1993 Specifications

SPECIAL SPECIFICATION

3364

Thin Bonded Permeable Friction Course (TBPFC)

1. **Description.** Construct a surface course composed of a warm spray-applied polymer modified emulsion membrane followed immediately with a permeable mixture of aggregate, asphalt binder, and additives mixed hot in a mixing plant.

2. **Materials.** Furnish materials of uniform quality throughout that meet the requirements of the plans and specifications. The Engineer will sample and test materials in accordance with this Item. When directed or when specified in this Item, sample or test materials proposed for use. Do not use contaminated materials. Notify the Engineer of all materials sources. Notify the Engineer before changing any material source or formulation. When making a source or formulation change, the Engineer will verify that the specification requirements are met and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time throughout the duration of the project to verify specification compliance.

A. **Aggregate.** Furnish aggregates from sources that conform to the requirements shown in Table 1, and as specified in this Section, unless otherwise shown on the plans. Provide aggregate stockpiles that meet the definition in this Section for coarse aggregate. Do not use fine aggregate or recycled asphalt pavement (RAP) in permeable friction course (PFC) mixtures. Supply mechanically crushed gravel or stone aggregates that meet the definitions in Tex-100-E. The Engineer will designate the plant or the quarry as the sampling location. Samples must be 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 and perform Tex-107-E on mineral fillers if used. 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 Tex-200-F, Part II “Washed Sieve Analysis.” Do not add material to an approved stockpile from sources that do not meet the aggregate quality requirements of the Department’s Bituminous Rated Source Quality Catalog (BRSQC) unless otherwise approved.

1. **Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Provide aggregates from sources
listed in the BRSQC. Provide 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 a minimum SAC as shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes, unless otherwise shown on the plans. The SAC for sources on the Department’s Aggregate Quality Monitoring Program (AQMP) are listed in the BRSQC.

Unless otherwise shown on the plans, Class B aggregate, meeting all other requirements in Table 1, may be blended with a Class A aggregate in order to meet requirements for Class A materials. When blending Class A and B aggregates to meet a Class A requirement, ensure at least 50% by weight of the material retained on the No. 4 sieve comes from the Class A aggregate source. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. When blending, do not use Class C or D aggregates.

2. **RAP.** Do not use RAP in PFC mixtures.

Table 1

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deleterious Material, % , Max</td>
<td>Tex-217-F, Part I</td>
<td>1.0</td>
</tr>
<tr>
<td>Decantation, % , Max</td>
<td>Tex-217-F, Part II</td>
<td>1.5</td>
</tr>
<tr>
<td>Micro-Deval Abrasion, % , Max</td>
<td>Tex-461-A</td>
<td>18</td>
</tr>
<tr>
<td>Los Angeles Abrasion, % , Max</td>
<td>Tex-410-A</td>
<td>30</td>
</tr>
<tr>
<td>Magnesium Sulfate Soundness, 5 Cycle, % , Max</td>
<td>Tex-411-A</td>
<td>20</td>
</tr>
<tr>
<td>Coarse Aggregate Angularity, 2 Crushed Faces, % , Min</td>
<td>Tex 460-A, Part I</td>
<td>95</td>
</tr>
<tr>
<td>Flat and Elongated Particles @ 5:1, % , Max</td>
<td>Tex 280-F</td>
<td>10</td>
</tr>
</tbody>
</table>

1. Only applies to crushed gravel.

B. **Baghouse Fines.** Fines collected by the baghouse or other dust collecting equipment may be re-introduced into the mixing drum.

C. **Asphalt Binder.** Furnish performance grade (PG) asphalt binder and fibers unless the plans specify asphalt-rubber (A-R) binder. Provide asphalt binder that meets requirements of Item 300, “Asphalts, Oils, and Emulsions.”

1. **PG Binder.** When PG binder is specified, provide an asphalt binder with a high temperature grade of PG 76 and low temperature grade as shown on the plans in accordance with Section 300.2.J, “Performance Graded Binders.”

2. **A-R Binder.** When A-R binder is specified, provide A-R binder that meets the Type I or Type II requirements of Section 300.2.I, “Asphalt-Rubber Binders,” unless otherwise shown on the plans. Use at least 15.0% by weight of Crumb Rubber Modifier (CRM) that meets the Grade B or Grade C requirements of Section 300.2.G, “Crumb Rubber Modifier,” unless otherwise shown on the plans.
D. **Membrane.** Provide a smooth and homogeneous polymer modified emulsion meeting the requirements of Table 2.

### Table 2

<table>
<thead>
<tr>
<th>Test on Emulsion</th>
<th>Test Method</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity @ 77°F, SSF</td>
<td>Tex-513-C</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>Storage Stability¹, %</td>
<td>Tex-521-C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demulsibility (for anionic emulsions), 35 ml of 0.02 N CaCl₂, %</td>
<td>Tex-521-C</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Demulsibility (for cationic emulsions), 35 ml 0.8% sodium dioctyl sulfosuccinate, %</td>
<td>Tex-521-C</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Sieve Test², %</td>
<td>Tex-521-C</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Residue from Distillation @400°F, % Oil Portion from Distillation ml of Oil per 100 g Emulsion ³</td>
<td>Tex-521-C</td>
<td>63</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test on Residue from Distillation</th>
<th>Test Method</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Recovery @ 50°F, 50 mm/min, %</td>
<td>Tex-539-C</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Penetration @ 77°F, 100 g, 5 sec, 0.1 mm</td>
<td>Tex-502-C</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

¹. After standing undisturbed for 24 hours, the surface must be smooth, must not exhibit a white or milky colored substance, and must be a homogeneous color throughout.

². May be required by the Engineer only when the emulsion cannot be easily applied in the field.

³. The temperature on the lower thermometer shall be brought slowly to 350°F ± 10°F and maintained at this temperature for 20 minutes. The total distillation shall be completed in 60 ± 5 minutes from the first application of heat.

E. **Additives.** When shown on the plans, use the type and rate of additive specified. Other additives that facilitate mixing or improve the quality of the mixture may be allowed when approved.

1. **Fibers.** When PG binder is specified, provide cellulose or mineral fibers. Do not use fibers when A-R binder is specified. Submit written certification to the Engineer that the fibers proposed for use meet the requirements of DMS-9204, “Fiber Additives for Bituminous Mixtures.”

2. **Lime Mineral Filler.** When PG binder is specified, add lime as mineral filler at a rate of 1.0% by weight of the total dry aggregate. 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 re-introduces the lime back into the drum.

3. **Antistripping Agents.** If lime or a commercial antistripping (liquid antistrip) agent is specified or selected for use, add in accordance with Item 301, “Asphalt Antistripping Agents.” When the plans require lime to be added as an antistripping agent, lime added as mineral filler will count towards the total quantity of lime specified.

3. **Equipment.** Provide equipment to produce, haul, and place hot mixed asphalt materials. Ensure weighing and measuring equipment complies with Item 520, “Weighing and Measuring Equipment.” Synchronize equipment to produce a mixture meeting the required proportions.

A. **Production Equipment.** Provide:

- drum-mix type, weigh-batch, or modified weigh-batch mixing plants that
ensure a uniform, continuous production;

- automatic proportioning and measuring devices with interlock cut-off circuits, which stop operations if the control system malfunctions;
- visible readouts indicating the weight or volume of asphalt and aggregate proportions;
- safe and accurate means to take required samples by inspection forces; and
- permanent means to check the output of metering devices and to perform calibration and weight checks.
- additive-feed system to ensure a uniform, continuous material flow in the desired proportion.
- When A-R binder is specified, equip the hot mix plant with an in-line viscosity measuring device located between the blending unit and the mixing drum.

1. **Drum-Mix Plants.** Provide a mixing plant that complies with the requirements below.

a. **Aggregate Feed System.** Provide:
   - a minimum of 1 cold aggregate bin for each stockpile of individual materials used to produce the mix;
   - bins designed to prevent overflow of material;
   - scalping screens or other approved methods to remove any oversized material, roots, or other objectionable materials;
   - a feed system to ensure a uniform, continuous material flow in the desired proportion to the dryer;
   - an integrated means for moisture compensation;
   - belt scales, weigh box, or other approved devices to measure the weight of the combined aggregate; and
   - cold aggregate bin flow indicators that automatically signal interrupted material flow.

b. **Mineral Filler Feed System.** If lime mineral filler is required, provide a closed system for mineral filler that maintains a constant supply with minimal loss of material through the exhaust system. Tie the measuring device into the automatic plant controls to automatically adjust the supply of mineral filler to plant production and provide a consistent percentage to the mixture.

c. **Heating, Drying, and Mixing Systems.** Provide:
   - a dryer or mixing system to agitate the aggregate during heating;
   - a heating system that controls the temperature during production to prevent aggregate and asphalt binder damage;
• a heating system that completely burns fuel and leaves no residue;
• a recording thermometer that continuously measures and records the mixture discharge temperature.

d. **Asphalt Binder Equipment.** Supply equipment to heat binder to the required temperature. Equip heating apparatus with a continuously recording thermometer located at the highest temperature point. Produce a 24-hour chart of the recorded temperature. Place a device with automatic temperature compensation, which accurately meters the binder in the line leading to the mixer.

Furnish a sampling port on the line between the storage tank and mixer. Supply an additional sampling port between any additive blending device and mixer.

e. **Mixture Storage and Discharge.** Provide a surge-storage system to minimize interruptions during operations, unless otherwise approved. Furnish a gob hopper or other device to minimize segregation in the bin. Provide an automated system that weighs the mixture upon discharge and produces a ticket showing:
• date,
• project identification number,
• plant identification,
• mix identification,
• vehicle identification,
• total weight of the load,
• tare weight of the vehicle,
• weight of mixture in each load, and
• load number or sequential ticket number for the day.

f. **Truck Scales.** Provide standard platform scales at an approved location.

2. **Weigh-Batch Plants.** Provide mixing plant that complies with Section 3.A.1, “Drum-Mix Plants,” except as required below.

a. **Screening and Proportioning.** Provide enough hot bins to separate the aggregate and to control proportioning of the mixture type specified. Supply bins that discard excessive and oversized material through overflow chutes. Provide safe access for inspectors to obtain samples from the hot bins.

b. **Aggregate Weigh Box and Batching Scales.** Provide a weigh box and batching scales to hold and weigh a complete batch of aggregate. Provide an automatic proportioning system with low bin indicators,
which automatically stop when material level in any bin is not sufficient to complete the batch.

c. **Asphalt Binder Measuring System.** Provide bucket and scales of sufficient capacity to hold and weigh binder for 1 batch.

d. **Mixer.** Equip mixers with an adjustable automatic timer that controls the dry and wet mixing period and locks the discharge doors for the required mixing period. Furnish a pug mill with a mixing chamber large enough to prevent spillage.


   a. **Aggregate Feeds.** Aggregate control is required at the cold feeds. Hot bin screens are not required.

   b. **Surge Bins.** Provide 1 or more bins large enough to produce 1 complete batch of mixture.

B. **Hauling Equipment.** Provide trucks with enclosed sides to prevent asphalt mixture loss. Cover each load of mixture with waterproof tarpaulins. Before use, clean all truck beds to ensure the mixture is not contaminated. When necessary, coat the inside truck beds with an approved release agent from the list maintained by the Construction Division.

C. **Placement and Compaction Equipment.** Provide equipment that does not damage underlying pavement. Comply with laws and regulations concerning overweight vehicles.

   1. **Paver.** Furnish a paver that will spray the membrane, apply the PFC mixture, and level the surface of the mat in a single pass. Configure the paver so that the PFC mixture is placed no more than 5 seconds after the membrane is applied. Ensure the paver does not support the weight of any portion of hauling equipment other than the connection. Provide loading equipment that does not transmit vibrations or other motions to the paver that adversely affects the finished pavement quality. Equip the paver with an automatic dual longitudinal-grade control system and an automatic transverse-grade control system.

      a. **Tractor Unit.** Supply a tractor unit that can push or propel vehicles, dumping directly into the finishing machine to obtain the desired lines and grades to eliminate any hand finishing. Equip the unit with a hitch sufficient to maintain contact between the hauling equipment’s rear wheels and the finishing machine’s pusher rollers while mixture is unloaded.

      b. **Membrane Storage Tank and Distribution System.** Equip the paver
with an insulated storage tank having a minimum capacity of 900 gallons. Provide a metered mechanical pressure sprayer on the paver to apply a uniform membrane at the specified rate. Locate the spray bar on the paver so that the membrane is applied immediately in front of the screed unit. Provide a read out device on the paver to monitor the membrane application rate.

Unless otherwise directed, furnish a volumetric calibration and strap stick for the tank in accordance with Tex-922-K, Part I. Calibrate the tank within the previous 5 yr. of the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, Part II.

c. **Variable Width Screed.** Provide a heated compacting (vibratory-tamping bar) screed that will produce a finished surface which meets longitudinal and transverse profile, typical section, and placement requirements. Screed extensions must provide the same compacting action and heating as the main unit, unless otherwise approved.

d. **Grade Reference.** Provide a grade reference with enough support that the maximum deflection does not exceed 1/16 in. between supports. Ensure that the longitudinal controls can operate from any longitudinal grade reference, including a string line, ski, mobile string line, or matching shoes. Furnish paver skis or mobile string line at least 40 ft. long unless otherwise approved.

2. **Material Transfer Devices.** Provide the specified type of device when shown on the plans. Ensure devices provide a continuous, uniform mixture flow to the asphalt paver. When used, provide windrow pick-up equipment constructed to pick up substantially all roadway mixture placed in the windrow.

3. **Remixing Equipment.** When required, provide equipment that includes a pug mill, variable pitch augers, or variable diameter augers operating under a storage unit with a minimum capacity of 8 tons.

4. **Motor Grader.** When allowed, provide a self-propelled grader with a blade length of at least 12 ft. and a wheelbase of at least 16 ft.

5. **Handheld Infrared Thermometer.** Provide a handheld infrared thermometer meeting the requirements of Tex-244-F.

6. **Rollers.** Provide steel-wheel rollers meeting the requirements of Item 210, “Rolling (Flat Wheel),” for each type of roller required.

7. **Straightedges and Templates.** Furnish 10-ft. straightedges and other templates as required or approved.

D. **Field Laboratory.** Unless otherwise shown on the plans, provide and maintain a
Type D Structure (Asphalt Mix Control Laboratory) in accordance with Item 504, “Facilities for Field Office and Laboratory,” and details shown on the plans.

4. **Construction.** Produce, haul, place, and compact the specified paving mixture. When shown on the plans, notify the Engineer to schedule and participate in a prepaving meeting as required in the Quality Control Plan (QCP).

   A. **Certification.** Personnel certified by the Department-approved program must conduct all mixture designs, sampling, and testing in accordance with Table 3. In addition to meeting the certification requirements in Table 3, all Level II certified specialists must successfully complete an approved Superpave (SP) training course. 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 that is developed and signed by a Level II certified specialist. Provide a Level IA certified specialist at the plant during production operations. Provide a Level IB certified specialist to conduct placement tests.
Table 3
Test Methods, Test Responsibility, and Minimum Certification Levels

<table>
<thead>
<tr>
<th>1. Aggregate Testing</th>
<th>Test Method</th>
<th>Contractor</th>
<th>Engineer</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>Tex-400-A</td>
<td>✓</td>
<td>✓</td>
<td>IA</td>
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<tr>
<td>Dry Sieve</td>
<td>Tex-200-F, Part I</td>
<td>✓</td>
<td>✓</td>
<td>IA</td>
</tr>
<tr>
<td>Washed Sieve</td>
<td>Tex-200-F, Part II</td>
<td>✓</td>
<td>✓</td>
<td>IA</td>
</tr>
<tr>
<td>Deleterious Material</td>
<td>Tex-217-F, Part I</td>
<td>✓</td>
<td>✓</td>
<td>II</td>
</tr>
<tr>
<td>Decantation</td>
<td>Tex-217-F, Part II</td>
<td>✓</td>
<td>✓</td>
<td>II</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>Tex-410-A</td>
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<tr>
<td>Magnesium Sulfate Soundness</td>
<td>Tex-411-A</td>
<td>✓</td>
<td></td>
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<tr>
<td>Micro-Deval</td>
<td>Tex-461-A</td>
<td>✓</td>
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<tr>
<td>Coarse Aggregate Angularity</td>
<td>Tex-460-A</td>
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<td>✓</td>
<td>II</td>
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<tr>
<td>Flat and Elongated Particles</td>
<td>Tex 280-F</td>
<td>✓</td>
<td>✓</td>
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<thead>
<tr>
<th>2. Mix Design &amp; Verification</th>
<th>Test Method</th>
<th>Contractor</th>
<th>Engineer</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and JMF Changes</td>
<td>Tex-204-F</td>
<td>✓</td>
<td>✓</td>
<td>II</td>
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<tr>
<td>Mixing</td>
<td>Tex-205-F</td>
<td>✓</td>
<td>✓</td>
<td>II</td>
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<tr>
<td>Molding (SGC)</td>
<td>Tex-241-F</td>
<td>✓</td>
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<td>IA</td>
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<tr>
<td>Laboratory-molded Density</td>
<td>Tex-207-F</td>
<td>✓</td>
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<td>IA</td>
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<tr>
<td>Rice Gravity</td>
<td>Tex-227-F</td>
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<tr>
<td>Ignition Oven Calibration¹</td>
<td>Tex-236-F</td>
<td>✓</td>
<td></td>
<td>II</td>
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<tr>
<td>Drain-down</td>
<td>Tex-235-F</td>
<td>✓</td>
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<td>IA</td>
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<tr>
<td>Boil Test</td>
<td>Tex-530-C</td>
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<tr>
<td>Cantabro Loss</td>
<td>Tex-245-F</td>
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<table>
<thead>
<tr>
<th>3. Production Testing</th>
<th>Test Method</th>
<th>Contractor</th>
<th>Engineer</th>
<th>Level</th>
</tr>
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<tbody>
<tr>
<td>Control Charts</td>
<td>Tex-233-F</td>
<td>✓</td>
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<td>IA</td>
</tr>
<tr>
<td>Mixture Sampling</td>
<td>Tex-222-F</td>
<td>✓</td>
<td></td>
<td>IA</td>
</tr>
<tr>
<td>Gradation &amp; Asphalt Content¹</td>
<td>Tex-236-F</td>
<td>✓</td>
<td></td>
<td>IA</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>Tex-212-F</td>
<td>✓</td>
<td></td>
<td>IA</td>
</tr>
<tr>
<td>Micro-Deval</td>
<td>Tex-461-A</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain-down</td>
<td>Tex-235-F</td>
<td>✓</td>
<td></td>
<td>IA</td>
</tr>
<tr>
<td>Boil Test</td>
<td>Tex-530-C</td>
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</tr>
<tr>
<td>Aging Ratio</td>
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<thead>
<tr>
<th>4. Placement Testing</th>
<th>Test Method</th>
<th>Contractor</th>
<th>Engineer</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Charts</td>
<td>Tex-233-F</td>
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<td></td>
<td>IA</td>
</tr>
<tr>
<td>Ride Quality Measurement</td>
<td>Tex-1001-S</td>
<td>✓</td>
<td></td>
<td>IB</td>
</tr>
<tr>
<td>Thermal profile</td>
<td>Tex-244-F</td>
<td>✓</td>
<td></td>
<td>IB</td>
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<tr>
<td>Tack Coat Adhesion</td>
<td>Tex-243-F</td>
<td>✓</td>
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<td></td>
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<tr>
<td>Permeability</td>
<td>Tex-246-F</td>
<td>✓</td>
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</tr>
</tbody>
</table>

¹ Refer to Section 4.E for exceptions to using ignition oven.

B. Reporting. Use Department-provided software to record and calculate all test data. The Engineer and the Contractor will provide any available test results to the other party when requested. The Engineer and the Contractor will immediately report to the other party any test result that requires production to be suspended or fails to meet the specification requirements. Use the approved communication method (e.g., email, diskette, hard copy) to submit test results to the Engineer.

When directed, use the procedures described in Tex-233-F to plot the results of all productions and placement 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.
C. **Quality Control Plan (QCP).** Develop and follow the QCP in detail. Obtain approval from the Engineer for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

When directed, submit a written QCP to the Engineer before the mandatory prepaving meeting. Receive the Engineer’s approval of the QCP before beginning production. Include the following items in the QCP.

1. **Project Personnel.** For project personnel, include:
   - a list of individuals responsible for QC with authority to take corrective action and
   - contact information for each individual listed.

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 and the polymer modified emulsion membrane.

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, lime, liquid antistrip),
   - procedures for reporting job control test results, and
   - procedures to avoid segregation and drain-down in the silo.

4. **Loading and Transporting.** For loading and transporting, include:
   - type and application method for release agents and
   - truck loading procedures to avoid segregation.

5. **Placement and Compaction.** For placement and compaction, include:
   - proposed agenda for mandatory prepaving meeting including date and location;
   - 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;
• 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.

D. Mixture Design. Unless otherwise shown on the plans, use Tex-204-F, Part V, to design a mixture meeting the requirements listed in Tables 1, 3 and 4. Use $N_{\text{des}} = 50$ as the design number of gyrations.

At any time during the project, the Contractor may submit a new mixture design. The Engineer will approve all mixture designs before the Contractor can begin production. When shown on the plans, the Engineer will provide the mixture design.

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

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

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>PG 76 Mixtures</th>
<th>A-R Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>80.0 – 100.0</td>
<td>95.0 – 100.0</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>35.0 – 60.0</td>
<td>50.0 – 80.0</td>
</tr>
<tr>
<td>#4</td>
<td>1.0 – 20.0</td>
<td>0.0 – 8.0</td>
</tr>
<tr>
<td>#8</td>
<td>1.0 – 10.0</td>
<td>0.0 – 4.0</td>
</tr>
<tr>
<td>#200</td>
<td>1.0 – 4.0</td>
<td>0.0 – 4.0</td>
</tr>
<tr>
<td><strong>Binder Content, %</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.5 – 7.0</td>
<td>8.0-10.0</td>
</tr>
</tbody>
</table>
Table 5
Laboratory Mixture Design Properties

<table>
<thead>
<tr>
<th>Mixture Property</th>
<th>Test Method</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain-down, %</td>
<td>Tex-235-F</td>
<td>–</td>
<td>0.20</td>
</tr>
<tr>
<td>Laboratory-molded Density, %</td>
<td>Tex-207-F, Part VI</td>
<td>78.0¹</td>
<td>82.0</td>
</tr>
<tr>
<td>Fiber Content¹, %</td>
<td>Calculated</td>
<td>0.20</td>
<td>0.50</td>
</tr>
<tr>
<td>Lime Content¹, %</td>
<td>Calculated</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>CRM Content³, %</td>
<td>Calculated</td>
<td>15.0</td>
<td>None</td>
</tr>
<tr>
<td>Boil test</td>
<td>Tex-530-C</td>
<td>–</td>
<td>None</td>
</tr>
<tr>
<td>Cantabro Loss, %</td>
<td>Tex-245-F</td>
<td>–</td>
<td>20.0¹</td>
</tr>
</tbody>
</table>

1. Suggested limit. Test and report for informational purposes only.
2. By weight of total mixture. Not required when using A-R.

1. **Job Mix Formula (JMF) Approval.** The JMF is the combined aggregate gradation 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. 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.

   a. **Contractor’s Responsibilities.**

      (1) **Providing Superpave Gyratory Compactor (SGC).** Furnish a calibrated SGC for molding production samples. Locate the SGC at the field laboratory and make the SGC available to the Engineer for use in molding production samples.

      (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.

      (3) **Submitting JMF1.** Furnish the Engineer a mix design report (JMF1) and request approval to produce the trial batch.

      (4) **Supplying Aggregates.** Provide the Engineer with approximately 40 lb. of each aggregate stockpile unless otherwise directed.

      (5) **Supplying Asphalt.** Provide the Engineer at least 1 gal. of the asphalt material and sufficient quantities of any additives proposed for use.

      (6) **Ignition Oven Correction Factors.** Determine the aggregate and asphalt correction factors from the ignition oven using Tex-236-F. Provide the Engineer with split samples of the mixtures and blank samples used to determine the correction factors.
(7) **Boil Test.** Perform the test and retain the tested sample from Tex-530-C. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test. If signs of stripping exist, add lime or commercial antistripping agents (liquid antistrip) as directed.

(8) **Trial Batch Approval.** Upon receiving conditional approval of JMF1 from the Engineer, provide a plant-produced trial batch for verification testing of JMF1 and development of JMF2.

(9) **Trial Batch Production Equipment.** To produce the trial batch, use only equipment and materials proposed for use on the project.

(10) **Trial Batch Quantity.** Produce enough quantity of the trial batch to ensure that the mixture is representative of JMF1.

(11) **Number of Trial Batches.** Produce trial batches as necessary to obtain a mixture that meets the operational tolerances in Table 6.

(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.

(13) **Trial Batch Testing.** Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the verification testing requirements for gradation, binder content, laboratory-molded density, and drain-down listed in Table 6. Provide the Engineer with a copy of the trial batch test results.

(14) **Development of JMF2.** After the Engineer grants full approval of JMF1 based on results from the trial batch, evaluate the trial batch test results, determine the optimum mixture proportions, and submit as JMF2.

(15) **Mixture Production.** After receiving approval for JMF2, use JMF2 to produce Lot 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.

(17) **JMF Adjustments.** If necessary, adjust the JMF before beginning a new lot. The adjusted JMF must:
- be provided to the Engineer in writing before the start of a new lot,
- be numbered in sequence to the previous JMF,
- meet the master gradation limits shown in Table 4,
• be within the operational tolerances of JMF2 listed in Table 6.

(18) **Requesting Referee Testing.** If needed, use the referee testing in accordance with Section 4.1.1, “Referee Testing,” to resolve testing differences with the Engineer.

### Table 6
**Testing Frequency and Mixture Production Tolerances**

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Test Method</th>
<th>Minimum Contractor Testing Frequency</th>
<th>Minimum Engineer Testing Frequency</th>
<th>Operational Tolerance from JMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual % retained for sieve sizes larger than #200</td>
<td>Tex-200-F</td>
<td>1 per subplot</td>
<td>1 per 12 sublots</td>
<td>±5.0¹</td>
</tr>
<tr>
<td>% Passing the #200</td>
<td>Tex-200-F</td>
<td>1 per subplot</td>
<td>1 per 12 sublots</td>
<td>±2.0¹</td>
</tr>
<tr>
<td>Laboratory-molded Density, %</td>
<td>Tex-207-F, Part VI</td>
<td>1 per subplot</td>
<td>1 per lot</td>
<td>Table 5</td>
</tr>
<tr>
<td>Binder Content, %</td>
<td>Tex-236-F</td>
<td>1 per subplot</td>
<td>1 per lot</td>
<td>±0.3</td>
</tr>
<tr>
<td>Drain-down, %</td>
<td>Tex-235-F</td>
<td>1 per subplot</td>
<td>1 per 12 sublots</td>
<td>Table 5</td>
</tr>
<tr>
<td>Boil Test³</td>
<td>Tex-530-C</td>
<td>1 per project</td>
<td>1 per project</td>
<td>N/A</td>
</tr>
<tr>
<td>Asphalt Binder and Membrane Sampling³</td>
<td>Tex-500-C</td>
<td>1 per lot (sample only)</td>
<td>1 per project</td>
<td>N/A</td>
</tr>
<tr>
<td>Thermal profile</td>
<td>Tex-244-F</td>
<td>1 per subplot</td>
<td>Optional</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1. Aggregate gradation will not exceed limits shown in Table 4.
2. May be obtained from asphalt meter readouts.
3. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history. Obtain membrane sample from the spray bar on the paver.

### b. Engineer’s Responsibilities.

(1) **Gyratory Compactor.** For molding trial batch and production samples, the Engineer will use the Contractor-provided SGC at the Contractor’s field laboratory or provide and use a Department SGC at an alternate location.

(2) **Conditional Approval of JMF1.** Within 2 working days of receiving the mixture design report (JMF1) and all required materials, the Engineer will review the Contractor’s mixture design report and verify conformance with all aggregates, asphalt, additives, and mixture specifications. The Engineer may perform tests to verify the aggregates meet the requirements listed in Table 1. The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates the Contractor’s mixture design meets the specifications. Full approval of JMF1 will be based on the Engineer’s test results on mixture from the trial batch.

(3) **Authorizing Trial Batch.** After conditionally approving JMF1, the Engineer will authorize the Contractor to produce a trial batch.

(4) **Ignition Oven Correction Factor.** The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven in accordance with Tex-236-F.
(5) **Testing the Trial Batch.** Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the gradation, binder content, and laboratory-molded density meet the requirements listed in Table 6.

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

- Tex-235-F to verify that drain-down meets the requirement shown in Table 5.
- Tex-461-A to determine the need for additional magnesium sulfate soundness testing.
- Tex-530-C to retain and use for comparison purposes during production.
- Tex-245-F to verify the Cantabro loss meets the requirement shown in Table 5.

(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 gradation, asphalt content, and laboratory-molded density confirm that the trial batch meets the requirements in Table 6.

The Engineer will notify the contractor that an additional trial batch is required if the trial batch does not meet the requirements in Table 6.

(7) **Approval JMF2.** The Engineer will approve JMF2 within 1 working day if it meets the master grading limits shown in Table 4 and is within the operational tolerances of JMF1 listed in Table 6.

(8) **Approval Lot 1 Production.** The Engineer will authorize the Contractor to proceed with Lot 1 production after approving JMF2.

(9) **Approval of JMF3.** The Engineer will approve JMF3 within 1 working day if it meets the master grading limits shown in Table 4 and is within the operational tolerances of JMF2 listed in Table 6.

2. **JMF Adjustments.** Produce the mixture within the operational tolerances listed in Table 6. The Engineer may suspend production if corrective actions are not taken when operational tolerances are exceeded. With approval from the Engineer, the JMF target values may be adjusted as needed. Document any changes to the JMF with a subsequent JMF number. The Engineer may adjust the target asphalt percentage or fiber percentage within the operational tolerances of the JMF.
E. **Production Operations.** Perform a new trial batch when the plant or plant location is changed. Perform quality control at the frequency and within the tolerances listed in Table 6. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification.

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

- lime content (within ± 0.1% of JMF), when PG binder is specified;
- fiber content (within ± 0.03% of JMF), when PG binder is specified; and
- CRM content (within ± 1.5% of JMF), when A-R binder is specified.

When A-R binder is specified, maintain the in-line measuring device to verify the A-R binder viscosity of at least 2,500 centipoises unless otherwise approved.

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

1. **Storage and Heating of Materials.** Do not heat the asphalt binder above the temperatures specified in Item 300, “Asphalts, Oils, and Emulsions” or from the manufacturer’s recommended values. On a daily basis, provide the Engineer with the records of asphalt binder and hot mix asphalt discharge temperatures in accordance with Section 3.A.1.c. “Heating, Drying, and Mixing Systems”. Unless otherwise approved, do not store hot mix for more than 12 hrs. or a time period that affects the quality of the mixture.

2. **Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F. The Department will not pay for or allow placement of any mixture produced at more than 350°F.

   Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. If requested, perform 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.

F. **Hauling Operations.** Before use, clean all truck beds to ensure mixture is not contaminated. When a release agent is necessary, use a release agent on the approved list maintained by the Construction Division to coat the inside bed of the truck.

G. **Placement Operations.** Prepare the surface by removing raised pavement
markers and objectionable material such as moisture and dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Use an approved paver to concurrently apply the membrane and place the PFC mixture to produce a smooth, finished surface with a uniform appearance and texture that meet typical section requirements. Control the speed of the paver to insure that the membrane is exposed for no more than 5 seconds before being covered with PFC. Offset longitudinal joints of successive courses of hot mix at least 6 in. Place mixture so longitudinal joints on the surface course coincide with lane lines, or as directed. Place the hot mix adjacent to gutters and structures so that the pavement will drain properly.

1. **Weather Conditions.** Place the PFC mixture when the roadway surface temperature is 70°F or higher unless otherwise approved. Measure the roadway surface temperature with a handheld infrared thermometer. Place mixtures only when general weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer.

2. **Application of Membrane.** Unless otherwise directed by the Engineer, apply the membrane at the rates shown in Table 7. Spray the membrane using a metered mechanical pressure spray bar at a temperature of 140°F to 180°F. Monitor the membrane application rate and make adjustments to the rate when needed or when directed. If required, verify that the spray bar is capable of applying the membrane at a uniform rate across the entire paving width as directed. Do not let the wheels or other parts of the paving machine contact the freshly applied membrane.

<table>
<thead>
<tr>
<th>Membrane Application Rate, (gallons per square yard)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PFC Lift Thickness</strong></td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>3/4&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
</tr>
<tr>
<td>1½&quot;</td>
</tr>
<tr>
<td>1¾&quot;</td>
</tr>
</tbody>
</table>

3. **Lay-Down Operations.** Measure the temperature of mixture delivered to the paver and take corrective action if needed to insure the temperature does not drop below 290°F.

For each sublot use a handheld infrared thermometer to obtain a thermal profile of the uncompacted mat immediately behind the paver. Record the information on Department QCQA forms and submit the forms to the Engineer. The Engineer may reduce the testing frequency based on a satisfactory test history.

a. **Thermal Profile.** For each sublot, obtain a thermal profile using Tex-
The Engineer may also obtain as many thermal profiles as deemed necessary.

No more than a 50°F differential will be allowed along the profile of the uncompacted mat surface immediately behind the paver. Unless otherwise directed, suspend operations and remove and replace material that exceeds the maximum temperature differential of 50°F. Resume operations when the Engineer determines that subsequent production will meet the specifications.

If the temperature differential is between 25°F and 50°F, the area will be deemed as having thermal segregation. Take corrective action to eliminate areas that have thermal segregation.

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

H. Compaction. Roll the freshly placed PFC with a steel-wheeled roller, operated in static mode, to seat the mixture without excessive breakage of the aggregate and to provide a smooth surface and uniform texture. Do not use pneumatic rollers. Thoroughly moisten the roller drums with a soap and water solution to prevent adhesion. Furnish compaction equipment meeting the requirements of Item 210, “Rolling (Flat Wheel).” Unless otherwise directed, use only water or a Department-approved release agent on rollers, tamps, and other compaction equipment.

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

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. When directed, sprinkle the finished mat with water or limewater to expedite opening the roadway to traffic.

I. Acceptance Plan. Sample and test the hot mix on a lot and sublot basis. A production lot consists of 4 equal sublots. Lot 1 will be 1,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production. The lot size will be at least 1,000 tons, but no greater than 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot. If the production or placement test results are not within the acceptable tolerances listed in Table 6, suspend production until test results or other information indicate, to the satisfaction of the Engineer, that the next material produced or placed will meet the specified values.

1. Referee Testing. The Construction Division is the referee laboratory. The Contractor may request referee testing if the differences between Contractor and Engineer test results exceed the operational tolerances shown in Table 6.
and the differences cannot be resolved. Make the request within 5 working
days after receiving test results and cores from the Engineer. Referee tests
will be performed only on the sublot in question and only for the particular
test in question. Allow 10 working days from the time the samples are
received at the referee laboratory for test results to be reported. The
Department may require the Contractor to pay for additional referee tests if
more than 3 referee tests per project are required and the Engineer’s test
results are closer to the referee test results than the Contractor’s test results.

2. **Asphalt Binder Sampling.** Obtain a 1-qt. (1 gal. for A-R binder) sample of
the asphalt binder for each sublot of mixture produced. Obtain the sample at
approximately the same time the mixture random sample is obtained.
Sample from a port located immediately upstream from the mixing drum or
pug mill. Take the sample in accordance with Tex-500-C, Part II. Label the
can with the corresponding lot and sublot numbers, and deliver the sample
to the Engineer.

The Engineer may also obtain independent samples. If the Engineer chooses
to obtain an independent asphalt binder sample, the Engineer will split a
sample of the asphalt binder with the Contractor. The Engineer will test at
least 1 asphalt binder sample per project to verify compliance with Item
300.

3. **Membrane.** Obtain a 1-qt. sample of the membrane material for each lot.
Obtain the sample from the spray bar on the paver. Label the can with the
corresponding lot number, and deliver the sample to the Engineer. The
Engineer may also obtain independent samples. If the Engineer chooses to
obtain an independent sample, the Engineer will split a sample of the
membrane with the Contractor. The Engineer will test at least 1 membrane
sample per project to verify specification compliance.

4. **Operational Tolerances.** Control the production process within the
operational tolerances listed in Table 6. 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.

5. **Recovered Asphalt DSR.** The Engineer may take production samples or
cores from suspect areas of the project to determine recovered asphalt
properties. Asphalt binders with an aging ratio greater than 3.5 do not meet
the requirements for recovered asphalt properties and may be deemed
defective when tested and evaluated by the Construction Division. The
aging ratio is the dynamic shear rheometer (DSR) value of the extracted
binder divided by the DSR value of the original unaged binder. DSR values
are obtained according to AASHTO T315 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 using Tex-211-F.

6. **Irregularities.** Immediately take appropriate corrective actions if surface irregularities, including but not limited to segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles, are detected. The Engineer may allow placement to continue for at most 1 day of production while taking appropriate action. If the problem still exists after that day, suspend paving until the problem is corrected to the satisfaction of the Engineer.

At the expense of the Contractor and to the satisfaction of the Engineer, remove and replace any mixture that does not bond to the existing pavement or has other surface irregularities identified above.

7. **Ride Quality.** Unless otherwise shown on the plans, measure ride quality in accordance with Special Specification, “Ride Quality for Pavement Surfaces.”

5. **Measurement.** Thin Bonded Permeable Friction Course (TBPFC) will be measured by the ton of composite TBPFC. The composite TBPFC is defined as the membrane, asphalt, aggregate, and additives. The weights of asphalt and aggregate will be calculated based on the measured weight of PFC and the target percentage of asphalt and aggregate. Measure on scales in accordance with Item 520, “Weighing and Measuring Equipment.”

   A. **Membrane.** Unless otherwise noted on the plans, membrane material will be measured by one of the following methods:

   1. **Volume.** Membrane material 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 distributor’s calibrated strap stick. The quantity to be measured for payment will be the number of gallons used, as directed, in the accepted membrane.

   2. **Weight.** Membrane material will be measured in tons using certified scales meeting the requirements of Item 520, “Weighing and Measuring Equipment,” unless otherwise approved. The transporting truck must have a seal attached to the driving device and other openings. The Engineer may require random checking on public scales, at the Contractor’s expense, to verify weight accuracy.

   Upon work completion or temporary suspension, any remaining membrane material will be weighed by a certified public weigher, or measured by volume in a calibrated distributor or tank and the quantity converted to tons at the measured temperature. The quantity to be measured will be the number of tons received, minus the number of tons remaining after all directed work is complete, and minus the amount used for other item.

   B. **Asphalt.** The asphalt weight in tons will be determined from the total weight of
PFC. Measured asphalt percentage will be obtained using Tex-236-F or asphalt flow meter readings, as determined by the Engineer.

1. **Target Percentage.** The JMF target asphalt percentage will be used to calculate the weight of asphalt binder unless the measured asphalt binder percentage is more than 0.3 percentage points below the JMF target asphalt percentage. Volumetric meter readings will be adjusted to 140°F and converted to weight.

2. **Measured Percentage.** The measured asphalt percentage will be used for payment for that lot’s production when the measured percentage is more than 0.3 percentage points below the JMF target asphalt percentage.

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

6. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement,” will be paid for at the unit price bid for “TBPFC (Membrane),” for “TBPFC (Asphalt),” and for “TBPFC (Aggregate)” of the types specified. These prices are full compensation for all materials, equipment, labor, tools, and incidentals.

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

Pay adjustment for ride quality will be determined in accordance with Special Specification, “Ride Quality for Pavement Surfaces.”