
Section 407

Construction Guide Specification for Hot Applied Asphalt Chip Seal

407.1. DESCRIPTION

This guide specification is intended to provide information needed for owners or contractors to construct hot applied asphalt chip seals. A hot applied asphalt chip seal is the application of hot applied asphalt binder, followed immediately by an application of a single layer of pre-coated aggregate. .

This guide specification refers to quality requirements for materials and a design method for chip seals available in other AASHTO documents. However, the main purpose is to provide guidance for the construction of hot applied asphalt chip seals applied in one layer.

All units of measurement are expressed in English units in accordance with U.S. practice.

Commentaries are included in this guide specification to 1) emphasize and further explain the section, 2) present options to be considered by the user, or 3) provide sources of additional information. An example of these commentaries is shown below:

Commentary

This guide specification covers construction of single-application chip seals. If this process is repeated with another application of hot asphalt and another layer of cover aggregate, the process is known as a double chip seal. . Other terms have been used referring to chip seals such as “seal coat,” “surface treatment,” “surface seal,” “surface dressing,” “sprayed seal,” and others. Sometimes, a fog seal is applied over the completed chip seal.

407.2. REFERENCED DOCUMENTS

407.2.1.

AASHTO Standards

- M 140, Emulsified Asphalt for Fog Seal
- M 320, Performance-Graded Asphalt Binder
- M 332, Performance-Graded Asphalt Binder Using Multiple Stress Creep Recovery (MSCR) Test
- R 66, Sampling Bituminous Materials
- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 96, Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- T 301, Elastic Recovery Test of Asphalt Materials by Means of a Ductilometer
- T 335, Determining the Percentage of Fracture in Coarse Aggregate
- AASHTO Guide Specification for Highway Construction, 2020, 10th edition

407.2.2.

ASTM Standards

- D5624, Standard Practice for Determining the Transverse-Aggregate Spread Rate for Surface Treatment Applications
- D6114, Standard Specification for Asphalt Rubber Binder
- D7564, Standard Practice for Construction of Asphalt Rubber Cape Seal

- D7741, Standard Test Method of Apparent Viscosity of Asphalt Rubber or Other Asphalt Binders by Using a Rotational Hand Held Viscometer

407.2.3. *Other Documents*

- Texas DOT, Determining Flakiness Index, TXDOT Designation:Tex-224-F, August 2016
- Texas Department of Transportation, Seal Coat and Surface Treatment Manual, 2017
<http://onlinemanuals.txdot.gov/txdotmanuals/scm/scm.pdf>

407.3. TERMINOLOGY

Three broad classes of asphalt binders are used in hot applied chip seals. They include asphalt-rubber, rubber modified asphalt, and performance-graded (PG) binders. The latter two are PG graded.

407.3.1. *asphalt-rubber binder*—a blend of coarse crumb rubber and an asphalt binder, meeting the requirements of ASTM D6114. The binder shall include at least 15 percent crumb rubber and can be as high as 22 percent.

407.3.2. *rubber modified asphalt*—a blend of fine rubber and an asphalt binder mixed at an asphalt terminal. The binder may also include polymers. This product is also referred to as a terminal blend. This product includes a minimum of 5 percent crumb rubber, but can contain as much as 18 percent. There is no national specification for these products.

407.3.3. *performance -graded (PG) hot applied binders*—these binders shall meet the requirements of M 320. An unmodified or a modified binder could be used in a chip seal application.

407.3.4. Emulsified asphalts for fog seals, if used, include:

- *CSS-1h*—a cationic emulsified asphalt that is slow setting and has a residual binder residue with lower penetration than CSS-1.
- *SS-1h*—an anionic emulsified asphalt that is slow setting and has a residual binder residue with lower penetration than SS-1.

Commentary

In colder environments, a CRS-1h has been used to get a faster set.

407.4. MATERIALS

407.4.1. *Asphalt Binder*

407.4.1.1. *Asphalt-Rubber Binder*—this binder shall meet all the requirements of ASTM D6114. It is a combination of asphalt binder, extender oil, and Crumb Rubber Modifier (CRM). If used, the asphalt modifier (or extender oil) shall be between 2.5 to 6.0 percent by weight of the asphalt binder in the asphalt-rubber binder.

The asphalt binder (and, if used, the asphalt modifier) must be combined with the CRM at the asphalt-rubber binder production site. The asphalt binder and asphalt modifier blend must be between 350 to 425°F when the CRM is added. Combined ingredients must be allowed to react at least 45 min at temperatures from 350 to 400°F, except the temperature shall not be higher than 10°F below the actual flashpoint of the asphalt-rubber binder. After reacting for at least 45 min, the asphalt-rubber binder must comply with the requirements shown in ASTM D6114.

Commentary. Because of the high temperatures used with hot applied binders, health and safety issues are of more concern.

407.4.1.2. *Rubber Modified Asphalt*—this binder shall consist of a PG asphalt binder with a minimum of 5 percent scrap tire rubber and 2 percent Styrene Butadiene Styrene (SBS) block copolymer blended at a terminal. The binder needs to meet the requirements of M 320 and exhibit an elastic recovery greater than 60 percent when tested in accordance with T 301. The actual PG grading of the rubberized asphalt would be per the design or as specified.

Commentary

In Arizona, Texas, and California, this product is often referred to as a terminal blend. The CRM content may vary from 5 percent to 18 percent or more.

407.4.1.3. *PG Asphalt*—these binders shall meet the requirements of M 320 or M 322 with exhibit elastic recovery greater than or equal to 60 percent when tested in accordance with T 301. The performance grade to be used shall be determined by the Engineer or Contractor.

Commentary

Both polymer-modified and unmodified binders can be used. Agencies shall designate the grade commonly used in their state.

407.4.2. *Granulated Rubber*

Crumb rubber shall be vulcanized rubber using an ambient temperature processing of scrap tires. Granulated rubber shall meet the requirements given in ASTM D 6114.

The use of rubber from multiple sources is acceptable provided that the overall blend of rubber meets the specified gradation. Certification of the gradation and quality of the rubber shall be provided by the rubber supplier.

Commentary

The crumb rubber gradations used vary between states. Also, for asphalt rubber, most states use a binder that does not contain any extender oil or high natural rubber, while some use a binder that does contain both.

407.4.3. *Aggregate*

Chip seal aggregate shall be durable, uniform in quality, and free from wood, bark, roots, and other deleterious materials. Gradations and quality requirements are specified in Table 1 where all percentages are by weight. The aggregate gradation to be used will be as shown in the plans or other contract documents. Gradation A is for asphalt rubber while gradation B is for rubberized and performance-graded asphalts. All aggregate retained on the No. 4 screen shall be crushed by mechanical means and meet the requirements shown in Table 2.

Table 1—Chip Seal Aggregate Gradations

Sieve Size	A	B
	Asphalt Rubber % passing	RMA and PG Asphalts % passing
3/4 in.	100	—
1/2 in.	95–100	100
3/8 in.	70–100	70–100
No. 4	0–15	0–15
No. 8	0–5	0–5
No. 16	—	—
No. 30	—	—
No. 50	—	—
No. 200	0–1	0–1

Table 2—Fracture and Abrasion Requirements

Property	Chip Seal Class ^a		
	I	II	III
Fracture, 1 Face, % min T 335	70	85	95
Fracture, 2 Faces, % min T 335	60	80	90
Los Angeles Abrasion, max. % loss, T 96	37	35	30
Flakiness Index, max. % FLH T 508	25	20	17

^a Traffic Class I is less than 500 AADT, II is 501 to 5000 AADT, and III is greater than 5000 AADT.

Prior to placing, the aggregate shall be uniformly pre-coated with a Performance-Graded Asphalt which meets the requirements of M 320 or M 322 and is typically used by the agency based on climate. The pre-coating shall be accomplished by mixing at a central hot mix plant. The binder shall have a minimum temperature of 250°F at the time of pre-coating with approximately 0.40 to 0.80 percent asphalt cement, by weight of the aggregate. The end result shall be a dust free aggregate.

407.5. CONSTRUCTION

407.5.1. *Weather Limitations*—Construct chip seal per the following conditions:

- Ambient or pavement surface temperatures shall be 50°F and rising.
- Suspend chip sealing if the pavement surface temperature exceeds 140°F.
- The road surface shall be dry and swept clean of dirt and debris.

407.5.2. *Mix Design*

407.5.2.1. *Asphalt Rubber*—Design of the rubberized asphalt chip seal surface treatment shall be the responsibility of the contractor using a method approved by the agency. The application rate of the asphalt rubber is normally from 0.6 +/- 0.1 gal/ yd². The application rate of the pre-coated aggregate is normally between 30 to 40 lb/yd². No later than two weeks before work commences, the contractor shall submit for the approval of the Engineer the chip seal design, which specifies the additives for the asphalt rubber, the binder profile for the product showing the physical properties, application rate of the asphalt rubber, and the source, composition, and application rate of the cover aggregate. Samples of each material shall be included with the submittal. Once the materials and design are approved, no substitution will be permitted unless approved by the Engineer. The supplier of the binder shall certify the percent of granulated rubber in the blend and whether the blend includes an extender oil. The temperature of the asphalt cement shall be between 350 and 425°F at the time the CRM is added. The components shall be mixed together in the blender and reacted for a minimum of 1 hour. The temperature of the binder shall be above 350°F during the reaction period.

Commentary

Most blending units have a mass flow meter capable of measuring and recording the total quantity of asphalt binder in tons. The quantity of ground rubber shall be determined by weight utilizing either a hopper equipped with load cells or feeder equipped with belt scales. The total weight in tons and percentage of ground rubber based on total asphalt rubber binder shall be recorded. All data shall be reported to the awarding authority. As part of the blending operation, a dedicated asphalt rubber reaction/heated storage tank with proper heating and mixing capabilities is required.

407.5.2.2. *Rubber Modified Asphalt (RMA)* — The chip seal design shall follow the method approved by the agency. If none is available, the Kirby method in the Texas Seal Coat Manual (2017) shall be used. The application rate of the binder is normally in the range of 0.50 ± 0.10 gal/yd². The Engineer will specify the exact application rate based on the aggregate texture and absorption and

the existing surface condition. Aggregate application rates should be in the range between 25 and 35 lb/yd².

407.5.2.3. *PG asphalts*—The chip seal design shall follow the method approved by the agency. If none is available, the Kearby method in the Texas Seal Coat Manual (2017) shall be used. The application rate of the binder will be 0.30 ± 0.10 gal/yd². The Engineer will specify the exact rate based on the surface and the characteristics of the aggregate material. Aggregate application rates shall be 20 to 30 lb/yd² for conventional aggregates or as directed by the Engineer.

407.5.3. *Preconstruction Meeting*—Coordinate a preconstruction meeting prior to construction with the engineer to discuss the following schedule:

- Construction process
- Quality control plan, required to be submitted
- Mix design, required to be submitted
- Materials control
- Materials measurement
- Equipment calibration, required to be submitted
- Traffic control plan
- Equipment/process overview
- Inspection
- Test strip
- Unique project conditions
- Project documentation
- Expectations

407.5.4. *Road Surface Preparations*

407.5.4.1. *Cleaning Pavement*—Clean the roadway surface by sweeping no more than 30 min prior to application of the hot asphalt and chips. This 30-min window may be extended if authorized by the engineer in cases where extending the time does not jeopardize a clean surface prior to chip seal operations. Sweep the pavement with a motorized broom to remove loose material. Clean depressions not reached by the motorized broom with a hand broom. Clean the outer edges of the pavement to be sealed.

407.5.4.2. *Protecting Accessories*—Cover utility castings (manholes, gate valve covers, catch basins, sensors, etc.) to prevent coating with asphalt binder. Suitable coverings include plywood disks, Kraft paper, roofing felt or other approved methods. Remove the protective coverings before opening the road to traffic.

407.5.4.3. *Traffic Markings Removal*—Pavement markings shall be removed by grinding or other approved methods prior to chip seal operations.

407.5.5. *Equipment*

407.5.5.1. *Blending Unit*—A mechanical blender for proper proportioning and thorough mixing of the asphalt-cement and granulated rubber is required to produce the asphalt-rubber binder. This unit shall be equipped with: asphalt mass flow meter (gallons); a flow rate meter (gallons per minute); a positive displacement auger to feed the rubber properly to the mixing chamber at the specified rate; and a static motionless mixer or a blending tank with a high-speed mixer. The blender shall have a separate asphalt binder feed pump and finished product pump to maximize production, and shall be capable of providing 100 percent proportional blend at any given time during the blending cycle; supporting documentation from the manufacturer shall be submitted to the Engineer.

Commentary

A blending unit shall not be required for terminal blends.

407.5.5.2. *Asphalt Distributor*—The asphalt distributor shall be self-propelled with a ground speed control device interconnected with the asphalt pump such that the specified application rate will be supplied at any speed. The asphalt distributor shall be capable of maintaining the asphalt binder at the specified temperature. For asphalt rubber applications, the asphalt distributor shall be equipped with internal mixing capabilities. The spray bar nozzles shall produce a uniform triple lap application fan spray, and the shutoff shall be instantaneous, with no dripping. All nozzles shall be oriented at the same angle between 15 and 30 degrees using the wrench supplied by the distributor manufacturer. Each pressure distributor shall be capable of maintaining the specified application rate within ± 0.015 gal/yd² for each distributor load.

407.5.5.3. *Aggregate Spreader*—A variable width, self-propelled mechanical type aggregate spreader with a computerized spread control capable of distributing the aggregate uniformly to the required width and at the designed rate shall be used. The spreader shall be a self-propelled type mounted on pneumatic-tired wheels capable of an application width of 14 ft. or greater.

407.5.5.4. *Pneumatic-Tire Rollers*—A minimum of three self-propelled pneumatic-tire rollers capable of ballast loading, either with water or sand to allow the weight of the machine to be varied from 6 to 12 tons to achieve a minimum contact pressure of 80 lb/in.² shall be used. The alignment of the axles shall be such that the rear-axle tires, when inflated to the proper pressure, can compact the voids untouched by the front-axle tires. All tires shall be as supplied by the roller manufacturer. Width of the rollers shall exceed 60 inches.

Commentary

Steel-wheel rollers have been used as the final roller on some chip seals with success. The advantage is a more even final elevation. This produces fewer prominent aggregate edges extruding above the surface which can be susceptible to snow plow damage. The disadvantage of steel-wheel rollers is the potential for crushing of aggregate that cannot withstand the high stress imparted at the steel roll-chip interface. Therefore, if used, steel rollers should be limited to 5 tons. Vibration shall not be used if the rollers are so equipped.

407.5.5.5. *Brooms*—Motorized brooms with a positive means of controlling vertical pressure shall be used to clean the road surface prior to spraying the asphalt binder. Plastic bristle brooms are required to remove loose aggregate after rolling.

Commentary

Vacuum brooms or pickup sweepers are preferred in urban or residential areas, but push brooms are acceptable in rural areas where chips being scattered off the roadway do not pose a hazard to pedestrians or vehicles.

407.5.5.6. *Trucks*

407.5.5.6.1. *Asphalt Rubber Binder*—All trucks for the asphalt-rubber binder shall be equipped with internal agitation and heating capabilities. Trucks for the other binder types do not require these capabilities unless separation is an issue.

407.5.5.6.2. *Aggregate*—Trucks for hauling aggregate shall be rear discharge equipped with a device to lock onto the hitch at the rear of the aggregate spreader to prevent spillage. Sufficient hauling vehicles shall be available to ensure continuous operations of the distributor and the aggregate spreader.

407.5.6. *Equipment Calibration*

The contractor shall provide proof of calibration of the asphalt distributor and the aggregate spreader. The asphalt distributor shall be calibrated prior to the job. The asphalt application rated

will be verified on a daily basis as calculated by dividing the total gallons asphalt by the total area treated. The contractor shall submit the results of the calibration procedure to the Engineer.

Flow from each nozzle in the pressure distributor must be within ± 10 percent of the average flow of all nozzles as measured by the procedure described as described in NCHRP Report 680, Chapter 7 (Shuler, et al 2011).

Uniformity of the aggregate applied transverse to the pavement centerline shall be judged using ASTM D5624. Tolerance for each pad tested for transverse spread rate shall be ± 10 percent of the average of the total transverse rate.

Commentary

Calibration is very important to assure the quantity of asphalt and chips applied to the pavement are correct. Although many modern asphalt distributors and aggregate spreaders are computer controlled, calibration is required to tell the computer how much asphalt is being applied. This quantity must be checked prior to spraying asphalt and spreading aggregate and checked against the quantity the computer (if the distributor is so equipped) indicates is being applied.

407.5.6.1. *Asphalt Distributor*

All nozzles shall be the same size, provide the same flow rate, be oriented in the same direction, and be the same distance above the pavement.

Commentary:

The distributor truck applies hot asphalt to the pavement surface. This application must be done uniformly both transverse and longitudinal to the centerline of the pavement to provide the proper adhesive layer necessary for aggregate adhesion.

When lower application rates are determined necessary or shown in the plans, smaller nozzles shall be inserted in the spray bar where the asphalt rate is reduced.

Commentary

Due to minor rutting or heavy truck traffic, it may be desirable to reduce the asphalt application rate in the wheel paths.

407.5.6.1.1. *Nozzle Angle*

Nozzles shall be positioned at an angle of 15 to 30 degrees from the horizontal of the spray bar in accordance with the spray bar manufacturer's recommendation. All nozzles shall spray a full fan except for the right and left edge nozzles. The right and left edge nozzles shall be adjusted to a half fan such that the spray stays to the inside of the spray bar.

Commentary

The next step in calibrating the distributor is adjustment of the spray bar nozzle angles. Each nozzle has a slot cut across the face of the nozzle. When the nozzle is threaded into the spray bar, the slot should all be positioned at an angle of 15 to 30 degrees to the direction of the spray bar as shown in Figure 1. This angle provides the best position for achieving uniformity in the spray and the triple overlap coverage. The angle should be adjusted using the wrench supplied with the distributor. This wrench is designed when used properly to set the correct angles for each nozzle. Any wrench that fits the hexagonal nozzle can adjust the nozzle angle but correctness of the angle would have to be visually verified.

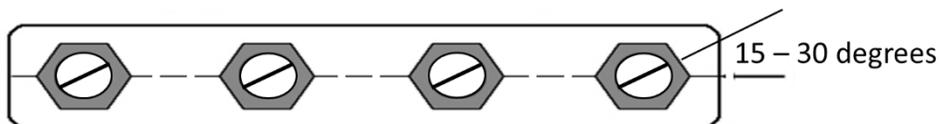


Figure 1—Spray Bar Nozzle Orientation in Spray Bar

The angle at which the nozzles are positioned shall be adjusted using the wrench supplied with the distributor. However, in cases where this wrench is unavailable, a wrench that fits the hexagonal nozzle will suffice but the angle must be judged visually.

All nozzles fitted to the spray bar shall be full fan nozzles except for the right and left edge nozzles. These nozzles shall be half fan nozzles adjusted so the spray from the nozzle remains to the inside of the spray bar.

407.5.6.1.2. *Spray Bar Height*

The spray bar height must be adjusted so that the asphalt provides exactly two or three overlaps across the entire spray width.

Commentary

Streaking of the emulsified asphalt will occur if the spray bar is set too high or too low as shown in Figures 2 and 3.

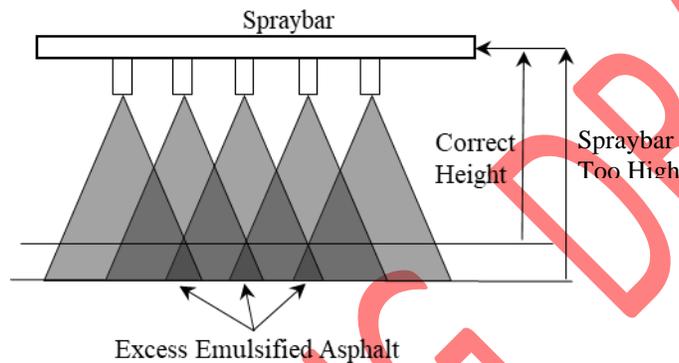


Figure 2—Streaks with Spray Bar Too High for Double Overlap

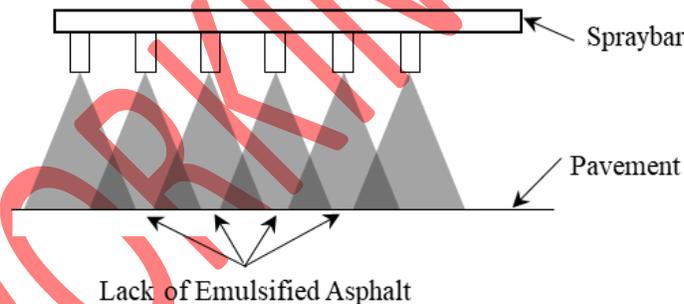


Figure 3—Streaks with Spray Bar Too Low for Double Overlap

To avoid this streaking the bar must be adjusted to the correct height. This adjustment process is accomplished by shutting off nozzles to determine where the spray pattern contacts the pavement as shown in Figures 4 and 5.

407.5.6.1.3. *Bar Height Adjustment to Achieve Double Lap*

Every other nozzle shall be turned off when a double lap application is desired as shown in Figure 4. The distributor operator shall spray asphalt onto the pavement surface for as short an interval as possible while an observer watches where the asphalt hits the pavement from each nozzle left open. If there is overlap of asphalt from adjacent nozzles, the bar is too high. If there is a lack of asphalt from adjacent nozzles, the bar is too low.

Once it is confirmed the bar height is correct, the nozzles that were turned off can be turned back on and a double application of asphalt will result when spraying resumes.

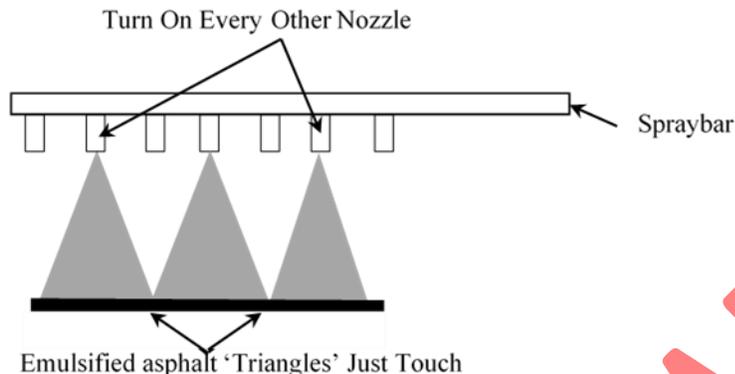


Figure 4—Adjustment of Spray Bar Height for Double Overlap

407.5.6.1.4. *Triple Lap Application Bar Height Adjustment*

Every third nozzle shall be turned off when a triple lap application is desired as shown in Figure 5. The distributor operator shall spray asphalt onto the pavement surface for as short an interval as possible while an observer watches where the asphalt hits the pavement from each nozzle left open. If there is overlap of asphalt from adjacent nozzles, the bar is too high. If there is a lack of asphalt from adjacent nozzles, the bar is too low.

Once it is confirmed the bar height is correct, the nozzles that were turned off can be turned back on and a triple application of asphalt will result when spraying resumes.

As the distributor empties during spraying, the bar height will rise. However, this is not usually enough to cause significant streaking worth adjustment of the spray bar.

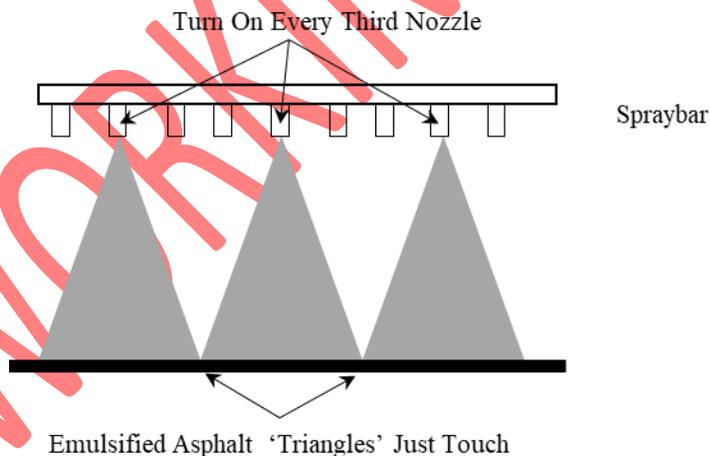


Figure 5. Adjustment of Spray Bar Height for Triple Overlap

Transverse Flow Rate—The flow rate across the spray bar shall be uniform with each nozzle spraying within +/-10 percent of the average flow rate.

Commentary

This is done by measuring the width of the slot in the nozzle and by measuring the orifice diameter. Also, some nozzles are labeled by the manufacturer. Manufacturers supply a list of

nozzles in the owner's document describing which nozzles shall be used for various application rates or on a placard mounted on the equipment.

However, nozzles of the same apparent size have been measured with different flow rates. Therefore, it is recommended that all nozzles be checked for flow rate before chip seal operations begin. This is easily accomplished by fabricating a flow apparatus. This apparatus consists of a pipe to which each nozzle can be fitted, in turn, on one end and a water source can be fitted to the other end. The flow of water through each nozzle shall be measured by filling a 1-gal container in a measured period. This shall be done for each nozzle to be used on the project. If the flow rate of any of the nozzles is greater than 10 percent of the average of all the nozzles to be used these nozzles shall be discarded, or modified to flow within the 10 percent tolerance.

Determination of uniform lateral flow from the spray bar is determined by collecting a measured volume of asphalt in containers placed under each nozzle. This process is practical using standard 6-in. by 12-in. concrete cylinder molds lined with 1-gal zip-lock freezer bags. The cylinder molds can be reused and the zip-lock bags discarded appropriately with the contents.

407.5.6.1.5. *Longitudinal Flow Rate*—The longitudinal spray rate shall be accomplished by measuring the volume of asphalt in the distributor before and after spraying enough asphalt to reduce the volume of asphalt in the distributor by 70 to 90 percent.

Commentary

The longitudinal flow rate must be measured with all nozzles inserted in the distributor bar. First, the quantity of asphalt in the truck must be determined. Although there is a volume indicator on the rear of most modern distributors, these are not calibrated in small enough increments to be of use for longitudinal flow rate calibration and shall not be used for this purpose. Instead, the dipstick supplied with the distributor must be used. This dipstick is usually carried on the top of the tank near the inspection hatch. Prior to shooting asphalt, take a volume reading with the dipstick. Pay attention to how the dipstick is used. Many dipsticks are not intended to be submerged in the asphalt, but instead, are inserted into the top of the tank only until the tip of the dipstick touches the surface of the asphalt. Then, the volume in the tank is read by indexing the top of the inspection cover to the reading on the dipstick.

Record this volume as 'beginning volume'. Set up the truck to shoot asphalt and shoot a minimum of 3000 ft. by 12 ft. of asphalt at the design rate using the gallon per minute pump flow volume and truck speed required by the manufacturer to attain this flow rate. Take a second dipstick reading. Record this reading as 'ending volume'. Subtract 'ending volume' from 'beginning volume' and record this as 'volume used'. Determine the area of asphalt sprayed. Divide 'volume used' by the area sprayed in square yards. This is the gallons per square yard applied to the pavement. This value shall then be compared to the distributor computer, if equipped, to evaluate the accuracy of the computer. A correction factor may then be applied to the computer output, if needed, and used for the remainder of the day. This calibration shall be accomplished each day.

An example of this calibration is presented below:

Given:

1800-gal capacity asphalt distributor

12-ft wide spray width

Trial spray distance = 3630 ft

0.32 gal/yd² design spray rate

Dipstick reading beginning of shot = 1765 gal

Dipstick reading end of shot = 265 gal

Calculations:

1. Check to see if enough volume shot. $1765 - 265 = 1500$ gal
2. $1500/1765 = 85$ percent >70 percent and <90 percent. OK, enough applied to be valid
3. Calculate spray rate = $1500 \text{ gal} / (12 \times 3630/9) = 0.31 \text{ gal/yd}^2$

Therefore, decrease distributor speed, or recalibrate computer and recheck.

407.5.6.2. *Aggregate Spreader*

407.5.6.2.1. *Transverse Spread Rate*

The aggregate spread rate shall be uniform across the veil and within +/-10 percent of the average spread rate.

Commentary

Various methods of calibrating this equipment have been used and the ASTM D5624 procedure can be effective. However, a visual assessment of the lateral distribution of aggregate is a good place to start the process since non-uniform distribution can easily be seen. The veil of aggregate deposited on the pavement from the spreader box can be viewed from behind with the spreader moving away from the observer or from the front. Either position for the observer is adequate for viewing how uniform the veil of aggregate is falling out of the spreader box. However, viewing from either front quarter affords the observer a better view of the entire spreader width and is, of course, safer than directly in front of the spreader. Any variation in light passing through the veil of aggregate indicates variation in application rate. More light means a lack of aggregate. Variation in light means the machine shall be stopped, the gates on the spreader contributing to the non-uniformity adjusted and the trial rerun. This procedure provides adjustment to the transverse spread rate. Then, to obtain an objective means of measuring the amount of chips aggregate being deposited, ASTM D5624 is a good procedure to use.

407.5.6.2.2. *Longitudinal Spread Rate*

The longitudinal spread rate shall be uniform and be within +/- 10 percent of the design spread rate.

Commentary

Once the transverse spread rate is adjusted the longitudinal rate can be adjusted. This is also done visually, at first. Begin spreading aggregate into the fresh asphalt when a small quantity of aggregate cast by hand sticks to the asphalt and does not roll over. This shall be done well before the asphalt begins to cool, but not immediately after spraying unless temperature and wind demand it.

The application rate of the aggregate shall be similar to the design rate. This is a rate where immediately upon dropping the aggregate; the appearance of the surface has some asphalt showing between the aggregates. In fact, the aggregate quantity should seem somewhat inadequate. The aggregate spread rate should not be low enough to cause pickup problems on rubber-tire rollers. However, the rate should be such that a small decrease in rate would cause pickup. Asphalt should be visible between the aggregates upon dropping and before rolling. If all asphalt is covered before rolling, there is an excess of aggregate and the rate shall be reduced. It is the responsibility of the construction superintendent to achieve this application rate.

Evaluating the quantity of aggregate being placed is important after the rate is established. This provides a quantitative baseline for future work. The best method to accomplish this evaluation is by weighing the aggregate spreader before and after applying the aggregates and calculating the spread rate based on the area covered. This is often not practical. Therefore, a suitable alternative includes estimating the quantity of aggregate spread over a known area by knowing the weight of each transport truck supplying the spreader and dividing the estimated weight of chips spread by the area covered for that load.

An example follows:

Given:

Trucks loading the chip spreader are 12-ton capacity tandem dumps

12-foot-wide pavement

28 pounds per square yard design spread rate

Calculations:

1. *Check Truck No. 1*
 - a. *Load = 23,803 lb*
 - b. *Spreader distance = 640 ft*
 - c. *Rate = 23,803/640 × 12/9 = 27.9 lb/yd²*
2. *Check Truck No. 2*
 - a. *Load = 23,921 lb*
 - b. *Spreader distance = 634 ft*
 - c. *Rate = 23,921/634 × 12/9 = 28.3 lb/yd²*
3. *Check Truck No. 3*
 - a. *Load = 23,848 lb*
 - b. *Spreader distance = 639 ft*
 - c. *Rate = 23,848/639 × 12/9 = 28.0 lb/yd²*
4. *Average Rate = (27.9 + 28.3 + 28.0) / 3 = 28.1 lb/yd²*
5. *No adjustment needed since measured rate is within 1 percent of design.*

Compensation for moisture on the aggregate must be considered when calibrating chip spreaders. The above example indicates no adjustment is needed since the measured spread rate is within 0.10 lb/yd² of the design spread rate. However, if the aggregate above had contained as much as 1.02 percent moisture that was unaccounted for, the application rate would have been too low.

407.5.7. *Test Strip*—A test strip shall be constructed on or near the project site. Construct the test strip under similar placement conditions of time of day, temperature, and humidity as expected for the duration of the project. The test strip shall be a minimum of 500 feet in length and shall be constructed with the job mix proportions, materials, and equipment to be used on the project. Adjustments to the mixture formula shall be permitted provided they do not exceed the values stated in the mix design. The Agency shall evaluate the test strip to determine whether project specifications are met. If specifications are not met, additional test strips will be constructed until specifications are met, at no additional cost to the Agency.

407.5.8. *Application of Asphalt Binder*
Apply the asphalt binder at the rate determined by the design. This rate shall be within ±5 percent of the chip seal design rate. After applying the binder, place the cover aggregate at the design application rate. Adjust the rate of application, if necessary, so that some binder can be seen between the aggregate chips, but not so much that aggregate chips adhere to the pneumatic rollers. Inspect the aggregate in the wheel paths for proper embedment. Embedment shall be 50 to 70 percent after rolling. Make additional adjustments to the rate of application during the project, if needed.

The temperature of the binder asphalt at the time of application shall be as recommended by the contractor and approved by the Engineer. Recommended application temperatures are given in Table 3.

Table 3—Suggested Application Temperatures as a Function of Binder Type

Binder Type	Minimum Application Temperature, °F
Asphalt Rubber	375
Rubber Modified Asphalt	350
PG Asphalt Polymer Modified	325
PG Asphalt Non-Modified	275

Commentary

If the temperature is lower than 275°F, there is risk of less material being applied than desired due to high viscosity.

The longitudinal construction joint for a single course chip seal must coincide with the painted lane line or at the outside edge of the shoulder. There shall be no overlap of the longitudinal construction joint for a single application chip seal.

407.5.9.

Application of Aggregate

Aggregates shall be applied immediately after applying the hot asphalt at the design rate using uniformly pre-coated aggregates heated to 175 to 225°F at the time of placement. The longitudinal spread rate shall be measured by placing one measuring pad in front of the spreader at 500-ft intervals for 1,500 ft.

The speed of the spreader shall be restricted to prevent the aggregates from rolling. Starting and stopping of the spreader shall be minimized. The edges of the aggregate application shall be sharply defined. Previously used aggregates from sweeping shall not be returned to the stockpile or the spreader for reuse.

Commentary

Although a design was done to determine the aggregate application rate, adjustments are almost always needed in the field. This should be done during the first day of construction to make sure the aggregate quantity is correct. This is best done by observing the appearance of the aggregate after they have been dropped into the asphalt, but before rolling. Some asphalt should be visible between the aggregate. If asphalt cannot be seen between the aggregate, the rate is too high. Conversely, too much asphalt showing through between the aggregates will cause pickup on rubber tires.

407.5.10.

Transverse Paper Joints—When beginning a new application of the chip seal transversely abutting the previously placed chip seal, a transverse paper joint shall be used so excess asphalt and chips are not placed at the joint. The transverse paper joint shall be formed by placing 36-in. wide Kraft paper on top of the previously applied chip seal so the edge of the paper aligns with the joint that will be formed when the previously placed chip seal meets the newly applied chip seal. The asphalt distributor shall begin applying asphalt binder by starting the application on top of the Kraft paper. After the distributor moves forward and over the joint the paper shall be removed.

Commentary

Ideally, the paper should also be placed at the end of the distributor shot, as well. This creates a clean edge with the correct asphalt and chip quantity at the joint. The placement of the paper is calculated based on the binder shot rate and the quantity of binder in the distributor. The distance the distributor travels before encountering the paper and turning off the bar should be approximately equivalent to 80 percent of the distributor tank volume. This assures the distributor does not spray until empty which can result in less asphalt applied than desired at the end of the shot.

407.5.11.

Rolling Operations—Complete the first roller pass as soon as possible but not longer than 2 min after applying the aggregate. Proceed in a longitudinal direction at a speed less than or equal to 5 to 7 mph. Three complete roller passes over the aggregate are required. One pass is defined as the roller moving over the aggregate in a single direction. Ensure the rolling is completed quickly enough to embed the aggregate, before the binder cools and no longer than 15 min after the binder is applied. Position the rollers in echelon so the entire width of the pavement lane is covered in one pass of the rollers.

Commentary

If desired, final rolling may be accomplished using the steel wheel roller in one pass.

407.5.12.

Sweeping—The removal of loose aggregate material shall commence after final rolling is completed such that the aggregate is not displaced and the asphalt surface is not damaged.

- 407.5.13. *Traffic Control*—The treated roadway shall not be used by the contractor or its agents until it has been established by the Engineer that the roadway will not be damaged or marred under the action of traffic. The contractor shall use signs or other traffic control devices to prevent traffic operating on the newly placed chip seal. Any damage to the hot applied chip seal shall be repaired by the Contractor at no additional cost to the agency.
- 407.5.14. *Protection of Motor Vehicles*—The Contractor shall be responsible for claims of damage to vehicles until the roadways and shoulders have been swept free of loose aggregate and permanent markings have been applied. If permanent pavement markings are to be applied by Agency forces, the Contractor’s responsibility ends after completion of the chip seal.
- 407.5.15. *Fog Seal*—If, in accordance with the plans, a fog seal is applied to the surface of the completed chip seal, spray the fog seal after sweeping and before placement of permanent pavement markings, but not sooner than 24 h after final rolling. Refer to the AASHTO Construction Guide Specification for Fog Seals (Section 410) in the section for application over chip seals for specific requirements.
- Commentary
- Fog seals are applied to the surface of completed chip seals for two reasons: 1) The dark color provides more contrast to pavement markings, 2) the fog seal provides a slight increase in binder residue to increase aggregate retention.*
- A fog seal may also be applied to recent hot mix asphalt patches in the pavement to be chip sealed. These fresh hot mix patches can be more absorptive than the surrounding pavement due to higher air void content. The fog seal helps prevent the new chip seal asphalt from being absorbed into the substrate unevenly.*
- 407.5.16. *Sequence of Work*—Construct the chip seal so that adjacent lanes are sealed on the same day when possible. If the adjacent lane(s) has not been sealed sweep all loose aggregate from the unsealed lane(s) before traffic is allowed on the surface without traffic control. The permanent pavement markings shall not be placed for three days after placing the fog seal for water borne pavement marking or ten days for other types of markings.
- Commentary
- The chip seal will usually cure within 24 hours under dry conditions and temperatures above 60°F. The fog seal can be applied after the chip seal coat is cured. The fog seal will usually cure within 2 hours under dry conditions and temperatures above 60°F. Interim pavement markings can be placed after the fog seal cures. Do not allow traffic on the fog seal until cured.*
- 407.5.17. *Quality Control*
- 407.5.17.1. *General*
- The Contractor is responsible for quality control (QC) of the materials and workmanship and shall submit a QC plan s for verifying the quality of the materials and workmanship. The Contractor’s QC plan shall include but is not limited to sampling, testing, inspection, monitoring, documentation, and corrective action procedures during transport, stockpiling and placement operations.
- A written Quality Control Plan (QCP) shall be developed which details the Contractors’ QC program that meets the requirements of these specifications. The QCP shall be contract specific and signed by the Contractors’ representative. Chip seal construction shall not proceed without Agency acceptance of the QCP and QC personnel present on the project. The Contractor shall at a minimum, provide the name of the person responsible for each position listed below, including their telephone number, email, and their qualifications/certifications
- Failure to comply with these provisions will result in shutdown of the operations until such time as the Contractor’s operations are in compliance.
- 407.5.17.2. *Personnel*—QC staff requirements and responsibilities shall include the following as a minimum:

- a) *QCP Manager*—The person responsible for the execution of the QCP and liaison with the Agency. This person shall be on the project, and have the authority to stop or suspend construction operations.
- b) *QC Technicians*—The person(s) responsible for conducting QC tests and inspection to implement the QCP. QC technicians shall have Level 2 Aggregate Testing Certification from the American Concrete Institute (ACI) or other accrediting body approved by the Agency.
- c) *Certified Crew Members*—Three crew members (job foreman, aggregate spreader operator, and asphalt distributor operator), at a minimum, shall possess a valid chip seal certification and be on the project at all times the chip seal is being constructed. The chip seal certification is administered by the National Center for Pavement Preservation (NCP) on behalf of AASHTO TSP2 (Transportation System Preservation Technical Services Program).

407.5.17.3. *Testing Facilities and Equipment*

- a) The laboratory that performs the QC for production can be either qualified or agency approved. The Contractor shall provide the name of the agency approved lab for all tests within the relevant scope of testing
- b) Testing and sampling equipment and measuring devices shall meet the requirements of the specified standards and test methods. The lab shall maintain records of the calibration and maintenance of all sampling, testing, and measuring equipment, and all documents required by the agency.
- c) Placement Equipment Calibration -prior to the commencement of work , the asphalt emulsion distributor and aggregate spreader shall be calibrated in the presence of the Agency representative utilizing the materials to be used on the project. Calibration will be performed consistent with procedures in FHWA-HIF-19-029, Chip Seal Checklist, 2019.

407.5.17.4. *Materials Testing*—Chip seal aggregates and asphalt binders shall be tested for compliance with the specifications. Only asphalt binders from certified or approved sources shall be allowed.

407.5.17.4.1. *Chip Seal Aggregate method A or Method B :*

A) *Stockpile* Aggregate samples will be taken at the project stockpile site using AASHTO R 90 Method B a minimum of once per day of placement and for every change of source. Samples shall be tested in accordance with AASHTO T 27 to determine compliance with Table 1 requirements. The testing rate for quality values in Table 2 shall be once per source. If the material is hauled to a temporary stockpile on the project, sample and test the temporary stockpile.
OR

B) *Hopper During Construction*— Aggregate samples shall be taken from the hopper of the aggregate spreader a minimum of once per day of placement or every change of source. Samples shall be tested in accordance with AASHTO T 27 to determine compliance with Table 1 requirements. The testing rate for quality values in Table 2 shall be once per source.

407.5.17.4.2. *Asphalt Rubber*—Sampling shall be completed at the point of manufacture, at either the terminal or field blending unit for safety reasons. Testing and reporting shall be completed on these samples. As a minimum, the following data shall be reported for all samples:

- Total quantity of binder in tons;
- Tons and percentage of ground tire rubber based on total asphalt rubber binder; and
- ASTM D6114 certified test results.

407.5.17.4.3. *Rubber Modified Asphalt*

407.5.17.4.3.1. Only asphalt binder from a certified or approved source is allowed for use.

407.5.17.4.3.2. Verify the RMA meets specifications by obtaining a certificate of compliance for each load provided.

407.5.17.4.4. *Performance Graded Asphalts*

407.5.17.4.4.1. Only PG asphalt binder from a certified or approved source is allowed for use.

407.5.17.4.4.2. Verify the PG binder meets specifications by obtaining a certificate of compliance for each load provided.

407.5.17.4.5. *Emulsified Asphalt for Fog Seal*

If required, only emulsified asphalt from certified or approved sources is allowed for use. Verify the asphalt(s) meet the specifications by obtaining certificates of compliance from the supplier.

Verify the application rate of the emulsified asphalt by dividing the volume of emulsified asphalt used by the area chip sealed each day. Allowable variation is ± 5 percent of the application rate adjusted from the design quantity. Provide material certification and quality control test results for each batch of emulsified asphalt used on the project. Include the supplier name, plant location, asphalt grade, and batch number on all reports.

407.5.17.5. *Calibration of Equipment and Workmanship*—Describe the equipment and methods used to calibrate the chip spreader and asphalt distributor including:

407.5.17.5.1. *Longitudinal Application Rates*

407.5.17.5.2. *Transverse Application Rates*—Describe the process to be used to ensure

- Good workmanship including asphalt transverse application uniformity
- Transverse joint construction technique
- Longitudinal and transverse joints construction techniques
- Monitoring methods for application rates to minimize bleeding, aggregate loss, and streaking
- Rolling operations detailing rolling pattern and number of passes or coverages
- Sweeping operations and schedule
- Method of controlling traffic

407.5.17.6. *Documentation*—Describe the documentation and reporting procedures for all QC activities. Include samples of all QC test forms, inspection and test reports.

407.5.17.7. *Records and Documentation*

The Contractor shall maintain complete records of all QC tests and inspections.

All QC test results shall be submitted to the Agency as required or at the end of the contract. A material certification shall be submitted from each supplier for each batch of material delivered to the project, including test results.

The QC records shall contain all test and inspection reports, forms and checklists, equipment calibrations, supplier material certificates, and non-conformance and corrective action reports.

The QC records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities conforming and non-conforming, and the nature of corrective action taken as appropriate for materials as well as workmanship. The QC records shall be available to the Agency at all times, and shall be retained by the contractor for the life of the contract. The Contractor's documentation procedures will be subject to approval by the Agency prior to the start of work, and to compliance checks by the Agency during the progress of the work.

407.5.17.8. *Compliance with Specifications*—The Contractor shall attest in writing to the Agency that the chip seal has been constructed in accordance with and meets the requirements of the specifications at the conclusion of the project.

407.5.18. *Agency Acceptance*

407.5.18.1. *General*

The Agency will conduct acceptance sampling, testing, and inspection activities to ensure material quality, correct application rates, rolling, sweeping, and traffic control are within specification requirements. These activities will be done randomly by the Agency.

407.5.18.2. *Acceptance Activities*

407.5.18.2.1. *Materials Testing*

407.5.18.2.1.1. *Asphalt Binders*—Sample the first shipment and provide one sample for every 50,000 gal (approximately 200 tons) thereafter. Testing of the binders shall be in accordance with M 320 or M 322.

407.5.18.2.1.2. *Aggregate*

Sample aggregate taken from project stockpile or the aggregate spreader hopper once per day . Samples shall be stored and tested for gradation at the discretion of the Agency. If the results vary from the requirements of AASHTO T 27 Tables 2 and 3, a price reduction shall be applied per the Schedule of Price Reduction prepared by the owner agency.

Price adjustments are not included in this guide since most agencies do not use them for this type of treatment.

407.5.18.2.1.3. *Fog Seal Emulsion*—(If used) Sample the first shipment and provide one sample for every 50,000 gal (approximately 200 tons) thereafter. Testing of emulsified asphalts shall be in accordance with M 140, M 208, and M 316.

407.5.18.2.2. *Equipment*—All equipment to be used on the project shall be evaluated by the Agency to assure it is in acceptable operating condition, calibrated correctly and shall provide the quantities of material specified.

407.5.18.2.3. *Final Inspection*—A final inspection shall be done to assure that no bleeding or flushing, excessive chip loss, or crushed aggregate has occurred. Longitudinal and transverse joints shall be inspected to assure that no excessive overlap has occurred.

407.6. MEASUREMENT

The Engineer shall measure work acceptably completed as specified in the *AASHTO Guide Specifications for Highway Construction* and as follows:

407.6.1. *When Payment Is by Unit Price*

407.6.1.1. *Asphalt Binders*—Measure the asphalt binder used for the for chip seal by volume, at 60°F.

407.6.1.2. *Aggregate* —Aggregate will be measured by the area of pavement surfaced.

407.6.1.3. Fog seal. Measure the emulsified asphalt used in the fog seal by Volume, at 60°F.

Commentary

Aggregate s can be paid for by the ton, as well. This is easier to verify, but results in an incentive to place more aggregate s than necessary. Applying too much aggregate is poor practice and results in dislodgement of embedded aggregates. Also, paying by the ton will result in unnecessary additional cost.

407.7. PAYMENT

Payment for chip seals can be done by either paying for the materials in unit costs, or for the completed chip seal by area of pavement sealed.

Commentary

The advantage of payment by the square yard for a completed chip seal is simplicity if the area is easily defined. The disadvantage is that an incentive is created to reduce material quantities. Reduced asphalt quantities can lead to aggregate loss and vehicle damage.

407.7.1. *Payment by Unit Price*—The Agency shall pay for accepted quantities at the contract price as follows:

1. Payment for the accepted quantity of asphalt binder and aggregate for chip seal (including any required additives) at the contract bid price of measure is compensation in full for all costs of furnishing and applying the material as specified.
2. If used, payment for the accepted quantity of the fog seal at the contract bid price of measure is compensation in full for all costs of furnishing and applying the material as specified.
3. Payment shall be made in accordance with the schedule set forth below at the Contract bid price for the specified unit of measure.

Item No.	Item	Unit
State ##	Hot asphalt for chip seal	gal
State ##	Aggregate for chip seal	tons
State ##	Diluted emulsion for fog seal, if used	gal

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

407.7.2. *Payment for Completed Chip Seal*

1. Payment for the accepted quantity of the chip seal at the Contract bid unit price of measure is compensation in full for all costs of furnishing and applying the material as specified. Payment shall be made in accordance with the schedule set forth below at the Contract bid price for the specified unit of measure.

Item No.	Item	Unit
State ##	Chip seal	yd ²
State ##	Diluted emulsion for fog seal, if used	gal

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.