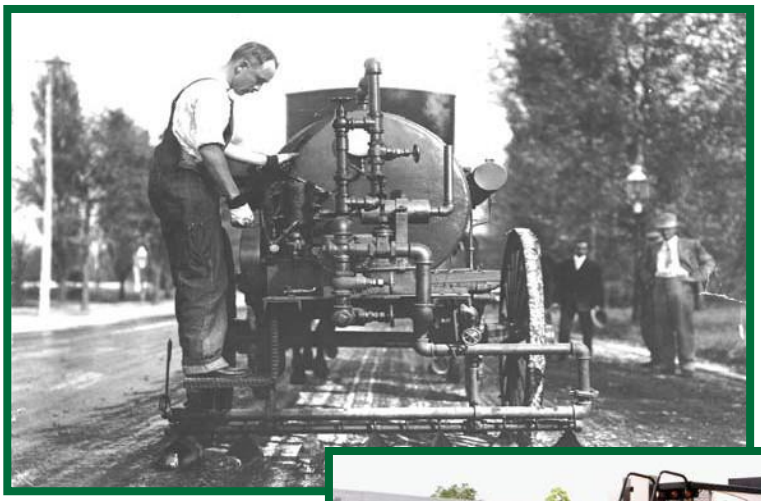
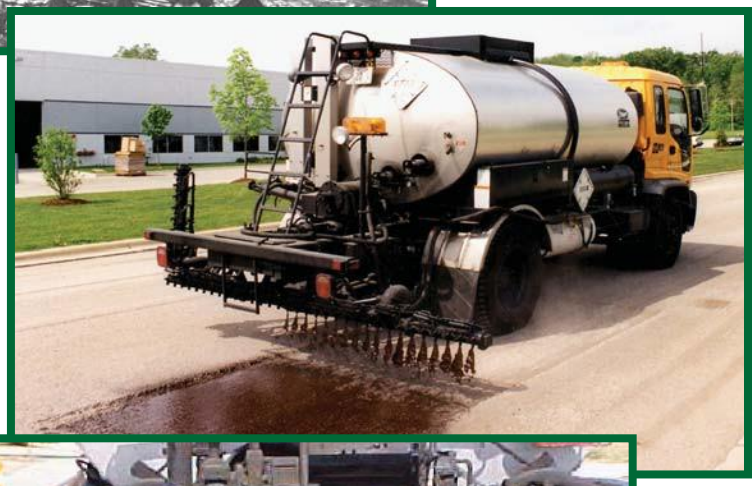
Tack Coat Guidelines





STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
Division of Construction
April 2009

Caltrans

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Tack Coat Guidelines

Issued by
Division of Construction
California Department of Transportation
State of California

April 2009

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Tack Coat Guidelines

These guidelines provide general tack coat material terminology, tack coat type, and grade selection criteria. They explain how to estimate the quantity of tack coat, how to determine tack coat application rates, how to sample and test tack coat, and how to measure and pay for tack coat. The guidelines do not address the chemistry of tack coat materials, storing and handling procedures, construction equipment, or materials testing.

1.0 GENERAL

A tack coat is a very light application of asphaltic emulsion or asphalt binder to an existing pavement surface or between layers of hot mix asphalt. A tack coat is used to ensure a good bond:

- Between the existing pavement surface and the new hot mix asphalt overlay, including planed surfaces.
- Between the layers of each lift of hot mix asphalt.
- At any vertical surfaces that the new hot mix asphalt will be placed against (curbs, gutters, and construction joints).

A tack coat is not required before placing a chip seal. However, some chip seals require a flush coat (fog seal and sand cover) on their surfaces.

A tack coat is not generally required before a slurry seal or a micro-surfacing application unless the existing pavement surface is extremely dry and raveled or is concrete pavement.

For a geosynthetic pavement interlayer, apply only asphalt binder as tack coat in accordance with Section 39 “Hot Mix Asphalt,” of the *Standard Specifications*. Do not allow the use of an emulsion. The asphalt binder tack coat used to bond the geosynthetic pavement interlayer is sufficient to provide the bond for the layer of hot mix asphalt that will placed over the geosynthetic pavement interlayer.

2.0 ESSENTIAL TERMINOLOGY

Anionic—Emulsified asphalt particles can be anionic (negatively charged) and, in theory, should be used with aggregates carrying a positive charge. Absence of the letter "C" in an emulsion type denotes anionic emulsified asphalt particles. For example, SS1 grade emulsion is anionic, and CSS1 grade emulsion is cationic.

Cationic—Emulsified asphalt particles can be cationic (positively charged) and, in theory, should be used with aggregates carrying a negative charge. The type of emulsifying agent used in the asphaltic emulsion determines if the emulsion will be cationic or anionic. The principal difference in the two is that cationic emulsion gives up water faster. The letter "C" in the emulsion type denotes cationic emulsified asphalt particles. For example, SS1 grade emulsion is anionic, and CSS1 grade emulsion is cationic. Do not use cationic and anionic emulsions together.

Diluted Emulsion—An emulsion that has been diluted by adding an additional amount of water equal to or less than the total volume of emulsion.

Emulsion—Made of asphalt binder and water containing a small amount of emulsifying agent. For example, slow-setting grade emulsions contain up to 43 percent water and additives, and rapid-setting grade emulsions contain up to 45 percent water and additives.

Residual Asphalt—The amount of asphalt binder remaining on the pavement surface after all water has evaporated from an emulsion.

Tack Coat Break—When water separates from the emulsion and the color of the tack coat begins to change from brown to black.

Tack Coat Set—When water has completely evaporated from an emulsion leaving a thin film of asphalt binder on the pavement.

3.0 TACK COAT MATERIALS

Asphaltic Emulsion

Asphalt emulsion consists of three basic ingredients: asphalt binder, water, and emulsifying agent. At times, other additives such as polymers are added. Polymers are either preblended with asphalt binder before emulsification or added as latex. Whenever the term emulsion is used in these guidelines, it means asphaltic emulsion.

Emulsions must comply with the requirements in Section 94, "Asphaltic Emulsion," of the *Standard Specifications.*

Asphaltic Emulsion Notations

The following notations are typically used for identification of the different emulsion grades:

C Cationic (positively charged) emulsified asphalt particles. If there is no **C** at the beginning of the emulsion grade then the emulsified asphalt particles are anionic (negatively charged).

SS Slow setting

RS Rapid setting **QS** Quick setting **LM** Latex modified **HF** High float

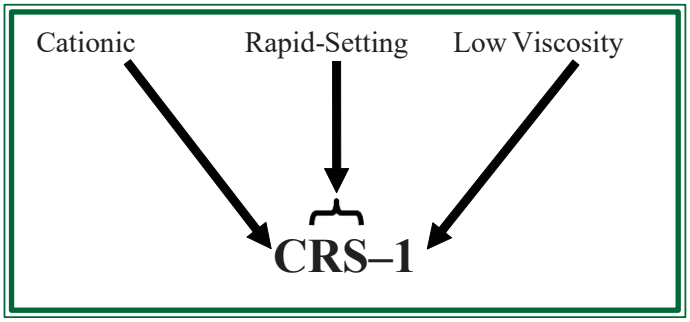
PM Polymer modified

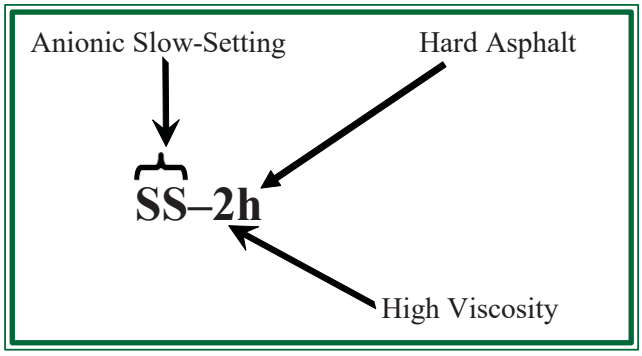
1 Low viscosity

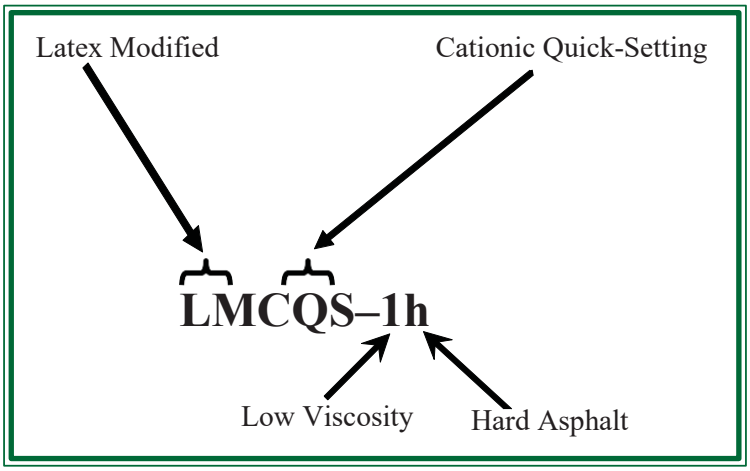
2 High viscosity

h Hard grade asphalt (low penetration)

The following are examples of how these notations are used:







Emulsions are typically classified by how quickly they set according to the following:

Slow-setting grades—Slow-setting grades of emulsion, used for tack coats are SS1, SS1h, CSS1, and CSS1h. Original slow-setting emulsions already contain a maximum of 43 percent water and additives and may be diluted with additional water.

Rapid-setting grades—Rapid-setting grades of emulsion, including polymer modified emulsions are RS1, RS2, CRS1, CRS2, PMRS2, PMRS2h, PMCRS2, and PMCRS2h. Rapid- setting emulsions already contain a maximum of 45 percent water and additives and must not be diluted with additional water.

Quick-setting grades—Quick-setting grades of emulsion used for tack coats are QS1, QS1h, CQS1 and CQS1h. Quick-setting emulsions used as a tack coat are made by adding a specially formulated additive to the emulsion that reduces the setting time. Quick-setting emulsions already contain a maximum of 43 percent water and additives and may be diluted with additional water.

Note that emulsion manufacturers may not stock all grades of emulsion.

Asphaltic Binder

The principal source of asphalt binders is the refining of crude oil. Asphalt binders must conform to the requirements in Section 92, "Asphalts," of the *Standard Specifications*. An asphalt binder, unlike emulsions, carries no charge (nonionic). Asphalt binder may not be diluted with water. Any grade of asphalt binder is acceptable as tack coat material. It is generally preferable to use the same grade of asphalt binder used in the hot mix asphalt for tack coat.

4.0 SELECTION OF TACK COAT MATERIAL

The contractor has the option of using any emulsion or asphalt binder that conforms to the *Standard Specifications* for a tack coat. For emulsions, the rate of setting is dependent upon the type of emulsion, the amount of water added, the type and concentration of the emulsifying agent, and atmospheric conditions. Cationic emulsions should be used in areas with damp pavement, for example, coastal areas, because they are less sensitive to moisture and temperature. The contractor must select either a cationic or anionic emulsion to be used for tack coat because cationic and anionic emulsions cannot be used together.

Local contractor experience and manufacturer availability of tack coat material types and grades may dictate which type of material is ultimately selected by a contractor. The following information, based on contractor experience, is offered for each tack coat material type:

Slow-setting emulsions are most commonly used by contractors for tack coat. However, they take longer to set than rapid-setting or quick-setting emulsions. For this reason, they are not recommended for use as a tack coat in relatively cool weather, at night, or when there is a short construction window.

Rapid-setting emulsions should be considered for use at night or in cooler weather since their break time is quicker than slow-setting emulsions. Rapid-setting emulsions typically have a higher viscosity than slow-setting emulsions, so they are harder to apply and get uniform coverage. Rapid-setting emulsions can have tracking problems similar to asphalt binder because of the higher residual rate required for RS1 and RS2. Rapid-setting emulsion PMCRS2 may cause "spider-webbing" when number 1 nozzles are used with high pressure to obtain a low application rate.

Quick-setting emulsions are used for night work or work in cool weather as well as when rapid construction is needed. Quick-setting emulsions were originally designed for use in slurry seals and with micro-surfacing. Uniform tack coat coverage can be better obtained with quick-setting emulsions because they have lower viscosities than rapid-setting emulsions and can be diluted with water. Quick-setting emulsions are not available statewide, and emulsion manufacturers will typically not allow excess tack coat to be returned.

Asphalt binder is always used as a tack coat material when a geosynthetic pavement interlayer is placed. Asphalt binder should be considered for use for night work or in cooler weather. Asphalt binder is heated and applied at a much higher temperature than an emulsion. When the ambient temperature is above 85ºF, asphalt binder will easily adhere to equipment tires, so tracking may be a problem. Asphalt binder should not be used when the pavement surface is damp, dusty, or on planed surface, because the binder will bead up and not penetrate the existing surface, preventing a good bond.

5.0 ESTIMATING TACK COAT QUANTITY

To properly estimate the quantity of tack coat to include in the engineer's estimate a designer must determine three factors:

- Number of layers in which a contractor will place the planned thickness of hot mix asphalt.
- Tack coat application rate.
- Area that will be paved shown on the plans.

For the purpose of estimating tack coat quantities, the designer should use Table 1 as a guide to determine the number of layers in which hot mix asphalt will be placed. For new construction, tack coat is not required for hot mix asphalt placed over aggregate base, so the number of layers should be reduced by one when determining the total number of layers requiring tack coat.

Table 1—Number of Layers for Hot Mix Asphalt Spreading and Compaction

Total Thickness Shown on Plans	Number of Layers
0.25 foot or less	1
0.26–0.50 foot	2
0.51–0.75 foot	3
0.76–1.00 foot	4

The tack coat application rate varies with the condition of the existing surface to which it is applied. In general, a tight or dense surface requires less tack coat than an open textured, raveled, or milled surface. A flushed or bleeding surface requires less tack coat than a dry or aged surface. The proper application rate also varies with the type of tack coat material used and the hot mix asphalt that will be placed as an overlay. Dense and gap-graded hot mix asphalt overlays require less tack coat than open-graded friction courses (OGFC) overlays.

Section 39-1.09C "Tack Coat," of the *Standard Specifications* specifies residual tack coat application rates for the different types of tack coat material and pavement

surface condition. Because emulsions contain water, the tack coat application rates used by contractors are higher in order to achieve the minimum residual rates specified in Section 39. Measurement and payment for emulsion used as tack coat are based on the weight of emulsion (residual asphalt and water). Therefore, the estimated quantity of tack coat should be based on the emulsion application rate and not on residual application rates specified in Section 39.

A designer should use the highest minimum application for asphaltic emulsions to provide a conservative tack coat quantity estimate, because a contractor is allowed to use any tack coat material specified in Section 39-1.09C, "Tack Coat," of the *Standard Specifications*. For estimating tack coat quantity, use calculated minimum tack coat application rates shown in Table 2, "Tack Coat Application Rates for Estimating," is based on the application rate for RS1/QS1/CQS1 asphaltic emulsion, which is the highest minimum application rate for all emulsions and asphalt binder. For the purpose of estimating tack coat quantity, the designer should use minimum tack coat application rates shown in Table 2a, "Tack Coat Application Rates for Estimating for Hot Mix Asphalt Type A, Type B, and RHMA-G" (Rubberized Hot Mix Asphalt–Gap Graded) and in Table 2b, "Tack Coat Application Rates for OGFC."[1]

Table 2a Tack Coat Application Rates for Estimating HMA Type A, Type B, and RHMA-G

Overlay Over	Minimum Application Rate (gallons/sq. yd.)
New HMA (between layers)	0.05
Existing HMA and PCC pavement	0.07
Planed pavement	0.11

[1] The minimum application rates shown in Tables 2a and 2b were calculated by dividing the highest residual rate (RS1/QS1/CQS1) shown in Section 39 of the *Standard Specifications* by the lowest percentage of residual by distillation (55 percent for RS1) in Section 94 of the *Standard Specifications*. Example: New HMA .03 (residual rate) ÷.55 (% residual by distillation) = .05

Table 2b Tack Coat Application Rates for Estimating OGFC

Overlay Over	Minimum Application Rate (gallons/sq. yd.)
New HMA	0.07
Existing HMA and PCC pavement	0.11
Planed pavement	0.12

For tack coat quantity estimating, a designer should use the following procedure:

1. Use Table 1 as a guide to determine the number of layers in which hot mix asphalt will be spread and compacted and, therefore, the number of times tack coat will need to be applied.
2. Choose tack coat minimum application rate from Table 2a or 2b based on hot mix asphalt or OGFC and underlying material or planed pavement.
3. The emulsion quantity is calculated by multiplying the number of layers determined in item 1 above by the application rate chosen from Table 2a or 2b, multiplied by the estimated square yards of area to be paved for the project.
4. The engineer's estimate for tack coat in tons is then calculated by using the conversion table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*.
5. For a geosynthetic pavement interlayer, the engineer's estimate for asphalt binder used as tack coat is calculated using the rate of 0.25 gallon of asphalt binder per square yard of interlayer as specified in Section 39-1.09D "Geosynthetic Pavement Interlayer," of the *Standard Specifications*.

Tack Coat Estimating Examples

Example 5.1

Calculate the estimated tack coat quantity for a mill (cold plane) and fill project for a 20-mile, four-lane section designed to receive 0.25 foot of hot mix asphalt at 60°F.

1. From Table 1, the estimated number of layers is one layer for 0.25 foot or less.
2. From Table 2a, the tack coat application rate for planed pavement is 0.11 gallons per square yard for hot mix asphalt. The required volume in gallons of emulsion is calculated as follows:

Gallons of Emulsion	=	(number of layers) x (application rate) x (total area in square yard)
	=	(1 layer) x (0.11 gal./sq. yd.) x ([{20 miles x 5280 feet/mile x 12 feet per lane} ÷ 9 sq. ft./sq. yd.] x 4 lanes)
Gallons of Emulsion	=	61,952 gallons

3. From the table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*, there are 240 gallons per ton of emulsion at 60ºF. Therefore, the estimated quantity of tack coat is determined as follows:

Quantity of Tack Coat	=	(quantity of emulsion in gallons) ÷ (gallons of emulsion per ton)
	=	61,952 gallons ÷ 240 gal./ton
	=	258.1 tons
Quantity of Tack Coat	=	259 tons.

Example 5.2

Calculate the estimated tack coat quantity for a mill (cold plane) and fill project for a 20-mile, four-lane highway section designed to receive 0.75 foot of hot mix asphalt at 60°F.

1. From Table 1, based on the 0.75 foot design, the estimated number of layers for total thickness between 0.51 and 0.75 foot, is three layers.
2. From Table 2a, the application rate of asphaltic emulsion is 0.07 gallons per square yard for the first layer placed on existing hot mix asphalt. The required volume in gallons of emulsion is calculated as follows:

Gallons of Emulsion	=	(number of layers) x (application rate) x (total area in square yards)
	=	(1 layer) x (0.07 gal./sq. yd.) x ([{20 miles x 5280 feet/mile x 12 feet per lane} ÷ 9 sq. ft./sq. yd.] x 4 lanes)
Gallons of Emulsion	=	39,424 gallons

3. From Table 2a, the application rate of asphaltic emulsion is 0.05 gallons per square yard between layers of new hot mix asphalt for the next two layers, and the required volume in gallons of emulsion is calculated as follows:

Gallons of Emulsion	=	(number of layers) x (application rate) x (total area in square yards)
	=	(2 layers) x (0.05 gal./sq. yd.) x ([{20 miles x 5,280 feet/mile x 12 feet per lane} ÷ 9 sq. ft./sq. yd.] x 4 lanes)
Gallons of Emulsion	=	56,320 gallons.

4. From the table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*, there are 240 gallons per ton of emulsion at 60ºF. Therefore the estimated quantity of tack coat is determined as follows:

Quantity of Tack Coat	=	(quantity of emulsion in gallons) ÷ (gallons of emulsion per ton) = (39,424 gallons + 56,320 gallons) ÷ 240 gal./ton
	=	398.9 tons
Quantity of Tack Coat	=	399 tons

Example 5.3

Calculate the estimated tack coat quantity at 60°F for a new ten-mile, two-lane highway section designed to receive 0.1 foot of OGFC over 0.75 foot of hot mix asphalt Type A on aggregate base.

1. From Table 1, based on the 0.75 foot design for hot mix asphalt, the estimated number of layers for total thickness between 0.51 and 0.75 foot or less is three layers. Because the hot mix asphalt is placed on aggregate base the number of layers requiring tack coat is reduced from three to two.

2. From Table 2a the application rate of asphaltic emulsion is 0.5 gallons per square yard between layers, and the total roadway width is 40 feet (two 12-foot lanes and two 8-foot shoulders). The required volume in gallons of emulsion is calculated as follows:

Gallons of Emulsion	=	(number of layers) x (application rate) x (total area in square yards)
	=	(2 layers) x (0.05 gal./sq. yd.) x ([10 miles x 5280 feet/mile x 40 width] ÷ 9 sq. ft./sq. yd.)
Gallons of Emulsion	=	23,467 gallons

3. From Table 1, based on 0.1 foot of OGFC, the estimated number of layers for 0.25 foot or less is one layer.

4. From Table 2b, the application rate of asphaltic emulsion is 0.07 gallons per square yard for OGFC on new hot mix asphalt, and the roadway total roadway width is 40 feet (two 12-foot lanes and two 8-foot shoulders). The required volume in gallons of emulsion is calculated as follows:

Gallons of Emulsion	=	(number of layers) x (application rate) x (total area in square yards)
	=	(1 layer) x (0.07 gal./sq. yd.) x ([10 miles x 5280 feet/mile x 40 width] ÷ 9 sq. ft./sq. yd.)
Gallons of Emulsion	=	16,427 gallons

5. The table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*, calls for 240 gallons per ton of emulsion at 60ºF. Therefore, the estimated quantity of tack coat is determined as follows:

Quantity of Tack Coat	=	(quantity of emulsion in gallons) ÷ (gallons of emulsion per ton)
	=	(23,467 + 16,427) gallons ÷ 240 gal./ton
	=	166.2 tons
Quantity of Tack Coat	=	167 tons

Example 5.4

Calculate the estimated tack coat quantity at 60°for a five-mile, two-lane highway section designed to receive 0.5 foot of hot mix asphalt over a geosynthetic pavement interlayer.

1. From Table 1, based on the 0.5 foot design, the estimated number of layers is two.

2. For the geosynthetic pavement interlayer, the application rate of performance-graded asphalt binder is 0.25 gallons per square yard, and the roadway total roadway width is 40 feet (two 12-foot lanes and two 8-foot shoulders). The required volume in gallons of asphalt binder is calculated as follows:

Gallons of Asphalt Binder	=	(number of layers) x (application rate) x (total area in square yards)
	=	(1 layer) x (0.25 gal./sq. yd.) x ([5 miles x 5280 feet/mile x 40 width] ÷ 9 sq. ft./sq. yd.)
Gallons of Asphalt Binder	=	29,333 gallons.

3. From Section 92-1.04 "Measurement," of the *Standard Specifications,* it is determined that the density of performance-graded asphalt binder at 60°F is 235 gallons per ton. Therefore, the estimated quantity of the asphalt binder is determined as follows:

Quantity of Asphalt Binder	=	(quantity of asphalt in gallons) ÷ (gallons of asphalt per ton)
	=	29,333 gallons ÷ 235 gal./ton
	=	124.8 tons
Quantity of Asphalt Binder	=	125 tons

4. For the next layer, from Table 2a, the application rate of asphaltic emulsion is 0.05 gallons per square yard for hot mix asphalt between lifts, and the roadway total roadway width is 40 feet (two 12-foot lanes and two 8-foot shoulders). The required volume in gallons of emulsion is calculated as follows:

Quantity of Emulsion	=	(number of layers) x (application rate) x (total area in square yards)
	=	(1 layer) x (0.05 gal./sq. yd.) x ([5 miles x 5280 feet/mile x 40 width] ÷ 9 sq. ft./sq. yd.)
Quantity of Emulsion	=	5,867 gallons.

5. The table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*,

calls for 240 gallons per ton of emulsion at 60ºF. Therefore, the estimated quantity of tack coat is determined as follows:

Quantity of Tack Coat	=	(quantity of emulsion in gallons) ÷ (gallons of emulsion per ton)
	=	5,867 gallons ÷ 240 gal./ton
	=	24.4 tons
Quantity of Tack Coat	=	25 tons

Use standard Basic Engineering Estimate System (BEES) item code 397007, "Tack Coat," (ENGMET) in the Engineer's Estimate. If a geosynthetic pavement interlayer is included in a project, use BEES item code 391007, "Paving Asphalt (Binder, Geosynthetic Pavement Interlayer)," (ENGMET) for including asphalt binder used as tack coat in the Engineer's Estimate. When standard special provision 39-300, "Minor Hot Mix Asphalt," or 39-600, "Replace Asphalt Concrete Surfacing," is used, compensation for tack coat is included in the payment for the contract item.

6.0 EMULSION DILUTION

Sometimes emulsion used for tack coats is diluted with water to increase the total volume of liquid while maintaining the same volume of asphalt within the emulsion. Dilution can help achieve a more uniform application without applying excessive residual amounts of asphalt. Caution should be used when emulsions are diluted because of various problems that can result from improper dilution. For example, when emulsion is excessively diluted, dilution can cause delayed emulsion break. Other methods to obtain tack coat coverage, such as adjusting nozzle opening size or tack coat application pressure, should be investigated before dilution.

If an emulsion is being diluted:

- The emulsion supplier and not the contractor should dilute the emulsion.
- Dilution may be done up to a 1:1 (water : emulsion) ratio basis.
- Dilute only by adding water to the emulsion and not vice versa, which could cause the tack to break.
- Dilute only slow-setting or quick-setting emulsions grades SS1, SS1h, CSS1, CSS1h, QS1, CQS1, QS1h, and CQS1h.
- Diluted emulsions must be applied at higher application rates to obtain the specified residual asphalt rate.

Additional water added to an emulsion must be measured by either weight or metered so that a weight can be determined for the additional water. Payment for tack coat is made for the quantity of original emulsion, not for the diluted emulsion. Do not pay for water that has been added to dilute the emulsion.

Dilution ratio (water : emulsion) is determined by the contractor. In cooler weather a dilution ratio of 0.5:1 (water : emulsion) may be appropriate. For milled pavement and warm ambient temperatures a dilution ratio of 1:1 (water : emulsion) is appropriate. No dilution or a low dilution ratio is required when the pavement has high cross slopes and steep grades. Use caution when the tack coat application rate is above 0.15 gallons per square yard because of the possibility for tack coat puddling and tack coat runoff.

For hot mix asphalt Type A and Type B, rubberized hot mix asphalt-gap graded, and OGFC, contractors must determine the tack coat application rate based on the dilution ratio to meet the specified minimum residual rate. For a diluted emulsion, to calculate the necessary application rate to ensure the specified residual rate perform the following calculation:

Diluted emulsion application rate = (undiluted application rate) x (1+ water/emulsion)

To determine emulsion undiluted application rate based on emulsion type, use Table 5a or 5b later in these guidelines.

Example 6.1

Diluted emulsion is CSS1 (0.5 :1) ratio to be used for hot mix asphalt type A between layers.

Diluted CSS1 application rate = (undiluted application rate) x (1+ water/emulsion)
= (0.04 gal. / sq. yd.) x (1+0.5 / 1)

Diluted CSS1 application rate = 0.06 gallon per square yard

A contractor must apply the diluted CSS1 at an minimum application rate of 0.06 gallons per square yard to obtain the specified minimum residual rate.

For emulsion diluted (1:1 ratio), use Table 3a, "Application Rates for Diluted (1:1) Tack Coat," as a guide to determine the approximate application rate so that the minimum residual rate specified in Section 39, "Hot Mix Asphalt," of the *Standard Specifications* is obtained.

Table 3a Application Rates for Diluted (1:1) Tack Coat HMA Type A, Type B, and RHMA-G

HMA over:	Minimum Application Rates (gallons per square yard)	
	QS1 / CQS1 Asphaltic Emulsion	CSS1 / CSS1h SS1 / SS1h QS1h / CQS1h Asphaltic Emulsion
New HMA (between layers)	0.1	0.08
Existing HMA and PCC pavement	0.14	0.10
Planed pavement	0.22*	0.18*

* Use caution when application rates are above 0.15 gallons per square yard because of potential tack coat puddling and runoff.

Table 3b Application Rates for Diluted (1:1) Tack Coat OGFC

	Minimum Application Rates (gallons per square yard)	
OGFC over:	QS1 / CQS1 Asphaltic Emulsion	CSS1 / CSS1h SS1 / SS1h QS1h / CQS1h Asphaltic Emulsion
New HMA	0.14	0.10
Existing HMA and PCC pavement	0.22*	0.18*
Planed pavement	0.24*	0.22*

* Use caution when application rates are above 0.15 gallons per square yard because of potential tack coat puddling and runoff.

7.0 SAMPLING AND TESTING TACK COAT MATERIALS

Obtain the required test report and certificate of compliance from each truckload of tack coat delivered to the project before the application of tack coat starts. Compare the test report with the specifications. Shipments may be used before sampling and testing if certificates

of compliance and the test results accompanying them comply with the specifications. However, for rapid-setting emulsions, if the contractor elects to use the test for polymer content (CT 401) in lieu of torsional recovery (CT 332) for measuring polymer content, samples of the base asphalt must be submitted to METS at least ten working days before beginning work. See Section 94-1.03 "Sampling," of the *Standard Specifications* for additional information.

During progress of the work, the contactor should take samples of tack coat materials in the presence of the engineer, who sends the samples to METS for testing as detailed below. Shipments of rapid-setting and polymer modified tack coat samples need to be expedited because the material has a shorter shelf life (typically 15 days) than other emulsions.

Requirements for sampling and testing emulsion and asphalt binder are provided in Table 6-1.6 in Chapter 6 of the *Construction Manual.*

General Sampling Details

- Take samples of emulsion in conformance with the requirements in American Association of State Highway and Transportation Officials (AASHTO) Designation: T40, "Sampling Bituminous Materials," Chapter 6 of the Construction Manual and California Test 125.
- Observe safety procedures. The boot truck driver must do the sampling in the presence of the Engineer. Obtain a split sample, one to test and the other to store for potential dispute resolution.
- Sample each shipment of emulsion using new, clean, dry two-quart plastic jugs.
- Sample asphalt binder daily using new, clean, dry one-quart round friction-top containers.
- Samples are normally taken from the spray bar at the rear of the distributor. Observe that sufficient material has been drained off through the nozzle to ensure removal of any material lodged there before collecting the sample.
- Samples should be taken after one-third and not more than two-thirds of the load has been removed.

- Immediately after sampling, use only a dry clean cloth to clean containers. Do not submerge sample containers in solvent or wipe containers with solvent saturated cloth.
- Attach a Sample Identification Form (TL-0101) to each material sample in accordance with Chapter 6 of the *Construction Manual* and instructions printed on the TL-0101 booklet. Protect the TL-0101 against moisture and stains.
- Provide the e-mail address of the resident engineer on the TL-0101.
- If the original emulsion was diluted, provide the dilution rate, on the TL-0101. Emulsion test results are meaningless if the dilution rate is unknown or incorrect.
- If contract special provisions include tack coat material requirements provide the required testing information on the TL-0101.
- Rapid-setting and polymer-modified emulsion has a shelf life so it is important that samples be sent to METS daily.
- Store all samples in a cool environment, and do not allow samples to roll around or to be shaken during transportation.
- Send samples by commercial parcel delivery for testing to METS:

  Materials Engineering and Testing Services
  Office of Flexible Pavement Materials, MS #5
  5900 Folsom Boulevard
  Sacramento, CA 95819-4612

- Do not ship samples C.O.D. (Cash on Delivery).

General Testing Details

Asphalt binder will be tested for compliance with Section 92, "Asphalts," of the *Standard Specifications*.

Emulsion will be tested for compliance with Section 94, "Asphaltic Emulsions," of the *Standard Specifications*.

To expedite return of test results, test results are emailed or faxed to resident engineers. Failing test results are sent the same day the test is completed.

8.0 TACK COAT APPLICATION

The amount of asphalt binder left on the pavement surface is the most important factor in obtaining a bond between the existing pavement surface and the new hot mix asphalt overlay. Consequently, the application rate for an emulsion used as a tack coat should be based on the desired residual amount of asphalt binder. It is important to differentiate between the two spread rate types:

Tack Coat Residual Rate—The amount of asphalt binder remaining on the pavement surface after the water has evaporated from an emulsion.

Tack Coat Application Rate—The amount of asphalt binder or emulsion sprayed from the distributor.

Section 39 "Hot Mix Asphalt," of the *Standard Specifications* specifies residual tack coat spread rates for the different types of tack coat material. When asphalt binder is used for tack coat, the residual amount of asphalt on the pavement surface will be the same as the applied rate, because there is no water to evaporate from the asphalt binder. Because emulsions contain water, the tack coat application rates used by contractors must be higher than the residual tack coat spread rates specified in Section 39. Tack coat residual rates in gallons per square yard are shown in Table 4a for Hot MixAsphalt Type A, Type B, and RHMA-G, and in Table 4b for OGFC.

Table 4a Tack Coat Residual Rates HMA Type A, Type B, and RHMA-G

HMA over:	Minimum Residual Rates (gallons per square yard)		
	CSS1/CSS1h SS1/ SS1h and QS1h/ CQS1h Asphaltic Emulsion	RS1/RS2 and QS1/CQS1 Asphaltic Emulsion	Asphalt Binder and PMRS2/PMCRS2 and PMRS2h/PMCRS2h Asphaltic Emulsion
New HMA (between layers)	0.02	0.03	0.02
Existing HMA and PCC pavement	0.03	0.04	0.03
Planed pavement	0.05	0.06	0.04

Table 4b Tack Coat Residual Rates OGFC

OGFC over:	Minimum Residual Rates (gallons per square yard)		
	CSS1/CSS1h SS1/SS1h and QS1h/CQS1h Asphaltic Emulsion	RS1/RS2 and QS1/ CQS1 Asphaltic Emulsion	Asphalt Binder and PMRS2/PMCRS2 and PMRS2h/PMCRS2h Asphaltic Emulsion
New HMA	0.03	0.04	0.03
Existing HMA and PCC pavement	0.05	0.06	0.04
Planed pavement	0.06	0.07	0.05

The specified minimum residual rates for QS1h and CQS1h are lower than QS1 and CQS1, since QS1h and CQS1h are made using a harder base asphalt. Harder base asphalt will provide more cohesion and stronger bonding for the tack coat. The specified minimum residual rates for CSS1 and SS1 are lower than RS1 and RS2, because RS1 and RS2 emulsions break much more quickly than CSS1 and SS1. Therefore more volume of RS1 and RS2 is required to obtain uniform coverage. For CSS1 and SS1, contractors typically dilute SS1 and CSS1 for even better uniform spreading, but RS1 and RS2 emulsions cannot be diluted to obtain better uniform spreading.

For undiluted emulsions, tack coat application rates shown in Tables 5a and 5b, "Tack Coat Application Rates," have been calculated based on the minimum percentage of residual by evaporation or distillation shown in Section 94, Asphaltic Emulsions," of the *Standard Specifications* and the minimum residual rates shown in Table 4. The contractor and hot mix asphalt inspector should ensure that the minimum tack coat application rates shown in Tables 5a and 5b are used to ensure that minimum specified residual application rate is achieved. For tack coat application rates for diluted emulsion see "Emulsion Dilution" in these guidelines.

Table 5a Tack Coat Application Rates HMA Type A, Type B, and RHMA-G

HMA over:	Minimum Application Rates (gallons per square yard)				
	CSS1/CSS1h, SS1/SS1h and QS1h/CQS1h Asphaltic Emulsion	RS1/QS1/ CQS1 Asphaltic Emulsion	RS2 Asphaltic Emulsion	PMRS2/PMCRS2 and PMRS2h/ PMCRS2h Asphaltic Emulsion	Asphalt Binder
New HMA (between layers)	0.04	0.05	0.05	0.03	0.02
Existing HMA and PCC pavement	0.05	0.07	0.06	0.05	0.03
Planed pavement	0.09	0.11	0.10	0.06	0.04

Table 5b Tack Coat Application Rates OGFC

OGFC over:	Minimum Application Rates (gallons per square yard)				
	CSS1/CSS1h, SS1/SS1h and QS1h/CQS1h Asphaltic Emulsion	RS1/QS1/ CQS1 Asphaltic Emulsion	RS2 Asphaltic Emulsion	PMRS2/PMCRS2 and PMRS2h/ PMCRS2h Asphaltic Emulsion	Asphalt Binder
New HMA	0.05	0.07	0.06	0.05	0.03
Existing HMA and PCC pavement	0.09	0.11	0.10	0.06	0.04
Planed pavement	0.11	0.12	0.11	0.08	0.05

Where to Apply Tack Coat

Apply tack coat to existing pavement including planed surfaces, between hot mix asphalt layers, and to vertical surfaces of curbs, gutters, construction joints, dig-outs (remove and replace surfacing), and milled pavements.

Additional Tack Coat Requirements

- Apply to vertical surfaces with a residual tack coat rate that will thoroughly coat the vertical face without running off.
- When the contractor requests, in writing, a change in specified tack coat residual rates, the engineer authorizes it.
- Immediately in advance of placing hot mix asphalt, apply additional tack coat to damaged areas or where loose or extraneous material is removed.
- Close areas receiving tack coat to traffic. Do not track tack coat onto pavement surfaces beyond the project site.
- Asphalt binder tack coat must be between 285ºF and 350ºF when applied.
- When geosynthetic pavement interlayer is used, apply asphalt binder as tack coat in accordance with Section 39-1.09D "Geosynthetic Pavement Interlayer," of the Standard Specifications.
- The contractor may request and the engineer authorize that the application of tack coat is waived between hot mix asphalt layers when both of the following applies:

1. The surface to be paved does not have a film of dust or clay that could prevent bonding.
2. The surface to be paved is ≥ 140ºF.

Where Not to Apply Tack Coat

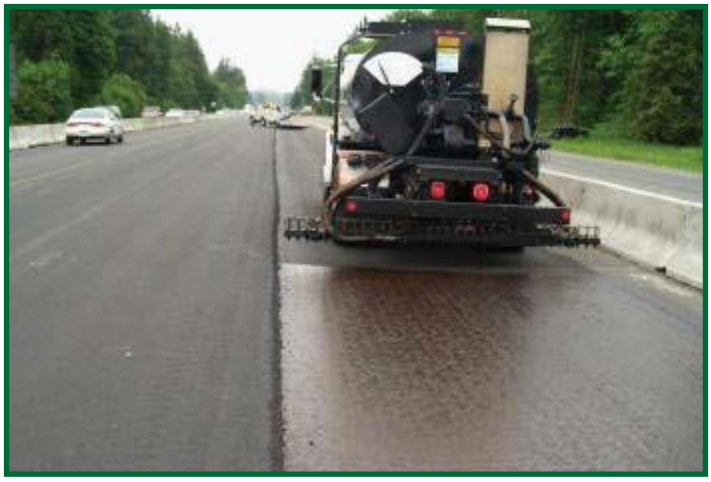
Tack coat application must be limited to an area that ensures its coverage in the same day's paving. It should not be applied to a bleeding surface.

For bituminous seals, a tack coat is not required before placing a chip seal. However, a chip seal should receive a flush coat (fog seal and sand cover) on surface of chip seal.

A tack coat is generally not required before a slurry seal or micro-surfacing application unless the existing surface is extremely dry and raveled or is concrete pavement.

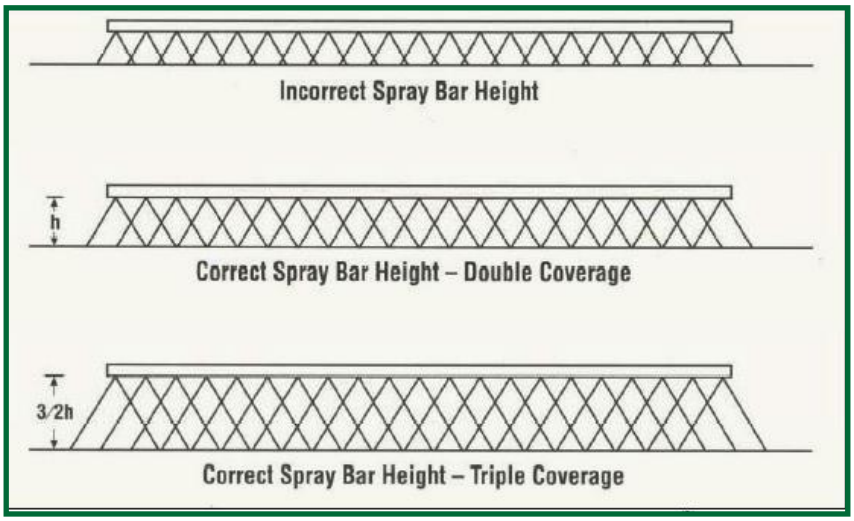
Placement Considerations for Tack Coat

When tack coat is applied, use the following guidance to ensure a proper placement:

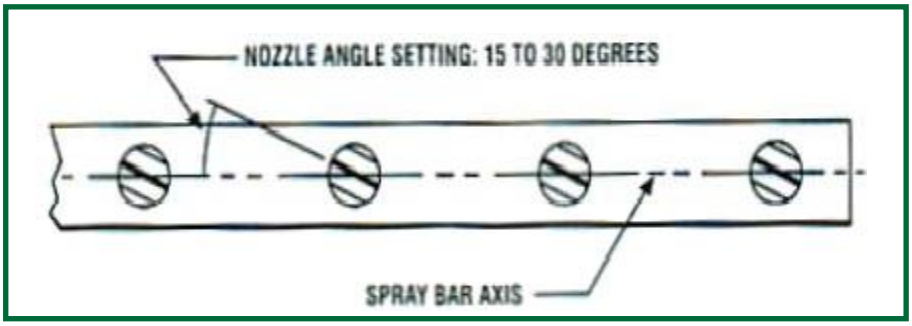


- A surface free of substances is critical. A dirty or dusty surface will inhibit the ability of the tack coat to bond, potentially resulting in a slippage plane. A fine dust coating can occur overnight and a sweeper should be used to remove the dust. In some parts of the state, liquid agricultural waste spilled on the surface (for example, juice from tomatoes leaked on highway during harvesting season) may need to be removed by washing prior to tack coat application. When washing of surface is required, water pollution control BMPs (best management practices) may be required.
- Obtain the required test report and certificate of compliance from each truckload of emulsion or asphalt binder before the application of tack coat starts. Compare the test report with the specifications. Shipments may be used before sampling and testing if certificates of compliance and the test results accompanying them comply with the specifications.
- Obtain initial load slips or weight certificates from each load of emulsion or asphalt binder. For diluted emulsions, obtain weight or meter readings to determine emulsion dilution ratio and pay quantity. If partial loads were used, collect weigh-back slips to determine pay quantities.
- It is essential that the application is uniform. Distributor application rates are dependent upon pump rates and speed of the truck.

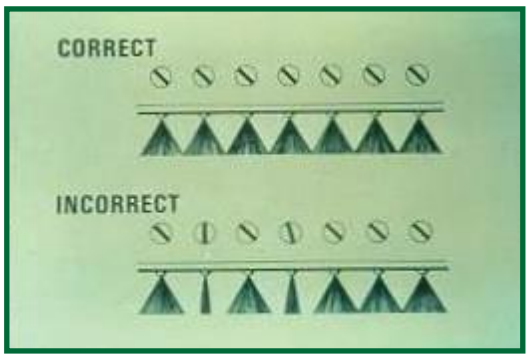
Set the height of the spray bar high enough above the roadway for the surface to receive double or triple coverage.



The spray bar should be set high enough to get double coverage.



Set the spray bar nozzles at an angle between 15º and 30º.



Streaking and puddling, two extremes of application, indicate improper spread rates or improper height of the spray bar.

Poor (left) versus good (right) tack coat coverage. Note streaky coverage of poor coat and nearly complete coverage of good.

- Test distributor for spread rate in accordance with California Test 339. Work with the distributor truck driver to complete the following procedure:

    1. Record the weight of a one-square-yard pan or nonwoven geotextile materials.
    2. Place the pan or geotextile on the road surface.
    3. Have the distributor apply the tack coat over the pan or geotextile.
    4. Record the weight of the pan and tack coat or the geotextile with tack coat.
    5. Record the temperature of the tack coat.
    6. Subtract the tare weight to determine the weight of tack coat.

7. Convert the weight of tack coat to application rate, using the table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*.
8. Correct the calculated application rate using temperature correction multiplier found in the table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*.
9. Calculate the tack coat residual application rate using the residual percentages shown in the tables in Section 94, "Asphaltic Emulsion," of the *Standard Specifications*.
10. If the minimum residual rate for the grade of emulsion and for the condition of the underlying surface does not meet the specification requirement, have the contractor adjust the application rate and retest.

Example 8.1

If you run a distributor spread rate test for undiluted SS1h emulsion and find that the weight of the empty one square yard of the non-woven geotextile material is 0.45 pounds and that the weight of the saturated geotextile is 1.15 pounds at 80ºF, the weight of the sprayed tack coat = 1.15 - 0.45 = 0.7 pounds.

The table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*, indicates 8.33 pounds of emulsion per gallon at 60ºF.

The application rate = 0.7 pounds ÷ 8.33 pounds/gallon = 0.084 gallons per square yard.

Using a 0.99500 temperature correction multiplier found in the table at the end of Section 94, you see that the corrected application rate = 0.084 x 0.99500 = 0.0836, or 0.08 gallons per square yard at 60ºF.

To determine the residual application rate, use Table 1, "Requirements for Anionic Asphaltic Emulsion," in Section 94, "Asphaltic Emulsions," of the *Standard Specifications*. The columns for slow-setting show the residue by distillation to be 57% for SS1h. To determine the residual asphalt application rate calculate the following:

Tact Coat Residual Application Rate = (actual application rate) x (% residual)

= .0836 gallons per square yard x .57

= .0476 gallons per square yard

Tack Coat Residual Application Rate = .05 gallons per square yard

An alternative method of measuring spread rate can be done by using the distributor dipstick or the meter on the pump to measure the volume in gallons that was applied, as follows:

1. Park the distributor on level ground, and measure and record the number of gallons of tack coat.
2. Measure off a known area for a test section.
3. Have the distributor apply tack coat to the test section.
4. Park the distributor on level ground and re-measure the tack coat.
5. Subtract the second measurement from the first to determine the volume of tack coat applied.
6. Record the temperature of the tack coat.
7. Determine the application rate in gallon per square yard by dividing the amount of tack coat applied by the test area (using feet, [length x width] ÷ 9 = square yards).
8. Correct the calculated application rate using temperature correction multiplier found in the table at the end of Section 94, "Asphaltic Emulsion," of the *Standard Specifications*.
9. Calculate the tack coat residual application rate using the residual percentages shown in the tables in Section 94.
10. If the minimum residual rate for the grade of emulsion and for the condition of the underlying surface does not meet the specification requirement, have the contractor adjust the application rate and retest.

Example 8.2

You run a distributor spread rate test for PMCRS2 emulsion first by determining that the distributor is loaded with emulsion and that the volume of the emulsion in the tank of the distributor is 500 gallons.

The area sprayed with the emulsion was 3600 square feet (3600 sq. ft. ÷ 9 sq. ft. per sq. yd.

= 400 square yards), and the remaining emulsion in the tank was 475 gallons at 70ºF. The volume of the sprayed emulsion = 500 – 475 = 25 gallons at 70ºF.

The application rate = 25 gal ÷ 400 sq. yd. = 0.062 gallons per square yard at 70ºF.

A 0.99750 temperature correction multiplier found in the table at the end of Section 94, "Asphaltic Emulsions," of the *Standard Specifications,* shows that the corrected application rate = 0.062 x 0.99750 = 0.0618 or 0.06 gallons per square yard at 60ºF.

To determine the residual application rate, use Table 3, "Requirements for Polymer Modified Asphaltic Emulsion" in Section 94, "Asphaltic Emulsions," of the *Standard Specifications*. The columns for cationic grade PMCRS2 show the residue by evaporation to be 65% for PMCRS2. To determine the residual asphalt application rate calculate the following:

Tact Coat Residual Application Rate = (actual application rate) x (% residual)

= .0618 gallons per square yard x .65

= .0401 gallons per square yard

Tack Coat Residual Application Rate = .04 gallons per square yard

Tack coat integrity must be maintained until the paving is complete. Additional activities include:

- Blotting excessive tack coat by applying sand and using a pneumatic-tired roller. This action prevents excessive tack coat from acting as a slip plane.
- Ensuring that the tack coat has broken before paving or, if the contractor chooses to pave before the tack coat has broken, that tracking is minimized.

The brown color indicates that the freshly placed emulsion tack coat has not yet broken.

The same tack coat 23 minutes later. The brown color now appears in splotches, indicating it is beginning to break.

Tack coat using an asphalt emulsion.
The black color indicates it has broken.

- When tracking tack coat materials by vehicle tires occurs, clean the affected areas and reapply the tack coat before resuming paving operations.

Tack coat tracking resulting in
no tack coat in the wheel path.

- Requiring contractors to clean tack coat tracked onto adjacent structures or concrete pavement.
- For safety reasons, keep traffic off a tack coat surface. If traffic must use the surface where tack coat has been applied, apply a sand cover and take other appropriate action to provide adequate skid resistance.
- The tack coat may become slick if it rains on a newly placed tack coat. It is prudent to have a source of sand available for these situations, or lane closures must remain in place during inclement weather. If sand is applied to the tack coat, the pavement will have to be swept or flushed with water to remove the sand. Reapply the tack coat before resuming paving operations.
- Comply with tack coat material sampling and testing frequency in Chapter 6, "Sampling and Testing," of the Construction Manual (see the "Sampling and Testing Tack Coat Materials" section of these guidelines for more information).
- Verify the tack coat application rate on a daily basis either by an application test section or by calculation based on daily tack coat placed versus daily area covered.
- If you need to verify the hot mix asphalt bond to existing pavement surface or between layers of hot mix asphalt, contact the Office of Flexible Pavements at METS for advice.

9.0 MEASUREMENT AND PAYMENT

Emulsion and asphalt binder are measured for payment by weight and the unit of weight is the ton. Switching to specifying residual tack coat rates in lieu of application rates has not changed the way tack coat materials are measured and paid for. Note that payment is made for the emulsion, not for the diluted emulsion. Do not pay for additional water that has been added to the emulsion on site.

The hot mix asphalt paving inspector should collect initial load slips or weight certificates from each load of emulsion or asphalt binder and, if partial loads were used, collect weigh-back slips or certificates to determine pay quantities. The paving inspector should sign or initial all load slips or weight certificates to indicate that the material represented thereon was incorporated in the work.

When partial loads of emulsion or asphalt binder are used for tack coat and no scales are located within 20 miles of the jobsite, the weight of the emulsion and asphalt binder remaining on the distributor can be determined from volumetric measurements. The unit of volume is the gallon. To determine the volume of material used, stab the tank after spreading or read the vehicle tank meter, to determine the temperature of the remaining material. It is important to record the temperature of the material to be able to convert the volume of the material at any other temperature to the volume it would occupy at 60°F. The volume of the emulsion or asphalt binder at 60°F is then converted to weight. See the requirements in Section 92-1.04, "Measurement," of the *Standard Specifications* for asphalt or Section 94-1.07, "Measurement," for emulsions.

Example 9.1a

Suppose a partial load of slow-setting diluted (1:1) emulsion was used for a tack coat and no scales are located within 20 miles of the jobsite. The difference in the vehicle tank meter before and after spreading the tack coat is 130 gallons. The temperature of the emulsion is 122°F. Calculate the pay quantity for the tack coat.

It is determined from the Conversion Table in Section 94-1.07 of the *Standard Specifications* that the multiplier for converting the volume of the emulsion at 122°F to the volume it would occupy at 60°F is 0.98450. Therefore, the volume of emulsion used is calculated as follows:

Volume of Emulsion	=	130 gallons x 0.98450
	=	127.985
Volume of Emulsion	=	128 gallons

Section 94-1.07 gives the density of emulsion at 60°F as 240 gallons per ton.

Weight of Emulsion	=	128 gallons ÷ 240 gallons/ton
Weight of Emulsion	=	.5333 tons

However, because the slow-setting emulsion was diluted 1:1 with water and no payment is allowed for the additional water, the final pay quantity is calculated as follows:

Tack Coat Quantity	=	0.5333 tons x 0.50 (emulsion to water ratio)
	=	0.2667
Tack Coat Quantity	=	0.27 tons

Payment is made for the emulsion not including the additional water in the diluted emulsion.

Example 9.1b

If a partial load of slow-setting emulsion was used for a tack coat and scales were located within 20 miles of the jobsite, the weigh-back slips or weight certificates would have shown directly that approximately 0.53 ton of emulsion was spread. Since the emulsion was diluted 1:1 with additional water, the pay quantity would still be 0.27 tons.

Example 9.1c

If a rapid-setting emulsion was used for tack coat, the final pay quantity would have been 0.53 tons, because the rapid-setting emulsion was not diluted with additional water.

Example 9.2

A partial load of slow-setting diluted (0.5:1) emulsion is used for tack coat and no scales are located within 20 miles of the jobsite. The difference in the vehicle tank meter before and after spreading the tack coat is 221 gallons. The temperature of the emulsion is 122°F.

It is determined from the Conversion Table in Section 94-1.07 of the *Standard Specifications* that the multiplier for converting the volume of the emulsion at 122°F to the volume it would occupy at 60°F is 0.98450. Therefore, the volume of emulsion used is calculated as follows:

Volume of Emulsion	=	221 gallons x 0.98450
	=	217.574
Volume of Emulsion	=	218 gallons

Section 94-1.07 gives the density of emulsion at 60°F as 240 gallons per ton.

Weight of Emulsion	=	218 gallons ÷ 240 gallons/ton
Weight of Emulsion	=	.9083 tons

However, because the slow-setting emulsion was diluted 0.5 :1 (1÷ 1.5 = .67 emulsion ratio) with water and no payment is allowed for the additional water, the final pay quantity is calculated as follows:

Tack Coat Quantity	=	0.9083 tons x 0.67 (emulsion ratio)
	=	0.6086
Tack Coat Quantity	=	0.61 tons

Example 9.3

A partial load of PG 64-10 asphalt binder is used for a tack coat, and no scales are located within 20 miles of the jobsite. The difference in the vehicle tank meter before and after spreading the tack coat is 130 gallons, and the temperature of the asphalt binder is 321°F. Determine the payment quantity of tack coat placed.

It is determined from Section 92-1.04 of the *Standard Specifications* that the density of PG 64-10 at 60°F is 235 gallons per ton or 64 pcf.

According to the Conversion Table in Section 93-1.04, the "A" multiplier used for reducing volumes of asphalt with a density greater than 60 pcf to the volume it would occupy at 60°F is 0.9118 at 321°F.

Therefore, the volume of asphalt binder used is calculated as follows:

Volume of Asphalt Binder	=	130 gallons x 0.9118
	=	118.534
Volume of Asphalt Binder	=	119 gallons

Section 92-1.04 gives the density of asphalt at 60°F as 235 gallons per ton.

Tack Coat Quantity (Weight of Asphalt Binder)	=	119 gallons ÷ 235 gallons/ton
	=	.5064 tons
Tack Coat Quantity	=	.51 tons

10.0 COMPENSATION ADJUSTMENT FOR PRICE INDEX FLUCTUATIONS FOR ASPHALT

Both emulsions and asphalt binder used for tack coats are eligible for asphalt price adjustment if the price of asphalt increases or decreases more than 5 percent based on the California Statewide Paving Asphalt Price Index. Before making any adjustments, the engineer verifies that the project's special provisions allow the adjustment and other requirements. The engineer will use the residual percentage specified in Section 94, "Asphaltic Emulsions," of the *Standard Specifications* to determine the quantity of asphalt in an emulsion subject to adjustment. The contractor may provide daily test results for actual percentage of asphalt residue in emulsions used as tack coat.

The quantity of asphalt calculated using the asphalt residual percentage in a tack coat for the paving asphalt price fluctuation adjustment calculation and the quantity of tack coat paid in the contract item for tack coat will be different quantities.

For asphalt binder used as tack coat, the quantity used to calculate compensation for paving asphalt price fluctuation adjustment will be the same quantity of tack coat paid in the contract item for tack coat.