination of absorption only.
 - 6.3.2 Decant the water, avoiding loss of fines, and spread the test sample in a thin layer on a clean, flat, nonabsorbent, smooth surface such as a metal-topped workbench.
 - 6.3.3 Allow the sample to air dry or use a fan to expose the sample to a slow-moving current of air without applying additional heat.
 - 6.3.4 Stir frequently with a small trowel or cultivator to ensure uniform drying.
 - 6.3.5 Test the surface moisture using the metal cone and tamper as specified in Section 6.3.5.1 through 6.3.5.8. to determine if the SSD condition is achieved.
 - 6.3.5.1 Firmly hold the cone continuously with cupped fingers on a smooth, nonabsorbent surface, with the larger diameter facing down.
 - 6.3.5.2 Using a small scoop, place a portion of the fine aggregate into the cone until it overflows above the top of the cone.
 - 6.3.5.3 Lightly tamp the fine aggregate in the cone with 25 drops of the tamper. Start each drop approximately 0.2 in. (5 mm) above the top surface of the fine aggregate. Allow the tamper to fall freely and adjust the starting height to the new surface elevation after each drop. Distribute the drops over the entire surface of the fine aggregate.
 - 6.3.5.4 Remove loose sand from around the base of the cone using a small brush or fingers.
 - 6.3.5.5 Lift the cone vertically.
 - 6.3.5.6 When surface moisture is still present, the fine aggregates will retain the molded shape. Proceed back to Section 6.3.4.
 - 6.3.5.7 Slight slumping on one or more sides of the molded fine aggregate indicates it has reached a surface-dry condition. Proceed to 6.3.6.
 - 6.3.5.8 When slumping of the molded fine aggregate produces a spire with a top flat surface less than the diameter of the tamper, the fine aggregate is too dry and has passed the surface-dry condition. Thoroughly mix a few milliliters of water with the fine aggregate sample and let it stand in a covered container for approximately 30 min. Repeat Section 6.3.5.
 - 6.3.6 Immediately weigh $1,200 \pm 10$ g of SSD aggregate to prevent the loss of moisture and record the mass.

- 6.3.7 When measuring the absorption, immediately weigh a separate $1,200 \pm 10$ g of SSD aggregate and record as X to the nearest 0.1g in Section 7.5.
- 6.3.7.1 Dry the sample to a constant weight in an oven and cool to room temperature.
- 6.3.7.2 Determine the mass of the oven-dry sample and record as X_1 to the nearest 0.5g in Section 7.5.
- 6.3.8 Partially fill a pycnometer approximately one-quarter full of water.
- 6.3.9 Place the SSD sample from Section 6.3.6 into the pycnometer using a wide-mouthed funnel not to lose any of the material.
- 6.3.10 Rinse the funnel over the pycnometer with water to wash any clinging particles into the jar.
- 6.3.11 Fill the pycnometer with water to within approximately 0.5 in. of the rim, secure the cap tightly, and completely fill with water.
- 6.3.12 Stop the hole in the cap with a finger and manually roll, invert, or agitate the pycnometer to free all entrapped air. Raise and lower the pycnometer in such a manner that the material will flow from one end of the pycnometer to the other while rolling.
- 6.3.13 When a quantity of air bubbles has accumulated, refill the pycnometer to wash out the air until air has been removed. Take care not to lose material.
- 6.3.14 Repeat Section 6.3.12 and 6.3.13 until all the air is removed.
- 6.3.15 Dry the outside of the pycnometer and cap.
- 6.3.16 Place the pycnometer on the scale.
- 6.3.16.1 Use a syringe or rubber bulb to fill the pycnometer carefully with water, leaving a rounded bead of water on top of the cap.
- 6.3.17 Determine the mass of the pycnometer and contents to the nearest 0.5 g and record as Z in Section 7.
- 6.3.18 Determine and record the temperature of the water.
- 6.3.19 Place the pycnometer in a clean, tared pan. Remove the pycnometer cap and pour the water and sample into the pan.
- 6.3.20 Rinse the cap, glass jar, and hands thoroughly over the pan to collect the remainder of the test sample.
- 6.3.21 Allow the material to settle and the water to become clear.
- 6.3.22 Decant or siphon the water not to lose any of the test sample.
- 6.3.23 Dry the aggregate to constant weight in an oven and cool to room temperature.
- 6.3.24 Determine the mass of the test sample to the nearest 0.5 g.
- 6.4 *Testing Coarse Aggregate.*
- 6.4.1 Place the sample in a pan and cover with water. Do not use metal pans, which react with aggregates.

- 6.4.1.1 Use Tex-409-A, Part II for field determination of absorption only.
- 6.4.2 Soak the sample for a minimum of 24 hr.
- 6.4.3 Drain or siphon the water from the sample and transfer the sample to a large, lint-free cloth or towel.
- 6.4.4 Roll the material in the lint-free cloth or towel until all visible films of water are removed from the surface of the aggregate to achieve SSD condition. Avoid evaporation of water from the aggregate pores.
- 6.4.5 Transfer the SSD sample to a tared pan placed on the balance above the suspended apparatus and the water tank.
- 6.4.6 Determine the mass of the sample to the nearest 0.5 g.
- 6.4.7 Immediately transfer the SSD sample in the sample container and completely immerse into the water tank containing water at 73 ± 3 °F.
- 6.4.8 Remove all entrapped air by shaking and twisting the container while immersed in the water tank.
- 6.4.9 Determine the mass of the sample in water to the nearest 0.5 g.
Note 1—The difference between the mass in air and the mass in water equals the mass of water displaced by the sample.
- 6.4.10 Remove the sample container from the water tank and transfer the aggregate sample into a tared pan.
- 6.4.11 Dry the aggregate in an oven to constant weight and allow to cool to room temperature.
- 6.4.12 Determine the mass of the test sample to the nearest 0.5 g.
- 6.5 *Testing Coarse Aggregate Greater than 2 in. and Rip Rap Stone.*
- 6.5.1 Place the sample in one or more clean five-gallon buckets and cover with water. Allow the sample to soak for a minimum of 24 hr.
- 6.5.2 Perform Sections 6.4.4 through 6.4.12 on each individual aggregate particle for the entire sample.
- 6.5.2.1 Record the individual SSD mass and the mass submerged in water for each aggregate particle to the nearest 0.5g.
- 6.5.2.2 Calculate the total sum of the individual SSD masses to the nearest 0.5 g.
- 6.5.2.3 Calculate the total sum of the individual masses submerged in water to the nearest 0.5 g.
- 6.5.3 Place the entire test sample into one or more tared pans.
- 6.5.4 Dry the test sample to constant weight and cool to room temperature.
- 6.5.5 Determine the mass of the test sample to the nearest 0.5 g.

7. CALCULATIONS

- 7.1 Calculate the SSD specific gravity (G_{SSD}) of coarse and fine aggregate using the following equations.

For coarse aggregate: $G_{SSD} = \frac{X}{(X - S)}$

For fine aggregate: $G_{SSD} = \frac{X}{(X + Y - Z)}$

Where:

G_{SSD} = SSD specific gravity of aggregate

S = Submerged sample weight, in basket, g

X = Weight of SSD sample, g

Y = Weight of calibrated pycnometer filled with water, g

Z = Weight of pycnometer, SSD sample, and water, g

7.2 Calculate the bulk specific gravity (G_{BULK}) of coarse and fine aggregate using the following equations.

For coarse aggregate: $G_{BULK} = \frac{X_1}{(X - S)}$

For fine aggregate: $G_{BULK} = \frac{X_1}{(X + Y - Z)}$

Where:

G_{BULK} = Bulk (oven-dry) specific gravity of aggregate

S = Submerged sample weight, in basket, g

X_1 = Weight of oven-dry sample, g

X = Weight of SSD sample, g

Y = Weight of calibrated pycnometer filled with water, g

Z = Weight of pycnometer, SSD sample, and water, g

7.3 Calculate the apparent specific gravity (G_A) of coarse and fine aggregate using the following equations.

For coarse aggregate: $G_A = \frac{X_1}{(X_1 - S)}$

For fine aggregate: $G_A = \frac{X_1}{(X_1 + Y - Z)}$

Where:

G_A = Bulk (oven-dry) specific gravity of aggregate

S = Submerged sample weight, in basket, g

X_1 = Weight of oven-dry sample, g

Y = Weight of calibrated pycnometer filled with water, g

Z = Weight of pycnometer, SSD sample, and water, g

- 7.4 Calculate the average bulk specific gravity (G_b) of combined sizes of aggregate or combination of materials using the following equation.

$$G_b = \frac{100}{\left[\frac{W_1}{G_1} + \frac{W_2}{G_2} + \dots + \frac{W_n}{G_n} \right]}$$

Where:

G_b = Average bulk specific gravity of combined aggregate

G_1 = Bulk specific gravity of material No. 1

G_2 = Bulk specific gravity of material No. 2

G_n = Bulk specific gravity of material No. n

W_1 = Percentage of material No. 1 from screen analysis or based on total weight of combination

W_2 = Percentage of material No. 2 from screen analysis or based on total weight of combination

W_n = Percentage of material No. n from screen analysis or based on total weight of combination

$W_1 + W_2 + \dots + W_n$, must total 100%

- 7.5 Using the test data secured in determining the bulk specific gravity, calculate the water absorption (A) of the aggregate using the following equation.

$$A = \frac{(X - X_1)}{X_1} \times 100$$

Where:

A = Percent water absorption (24 hr.) of aggregate based on the oven-dry weight of sample

X = Weight of SSD sample, g

X_1 = Weight of oven-dry aggregate, g

- 7.6 Calculate the average percent water absorption (A) of combined materials using the following equation.

$$A = \frac{A_1 W_1 + A_2 W_2 + \dots + A_n W_n}{100}$$

Where:

A = Average percent water absorption (24 hr.) of combined materials based on the total weight of oven-dry combination

A_1 = Percent water absorption of material No. 1

A_2 = Percent water absorption of material No. 2

A_n = Percent water absorption of material No. n

W_1 , W_2 , and W_n are the same as defined earlier in Section 7.4

8. TEST REPORT

- 8.1 Specific gravity, results to the nearest 0.01.

- 8.2 Absorption, results to the nearest 0.1%.

Test Procedure for**DETERMINING UNIT MASS (WEIGHT) OF
AGGREGATES****TxDOT Designation: Tex-404-A****Effective Date: August 1999**

1. SCOPE

- 1.1 This method describes the determination of the loose mass per m^3 (ft^3) of both fine and coarse aggregates.
 - 1.1.1 The unit mass of aggregate in a saturated surface-dry (SSD) condition is intended for use in portland cement concrete mix design.
 - 1.1.2 The dry rodded condition is intended for use in the American Concrete Institute (ACI) design procedure.
 - 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 *Scoops*, one medium, one small, having square points.
 - 2.2 *Quartering cloth or large flat metal pan*.
 - 2.3 *Balance*, accurate within 0.1% of the mass of the test sample, readable to 5 g for aggregate passing the No. 4 sieve, and readable to 10 g for aggregate retained on the No. 4 sieve.
 - 2.4 *Metal straightedge*.
 - 2.5 *Volume measures*, calibrated in accordance with Tex-905-K, with volumes of 0.003 m^3 (0.1 ft^3) and 0.01 m^3 (0.5 ft^3).
 - 2.6 *Denim cloth sleeve*, approximately $216 \times 762 \text{ mm}$ ($8.5 \times 30 \text{ in.}$) long (flat measure).
 - 2.7 *Tamping rod*, a round straight steel rod, 16 mm ($5/8 \text{ in.}$) diameter, approximately 600 mm (24 in.) in length, having one end rounded to a hemispherical tip of the same diameter as the rod.
-

3. PREPARING SAMPLE

- 3.1 Secure a field sample in accordance with Tex-400-A, obtaining a representative test sample of more than sufficient quantity to fill the measure.
 - 3.2 The test may be performed on material at various uniform moisture conditions (including stockpile condition); however, the water content of the sample at the time of the test needs to be in the SSD condition.
 - 3.3 Do not test fine aggregate at water content wetter than SSD condition, since this may cause bulking or bridging of the wet sand.
 - 3.4 If oven dry condition is desired, place the sample in a $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) oven until constant mass is obtained. Cool to room temperature.
 - 3.5 If SSD condition is desired, air dry at room temperature to the SSD condition.
-

4. PROCEDURES

- 4.1 *Determining Unit Mass (Weight)—Loose Method:*
 - 4.1.1 *Coarse Aggregate:*
 - 4.1.1.1 Place the sample on a smooth, flat surface and mix thoroughly.
 - 4.1.1.2 Place the 0.01 m^3 (0.5 ft.^3) measure on a level surface near the sample.
 - 4.1.1.3 Take a medium scoop of the aggregate from the thoroughly mixed sample pile.
 - 4.1.1.4 Hold the scoop 51 mm (2 in.) above the measure.
 - 4.1.1.5 Pour the material uniformly over the entire area in such a manner that each layer placed is nearly level and such that the surface of the material when the measure is full will be level with the rim of the measure.
 - 4.1.1.6 While taking care not to jar the measure, level off the surface of the aggregate with the fingers in such a way that slight projections of the larger particles above the rim balance the larger voids in the surface below the top of the measure.
 - 4.1.1.7 Weigh measure to nearest 10 g (0.02 lb.) and subtract the calibrated tare mass of the measure to obtain the net mass of the material.
 - 4.1.1.8 Repeat above step to obtain a second determination. If two determinations are not within 1% for the same operator, run additional unit mass determinations until two non-consecutive unit masses vary by less than 1%.
 - 4.1.1.9 Record the average mass of the aggregate as W_{SSD} if aggregate was tested at SSD or as X if the aggregates were dried to constant weight before testing, under Section 5.
-

4.1.2 *Fine Aggregate:*

- 4.1.2.1 The fine aggregate sample should be large enough (after drying) to fill the 0.003 m³ (0.1 ft.³) measure to overflowing. Use a small scoop to place the sample of sand into the denim sleeve.
- 4.1.2.2 Place the 0.003 m³ (0.1 ft.³) measure in a large flat pan so that excess material may be recovered for check tests.
- 4.1.2.3 Thoroughly mix the fine aggregate in the sleeve by closing the ends with both hands and then alternately raising and lowering one end and then the other.
- 4.1.2.4 Close the open end of the sleeve with one hand, allowing several millimeters (inches) of the empty part of the sleeve to extend beyond the hand.
- 4.1.2.5 Place this end on the bottom of the measure and release it.
- 4.1.2.6 Hold the measure firmly with one hand while steadily withdrawing the sleeve with the other.
- 4.1.2.7 Use a straightedge to strike off excess material even with the top of the measure.
- 4.1.2.8 Tap the side of the measure lightly to slightly settle the material and prevent material loss when weighing.
- 4.1.2.9 Weigh the measure full of aggregate to the nearest 5 g (0.01 lb.) and subtract the tare mass of the empty measure to obtain net mass of material required to fill the measure.
- 4.1.2.10 Repeat above step to obtain a second determination. If the two mass determinations are not within 1% for the same operator, run additional unit mass determinations until two non-consecutive unit masses vary by less than 1%.
- 4.1.2.11 Record the average net mass of aggregate as *X* under Section 5.

4.1.3 *Coarse Lightweight Aggregate:*

- 4.1.3.1 Standardize the gradation on which the dry loose unit mass determination is made when this unit mass is used as a quality acceptance criterion, as noted under the Materials article in the governing Department *Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges*.
- 4.1.3.2 When used as a volume measure for mass volume conversion, distribution rate, or pay item, make the dry loose unit mass determination on the total sample.
- 4.1.3.3 Dry the material to a constant mass at approximately 110°C (230°F). Cool to room temperature.
- 4.1.3.4 Sieve enough material to fill the 0.01 m³ (0.5 ft.³) measure into the percentages specified in Table 1.

Note 1—Use standard gradation when dry loose unit mass fails the specification requirement at received gradation, and note this on the test report.

- 4.1.3.5 Place the sample on a smooth, flat surface and mix thoroughly.
- 4.1.3.6 Place the 0.01 m³ (0.5 ft.³) measure on a level surface near the aggregate sample.
- 4.1.3.7 Take a medium scoop full of the aggregate from the thoroughly mixed sample pile.
- 4.1.3.8 Hold the scoop 51 mm (2 in.) above the measure.
- 4.1.3.9 Pour the aggregate into the measure.
- 4.1.3.10 Pour the material uniformly over the entire area in such a manner that each layer placed is nearly level and such that the surface of the material when the measure is full will be level with the rim of the measure.
- 4.1.3.11 Taking care not to jar the measure, level off the surface of the aggregate with the fingers in such a way that slight projections of the larger particles above the rim balance the larger voids in the surface below the top of the measure.
- 4.1.3.12 Weigh measure to nearest 10 g (0.02 lb.) and subtract the calibrated tare mass of the measure to obtain the net mass of the material.
- 4.1.3.13 Repeat Steps 4.1.3.6–4.1.3.12 to obtain a second determination.
- 4.1.3.14 If the two determinations are not within 1% for the same operator, run additional unit mass determinations until two non-consecutive unit masses vary by less than 1%.
- 4.1.3.15 Record average net mass of aggregate of the satisfactory determinations as *W* under Section 5.

Note 2—Mix the aggregates thoroughly and take precautions to prevent segregation of the particles when filling the unit mass measures.

Table 1—Size of Material by % Retained by Mass

Size	% Retained by Mass
12.5 mm (1/2 in.)	0
9.5 mm (3/8 in.)	40–60
4.75 mm (No. 4)	100

- 4.2 *Determining Unit Mass (Weight)—Rodded Method:*
 - 4.2.1 *Coarse or Fine Aggregate:*
 - 4.2.1.1 Dry the sample to constant mass.
 - 4.2.1.2 Place the dry sample on a smooth, flat surface and mix thoroughly. Use the 0.01 m³ (0.5 ft.³) measure for coarse and the 0.03 m³ (0.1 ft.³) for fine aggregate.

- 4.2.1.3 Fill the measure one-third full with a scoop and level the surface with the fingers.
- 4.2.1.4 Rod the layer of aggregate with 25 strokes of the tamping rod so the aggregate distributes evenly over the surface. Do not allow the rod to strike the bottom of the measure forcibly.
- 4.2.1.5 Fill the measure two-thirds full and again level and rod as in Section 4.2.1.4. The rod should not penetrate into the first layer.
- 4.2.1.6 Fill the measure to overflowing and rod again. The rod should not penetrate into the middle layer.
- Note 3**—In rodding the larger sizes of coarse aggregate, it may not be possible to penetrate through the layer being consolidated to the lower level, especially with angular aggregates. Nevertheless, the intent of the procedure will be accomplished as long as vigorous effort to penetrate is used.
- 4.2.1.7 Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.
- 4.2.1.8 Weigh the full measure to the nearest 10g (0.02 lb.) for coarse aggregate and 5g (0.01 lb.) for fine aggregate. Subtract the calibrated tare mass to obtain net mass of the material.
- 4.2.1.9 Repeat Sections 4.2.1.3–4.2.1.8 to obtain a second determination. If two determinations are not within 1% for the same operator, then run additional unit mass determinations until two non-consecutive unit masses vary by less than 1%.
- 4.2.1.10 Record average net mass of aggregate as X under Section 5.
-

5. CALCULATIONS

- 5.1 Calculate Rodded U_{dry} :

$$U_{\text{DRY}} = X / V$$

- 5.2 If the aggregate was dried to a constant mass when tested, calculate W as:

$$W = X[(100 + A) / 100]$$

- 5.3 If aggregate is less than SSD, calculate W as:

$$W = X_I[(100 + A - A_I) / 100]$$

-OR-

$$W = X_I[(100 + A_2) / 100]$$

- 5.4 If the free moisture has been removed but the aggregate still contains some absorbed moisture when tested and the oven-dry mass is desired, then calculate W_{dry} as:

$$W_{DRY} = 100 [X_1 / (100 + A_1)]$$

- 5.5 For coarse aggregate only, if the moisture content at the test condition of the aggregate is greater than SSD and the SSD mass is desired, calculate W_{SSD} as:

$$W_{SSD} = X_2 [(100 - M) / 100]$$

- 5.6 Calculate the unit mass (U):

$$U = W / V, \text{ in } kg / m^3 \text{ (lb./ft}^3 \text{)}$$

-OR-

$$U = X / V, \text{ kg } / m^3 \text{ (lb./ft}^3 \text{)}$$

Where:

A = percent absorption as determined in Tex-403-A.

A_1 = percent absorbed moisture at the test condition of the aggregate

A_2 = percent absorption based on stockpile condition mass as determined in Part II of Tex-409-A

M = percent free moisture as determined in Part I of Tex-409-A

V = Volume of the measure; either 0.01 or 0.003 m³ (0.5 or 0.1 ft.³)

W = average net mass of saturated surface-dry (SSD) aggregate to fill the measure

X = mass of aggregate (oven dry) in the container, kg (lb.)

X_1 = mass of aggregate (less than SSD) in the container, kg (lb.)

X_2 = mass of aggregate (greater than SSD) in the 0.01 m³ (0.5 ft.³) container, kg (lb.)

Note 4—Avoid unnecessary delays when testing saturated surface-dry material to prevent excessive loss of moisture by evaporation.

6. REPORT

- 6.1 Report the unit mass to the nearest kg/m³ (0.1 lb./ft.³) using the Unit Weight of Lightweight Surface Treatments Aggregates worksheet.

Test Procedure for

MATERIAL FINER THAN 75 μm (NO. 200) SIEVE IN MINERAL AGGREGATES (DECANTATION TEST FOR CONCRETE AGGREGATES)



TxDOT Designation: Tex-406-A

Effective Date: August 1999

1. SCOPE

- 1.1 Use this method to perform the decantation test for concrete aggregates on material finer than the 75 μm (No. 200) sieve.
 - 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.
-

PART I—LABORATORY METHOD

2. SCOPE

- 2.1 Use this procedure to perform the laboratory method for the decantation test.
-

3. APPARATUS

- 3.1 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 6000 g.
 - 3.2 *Drying oven*, maintained at $110 \pm 5^\circ\text{C}$ ($230 \pm 9^\circ\text{F}$).
 - 3.3 *Drying oven*, maintained at $60 \pm 5^\circ\text{C}$ ($140 \pm 9^\circ\text{F}$).
 - 3.4 *Pan*, approximately 305 mm (12 in.) in diameter and 127 mm (5 in.) deep.
 - 3.5 *Set of standard U.S. sieves*, meeting requirements of Tex-907-K, in the following sizes:
 - 4.75 mm (No. 4)
 - 75 μm (No. 200).
 - 3.6 *Sample splitter or quartering cloth*.
 - 3.7 *Plaster of paris molds*, with filter paper (optional).
-

4. PROCEDURE

- 4.1 If sample contains fine and coarse aggregates, which have separate specification requirements, separate the materials into coarse and fine aggregate samples as defined by the specifications. Test these samples separately.
- 4.2 Mix sample thoroughly.
- 4.3 If testing sample in accordance with Tex-401-A, reduce the sample to the minimum test sample mass described in that method. If not testing in accordance with Tex-401-A, reduce the sample to one of the masses according to its nominal maximum size listed in Table 1.
- 4.4 Dry the aggregate to constant mass at 110°C (230°F). Weigh the oven-dry mass to the nearest 0.1 g and record as W_1 in Section 5.
Note 1—When drying bituminous (RAP) materials, dry at 60°C (140°F) to a constant mass.
- 4.5 Place the sample into a pan and fill with tap water until all of the material is submerged. Soak the material for a minimum of 12 hours.
- 4.6 After the aggregate is thoroughly saturated, vigorously agitate the material and then decant the wash water over the 75 μm (No. 200) sieve.
- 4.7 Add water to the pan and repeat washing and decanting until wash water is clear.
- 4.8 Recover any aggregate retained on the 75 μm (No. 200) sieve and return to the pan.
- 4.9 If the material finer than the 75 μm (No. 200) sieve is to be tested for percent limestone in Part III, follow Sections 4.10–4.14; if not, go to Section 4.14.
- 4.10 Place the pan containing the minus (-) 75 μm (No. 200) sieve material and wash water aside where it will not be disturbed. Allow all of the fine material to settle to the bottom of the pan (approximately 2–3 hours). If material fails to settle in this amount of time, proceed to Section 4.12.
- 4.11 Decant or siphon off the clear water.
- 4.12 In cases where the material fails to settle in a reasonable period, decant the water onto plaster of paris molds lined with filter paper. After the water has disappeared, dry the filter paper in the 60 $\pm$ 5°C (140 $\pm$ 9°F) oven, then brush the fines from the filter paper with a stiff brush into the pan of fines.
- 4.13 Dry the remaining material to a constant weight, using a 60 $\pm$ 5°C (140 $\pm$ 9°F) oven if there is difficulty in removing the moisture from the pan.
- 4.14 Dry the washed plus (+) 75 μm (No. 200) material to a constant mass in a 110 $\pm$ 5°C (230 $\pm$ 9°F) oven; weigh the net mass of the washed aggregate to the nearest 0.1 g and record as W_2 in Section 5.

Table 1—Nominal Maximum Size

Nominal Max. Size	Minimum Mass, g
37.50 mm (1-1/2 in.) or larger	5000
25.00 mm (1 in.) or larger	3500
19.00 mm (3/4 in.)	2500
9.5 mm (3/8 in.)	1000
4.75 mm (No. 4)	500
less than 4.75 mm (No. 4)	200

5. CALCULATIONS

- 5.1 Calculate the Percent Loss of material finer than 75 μm (No. 200):

$$\text{Percent Loss} = 100 [(W_1 - W_2) / W_1]$$

Where:

W_1 = original dry mass of the sample, g

W_2 = final dry weight, g.

6. REPORT

- 6.1 Report Percent Loss to the nearest 0.1%.

PART II—FIELD METHOD FOR CONCRETE AGGREGATES

7. SCOPE

- 7.1 Part II provides a rapid approximation intended only when correlated with Part I. When material is borderline, use Part I.

8. APPARATUS

- 8.1 *Balance*, same as used in Part I.
- 8.2 *Wide mouth funnel*.
- 8.3 *Pycnometer*, 2 L (1/2 gal.) glass Mason jar with a pycnometer cap, calibrated in accordance with Tex-403-A.

9. PROCEDURE

- 9.1 If sample contains fine and coarse aggregates, which have separate specification requirements, separate coarse and fine aggregates into different samples as defined by the specifications. Test the samples separately.

- 9.2 Mix sample thoroughly.
- 9.3 Secure a portion weighing approximately 1200 g. (The sample need not be weighed, and the moisture content of the material is not considered since these factors have no bearing upon the test values.)
- 9.4 Place the sample into the pycnometer jar and cover with water.
- 9.5 If the material is not drier than saturated surface-dry (SSD), proceed immediately to Section 9.6. If the moist condition of the material is in doubt, or if the material is in stockpile condition and drier than SSD, allow to stand undisturbed for at least 12 hours.
- 9.6 Fill the jar with water at approximately $23 \pm 2^\circ\text{C}$ ($73 \pm 3^\circ\text{F}$), to within 12.5 mm (0.5 in.) of the rim and screw the lid on. Then finish filling the jar with water to the top.
- 9.7 Stop the hole in the cap with a finger and roll the jar to free the entrapped air. Raise and lower the jar in such a manner that the material will flow back and forth in the jar while being rolled.
- 9.8 Refill the cap to remove any air bubbles. Take precautions to prevent loss of fine material while removing the entrapped air.
- 9.9 Use a towel to dry the outside of the jar and add water until the jar is full and has a rounded bead of water at the top. Weigh and record the mass to the nearest 0.5 g as Z_1 under Section 10.
- 9.10 When testing sands, close the opening in the cap with a finger and agitate the contents of the jar by rolling the pycnometer with a swinging motion. When testing coarse aggregate, gently roll the pycnometer to avoid breaking the jar.
- 9.11 Place the jar upright and remove the cap.
- 9.12 Slowly pour the liquid over a 75 μm (No. 200) sieve, taking care to lose none of the plus (+) 75 μm (No. 200) material.
- 9.13 Replace the cap and fill to full again, leaving a rounded bead of water at the top of the cap. Repeat Sections 9.10–9.12 until the water above the aggregate is reasonably clear.
- 9.14 Recover any material that retained on the 75 μm (No. 200) sieve and return it to the pycnometer.
- 9.15 Screw the lid onto the jar and fill again with water at $23 \pm 2^\circ\text{C}$ ($73 \pm 3^\circ\text{F}$).
- 9.16 Dry the outside of the pycnometer and complete filling with water, leaving a rounded bead of water on top of the pycnometer cap.
- 9.17 Weigh and record the mass to the nearest 0.5 g as Z_2 under Section 10.

10. CALCULATIONS

- 10.1 Calculate the Percent Loss of material finer than the 75 μm (No. 200):

$$\text{Percent Loss} = 100[(Z_1 - Z_2)/(Z_1 - Y)]$$

Where:

Z_1 = mass of pycnometer containing sample and water to fill, before washing, kg (lb.)

Z_2 = mass of pycnometer containing sample and water to fill, after washing, kg (lb.)

Y = calibrated mass of pycnometer filled with only water at approximately the same temperature at which Z_1 and Z_2 were determined (Tex-403-A, Section 6).

11. REPORT

- 11.1 Report percent loss to the nearest 0.1%.

Note 2—The percentage by mass of material lost by decantation is equal to the percentage by absolute volume, assuming that the specific gravity of the material is the same as that of the particles remaining.

Note 3—Any pan of suitable size and texture will be satisfactory. Avoid the use of metal pans, which react with aggregates.

Note 4—When correlating the field method (Part II) with the laboratory method (Part I), perform the tests according to both Part I and Part II and record the results. The difference between the results for Part I and Part II becomes a factor, which should be added to the results obtained when using the Part II method. If the results from using Part II plus the factor produce a failing value, rerun the test using Part I.

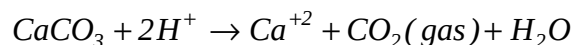
PART III—PERCENT OF LIMESTONE IN DECANTATION MATERIAL

12. SCOPE

- 12.1 This procedure is intended to distinguish between the limestone and non-limestone fractions of minus (-) 75 μm (No. 200) material.

- 12.2 The calcium carbonate (CaCO_3) limestone portion of the sample can be determined accurately by a dilute hydrochloric acid titration. The dilute acid will react with the CaCO_3 but will not affect the non-limestone particles.

- 12.3 The basic chemical equation is:



- 12.4 Using a known sample weight and known acid concentration, the CaCO_3 content of the sample can be calculated from the amount of acid used in titration.

13. APPARATUS

- 13.1 *Oven*, maintained at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).
- 13.2 *Desiccator*, with indicating type silica-gel desiccant.
- 13.3 *Balance*, Class G1 in accordance with Tex-901-K, minimum capacity of 100 g, suitable for rapid weighing.
- 13.4 *Beaker*, 400 mL (12 oz.)
- 13.5 *Stirrer*, magnetic type, with a Teflon-covered bar.
- 13.6 *Buret*, Class A, 50 mL (1.7 fl. oz.) capacity graduated to 0.1 mL (0.003 fl. oz.)
- 13.7 *pH meter*, accuracy of ± 0.1 pH unit or better within a temperature range of $0\text{--}100^{\circ}\text{C}$ ($32\text{--}212^{\circ}\text{F}$). The meter should have either a manual or automatic temperature compensator.

14. MATERIALS

- 14.1 *Hydrochloric acid solution*, 1.00 ± 0.005 N, with the normality of the solution accurately determined by direct comparison with a 1.000 ± 0.005 N sodium hydroxide solution prepared and standardized in accordance with Tex-600-J, Part II.
- 14.2 *Distilled or deionized water*.

15. PREPARING SAMPLE

- 15.1 Perform Part I, Section 4, and save the material passing the 75 μm (No. 200) sieve from the concrete coarse aggregate, as stated in Section 4.9 of the procedure.
- 15.2 Dry the material to a constant mass in the oven and then cool in a desiccator.
- 15.3 Pulverize with a mortar and pestle.

16. PROCEDURE

- 16.1 Weigh out 2 ± 0.01 g of material into a 400 mL (12 fl. oz.) beaker of known mass.
- 16.2 Carefully add 125–150 mL (4–5 fl. oz.) of distilled or deionized water, add the stirring bar to the beaker, and place on magnetic stirrer.
- 16.3 Start the stirrer and insert the pH meter electrodes into the mixture.

- 16.4 Titrate the mixture with the acid solution until a stable pH of 2.7 is attained (approximately 3 minutes). As acid is added, the pH of the mixture will go down to about 5.5, at which time CO_2 will start to be generated.
- 16.4.1 Add acid more slowly at this point, so the effervescence will not splatter sample from the beaker.
- 16.4.2 If the pH meter has a manual temperature compensator, make the adjustment to correct for the temperature of the solution at the endpoint.
- 16.4.3 At a pH of 2.7, read the volume of acid used in mL (fl. oz.)
-

17. CALCULATIONS

- 17.1 Calculate the Percent Loss of minus (-) 75 μm (No. 200) material as percent limestone:

$$\% \text{ Limestone} = 5 [N(V) / X]$$

Where:

N = Normality of HCl used

V = Volume of HCl used in titration, mL (fl. oz.)

X = Sample weight, g.

Note 5—Unless a value is specified elsewhere in the plans or specifications, the minus (-) 75 μm (No. 200) material obtained from the limestone coarse aggregate can be considered as dust of fracture when the percent limestone is equal to or more than 75.

Test Procedure for**ORGANIC IMPURITIES IN FINE AGGREGATE FOR CONCRETE****TxDOT Designation: Tex-408-A****Effective Date: December 2016**

1. SCOPE

- 1.1 Use this method to determine the presence of organic compounds in fine aggregates intended for use in cement mortar or concrete. The test provides a quick, relative measure to determine if further tests of the fine aggregate are necessary before approval for use
 - 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 *Glass bottles*, 355–473 mL (12–16 fl. oz.), clear glass, graduated in milliliters (ounces), with screw type caps or rubber stoppers.
 - 2.2 *Glass color standard*, mounted in a plastic holder with five organic color numbers, one through five (Gardner Color Standard Numbers 5, 8, 11, 14, and 16, ASTM D 1544 [06.01]).
-

3. REAGENTS

- 3.1 *Sodium hydroxide solution*, 3%, prepared by dissolving 30 g of sodium hydroxide (NaOH) crystals in 970 mL (33 fl. oz.) of distilled water.
-

4. PROCEDURE

- 4.1 Obtain a 300 g air-dried sample in accordance with Tex-400-A.
 - 4.1.1 If the fine aggregate consists of a combination of sands, combine the sands in the proportions by mass in which they are to be used.
 - 4.2 Fill the glass bottle to the 133 mL (4.5 fl. oz.) mark with the material to be tested.
 - 4.3 Add enough NaOH solution to the bottle to cover the sample. Place cap or stopper on jar and shake jar vigorously to remove air bubbles.
-

- 4.4 Bring the solution level up to the 207 mL (7 fl. oz.) mark, stopper, and shake again.
- 4.5 Allow the bottle and contents to stand undisturbed for 24 hours.
- 4.6 At the end of the 24-hour standing period, compare the color of the supernatant liquid above the test sample with that of the Glass Color Standard, Organic Color No. 3 (Gardner No. 11), as described under Section 2.
- Note 1**—Do not disturb the contents while handling the bottles to make the color comparison, since this could cause the liquid to become cloudy.
-

5. REPORTING

- 5.1 Report results as lighter, darker, or equal to the standard. Test samples rated darker than the standard in accordance with AASHTO T 71. Compressive strength at 7 days should not be less than 95%.
-

6. ARCHIVED VERSIONS

- 6.1 Archived versions are available.

Test Procedure for**DELETERIOUS MATERIAL OF COARSE AND FINE AGGREGATE****TxDOT Designation: Tex-413-A****Effective Date: July 2023**

1. SCOPE

- 1.1 Use this test method to determine the percentage of deleterious material of coarse and fine aggregate stockpiles used for hydraulic cement concrete. Deleterious material includes clay lumps, shale, or laminated and friable particles. Concrete produced with deleterious materials may have lower strength.
- 1.2 Clay lumps consist of a stiff, sticky fine-grained soil typically yellow, red, or bluish-gray in color. Shale is considered hard sedimentary rock consisting predominately of clay and silt sized grains. Laminated particles have layering or bedding within them resulting from the distinct alteration of material of different grain size and composition. Friable particles easily crumble apart.

2. APPARATUS

- 2.1 *Balance*, Class G2 in accordance with Tex-901-K, minimum capacity of 5,000 g.
- 2.2 *Drying oven*, maintained at 230°F ± 9°F.
- 2.3 *Pan*.
- 2.4 *Quartering canvas blanket*.
- 2.5 *Small spatula*, having a blade with a minimum length of 4 in. and minimum width of 3/4 in.
- 2.6 *Sample splitter*, equipped with an even number of equal width chutes, but not less than eight for coarse aggregate or 12 for fine aggregate. Must be equipped with a minimum of two receptacles (sides) to hold two halves of the sample after splitting. The minimum width of the chutes for coarse aggregate is approximately 50% larger than the largest particle. The width of the chutes for fine aggregate is 1/2 to 3/4 in.
- 2.7 *Standard U.S. sieves*, No. 4, 16, 20, and 200.

3. SAMPLE PREPARATION

- 3.1 Sample coarse and fine aggregate stockpiles in accordance with Tex-400-A.
- 3.2 Dry the aggregate to at least the saturated surface-dry condition using an oven at a maximum temperature of 230°F ± 9°F or at room temperature.
- 3.3 Split the sample in accordance with Section 3.4 or quarter the sample in accordance with Section 3.5.
- 3.4 Split the sample using a sample splitter from Section 2.6.

- 3.4.1 Place the sample in the sample splitter and uniformly distribute it from edge to edge. Equal amounts must flow through each chute.
- 3.4.2 Reintroduce the sample from one of the receptacles (side) into the splitter as many times as necessary, alternating each side.
- 3.4.3 Reduce the sample to the minimum weight required from Table 1. The minimum weight is after drying.
- 3.4.4 Proceed to Section 4.
- 3.5 Quarter the sample on a hard, clean, level surface. When the surface is uneven, place the sample on a canvas blanket.
- 3.5.1 Use a shovel and mix the sample thoroughly by turning the entire sample at least three times. When using a canvas blanket, lift each corner pulling it over the sample toward the diagonally opposite corner causing the sample to be rolled.
- 3.5.2 Flatten the sample to a uniform thickness and diameter. The diameter must be approximately four to eight times the thickness.
- 3.5.3 Divide the flattened mass into approximately four equal quarters with a shovel or trowel.
- 3.5.4 Remove two diagonally opposite quarters, including all fine material and brush the cleared spaces clean.
- 3.5.5 Repeat mixing and quartering until the sample is reduced to the minimum weight required from Table 1. The minimum weight is after drying.

Table 1. Minimum Test Sample Weight

Max Aggregate Size ¹	Min Dry Weight, g
Greater than 1-1/2 in.	5,000
3/4 to 1-1/2 in.	3,000
3/8 to 3/4 in.	2,000
No. 4 to 3/8 in.	1,000
Smaller than No. 4	300

1. Largest sieve size to retain any aggregate.

4. PROCEDURE

- 4.1 Determine the percent of deleterious material of coarse aggregate in accordance with Section 4.2 and fine aggregate in accordance with Section 4.3.
- 4.2 *Coarse Aggregate*
 - 4.2.1 Sieve the split or quartered sample over a No. 4 sieve.
 - 4.2.2 Dry the aggregate particles retained in an oven to constant weight at a temperature of 230°F ± 9°F.

- 4.2.3 Weigh and record to the nearest 0.1 g. This weight must meet the minimum weight from Table 1.
- 4.2.4 Spread the particles out on a clean and level workspace large enough to inspect all the aggregate particles.
- 4.2.5 Use the edge of a spatula to separate particles of deleterious materials from the remainder of the sample. Slide and separate them into three individual piles for clay lumps, shale, and laminated and friable particles.
- 4.2.6 Break friable particles by squeezing and rolling them between the thumb and forefinger. Do not use fingernails or press them against a hard surface.
- 4.2.7 Weigh the individual piles of deleterious material and record to the nearest 0.1 g.
- 4.3 *Fine Aggregate*
- 4.3.1 Place the sample in a pan and add enough water to cover the sample.
- 4.3.2 Agitate the sample and water to separate all the particles finer than the No. 200 sieve.
- 4.3.3 Pour the wash water over a No. 200 sieve. Larger sieves may be nested atop to avoid pouring the larger aggregates onto the No. 200 sieve.
- 4.3.4 Pour enough water to cover the sample and repeat Sections 4.3.1 – 4.3.3 until the wash water is clear.
- 4.3.5 Return all material retained on the No. 200 sieve to the pan.
- 4.3.6 Dry the sample in an oven to constant weight at a temperature of $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$.
- 4.3.7 Sieve the sample over a No. 4 and No. 16 sieve. Save the material retained on the No. 16 sieve and discard the material retained on the No. 4 and passing the No. 16 sieves.
- 4.3.8 Split the material retained on the No. 16 sieve to a minimum weight of 25 g in accordance with Section 3.
- 4.3.9 Weigh and record to the nearest 0.1 g.
- 4.3.10 Place the test sample in a pan and add enough water to cover the sample and let it soak for 24 ± 4 hr.
- 4.3.11 Roll and squeeze the fine aggregate particles individually between the thumb and forefinger. Do not use fingernails or press them against a hard surface.
- 4.3.12 Place the tested particles on a No. 20 sieve.
- 4.3.13 Separate the particles from the fines broken down with the fingers by wet sieving over the No. 20 sieve.
- 4.3.14 Return all the particles retained on the No. 20 sieve to a pan and oven dry to constant weight at a temperature of $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$. Constant weight is defined as the particles that are oven-dried such that they will not lose more than 0.1% moisture after 2 hr. of drying.
- 4.3.15 Allow the particles to cool to room temperature; and weigh and record to the nearest 0.1 g.

5. CALCULATIONS

- 5.1 Calculate the percent of clay lumps from coarse aggregate using the following equation:

$$\% \text{ Clay Lumps} = 100 \times \left[\frac{W_{\text{Clay Lumps}}}{W_T} \right]$$

Where:

$W_{\text{Clay Lumps}}$ = weight of clay lumps (Section 4.2.7);

W_T = weight of test sample (Section 4.2.3).

- 5.2 Calculate the percent of shale from coarse aggregate using the following equation:

$$\% \text{ Shale} = 100 \times \left[\frac{W_{\text{Shale}}}{W_T} \right]$$

Where:

W_{Shale} = weight of shale (Section 4.2.7);

W_T = weight of test sample (Section 4.2.3).

- 5.3 Calculate the percent of laminate and friable particles from coarse aggregate using the following equation:

$$\% \text{ Laminate and Friable Particles} = 100 \times \left[\frac{W_{\text{Friable}}}{W_T} \right]$$

Where:

W_{Friable} = weight of laminate and friable particles (Section 4.2.7);

W_T = weight of test sample (Section 4.2.3).

- 5.4 Calculate the percent of clay lumps from fine aggregate using the following equation:

$$\% \text{ Clay Lumps} = 100 \times \left[\frac{W_T - W_{\text{No.20}}}{W_T} \right]$$

Where:

W_T = weight of test sample (Section 4.3.9);

$W_{\text{No.20}}$ = weight of particles retained on the No. 20 sieve (Section 4.3.15).

6. REPORTING

- 6.1 Report the percentage of deleterious material to the nearest 0.1%.

Test Procedure for**DETERMINING CRUSHED FACE PARTICLE COUNT****TxDOT Designation: Tex-460-A****Effective Date: August 1999**

1. SCOPE

- 1.1 Use this method to determine the percent of coarse aggregate particles meeting the crushed face requirement and the percent of non-polishing aggregate.
- 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.

PART I—DETERMINING CRUSHED FACE COUNT

2. SCOPE

- 2.1 This part describes the steps necessary to determine the crushed face count of aggregate.

3. DEFINITIONS

- 3.1 *Crushed Face*—a fractured surface produced by the mechanical crushing of an aggregate. Identify crushed aggregate faces by fresh fractures and lack of evidence of weathering.
- 3.2 *Particle Projected Area*—the maximum cross sectional area of the fractured particle.

4. APPARATUS

- 4.1 *Drying oven*, maintained at $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$).
- 4.2 *Standard U.S. sieve*, meeting the requirements of Tex-907-K, 4.75 mm (No. 4).

5. PROCEDURE

- 5.1 Secure a representative aggregate sample. (In the event that foreign matter hinders determination of crushed face, wash the sample.)
- 5.2 Aggregate samples should have a surface dry condition.

- 5.3 Quarter the sample in accordance with Tex-400-A so that the material retained on the 4.75 mm (No. 4) sieve contains approximately 400 particles. Take larger test samples to improve test accuracy.
- 5.4 Sieve the sample over the 4.75 mm (No. 4) sieve and discard the passing material. Spread the retained material on a smooth surface. (A contrasting surface color is preferable.)
- 5.5 Closely examine the surface of each aggregate particle in the sample. To verify that a particle meets the crushed face criteria, hold the aggregate particle to view the face directly. If the face constitutes at least one quarter of the particle projected area of the rock particle, consider it a crushed face.
- 5.5.1 Place particles with two or more crushed faces in one pile.
- 5.5.2 Place particles with fewer than two crushed faces in a second pile.
- 5.5.3 Place particles that are questionable in a third pile.
- 5.6 After completely separating the test sample, count the number of particles in each pile.
- 5.6.1 Record the number of particles in the pile with two or more crushed faces as N_F under Section 6.
- 5.6.2 Record the number of particles with one or no crushed faces as N_U under Section 6.
- 5.6.3 Record the number of particles in the questionable pile as N_Q under Section 6.
- Note 1**—If for any one determination, the number of questionable particles exceeds 15%, repeat the determination until less than 15% is present in that category.
-

6. CALCULATIONS

- 6.1 Calculate the Percent Crushed Particles:

$$100 \{ [N_F + (N_Q / 2)] / [(N_F + N_U + N_Q)] \}$$

Where:

N_F = particles in pile with two or more crushed faces

N_U = particles with fewer than two crushed faces

N_Q = particles in the questionable pile.

7. REPORT

- 7.1 Report results to the nearest whole percent.
-

PART II—DETERMINING PERCENT BY VOLUME OF NON-POLISHING AGGREGATE

8. SCOPE

- 8.1 Part II of this procedure is a method for checking the percent of non-polishing aggregate added to an aggregate blend to improve the polish value. Method B is for use with samples that have a significant specific gravity difference (i.e., synthetic aggregates, fired clay, and slag).

9. PROCEDURES

9.1 *Method A (Numeric):*

- 9.1.1 Repeat Part I, Sections 5.1–5.4.

Note 2—Substitute the 2.00 mm (No. 10) sieve for the 4.75 mm (No. 4) sieve when the specification requires testing of the 2.00 mm (No. 10) size fraction.

- 9.1.2 Separate the sample into two piles according to visual differences such as color and shape.

- 9.1.3 After completely separating the test sample:

- 9.1.3.1 Count the number of particles in the non-polishing pile and record as N_N under Section 10.

- 9.1.3.2 Count the number of total particles and record as N_T under Section 10.

9.2 *Method B (Volumetric):*

- 9.2.1 Repeat Part I, Sections 5.1–5.4.

Note 3—Substitute the 2.00 mm (No. 10) sieve for the 4.75 mm (No. 4) sieve when the specification requires testing of the 2.00 mm (No. 10) size fraction.

- 9.2.2 Separate the sample into two piles according to visual differences such as color and shape.

- 9.2.3 After completely separating the test sample:

- 9.2.3.1 Weigh the particles in the non-polishing pile and record the mass as M_N under Section 10.

- 9.2.3.2 Weigh the retained material and record the mass as M_R under Section 10.

10. CALCULATIONS

- 10.1 Calculate percent of non-polishing aggregate:

$$\text{Percent} = 100 \bullet N_N / N_T$$

Where:

N_N = number of particles in the non-polishing pile

N_T = total number of particles.

- 10.2 Calculate volume of retained material, (V_R), m^3 (ft^3):

$$V_R = M_R / (G_B \bullet W_W)$$

- 10.3 Calculate volume of non-polishing aggregate, (V_N), m^3 (ft^3):

$$V_N = M_N / (G_N \bullet W_W)$$

Where:

G_B = bulk specific gravity of the aggregate blend as tested in Tex-403-A in the proper proportions tested here

G_N = bulk specific gravity of the non-polishing aggregate as tested in Tex-403-A in the proper proportions tested here

M_R = mass of retained material, kg

M_N = mass of non-polishing aggregate, kg

W_W = unit mass of water, 1000 kg/m^3 (62.4 lb./ft.^3)

- 10.4 Calculate percent of non-polishing aggregate:

$$\text{Percent} = 100 \bullet V_N / V_R$$

Where:

V_R = volume of retained material

V_N = volume of non-polishing aggregate.

11. REPORT

- 11.1 Report results to the nearest whole percent.

Test Procedure for

MICRO-DEVAL ABRASION OF AGGREGATE



TxDOT Designation: Tex-461-A

Effective Date: November 2016

1. SCOPE

- 1.1 Use this test procedure to determine the Micro-Deval abrasion loss of coarse, intermediate, and fine aggregates. This loss is an indication of an aggregate's resistance to abrasion, weathering, and degradation using the Micro-Deval testing equipment with abrasive stainless steel balls and water.
- 1.2 Determining the Micro-Deval abrasion loss is useful for:
- detecting changes in the properties of aggregate produced from an aggregate source as part of a quality control process,
 - estimating the magnesium sulfate soundness loss of coarse aggregate sources used for hot-mix asphalt (HMA),
 - determining when blending is allowed for fine aggregate sources not meeting the acid insoluble requirements for hydraulic cement concrete, and
 - polishing coarse and fine aggregates for measuring texture and frictional loss properties.
-

2. DEFINITION

- 2.1 *Constant Weight*—Aggregates are oven-dried such that they will not lose more than 0.1% moisture after 2 hr. of drying. Limestone Rock Asphalt (LRA) is oven-dried at a temperature of $140 \pm 5^{\circ}\text{F}$. All other aggregates are oven-dried at a temperature of $230 \pm 9^{\circ}\text{F}$. Verify constant weight by measuring the moisture content from weighing a sample before and after consecutive 2-hour drying periods.
-

3. APPARATUS

- 3.1 *Micro-Deval apparatus*, an enclosed, multi-tiered unit equipped with an electronic controller and an optical sensing system to accurately track the test time and total revolutions, in accordance with AASHTO T 327.
- 3.2 *Micro-Deval container*, jar with a locking cover.
- 3.3 *Micro-Deval abrasive charge*, magnetic stainless steel balls, 9.5 mm diameter.
- 3.4 *Micro-Deval magnet*.
-

- 3.5 Standard U.S. sieves, meeting the requirements of Tex-907-K.
- 3.6 Oven, capable of maintaining a temperature of either or both $140 \pm 5^\circ\text{F}$ and $230 \pm 9^\circ\text{F}$.
- 3.7 Balance, Class G2 in accordance with Tex-901-K.

4. PREPARING TEST SAMPLE

- 4.1 Obtain a representative sample in accordance with Tex-400-A.
- 4.2 Refer to Table 1 and select a gradation for the test sample.

Note 1—Use Gradations A and B for coarse aggregate stockpiles and Gradation C for coarse and intermediate aggregate stockpiles that best match the material sampled. Refer to the applicable specification for criteria defining aggregate stockpiles as coarse, intermediate, and fine.

Table 1—Sieve Sizes and Aggregate Weights for Preparing Test Samples

Sieve Size	Gradation A	Gradation B	Gradation C	Fine Aggregate
	Individual Retained Sieve Weights, g			
3/4–1/2"	660 ± 5	—	—	—
1/2–3/8"	330 ± 5	750 ± 5	—	—
3/8–1/4"	330 ± 5	375 ± 5	750 ± 5	—
1/4"–#4	180 ± 5	375 ± 5	750 ± 5	—
#4–#8	—	—	—	50 ± 1
#8–#16	—	—	—	125 ± 1
#16–#30	—	—	—	125 ± 1
#30–#50	—	—	—	100 ± 1
#50–#100	—	—	—	75 ± 1
#100–#200	—	—	—	25 ± 1
Total Weight, g	$1,500 \pm 5$	$1,500 \pm 5$	$1,500 \pm 5$	500 ± 5
Timer, minutes ¹	120 ± 1	105 ± 1	95 ± 1	15 ± 5

1. Test all samples at 100 ± 5 revolutions per minute throughout the duration of the test.

- 4.3 *Coarse and Intermediate Aggregate:*
- 4.3.1 Sieve the material into individual size fractions in accordance with Tex-401-A using the applicable sieves listed in Table 1 for the selected gradation.
- 4.3.2 Thoroughly wash each size fraction individually using a No. 12 sieve until the wash water is clear.

- 4.3.3 Dry the material in an oven to constant weight, as defined in Section 2.1.
 - 4.3.4 Proceed to Section 4.5.
 - 4.4 *Fine Aggregate:*
 - 4.4.1 Thoroughly wash a sufficient amount of material to prepare a test sample using a No. 200 sieve until the wash water is clear.
 - 4.4.2 Dry the material in an oven to constant weight, as defined in Section 2.1.
 - 4.4.3 Sieve the material into individual size fractions in accordance with Tex-401-A using the applicable sieves listed in Table 1.
 - 4.5 Prepare the test sample using the weights listed in Table 1.
 - 4.6 Substitute a maximum of 10% from an adjacent sieve listed in Table 1 when there is not enough aggregate for any given sieve to prepare the test sample. Crush parent or coarser aggregate to obtain additional material when necessary.
 - 4.7 Record the weight of the test sample, to the nearest 0.1 g, as *A* under Section 7.2.
-

5. PROCEDURE FOR COARSE AND INTERMEDIATE AGGREGATES

- 5.1 Obtain a clean Micro-Deval container.
 - 5.2 Place 5000 ± 5 g of magnetic stainless steel balls into the Micro-Deval container.
 - 5.3 Add the test sample prepared in Section 4 to the Micro-Deval container with the steel balls.
Note 2—Placing the aggregate test sample into the container after the steel balls will reduce potential abrasion and wear of the aggregate prior to testing.
 - 5.4 Add 2000 ± 500 mL of tap water at a temperature of $68 \pm 9^{\circ}\text{F}$ to the Micro-Deval container with the steel balls and test sample, and let stand for a minimum of 1 hr.
 - 5.5 Set the timer on the Micro-Deval machine to the number of minutes listed in Table 1 for the gradation selected, record this time as *T* under Section 7.1, and start the machine.
 - 5.6 After the test is completed, record the number of revolutions registered by the tachometer as *N* under Section 7.1.
 - 5.7 Calculate the RPM throughout the duration of the test in accordance with Section 7.1.
 - 5.8 Stack a No. 4 sieve on top of a No. 16 sieve, and pour the test sample and steel balls from the Micro-Deval container into the No. 4 sieve.
Note 3—Pour the test sample and steel balls carefully to prevent any loss of material.
-

- 5.9 Wash the inside of the Micro-Deval container until it does not contain any material or residue from the test. Pour the wash water into the No. 4 sieve.
Note 4—Wash the inside of the container carefully to prevent any loss of material.
- 5.10 Wash the aggregate and the steel balls retained on the No. 4 sieve with water until the wash water is clear and all materials smaller than No. 16 pass the sieve.
- 5.11 Remove the stainless steel balls using a magnet.
Note 5—Use the magnet carefully to prevent any loss of material.
- 5.12 Combine the aggregate retained on the No. 4 and No. 16 sieves. Discard the material passing the No. 16 sieve.
- 5.13 Oven-dry the combined aggregate to constant weight, as defined in Section 2.1.
- 5.14 Allow the sample to cool to room temperature.
- 5.15 Weigh the sample to the nearest 0.1 g and record as *B* under Section 7.2.
-

6. PROCEDURE FOR FINE AGGREGATES

- 6.1 Obtain a clean Micro-Deval container.
- 6.2 Place 1250 ± 5 g of magnetic stainless steel balls into the Micro-Deval container.
- 6.3 Add the test sample prepared in Section 4 to the Micro-Deval container with the steel balls.
Note 6—Placing the aggregate test sample into the container after the steel balls will reduce potential abrasion and wear of the aggregate prior to testing.
- 6.4 Add 750 ± 50 mL of tap water at a temperature of $68 \pm 9^\circ\text{F}$ to the Micro-Deval container with the steel balls and test sample and let stand for a minimum of 1 hr.
- 6.5 Set the timer on the Micro-Deval machine to 15 minutes, record this time as *T* under Section 7.1, and start the machine.
- 6.6 After the test is completed, record the number of revolutions registered by the tachometer as *N* under Section 7.1.
- 6.7 Calculate the RPM throughout the duration of the test in accordance with Section 7.1.
- 6.8 Stack a No. 4 sieve on top of a No. 200 sieve, and pour the test sample and steel balls from the Micro-Deval container into the No. 4 sieve.
Note 7—Pour the test sample and steel balls carefully to prevent any loss of material.
- 6.9 Wash the inside of the Micro-Deval container until it does not contain any material or residue from the test. Pour the wash water into the No. 4 sieve.
Note 8—Wash the inside of the container carefully to prevent any loss of material.
-

- 6.10 Wash the aggregate and the steel balls retained on the No. 4 sieve with water until the wash water is clear and all materials smaller than No. 200 pass the sieve.
- 6.11 Remove the stainless steel balls using a magnet.
Note 9—Use the magnet carefully to prevent any loss of material.
- 6.12 Combine the aggregate retained on the No. 4 and 200 sieves. Discard the material passing the No. 200 sieve.
- 6.13 Oven-dry the combined aggregate to constant weight, as defined in Section 2.1.
- 6.14 Allow the sample to cool to room temperature.
- 6.15 Weigh the sample to the nearest 0.1 g and record as *B* under Section 7.2.
-

7. CALCULATIONS

- 7.1 Calculate the RPM throughout the duration of the test:

$$RPM = \frac{N}{T}$$

Where:

N = number of revolutions registered by the tachometer of the Micro-Deval machine; and

T = time set on the timer of the Micro-Deval machine, minutes.

- 7.2 Calculate the Micro-Deval abrasion loss:

$$\text{Percent Loss} = \frac{(A - B)}{A} \times 100$$

Where:

A = initial dry weight of the test sample before testing, g

B = final dry weight of the test sample after testing, g.

- 7.3 Round and report the RPM and percent loss to the nearest whole percent.
-

8. ARCHIVED VERSIONS

- 8.1 Archived versions are available.

Item 302

Aggregates for Surface Treatments



1. DESCRIPTION

Furnish aggregate for surface treatments in conformance to the type, grade, and Surface Aggregate Classification (SAC) shown on the plans.

2. MATERIALS

Furnish uncontaminated materials of uniform quality throughout that meet the requirements of the plans and specifications. Notify the Engineer of all proposed material sources and of changes to material sources. The Engineer will designate the sampling location.

- 2.1. **Aggregate.** Stockpile aggregates for each source and type separately. Do not add materials to approved stockpiles without the approval of the Engineer.

Furnish aggregate of the type shown on the plans and listed in Table 1. Use Tex-100-E material definitions.

Table 1
Aggregate Types

Type	Material
A	Gravel, crushed slag, crushed stone, or limestone rock asphalt (LRA)
B	Crushed gravel, crushed slag, crushed stone, or LRA
C	Gravel, crushed slag, or crushed stone
D	Crushed gravel, crushed slag, or crushed stone
E	Aggregate as shown on the plans
L	Lightweight Aggregate
PA	Precoated gravel, crushed slag, crushed stone, or LRA
PB	Precoated crushed gravel, crushed slag, crushed stone, or LRA
PC	Precoated gravel, crushed slag, or crushed stone
PD	Precoated crushed gravel, crushed slag, crushed stone
PE	Precoated aggregate as shown on the plans
PL	Precoated lightweight aggregate

Ensure the aggregate gradation meets the requirements in Table 2 for the specified grade, unless otherwise approved.

Furnish aggregate that meets the requirements shown in Table 3, unless otherwise shown on the plans. Furnish LRA in accordance with DMS-9210, "Limestone Rock Asphalt (LRA)," when used. Provide aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC). Use material not listed or not meeting the requirements of the BRSQC only when tested by the Engineer and approved before use. Allow 30 calendar days for testing of material from such sources.

Provide aggregates for final surfaces that meet the SAC shown on the plans. Do not blend to meet the SAC. The SAC requirement will apply only to the aggregate used on the travel lanes unless otherwise shown on the plans. The BRSQC lists the SAC for sources on the *Aggregate Quality Monitoring Program* (AQMP).

Table 2
Aggregate Gradation Requirements (Cumulative % Retained¹)

Sieve	Grade								
	1	2	3S ²	3		4S ²	4	5S ²	5
				Non-Lightweight	Lightweight				
1"	-	-	-	-	-	-	-	-	-
7/8"	0-2	0	-	-	-	-	-	-	-
3/4"	20-35	0-2	0	0	0	-	-	-	-
5/8"	85-100	20-40	0-5	0-5	0-2	0	0	-	-
1/2"	-	80-100	55-85	20-40	10-25	0-5	0-5	0	0
3/8"	95-100	95-100	95-100	80-100	60-80	60-85	20-40	0-5	0-5
1/4"	-	-	-	95-100	95-100	-	-	65-85	-
#4	-	-	-	-	-	95-100	95-100	95-100	50-80
#8	99-100	99-100	99-100	99-100	98-100	98-100	98-100	98-100	98-100

1. Round test results to the nearest whole number.
2. Single-size gradation.

Table 3
Aggregate Requirements

Property	Test Method	Requirement	Remarks
Sampling	<u>Tex-221-F</u>	-	
SAC	<u>AQMP</u>	As shown on the plans	
Deleterious Material, %, Max	<u>Tex-217-F, Part I</u>	2.0	Not required for lightweight aggregate.
Decantation, %, Max	<u>Tex-406-A</u>	1.5	
Flakiness Index, Max	<u>Tex-224-F</u>	17	Unless otherwise shown on the plans.
Gradation	<u>Tex-200-F, Part I</u>	See Table 2	
Los Angeles Abrasion, %, Max	<u>Tex-410-A</u>	35	
Magnesium Sulfate Soundness, 5 Cycle, %, Max	<u>Tex-411-A</u>	25	
Micro-Deval Abrasion, %, Max	<u>Tex-461-A</u>	-	Not used for acceptance purposes. Used by the Engineer as an indicator for further investigation.
Coarse Aggregate Angularity, 2 Crushed Faces, %, Min	<u>Tex-460-A, Part I</u>	85	Unless otherwise shown on the plans. Only required for crushed gravel
Additional Requirements for Lightweight Aggregate			
Dry Loose Unit Wt., lb./cu. ft.	<u>Tex-404-A</u>	35-60	
Pressure Slaking, %, Max	<u>Tex-431-A</u>	6.0	
Freeze-Thaw Loss, %, Max	<u>Tex-432-A</u>	10.0	
Water Absorption, 24 hr., %, Max	<u>Tex-433-A</u>	12.0	Unless otherwise shown on the plans.

2.2.

Precoating. Precoat aggregate uniformly and adequately with asphalt material to the satisfaction of the Engineer when shown on the plans. Specific aggregates may be prohibited from being precoated when shown on the plans. Meet Table 2 and Table 3 requirements before precoating. Furnish precoated aggregate that spreads uniformly using approved mechanical spreading equipment.

The Engineer retains the right to select a target value for the desired percent by weight of residual bitumen coating on the aggregate. Furnish precoated aggregate that is within $\pm 0.3\%$ of the target value when tested in accordance with Tex-236-F. The Engineer may require trial batches to assist in selecting the target value.

The Engineer retains the right to remove precoat material from aggregate samples in accordance with Tex-236-F and test the aggregate to verify compliance with Table 2 and Table 3 requirements. Gradation testing may be performed with precoat intact.

- 2.2.1. **Asphalt Material.** Precoat the aggregates with asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions." Use any asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," unless a specific precoat material is specified on the plans.
- 2.2.2. **Additives.** Use the type and rate of additive specified when shown on the plans. Add in accordance with Item 301, "Asphalt Antistripping Agents." Use Tex-530-C for verification during production testing unless otherwise directed.

3. **EQUIPMENT**

Manufacture precoat aggregate in a mixing plant that produces uniformly coated aggregate.

4. **CONSTRUCTION**

Deliver aggregate to the locations shown on the plans. Prevent segregation, mixing of the various materials or sizes, and contamination with foreign materials when aggregates are stockpiled. The Engineer will reject contaminated stockpiles.

Provide adequate initial cooling of precoat aggregate to prevent asphalt or aggregate damage due to excessive heat buildup in stockpiles. Limit stockpile height to 3 ft. immediately after production when asphalt cement is the precoat material. Consolidate stockpiles after adequate cooling, as approved. The Engineer will reject stockpiles showing evidence of damage due to excessive heat buildup.

5. **MEASUREMENT AND PAYMENT**

The work performed, materials furnished, equipment, tools, and incidentals will not be measured or paid for directly but is subsidiary to or included under "Payment" in other pertinent Items.

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	<u>Tex-499-A</u> (AQMP)	As shown on the plans
Deleterious material, %, Max	<u>Tex-217-F</u> , Part I	1.0
Decantation, %, Max	<u>Tex-217-F</u> , Part II	1.5
Micro-Deval abrasion, %	<u>Tex-461-A</u>	Note 1
Los Angeles abrasion, %, Max	<u>Tex-410-A</u>	35 ²
Magnesium sulfate soundness, 5 cycles, %, Max	<u>Tex-411-A</u>	25 ³
Crushed face count, ⁴ %, Min	<u>Tex-460-A</u> , Part I	85
Flat and elongated particles @ 5:1, %, Max	<u>Tex-280-F</u>	10
Fine Aggregate		
Linear shrinkage, %, Max	<u>Tex-107-E</u>	3
Sand equivalent, %, Min	<u>Tex-203-F</u>	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 RAP¹

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	<u>Tex-221-F</u>	✓	✓	1A/AGG101
Dry sieve	<u>Tex-200-F, Part I</u>	✓	✓	1A/AGG101
Washed sieve	<u>Tex-200-F, Part II</u>	✓	✓	1A/AGG101
Deleterious material	<u>Tex-217-F, Parts I & III</u>	✓	✓	AGG101
Decantation	<u>Tex-217-F, Part II</u>	✓	✓	AGG101
Los Angeles abrasion	<u>Tex-410-A</u>		✓	TxDOT
Magnesium sulfate soundness	<u>Tex-411-A</u>		✓	TxDOT
Micro-Deval abrasion	<u>Tex-461-A</u>		✓	AGG101
Crushed face count	<u>Tex-460-A</u>	✓	✓	AGG101
Flat and elongated particles	<u>Tex-280-F</u>	✓	✓	AGG101
Linear shrinkage	<u>Tex-107-E</u>	✓	✓	AGG101
Sand equivalent	<u>Tex-203-F</u>	✓	✓	AGG101
Bulk specific gravity	<u>Tex-201-F</u>	✓	✓	AGG101
Unit weight	<u>Tex-404-A</u>	✓	✓	AGG101
Organic impurities	<u>Tex-408-A</u>	✓	✓	AGG101
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	<u>Tex-500-C, Part II</u>	✓	✓	1A/1B
Tack coat sampling	<u>Tex-500-C, Part III</u>	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	<u>Tex-204-F</u>	✓	✓	2
Mixing	<u>Tex-205-F</u>	✓	✓	2
Molding (SGC)	<u>Tex-241-F</u>	✓	✓	1A
Laboratory-molded density	<u>Tex-207-F, Parts I & VI</u>	✓	✓	1A
Rice gravity	<u>Tex-227-F, Part II</u>	✓	✓	1A
Ignition oven correction factors ²	<u>Tex-236-F, Part II</u>	✓	✓	2
Indirect tensile strength	<u>Tex-226-F</u>	✓	✓	1A
Hamburg Wheel test	<u>Tex-242-F</u>	✓	✓	1A
Boil test	<u>Tex-530-C</u>	✓	✓	1A
4. Production Testing				
Selecting production random numbers	<u>Tex-225-F, Part I</u>		✓	1A
Mixture sampling	<u>Tex-222-F</u>	✓	✓	1A/1B
Molding (SGC)	<u>Tex-241-F</u>	✓	✓	1A
Laboratory-molded density	<u>Tex-207-F, Parts I & VI</u>	✓	✓	1A
Rice gravity	<u>Tex-227-F, Part II</u>	✓	✓	1A
Gradation & asphalt binder content ²	<u>Tex-236-F, Part I</u>	✓	✓	1A
Control charts	<u>Tex-233-F</u>	✓	✓	1A
Moisture content	<u>Tex-212-F, Part II</u>	✓	✓	1A/AGG101
Hamburg Wheel test	<u>Tex-242-F</u>	✓	✓	1A
Micro-Deval abrasion	<u>Tex-461-A</u>		✓	AGG101
Boil test	<u>Tex-530-C</u>	✓	✓	1A
Abson recovery	<u>Tex-211-F</u>		✓	TxDOT
5. Placement Testing				
Selecting placement random numbers	<u>Tex-225-F, Part II</u>		✓	1B
Trimming roadway cores	<u>Tex-251-F, Parts I & II</u>	✓	✓	1A/1B
In-place air voids	<u>Tex-207-F, Parts I & VI</u>	✓	✓	1A
In-place density (nuclear method)	<u>Tex-207-F, Part III</u>	✓		1B
Establish rolling pattern	<u>Tex-207-F, Part IV</u>	✓		1B
Control charts	<u>Tex-233-F</u>	✓	✓	1A
Ride quality measurement	<u>Tex-1001-S</u>	✓	✓	Note 3
Segregation (density profile)	<u>Tex-207-F, Part V</u>	✓	✓	1B
Longitudinal joint density	<u>Tex-207-F, Part VII</u>	✓	✓	1B
Thermal profile	<u>Tex-244-F</u>	✓	✓	1B
Shear Bond Strength Test	<u>Tex-249-F</u>		✓	TxDOT

- Level 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
- Refer to Section 3077.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
- 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

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 subplot
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 subplot
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 subplot.
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 subplot 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 antistripping, 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 (N_{design}). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the N_{design} value as noted in Table 10. The N_{design} 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 N_{design} 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 Gyrotory 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 subplot 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	$\pm 5.0^{2,3}$	± 5.0
Individual % retained for sieves smaller than #8 and larger than #200			$\pm 3.0^{2,3}$	± 3.0
% passing the #200 sieve			$\pm 2.0^{2,3}$	± 1.6
Asphalt binder content, %	Tex-236-F	± 0.5	$\pm 0.3^3$	± 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

- Contractor may request referee testing only when values exceed these tolerances.
- 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.
- Only applies to mixture produced for Lot 1 and higher.
- Defined as % passing #200 sieve divided by asphalt binder content.
- Verify that Table 10 requirement is met.
- 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any subplot 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot 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	<u>Tex-200-F</u> or <u>Tex-236-F</u>	1 per subplot	1 per 12 sublots ¹
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	<u>Tex-207-F</u>	N/A	1 per subplot ¹
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	<u>Tex-204-F</u>		
Segregation (density profile)	<u>Tex-207-F</u> , Part V	1 per subplot ²	1 per project
Longitudinal joint density	<u>Tex-207-F</u> , Part VII		
Moisture content	<u>Tex-212-F</u> , Part II	When directed	
Theoretical maximum specific (Rice) gravity	<u>Tex-227-F</u>	N/A	1 per subplot ¹
Asphalt binder content	<u>Tex-236-F</u>	1 per subplot	1 per lot ¹
Hamburg Wheel test	<u>Tex-242-F</u>	N/A	1 per project
Recycled Asphalt Shingles (RAS) ³	<u>Tex-217-F</u> , Part III	N/A	
Thermal profile	<u>Tex-244-F</u>	1 per subplot ²	
Asphalt binder sampling and testing	<u>Tex-500-C</u> , Part II	1 per lot (sample only) ⁴	
Tack coat sampling and testing	<u>Tex-500-C</u> , Part III	N/A	
Boil test ⁵	<u>Tex-530-C</u>	1 per lot	
Shear Bond Strength Test ⁶	<u>Tex-249-F</u>	1 per project (sample only)	

- 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.
- To be performed in the presence of the Engineer, unless otherwise approved. Not required when a thermal imaging system is used.
- Testing performed by the Materials and Tests Division or designated laboratory.
- Obtain samples witnessed by the Engineer. The Engineer will retain these samples for one year.
- The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
- 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 subplot 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 subplot 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 subplot 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 subplot.

- 4.9.2.4.3. **Voids in Mineral Aggregates (VMA).** The Engineer will determine the VMA for every subplot. 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 subplot 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 subplot 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 subplot 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 subplot 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 subplot consists of the area placed during a production subplot.

- 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 subplot 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 subplot 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 subplot.

- 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 Article 3077.6, "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 subplot is completed. Mark the roadway location at the completion of each subplot and record the station number. Determine one random sample location for each placement subplot 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 subplot and a 1.000 pay factor will be assigned to that subplot.

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 subplot 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 subplot. 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 subplot 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 subplot 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 subplot 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 subplot. 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 Grade¹	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 subplot 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 subplot 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 subplot 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 subplot unless otherwise directed.

4.9.3.3.3.2. **Record Tests.** Perform a joint density evaluation for each subplot 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 subplot 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 $\pm 1.0\%$ 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 Density¹

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 subplot 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 subplot.

- 6.1.2. **Production Sublots Subject to Removal and Replacement.** If after referee testing, the laboratory-molded density for any subplot results in a "remove and replace" condition as listed in Table 20, the Engineer may require removal and replacement or may allow the subplot to be left in place without payment. The Engineer may also accept the subplot 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 subplot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the subplot will be averaged to determine the placement payment adjustment factor in accordance with Table 21 for each subplot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire subplot 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 subplot will be determined by applying the placement random number to the length of the subplot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that subplot 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 subplot 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 subplot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the subplot will be averaged to determine the new payment adjustment factor of the subplot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that subplot. If the new payment adjustment factor is less than 0.700, no payment will be made for the subplot. Remove and replace the failing subplot, or the Engineer may allow the subplot to be left in place without payment. The Engineer may also accept the subplot 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