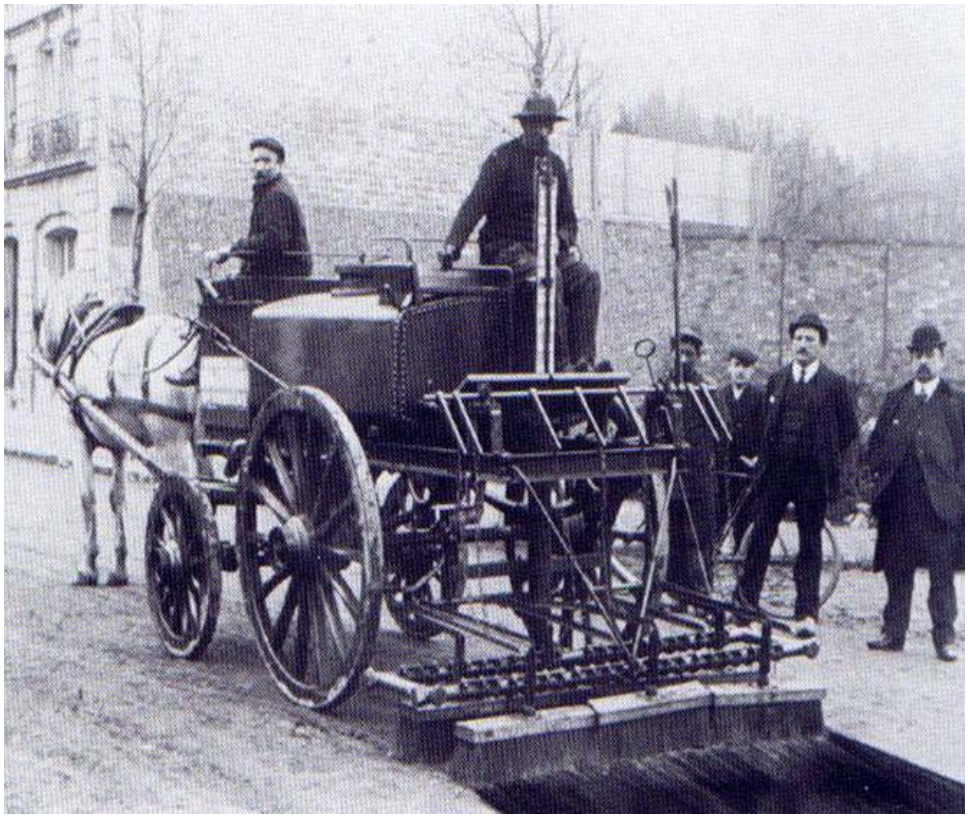
FOG SEAL GUIDELINES



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PREFACE

Highway agencies throughout the world face increasing demands and decreasing resources to maintain and preserve their highway networks. The demand to "do more with less" has been an operating slogan for many of these agencies. Historically, the emphasis has been on new facility construction, and rehabilitation or reconstruction of existing facilities. However, most agencies are currently in a maintenance and/or preservation mode, a trend that can be expected to continue in the foreseeable future.

Pavement preservation is a method by which roads are treated before significant failure has occurred. This has the advantage of allowing action before user complaints, and also saving the agency money over the life of the pavement.

This document was prepared by HQ Maintenance to assist in making better and more informed decisions on Fog Seal and rejuvenating seal practices. This guide details when and how these seals are to be used by design and field personnel.

ACKNOWLEGMENTS

This document was prepared under the technical direction of Dr. Shakir Shatnawi, Chief of the Office of Pavement Preservation. The document was reviewed by Caltrans Pavements Standards Team, the Caltrans Industry Maintenance Task Force, and by Caltrans Maintenance Personnel. For questions on the guide, please contact:

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1.0 INTRODUCTION

Fog seals are a method of adding asphalt to an existing pavement surface to improve sealing or waterproofing, prevent further stone loss by holding aggregate in place, or simply improve the surface appearance. However, inappropriate use can result in slick pavements and tracking of excess material.

The Asphalt Emulsion Manufacturers Association (AEMA) defines a fog seal as "a light spray application of dilute asphalt emulsion used primarily to seal an existing asphalt surface to reduce raveling and enrich dry and weathered surfaces" (1). Others refer to fog seals as enrichment treatments since they add fresh asphalt to an aged surface and lengthen the pavement surface life (2). Fog seals are also useful in chip seal applications to hold chips in place in fresh seal coats. These are referred to as flush coats. This can help prevent vehicle damage arising from flying chips. The Asphalt Institute also adds that fog seals can seal small cracks (3).

1.1 FUNCTION OF A FOG SEAL

A fog seal is designed to coat, protect, and/or rejuvenate the existing asphalt binder. The addition of asphalt will also improve the waterproofing of the surface and reduce its aging susceptibility by lowering permeability to water and air. To achieve this, the fog seal material (emulsion) must fill the voids in the surface of the pavement. Therefore, during its application it must have sufficiently low viscosity so as to not break before it penetrates the surface voids of the pavement. This is accomplished by using a slow setting emulsion that is diluted with water. Emulsions that are not adequately diluted with water may not properly penetrate the surface voids resulting in excess asphalt on the surface of the pavement after the emulsion breaks, which can result in a slippery surface. Figure 1 conceptually shows a fog seal application.

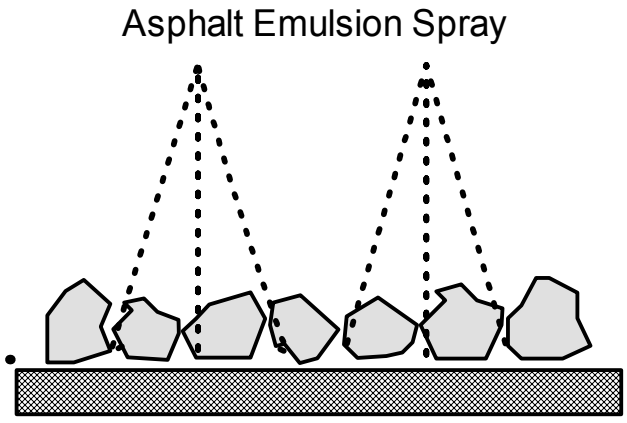

Figure 1: Schematic of Fog Seal Application (5)

During application, the emulsion wets the surface of the aggregate and the existing binder film. Cationic (positively charged) emulsions can displace water from the surface of an aggregate or aged asphalt film. The emulsion then breaks by loss of water and chemical action, forming a film of new binder on the aggregate and existing binder film. The rate at which the emulsion breaks is dependent on several factors with weather conditions (e.g., wind, rain, temperature, etc.) being dominant factors. For anionic (negatively charged) emulsions, there is no surface specific interaction with most aggregates. The emulsion breaks due to water loss by evaporation and absorption of water by the aggregates and surface voids of the pavement.

1.2 FUNCTION OF A REJUVENATING SEAL

Rejuvenating emulsions (e.g. Reclamite (oil emulsion), PASS (asphalt, oil and additives) and Topien C (asphalt, oil and additives)) have oils that soften the existing binder, thus reducing its viscosity. These also improve the flexibility of the binder, which reduces the likelihood of cohesive failure. This may be beneficial in situations where the surface has an open texture and the existing binder is brittle from age. As with conventional emulsions, if these types of emulsion do not penetrate the surface, they may create a slippery surface after they break.

2.0 FOG SEAL PROJECT SELECTION

Fog seals are used as a method of enrichment of a pavement surface and as a method of holding stone in place. Thus, they are suitable to treat raveled and aged pavements. There is, at the present time, no simple way of quantifying the degree of aging in a pavement other than by visual inspection. Different asphalts will age at different rates and the experience of individual districts is key to determination of treatment timing. Some modified asphalts such as asphalt rubber and polymer modified asphalts will age at a slower rate than conventional binders. Fog seals will not correct distresses such as cracking, base failures, excessive stone already lost, or any other severe pavement defects.

On the traveled way, fog seals should only be used where surface penetration of the emulsion can be expected; that is, aged and raveled hot mix surfaces, chip-sealed surfaces, and open graded asphalt surfaces. On shoulders, gores, or dikes, penetration is desirable, but it is not essential. Fog seals darken the pavement surface and create distinct demarcation in these regions.

In general, traffic level is not a determining factor except in job set up. For situations requiring that the sealed pavement be opened to traffic shortly after the application of the seal, a blotter coat of sand may be used to prevent pick-up.

2.1 OLD OR DAMAGED SURFACES

All asphalts harden as they age, primarily due to oxidation, volatile loss and other aging mechanisms (4). Hardening of an asphalt film takes place at different rates according to the access of air and temperature conditions in the pavement. Permeable pavements or pavements with high void contents can therefore age faster. Water ingress can also carry dissolved oxygen and trace elements that may promote aging. This means that pavements with open surfaces tend to age faster than those with closed surfaces. However, if modified binders are used (e.g., asphalt rubber, polymer modified asphalt), the thicker films created by the higher binder content reduce the rate of aging.

Aging results in a binder that is more brittle. These binders eventually experience cohesive binder failures under traffic loads and stone loss or raveling. In some cases, the asphalt produces oxidized compounds that are acidic and bond well to the aggregate; however, these compounds may also react with water causing adhesive failure or stripping.

Fog seal use on the traveled way should generally be limited to only those locations having an open surface texture. This includes chip seals, heavily aged dense graded and open graded. However, the seal may fill voids and reduce or eliminate the drainage function of Open-Graded Friction Coarse (OGFC). Figure 2 shows a typical fog seal application, while Figures 3 through 5 shows a range of suitable and unsuitable surfaces for fog seal project selection. The results of good fog seal applications are shown in Figures 6 and 7. It is important to always check the application rate and ensure that the emulsion has been diluted correctly.

Figure 2: Fog Seal Application

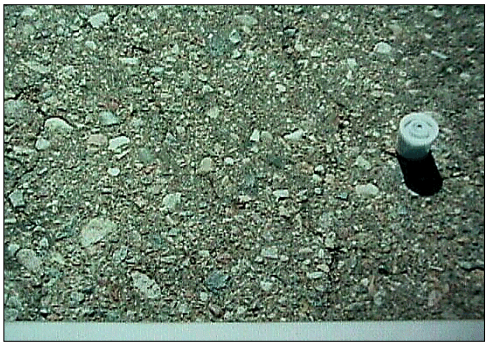

Figure 3: Suitable Surface, Heavily Aged Dense Graded HMA

Figure 4: Unsuitable Surface, Dense Graded HMA With Closed Surface

Figure 5: Suitable Surface, Open Graded HMA

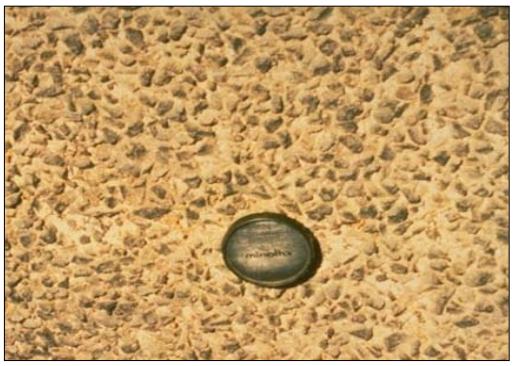

Figure 6: Chip Seal Before and After Fog Seal

a) Before Treatment b) After Treatment

Figure 7: Suitable Surface, Open Texture Dense Graded HMA

Fog seals (with sand blotter coats) may be used as a pavement maintenance treatment on lower speed roads or low traffic volume roads and shoulders. This protects the hot mix asphalt or chip seal surface. In some instances (where traffic is straight), a fog seal with a blotter coat may also be acceptable. The sand will generally be removed by the traffic leaving a good surface texture.

2.2 NEW SURFACES

Flush coats (fog seals with light sanding) are used as a construction seal for new chip seals to lock the chips in place. This reduces vehicle/windshield damage due to flying chips when traffic is allowed on the new seal. These fog seals with sand blotter coats may also be used as a pavement maintenance treatment on lower speed roads or low traffic volume roads. This protects the hot mix asphalt or chip seal surface.

Fog seals are also suitable for sealing new shoulders, gores, or dikes. During construction on milled or ground HMA surfaces, fog seals may be used to keep dust down and prevent rock loss before the next surface is placed.

2.3 SURFACE PROTECTION

Fog seals may be used to protect a hot-mix asphalt (HMA) surface that is not aged significantly (i.e., within 1-2 years of placement after a major rehabilitation or maintenance treatment). This creates a layer of asphalt that seals surface voids and prevents air and water ingress. Do not seal any pavement less than one year old unless the pavement is showing severe raveling resulting from an oil shortage in the mix.

2.4 FOG SEAL PERFORMANCE – BENEFITS AND LIMITATIONS

Fog seals are an inexpensive way of arresting raveling and adding binder back into aged surfaces. They can also hold chips in place in fresh chip seals, (or older chip seals beginning to loose rock) reducing the potential for vehicle damage.

Fog seals are not useful as seal coats on tight surfaces without the addition of aggregates as they will reduce surface texture and may create a slippery surface. Fog seals should not be used on Rubberized Asphalt Concrete (RAC) or polymer modified mixes unless the pavements are over five years old as these binders age at a different rate.

The application of fog seals is also limited by weather. A cut off date in the fall (e.g. September 1st) will ensure that rain will not be a factor and that the emulsion will fully cure before freezing conditions are encountered. In addition, seal coats applied in the winter have less time to penetrate the pavement and are more prone to cause slick surface conditions.

3.0 FOG SEAL MATERIALS AND SPECIFICATIONS

3.1 WHAT MATERIALS ARE USED?

The materials used in fog seals are usually asphalt emulsion and water. In some cases, the emulsions are made with a range of additives for special purposes. For example, rejuvenation oils may be used to soften and revitalize the aged binder in the pavement. Rejuvenation treatments require special attention in design and application and are covered in SSP 37-600 and SSP 37-600_M.

The emulsion types recommended for fog seals may be cationic (i.e., a positive surface charge on the asphalt particles), or anionic (i.e., a negative surface charge on the asphalt particles). The primary types used are CSS-1h and SS-1h. In some circumstances, CQS-1h (and LMCQS-1h) will give a faster set. These are still nominally CSS type emulsions, but will not usually pass the cement-mixing test. Caltrans Standard Specifications (6) provides the required properties for the standard emulsions referred to above. The cement-mixing test (a part of AASHTO test method T59 as required in Caltrans specifications on emulsions) may be omitted as this relates to aggregate mixing stability and not fog sealing.

Note that asphalt emulsions of this type contain up to 43% water. However, any dilution referred to is *additional* water added to the emulsion. Residual asphalt is the binder left after *all* water (i.e., any added water and the original emulsion water) has evaporated.

Rejuvenating emulsions may take several forms and should only be used on pavement showing significant age related distress associated with stiffening of existing binder. They may be emulsions of rejuvenating oils and may include asphalt, polymer latex, and other additives. These are defined in manufacturer's literature and are covered by SSP 37-600 and SSP 37-600_M. The main rejuvenating emulsions that have been used in California are trade named "Reclaimite (oil emulsion), PASS (asphalt, oil and additives) and Topien C (asphalt, oil and additives)". For such products, the manufacturer should be consulted to ensure correct handling.

3.2 DESIGN CONSIDERATIONS

Fog seals are designed for application rate and sometimes dilution rate. This is also a part of the construction process as it is very surface dependent (see Section 4.4).

ESSENTIAL EMULSION TERMINOLOGY

- **Original emulsion** – An emulsion of paving asphalt and water that contains a small amount of emulsifying agent. Original slow-setting grade emulsions contain up to 43 percent water and original rapid setting grade emulsions contain up to 45 percent water.
- **Diluted emulsion** – An original emulsion that has been diluted by adding an amount of water equal to or more than the total volume of original emulsion.
- **Residual asphalt content** – The amount of paving asphalt remaining on the pavement surface after the emulsion has broken and cured (after all water has evaporated).

4.0 FOG SEAL CONSTRUCTION

4.1 SITE CONDITIONS

To be effective, fog seals need to break quickly (revert to solid asphalt) and cure completely (lose water to form a cohesive film). This should be at a rate that allows traffic to be accommodated without the binder being picked up by vehicle tires. To achieve this behavior, the film forming properties of the binder must be adequate (i.e., the binder must be able to coalesce into a continuous film prior to allowing traffic on the new seal). Asphalt films do not form well at low temperatures in the absence of low viscosity diluents. Thus, warm conditions with little to no chance of rain are necessary to ensure successful applications. Fog seals should not to be applied when the atmospheric temperature is below 10°C (50°F), and pavement temperature below 15°C (59°F).

If unexpected rain occurs, prior to the emulsion breaking, the emulsion may wash out of the pores of the pavement and break on the surface of the pavement creating a slippery surface.

4.2 SURFACE PREPARATION

Immediately before applying a fog seal, the pavement surface must be cleaned with a road sweeper, power broom, or flushed with a water pump-unit to remove dust, dirt, and debris. The pavement surface must be clean and dry before applying the fog seal. If flushing is required, it should be completed 24 hours prior to the application of the fog seal to allow for adequate drying.

4.3 MATERIALS PREPARATION

Asphalt emulsions (original emulsions) contain up to 43% water, but must be diluted further before use. This additional dilution reduces viscosity (see Figure 8) and allows the application of small amounts of residual binder to be adequately controlled. Generally, the supplier will dilute the original emulsion, in the field or at the plant. A dilution rate of 50% (1:1) (equal parts water to equal parts emulsion) is recommended. Dilution water must be potable and free from detectable solids or incompatible soluble salts (hard water).

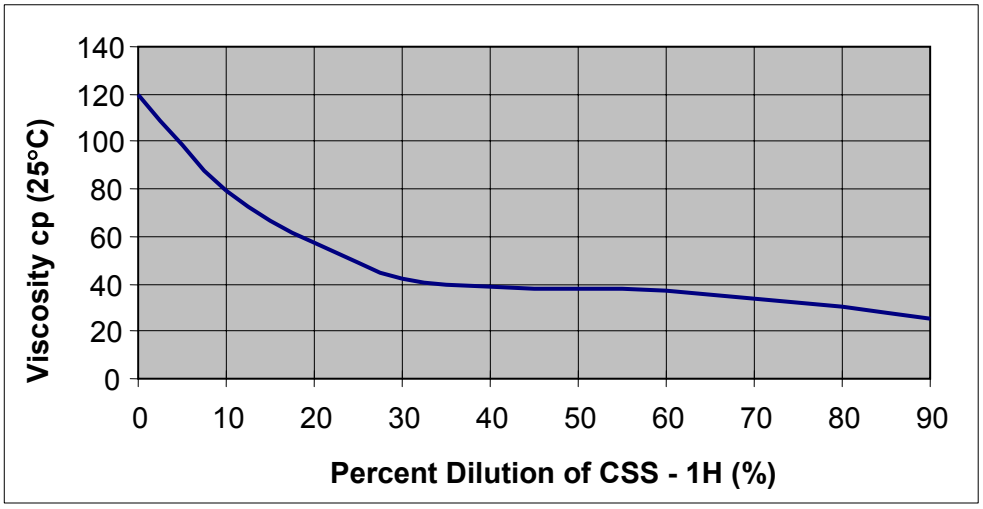

Figure 8: Viscosity Change with Dilution (5)

Water can be checked for compatibility with the emulsion by mixing a small amount of the emulsion in a can (approximately 1 liter). The materials are mixed for 2 to 3 minutes with a stirrer and the resulting mixture is poured through a pre-wetted 150 μm sieve. If more than 1% by weight of material is retained on the sieve, the water is not compatible and clogging in spray jets may result. This test is illustrated in Figure 9.

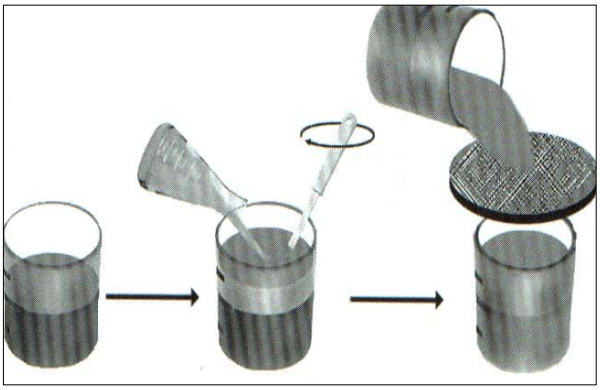

Figure 9: Simple Water Compatibility Test Method (3)

Incompatible water may be treated with 0.5 to 1.0% of a compatible emulsifier solution (the emulsion manufacturer can provide advice regarding compatible solutions). The emulsifier solution should be added to the water tanker and circulated for 10 to 15 minutes via pump before adding to the emulsion. If a water treatment is used, the compatibility test should be repeated using the treated water to ensure compatibility.

The emulsion should be diluted no more than 24 hours before its intended use (7). This is to avoid settlement of the diluted emulsion. Water is always added to the emulsion and not the other way around. The emulsion may be circulated using a centrifugal or other suitable pump to ensure uniformity (7).

4.4 APPLICATION RATES AND SPRAYING

Properly calibrated distributor trucks shall be used to apply the emulsion (see Figure 2). Spray nozzles with 4 to 5 mm (1/8" to 3/16") openings are recommended (7). The emulsion may be heated to 50°C (122 °F) maximum, although, generally the emulsion is sprayed at ambient temperature (7). The emulsion is sprayed at a rate that is dependant on the surface conditions (see Table 1). A test section representative of the entire surface should be chosen to approximate application rates (see Section 4.5). Typical application rates for diluted emulsion (1:1) range from 0.15 to 1.0 l/m^2 (0.03 to 0.22 gal/yd^2) depending on the surface conditions (5). A 1:1 diluted emulsion is an original emulsion that has been subsequently diluted with equal parts water.

Table 1: AEMA Recommendations for Application Rates (5)

% ORIGINAL EMULSION	DILUTION RATE	TIGHT SURFACE*		OPEN SURFACE**	
		(l/m^2)	(gal/yd^2)	(l/m^2)	(gal/yd^2)
50	1:1	0.15 - 0.5	0.03 – 0.11	0.4 - 1.0	0.09 – 0.22

* *A tight surface is of low absorbance and relatively smooth (7).*
** *An open surface is relatively porous and absorbent with open voids (7).*

Ideally, one-half of the application should be sprayed in each direction to prevent build up on one side of stones only (this is particularly important in the case of chip seals) and rough surfaces. Build up on one side can result in a slippery surface and inadequate binder to fully enrich the surface or hold the stone.

4.5 ESTIMATING APPLICATION RATES

To estimate the application rate, the RE shall take a one-liter can of diluted emulsion (usually 1:1 dilution rate) and pour evenly over an area of 1 m^2. This represents a diluted application rate of 1 l/m^2. If the emulsion is not absorbed into the surface after 2-3 minutes, decrease the application rate of the emulsion and apply to a new 1 m^2 area and repeat until the approximate application rate is found. If, after the first test, the surface looks like it can absorb more emulsion, increase the application rate of the emulsion and spread it over a new 1 m^2 area. Repeat until the approximate application rate is found. This same procedure can be followed using gallons and square yards to determine application rate.

4.6 TRAFFIC CONTROL

Traffic control should be in place before work forces and equipment enters onto the roadway or into the work zone. Traffic control is required both for the safety of the traveling public and the personnel performing the work. Traffic control includes construction signs, construction cones and/or barricades, flag personnel, and pilot cars to direct traffic clear of the construction operation. For detailed traffic control requirements, refer to the Caltrans project specifications and the Caltrans Code of Safe Operating Practices.

Traffic control is also required to protect the integrity of the application. The curing time for the fog seal material will vary depending on the pavement surface conditions and the weather conditions at the time of application. Under ideal conditions, including increasing air and surface temperatures, it is suggested that traffic be kept off the fog seal material for at least two hours and acceptable skid test (CT 342) values are achieved.

4.7 SAFETY (PERSONAL PROTECTIVE EQUIPMENT–PPE)

All employees are advised to wear and use the safety gear required for a fog seal operation. This includes, but is not limited to, items such as hard hats, approved Caltrans shirts, safety vests, earplugs, gloves, and safety glasses (8, 9).

4.8 QUALITY CONTROL

Quality control and workmanship are critical to the performance and life of a fog seal treatment. There must be a cooperative effort between the Caltrans representative and the contractor's representative to conduct inspections of all project equipment before and during the project. The primary pieces of equipment for a fog seal operation are the boot truck/equipment and distributor bar. It is critical that each is functioning as required by the project specifications. The spray bar must be set to the appropriate height (distance) from the pavement surface and the nozzles must be set at the proper angle to assure a uniform application of material (1). The material temperatures should also be measured for quality control purposes.

The emulsion must be certified to specification according to established sampling and testing procedures (6). Excess emulsion can create slick pavements.

It is recommended that project inspections be conducted so that any deficiencies in workmanship or materials are addressed and corrected. This process will also assist the department in identifying the performance of various fog seal materials; how they are performing on various surface conditions and how they are performing in various climatic zones.

4.9 POST TREATMENT

Sand blotters may be used, at approximately 1 kg/m^2, to allow early opening to traffic. Sweeping may be required. The Resident Engineer or district maintenance personnel should assess this after application and opening to traffic. Even with sand cover, traffic control may be required to keep speeds down.

Skid resistance (coefficient of friction) can be measured using CT 342. It is recommended that this be done after the application has cured to ensure the proper value is measured. The final surface shall yield a coefficient of friction not less than 0.30 as determine by CT 342. A treated pavement shall not be opened to traffic until an acceptable value is recorded. If a treated pavement does not produce an acceptable coefficient of friction, see Table 3 for corrective action. Permeability may be monitored by CT 341 to ensure that an effective seal has been achieved. This should be done at the discretion of the Resident Engineer.

5.0 TROUBLESHOOTING

This section provides information to assist field personnel in troubleshooting problems with fog seals, along with "dos and don'ts" that address common problems that may be encountered during the course of a project.

5.1 TROUBLESHOOTING GUIDE

The troubleshooting guide presented in Table 2 associates common problems to their potential causes. For example, a slick surface may be caused by wet pavement, a high application rate, or rain. Cold weather could also contribute to slick pavements as the emulsion break may be delayed. The emulsion will be tacky and pickup if the existing road surface is dry or dusty, or the wrong emulsion is used.

In addition to the troubleshooting guide, Table 3 lists some application problems and their recommended solutions.

TABLE 2: TROUBLE SHOOTING FOG SEAL PROBLEMS

CAUSE	PROBLEM						
	SLICK SURFACE	NOT BREAKING	WASHES OFF	TACKY PICKS UP	WILL NOT DILUTE	BREAKS TOO FAST	DILUTION WRONG
Road Wet	●	●	●				
Road Too Dry				●		●	
Road Dusty				●		●	
Hard Water					Anionic		
Alkaline Water					Cationic		
Acidic Water					Anionic		
Application Too High	●	●	●	●			●
Application Too Low						●	●
Wrong Emulsion		●	●	●	●	●	
Rain	●	●	●				
Cold Weather	●	●					
Hot Weather				●		●	

TABLE 3: APPLICATION PROBLEMS AND RELATED SOLUTIONS

PROBLEM	SOLUTION
Spattering of the Emulsion	▪ Reduce the rate of dilution. ▪ Ensure the spray bar height is set correctly. ▪ Ensure the spray pressure is not set too high.
Streaking of the Emulsion	▪ Ensure the emulsion is not too cold. ▪ Ensure the emulsion viscosity is not too high. ▪ Ensure the nozzles are at the same angle. ▪ Ensure the spray bar is not too high or too low. ▪ Ensure the spray bar pressure is not too high. ▪ Ensure all nozzles are not plugged.
Bleeding or Flushing of the Emulsion	▪ Ensure the emulsion application rate is not too high. ▪ Check application and dilution rate and recalibrate sprayer, if necessary.
Surface Coefficient of Friction is too Low per CT 342	▪ Apply coating of clean dry sand. ▪ Sweep sand with rotary broom to absorb excess binder. ▪ Perform CT 342. ▪ Repeat process until coefficient of friction is at least 0.30.

**Do not open treated surface until coefficient of friction is at least 0.30 as determined by CT 342.*

5.2 Dos and Don'ts

The following dos and don'ts list provides a quick reference to avoid making common mistakes with fog seals.

Do check water compatibility before dilution.
Do check dilution - has it been done, by whom, and when?
Do ensure that there is no contamination of the base emulsion by water, oils, or other liquids.
Do prevent contamination by other emulsions.
Do protect emulsions from freezing or localized boiling due to the application of direct heat.
Do heat emulsion gently and ensure heating coils are under the liquid level (max 50°C (122°F)).
Do load from the bottom of tankers or sprayers to avoid foaming.
Do check equipment and nozzles.
Do check application rates.
Do exercise proper traffic control.
Do ensure the know-how is available on the job.
Do add water to emulsion, not emulsion to water.
Don't store diluted emulsion longer than 24 hours.
Don't continuously stir or circulate emulsion.
Don't apply emulsion if air temperature is <10°C (50°F) and pavement temperature <15°C (59°F).
Don't apply emulsion if rain or cool temperatures are imminent.
Don't continue application if adequate breaking period is not available.
Don't open treated surface to traffic until coefficient of friction is at least 0.30 as determined by CT 342.

6.0 KEY REFERENCES

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2. Booth, EHS, Gaughan, R., Holleran, G., "Some Uses of Bitumen Emulsions in SA and NSW", Proceedings, Australian Road Research Board, pp. 387-401, March 1988.

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4. Barth, E.J., "Asphalt Science & Technology", Chapter 9 "Durability", Gordon and Breach, New York, 1962.

5. Hicks R.G., Holleran G., "Purpose and Use of Fog Seals and Rejuvenators", Sealer Binder Workshop, Foundation For Pavement Preservation, Federal Highway Administration, March 2002.

6. California Department of Transportation, "Standard Specifications", Sections 37 and 94, Sacramento, California, 1999.

7. Asphalt Emulsion Manufacturers Association, "Recommended Performance Guidelines", AEMA, Washington, D.C., 1990.

8. California Department of Transportation, "Caltrans Code of Safe Operating Practices", Chapter 12, Sacramento, California, 1999.

9. California Department of Transportation, "Caltrans Code of Safe Operating Practices", Appendix C, Sacramento, California, 1999.

10. California Department of Transportation, "Standard Specification", Section 40-1.01, Sacramento, California, 1999.

APPENDIX A

SUGGESTED FIELD CONSIDERATIONS FOR FOG SEALS

The following field considerations are a guide through the important aspects of performing a fog-sealing project. The various tables contain items that should be considered in order to promote a successful job outcome. Thorough answers to these questions should be determined, as required, before, during, and after application of fog seal. The appropriate staff to do this will vary by job type and size. Some topics may need attention from several staff members. The field personnel should be acquainted with its contents. The intent of the tables is not to form a report but to bring attention to important aspects and components of the project process. Some information is product specific and contained in the relevant standard specifications, standard special provisions, or special provisions.

PRELIMINARY RESPONSIBILITIES	
PROJECT REVIEW	▪ Is the project a good candidate for a fog seal? ▪ What is the existing surface type? ▪ Has an assessment been made of the surface absorption? ▪ How much stone has been lost? ▪ How much bleeding or flushing exists? ▪ Review project for bid/plan quantities. ▪ What is the relative cost?
DOCUMENT REVIEW	▪ Bid specifications. ▪ Special provisions. ▪ Emulsion Specifications. ▪ Traffic control plan (TCP). ▪ Material safety data sheets.
MATERIALS CHECKS	▪ Emulsion selection. Type and dilution rate. ▪ The emulsion is from an approved source (if required)? ▪ The emulsion has been sampled and submitted for testing (if required)? ▪ The water to be used is compatible with the emulsion? ▪ Is sand required? Is it within specification and dry? ▪ Is the emulsion temperature within application temperature specification?
PRE-SEAL INSPECTION RESPONSIBILITIES	
SURFACE PREPARATION	▪ Is the surface clean and dry? ▪ Have all pavement distresses been repaired? ▪ Has the existing surface been inspected for drainage problems?

EQUIPMENT INSPECTION RESPONSIBILITIES	
BROOM	▪ Are the bristles the proper length? ▪ Can the broom be adjusted vertically to avoid excess pressure on the surface?
SPRAY DISTRIBUTOR	▪ Is the spray bar at the proper height? ▪ Are all nozzles uniformly angled at 15 to 30 degrees from the spray bar axis? ▪ Are all nozzles free of clogs? ▪ Is the spray pattern uniform and does it properly overlap (double or triple)? ▪ Is the application pressure correct? ▪ Is the distributor properly calibrated? ▪ Is there a working and calibrated thermometer on site? ▪ Has water been added to emulsion in correct proportion and circulated? ▪ Is the application rate being monitored throughout the day/project?
SAND SPREADER	▪ Do the spreader gates function properly and are their settings correct? ▪ Is the sand spreader's calibration uniform across the entire head? ▪ Is the sand free flowing? ▪ Are the truck hook-up hitches in good condition?
TRUCKS	▪ Is the truck box clean and free of debris and other materials? ▪ Is the truck hook-up hitch in working order? ▪ Is a truck box apron or extension required for loading the sand spreader?
ALL EQUIPMENT	▪ Is all equipment free of leaks? ▪ Is all equipment calibrated and clean?
SITE CONSIDERATIONS	
TRAFFIC CONTROL	▪ Do the signs and devices used match the traffic control plan? ▪ Does the work zone comply with Caltrans traffic control policies as laid out in the Caltrans Safety Manual? ▪ Do flaggers not hold the traffic for extended periods of time? ▪ Does the pilot car lead traffic slowly — 40 kph (25 mph) or less—over fresh sand blotted fog seals? If not sanded, allow at least 2 hours before opening to traffic. ▪ Are unsafe conditions promptly reported to a supervisor (contractor or agency)? ▪ Are signs removed or covered when they no long apply?

SITE CONSIDERATIONS	
WEATHER REQUIREMENTS	▪ Are minimum surface and air temperatures adhered to? ▪ Are air and surface temperatures checked at the coolest location on the project? ▪ Do air and surface temperatures meet agency requirements? ▪ Are high winds expected during application of the fog seal? High winds can create problems with the diluted emulsion application. ▪ Will the expected weather conditions delay the breaking of the emulsion? High temperatures, humidity, and wind will effect how long the emulsion takes to break. ▪ Is the application of the fog seal discontinued if rain is likely?
BINDER CONSIDERATIONS	
BINDER APPLICATION	▪ Are the agency guidelines and requirements being followed? ▪ Has a check been done on the absorption ability of surface? ▪ Is the surface oxidized and porous? More oil can be applied to dried-out and porous surfaces. ▪ Is the surface smooth, non-porous, or bleeding (asphalt rich)? Do not apply to smooth, non-porous, and asphalt-rich surfaces. ▪ Is the traffic volume on the road high? Less oil must be applied on roads with high traffic volumes. ▪ Does the emulsion soak into the surface? If not, application rate is too high. ▪ Is the surface texture coarse? If so, spray should be applied in both directions to avoid build up on one side of stones. ▪ Are manhole covers and drainage inlets covered to keep binder from entering water bodies?
CHECKING APPLICATION RATES	**Binder - Method A (Recommended for Calibration)** ▪ The weight of a 0.84 m^2 (1yd^2) carpet, pan or, non-woven geotextile material is recorded and placed on the road surface. ▪ The distributor applies emulsion over the carpet, pan, or geotextile material. ▪ The weight of the carpet and emulsion, pan and emulsion, or geotextile material and emulsion is recorded. ▪ The weight of the carpet, pan, or geotextile material without emulsion is subtracted from the weight of the carpet, pan, or geotextile material with emulsion. ▪ The weights applied to the area of carpet (i.e., kg/m^2 or lb/yd^2) must be converted to the units of the control mechanism, which is l/m^2 or gal/yd^2, through knowledge of the specific gravity of the emulsion. If the distributor is not spraying the binder at the correct application rate, adjustments must be made to the controls and the process described above repeated until the correct application rate is achieved. Although this is the responsibility of the contractor, the inspector should verify that the distributor is spraying the binder at the correct application rate.

BINDER CONSIDERATIONS

CHECKING APPLICATION RATES

Example – Checking Fog Seal Application Rate (Method A)

- Given:
  Applying a Fog Seal with a 1:1 diluted emulsion.
  Tight surface texture.
  Recommended application rate of 0.15 – 0.5 l/m^2 (0.03 – 0.11 gal/yd^2) (see Table 1).
  Specific gravity of Emulsion (G_E) = 1.010.
  Unit Weight of Water (γ_W) = 1 g/cm^3 or 1000 kg/ m^3 (62.4 lb/ft^3).
  Conversion Factor (C_{fl}) = 1000 l/m^3 (7.5 gal/ft^3).

Find the actual application rate ($W_{A'}$).

- Measure the weight of a 1 m^2 (1 yd^2) carpet (W_C).
  (W_C) = 1.8144 kg (4.0 lb)
- Measure the weight of 1 m^2 (1 yd^2) carpet and applied emulsion (W_{C+E}).
  (W_{C+E}) = 2.1944 kg (4.7 lb)
- Calculate the weight of emulsion covering the 1 m^2 (1 yd^2) carpet (W_E).
  (W_E) = (W_{C+E} - W_C)
  (W_E) = (2.1944 kg – 1.8144 kg) (4.7 lb - 4.0 lb)
  (W_E) = 0.38kg (0.7 lb)
- The application rate is the weight of emulsion applied per unit area (W_A).

$$(W_A) = \left(\frac{W_E}{1m^2}\right) \text{ or } \left(\frac{W_E}{1yd^2}\right)$$

$$(W_A) = \left(\frac{0.38kg}{1m^2}\right) \text{ or } \left(\frac{0.7lb}{1yd^2}\right)$$

$$(W_A) = 0.38\frac{kg}{m^2} \text{ or } 0.7\frac{lb}{yd^2}$$

Convert this application rate to gal/yd^2.

- Calculate the unit weight of the emulsion (γ_E) by multiplying the specific gravity of the emulsion (G_E) by the unit weight of water (γ_W).

$$(\gamma_E) = (G_E \times \gamma_E)$$

$$(\gamma_E) = \left(1.010 \times 1000\frac{kg}{m^3}\right) \text{ or } \left(1.010 \times 62.4\frac{lb}{ft^3}\right)$$

$$(\gamma_E) = 1010.0\frac{kg}{m^3} \text{ or } 63.024\frac{lb}{ft^3}$$

BINDER CONSIDERATIONS

CHECKING APPLICATION RATES

***Example* – Checking Fog Seal Application Rate (Method A) (continued)**

- Convert the unit weight of the emulsion (γ_E) to kg/l (lb/gal) (γ_{Ekg}) by dividing (γ_E) by (C_{f1}).

$$\left(\gamma_{Ekg}\right) = \left(\frac{\gamma_E}{C_{f1}}\right)$$

$$\left(\gamma_{Ekg}\right) = \left(\frac{1010.0\frac{kg}{m^3}}{1000\frac{l}{m^3}}\right) \text{ or } \left(\frac{63.024\frac{lb}{ft^3}}{7.5\frac{gal}{ft^3}}\right)$$

$$\left(\gamma_{Ekg}\right) = 1.01\frac{kg}{l} \text{ or } 8.4\frac{lb}{gal}$$

- Convert (W_A) in kg/m^2 (lb/yd^2) to ($W_{A'}$) in l/ m^2(gal/yd^2) by dividing (W_A) by (γ_{Ekg}).

$$\left(W_{A'}\right) = \left(\frac{W_E}{\gamma_{Ekg}}\right)$$

$$\left(W_{A'}\right) = \left(\frac{0.38\frac{kg}{m^2}}{1.01\frac{kg}{l}}\right) \text{ or } \left(\frac{0.7\frac{lb}{yd^2}}{8.4\frac{lb}{gal}}\right)$$

$$\left(W_{A'}\right) = 0.3763\frac{l}{m^2} \text{ or } 0.08\frac{gal}{yd^2}$$

Check this value against the recommended application rates given in Table 1. For the given surface condition and dilution rate this application rate is acceptable.

BINDER CONSIDERATIONS	
CHECKING APPLICATION RATES	**Binder – Method B (Recommended for Random Checks)** ▪ Park the distributor on level ground and measure the number of liters or gallons of emulsion. ▪ Measure off a known distance for a test section. ▪ Have the distributor apply diluted emulsion to the test section. ▪ Park the distributor on level ground and re-measure the number of liters or gallons of emulsion. ▪ Make necessary adjustments to volume based on temperature corrections per Standard Specifications section 93-1.04. ▪ Subtract the number liters or gallons after application from the original number of liters or gallons to obtain the number of liters or gallons applied. ▪ Divide the number of liters or gallons applied by the number of square meters or square yards covered by emulsion to give the application rate in l/m^2 or gal/yd^2. ▪ If the distributor is not spraying the binder at the correct application rate, adjustments must be made to the controls and the process described above repeated until the correct application rate is achieved. Although this is the responsibility of the contractor, the inspector should verify that the distributor is spraying the binder at the correct application rate throughout the project.
PROJECT INSPECTION RESPONSIBILITIES	
BINDER APPLICATION	▪ Is building paper used to start and stop emulsion application for straight edges? ▪ Is the emulsion within the required application temperature range? ▪ Does the application look uniform? ▪ Are any nozzles plugged? ▪ Is there streaking on the applied emulsion? ▪ Are application rates randomly checked? ▪ Is the speed of the distributor adjusted to match that of the sand spreader (if used) and to avoid start-and-stop operations? ▪ Is the distributor stopped if any problems are observed?
TRUCK OPERATION	▪ Are the trucks staggered across the fresh fog seal coat to avoid driving over the same area? ▪ Do the trucks travel slowly on the fresh seal? ▪ Are stops and turns made gradually? ▪ Do truck operators avoid driving over exposed oil?

PROJECT INSPECTION RESPONSIBILITIES	
OPENING A FOG SEAL TO TRAFFIC	▪ Are results from CT 342 at least 0.30? ▪ Does traffic travel slowly — 40 kph (25 mph) or less—over the fresh seal until seal is broomed and opened to normal traffic? If not sanded, allow 2 hours before opening to traffic. ▪ Are reduced speed limit signs used when pilot cars are not used? ▪ Are pavement markings placed after brooming and before opening to normal traffic? ▪ Are all construction related signs removed when opening to normal traffic?
CLEAN-UP	▪ Is all loose (excess) sand from brooming operation removed from travel way? ▪ Are binder spills cleaned up?
REMOVAL OF EXCESS BINDER FROM SURFACE	
SAND APPLICATION	▪ Are enough aggregate trucks on hand to maintain a steady supply of sand to the spreader? ▪ Is clean dry sand being used? ▪ Does the sand application appear uniform? ▪ Is sand used only once?
BROOMING	▪ Does brooming begin as soon as possible after sand is applied? ▪ Is initial brooming done lightly with a rotary broom to distribute and set sand in surface? ▪ Is secondary brooming done to remove loose sand coated with excess binder? ▪ Is brooming process repeated until results from CT 342 at least 0.30?