



## Best Practices from Six State DOTs



# Tack Coats

Short-term Research

NRRA Flexible Team

June 2018

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# Tack Coats

NRRA State of Practice

June 2018

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## Summary Statement:

A tack coat is a light application of asphalt cement or asphalt emulsion applied to enhance bond between a new HMA surface constructed over an existing surface. Adequate bonding between construction lifts supports pavement layers acting as a beam, a monolithic structure, that better supports wheel loads as intended by pavement designers. Inadequate bond strength between lifts can allow excessive bending and strain as well as may allow slippage that results in delamination (debonding) followed by premature failures and a reduction in pavement life.



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## 1 Background

### 1.1 What is a tack coat?

**Tack coat** – A thin surface treatment of liquid asphalt cement or emulsion applied to enhance bond between a new HMA surface and existing road surface and recommended between each lift of new HMA (Figures 1.1-1 and 1.1-2). The liquid asphalt material is applied to new, milled, or un-milled bituminous or to concrete surfaces being overlain to improve bonding between layers and create the monolithic structure needed to support wheel loads as intended by pavement designers. Pavement layers act as a beam and inadequate bond between lifts can allow excessive bending, strain, or slippage that results in delamination or premature failure.



Figure 1.1-2 - Tack coat application at MnROAD 2016.

### 1.2 FHWA Guidance

FHWA Tech Brief FHWA-HIF-16-017 reported the costs of tack coats on new or reconstructed facilities to be 0.1-0.2 percent of total project costs and 1.0-2.0 percent of total project costs on mill and overlay type projects. AASHTO and other collaborating organizations recommend diluted application rates that leave undiluted residual asphalt, after breaking or curing, ranging from approximately 0.04 to 0.06 gal/yd<sup>2</sup> for smooth non-milled surfaces and up to 0.08 gal/yd<sup>2</sup> for milled or very rough surfaces.

The FHWA tech brief recommends similar application rates that leave residual asphalt ranging from 0.02 to 0.07 gal/yd<sup>2</sup> for new or smooth non-milled surfaces and up to 0.08 gal/yd<sup>2</sup> for milled or very rough surfaces.



Figure 1.1-2 - Tack coat application at MnROAD 2016 construction – note this was not acceptable and was reapplied before paving.

A tack coat should be applied to a clean dry surface uniformly across the entire pavement surface to be overlain. A clean surface is important to achieving the desired bond. Milling increases the required application rate based on surface area and also promotes additional mechanical bonding through aggregate interlock with the rough milled surface.

## 1.3 Why NRRRA Members Wanted This

### 1.3.1 NRRRA Members Involved

Six state agencies that are currently involved in the tack coat technology transfer, are California DOT, Illinois DOT, Michigan DOT (Bond Coat), Minnesota DOT, Missouri DOT, and Wisconsin DOT.

### 1.3.2 Why This Effort is Being Done

The purpose of this paper is to compile a synthesis of best practices being used by participating NRRRA members in the area of tack coats and identify inconsistencies or contradictions in understanding or approach that can be evaluated during the next round of investigation at MnROAD.

## 2 NRRRA State Member Specifications

### 2.1 Specifications by State

Specifications for materials and for construction/application are typically separate. The following Table 2.1-1 provides the specification numbers by member States which govern tack coat construction/application.

Agency	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT	Missouri DOT	Wisconsin DOT
Specification #	39-2.01C(3)(f)	406.05b(1)	501.03	2357 & 2360	407	455.2.5 & 455.3

**Table 2.1-1 – Tack Coat Application Specification**

The following Table 2.1-2 provides the specification numbers by member State which govern the asphalt material used for tack coats.

Agency	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT	Missouri DOT	Wisconsin DOT
Bituminous Materials	Asphaltic emulsion or asphalt binder	Emulsified asphalt or cutback asphalt	Emulsified asphalt	Emulsified asphalt or medium cure cutback asphalt	Emulsified asphalt or performance graded asphalt binder	Emulsified asphalt or modified emulsified asphalt
Spec	39-2.01B(10) & 39-2.01C(3)(f)	406.02	501.02	2357.2	407.2 & 1015	455.2.5

**Table 2.1-2 – Bituminous Materials for Tack Coat**

Links to each member State Construction Specifications:

- [California – 2015 Standard Specifications](#)
- [Illinois – 2016 Standard Specifications for Road and Bridge Construction](#)
- [Michigan – 2012 Standard Specifications for Construction](#)



- [Minnesota – 2016 Standard Specifications for Construction](#)
- [Minnesota – 2018 Standard Specifications for Construction](#)
- [Missouri – 2016 Standard Specifications for Highway Construction](#)
- [Missouri – 2017 Standard Specifications for Highway Construction](#)
- [Wisconsin – 2018 Standard Specifications for Highway and Structure Construction](#)

## 2.2 Bituminous Material Comparison Between Agencies

The following table provides a summary of bituminous material permissible for tack by participating State.

Agency	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT	Missouri DOT	Wisconsin DOT
PG Asphalt Binder	X				X	
Cutback Asphalt						
MC-250				X		
RC-70		X				
Asphalt Emulsions						
CSS-1h	X	X	X	X	X	X
CSS-1	X	X		X	X	X
SS-1h	X	X	X		X	X
SS-1	X	X			X	X
RS-1	X	X			X	
RS-2	X	X			X	
CRS-1	X	X			X	
CRS-2	X	X			X	
SS-1hP		X			X	
CSS-1hP		X			X	
SS-1vh		X				
MS-2						X
QS-1	X					
QS-1h	X					
CQS-1	X					
CQS-1h	X					
PMRS-2	X					
PMRS-2h	X					
PMCRS-2	X					
PMCRS-2h	X					
HFE-90		X				

Table 2.2-1 – List of Bituminous Materials



### 2.3 Application Rate Criteria

Specification and acceptance requirements for surveyed States generally define application rates intended to provide a minimum residual asphalt content uniformly distributed across the surface to be overlain after application and curing. An emulsion is a blend of paving grade binder material mixed with water or a chemical emulsifying agent. Residual Asphalt is the asphalt remaining after an emulsion has set or cured. States use visual inspection for coverage and a calculated or measured residual asphalt rate for verification, payment, and acceptance, methods important when verifying uniform and complete distribution for acceptance.

**California DOT** – Provides a required residual asphalt rate in gallons per square yard, with a slight variation based upon asphalt type as well as surface to be overlain, for acceptance. Contractor may dilute material in the field and any diluting must be reported to the Engineer and is limited to 1:1. If authorized, tack coat may be omitted between layers of new HMA if no dust, dirt, or extraneous material is present and the surface to be overlain is at least 140°F.

HMA over:	Minimum residual rates (gal/sq yd)		
	CSS1/CSS1h, SS1/SS1h and QS1h/CQS1h asphaltic emulsion	CRS1/CRS2, 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
Concrete pavement and existing asphalt concrete surfacing	0.03	0.04	0.03
Planed pavement	0.05	0.06	0.04

**Table 2.3-1 California Minimum Residual Asphalt Rates**

**Illinois DOT** – acceptance based upon residual asphalt content in pounds per square foot at two rates dependent upon the surface to be overlain. The lower rate is required between lifts of HMA. Any dilution of asphaltic material must be performed by the producer. The following Table provides residual asphalt rates required.

Type of Surface to be Tacked	Residual Asphalt Rate lb/sq ft (kg/sq m)
Milled HMA, Aged Non-Milled HMA, Milled Concrete, Non-Milled Concrete & Tined Concrete	0.05 (0.244)
HMA Lifts, IL-4.75 & Brick	0.025 (0.122)

**Table 2.3-2 Illinois Minimum Residual Asphalt Rates**

The residual asphalt rate is verified by physical testing a minimum of once per type of surface to be tacked for which at least 2000 tons of HMA is placed in accordance with Illinois test procedure “Determination of Residual Asphalt in Prime and Tack Coat Materials”.



**Michigan DOT** – Specification refers to bond coat rather than tack and references are to SS-1h and CSS-1h material. Application rate is not defined in the general specifications which includes the following note: *Obtain the approval of the Engineer for the application rate after work begins.* Michigan allows dilution with minimum undiluted application rates ranging from a minimum of .05 gal/square yard and a maximum of .10 gal/square yard.

**Minnesota DOT** – Specifications call for CSS-1 or CSS-1h material from certified sources. Material if diluted must be diluted by the manufacturer, dilution in the field is not allowed. During freezing weather cutback asphalt, MC-250, may be allowed with the approval of the Engineer. The following provides required application rate ranges.

<b>Table 2357-2 Tack Coat Application Rates</b>			
Application Rates -- gallons/square yard			
Surface Type	Undiluted Emulsion	Diluted Emulsion (7:3) <sup>1</sup>	MC Cutback <sup>2</sup>
New Asphalt	0.04 to 0.06	0.06 to 0.09	0.05 to 0.07
Old Asphalt <sup>3</sup> and PCC	0.05 to 0.09	0.075 to 0.135	0.09 to 0.11
Milled Asphalt and Milled PCC	0.06 to 0.09	0.09 to 0.135	0.09 to 0.11

**Table 2.3-3 Minnesota Tack Coat Application Rates**

The above application rates are intended to provide residual asphalt contents as follows:

<b>Table 2357-1 Residual Asphalt Content</b>		
Minimum Residual Asphalt Content		
Emulsion	Undiluted	Diluted (7:3)
CSS-1 or CSS-1h	57%	40%

**Table 2.3-4 Minnesota Residual Asphalt Content**

Specifications require a yield check at the beginning of each project using a distance of 1,000 feet. The Engineer may also require additional yield checks or for the contractor to verify the application is within 10 percent of the required application rate following ASTM D 2995, test method A, Estimating Application Rate and Residual Application Rate of Bituminous Distributors, a direct measurement of applied tack coat material.

**Missouri DOT** – Specifications provide “Target Application Rates”. If the material is provided diluted, dilution must be by the manufacturer. Dilution in the field is not allowed. These application rates may be varied +/- 0.02 gallons per square yard based upon field observations of surface condition and only with the approval of the Engineer. Acceptance is based upon a measurement of the asphalt emulsion material applied.





Tack Coat Application Rates		
Surface Type	Target Application Rate; Undiluted (gal/yd <sup>2</sup> )	Target Application Rate; 20% Diluted (gal/yd <sup>2</sup> )
New Asphalt Surfaces	0.05	0.06
Existing Asphalt or Concrete Surfaces	0.08	0.10
Coldmilled Asphalt or Concrete Surfaces	0.10	0.13

**Table 2.3-5 Missouri Task Coat Application Rates**

**Wisconsin DOT** – Specifications define an application rate of 0.050 to 0.070 gallons per square yard after dilution. Dilution is allowed by the manufacturer or on site by the contractor but the contractor must show that as-placed material has 50 percent or more residual asphalt content. Application rates may be adjusted in the contract or by the Engineer based on surface conditions.

In summary States generally focus on desired residual asphalt for acceptance and payment. Residual asphalt is generally calculated from documentation that includes volume of emulsion applied, dilution rate of the emulsion, and total area of application. The general minimum residual asphalt contents desired by member States are summarized in the following Table 2.3-1:

	California DOT	Illinois DOT	Michigan DOT	Minnesota DOT	Missouri DOT	Wisconsin DOT
Rate	gal/yd <sup>2</sup>	lb/ft <sup>2</sup>	*	Application Rate: gal/yd <sup>2</sup>	gal/yd <sup>2</sup>	gal/yd <sup>2</sup>
New HMA	.02 – .03	.025	*	.023 – .035	.03	.025 – .035
Existing HMA or Concrete	.03 – .04	.05	*	.030 – .055	.05	
Milled Surface	.04 – .06	.025		.036 – .055	.06	

\* No rates are shown for Michigan as the standard specifications for construction state: *Obtain the approval of the Engineer for the application rate after work begins.*

**Table 2.3-6 Minimum Residual Asphalt Content**



Specifications require spray application by a pressure distributor at temperatures in accordance with the following table:

Agency	California DOT		Illinois DOT		Michigan DOT		Minnesota DOT		Missouri DOT		Wisconsin DOT
Spec	39-2.01C(3)(f)		1032.04		904.02		2357.3.E		1015.5		455.3.1
Bit Material	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Within the limits the supplier specifies
Asphalt Binder											
PG 46-28	-	-	-	-	-	-	-	-	260	325	
All Other Grades	285	350	-	-	-	-	-	-	285	350	
Cutback Asphalt											
MC-250	-	-	-	-	-	-	165	220	-	-	
RC-70	-	-	120	225	-	-	-	-	-	-	
Asphalt Emulsions											
CSS-1h	-	-	75	130	85	135	70	160	120	160	
CSS-1	-	-	75	130	-	-	70	160	120	160	
SS-1h	-	-	75	130	85	135	-	-	120	160	
SS-1	-	-	75	130	-	-	-	-	120	160	
RS-1	-	-	75	130	-	-	-	-	120	140	
RS-2	-	-	110	160	-	-	-	-	125	185	
CRS-1	-	-	75	130	-	-	-	-	125	185	
CRS-2	-	-	110	160	-	-	-	-	125	185	
SS-1hP	-	-	75	130	-	-	-	-	-	-	
CSS-1hP	-	-	75	130	-	-	-	-	-	-	
SS-1vh	-	-	160	180	-	-	-	-	-	-	
HFE-90	-	-	150	180	-	-	-	-	-	-	

Table 2.3-7 Spraying Application Temperature for Bituminous Materials (°F)

## 2.4 General Construction Requirements

### 2.4.1 Surface Preparation

Prior to tack coat application it is generally required that the road surface to be clean, and either dry or with no standing water, and allow application only when weather conditions are suitable. All necessary repairs or reconditioning must be complete prior to application. The Illinois, Missouri, and Wisconsin DOTs allow pre-wetting of existing surfaces just prior to tack coat application, in accordance with 407.4.1.2.



## 2.4.2 Application

All participating NRRRA states generally require the contractor to provide a distributor capable of uniformly applying tack coat material uniformly to the surface to be overlain and the following:

- (1) An accurate volume measuring device with tachometer
- (2) Pressure gauges
- (3) Thermometer for measuring temperatures of tank contents
- (4) Power-operated pump
- (5) Full circulation spray bars with lateral and vertical adjustments

After application, it is recommended to keep traffic off the tacked surface. States generally require additional tack coat be applied to damaged areas or where loose extraneous material is removed.

All participating states require that the tack coat must be fully cured prior to placement of HMA. Minnesota DOT describes a color change from brown to black and the use of construction paper as a guide to the correct color. When diluted into an emulsion the applied tack material must be allowed to break, water or other diluting agent to evaporate, prior to placement of the overlying HMA. HMA delivery trucks often need to drive on a tacked mat as material is being delivered. This action may foul the tack by depositing material or may adhere to vehicle tires and be removed from the surface reducing the effectiveness of the tack material. Allowing tack coats to break or set as is the case for emulsions or cure for cutbacks before driving on them substantially reduces the potential for tracking. Contractors should plan operations to ensure HMA material delivery vehicles are generally clean before driving on the tacked surface.

## 2.4.3 Additional Field Requirements

All participating states require that the tack coat must be fully cured prior to placement of HMA and that additional tack material be applied to damaged areas or where loose extraneous material is removed. Specific requirements for each state are as follows:

### California DOT (39-2.01C(3)(f))

If authorized, tack coat can be omitted between layers of new HMA during the same work shift if there is no dust, dirt, or extraneous material present and the surface is at least 140°F immediately in advance of placing HMA mat.

### Illinois DOT (406.05(b))

The residual asphalt rate will be verified a minimum of once per type of surface to be tacked as specified herein for which at least 2000 tons of HMA will be placed. The test will be according to the Illinois DOT procedure for "Determination of Residual Asphalt in Prime and Tack Coat Materials". If pickup occurs, paving shall be cease in order to provide additional cure time, and all areas where the pickup occurred shall be repaired.

### Minnesota DOT (2357.3.D)

All tack must break, turn from brown to black, before paving the subsequent lift or course. Do not allow vehicles to drive on tack that has not broken. The Engineer will compare the freshly sprayed emulsion to a brown sheet of construction paper or a black sheet of construction paper for broken tack to determine



conformance with tack application uniformity. Using a distance of 1,000 feet, perform a yield check at the beginning of each project to verify the application rate is correct. The Engineer may also require the Contractor to verify application is within 10 percent of the intended application rate by ASTM D 2995 test method A.

**Missouri DOT (407.4.2 & 407.4.3)**

Upon approval by the Engineer, the target application rate may be varied by +/- 0.02 gal/yd<sup>2</sup> in the field, based upon the existing pavement condition. Re-application of tack due to excess tracking or non-uniform coverage shall be at the contractor's expense.

**Wisconsin DOT**

No additional field requirements.

**2.4.4 Measurement and Payment**

Measurement and payment for emulsion used as tack coat are typically based on the weight of asphalt emulsion (residual asphalt) without water that may be used for dilution. In some cases the application and payment for tack coat material is considered incidental to the placement of the asphalt material for which no additional or separate payment is made.

**California DOT (39-2.01D)**

Tack coat will be paid for at the contract unit price per ton of residual asphalt placed. Tack coat used in minor HMA operations may be incidental to the payment for hot mix asphalt. The Department does not adjust the unit price for an increase or decrease in the tack coat quantity.

**Illinois DOT (406.14)**

Tack coat is paid for at the contract unit price per pound of residual asphalt for bituminous materials.

**Michigan DOT (109.01.B.2.b)**

The application of tack coat is incidental to placement with no separate payment for the tack material.

**Minnesota DOT (2357.5)**

Payment for the accepted quantity of asphalt emulsion and cutback shall be at the Contract price per unit of measure. If the contract does not contain Bituminous Material for Tack Coat, the Department has included the cost of providing and applying tack coat material with other relevant pay items.

**Missouri DOT (407.6)**

The accepted quantity of tack coat will be paid for at the contract unit price. No direct payment shall be made for water added to the asphalt emulsion.

**Wisconsin DOT (455.5.3)**

The department will measure the Asphaltic Material Tack Coat bid item by the ton or gallon, based on either shipment net weight, or corrected volume. The Department will adjust pay for tack coat under the Nonconforming Tack Coat administrative item for nonconforming material which the Engineer allows to remain in place at 75 percent of the contract unit price.



### 3 NRRA Summary of the State of Practice

The performance of an HMA pavement is related to the performance of tack coats constructed between lifts of HMA pavement and their ability to enhance the bond between lifts. Lifts that are well bonded allow pavement layers to act as a beam. Unbonded lifts can lead to premature failure of the pavement system by delamination, fatigue cracking or potholing.

States all require surfaces to be overlain to be clean with no standing water or dry condition to allow for the applied tack material to adhere to the new and old surfaces. On milled surfaces MnDOT reports that there may be benefit from allowing traffic to drive over the milled surface for a few days before paving and that the action of the traffic benefitted the milled surface by removing fines. Where milling and overlaying in the same day has been performed a fine layer of dust on the roadway affecting the bond of the tack has been observed and resulted in the need to sweep the milled surface twice with the power broom prior to tack application.

Paving specifications typically identify application temperatures. Above freezing temperatures are generally required particularly when using and water based emulsions.

With respect to suitable material for tack a broad range of acceptability exists between the States. Michigan and Minnesota generally designate two allowable material types, Wisconsin allows five material types, Missouri and Illinois allow from ten to twelve material types that are also similar, and California allows for sixteen material types. Only one material CSS-1h appears to be acceptable to all States.

State specifications appear to be generally developed with a focus on residual asphalt for acceptance and payment. Although optional in some States, only Illinois appears to routinely requires direct field test measurements of residual asphalt. Most States choose to monitor application rates and asphalt material to calculate a residual rate based upon an applied volume adjusted for any dilution performed either by the supplier or on site by the contractor.

After application, and prior to overlaying with HMA, emulsion must be allowed to break, water or other diluting agent to evaporate, generally visually determined as an emulsion will be dark brown in color turning black. Inspectors should observe contractor operations to ensure HMA material delivery vehicles are generally clean before driving on the tacked surface and that the tack material is set or cured and ready to be overlain and not tracking off the surface.

The following steps are followed to calculate the quantity of material placed:

1. Determine area covered by physical measurement.
2. Determine the gallons of material applied to the area measured corrected to 60°F.
3. Calculate residual asphalt by subtracting volume of water or other chemical used for dilution.

For direct measurement of residual asphalt material applied two methods are described by ASTM D2995. Method A uses calibration pads that are pre-weighed. The pads are weighed before and after tack application and the rate is determined by taking the difference weights. For Method B, the distributor discharges material into containers placed under each nozzle for a set period of time. The



volume is then calculated and the application rate becomes a function of the truck's ground speed. Uniformity of application is also verified by checking the volume consistency between each container.

In one study at MNROAD tack coat residual rates were measured by applying the tack material over 12-inch by 12-inch geosynthetic fabric squares mounted to impervious plates. Just prior to tack coat application, the fabric/plate assemblies were weighed, and then placed on the road. The tack was then permitted to cure and subsequently weighed. Good agreement was found between measured and calculated residual asphalt rates.

## 4 Research to Consider

### 4.1 Traffic on tack coats less tracking tack

Often vehicles are required to drive on a tack coat after application to deliver HMA material to the paver and at times to manage traffic such as at intersections. When this occurs tack material may adhere to the vehicle tires and be carried away and re-deposited or soil and other deleterious material may be left behind. Both actions adversely affect ultimate bond strength.

In general when a tack material is allowed to break, set, or cure, the material is well adhered to the surface to which applied. Trackless Tack is a potential area of future research for NRRRA. In general implementation of trackless tack has been to use either very hard binder materials and material with an electrical charge intending to affect its affinity to other materials. Michigan DOT allows Low Tracking Bond Coat by Special Provision to contracts and names 2 approved products for this use. The specification allows for approved equal products to also be used and provides material specification and requirements for laboratory testing.

The Illinois DOT maintains a specification allowing for the application of a fine aggregate material when placing tack coat through an intersection where it is not possible to keep the lane closed. This action likely adversely impacts bond strength through an intersection where bond strength remains important.

### 4.2 Bond Strength of Tack Materials and Polymer Modified Tack

With respect to suitable material for tack a broad range of acceptability exists between the States. Michigan and Minnesota generally designate two allowable material types and California allows for sixteen material types. Only one material, CSS-1h appears to be acceptable to all States.

## 5 Innovation

### Full Lane Sealant

The Illinois Dept. of Transportation (IDOT) is currently evaluating the use of a modified version of the IDOT Longitudinal Joint Sealant as a tack coat alternative referred to as Full Lane Sealant (FLS). FLS is a highly polymerized asphalt which is hot applied and can be used as a tack coat alternative at rates as low as 0.13 lb/ft<sup>2</sup> or as a premium tack coat/interlayer at higher rates > 0.2 lb/ ft<sup>2</sup> to improve the performance of the pavement. FLS has been demonstrated to distribute and flow well and cool to a tack free condition in



less than five minutes. At the higher rates, when the FLS is overlaid, the heat from the HMA mixture reduces the viscosity of the FLS causing it to migrate up into the HMA layer being paved. The migration of the FLS into the above layer of HMA serves to improve density, flexibility, bond between the layers of HMA, and decrease the water permeability of the resultant pavement.

IDOT has already demonstrated this concept on a couple of projects to evaluate constructability. Lessons learned to date include the importance of having the underlying surface thoroughly dry and clean for proper adhesion. This is especially important if the underlying surface has been milled. When used at an application rate of 0.15 lb/ft<sup>2</sup>, loaded trucks were driving on the freshly placed material within minutes after application without pickup.



IDOT intends to construct additional experimental projects over the next few years to identify the optimum application rate, quantify the improvement in permeability, flexibility and density, and learn more about constructability, added performance and life cycle cost. The current special provision can be accessed using the following link: [HOT-MIX ASPHALT – FULL LANE SEALANT \(EXPERIMENTAL FEATURE\)\(CBM\)](#). For more information about the experimental feature workplan or status contact the IDOT Central Bureau of Materials (217) 782-7200.

## 5 References

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