Quality Improvement Publication **128**

Best Practices for EMULSION TACK COATS

Dale S. Decker, P.E.
Consulting Engineer
Dale S. Decker LLC

NATIONAL ASPHALT PAVEMENT ASSOCIATION

This publication is provided by the Members of the National Asphalt Pavement Association (NAPA), who are the nation's leading asphalt producer/contractor firms and those furnishing equipment and services for the construction of quality asphalt pavements.

NAPA Members are dedicated to providing the highest quality asphalt paving materials and pavements, and to increasing the knowledge of quality asphalt pavement design, construction, maintenance and rehabilitation. NAPA also strongly supports the development and dissemination of research, engineering and educational information that meets America's needs in transportation, recreational, and environmental pavements.

This publication is designed to provide information of interest to NAPA Members and is not to be considered a publication of standards or regulations. The views of the authors expressed herein do not necessarily reflect the decision making process of NAPA with regard to advice or opinions on the merits of certain processes, procedures, or equipment.

Best Practices for Emulsion Tack Coats

Quality Improvement Publication 128

Published October, 2020

Best Practices for EMULSION TACK COATS

Dale S. Decker, P.E.
Consulting Engineer
Dale S. Decker LLC

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

6406 Ivy Lane, Suite 350, Greenbelt, MD 20770-1441
Tel: 301-731-4748 | Fax: 301-731-4621 | Toll free 1-888-468-6499
www.AsphaltPavement.org

Audrey Copeland, Ph.D., P.E., *President & CEO*
Monica Dutcher, *Editorial Director*
PJB Marketing, *Design / Layout*

@NAPATweets
at National Asphalt Pavement Association
at National Asphalt Pavement Association
at National Asphalt Pavement Association
@goasphalt

ACKNOWLEDGEMENTS

Acknowledgement is given to the Transportation Research Board through the National Academy of Sciences for granting permission to reproduce material from NCHRP Report 712: Optimization of Tack Coat for HMA Placement in the development of this publication. Inclusion of this material does not imply Transportation Research Board, AASHTO , Federal Highway Administration, Transit Development Corporation, Federal Transit Administration, Federal Aviation Administration, or Federal Motor Carriers Safety Administration endorsement of a particular product, method, or practice.

Additional recognition is given to the following companies and individuals for sharing photographs and/or graphics on tack coat applications:

BearCat Manufacturing
Calder Brothers Corp.
E.D. Etnyre & Co.
Kent Hansen, P.E.
The HollyFrontier Asphalt Co.
Jim Scherocman, P.E.
Roadtec
Rosco/LeeBoy
Wirtgen

Sincere appreciation goes to the following members, friends, and staff of NAPA that provided technical review of this guide:

Jim Barnat, Road Science, division of ArrMaz Custom Chemicals
John Barrett, Carolina Sunrock LLC
Shane Buchanan, Oldcastle Materials Group
John Bukowski, Federal Highway Administration
Trenton Clark, Virginia Asphalt Association
Audrey Copeland, National Asphalt Pavement Association
William Fair, Flexible Pavements of Ohio
Frank Fee, NuStar Asphalt LLC
Jeff Graf, Maryland Paving Inc.
Kent Hansen, National Asphalt Pavement Association
Jim Huddleston, Asphalt Pavement Association of Oregon
Arlis Kadrmas, BASF Corp.
Jim Klett, Klett Construction, an Oldcastle Materials Co.
Larry Patrick, Oklahoma Asphalt Pavement Association
Eric Tulk, Blacklidge Emulsions Inc.
John Victory, Barriere Construction Co. LLC
Jim Warren, Asphalt Contractors Association of Florida
Scott Watson, Blacklidge Emulsions Inc.

Best Practices for EMULSION TACK COATS

INTRODUCTION

Long-term performance of an asphalt pavement is significantly related to the bond developed between successive pavement layers. To aid in achieving a bond between asphalt pavement layers, tack coat material is applied between pavement layers. The development of the bond between layers is strongly related to the tack coat application.

This publication provides guidelines for the selection of tack coat emulsion type, application rate, placement, and evaluation. Historically, tack coat selection has been based primarily on experience, convenience, and/or empirical judgment. While no clear protocol for quality assurance testing of the tack coat construction process is currently accepted, new tests with potential application are being developed and may be available in the future.

This publication is organized into the following chapters:

Chapter 1 – Describes the purpose of a tack coat
Chapter 2 – Discusses tack coat materials and their evaluation
Chapter 3 – Provides information on tack coat application equipment
Chapter 4 – Describes the determination of residual tack coat rate and evaluation of the existing pavement condition
Chapter 5 – Discusses the concepts of break and set times, the importance uniform tack coat application, and issues of tack coat misapplication
Chapter 6 – Presents a summary of tack coat best practices

Author Notes:
This publication presents state-of-the-practice for emulsion tack coats. As reported in *NCHRP Report 712: Optimization of Tack Coat for HMA Placement*, emulsion tack coat is overwhelmingly the tack coat of choice around the world and is the focus of this publication. For additional information on liquid asphalt binder and cutback asphalt applications, the reader is referred to NCH RP Report 712.

The terms "asphalt pavement" or "asphalt mixtures" will be used to encompass both hotmix asphalt and warm-mix asphalt.

1 PURPOSE OF A TACK COAT

This chapter provides an overview of tack coats and why they are used.

Tack coat is defined by American Society of Testing and Materials (ASTM) as "an application of bituminous material to an existing relatively non-absorptive pavement surface to provide a thorough bond between old and new surfacing." An adequate bond between pavement layers is necessary for traffic loads applied to a pavement's surface to be transmitted down through the pavement structure.

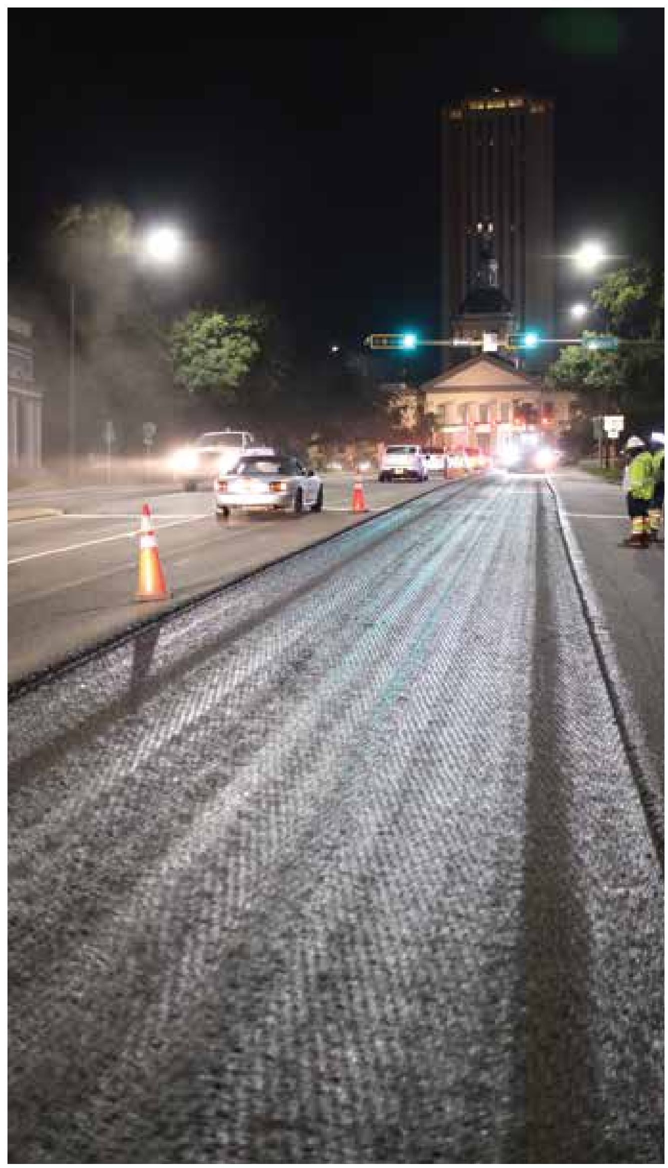
If the surface layer or other layers are not properly bonded to the underlying pavement layer, horizontal shear forces at the layer interface will increase the tendency for cracking, debonding, and fatigue failure in the upper portion of the pavement structure. The tack coat (also known as bond coat) and the subsequent bond created between the layers allow the various layers within a pavement structure to act as a composite system with the goal being a unified pavement structure.

Tack coat is normally applied to an existing pavement surface before a new layer of asphalt pavement is placed. It may also be applied to the surface of a new asphalt pavement layer before the next layer is placed, such as between a leveling course and a surface course. If a proper bond is not established between the existing pavement surface and the new asphalt pavement layer, delamination may occur between the layers. This will result in slippage of the new mix relative to the existing pavement surface. Thus, in order to construct a durable, long-lasting asphalt pavement, it is critical to apply the proper type and rate of tack coat between pavement layers.

The key factors in determining success of the tack coat application are:

- Condition of the existing pavement
- Tack coat application rate
- Residual binder content
- Proper distribution operation
- Emulsion break and set times

Selection of an optimum tack coat emulsion and application rate is critical for proper bond strength development between pavement layers. Pavement surfaces with different conditions (e.g., new, old, milled, grooved, cracked) require different tack coat application rates to achieve proper interface bond strength. Most importantly, it is the residual amount of asphalt, not the quantity of asphalt emulsion that should be controlled in tack coat applications.



2 MATERIALS USED FOR TACK COAT APPLICATION

This chapter discusses the several categories of tack coat emulsions, as well as how they should be handled, stored, and evaluated.

In order to be applied as a tack coat, asphalt binder must be in a liquid form. There are three ways to make asphalt binder a liquid: heating it, mixing with solvent to make a cutback, or mixing with water and an emulsifying agent (soap) to make an asphalt emulsion. All three of these applications have been used for tack coats over the years. Hot liquid asphalt binder is rarely used today because of safety issues related to the high temperature required for spraying. Cutback asphalts are rarely used today in the U.S. due to environmental considerations associated with the evaporation of the petroleum-based solvent (such as naphtha or kerosene) and because of the relatively low flash point of the materials, which creates a potential safety issue. By far, the most common type of material used for tack coats is asphalt emulsion. For this reason, and because of the safety and environmental concerns regarding liquid asphalt and cutbacks, asphalt emulsion will be the only product discussed in this publication.

Asphalt Emulsion Types

An asphalt emulsion consists of a blend of at least three materials. The majority of the emulsion is asphalt binder, typically between 55 and 70 percent of the total weight of the emulsion. Water is the second largest ingredient, typically from 44 to 29 percent of the total weight of the emulsion. The remaining material is a relatively small quantity of a surfactant or emulsifying agent. The percentage of each component varies as a function of the source and grade of the asphalt binder and the emulsion production process. The reader is encouraged to review the Basic Asphalt Emulsion Manual (Asphalt Institute, 2008) for detailed information on emulsion production.

Emulsions are manufactured in specialized production facilities and are divided into three categories: Anionic, Cationic, and Nonionic. For background, an anionic emulsion has a negative electrical charge and a cationic emulsion has a positive electrical charge associated with the asphalt droplets suspended in water. If the letter "C" is placed in front of the emulsion grade, the emulsion type is cationic. If the letter "C" is not shown in front of the emulsion grade, the emulsion type is anionic. Nonionic emulsions are not generally used for pavement construction. For use as tack coat, the differences between anionic or cationic emulsions are generally not significant due to the very small amount of emulsion applied to the existing pavement surface.

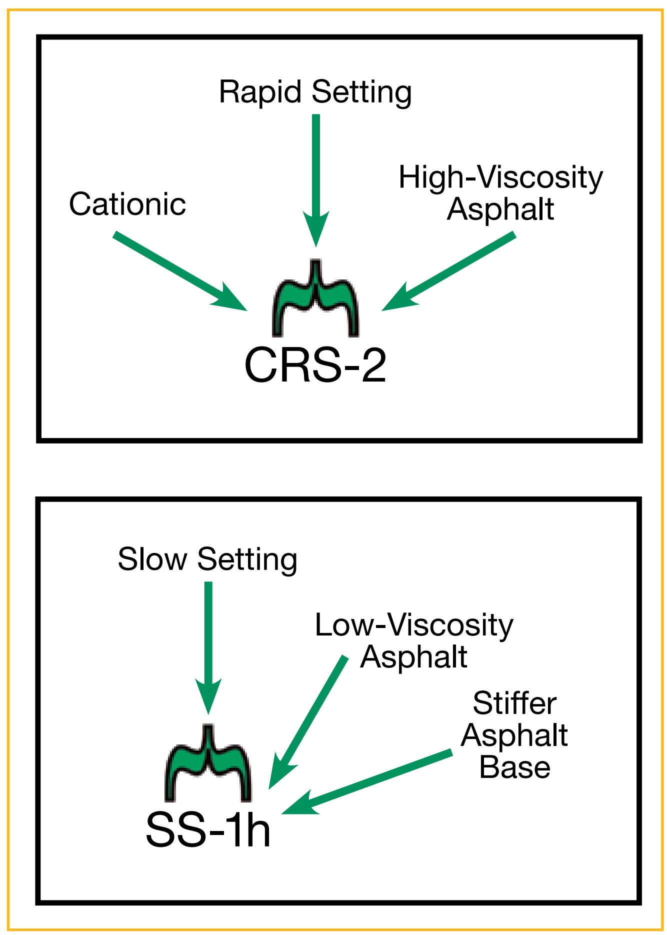


Figure 2-1. Crack the Code

Emulsions are further divided into four additional categories — rapid set (RS), medium set (MS), slow set (SS), and, although less commonly used in tack coat applications, quick set (QS) — depending on how quickly the asphalt will coalesce or revert back to the form of asphalt binder (this process is commonly called "breaking" of the emulsion, see Chapter 5). An additional emulsion classification is high float (HF) in which the emulsifier forms a gel structure in the asphalt residue. The thicker asphalt film allows HF emulsions to provide resistance to flow at higher temperatures. Some emulsions are graded with the letter "h" following the emulsion classification, indicating that a stiffer (harder) base asphalt was used in the emulsion. Figure 2-1 illustrates how to read emulsion grades.

SS emulsions are most commonly used for tack coats. SS -1, SS -1h, CSS -1, and CSS -1h are four types of slow-set emulsions. Other types of asphalt emulsions sometimes used as a tack coat include rapid-setting emulsions: RS-1, RS-2, CRS-1 and CRS-2.

A new product generically called "non-tracking tack" has been recently introduced. Several companies produce non-tracking products. Although there has been no official standardization of the nomenclature for the non-tracking products to date, many state specifications are using "NT" or "TT" to designate a non-tracking material.

Polymer-modified asphalt emulsions (PMAE) are often used for specialty applications, including spraypaver applications (see Chapter 3). The product may be identified as a conventional emulsion with a "P" following the designation, e.g., SS-1hP.

Table 2-1 presents the typical emulsions used for tack coat applications along with the appropriate ASTM standards and minimum residual asphalt binder content.

Many SS asphalt emulsions, although not polymer-modified or non-tracking tack, are diluted with additional water for use as a tack coat. The primary reason for diluting the emulsion is to provide for more uniform application of the tack coat emulsion. The greater volume of the diluted emulsion provides a more consistent and uniform spray pattern from the nozzles on the distributor because the distributor pump is more accurate at a greater volume. The most common dilution rate is a 1:1 ratio of SS asphalt emulsion to additional water, resulting in a material that is one part asphalt emulsion and one part additional water. This dilution provides great accuracy for spraying a small amount of material on a pavement.

Most often, dilution of the asphalt emulsion occurs at the terminal of the emulsion supplier. This is the preferred location as the dilution rate can be carefully controlled. The dilution can also be accomplished at an emulsion tank at the contractor's plant. When diluting an emulsion, a higher application rate may be required in order to obtain the desired residual asphalt content.

Table 2-1. Typical Tack Coat Emulsion Types

Emulsion Product	ASTM Standard	Minimum Residual Asphalt Binder in Emulsion, %
SS-1 and SS-1h	D977	57
CSS-1 and CSS-1h	D2397	57
RS-1	D977	55
RS-2	D977	63
CRS-1	D2397	60
CRS-2	D2397	65
PMAE	Agency Dependent	Producer Dependent
Non-Tracking Tack	Agency Dependent	Producer Dependent

Polymer-Modified Asphalt Emulsion

If a polymer-modified asphalt emulsion is to be used as a tack coat, the residual tack coat rate will typically be the same as for a non-polymer-modified asphalt emulsion. The use of a polymer-modified emulsion may be beneficial for some pavement applications.

Non-Tracking Tack Coat Emulsion

Some polymer-modified asphalt emulsions have been developed that incorporate a hard base asphalt as part of the emulsion. This harder base asphalt, combined with the polymer additive, reduces the amount of tracking that may occur on the tires of the haul trucks as well as the tire or tracks of the asphalt paver. The application rate for this material is similar to that of a normal, undiluted asphalt emulsion.

KEY POINTS

- **In order to maintain the quality of an emulsion product,** it is recommended that any dilution be performed at the emulsion terminal or in a tank at the asphalt plant. Emulsions should not be diluted in the distributor at the project site.
- **Polymer-modified and non-tracking emulsions** should not be diluted for use as tack coat.

That said, non-tracking tack coat emulsions typically break and set faster than a standard asphalt emulsion and yield a non-sticky residue at the temperatures associated with pavement construction. The heat from the new asphalt layer activates the non-tracking tack coat residue to create a strong bond. This may significantly reduce the amount of tracking that occurs on the tires of the construction traffic and passenger vehicles. (See Chapter 5.)

Storing Asphalt Emulsions

The Asphalt Institute (AI) and the Asphalt Emulsion Manufacturers Association (AEMA) provide a thorough list of storing and handling recommendations in the Basic Asphalt Emulsion Manual. This manual is an excellent reference for technical details regarding asphalt emulsions. Following is a simplified listing of the recommendations for tank storage:

- Obtain, read, and follow the emulsion supplier's storage recommendations.
- Whenever possible, use a vertical tank to minimize the surface area exposed to air. This minimizes "skinning" of the top surface of the emulsion in the tank.
- Store as shown in the following table.

Emulsion Grade	Min. Temp. °F	Max. Temp. °F
RS-2, CRS-1, CRS-2	125	185
RS-1, SS-1, SS-1h, CSS-1, CSS-1h	50	140
Non-Tracking Tack	120	180
PMAE	120	180

- Do not heat the emulsion above 185°F to avoid damaging the product.
- Do not let the emulsion freeze to avoid separation of the asphalt and water.
- Do not allow the temperature of the heating surface to exceed 212°F, but if this is unavoidable, such as with a direct fire heating source, ensure that the emulsion is agitated or circulated during heating to avoid boiling adjacent to the heating source.
- Do not use forced air to agitate the emulsion, as it will break the emulsion.
- Do not allow excessive agitation by mixing or pumping.

Handling Asphalt Emulsion

- Obtain, read, and follow the emulsion supplier's Material Safety Data Sheet (MS DS) or Safety Data Sheet (SDS) recommendations.
- Provide adequate ventilation to avoid exposure to fumes, vapors, and mist.

- Agitate gently when heating emulsion to minimize skin formation in the tank.
- Do not let pumps, valves, and lines freeze in winter.
- Clean out lines and leave drain plugs open when not in service.
- Ensure that tanks and equipment contain accurate thermometers. Gradually warm up the pump to about 150°F to facilitate start up.
- Dilution of the asphalt emulsion should only occur at the emulsion manufacturing facility. Dilution should not be done by the contractor in the distributor tank.
- Avoid repeated pumping and recirculation of the emulsion to ensure storage stability.
- Ensure that inlet pipes and return lines are at the bottom of the tank to prevent foaming.
- Pump emulsion from the bottom of the tank to minimize contamination from skin formation on the surface.
- Haul emulsion in truck transports with baffle plates to prevent sloshing.
- Agitate emulsions slowly if they have been in prolonged storage.
- Consult with emulsion supplier before mixing different emulsions of the same grade to ensure compatibility.
- Do not mix different classes, types, and grades of emulsified asphalt in storage tanks, transports, and/or distributors.
- Do not load emulsion into any tank containing remains of incompatible materials. A “heel” of liquid asphalt, cutbacks or any petroleum solvent in the tank will not only damage the emulsion but can create significant safety problems.
- Do not apply severe heat to pumps or valves handling emulsions.
- It is highly recommended that the emulsion tank be cleaned at least once annually.

The *Basic Asphalt Emulsion Manual* also provides troubleshooting guidelines for emulsion products.

Sampling Asphalt Emulsion

As with other construction materials, getting a good sample of asphalt emulsion is important to verify the quality and consistency of the emulsion. ASTM D140, “Standard Practice for Sampling Bituminous Materials,” provides standard practices for sampling emulsions. Some notes from that standard are as follows:

- Containers for emulsions are required to be widemouth jars or bottles made of plastic, wide-mouth plastic-lined cans with lined screw caps, or plasticlined triple-seal friction-top cans. (See Figure 2-2.)
- Containers should be 1 gallon in size.
- Sample containers shall be new and shall not be washed or rinsed or wiped with an oily cloth.
- Do not use any contaminated container. Top and container shall fit together tightly.
- Fill container completely to minimize skin formation.
- Care shall be taken to prevent the sample from becoming contaminated. Immediately after filling, the container shall be tightly and positively sealed.
- Use only a clean dry cloth to clean the sides of the filled container, if necessary.
- Protect the sample of emulsion from freezing.
- Do not transfer a sample from one container to another.
- Properly identify the sample on the side of the container or with a tag that will not be lost in transit.

Figure 2-2. Sample of Asphalt Emulsion

Testing Emulsions

Shown in Table 2-2 is a typical emulsion test results report. The emulsion supplier provides a copy of this "certification sheet" with delivery of the product or upon request. These tests are not performed by the contractor. The following is a brief description of what the test results mean, based on the *Basic Asphalt Emulsion Manual*.

Table 2-2. Typical Emulsion Test Results

	SS-1h				Test Method
	Specifications		Typical Test Data		
	Min.	Max.			
Tests on Emulsion Material					
Viscosity, Saybolt Furol @ 25°C, sec	20	100	37		AASHTO T 59
Sieve Test, %	—	0.10	0.00		AASHTO T 59
Storage Stability, 24 hrs	—	1.0	0.3		AASHTO T 59
Unit Weight @ 25°C, lbs/gal	n/a	n/a	8.492		AASHTO T 59
Cement Mixing	—	2.0	0.0		AASHTO T 59
Residue by distillation to 260°C, %	57	—	62		AASHTO T 59
Tests on Distillation Residue					
Pen @ 25°C, 100 g, 5 sec, 0.1 mm	40	90	80		AASHTO T 49
Ductility @ 25°C, 5 cm/min, cm	40	—	120		AASHTO T 51
Solubility in Trichloroethylene, %	97.5	—	99.9		AASHTO T 44

This statement of typical test results contains actual test results that are believed to be representative of the properties of the product shipped with this statement, in concrete form. The values may be from testing of product other than the product shipped with this statement.

Tests on Emulsion Material

Viscosity, Saybolt Furol at 25°C (77°F), sec: This test measures the "fluidity" or consistency of the emulsion. Viscosity is a key engineering property for asphalt materials and is a measure of the resistance to flow. A sample is poured into a viscosity container with a plugged hole in the bottom. At the test temperature, the plug is removed and the number of seconds for the sample to flow out of the container is measured and reported. This test ensures that the tack coat can be adequately applied to the pavement. If the viscosity is too high, the emulsion will not spray or flow and level properly. If the viscosity is too low, the emulsion may run off the edge of the road.

Sieve Test, %: This test is used to determine the percent of oversized particles of asphalt binder. These particles might clog the nozzles of the application equipment. The sample is washed over a No. 20 sieve to determine the retained percentage of asphalt particles. This test may be waived if successful field application can be demonstrated.

Storage Stability, 24 hrs, %: The purpose of this test is to detect the tendency of asphalt particles to "settle out" during storage of asphalt emulsions.

Unit Weight @ 25°C (77°F), lbs/gal: This test is to determine the mass of a known volume of emulsion. Asphalt emulsions are usually sold on a ton basis and therefore a pounds per gallon unit weight allows project personnel to convert that weight to volume to determine the average emulsion application or spread rate.

Cement Mixing, %: This test is used for slow-setting emulsions to ensure that the products won't rapidly coalesce in contact with fine-grained soils or dusty aggregates. Cement is mixed with emulsion and washed over a No. 14 sieve to determine the percent retained. While required by some specifications, this property is not generally considered critical to tack coat quality.

Residue by distillation to 260°C (500°F),%: Asphalt and water are separated by distilling the water from the emulsion. The proportions of asphalt and water are determined. The type of emulsion will determine the minimum required residue percentage. (Distillations at lower temperatures of 400°F (204°C) or 350°F (177°C) are typically used for polymer-modified emulsions to ensure that the polymer does not deteriorate or change due to the high temperatures.)

Tests on Distillation Residue

Penetration at 25°C (77°F), 100 g, 5 sec, 0.1 mm: This test is used to measure the hardness of the asphalt recovered from the distillation test. A 100-gram weight is applied to a needle placed on the surface of asphalt in a container at 77°F (25°C). The distance the needle penetrates in 5 seconds is recorded in tenths of a millimeter. Lower penetration rates indicate a harder asphalt.

Ductility @ 25°C (77°F), 5 cm/min, cm: A dog boneshaped sample of residue by distillation is formed in a mold, allowed to cool, and then brought to 77°F (25°C) in a water bath. The sample is then pulled at a rate of 5 cm per minute until it fractures. The ductility value is how far the material elongates, in centimeters, until it fractures.

Solubility in Trichloroethylene (TCE), %: This test measures the purity of the asphalt residue. A sample of asphalt or residue by distillation is dissolved in solvent and then filtered to determine percentage purity. Many agencies and suppliers no longer measure and report solubility because the test involves the use of a dangerous solvent which many polymers and other additives may not be soluble in this solvent, and because the results of this test are not critical to tack coat quality.

3 APPLICATION EQUIPMENT

This chapter covers tack coat application equipment, its use, maintenance, and common situations that may arise.

Asphalt Distributors

An asphalt distributor or a spray paver is employed to apply a tack coat to an existing pavement surface. The fundamentals of distributing tack coat on the pavement surface are relatively simple. A truck with a tank pumps emulsion through a spray bar onto the existing pavement. In order to achieve a uniform distribution of emulsion across the pavement, the following factors must be known and managed: speed of the distributor in feet per minute (ft/min or FPM), the flow rate from the pump in gallons per minute (gal/min or GPM), the spray width in feet and the nozzle type. These elements working together will achieve the proper application rate in gallons per square yard (gal/yd2). These elements are illustrated in Figure 3-1.

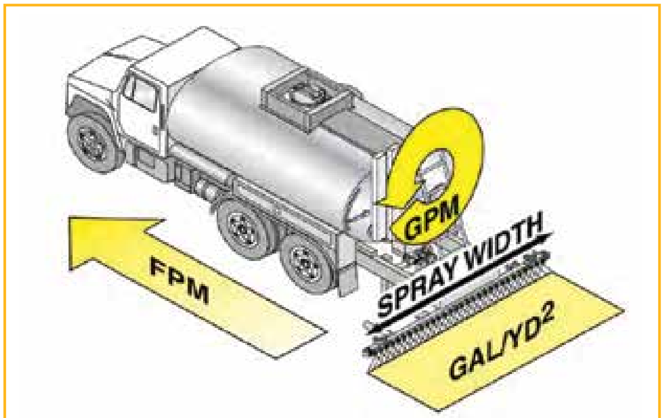


Figure 3-1. Fundamentals of Tack Spraying

The distributor consists of a number of primary parts, including the truck frame, asphalt tank, liquid heating system, variable- or constant-speed pump, spray bar with spray nozzles, and computer system to control the rate of the tack coat application. Tack coat emulsion, however, can also be applied manually, using a hand-wand spray nozzle system. Manual application of tack should be used only for small, inaccessible areas because the application is not as uniform as with a distributor.

Asphalt Tank

The asphalt tank holds tack coat emulsion until it is ready to be applied to the pavement surface. The tank is insulated and typically has a capacity of 500 to 5,500 gallons of emulsion. Tanks normally contain a series of baffle plates to minimize splashing of the emulsion while the truck is moving.

Emulsion Tack Coat Temperatures

Proper temperature for the emulsion is very important and depends on the type of product. Distributors are equipped with heaters, which are used to maintain the temperature of the emulsion to assure the correct viscosity needed for proper spraying. The heaters may be diesel or propane fired or they may be electrically controlled. Heating of emulsions should only occur while the material is being circulated.

The temperature at which an emulsion is maintained in the distributor tank depends on the grade of the emulsion. Table 3-1 presents a summary of guidelines of storage and application temperatures for emulsions. Details of storage, handling, and sampling are presented in Chapter 2.

Table 3-1. Guideline Temperatures for Tack Coat Emulsions

Type and Grade	Spraying Temperature, °F	Storage Temperature, °F
RS-1, SS-1, SS-1h, CRS-1, CSS-1, CSS-1h	70–160	70–140
RS-2, CRS-2	140–185	125–185
Non-Tracking Tack	160–180	120–130
Polymer-Modified Emulsion	140–180	120–130

Emulsion must be maintained in the distributor tank at the appropriate temperature in order to assure uniform flow of the material through the nozzles on the spray bar. If the tack coat emulsion is too cold when sprayed, the material will come out in strings instead of as a uniform spray. The distributor is equipped with a thermometer that displays the temperature of the tack coat emulsion in the tank. If the tack coat emulsion is not within the proper temperature range for the type of product being used, application of the tack coat should be delayed until the material is brought to the proper application temperature.

Cleaning the Distributor Tank

The interior of the tank on the asphalt distributor must be cleaned when changing from one asphalt product to another. For example, if hot asphalt binder is added to a distributor tank that still holds even a very small amount of an asphalt emulsion it may cause severe foaming depending on the amount of emulsion in the tank. This situation presents a significant safety hazard. In addition, mixing materials may significantly change both the properties of the desired emulsion and the appropriate application rate. In general, emptying the tank is the best practice to ensure both safety and product quality. The Basic Asphalt Emulsion Manual provides safety recommendations addressing cleaning the distributor. Be sure to dispose of the discharge and cleaning materials from the tank in accordance with local, state, and federal EPA regulations.

Distributor Pump

Asphalt distributors typically are equipped with either a variable-or constant-speed pump. Distributors may use alternate methods to maintain the pressure needed to pump asphalt materials at different temperatures and application rates. It is important for the pump on the distributor to operate at the proper speed and pressure in order to ensure the desired spray pattern and rate for the emulsion.

On older model asphalt distributors, a tachometer is usually employed to maintain a constant travel speed during the spraying process, as shown in Figure 3-2. A chart is used by the distributor operator to determine the correct combination of pump speed or pump pressure and travel speed. To achieve a consistent application rate with an older distributor, it is very important for the operator to maintain a constant travel speed while spraying the emulsion. This makes achieving a uniform spread rate of the tack coat more difficult when using older distributors.

Figure 3-2. Tachometer-Style Distributor Control

Newer model distributors are equipped with an onboard computer system that determines the relationship between the distributor travel speed and the pump speed or pressure, as shown in Figure 3-3. A consistent application rate is maintained by the computer, which automatically changes the pump pressure as the speed of the distributor changes to compensate for the change in travel speed.

Emulsion is circulated from the tank on the distributor to the spray bar via a pump on the distributor. In addition, when the tack coat application is complete, the pump is used to pull the emulsion material from the spray bar back into the tank.

It is not practical to describe all types of distributor functions in this publication. Therefore, the contractor should refer to the owner's manual or manufacturer instructions for the specific distributor.

Figure 3-3. Control Panel in Distributor Truck

Spray Bar

Emulsion is applied to the pavement surface using the nozzles on the spray bar. Figure 3-4 illustrates the location of the spray bar at the rear of the distributor truck. Optional extensions on the spray bar can be used to increase the width of tack application. These extensions simply fold upward (as shown in Figure 3-5) when the distributor is being relocated or when they are not needed.

Alignment of the nozzles on the spray bar is critical in achieving a uniform application of tack coat. Equally important is using the proper-size nozzles and the correct spray-bar height.

All nozzles used on the spray bar are set 4 inches apart. Thus, there are three nozzles per foot of width of the spray bar. The opening angle of each nozzle must be set the same to achieve the proper amount of spray overlap for adjacent nozzles. As shown in Figure 3-6, the proper nozzle angle setting is between 15 and 30 degrees from the spray bar axis. In normal practice, the angle is set at 30 degrees to the spray bar axis. Figure 3-7 illustrates a triple overlap with properly spaced and angled nozzles at the proper height.

If all the nozzles are not set at the same angle, the spray pattern from one nozzle will interfere with the spray pattern of the adjacent nozzle(s). This will result in non-uniform emulsion application with some portions of the surface receiving excessive emulsion and other portions receiving insufficient emulsion. For example, if all the nozzles are set parallel to the spray bar axis, there will be a heavy amount of tack coat applied where the spray from the adjacent nozzles strike each other and very little tack coat applied directly under the center of the nozzles.

Figure 3-4. Spray Bar on Distributor

Figure 3-5. Folded Spray Bar Configuration

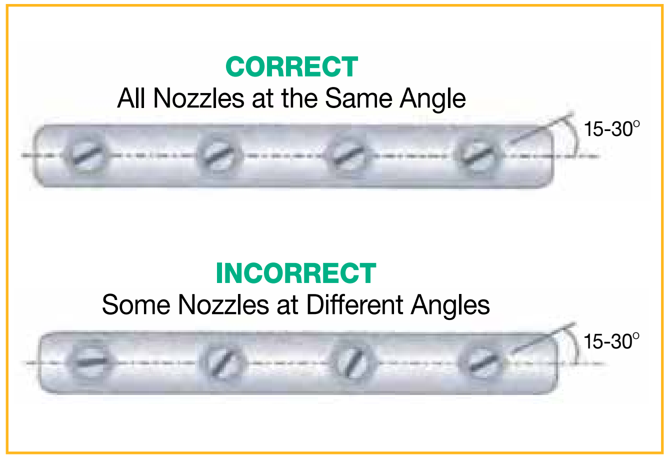


Figure 3-6. Spray-Bar Nozzle Alignment

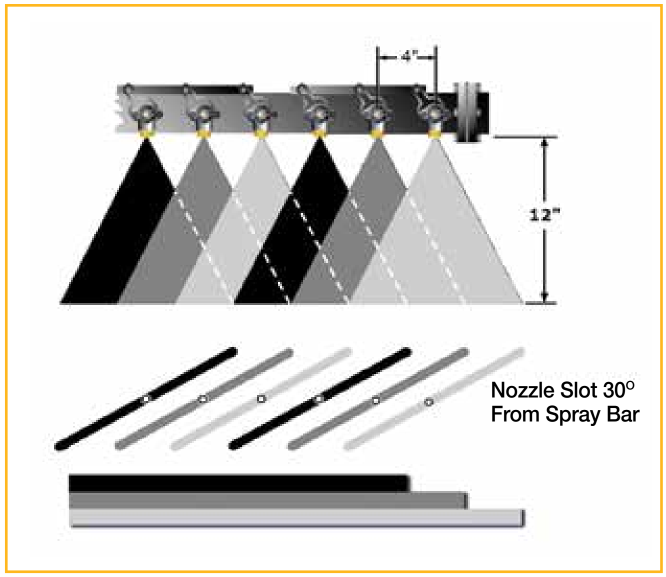


Figure 3-7. Nozzles Set at Correct Angle Provide Triple Overlap

To the other extreme, if the nozzles are set at an angle of 90 degrees to the spray bar axis, the resulting spray pattern will be strings of tack coat emulsion on the pavement surface (Figure 3-8). Those strings will be 4 inches apart. In this case, only a small percentage of the pavement surface will be covered with the tack coat, resulting in an insufficient and non-uniform bond. In some low rate applications it may be necessary to manually turn some nozzles to achieve normal spray patterns and pressures. This may be done by using only one nozzle per foot, in other words two nozzles off per one nozzle on across the spray bar.

Many distributor operators use a nozzle-alignment wrench to set the correct angle of the spray bar nozzles. Use of a wrench, as shown in Figure 3-9, simplifies the setting of all nozzles to the same angle.

Spray-Bar Height

Normally, the height of the spray bar from the pavement surface is set to achieve a triple overlap between the adjacent nozzles (Figure 3-10). This height, which depends, in part, on distributor type, is typically in the range of 9 to 12 inches. Single-lap coverage is rarely employed because of difficulty in matching the spray pattern from the adjacent nozzles. Some contractors choose to employ a double-lap coverage, which is acceptable if the resulting spray pattern uniformly covers the entire pavement surface.

Figure 3-8. **Poor Spray Pattern of Tack Coat Due to Improper Nozzle Alignment, Nozzle Size, and/or Pump Pressure**

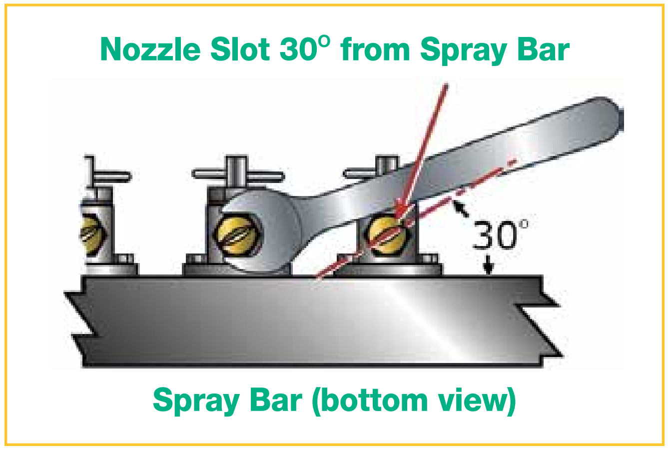


Figure 3-9. **Spray Bar Wrench for Setting Nozzle Angle**

As the emulsion quantity in the distributor tank decreases during application, the weight of the tank decreases and the height of the spray bar will increase. On some older distributors, it is necessary to lower the height of the spray bar as the amount of tack coat emulsion in the tank reduces. On most new distributors, the height of the spray bar is automatically adjusted as the weight of the emulsion in the distributor tank reduces. In either case, it is very important to maintain the correct height of the spray bar in relation to the pavement during application of the tack coat in order to achieve consistent coverage.

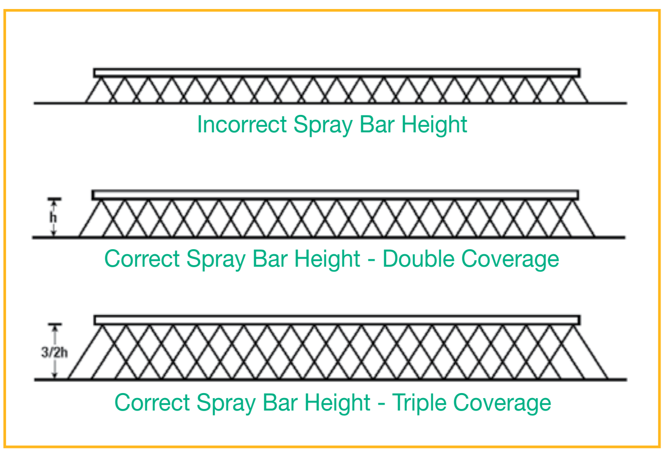


Figure 3-10. **Spray-Bar Height and Tack Coat**

Spray-Bar Nozzle Size

Proper spray-bar nozzle size depends on three primary factors: tack coat application rate, distributor speed, and the type of material being sprayed. Asphalt distributor manufacturers use different nozzle sizes and types for different application rates, and the application rate of the asphalt material is directly dependent upon the size of the nozzles. Recommendations of the distributor manufacturer for nozzle type and size should be understood and followed.

Some contractors use the same distributor to apply asphalt material for chip seals, surface treatments, tack coats, and prime coats. Although the same distributor can be used for these different applications, the same nozzle size cannot be used.

Plugged Nozzles

If an asphalt distributor is not properly maintained, it is possible for some of the nozzles to become plugged. A plugged nozzle will result in a non-uniform distribution of tack coat, as illustrated in Figure 3-11.

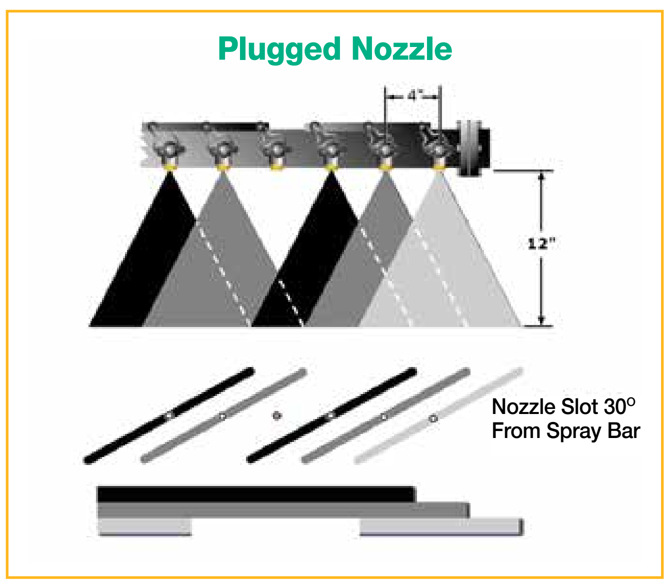


Figure 3-11. **Effect of a Plugged Nozzle**

KEY POINTS

- **Make sure all nozzles are of the same size** and type.
- **Ensure all the nozzles are at the same angle** to get uniform tack coat application.
- **Remember that the amount of residual asphalt needed** for tack coat application is significantly less than the amount of material needed for a chip seal or surface treatment application. The size of the nozzles on the spray bar must be checked to ensure that they are the correct size for uniform application of tack coat emulsions.

Figures 3-12a and 3-12b illustrate tack coat emulsion that was applied using a distributor spray bar with blocked nozzles and the resulting very poor spray pattern. The operator of the distributor should be able to use the truck side mirrors to observe tack coat-application uniformity. The paving crew foreman should also regularly inspect tack coat application to ensure uniformity. Some distributor operators have installed a video camera on the back of the truck with a screen in the cab of the truck, allowing the operator to monitor in real time the application of the tack.

Hand Application

There are often areas on an asphalt paving project where it is not feasible to use the distributor to apply the tack coat emulsion. Such locations include intersections, driveways, around drainage structures and the vertical face of the longitudinal joint (although longitudinal joints should be sprayed with the spray bar). In these cases, the tack coat emulsion is typically applied using a hand wand with the tack coat emulsion fed from the asphalt distributor. Occasionally, a crack sealing bucket or "pot" is used to apply the tack coat emulsion, but this is not considered an acceptable approach. Whichever method is employed, it is extremely important that the tack coat emulsion be

Figures 3-12 a and b. **Tack coat Spray Applied With Plugged Nozzles Other Issues Can Also Result in a Similar Streaky Appearance**

Figures 3-13 a and b. Improper Application of Tack Coat Using a Crack-Sealing Bucket

applied uniformly and that it completely covers the pavement surface. Whatever method is used, manual application of tack coat should be kept to a minimum.

Figures 3-13 and 3-14 are examples of improper application of the tack coat emulsion using hand methods. Figures 3-13a and 3-13b are examples of tack coat applied using a crack-sealing bucket. Figure 3-14 is an example of tack coat applied using a hand wand.

To avoid the inconsistencies of the hand wand, some contractors cover the surrounding area with asphalt roofing felt, use the conventional distributor to spray the asphalt, and then remove the felt. This procedure allows for a more uniform application of tack coat without overspray issues.

There is no measureable way to assure the correct application rate of a tack coat emulsion when using a hand wand. The application rate is solely dependent upon the experience and talent of the person waving the wand. It is important, however, for the application rate to be, as much as possible, the same as that for emulsion applied using the asphalt distributor. That is, hand wand applications should cover essentially 100 percent of the pavement surface and should be as uniform as possible. A crack-sealing bucket should NEVER be used to apply the emulsions, because it is practically impossible to achieve complete or uniform coverage of the emulsion with such a tool.

Figure 3-14. Improper Application of the Tack Coat Using a Hand Wand

Distributor Truck Inspection, Calibration, and Certification

Correct tack coat application begins with proper application equipment inspection and calibration. Periodically, a trial tack coat application should be placed over a test area to verify correct nozzle operation and configuration. Further, the distributor application rate needs to be calibrated, both in the transverse and longitudinal directions, using the procedure described in ASTM Method D 2995, "Standard Practice for Estimating Application Rate of Bituminous Distributors." Many owner agencies require a valid certification to

KEY POINT

▶ **Distributors that are not calibrated** should not be used for application of tack coats.

ensure the proper functioning of the distributor and its components. Other calibration procedures have been used successfully. At a minimum, calibration should address, spray-bar height, nozzle angle, spray-bar pressure, thermometers, and stabbing stick.

Figure 3-15 illustrates a calibration process. Absorptive pads of known weight are placed across the pavement width and the distributor drives across the pads as emulsion is sprayed. The weight of the applied emulsion is converted to a volume and divided by the area of the pad to determine the application rate in gal/yd2. The ASTM Standard Practice fully describes multiple calibration procedures.

Figure 3-15. Calibration of Tack Coat Distributor

Spray Pavers

European contractors have used spray pavers for a number of years. These pavers carry a tank of emulsion on the paver (Figures 3-16 and 3-17). A spray bar is installed on the paver immediately in front of the screed. Emulsion is applied to the pavement surface typically less than 2 feet in front of the placement of the mix (Figure 3-18). Emulsions commonly used in Europe for the spray paver are essentially the same as those specified in the United States, which are normally polymer-modified asphalt emulsions.

The nozzles used on the spray pavers are similar to nozzles used on conventional asphalt distributors, and must be adjusted and kept clean in a similar manner.

Figure 3-16. Asphalt Paver With Asphalt Emulsion Tank for Tack Coat

Figures 3-17. Spray Paver With the Spray Bar Located Between Track and Screed

Using a spray paver eliminates the possibility of any construction traffic driving through the tack coat, thereby eliminating tracking of the tack coat. Spray pavers have been successfully used for many years and continue to be used today in Europe and some parts of the United States. This is an indication that, when using a spray paver process and appropriate materials, it is possible to apply emulsion to a pavement surface and place a new asphalt mixture atop the unbroken emulsion while still creating a suitable bond between the pavement layers.

Figure 3-18. Tack Coat Application in Front of Auger Chamber Using Spray Paver

Spray Bar Clean Out

Regardless of the spray system used, it is important to clean out the spray bar and nozzles at the end of each work shift. With some distributors, the system is designed to pump the emulsion from the spray bar back into the tank. Depending upon the system design, some emulsion may remain in the nozzles, potentially plugging the nozzle. Cleaning the bar and nozzles may require flushing the bar and nozzles with a cleaning solvent. Solvents should be used sparingly to prevent contamination and softening of the residual binder in the tack coat emulsion, especially when using non-tracking tack coats.

It is important for the distributor operator to know and understand the manufacturer's recommendations for spray-bar and nozzle cleanup and observe good environmental practices in collecting and disposing of tack/solvent used for cleanup.

4 DETERMINATION OF RESIDUAL TACK COAT RATE AND EVALUATION OF EXISTING PAVEMENT CONDITION

This chapter covers the amount of tack coat that should be used based upon several factors, including the condition of the pavement being overlaid.

To ensure the layers of a pavement structure adequately bond, a sufficient quantity of tack coat should be applied to yield a thin, uniform coating of asphalt binder material with full coverage over the existing pavement surface. Coordinating the residual tack coat rate, and thus the actual application rate, of the tack coat to the pavement surface conditions is extremely important.

The tack coat application rate will vary depending on the existing pavement surface. What is really important is not total tack coat application rate, but the residual application rate (the amount of asphalt binder that remains once the water has evaporated out of the asphalt emulsion). The application rate must be calculated from the residual rate.

The residual rate of tack coat needed depends on the conditions of the existing pavement surface. The following pavement surface characteristics must be considered:

1. Cleanliness
2. Age
3. Texture
4. Milled
5. Bleeding
6. Pavement Type

Table 4-1 at the end of this chapter presents recommendations for residual asphalt binder application rates.

Cleanliness of Pavement

Tack coat must be applied to a clean surface. If the pavement surface is dusty or dirty, it must be cleaned in order to prevent the new asphalt pavement surface from sliding or delaminating, as seen in Figure 4-1.

Cleaning operations can be accomplished either through mechanical brooming, by flushing the surface with water, or blowing off debris using high-pressure air. Care must be taken to minimize dust problems if air cleaning is used.

Sliding failures often occur at locations where traffic decelerates (e.g., stop signs or traffic signals), where traffic accelerates, or where traffic makes tight turning maneuvers.

Figure 4-1. Delamination Type of Sliding Failure

The residual tack coat-application rate should not be changed to compensate for a dusty or dirty pavement surface. A heavier residual application rate may increase the potential for sliding failure. The dust coating will create a slip plane and any excess residual tack coat added will further weaken the bond between the layers, compounding the problem. The only remedy for a dusty or dirty pavement surface is to clean the surface.

A small amount of moisture on the pavement surface should not be detrimental to long-term tack coat performance, although a damp pavement will slow the cure and break time of the tack coat emulsion. If the pavement surface layer is saturated with water and the existing pavement surface is damp or has standing water, the ability of the tack coat emulsion to provide adequate bond between the existing and the new pavement layers will be significantly compromised.

Age of Pavement

New Pavement

A common opinion is that a tack coat may not be needed between two new asphalt pavement layers (e.g., two layers placed a day or two apart). However, NCHRP Report 712 recommends that tack coat be applied between two new asphalt pavement layers. This recommendation assumes the underlying surface is clean when the overlay is placed. If the bottom layer has become dirty or dusty through trafficking, the surface must be thoroughly cleaned prior to tack coat application.

A new asphalt pavement surface will typically not absorb a significant amount of tack coat emulsion. Because of the tightness of the new surface and the amount of asphalt binder in that surface, the residual asphalt binder of the applied tack coat normally needs to be significantly less than the amount needed for an old, aged pavement surface. The residual rate should therefore be reduced to compensate for reduced absorption of the tack coat emulsion by the new asphalt pavement layer. Such decisions are based on engineering experience and judgment in the field.

Old, Aged Asphalt Pavement

If the asphalt pavement surface is cracked, some tack coat may flow into the cracks and not be functional. Significant tack coat loss is usually a problem only when diluted emulsion is used. In this situation, the residual tack coat rate may need to be increased slightly in order to account for the tack coat loss. To avoid this problem, consider using undiluted emulsion along with the appropriate nozzle size to ensure proper coverage. Care must be taken that the residual tack coat in the non-cracked areas is not so heavy as to create a slip plane or bleeding. If the existing asphalt pavement surface is highly oxidized and brittle, a slightly higher residual tack coat rate may be needed.

An old, aged, oxidized asphalt pavement surface will normally absorb a significant amount of the applied tack coat emulsion. This is particularly true when using a diluted asphalt emulsion. In order to have enough tack coat remaining on the pavement surface to create an adequate bond between the old and new pavement layers, the residual tack coat rate will have to be increased.

Pavement Surface Texture

Pavement surface texture has a significant effect on the required residual tack coat. A fine surface texture will require less residual tack coat than a coarse surface texture.

A raveled or old, aged surface will normally have a rougher surface texture. In both cases, it will be necessary to increase the residual tack coat application rate in order to account for the rougher surface texture.

Because the variation in surface texture of an existing asphalt pavement surface can be significant due to a wide range of surface issues, the range of residual tack coat rates is also greater.

Figure 4-2. Clean Milled Surface

Tack coats should never be used over opengraded mixes. These mixes should not be overlaid due to the significant potential for stripping.

Milled Asphalt Surface

There is some debate as to whether a tack coat is needed when a new asphalt pavement layer is placed on top of a milled asphalt pavement surface. The rough surface texture of the clean milled surface, as shown in Figures 4-2a and 4-2b, may be sufficient to provide the required bond between the old pavement and the new overlay.

NCH RP Report 712 indicates that the bond generated between the milled surface and the new asphalt pavement with no tack coat is not sufficient to provide an adequate level of shear strength. However, experience in Virginia (McGhee and Clark, 2009) has shown that a tack coat may not be necessary with a milled surface.

In either case, it is necessary for dust created during the milling operation to be removed as much is practical prior to the new asphalt pavement being placed. Of particular importance is removing dust from the bottom of the milling grooves. If the dust is not removed from the grooves and a tack coat is applied, the emulsion can cause the dust to become sticky and adhere to the tires of the construction equipment (Figure 4-3). Experience indicates that leaving the milled surface open to traffic helps to clean the pavement.

NCHRP Report 712 suggests that if a tack coat is applied to a milled asphalt surface, the residual tack coat rate should be reduced to prevent the emulsion from collecting in the grooves. Experience from other sources does not agree with this approach. The contractor should rely on local experience. Using an undiluted asphalt emulsion is recommended for milled surfaces.

Bleeding Surface

If the existing pavement surface is bleeding, the best approach is to mill that surface and remove the excess binder material. If milling is not needed to correct the grade or cross slope of the existing pavement structure, the depth of milling can be minimal. If an unstable asphalt mix is the cause of the bleeding, the deficient layer should be removed entirely.

Figure 4-3. Tack Coat and Debris Picked Up by Construction Traffic From a Dirty Milled/Tacked Surface

Care must be taken when a tack coat is applied to a pavement surface that is flushed or bleeding. In this situation, the tack coat application rate must be reduced to account for the amount of asphalt material already on the pavement surface. In addition, the tack coat application rate may have to be adjusted for differing pavement surface conditions transversely across a traffic lane. Less tack coat may be needed, for example, in the wheel paths of a pavement surface that is bleeding compared to the amount of tack coat needed between the wheel paths and along the outside edges of the lane.

It is possible to use different size nozzles on the asphalt distributor spray bar to apply different amounts of tack coat emulsion at different transverse locations across the width of the pavement lane. This is feasible only if the bleeding areas are consistent in width and length. In the vast majority of cases when overlaying an existing asphalt pavement that is bleeding, the proper solution to the problem is to mill off the bleeding surface. Due to significant variation in the amount of bleeding that can occur on a pavement surface, it is virtually impossible to provide a typical range for the residual asphalt binder across all surface locations.

Pavement Type

For most PCC surfaces, the amount of residual tack coat will be the same as for an asphalt pavement surface. In general, no increase in the residual tack coat rate is required to account for the joints or cracks in the PCC surface.

If the PCC surface has been diamond ground, a slight increase in the tack coat residual rate may be necessary due to the increased texture of the diamond-ground surface.

If the PCC surface has been milled, the milled surface should be cleaned, as described above for a milled asphalt surface, and a tack coat should be applied. Milled PCC surfaces require a higher application rate for better bonding and performance of the overlay.

Application Rate vs. Residual Asphalt Binder

The residual asphalt binder is the amount of asphalt binder that effectively provides the bond between two pavement layers. Thus, the application rate of the emulsion must be calculated from the desired residual rate of the asphalt binder.

Calculation of the residual asphalt application rate is based on the percentage of liquid asphalt in the emulsion (the value provided by emulsion supplier on the Bill of Lading) and knowing the residual application rate desired.

For example:
% Asphalt in emulsion: 57%
(minimum asphalt for SS-1h)
Residual asphalt desired: 0.04 gal/yd2
Residual Application Rate =
0.04 ÷ 0.57 = 0.07 gal/yd2

It is very important to understand that the tack coat application rate must be determined by starting at the desired residual application rate for the type of asphalt material being used as a tack coat and then calculating the actual application rate. Table 4-1 presents a summary of the range of the residual asphalt binder application rates for the various pavement surface types. The values in the table are recommendations and will vary depending on existing conditions.

Table 4-1. Typical Residual Asphalt, Undiluted and Diluted Emulsion Application Rates

Existing Condition	Residual Asphalt Binder, gal/yd^2	Applied Undiluted Emulsion, gal/yd^2	Applied Diluted Emulsion, gal/yd^2
Dusty or Dirty	Clean the surface	Clean the surface	Clean the surface
New Asphalt	0.03–0.04	0.04–0.06	0.09–0.12
Old, Aged Asphalt	0.04–0.06	0.06–0.09	0.12–0.18
Milled Asphalt	0.03–0.05	0.04–0.07	0.09–0.15
PCC	0.04–0.06	0.06–0.09	0.12–0.18

5 APPLICATION OF TACK COAT

This chapter covers the definitions of break and set time and construction issues surrounding the application of tack coat. Also included are some typical problems with tack coat applications.

There are three key construction issues surrounding the proper application of an emulsion:

1. Ensuring uniformity and full coverage of the tack coat on the pavement surface;
2. Minimizing pickup of the tack coat by haul truck and paving equipment; and
3. Needing to pave over an emulsion tack coat before it has broken and/or set.

The following discussion covers these issues.

Break and Set Time

Immediately after application, an emulsion is brown in color. This color indicates that the material is emulsified, meaning that microscopic-sized asphalt particles are suspended in the water. When the color of the emulsion changes from brown to black, it is typically stated that the emulsion has "broken." This means the asphalt particles have separated from the water and two distinct substances now exist. When all of the water has evaporated, it is stated that the emulsion has "set." When the emulsion has set, all that remains on the pavement surface is the asphalt binder.

Factors Affecting Break and Set Times

Many factors can affect break and set times, particularly for an asphalt emulsion. Among the factors are:

- ambient air temperature,
- relative humidity,
- wind speed,
- pavement surface temperature,
- application rate of the tack coat emulsion,
- dilution rate of the asphalt emulsion, and
- type of emulsifying agent used
- tack coat emulsion temperature when sprayed (minor factor).

The primary factor affecting the emulsion break and set time is the application rate. The higher the application rate, the longer it will take for the emulsion to break and set. In addition, the use of a diluted asphalt emulsion will require more time to both break and set compared to an undiluted emulsion, simply because of the increased amount of water present. As their names imply, the break and set times for a rapid set (RS) emulsion are typically shorter than a slow set (SS) emulsion.

In general, if the ambient air temperature and/or the temperature of the existing pavement surface is relatively high, break and set times will be shorter. Humidity also plays a role, as greater humidity slows the evaporation of water and therefore the break and set times. Further, emulsions will set more quickly on a windy day compared to a calm one.

Depending upon the application rate and dilution, emulsions applied as a tack coat will typically break in 10 to 20 minutes. Complete setting of the emulsion typically requires from 30 minutes to more than 2 hours, depending on the conditions of the application. Unless the tack coat is set, there will be a tendency for the tack coat to be picked up on the tires of construction equipment, especially the tires of the trucks delivering asphalt mix to the material transfer vehicle or to the paver. This removal of the tack coat material from the underlying surface, or tracking, diminishes its function and performance.

It is noted that paving over an unbroken emulsion is routinely performed, as mentioned in the discussion of spray pavers in Chapter 3. If pickup of the emulsion is not a problem, this practice can be used when construction equipment does not come into contact with the uncured emulsion. With distributor-placed tack coat, it is preferred to allow time for the emulsion to set prior to mix placement. This is an issue in which local experience must be considered. It should also be noted that even non-tracking tack coats will pick up and track if the emulsion is not allowed to properly break and set.

Uniformity of Tack Coat Application

It is extremely important that the emulsion be uniformly applied to the pavement surface to obtain full coverage. Non-uniform application, as shown in Figure 5-1, can lead to a difference in the bond attained.

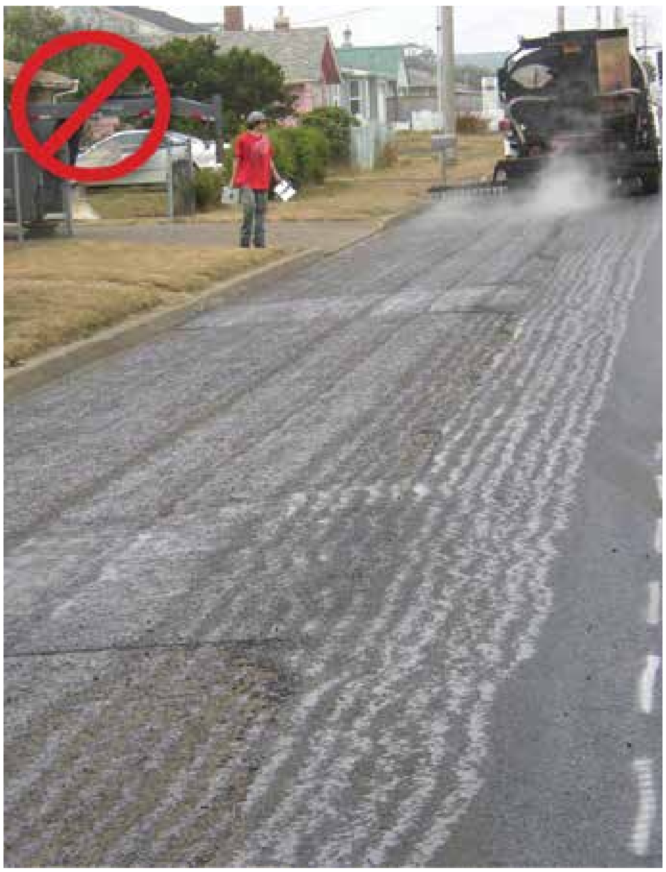


Figure 5-1. Non-Uniform Tack Coat Spray Application

As discussed in Chapter 3, poor uniformity can be due to many factors, including blocked nozzles, improper nozzle angle, improper nozzle size, improper distributor truck speed, or inadequate pump pressure.

Figures 5-2a and 5-2b illustrate proper tack coat application. All nozzles are open and functioning correctly. All nozzles are set at the same angle to the axis of the bar. Height of the spray bar is adjusted to provide a triple lap of spray from the adjacent nozzles.

Figure 5-2 a and b. Uniform Tack Coat Spray Application

Figure 5-3 illustrates blocked nozzles on the spray bar with no tack coat being applied at those locations. In this case, the distributor needs to be stopped, the blocked nozzles removed and cleaned, the nozzles replaced correctly on the spray bar, and tack coat application continued. In most cases, it is more efficient to simply remove and replace the blocked nozzles with spare nozzles. Blocked nozzles can be cleaned at a later time.

Figure 5-3. Non-Uniform Tack Coat Spray Application With Blocked and Oversize Nozzles

Also in Figure 5-3, the overlap of the tack coat spray from one nozzle to the adjacent nozzle is not correct. Proper overlap should be achieved by either adjusting the angle of the nozzles, the distributor pump pressure, and/or the speed of the distributor.

Figures 5-4a and 5-4b illustrate nozzles set incorrectly relative to the spray-bar axis. The spray fan from one nozzle comes in contact with the spray fan from the adjacent nozzle, resulting in an increase in the amount of tack coat applied at the point where the two spray fans meet. Figure 5-5 shows the opposite problem; the spray bar angles of the adjacent spray bars are such that no overlap is achieved between the nozzles. This type of application yields very nonuniform tack coat application.

Figures 5-4 a and b. Non-Uniform Tack Coat Spray Application Due to Improper Nozzle Setting

Figure 5-5. Non-Uniform Tack Coat Spray Application Due to Improper Nozzle Setting

Figure 5-6 shows excessive tack coat applied to a pavement surface. Although the tack coat application is uniform, this application rate is too heavy and will result in poor bonding of the overlay and/or bleeding of the tack through the new surface mix.

Figure 5-7 shows a spray pattern where some nozzles are not functioning, some are set at improper angles, and/or some are providing insufficient emulsion to the pavement surface. This distributor must be removed from the project until the spray bar nozzle problems are corrected.

Figure 5-6. Excessive Tack Coat Spray Application

Pickup of Emulsion on Construction Equipment Tires

Until an emulsion is fully set, the material may be sticky and will adhere to the tires of construction equipment, removing the tack coat from the pavement surface (Figure 5-8). Removal of the tack coat in the wheel paths can potentially result in isolated areas of insufficient bond.

Figure 5-7. Non-Uniform Tack Coat Spray Application With Nozzles Not Functioning and Not at the Correct Angle

In addition to tack coat loss, much of the tack coat picked up on the haul truck tires will be deposited on the adjacent pavement surface (Figure 5-9). Such an occurrence, referred to as tracking, creates an unsightly mess on adjacent surfaces. Depending upon how much tack coat emulsion is deposited on the adjacent pavement or intersection, a reduction in pavement skid resistance may occur, possibly creating a safety hazard.

One method that can be used to avoid pickup of the tack coat emulsion is to employ a material transfer device to convey asphalt mixture from the haul truck to the paver. This can be accomplished by offsetting the material transfer device so that it is located in a lane adjacent to the one being paved. Using this method of delivery, neither the haul trucks nor the transfer vehicle will travel over the tacked surface. However, traffic control constraints often do not allow this approach.

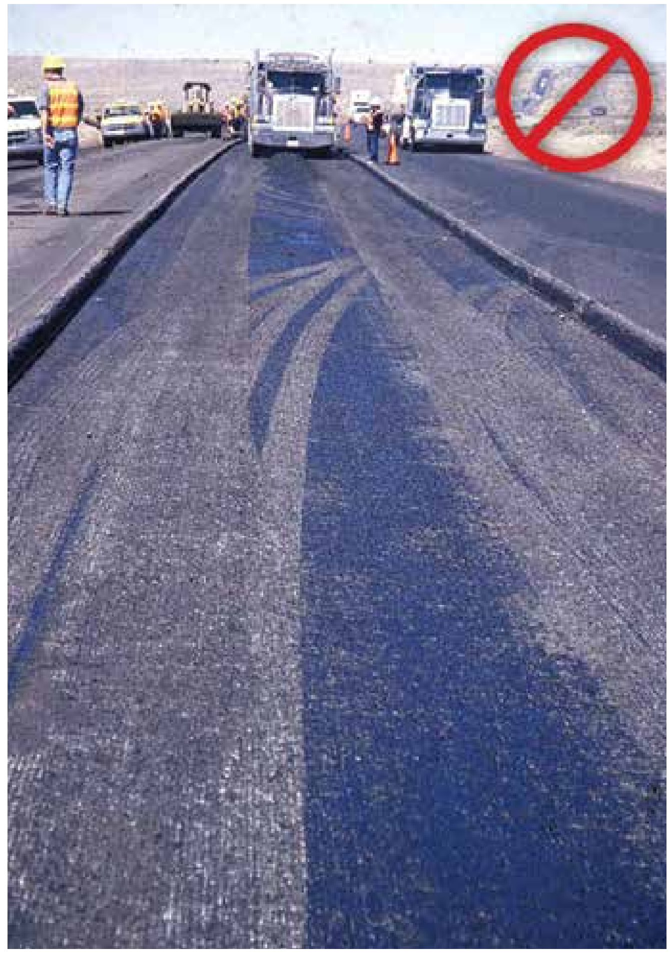


Figure 5-8. Pickup of Tack Coat Emulsion in Wheel Paths by Construction Traffic Should Be Avoided

Another option is to use non-tracking tack coats that are designed to break and set faster and yield a non-sticky residue at pavement construction temperatures. The non-tracking tack coat residue is then liquefied with the heat from the new asphalt pavement layer, creating a strong bond between the existing and new asphalt surface.

Paving Over an Unbroken Emulsion or in Wet Conditions

It is not correct or good practice to place an asphalt mixture over an emulsion that is not yet broken. One reason often cited is that water in the emulsion will affect the temperature of the placed asphalt mixture and the resulting bond will be inadequate. It is a best practice to allow the tack to set prior to paving to ensure the best possible bond between layers. With spray-paver applications, experience has indicated that the issue is not a problem for the specialized emulsions used. Non-tracking tack generally sets rapidly and presents no concerns.

Although it is not good practice to place an asphalt mixture in the rain, it is sometimes necessary to continue paving operations in light rain or slightly wet conditions. A significant concern is whether the amount of rainfall will wash the emulsion off the pavement before the emulsion breaks, thereby creating a pavement performance problem as well as a possible environmental issue. In the vast majority of the cases, the asphalt mix that has been placed in a light rain remains in place and performs properly over time and traffic. The bond between the old and the new pavement layers is formed even though some water remains in the emulsion or on the surface. The heat of the asphalt mixture causes the emulsion to break since the water in the emulsion escapes in the form of steam.

Figure 5-9. Pickup of Tack Coat Emulsion by Construction Traffic Should Be Avoided

6 SUMMARY OF BEST PRACTICES

This chapter summarizes best practices for the use and application of tack coats.

Long-term performance of an asphalt pavement is significantly related to the bond developed between successive pavement layers. The bond between layers is strongly related to the tack coat application.

The key factors in determining success of a tack coat application are as follows:

- Condition of the existing pavement,
- Tack coat application rate,
- Residual binder content,
- Proper distributor operation, and
- Emulsion break and set times.

Table 6-1 provides a best practices checklist for emulsion tack coat applications.

Following best practices as discussed herein will prevent premature failures related to poor bond. Pavement failure due to insufficient bond is extremely costly and generally preventable. Tack coat is an inexpensive means to ensure bonding between successive layers in an asphalt pavement.

Table 6-1. Emulsion Tack Coat Best Practices Checklist

- ✓ Clean the pavement
- ✓ Maintain emulsion at proper temperature
- ✓ Determine residual asphalt content required
- ✓ Calculate application rate
- ✓ Set spray-bar height for triple overlap of spray
- ✓ Ensure nozzles are correct size
- ✓ Ensure all nozzles are same size
- ✓ Set spray nozzles at same angle
- ✓ Ensure all nozzles are clean and functioning properly
- ✓ Ensure distributor is calibrated
- ✓ Ensure uniform application of tack coat
- ✓ Prevent tracking and pickup of the emulsion

BIBLIOGRAPHY

Asphalt Institute and Asphalt Emulsion Manufacturers Association. *Basic Asphalt Emulsion Manual* (MS-19), 4th Edition. Asphalt Institute, Lexington, Ky., 2008.

ASTM D140-09. Standard Practice for Sampling Bituminous Materials. *Annual Book of ASTM Standards, Vol. 04.03: Road and Paving Materials.* American Society for Testing and Materials International, West Conshokocken, Pa., 2012.

ASTM D2397-05. Standard Specification for Cationic Emulsified Asphalt. *Annual Book of ASTM Standards, Vol. 04.03: Road and Paving Materials.* American Society for Testing and Materials International, West Conshokocken, Pa., 2012.

ASTM D2995-99(09). Standard Practice for Estimating Application Rate of Bituminous Distributors. *Annual Book of ASTM Standards, Vol. 04.03: Road and Paving Materials.* American Society for Testing and Materials International, West Conshokocken, Pa., 2012.

ASTM D8-11. Standard Terminology Relating to Materials for Roads and Pavements. *Annual Book of ASTM Standards, Vol. 04.03: Road and Paving Materials.* American Society for Testing and Materials International, West Conshokocken, Pa., 2012.

ASTM D977-12. Standard Specification for Emulsified Asphalt. *Annual Book of ASTM Standards, Vol. 04.03: Road and Paving Materials.* American Society for Testing and Materials International, West Conshokocken, Pa., 2012.

Ball, J. Maintain Tack Truck for Best Preservation Success. *Asphalt Pro Magazine*, Vol. 5, No. 9, August/September 2012, pp. 18–20.

Calibrating Asphalt Distribution Equipment. Texas Test Procedure Tex-922-K. Texas Department of Transportation, Austin, Texas, 2009.

Colorado Asphalt Pavement Association. Tack Coats: How and What to Apply!. *The Asphalt RAP*, Vol. 11, No. 3, November 2011.

Determination of Transverse Distributor Spread Rate. Arizona Test Method 411. Arizona Department of Transportation, Phoenix, Ariz., 1980.

Division of Construction. *Tack Coat Guidelines.* California Department of Transportation. Sacramento, Calif., April 2009.

E.D. Etnyre & Co. *Black-Topper Computator* (A-113-94).

E.D. Etnyre & Co. *Centennial Series Black-Topper, Designing the Ideal Distributor* (A-142-12), 2004.

E.D. Etnyre & Co. *It's the Truck Thing* (A-136-09).

E.D. Etnyre & Co. *The Tack Truck – Materials and Solutions* (V-1020-01). Video.

McGhee, K.K., and Clark, T.M. VT RC 09-R21 Report: Bond Expectations for Milled Surfaces and Typical Tack Coat Materials Used in Virginia. Virginia Transportation Research Council, Charlottesville, Va., June 2009.

Mohammad, L.N., Elseifi, M.A., Bae, A., Patel, N., Button, J., and Scherocman, J.A. *NCHRP Report 712: Optimization of Tack Coat for HMA Placement.* Transportation Research Board of the National Academies, Washington, D.C., 2012.

Technical Bulletin: Proper Tack Coat Application. Flexible Pavements of Ohio, Dublin, Ohio, June 2012.

Tack Coat Application Inspection. Louisiana Transportation Research Center, Baton Rouge, La.

Testing and Certification of Bituminous Distributor Trucks. Policy and Procedure Directive No. 14. Arizona Department of Transportation, Phoenix, Ariz., 2009.

Photo Credits: Figure 2-2 courtesy The HollyFrontier Asphalt Co.; Table 2-2 courtesy The HollyFrontier Asphalt Co.; Figure 3-1 courtesy E.D. Entyre & Co.; Figure 3-2 courtesy E.D. Entyre & Co.; Figure 3-3 courtesy E.D. Entyre & Co.; Figure 3-4 courtesy Calder Brothers Corp.; Figure 3-5 courtesy Dale S. Decker, P.E.; Figure 3-6 from NCHRP Report 712; Figure 3-7 courtesy E.D. Entyre & Co.; Figure 3-8 courtesy Jim Scherocman, P.E.; Figure 3-9 courtesy E.D. Entyre & Co.; Figure 3-10 from NCHRP Report 712; Figure 3-11 courtesy E.D. Entyre & Co.; Figure 3-12a courtesy Jim Scherocman, P.E.; Figure 3-12b courtesy Jim Scherocman, P.E.; Figure 3-13a courtesy Jim Scherocman, P.E.; Figure 3-13b courtesy Jim Scherocman, P.E.; Figure 3-14 courtesy Jim Scherocman, P.E.; Figure 3-15 courtesy E.D. Entyre & Co.; Figure 3-16 courtesy Wirtgen America; Figure 3-17 courtesy Roadtec; Figure 3-18 from NCH RP Report 712; Figure 4-1 courtesy Dale S. Decker, P.E.; Figure 4-2a from NCHRP Report 712; Figure 4-2b from NCHRP Report 712; Figure 4-3 from NCHRP Report 712; Table 4-1 from NCHRP Report 712; Figure 5-1 courtesy Jim Scherocman, P.E.; Figure 5-2a courtesy Kent Hansen, P.E.; Figure 5-2b courtesy Jim Scherocman, P.E.; Figure 5-3 courtesy Jim Scherocman, P.E.; Figure 5-4a courtesy Jim Scherocman, P.E.; Figure 5-4b courtesy Jim Scherocman, P.E.; Figure 5-5 courtesy Jim Scherocman, P.E.; Figure 5-6 courtesy Jim Scherocman, P.E.; Figure 5-7 courtesy Jim Scherocman, P.E.; Figure 5-8 courtesy Jim Scherocman, P.E.; Figure 5-9 courtesy Jim Scherocman, P.E.; Cover Photo courtesy E.D. Entyre & Co.; Cover Photo Inset courtesy BearCat Manufacturing

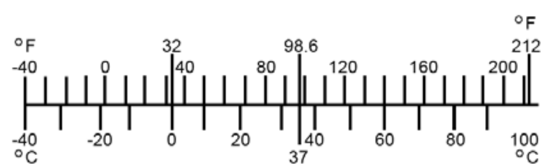
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSION TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
inches	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSION FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons(2000 lb)	T
TEMPERATURE (exact)				
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F



*SI is the symbol for the International System of Measurement.

NAPA: THE SOURCE

This publication is one of the many technical, informational, and promotional publications available from the National Asphalt Pavement Association (NAPA).

National Asphalt Pavement Association
NAPA Building, 5100 Forbes Boulevard, Lanham, MD USA 20706-4407
Toll Free: 1-888-468-6499 • Tel: 301-731-4748 • Fax: 301-731-4621
www.AsphaltPavement.org • NAPA@AsphaltPavement.org

August **2020**

METHODS FOR ADDRESSING TACK TRACKING

A Synthesis of Literature and Specification Reviews

James A. Musselman, P.E.
Senior Research Engineer

Raquel Moraes, Ph.D.
Assistant Research Professor

Travis B. Walbeck, P.E.
Training Manager

Randy C. West, Ph.D., P.E.
NCAT Director

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

Purpose of Tack Coats

Asphalt pavements are designed to behave as a single pavement layer in order to withstand traffic and environmental stresses. However, since most pavements typically are made up of multiple layers, it is critical that the layers are properly bonded together. If the layers are not properly bonded together, there is potential for a number of premature pavement distresses to occur, such as slippage (Figure 1), delamination and fatigue cracking.

Figure 1. Slippage Cracking (FDOT)

Tack coats are used to bond pavement layers together. If the proper materials are used, handled, and applied correctly, tack coats will provide an excellent bond between layers. However, one drawback of most tack coats is that in certain situations the tack material will adhere to the tires of construction vehicles that drive over the tacked surface. This material that is stuck to the tire is then removed from the pavement surface (Figure 2) and is typically deposited on a pavement surface elsewhere (Figure 3). In addition to removing the tack material from the pavement surface where it is most needed to provide a good bond between layers, the "tracked" material can also create aesthetic or safety concerns (e.g., low pavement friction) in other locations where it is deposited.

The purpose of this document is to provide guidance on the primary causes of tracking and steps that can be taken on paving projects to minimize or prevent tracking from occurring.

Figure 2. Tracking Example (TXDOT)

Figure 3. Tracked Tack Material (WVDOH)

Types of Tack Coat Materials

The materials most commonly used for tack coat can typically be categorized as asphalt emulsions and hot-applied asphalt binders.

Asphalt Emulsions

An asphalt emulsion is a combination of asphalt binder, water, and an emulsifying agent, which allows it to remain liquid and be applied at relatively lower temperatures (70 - 160°F). After an emulsion is applied to a pavement surface, a change in the emulsifying agent occurs and the asphalt and water physically separate, and the asphalt particles start to flocculate into small clumps and then coalesce (called "setting" and "breaking", respectively). Shortly afterwards, the water evaporates, and only the asphalt binder remains on the pavement surface. This step is called "curing". Once the emulsion has fully cured the residual asphalt will then properly bond with the layer placed on top of it.

One advantage of using asphalt emulsions is that they can be applied by an asphalt distributor (Figure 4) uniformly at lower application temperatures, which makes them safer to use in comparison to hot-applied asphalt binders, which are typically applied at temperatures greater than 350°F. In addition, most paving contractors are familiar with the handling, storage, and usage of conventional emulsions.

One of the biggest disadvantages of using an asphalt emulsion is the time it takes for the emulsion to break and cure, which can delay paving operations and can also create the potential for tracking if the emulsion is paved over before it has properly broken and cured.

Figure 4. Conventional Tack Application (CODOT)

Asphalt Emulsion Basics

Asphalt emulsions are identified by numbers and letters related to particle charge, set rate, viscosity of the liquid emulsion, hardness of the base asphalt binder, and/or the presence of polymer modification. Examples of this nomenclature include SS-1, CSS-1h, RS-1P, etc.

<u>Particle Charge:</u> The particle charge helps keep the asphalt binder particles in suspension and prevents them from coalescing. Emulsions can be positively charged (cationic), negatively charged (anionic), or have no charge (nonionic). Cationic emulsions are identified with a "C". If the C is not included, the emulsion is normally anionic. Nonionic emulsions are not widely used.

<u>Setting:</u> Emulsions are further classified based on how quickly the asphalt droplets in suspension will coalesce; i.e., revert to asphalt binder. *"Set"* is closely related to how soon an emulsion will *"break" (i.e., how long will it take until the emulsion reverts to a continuous asphalt phase)*. These categories are Quick Set (QS), Rapid Set (RS), Medium Set (MS), and Slow Set (SS).

<u>Emulsion Viscosity:</u> The numbers following the letter classification indicate the relative viscosity of the emulsion. For example, a CRS-2 emulsion is more viscous than a CRS-1 emulsion.

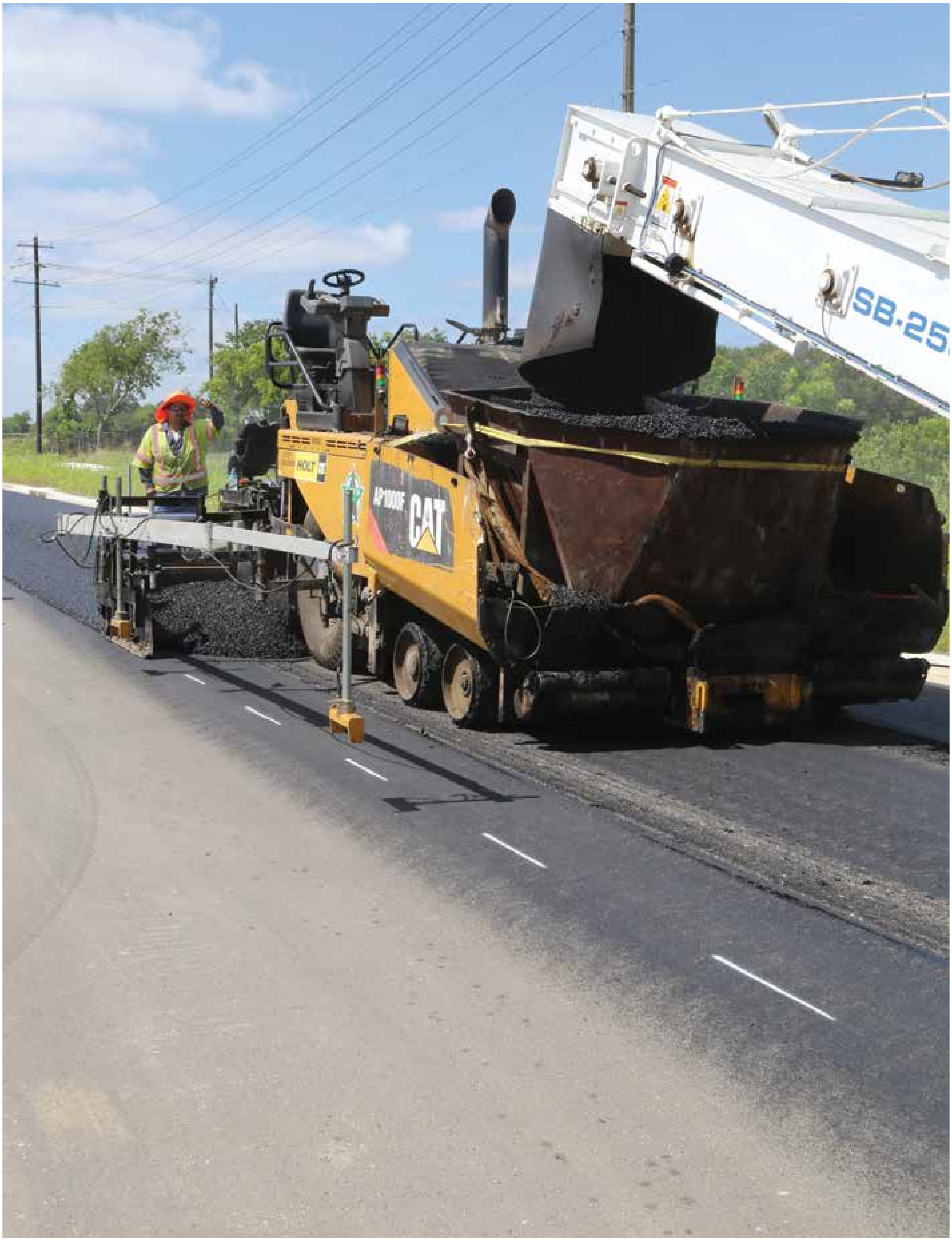
<u>Additional Nomenclature:</u> The addition of "P" in the emulsion classification indicates polymer has been added to the emulsion. "L" means a latex polymer has been used. On certain grades, an "h" follows the number, indicating that a harder base asphalt binder was used in the formulation of the emulsion.

Breaking and Curing of Emulsions

When an emulsion is in storage or is applied to a pavement surface, it has a brown appearance, which indicates that the microscopic-sized asphalt particles are still suspended in water. Once it is applied to the pavement surface, a chemical change occurs; the emulsion begins to set and break and its color changes from brown to black. An example of a broken and unbroken emulsion is shown in Figure 5. The breaking process indicates that the asphalt particles have separated from the water, and two distinct phases now exist – asphalt and water. When all of the water has evaporated, the emulsion is considered cured and is ready to be paved on.

Figure 5. Broken (left) and Unbroken Tack (Right) (WSDOT 2003)

Curing involves the development of the mechanical properties of the asphalt. For this to happen, the asphalt emulsion particles have to coalesce) and the water must completely evaporate to properly bond to the


SB-25
AP1000F
CAT
HOLT

underlying surface. The curing process is complete when the water particles present in the emulsion completely evaporate and all that remains on the pavement surface is the asphalt binder. If an emulsion is not fully broken and cured, the likelihood of tracking is very high.

There are several factors that can impact the time it takes for an asphalt emulsion to break and cure, but by far the most critical are air and pavement surface temperatures (hotter is faster), as well as humidity levels (less humid is faster). A summary of various conditions and their impact on emulsion cure times is in Table 1.

Table 1. Relationship of Various Conditions on Emulsion Cure Times

Condition	Impact on Cure Time
High Air Temperatures	Shorter
High Pavement Temperatures	Shorter
High Humidity Levels	Longer
Sunlight	Shorter
Higher Wind Speeds	Shorter
Heavy Application Rates	Longer
Diluted Emulsions	Longer

Conventional Emulsions in Use Today

While there are numerous asphalt emulsions available today, the conventional emulsions that are most commonly used for tack coat include: CSS 1h, SS-1h, SS-1, CSS-1, and CRS 1 (Figure 6).

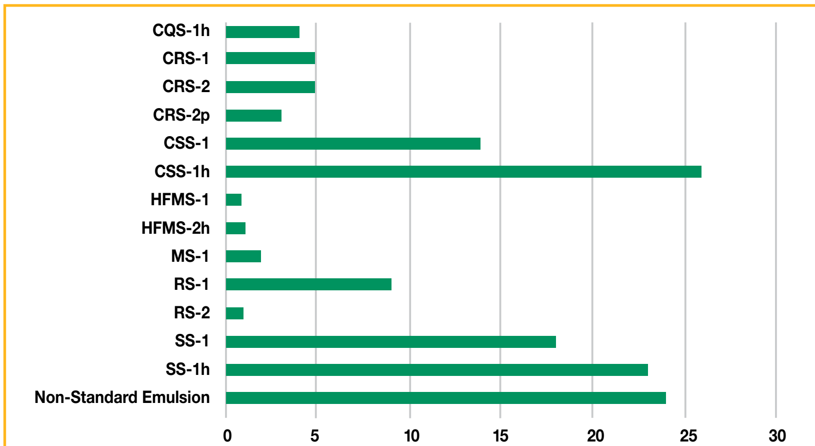


Figure 6. NCHRP Project 20-05, Topic 48-02 Survey Results for Type of Tack Coat Emulsion (Gierhart and Johnson, 2018)

Non-Tracking Asphalt Emulsions

Non-tracking (or reduced-tracking) tack coat emulsions are designed to minimize the tracking problems associated with conventional tack coat materials. They are typically formulated with a stiffer base asphalt binder and/or some type of chemical modification that either decreases the amount of time for the emulsion to break and cure as compared to conventional emulsions or makes the residue less tacky once it is applied. When a lift of hot asphalt mixture is placed over a reduced-tracking tack coat, the harder tack residue is reactivated by the heat and bonds the new overlay to the existing surface.

Reduced tracking and increased bond strengths are two of the main advantages of using a non-tracking asphalt emulsion. Disadvantages include increased cost and more stringent storage and handling requirements to keep them stable, as compared to conventional emulsions.

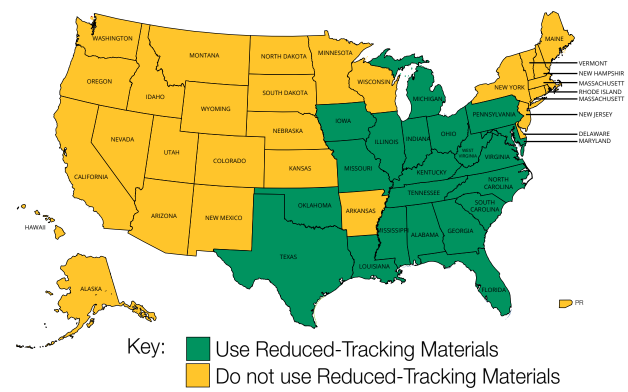


Figure 7. Map Showing Usage of Reduced-Tracking Materials

While non-tracking tack coats have become very popular in parts of the country (primarily the Southeast), there are still 28 State Highway Agencies (SHAs) that do not have trackless tack materials on their approved products list or in their specifications (Figure 7).

Non-Tracking Emulsions in Use Today

A review of SHA tack specifications as well as approved products lists indicated that there are currently 32 non-tracking emulsion products that are approved for use on SHA projects, with the most common as follows:

- NTSS-1HM (Blacklidge Emulsions)
- CBC- 1HT (Ergon Asphalt and Emulsions)

- EM-50-TT (Specialty Emulsions)
- AE-NT (K-Tec Specialty Coatings, Inc.).

A summary of this survey is in Figure 8.

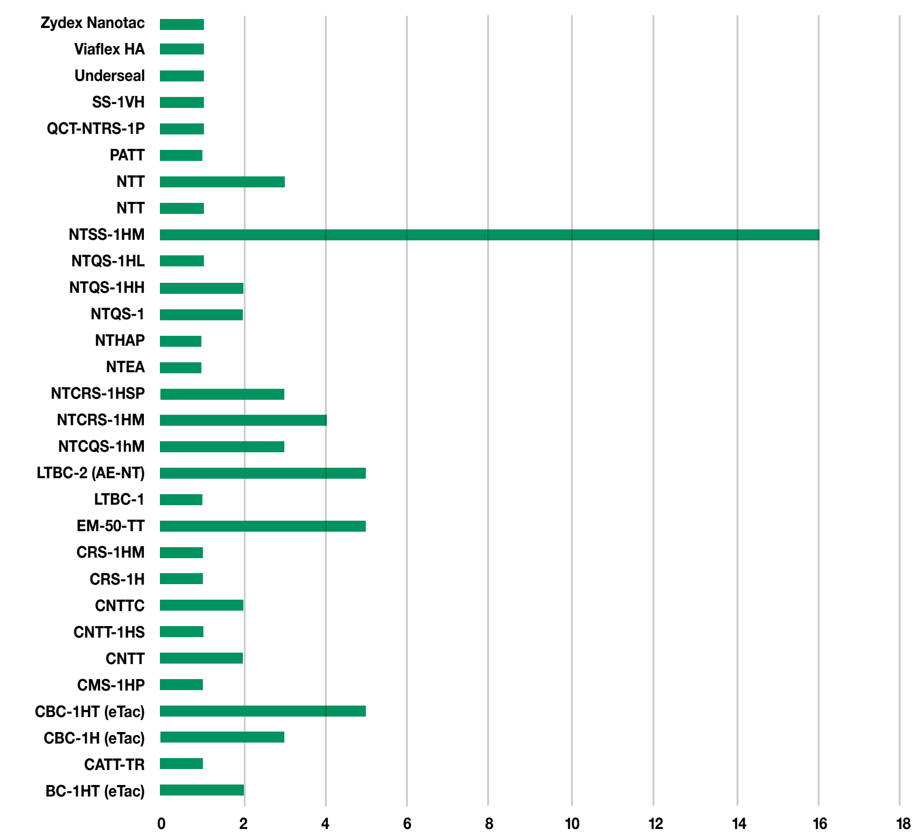


Figure 8. List of SHA Approved Non-Tracking Asphalt Emulsions

Asphalt Binders

Straight asphalt binders, typically paving grade, are sometimes used as tack. The types of asphalt binders permitted by SHAs generally range from PG 67-22 down to a PG 58-28.

There are a number of significant advantages to using a straight asphalt binder for tack. Once applied to the underlying pavement surface, the material cools to ambient temperatures very quickly, minimizing the potential for any tracking. And since there is no water to evaporate, paving operations can begin almost immediately, greatly speeding up the time of construction, particularly when paving at night or in cooler, more humid weather. Another advantage is that if a standard paving grade asphalt binder is used, there is one less material for a contractor to have to purchase, store, and handle. Costs are another advantage of straight asphalt binder as on a per gallon basis, asphalt binder is less costly than an asphalt emulsion. In addition, application rates are typically 40% lower than those for emulsions since there is no water to figure in when determining the amount of residue.

The disadvantages of using asphalt binders are primarily related to safety, as the binder must be heated to higher temperatures in order for the material to be applied uniformly with a distributor. This creates a significant safety concern with spraying a high-temperature (>350°F) asphalt binder in close proximity to workers as well as the traveling public. However, the contractors that frequently use asphalt binders as a tack material note that injuries are exceptionally rare, and that the safety issues are easily addressed by making certain that employees involved in the tacking operation are equipped with proper training and the appropriate Personal Protective Equipment (PPE), such as face shields, gauntlet gloves, and long sleeves.

While a number of SHAs have permissive specifications with respect to using asphalt binders for tack, they are rarely used today, primarily due to safety reasons.

Hot-Applied Non-Tracking Tack Coat Materials

Although not as common as non-tracking asphalt emulsions, hot-applied trackless products are becoming more popular. Hot-applied trackless tacks typically use a very stiff base asphalt binder or polymer modified binder. Within seconds of application, the tack cools, hardens, and resists tracking under traffic. The advantages of using a hot-applied trackless product are similar to the advantages of straight asphalt binders and include: less tracking, less delays for the paving operation, and lower application rates. Disadvantages include safety risks due to the higher application temperatures, and costs. One hot applied non-tracking additive (DOTC-LT) reduces the viscosity of the material when it is at application temperatures, allowing it to be applied at lower temperatures (approximately 230°F).

Hot-Applied Non-Tracking Tack Coat Materials in Use Today

Some of the hot-applied non-tracking materials in use today include:

- Ultrafuse® (Blacklidge Emulsions, Inc.)
- Underseal coat material (Jebro Inc.)
- e-Tac-HB (Ergon Asphalt and Emulsions)
- DOTC-10 and DOTC-LT (Asphalt and Wax Innovations).

Figure 9. Tracking Due to Unclean Underlying Surface

Tracking

Several factors can result in tracking on a paving project, and each must be considered when determining potential solutions. The three most critical factors that can result in tracking include:

1. Surface cleanliness
2. Unbroken/uncured asphalt emulsion
3. Stiffness of the residual binder

A table summarizing various causes and possible solutions to tracking is in the appendix.

Cleanliness of Underlying Pavement Layer:

Cause: Numerous studies have shown that it is essential that the tack coat material (whether an emulsion or asphalt binder) must be applied to a clean underlying surface. Surfaces that are dirty or dusty can result in the tack coat material sticking to the dust or dirt and not to the underlying pavement. This can easily result in tracking as well as having an overlay that will be prone to slipping and delamination. See an example of tracking due to an improperly cleaned underlying pavement surface in Figure 9.

Solution: Make sure the underlying surface is properly cleaned prior to tacking. Cleaning the surface can be accomplished either through mechanical brooming, by flushing the surface with water, blowing off debris using high-pressure air, or a combination of these. Allowing traffic on the underlying surface (if feasible) is another method of assuring that the surface is adequately cleaned.

Unbroken/Uncured Asphalt Emulsion:

Cause: If an emulsion has not had adequate time to break and fully cure, the residual asphalt will not properly adhere to the underlying layer and the material will track if any vehicles drive on it.

Solution: There are several options available when dealing with unbroken/uncured emulsions:

1. Allow the material to have adequate time to properly break and cure prior to driving or paving over it. It is critical that the time it takes for the emulsion to fully break and cure be determined and shared with the paving crew prior to paving. It is important to note that this time can vary based on paving conditions

(primarily air and pavement temperatures as well as humidity levels).
2. Make certain that the application rate is correct and the emulsion has not been diluted outside of the producer's recommendations. If possible, use an emulsion that has not been diluted. It is important to note that more water in the emulsion means more time to break and cure.
3. Use a trackless tack product that has shorter break and set times.
4. Use a hot-applied product, either straight asphalt binder or a hot-applied trackless product.
5. Use a spray paver.

Stiffness of the Residual Binder:

Cause: Once an emulsion has fully broken and cured, any tracking that occurs is likely due to the residual asphalt of the emulsion being too soft for the temperatures it is experiencing. High air and pavement temperatures are the most important factors affecting this type of tracking behavior.

Solution: The most common methods to resolve this type of tracking are:
1. Use a reduced-tracking emulsion that has a harder residual binder.
2. Use a hot-applied product, either straight asphalt binder or a hot-applied trackless product.
3. Use a spray paver.

Spray Pavers

A spray paver (Figure 10) is a paver outfitted with heated asphalt emulsion storage tanks, a recirculation system and an emulsion spray bar; it functions as a distributor and an asphalt paver. On a spray paver the tack material (either straight asphalt binder or emulsion) is applied to the pavement approximately one foot in front of the auger of the paver, and as soon as it is applied it is immediately overlaid by the asphalt mix. Since the tires or tracks of the paver are never in contact with the tack material, no tracking occurs.

Figure 10. Roadtec SP-200 Spray Paver

Approximately half of the SHAs currently allow the use of spray-pavers on their paving projects, while 15% require a spray paver for certain types of mixes.

The advantages of the spray paver system for tack coats is primarily that the tack is applied immediately in front of the screed. Consequently, it is not exposed to traffic before paving, meaning 100% of the tack sprayed on the underlying pavement surface is present during paving. Additional benefits of this process include higher bond strengths, less equipment cleanup after paving, and the elimination of tack being tracked onto other pavements.

While spray pavers can solve tracking problems quite effectively, there are several disadvantages, such as:

- Initial equipment costs are very high and the equipment can be more complex to operate than a standard distributor/paver operation.
- Since the storage tanks tend to be smaller than a standard distributor, there is need to frequently refill the tack reservoir, along with corresponding safety concerns when the refilling process is under traffic.
- Difficulties checking the uniformity and quality of the tack coat. For example, a clogged nozzle that is undetected could result in an unbonded strip of pavement and potential delamination or raveling.
- Concern with inadequate time for the emulsion to break and cure since the hot asphalt mixture is applied directly on top of the emulsion immediately after its application.

Reference Materials

There are a number of reference materials available concerning tack coat best practices:

- Federal Highway Administration. *Tack Coat Best Practices – TechBrief*. Office of Asset Management, Pavements, and Construction, 2016.
- *Best Practices for Emulsion Tack Coats*. Quality Improvement Publication 128, National Asphalt Pavement Association, 2013.
- NCHRP Report 712 *Optimization of Tack Coat for HMA Placement*. National Cooperative Highway Research Program, 2012.

Summary

Tack coats are used to bond pavement layers together, and if the proper materials are used, handled and applied correctly, they will provide an excellent bond between layers.

Tracking of tack coat materials can be a major problem from a performance, safety and aesthetics perspective and continually needs to be addressed. Understanding the causes of tracking is key to identifying the potential solutions.

Appendix 1 – Causes and Possible Solutions to Tracking

Source of Tracking	Description	Method of Addressing
Underlying surface is dirty or dusty.	If the underlying surface is dirty or dusty, the tack coat material will adhere to the dust or dirt, and not to the underlying pavement surface.	Properly clean the surface - either through mechanical brooming; by flushing the surface with water; blowing off debris using high-pressure air; or a combination of these. Allowing traffic on the underlying surface (if feasible) is another method of assuring that the surface is adequately cleaned.
Unbroken/Uncured Asphalt Emulsion	If the emulsion has not had adequate time to break and fully cure, the residual asphalt will not adhere to the underlying surface and the material will track if any vehicles drive on it.	Allow the tack coat emulsion to properly break and cure before driving or paving over it.
		Make certain that the application rate for the emulsion is correct and the emulsion has not been diluted outside of the producer's recommendations.
		Use a trackless tack product that has a shorter cure time.
		Use an additive that can reduce the cure time for the emulsion (i.e., NanoTac).
		Use a hot-applied product, either straight asphalt binder or a hot-applied trackless product.
		Use a spray paver
Inadequate stiffness of the residual asphalt binder	Once an emulsion has fully broken and cured, any tracking that occurs is likely due to the residual asphalt of the emulsion being too soft. High air and pavement temperatures are the most important factors affecting this type of tracking behavior.	Use a reduced-tracking emulsion which has a harder residual binder.
		Use a hot-applied product, either straight asphalt binder or a hot-applied trackless product.
		Use a spray paver

NATIONAL ASPHALT
PAVEMENT ASSOCIATION

6406 Ivy Lane, Suite 350, Greenbelt, MD 20770-1441

www.AsphaltPavement.org

NAPA@AsphaltPavement.org

Tel: 301-731-4748 | Fax: 301-731-4621 | Toll Free: 1-888-468-6499

@NAPATweets

at National Asphalt Pavement Association

at National Asphalt Pavement Association

at National Asphalt Pavement Association

@goasphalt