

**TECHNICAL REPORT DOCUMENTATION PAGE**

1. Report No. TX -97/0-1787-P	2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Seal Coat Field Manual			5. Report Date February 2001	
			6. Performing Organization Code TECH	
7. Author(s) Sanjaya Senadheera, Douglas Gransberg, and Tolga Kologlu			8. Performing Organization Report No. 1787-P	
9. Performing Organization Name and Address Texas Tech University Department of Civil Engineering Box 41023 Lubbock, Texas 79409-1023			10. Work Unit No. (TRAIS)	
			11. Contract or Grant No. Project 0-1787	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology P. O. Box 5080 Austin, TX 78763-5080			13. Type of Report and Period Cover Product	
			14. Sponsoring Agency Code	
15. Supplementary Notes Study conducted in cooperation with the Texas Department of Transportation. Research Project Title: "Seal Coat Constructability Review"				
16. Abstract  This seal coat field manual is intended for seal coat field personnel. It includes a brief introduction to seal coat inspection and seal coat materials. Three topics, seal coat preparation, seal coat equipment and seal coat application are treated in much greater detail specifically with the field personnel in mind. Information presented under seal coat preparation includes the pre-construction meeting, seal coat design and all other activities conducted prior to construction. The section on seal coat equipment includes brief descriptions on equipment as well as equipment selection issues. A procedure to calculate the number of rollers required is also included. Finally, the section on seal coat application is presented with details on each construction step including traffic control. Also, calculation methods are presented to set the binder and aggregate rates.				
17. Key Words seal coat, constructability, aggregate, surface treatment, asphalt			18. Distribution Statement  No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified		21. No. of Pages 104	22. Price



Seal Coat Field Manual

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Project Number: 0-1787

Report Number: 1787-P

Research Sponsor:

Texas Department of Transportation

Texas Tech University  
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Lubbock, TX 79409-1023

February, 2001



## IMPLEMENTATION STATEMENT

This seal coat field manual is intended for seal coat field personnel. It has been prepared with the idea that through this booklet, field personnel would find all the information they would ever need in the field in their back pocket.

Prepared in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration.

## **AUTHOR DISCLAIMER**

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view of policies of the Texas Department of Transportation.

## **PATENT DISCLAIMER**

There was no invention or discovery conceived or first actually reduced to practice including art, method process, machine, manufacture, design, or composition of matter in the course of this project which is or may be patentable under the patent laws of the United States of America or any foreign country.

## **ENGINEERING DISCLAIMER**

Not intended for construction, bidding or permit process.

# SI\* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

## APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<b>LENGTH</b>					<b>LENGTH</b>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<b>AREA</b>					<b>AREA</b>				
in <sup>2</sup>	square inches	645.2	square millimeters	mm <sup>2</sup>	mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>	m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	square meters	m <sup>2</sup>	m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>	km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
<b>VOLUME</b>					<b>VOLUME</b>				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>	m <sup>3</sup>	cubic meters	35.71	cubic feet	ft <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>	m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>MASS</b>					<b>MASS</b>				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")	Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
<b>TEMPERATURE (exact)</b>					<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<b>ILLUMINATION</b>					<b>ILLUMINATION</b>				
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m <sup>2</sup>	cd/m <sup>2</sup>	cd/m <sup>2</sup>	candela/m <sup>2</sup>	0.2919	foot-Lamberts	fl
<b>FORCE and PRESSURE or STRESS</b>					<b>FORCE and PRESSURE or STRESS</b>				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in <sup>2</sup>	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in <sup>2</sup>

NOTE: Volumes greater than 1000 l shall be shown in m<sup>3</sup>.

\* SI is the symbol for the International System of Units. Appropriate

(Revised September 1993)



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# SEAL COAT FIELD MANUAL

## INTRODUCTION TO INSPECTION

### INSPECTION TEAM:

A seal coat project should have minimum 3 people in inspection team to get a satisfying result from inspection.

The duty of the inspectors in the inspection team will be as follows;

- Inspector 1 (Chief Inspector): Ranges along the whole length of the job and adjusts the asphalt and aggregate rates.
- Inspector 2: Follows the asphalt distributor, controls the distribution rates based on the instructions from chief inspector.
- Inspector 3: Follows the aggregate spreader and controls the distribution of spread rate of aggregates. She/He monitors the performance of the roller team.

### DUTIES OF THE INSPECTOR:

As an Inspector, you are responsible for verifying that all materials and construction procedures meet the requirements of the specifications, Special Provisions, and Plans, as required by the Department.

You report to the Project Engineer, usually through the Chief Inspector, concerning the progress of the work and the manner in which it is being performed. Any deviation from the Specifications or Plans must be brought to the attention of the Chief Inspector, Resident (or Project) Engineer, and the Contractor.

In general terms, when assigned to inspect Seal Coat projects, you are responsible for:

- Becoming thoroughly familiar with Specifications, Special Provisions, and Plans prior to the beginning of the project.
- Ensuring that aggregate stockpiles are adequate and conveniently located.
- Ensuring that asphalt storage heating facilities are adequate.
- Inspecting all equipment to be used on the job.
- Sampling both aggregate and asphaltic materials as required.
- Monitoring the temperature of the surface, air, and asphalt.
- Ensuring that the amount of aggregate and asphalt used on the project are accurately recorded.
- Inspecting the quality of the finished project and bringing any deficiencies to the attention of the Contractor or his representative, for correction.
- Ensuring that all reasonable precautions are taken to provide for the safety of the motoring public and all personnel involved in the project.
- Establishing and maintaining a harmonious working relationship with the Contractor's personnel, while maintaining the highest possible professional image.

- Performing other duties as directed by the Chief Inspector, Resident Engineer, or their designated representatives.

## **SPECIFICATIONS:**

All work performed and all materials furnished to the Department shall comply with the following:

- Standard Specifications
- Special Specifications
- General Notes
- Plans

These documents are included in the contract between the State and the Contractor when they are applicable to a project.

### *Standard Specifications:*

Standard Specifications contain the majority of the Department's regulations covering the:

- Quality of most of the materials furnished to the Department by the Contractor or Supplier.
- Method and manner of the work to be performed for the Department by the Contractor or Fabricator.

The Standard Specifications are published by the Department as a handbook which is revised and updated periodically.

### *Special Specifications:*

Special Specifications describe the Department's regulations covering a special project or a new type or material or structure that is not covered by the Standard Specifications.

### *General Notes:*

General Notes revise or supplement the Standard or Special Specifications for the districts where the project will take place. The general notes are almost the same for same type of projects in same district.

### *Plans:*

The Plans (Contract Drawings) describe in detail the work to be accomplished by the Contractor.

### *Coordination:*

In cases of disagreement, Plans govern over all Specifications, and Special Provisions govern over both Specifications and Plans. Actual dimensions shall govern over scale dimensions.

All work is done under the supervision of the Engineer, to his satisfaction, and in accordance with the Contract, Plans, and Specifications. The Engineer is the State Highway Engineer of Texas, or his authorized representatives. The Engineer decides all questions which may

arise as to the quality or acceptability of materials furnished and work performed; the manner of performance and rate of progress of the work, the interpretations of the Plans and Specifications; and the acceptable fulfillment of the contract on the part of the Contractor. His decisions are final, and he has executive authority to enforce and make effective such decisions and orders that the Contractor fails to carry out promptly. The inspector has authority to act in behalf of the engineer in the absence of the engineer.

#### READING THE SPECIFICATIONS:

The 1993 Standard Specifications for Construction of Highways, Streets, and Bridges (referred to hereafter as Standard Specifications) are organized according to Items pertaining to Seal Coats and Surface Treatments are:

- Items 1-9                    General Requirements
- Item 210                   Rolling (Flat Wheel)
- Item 213                   Rolling (Pneumatic Tire)
- Item 300                   Asphalts, Oils and Emulsions
- Item 302                   Aggregate for Surface Treatments
- Item 303                   Aggregate for Surface Treatments (Lightweight)
- Item 316                   Seal Coat
- Item 352                   Cleaning and/or sealing joints and cracks (Asphaltic Concrete)

#### SAFETY:

A seal coat project may very well be one of the most dangerous highway projects. Control of traffic in seal coat work is difficult, at best. Heavy traffic volume and high traffic speed contribute to the hazards you will face daily. It is the responsibility of the Contractor to ensure the safety and convenience of the public. As agents of the State Government, however, we are also responsible for ensuring the safety of fellow human beings.

Traffic control is covered by the Texas Manual on Uniform Traffic Control Devices for Streets and Highways (TMUTCD). Part VI covers traffic controls for construction and maintenance operations. You should become familiar with the contents of that chapter. Additionally, there must be a Traffic Control Plan (TCP) included in the project plans. You must know the TCP thoroughly, for any project to which you are assigned.

The most important item used in traffic control is the flaggers. The use of flaggers to warn motorists of the hazards and control the flow of traffic through the work area is almost a must. The flagger, however, must realize the importance of his or her position, and take the responsibility seriously.

"Flaggers shall be English speaking, courteous, well informed, physically and mentally able to effectively perform their duties in safeguarding and directing traffic and protecting the work, and shall be neatly attired and groomed at all times when on duty. When directing traffic, flaggers shall use standard attire, flags and signals and follow the flagging

procedures set forth in the Texas Manual on Uniform Traffic Control Devices for Streets and Highways."

The TMUTCD requires the wearing of an orange colored safety vest, and recommends the wearing of a white safety helmet or orange cap. It also requires that all apparel be neat in appearance.

Improper attire, inattentiveness, or the flagger simply not doing the job properly can be controlled. Bring an unsafe condition to the attention of the Chief Inspector or the Contractor's foreman immediately.

Flaggers must be given a break occasionally, at least after a few hours. While it is the Contractor's responsibility, you should keep an eye on the situation. If necessary, remind the Contractor to give the flagger a break and ensure that whoever substitutes for the regular flagger is doing the job correctly.

### **PURPOSES OF SEAL COATS:**

A seal coat is a surface treatment using a single application of asphalt covered with aggregate for the purpose of sealing an existing pavement.

Seal coats are applied to existing pavements for the overall purpose of extending the life of the pavements. They are not intended as permanent pavement surfaces; they may only be expected to last for about five years. The service life of seal coats varies, however, depending upon volume of traffic, weather, and numerous other variables.

Other purposes seal coats serve are to correct surface deficiencies such as:

**Cracks** - Some cracks can be sealed, if they are not very wide. A seal coat will effectively prevent water from seeping through narrow surface cracks and ruining the pavement or base.

**Shelling (or Ravelling)** - This is where the aggregate particles in the old pavement have broken loose. A seal coat will cement new aggregate material in place and prevent additional raveling.

**Bleeding** - This is where asphalt in the existing pavement has risen to the surface. Bleeding appears as a black patch, and has relatively little or no skid resistance. A seal coat will often cover these spots with fresh aggregate and hold it in place.

**Lack of skid resistance** - A seal coat will bring fresh, irregularly shaped aggregate particles into contact with vehicle tires to improve skid resistance. This is especially important where bleeding has occurred or where the aggregate in the old pavement has worn smooth.

## SEAL COAT MATERIALS:

Seal coats are simply liquefied asphalt sprayed on an existing pavement in a thin, even layer, and covered with aggregate. We must be thoroughly familiar with both components.

### **ASPHALT:**

Asphalt is a black, cementing material that varies widely in consistency from solid to semisolid (soft solid) at normal air temperatures. When heated sufficiently, asphalt softens into a liquid which allows it to be poured to coat more stable substances. Asphalt is made up largely of a hydrocarbon called bitumen. Nearly all asphalt used for highway construction in the United States is derived from crude petroleum.

### *CLASSIFICATION OF ASPHALTS:*

- Asphalts used in highway pavements are classified into three broad classes:
- Asphalt cement
- Cutback asphalt
- Emulsified asphalt

#### *Asphalt Cement:*

Asphalt cement is asphalt specially prepared as to quality and consistency for direct use in the manufacture of asphaltic pavements. It is used in its pure form; not mixed with other chemical substances. The majority of hot mix asphaltic concrete is made with asphalt cement, and it is used commonly in seal coat work.

#### *Cutback Asphalt:*

Cutback asphalt is asphalt cement, which has been liquefied ("cut back") by blending with petroleum solvents (also called "dilutents"). This makes the asphalt more workable and easier to spray.

Upon exposure to the atmosphere, the solvents evaporate, leaving the pure asphalt cement to harden. The type of solvent used determines how quickly the asphalt hardens, since some solvents evaporate much quicker than others.

With the growing concern for air quality in recent years, cutback asphalts are not used as widely as they once were. As the solvents evaporate, the vapors are considered harmful to living organisms. Cutbacks are, however, used when other types of asphalt are not suitable.

#### *Emulsified Asphalt:*

Emulsified asphalt (also called "emulsions") is asphalt cement combined with water to make the asphalt more liquefied. Since asphalt cement and water do not naturally mix, a small amount of emulsifying agent is used.

This mixture is further categorized as either anionic or cationic, depending upon the emulsifying agent used. The important point about this difference that you must know as an Inspector, is cationic and anionic emulsions must never be mixed.

Upon exposure to the air, the water and emulsifying agent evaporate, leaving pure asphalt cement which hardens to bind the aggregate in place. The point when the water evaporates

is known as when the "emulsion breaks." This is visible on the roadway. The asphalt's color suddenly turns from a muddy brown to a clear black. Emulsions are commonly used in seal coat projects.

*Additives:*

Although these three classifications of asphalts are commonly used as we have described them here, you will sometimes encounter special purpose or experimental mixtures. Another compound may be added to the basic asphalt type to produce desirable properties or characteristics not abundant in the basic asphalt. For instance, latex has been successfully combined with asphalt cement, and is fairly common in seal coats.

**ASPHALT PROPERTIES:**

Asphalt is a thermoplastic. This simply means that it becomes more or less solid as its temperature changes. When it is heated, it becomes "thinner" or more liquid. As it cools, it becomes "thicker" and resists flowing. Temperature is a key factor in working with asphalt, and must be monitored closely.

*Viscosity:*

The viscosity of a mixture simply means its resistance to flowing. A mixture which is highly resistant to flowing is said to be a high viscosity fluid. One that flows easily (like water) is said to have low viscosity.

*Viscosity Grading:*

Viscosity is one method of grading asphalt. Since it is a thermoplastic, however, asphalt can be accurately graded only if it is tested at specific temperatures. These standard temperatures vary depending upon the classification of asphalt. The viscosity of asphalt cement is measured at 140° F and at 275° F. The standard temperature of measuring viscosity of the two types of cutback asphalt (rapid curing and medium curing) that we can use in Texas is 140° F. Emulsions are measured at 77° F and 122° F.

*Penetration:*

Another method of grading asphalt is by penetration. This means the distance a standard needle will penetrate the asphalt at a specific temperature, in a set time, under a given weight.

In Texas, we use the same criteria for nearly all types of asphalt. The asphalt temperature must be 77° F; the needle is loaded under 100 grams of weight; and the time is set at 5 seconds.

*Flash Point:*

Flash point is the temperature at which a substance will burn if in the presence of an open flame. Usually, in seal coat operations, asphalt temperatures remain well below the flash point, but you should never assume it is completely safe. The flash point of all grades of asphalt cement we use in the state are 425° F to 450° F. Cutback asphalts are much less safe



because of the solvents used. The flash point of the cutbacks we use is from 80° F to 150° F. Extreme care must be used around cutback asphalts.

Flash point is not applied to emulsions, due to the water content and the low temperatures at which emulsions are stored and sprayed. They are typically applied at between 110° F and 160° F and stored at a maximum of 170° F.

#### *Testing:*

Most of the testing of viscosity, penetration, and flash point are done by the Materials and Tests Division, laboratory personnel in Austin. Although you will not be directly involved in these tests, you will probably be required to take some of the samples for testing.

You should be familiar with these test methods. You can find a description of them in the D-9 Manual of Testing Procedures, Volume 2, 500C Series.

#### *Storage of Emulsified Asphalt:*

Extended storage of emulsified asphalts, through an entire winter, for example, will cause the asphalt and water to separate. This is caused by the emulsifying agent losing its charge. This will cause a tremendous mess, and the asphalt will no longer be usable.

Repeated heating of emulsions will also cause the water to evaporate, leaving almost pure asphalt cement. The same is true of repeated pumping of emulsions - since the viscosity tends to be quite unstable.

## **AGGREGATES:**

The second component of a seal coat is the mineral aggregate. The term that most "road hands" use for aggregate is "topping rock." This is logical since the layer of aggregate is spread on top of, and cemented in place by, the film of asphalt.

Aggregate is any hard, inert material used in graduated-size particles or fragments as a part of the seal coat. It is the aggregate that comes in contact with vehicle tires and provides the skid-resistant surface. For this reason, the choice of the correct aggregate is as important as the choice of the best asphalt for the job.

### **CLASSIFICATION OF AGGREGATES:**

In Texas, we use two broad categories to classify aggregates: natural and synthetic.

#### *Natural Aggregates:*

Natural aggregates are mineral particles which are formed by nature through the action of wind, air, water, and glacial movements. They may be used in their natural form with little or no processing, or they may be processed to include washing and crushing. As used in seal coat work, natural aggregates includes:

- Crushed gravel - Natural gravel which has been crushed to change the particle shape from round to angular and the surface from smooth to rough.

- Crushed stone - Large stones or pieces of bedrock which have gone through a series of crushing processes. This is quite often limestone.
- Natural limestone rock asphalt - A few locations around the state are sources of natural asphalt. This is limestone rock impregnated with natural asphaltic material.

*Synthetic Aggregates:*

There are certain properties that are highly desirable in an aggregate, but are not commonly found in the natural types. Consequently, some aggregates are manufactured or originate as by-products of industrial production. Most synthetic aggregates give us good skid resistance and resist polishing smooth under traffic. The two most common types are:

- Crushed slag - One or two districts have access to blast furnace slag, which is a by-product of steel production. When cooled, crushed and used as aggregate, it gives excellent skid resistance and good wear resistance.
- Lightweight aggregate - An excellent skid-resistant aggregate that is produced by heating clay to a high temperature. It is truly lightweight, only weighing between 35 and 60 pounds per cubic foot, by Standard Specifications.

**AGGREGATE PROPERTIES:**

The aggregate properties that are most important for seal coat construction are;

- Maximum particle size and gradation
- Cleanliness
- Toughness
- Particle shape
- Surface texture
- Absorption capacity
- Affinity for asphalt

*Size and Gradation:*

Items 302 and 303 of the Standard Specifications list the size and gradation requirements for aggregate used for seal coats and surface treatments. Maximum particle size is the largest size allowable. These items also require a variety of sizes with a certain percentage of each size. Gradation is determined by a sieve analysis, which is Test Method TEX-200-F, Part 1.

*Cleanliness:*

If the aggregate is excessively dirty or dusty, asphalt will not be able to hold the aggregate particles securely in place. The asphalt will stick to the coating of dirt or dust, but as soon as traffic passes over, the aggregate particle will dislodge. The aggregate should also be free of foreign matter such as leaves, grass, sticks, and lumps of clay or dirt. Dirty aggregate is a primary factor in windshield damage, as aggregate particles are dislodged under traffic.

*Toughness:*

The aggregate must be able to resist abrasion and polishing (wearing away or wearing smooth), as well as degradation (breaking apart). If the aggregate surfaces wear away and become smooth, the skid resistance will be lost. If the particles break apart, the broken pieces will probably dislodge (more windshield damage) and bleeding or flushing will likely result.

*Particle Shape:*

The ideal shape of aggregate particles would be cubical or pyramidal. This, of course, is not possible, but the particles should be angular for better skid resistance and for better bonding of the asphalt. Asphalt will stick to an irregular shaped particle much better than to a round smooth one.

*Surface Texture:*

A rough textured particle offers better asphalt bonding and better skid resistance than smooth surfaces. Blast furnace slag and lightweight aggregate offer the best surface textures, but are more expensive than simple crushed limestone.

*Absorption Capacity:*

All aggregates are somewhat porous and will absorb some liquids: water as well as asphalt. This is not always bad, especially when using an emulsion. However, if the aggregate absorbs water through the surface, it will tend to strip the asphalt away from the particle. The more porous aggregates are often precoated with a low viscosity flux well before being used in a seal coat. This minimizes the absorption of water and aids the asphalt bond.

*Affinity for Asphalt:*

An aggregate's affinity for asphalt is its tendency to resist the efforts of water to strip the asphalt away from the rock. Limestone and some other aggregates have a high affinity for asphalt, so have a low incidence of aggregate loss due to stripping. Precoating aggregate will help reduce stripping.

Although the properties just discussed are more design considerations than the direct concern of the Inspector, you should be aware of them. You are the eyes of the Department out on the road, and it is quite possible that you may encounter situations that relate directly to these aggregate properties. The people who design the seal coats do not see every load of aggregate delivered to the roadway - you do. Knowing these aggregate properties will help you better understand what you are seeing.

## **SEAL COAT PREPARATION:**

Seal coat projects take a great deal of planning and careful preparation. The more careful the preparations, the better the chances of a high quality seal coat job that will last for many years.

As an inspector assigned to a seal coat project, you could, and probably will, get involved in many of the preparatory phases. In the beginning, you may not get involved in analysis of the existing roadway or designing a seal coat, until you have considerable experience. But you should still be aware of how all these phases fit together with the application of the seal coat. By better understanding what has gone into the planning and preparation, you should be better able to understand the importance of careful project inspection.

The main preparatory stages for a seal coat project that the inspector would be involved in are:

- Repairs and Patching
- Planning and Contracting
- Seal Coat Design
- Stockpiling aggregate
- Preconstruction meeting

### **REPAIRS AND PATCHING:**

Any repair work that the pavement needs must be done well ahead of the beginning of seal coat work. Repair work is normally accomplished by the State's Maintenance Construction forces.

There is no absolute time frame during which repair work must be accomplished. This may vary with District policy or the availability of the maintenance personnel. Some experienced seal coat people prefer that all repair work be done as far as 8 months prior to applying the seal coat. This would mean doing the repairs during the fall of the previous year. This may be feasible in some regions of the state, and not in others.

Some districts merely ensure that the repair work will be done during the spring and seal coat work not started until June or July.

Many different types of repairs may be required. They may include:

Planning: High spots in the existing surface may be planed smooth with either a heater planer or, more commonly, a cold planer. This will help to smooth out a rough riding surface.

Patching: Depressions may require leveling up with either a hot mix or cold mix patch. The sizes of this type of patch will vary, of course, but may range from the size of a wheel path only a few feet long, to a full 2 lanes wide and 50 to 100 feet long.

Potholes: All potholes must be repaired. This entails cleaning them out, trimming around the edges, sealing them with liquid asphalt and patching them with hot or cold mix asphalt.

Crack Sealing: Large cracks must be sealed with liquid asphalt. if they are excessively large, it may be necessary to cut them out and apply a hot or cold mix patch.

In the standard specifications crack sealing construction is explained to be done accordingly "All joint and cracks shall be cleaned of infiltrated material with compressed air or other methods approved by the Engineer to a depth at least twice the joint or crack width. When routing of the joints is indicated on the plans, the joints shall be routed and blown clean with filtered compressed air. All material removed from joints and cracks shall be removed from the paved surface of the roadway.

The joint or crack sealing material shall be applied using a pressure nozzle. Polymer modified emulsion, rubber-asphalt crack sealing compound and hot poured rubber shall penetrate and completely fill each crack and/or joint. The amount of sealing compound used shall be limited so that after the squeegee has been applied, the finished band shall not be more than 1-1/2 inches wide and shall not exceed a depth of 1/8 inch above the pavement surface. All cracks and/or joints filled with these materials shall be squeezed. Self-leveling low modulus silicone joint sealing compound shall be applied so that it penetrates the joint and fills so that the top of the sealant shall be 1/4 inch to 3/8 inch below the pavement surface. When directed by the Engineer, a light coating of fine aggregate shall be applied to the cracks and joints prior to opening to traffic to prevent tracking.

When the number of cracks is so great that crack sealing in the described manner is impractical, the area shall be squeegee sealed. When all cracks in the area have been cleaned, the crack sealing material shall be applied and the excess shall be squeegeed over the area between the cracks. Areas to be squeegee sealed will be determined and marked by the Engineer. All polymer modified emulsion or hot poured rubber squeegee sealed areas shall be covered immediately with a light coating of fine aggregate. No sealing of any joints or cracks shall be done when the joints or cracks are damp, unless drying of the joints and cracks with compressed air can be demonstrated and meets with the approval of the Engineer."

The crack sealing should be measured by lineal mile method. Its purpose is to reduce the amount of sealing made by the contractor since the other methods as pound method, square yard method will encourage sealing more area than required.

Cracks this large, however, are not common in Texas, unless there has been a failure or distress in the base or subbase. In this event, the whole section must be removed, including the base or subbase, and completely rebuilt.

Cleaning: The repair work should also include cleaning all animal carcasses or other foreign matter that might contaminate the seal coat. If the grass on the shoulders has grown up onto the pavement, it may require blading the shoulder and spraying with herbicide.

Although you will not be involved in the actual repair work, it is necessary for you to know what repairs will be needed. Requirements must be coordinated with the responsible maintenance personnel as far in advance as possible. This will enable them to plan their schedules and needed materials accordingly.

## SEAL COAT PLANNING AND CONTRACTING:

Once the analysis of the pavement is done, and repairs are projected, preliminary planning of needed materials is possible. The first step is to determine how much roadway is to be covered.

### ROADWAY DISTANCE:

As each road is constructed originally, control points are designated, and are permanently assigned for the life of the road. Station numbers are also designated at every 100 feet.

**Example:** On one project a section has control number 256-2-16 and the station limits are 595+00 to 935+66.4.

Station numbers represent distance, in feet, from a known control point. The 595+00 represents 59,500 feet from a reference point. 935+66.4 equals 93,566.4 feet from the same reference point.

By subtracting the lower station number from the higher, we can tell how many feet of roadway are in between.

$$935 + 66.4$$

$$\underline{595 + 00}$$

$$340 + 66.4 \text{ or } 34,066.4 \text{ feet}$$

### AREA OF COVARAGE

Once the longitudinal distance has been determined, the total area of coverage must be computed. The area is found by multiplying the longitudinal distance (length) by the width of the road in feet. of course, the total will be expressed in feet.

The area in feet must be converted to square yards. This is done by dividing the total area expressed in feet by 9. This is necessary because asphalt application rates are expressed in gallons per square yard, and aggregate rates are based upon cubic yards (of aggregate) per square yard of highway.

Sometimes the shoulders are seat coated with light colored aggregate when black precoated or reddish light-weight aggregate is used in the main lanes. In this case, the total area of the shoulders would be calculated the same as the main lanes, and expressed separately. The same would be true of climbing lanes, if applicable.

### ESTIMATE OF MATERIALS:

Once the roadway area has been computed, a fairly close estimate can be made of the materials needed. This is also based upon the analysis of the pavement and traffic count. Usually, the estimates are based upon the following quantities. (Note: These are only approximations and estimates may vary considerably.)

Asphalt - Traffic Lanes: .35 gallons per square yard (GAL/SY).

Asphalt - Shoulders: .32 GAL/SY.

Aggregate - Traffic Lanes: 1 cubic yard per 140 square yards of highway (1 CY/140 SY).

Aggregate - Shoulders: 1 CY/165 SY.

### ESTIMATE ROLLING:

The basis for estimating the amount of time required for rolling is based upon 2500 square yards per hour for light pneumatic rollers. Some districts use steel wheeled rollers, which are usually operated at somewhat slower speeds. 1800 to 2000 square yards per hour might be a reasonable estimate for a steel wheeled roller.

### PREPARING PLANS:

As soon as the estimates of materials and rolling are made, the plans are drawn up. For seal coat projects, plans include a title sheet, general notes and specification data, an estimate summary, project location and data, and standard sheets depicting signs and traffic control devices.

The plans must be approved at the District level, usually by both the District Designing Engineer and the District Engineer. They must then be approved at the Main Office in Austin, by the Highway Design Division (D-8), and a date is established for the contract to be let.

### COMMUNICATING WITH CONTRACTOR:

Numerous details must be worked out between the responsible Engineer and the Contractor. The Engineer needs to know the approximate date the Contractor plans to start the operation, who will supply the materials, and to arrange for the preconstruction meeting, which will be explained in detail later.

### SEAL COAT DESIGN:

Seal coat design is a critical part of the seal coat project. Careful attention must be given to the needs of that particular road. Design quantities that work well in one place may not work at all in another. The final design is usually the result of a collective effort of numerous people, the experienced inspector, the design engineer, and many others. Seal coat design involves the selection of binder and the design of material application rates by incorporating the required mat depth and embedment depth. Districts perform this task in two ways. They are the Modified Kearby Method and the experience-based method. In addition, some districts use variable binder rates across the lanes and the others use a constant rate. You may, with little or no actual seal coat experience, be called upon to assist

with some of the design or analysis work, depending upon the alignment of responsibilities in your district. If you are not directly involved in this phase, it will help you be a more effective inspector if you understand the process of seal coat design.

When all information concerning the pavement condition, traffic type and volume, weather, and all additional relevant information have been analyzed, the designers have a general idea what type of seal coat will be needed.

The seal coat design process involves the determination of grade, type, and the application rate for binder and aggregate.

#### AGGREGATE SELECTION:

The cover aggregate is expected to transfer the load to the underlying surface. It should provide adequate skid resistance and should be durable against climatic effects and traffic wear. Item 302 categorizes aggregate as either uncoated or precoated. Within each category, aggregate is further divided into several types based on its formation in rock deposits and crushing. In addition, aggregate grades are identified based on the gradation and the maximum particle size. Grades 1 to 5 are identified depending on the coarseness of the aggregate with the coarsest aggregate being Grade 1. In addition, two additional gradations, 3 modified and 4 modified, have recently been added. These two gradations provide more uniformity compared to Grades 3 and 4 respectively. Item 303 specifies two aggregate categories (uncoated and precoated) and three gradations (Grades 3, 4 and 5) for lightweight aggregates.

Based on the comments made by TxDOT personnel, it appears that the use of precoated aggregate improves aggregate binding properties, reduce dust in the aggregate and result in better appearance of pavement and markings. Reduced dust enhances the bonding between the aggregate and binder. Good bonding will reduce windshield breakage complaints. The additional cost of precoated aggregate is justified in many projects due to these benefits as well as reduced public complaints. Another way to reduce windshield breakage problems is by using lightweight aggregate. Lightweight aggregate available in Texas also provides excellent skid resistance.

Selection of cover stone is directly influenced by its availability at close proximity. Aggregate gradation plays a major role in the performance of seal coats. Gradation of the aggregate is desired to be as uniform as possible. Uniformly graded cover stone provides the desired embedment depths leading to better aggregate retention.

The shape of cover aggregate is also crucial to the good performance of seal coats. Angular aggregate shapes such as cubical or pyramidal surfaces give satisfactory service. Rounded particles provide the least interfacial area between the aggregate and binder. Elongated and flat particles may be embedded 100 percent within the binder, thus reducing the pavement skid resistance. Flakiness index is used to control the maximum amount of such particles that can be present in cover stone.



Grade 3 and Grade 4 aggregates appear to be the most commonly used. Even though Grades 3(modified) and 4(modified) are preferred, economic considerations have forced most districts to use Grades 3 and 4. The coarser the aggregate, the higher the necessity for asphalt to obtain the same embedment depth. Grade 3 aggregate provides a thicker seal and better protection to the underlying surface. However, Grade 3 aggregate also results in more tire noise and windshield breakage complaints. Grade 3 seal coat applications can also be more expensive than other gradations due to the higher quantities of material used. Another advantage of Grade 3 aggregate is the relative tolerance of binder application rates. If the design rate is exceeded during construction, excess asphalt can be accommodated more easily without causing flushing problems due to larger voids between aggregate particles. Coarser aggregate grades are preferred for high volume roads but good results can also be obtained with Grade 4 rock if the asphalt rate and type of rock is selected well. Drainage properties of Grade 3 are better than for Grade 4.

#### BINDER SELECTION:

The main function of the binder is to seal the existing surface and bond the aggregate particles. It must provide an adequate bond with the existing surface. The binder should have a sufficiently low viscosity at application temperatures to enable uniform spraying and subsequent wetting of aggregate. There are two main binder types used for seal coat operations. These are asphalt cements and emulsified asphalts. The use of cutback asphalts has reduced over the years, primarily due to environmental concerns. However, some TxDOT districts still use cutbacks in their seal coat programs.

Asphalt cements are advantageous because after seal coat application, the roadway can be opened for traffic early. However its disadvantages include high application temperatures, sensitivity against moisture in rock particles, and the requirement of more rolling energy. High working temperatures can also create safety concerns that may limit their application season to hot summer months.

Emulsified asphalts have three constituents, asphalt particles, emulsifying agent and water. The asphalt droplets are suspended in water with the help of emulsifier. When water evaporates after the binder is applied, it leaves the asphaltic material residue that bonds the aggregate particles to the binder. This phenomenon that occurs when water evaporates is called "breaking" where binder color changes from brown to black. Emulsions are not as sensitive as asphalt cements to the moisture in aggregate and in the atmosphere. Since the presence of water enhances the flowability of the binder, emulsions require much lower application temperatures than asphalt cements. These characteristics of the emulsions make them suitable for colder weather seal coat work. Aggregate precoated with asphalt cement is not typically used with emulsions.

Emulsions can be either anionic or cationic depending on the chemistry created by the emulsifying agent. Cationic emulsions are considered to be suitable for use with all aggregate types whereas anionic emulsions may create some stripping problems if used with siliceous aggregates. There is evidence that during long storage periods and cold weather, the effect of the emulsifying agent may diminish resulting in the coagulation of asphalt

droplets. Emulsion can also give run-off problems if the pavement temperature is too high. One of the most critical issues with emulsion seal coats is the required time interval between binder spray and aggregate spread to enable breaking of the emulsion. This requirement can prolong the construction time causing problems with traffic control. Their use is more appropriate for low traffic highways.

The selection of binder-aggregate combination should incorporate the availability and compatibility of the materials as well as the district's experience with a particular combination. Special care should be taken when constructing seal coats in colder temperatures. Such weather conditions cause the binder to be more brittle and raveling (shelling) may occur as a result. In such situations, adequate embedment depth is critical to prevent raveling. If adequate embedment is not achieved due to inadequate rolling or binder quantity, raveling would be observed between wheel paths and along edges of the lane where the lowest levels of embedment is present due to less traffic action.

A formal design method such as the Modified Kearby Method can effectively serve to guide inexperienced personnel through the "art" of seal coat design and to train personnel including inspectors, designers and laboratory personnel. Correction factors for binder application rates for varying conditions including traffic, surface condition and aggregate which are developed for conditions unique to the districts such as the aggregate and binder availability will ensure a much faster learning curve for inexperienced personnel. Appendix A shows a series of Tables developed for adjustment factors. These Tables were developed several years ago at the Brownwood and Abilene Districts for emulsified asphalts.

#### MODIFIED KEARBY METHOD:

The design methodology requires the knowledge of some physical characteristics of the aggregate, such as unit weight, bulk specific gravity and the quantity of aggregate needed to cover one square yard of roadway. The unit weight test, bulk specific gravity test is done for calculating unit weight and bulk specific gravity. The Modified Kearby Method recommends laboratory Board Test method in order to find the quantity of aggregate needed to cover one square yard of roadway. The Board test is performed by placing an adequate number of rocks on an area of one half square yard. The weight of aggregates that cover this area is determined and converted into a unit of pounds per square yard. The quantity of aggregate needed to cover one square yard of roadway can also be determined in terms of volume as shown in Eq. 1.

$$S = 27 W / Q \quad (1)$$

Where S is the quantity of aggregate required in  $\text{yd}^2/\text{yd}^3$ , W is the dry loose unit weight in  $\text{lb}/\text{ft}^3$ , and Q is the aggregate quantity determined from board test in  $\text{lb}/\text{yd}^2$ . The quantity of asphalt can be obtained from Eq. 2 once the aggregate properties and existing roadway conditions are known.

$$A = 5.61E \left( 1 - \frac{W}{62.4G} \right) + T + V \quad (2)$$

Where A is the binder rate in gallons/yd<sup>2</sup> at 60°F and E is the embedment depth calculated using Eq. 3.

$$E = e * d \quad (3)$$

Where e is the percent embedment and d is the average mat depth in inches, as calculated from Eq. 4.

$$d = \frac{1.33Q}{W} \quad (4)$$

Where G is the dry bulk specific gravity of aggregate, T is the Traffic correction factor (from Tables 1- 5 Appendix A) and V is the correction factor for existing surface condition (from Tables 6-8, Appendix A). There may be other correction factors applied to the application rate calculated as Binder rate adjustment factors for aggregate gradation (Table 9, Appendix A) and binder rate adjustment factors based on type of rock (Table 10, Appendix 10).

The asphalt application rates obtained by the Modified Kearby method can be taken as the basis of estimate of the real asphalt rates and the field inspector can modify these rates on the day of construction. The actual real asphalt application rates used in the field and the related field conditions shall be noted in a construction record to be used in the planning of next year's seal coat program.

#### PAST EXPERIENCE METHOD:

Some districts use their wealth of experience to determine the basic binder and aggregate application rates to be used in the plans and these rates may be changed in the field based on the conditions on the day of construction.

#### STOCKPILING AGGREGATE:

Our Standard Specifications allow the Contractor to stockpile aggregate to be used on the project, at locations approved by the Engineer. For the sake of efficiency, most contractors will elect to do this. There are, however, some steps that must be taken before stockpiles are placed on the job site.

Before the Contractor even submits a bid on the project, he will have already received a tentative agreement from a supplier that the required materials will be made available. When the contract is awarded, the Contractor identifies his supplier to the Engineer.

Assuming the supplier is from Texas or the surrounding area, he will probably already be a participant in the State's Quality Monitoring Program (QMP).

The QMP is a system through which each District Lab or D-9 Inspector takes samples from suppliers within the District, and sends them to the Materials and Tests Division (D-9) at periodic intervals. The samples are tested, as appropriate, and the results are entered into a computerized system. Every District Office has access, by computer terminal, to the suppliers who participate, and the date each type of material was tested.

At present, limestone aggregate must have been tested within the last six months, and lightweight must have been tested within the last month. If these requirements have been met, it is not necessary to have them retested at D-9 in Austin. Approval can be granted by the project Engineer to stockpile the aggregate.

Normally, the Contractor proposes the stockpile locations to the project Engineer, who either approves or disapproves. Item 316.4 of the Standard Specifications gives broad restrictions on stockpile locations.

It is also important for stockpiles to be situated so that they are not contaminated. Extreme care must be taken that clay and mud do not pose a problem. Stockpiling should not be situated where there is a likelihood that roadway drainage will cause the aggregate to remain excessively wet.

If necessary, the Contractor may be required to prepare a stockpile area before the aggregate is placed on it. He may be required to level it with a dozer or motor grader, and to clear it of any debris, such as vegetation, rocks, and sticks.

Stockpiles should be placed in a manner that will minimize (or prevent) segregation and degradation.

- Segregation: The separation of the different sized aggregate particles. Segregation would result in one part of the stockpile containing only the coarser particles and another area containing only finer particles. Ideally, any sample taken from any area of the stockpile should contain a representative sampling of the complete range of sizes.
- Degradation: Degradation means the breaking apart of the aggregate particles. This, of course, would result in a finer gradation of aggregate than desired. Degradation occurs most commonly from improper operation of the front loader; rather than improperly constructed stockpiles.

In a proper aggregate stockpile the loads should be placed adjacent to each other to form a "chain." Stockpiles should not be placed in one high cone-shaped heap, since segregation is almost certain to occur in that situation.

This photo below shows a properly placed stockpile.

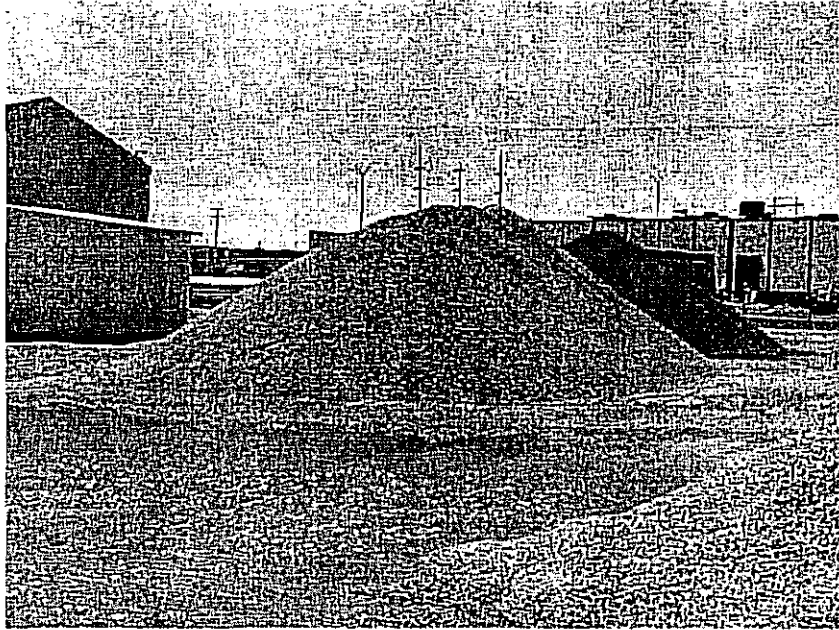


Figure 1: Aggregate Stockpile

#### **SAMPLING:**

It will probably be necessary to take samples of the stockpiled aggregate before completing the design process. Samples would be needed for a sieve analysis, determining unit weight, and checking the flakiness index at the responsible Residency or District lab.

When sampling from a stockpile, be certain that samples are taken from various sections of the pile. Proper sampling procedures are specified in the TxDOT Manual of Testing Procedures TEX 400-A on sampling and testing procedures.

#### **PRECONSTRUCTION MEETING:**

When all sampling and testing has been accomplished, and before work begins, it is necessary for the Contractor and his representatives to meet with the State's representatives. During this meeting, a "game plan" is developed and final details are worked out.

Specifically, the preconstruction meeting serves a number of valuable purposes:

- Allows the Contractor and his foreman and supervisors to meet the Project Engineer, Chief Inspector, and the other Project Inspectors personally. This is sometimes the first time these two groups have ever met each other in person.

- Provides an opportunity to establish a harmonious, yet professional working relationship between key personnel involved in the project. It is necessary for State personnel to be able to work in harmony with the Contractor's people; otherwise, every day of the project can be sheer agony. Yet, as representatives of the taxpayers of the State, we must maintain a "no-nonsense" professional image.
- Responsibilities should be defined during this meeting. It should be made clear, and be mutually agreed upon, who is responsible for what for the entire project. Each Inspector should know who the supervisory personnel are, and who he or she should talk to in the event of project-related difficulties. The same is true for the Contractor's personnel.
- A plan of action should be agreed upon. If numerous road segments are to be sealed, the sequence should be agreed upon. General agreement should be reached on the sequence of lanes to be sealed, and any unique features should be discussed.

Traffic control and handling must be discussed. One of our heaviest responsibilities as representatives of the State is to ensure the safety of the motoring public during construction projects. Traffic handling methods, devices, and signs and barricades must be discussed in detail. Emphasis must be placed on the correct flagging procedures.

Ground rules must be established. It must be clarified, and agreed upon, and what are valid reasons for delays. By contract, a project normally must be completed within a specified number of days. However, rain or other unacceptable weather conditions should not cause the Contractor to be penalized, since they are beyond his control. The Contractor should inform the Engineer if he intends to work any weekends or holidays.

Any other pertinent information concerning the project should be aired at this meeting. Both State and Contractor's representatives should leave the meeting with a full understanding of the project.

#### ATTENDEES:

There is no specific rule as to who should and should not attend the preconstruction meeting. As a minimum, the Contractor should be represented by his project supervisor, foreman, and any other supervisory personnel on the project. The Highway Department should be represented by the Project Engineer and Chief Inspector, as a bare minimum.

Quite often the meetings are held in the District Conference Room, and the District Construction or Maintenance Engineer will serve as chairman. The District Laboratory Engineer or Supervisor attend in some Districts, and also serve as Project Engineer in some Districts. Some Districts traditionally have all project inspectors attend, in addition to the Chief Inspector.

If traffic is expected to be a major factor, sometimes the Department of Public Safety (DPS) will be represented. Occasionally, a representative of the local Police Department will attend, especially if part or the entire project is in a major metropolitan area. Any other people who have a direct interest or responsibility in the project may be invited to attend.

## **SEAL COAT EQUIPMENT:**

One of the most critical concerns for an Inspector of seal coat work is to be thoroughly knowledgeable of the equipment used. It is not enough to know what equipment must be on the job, but you must also know the capabilities and limitations of each. Seal coat quality is highly determined by the availability and proper usage of appropriate equipment. Understanding the capabilities and limitations of each piece of equipment helps to attain a quality seal coat product. The following types of equipment are used in a seal coat construction project:

- Asphalt distributor
- Aggregate spreader
- Haul trucks
- Rollers
- Rotary broom
- Asphalt Transporter
- Heater and storage unit
- Miscellaneous equipment

As an inspector you will need a basic knowledge of the usual types of equipment you will encounter on the seal coat jobs. With the knowledge of this equipment and procedures for inspecting it, you will be able to perform the important task of equipment inspection with little difficulty.

Every contractor should have a copy of the manufacturer's manual for each piece of equipment on the job. Consult the manufacturer's manual whenever specific questions arise on the job.

## **ASPHALT DISTRIBUTOR:**

The asphalt distributor is the most complex piece of equipment in seal coat work since it has much more components that must be operating properly, than the other equipment.

Simply an asphalt distributor is a truck-mounted, insulated tank, with numerous special purpose components that are attached to it. The major components of an asphalt distributor are:

- Asphalt tank
- Heating system

- Circulation and pumping system
- Spray bar
- Hand sprayer
- Controls and gauges

This photo shows a typical asphalt distributor used in seal coat projects in Texas.



Figure 2: Asphalt Distributor

#### DISTRIBUTOR TANK:

The asphalt distributor tank used for most seal coat work hold from 1,000 to 2,000 gallons of liquefied asphalt. There are some larger or smaller ones used, but this range is probably the most efficient for most jobs.

The tank is insulated to prevent the asphalt from cooling. Asphalt temperatures for seal coat work are commonly well over 300<sup>o</sup> F when using asphalt cement so the tank is insulated to avoid the cooling of asphalt quickly near the skin of the tank.

The stabilization of the liquid asphalt in tank while the vehicle is in motion, is assured with the help of two or three baffle plates. This is particularly important where a constant spray pressure is necessary. In addition to the baffle plates, the tank is equipped with one or two flues – heat ducts running lengthwise of the tank. These flues in conjunction with a burner system allow the heating of the asphalt uniformly since heat loss is inevitable despite of the insulation. The temperature level of the asphalt can be closely monitored by means of a



thermometer installed in the side of the tank. Most thermometers has a range from 100 °F to 400 °F – to fit most seal coat project needs.

One particularly important measuring activity is strapping the distributor with a calibrated dipstick to measure the asphalt level in the tank. This measurement sets the basis for asphalt quantities used in a particular seal coat shot.

#### DISTRUBUTOR HEATING SYSTEM:

Asphalt temperature is a critical factor in success of a seal coat. Hence, according to the Standard Specifications the asphalt temperature should be within 15 °F of the temperature specified by the Engineer . To maintain these close tolerances, a heating system is necessary. Depending upon the make and size of distributor, either one or two gas or oil fired burners are used. These burners are mounted on the platform at the rear of the tank, and are positioned so the flame is directed into the flues that pass through the tank.

The need for heating the asphalt depends on the type of the asphalt, weather conditions, weather the tank was directly filled from the heated storage or whether asphalt has been carried some distances in an insulated transporter and the time asphalt spent in the tank before it was shot. For example, most emulsions are shot at 110<sup>0</sup> F to 160<sup>0</sup> F and may not require heating if used within just a few minutes. When using asphalt cement, temperatures may range from 275<sup>0</sup> F to 350<sup>0</sup> F; probably closer to the higher temperature. Cutback asphalts will probably be shot between 125<sup>0</sup> F and 230<sup>0</sup> F.

Heating asphalt always constitutes some degree of hazard, with the exception perhaps of emulsions. The most hazardous are the cutbacks because of the highly volatile solvents used. Extreme care must be taken not to allow open flames to come in contact with the asphalt or the gases from hot asphalt.

When working with asphalt cement (AC), remember also that extreme care must be taken as a result of the high temperatures involved. Being burned by 300<sup>0</sup> F asphalt is no joke.

#### DISTRIBUTOR CIRCULATION AND PUMPING SYSTEM

All asphalt distributors are equipped with a power-driven pump to spray asphalt under pressure onto the roadway. The pumps also serve other purposes such as a circulation system. The circulation and pumping system can be powered by either a separate diesel engine mounted on the platform at the rear of the tank or directly from the truck engine to operate the pump.

Asphalt is circulated and pumped throughout the tank for several reasons such as heating the asphalt uniformly, preventing the cooling and hardening of the remaining asphalt in the distributor bar, pumping the remaining asphalt in the tank, and filling the distributor tank in case the transporter is not equipped with a pump.

## DISTRIBUTOR SPRAY BAR:

The spray bar is an extremely important component of the asphalt distributor because the spray bar and spray nozzles regulate the amount of asphalt sprayed on the road and regulate the spray pattern.

This photo shows the location and appearance of a typical distributor spray bar.



Figure 3: Asphalt Distributor Spray Bar

There are many different bar widths available: as narrow as 6 feet and as wide as 30 feet. Narrow bars are impractical. The bars mainly used in Texas seal coat projects are 12 feet wide.

The spray bars are composed of a series of spray nozzles evenly spaced along the width of the bar. It contains a return line for continuous circulation of asphalt through the bar. Some models are equipped with shut-off valves on each nozzle to permit closing a few spray nozzles around curbs or narrow sections.

This photo shows the nozzles on a typical spray bar.

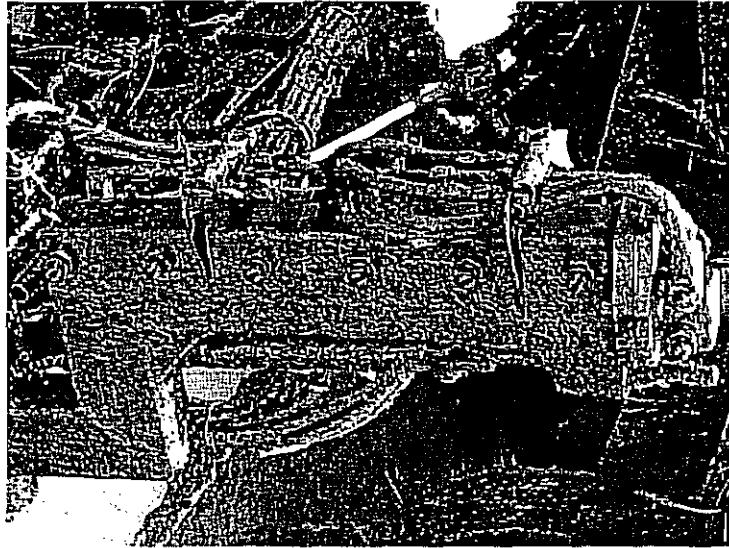


Figure 4: Spray Bar Nozzle

Nozzles are manufactured with different sized openings to permit different amounts of asphalt to pass through in a given time. Nozzles are designed to spray a fan-shaped pattern, rather than a circular spray.

The nozzles are installed in the spray bar so that the fan-shaped spray is at an angle to the axis of the spray bar, as illustrated below. The angle varies from one manufacturer to the next. The Contractor should have the manual for his machine, which contains the specifications.

This angle is usually from about  $15^{\circ}$  to  $30^{\circ}$ , depending on the manufacturer. All nozzles must be set at the same angle to avoid distortion of the spray pattern.

Some operators turn the end nozzle perpendicular to the spray bar axis, in an attempt to get a sharp edge and avoid overspraying aggregate in an adjacent lane. This practice is not recommended. It will cause a fat streak at the edge and it robs the next nozzle of overlap normally provided by the end nozzle. A curtain or deflector plate installed on the end of the spray bar is preferable, with the end nozzle at the same angle as the others. A deflector nozzle may also be used.

Spray bars are hinged at each end to permit the ends to be folded up whenever spraying is not in progress. The distributor should never be driven in traffic with the ends down, since they extend beyond the sides of the truck. Some have chains attached at the ends of the bar and to the truck chassis. The chains help to support the ends of the bar when they are down in the spray position. They also can double as a safety hitch to hold the ends securely in the upright position.

Another important factor to attain the desired pattern of asphalt is the height of the spray bar. The distance, the bar is above the surface of the roadway determines how wide the fan spreads. Seal coat jobs require either double or triple lap coverage; double lap being pattern from one nozzle overlaps half of the spray pattern of the nozzles on both sides of it.

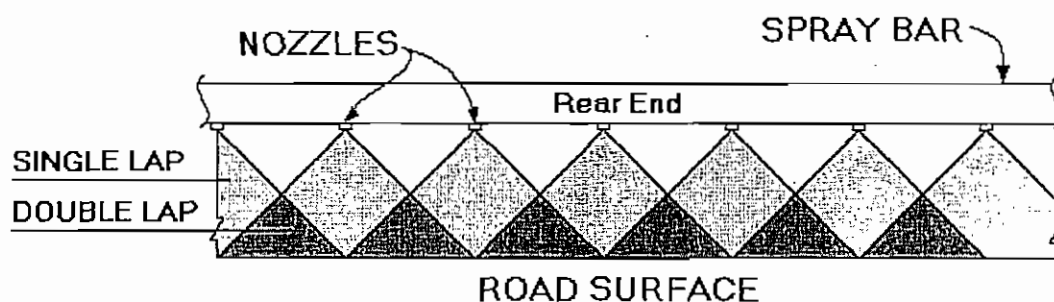


Figure 5: Single Lap- Double Lap Image

In a triple case, however, the pattern from one nozzle overlaps two thirds of the pattern of the nozzles on both sides of it plus one third of the pattern put out by the nozzles two positions away.

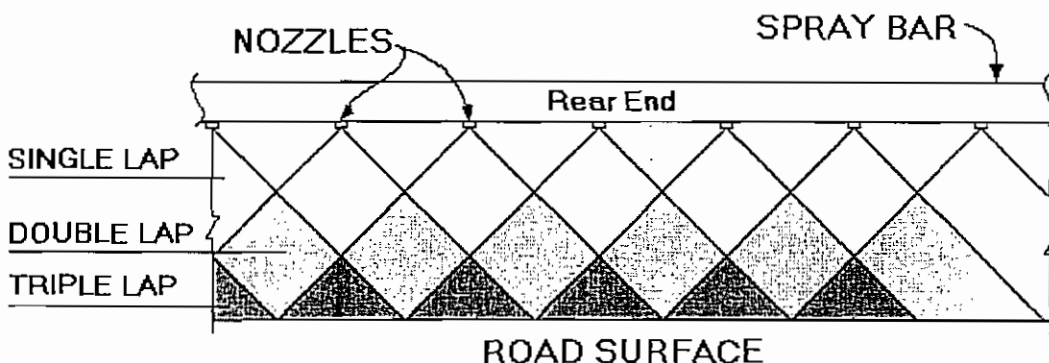


Figure 6: Single Lap-Double Lap- Triple Lap Image

The stabilization of the distributor's springs is very important because same spray bar is desired when both the tank is full and empty. Standard truck springs will compress under a heavy load, and flex back to an arch when the load is removed. If an asphalt distributor had standard springs, the spray bar would be one height when the tank is full. As the asphalt is sprayed and the tank empties, the spray bar would rise with the decreased weight on the springs. Consequently, the beginning of the shot would have double lap coverage, but the lap would increase as the spray bar rose.

To avoid this inconsistency, most distributors of recent manufacture are equipped to either prevent the springs from compressing under a load or to prevent them from arching back with a near-empty tank. Many are stabilized with compressed air. The most important point of this issue is that the spray bar should remain at the same height whether the tank is full or empty.

In narrow, irregular shaped areas that are inaccessible to the spray bar a hand sprayer is used. All distributors used in seal coat projects should be equipped with a hand sprayer.

This is a typical hand sprayer being used in a seal coat project. It would not be possible to shoot this area with the spray bar.



Figure 7: Hand Spray Bar

## DISTRIBUTOR CONTROLS AND GAUGES:

The distributor controls and gauges must be functioning accurately because the precise amount of asphalt delivered onto the roadway is a key element to obtain quality seal coat. Many controls and gauges are used to assure the consistency and accuracy of the asphalt rates.

Most tanks are equipped with a volume gauge. These should only be used as a convenience to the operator, to know when the tank is getting close to empty. Although it is possible to monitor the asphalt quantity in the tank with the volume gauge, this should never be used as a basis for payment due to low reliability of such devices. Instead a calibrated dipstick for each distributor tank should be used to measure the volume. In order to meet State requirements the stick or scale must show increments of every 10 gallons. The pump pressure and speed gauges are crucial devices since the pressure under which asphalt is being sprayed will greatly influence the uniformity of the job. If the pressure is too low, the asphalt will streak and be applied unevenly. If the pressure is too high, the asphalt will atomize and the pattern will be distorted. The pump should be operated at the highest pressure without atomizing the asphalt.

Another control part of the distributor is the bitumeter. It is used to ensure the desired speed of the distributor. It consists of a small wheel mounted behind the driver's door and it measures feet per minute that is converted from the number of revolutions per minute. An instrument in the cab is attached to the wheel and precisely displays the speed of the vehicle. The driver is responsible to monitor the consistent performance of pump pressure as well as distributor speed.

A distributor operator must be able to turn all spray nozzles on and off simultaneously and instantaneously. There is a valve control unit which turns the spray on and off.

At the beginning and end of a shot, the distributor passes over paper which masks the pavement to form a straight, sharp line. The distributor must pass over the masking paper on both ends at spraying speed. The operator must be able to turn all nozzles on in the split second that the distributor passes over the masking paper. It must be turned off in an equally short time.

We have mentioned the "distributor operator" numerous times. It should be pointed out that there are really two people involved. The driver lines up the machine and keeps it on line at the correct speed. The spray operator works the valve control, and on some models, sets the pump motor speed and monitors pump pressure. These two people must work as a team, with no room for error.

## ASPHALT DISTRIBUTOR INSPECTION:

Probably the most important piece of equipment, from the standpoint of inspection, is the asphalt distributor. If the asphalt binder is not applied correctly, the cover aggregate cannot be expected to stay in place under traffic. You can avert almost certain disaster by ensuring

that the distributor is carefully inspected. The first step is to record the serial number, model, and other required information. This will be entered in the project folder.

#### *Calibration:*

Every asphalt distributor used on a State project must have a current calibration certificate. This means that the distributor has been checked to determine the accuracy of the measuring stick and the capacity of the tank. The tank must have been certified by a Department representative. There is no specific time during which the calibration must have been performed. The calibration certificate is considered valid as long as there is no evidence or reason to suspect that any major modifications have been made to the distributor.

#### *Visual Inspection Inside:*

The tank unit should be visually inspected inside before it is filled. It should be clean to prevent contamination or mixing of different types of asphalt.

#### *Heater Unit:*

The heater unit should be checked for proper starting and operation, Each burner should operate independently to allow either one to be used alone, or both could be used simultaneously.

The burner flames must be adjustable to regulate the amount of heat being directed into the flues. The fuel lines and burners should be free of fuel leaks.

#### *Thermometer:*

The tank should be equipped with a thermometer. Many models have a mercury thermometer mounted in a well in the side of the tank. It should have a chain to prevent it from being dropped, and a screw-on cap to keep the well covered.

Other models of distributors use a dial-type thermometer mounted outside the tank. These use a thermocoupler that is mounted inside the tank.

Either type of thermometer is acceptable but should be checked for accuracy, if possible. If you have a thermometer of known accuracy, you could place both of them in a container of any liquid, and they should read approximately the same temperature. This, of course, would not be feasible with the dial-type thermometer.

#### *Pump Unit:*

If the distributor has the pump motor mounted on the rear, the pump motor should be visually checked for leaks and you should have the operator start the motor.

While the pump motor is running, check the pressure gauge as the throttle is moved to different settings. As the engine RPMs increase, the pump pressure should show an increase, also. You will have no way of checking the absolute accuracy of the pump pressure, but if you see it fluctuating erratically, you should have the operator check it.

#### *Bitumeter Gauge:*

Check the gauge in the cab of the truck. It should show speed measured in feet per minute and be equipped with an odometer to show distance traveled, as measured in feet. This gauge is extremely important, because the driver must bring the truck speed up to a specified number of feet per minute very quickly and maintain that exact speed for the entire shot. This is the only way that the application rate can be held constant.

Mark off a specified distance, on level ground. The distance should be a minimum of 100 feet; 500 is better; 1,000 feet would be better yet. Have the driver drive over this distance at a constant speed, perhaps 300 feet per minute (approximately 3.5 miles per hour). Instruct the driver to be certain that he maintains the exact speed specified.

Using a stopwatch, check the time it takes the distributor to travel the specified distance. Also check the odometer reading on the gauge to determine its accuracy. It is far more important that the feet per minute reading is accurate, than for the odometer to be exact. You can usually double check the distance against a State vehicle equipped with a calibrated odometer or against station markers. Some Districts measure, in advance, the distances for each shot and rock land, but the distributor speed must be accurate.

#### *Spray Bar:*

There are several items on the spray bar that must be visually checked.

- Be certain the ends of the bar can be raised and lowered. There should be some method of securing the ends in the raised position. Many models are equipped with a chain device to secure the ends when raised.
- Make sure the length of the bar is straight when the ends are lowered. This should be checked in both the vertical axis, as well as from front to rear. Fan widths will be distorted if it is crooked.
- Visually check to ensure there are no excessive leaks in any of the hoses, pipes, or joints in the bar. If asphalt leaks out onto the pavement while the distributor is stopped, a puddle of asphalt will form. No matter how much care is taken to clean it up before the shot, there is usually too much asphalt at that spot. It will tend to bleed up through the cover aggregate.



Additionally, there are several measurements that must be made.

- The spray bar must be checked to ensure it is the correct width. If the lanes to be sealed are 12 feet wide, ensure that the proper amount of extensions have been installed to have the nozzles measure 12 feet. All nozzles will be 4 inches apart, so you could count the nozzles rather than measuring the bar width.
- You must measure the spray bar height above the pavement surface. The distributor must be parked on a flat, level surface, with the bar in the lowered position. The height should be measured from the bottom of the nozzles to the ground. Measurements should be taken at various points across the width of the spray bar to ensure that the height is constant. Set the height according to the manufacturer's recommendations, for the type nozzles in use.

The bar height should be measured first with the tank empty, and checked again after the tank is full. If there is more than about 1 inch difference, the rear springs must be blocked or chained down to prevent the bar from raising as the tank empties toward the end of each shot. This will prevent uneven overlap between the beginning of a shot and the end.

#### *Spray Nozzles:*

Have the operator raise the spray bar and rotate it outward so the nozzles can be inspected, if the model of distributor permits it.

The nozzles are critical to obtaining the correct asphalt coverage. If they are not in good condition and properly adjusted, it will be impossible to get consistent asphalt coverage across the width of the lane being shot.

As mentioned previously, there will be a nozzle mounted every four inches along the width of the spray bar, on most models. First, check to see that there are the correct number of nozzles. If there are more nozzles than needed, have the operator remove the extras and replace them with solid plugs.

If a straight, sharp edge is desired on the asphalt coverage at either or both edges, the end nozzles should be deflector nozzles. Some operators believe that deflector nozzles are not necessary to achieve the desired result, but they are necessary. They provide the sharp edge and also ensure correct overlap with the nozzle next to the end.

Check the overall condition of the nozzles. If any are gouged or defaced (they are made of brass), they should be replaced; because they probably will not produce a proper spray pattern.

### *Nozzle Angle:*

The nozzles must be set at an angle in relation to the axis of the spray bar. Whatever is prescribed in the manufacturer's specifications should be followed. The angles usually range from 15 to 30 degrees, depending on the make of distributor.

The proper spray pattern depends directly on the exactness of the nozzle angles. If they are not set correctly, the fan pattern on one nozzle will interfere with, and distort, the pattern of the nozzles on either side of it. Streaking will be the probable result.

### *Fan Width:*

If at all possible, it is wise to check the fan width of each nozzle, to ensure that they are close to the same width.

If the fan width is not even, the desired overlap will not be obtained, and the asphalt will probably streak under those nozzles with a narrow fan.

To check the fan width, you can have the operator back onto a flat, sandy spot or place one or two thicknesses of brown wrapping paper under the spray bar. Have the operator turn the spray on - just momentarily. Make certain he turns it off as quickly as possible. This will not give an exact representation of the fan widths, but it will quickly uncover any nozzles that are greatly different from the rest. If this is not conclusive, you could have the operator drive forward for about 20-30 feet and spray a short test strip. This will usually reveal any nozzle problems.

### *Nozzle Output:*

The amount of asphalt being sprayed out of each nozzle will vary. District 23 in Brownwood has done extensive research on both fan widths and nozzle output. They have tested brand new nozzles which have never been used, and found that their fan widths will vary as much as 100 percent on dome nozzles. The total output of asphalt on new nozzles have varied, within the same set, by as much as 6 percent.

This means that even with brand new nozzles, straight from the manufacturer (which you will rarely see on a seal coat job) there may be a great deal of variation in the amount of asphalt applied, from one nozzle to the next. Consequently, the cover aggregate may be imbedded to 40 percent on one strip, and 70 or 80 percent on the strip next to it. How well the seal coat will last, is highly unpredictable.

### *Bucket Test:*

The best method of checking nozzle output is with the bucket test. If you decide to try this test, your sheet metal shop can manufacture buckets that will work well. They should be oval-shaped, so they will fit under the nozzles, side-by-side. This sketch shows the dimensions.

It is less messy if a plastic bag is placed inside each bucket and secured over the top with a stout rubber band. Each bucket with plastic bag and rubber band must be weighed empty. This technique will only work with emulsions, because hot AC or cutbacks will ruin the plastic bag.

Before the test begins, you should have the asphalt heated to whatever temperature at which it will be applied. The distributor should be moved off the test area to "blow out" the nozzles. This means that the sprayer is turned on for a short period to make certain none of the nozzles are clogged.

If all nozzles are working, you can proceed with the test. If not, any clogged nozzles should be removed and cleaned out with diesel fuel or gasoline. Nozzles should not be cleared with wire. This usually results in the hardened asphalt being pushed back into the nozzle, only to clog it again. The buckets are placed directly under the nozzles, and must be carefully positioned to ensure that none of the asphalt, which will be sprayed from the nozzles, will miss the bucket. When the buckets are all in position, have the operator turn the sprayer on briefly. Do not allow the buckets to overflow. When a good sample is in each bucket, have the sprayer turned off.

Weigh each bucket containing the sample. Subtract the empty weight of each container from the gross weight, to get the net weight of the asphalt alone. There should not be more than a 10 percent variation above or below the average.

#### *Transverse Variation:*

District 23 is presently the only District in the State that carefully controls the transverse variation of asphalt. To ensure correct application, that District furnishes the Contractor with a set of nozzles that have been modified to give precisely-controlled fan widths and quantities of sprayed asphalt.

Nozzles with larger openings are installed in the spray bar over areas outside and between the wheel paths. Smaller aperture nozzles directly over the wheel paths dispense a smaller amount of asphalt.

This District has been using this technique for more than 10 years, and is pleased with the results. Although it takes more time and careful control must be exercised, a good amount of evidence is accumulating that these controls will prolong the life of the seal coat.

#### **HAUL TRUCKS:**

The aggregate have to be hauled from stockpiles to the spreader box. This is done by the Haul Trucks. The trucks used on nearly all seal coat work done in Texas are the enddump

variety. They are normally either single axle or tandem axle trucks, like the one shown in this photo.

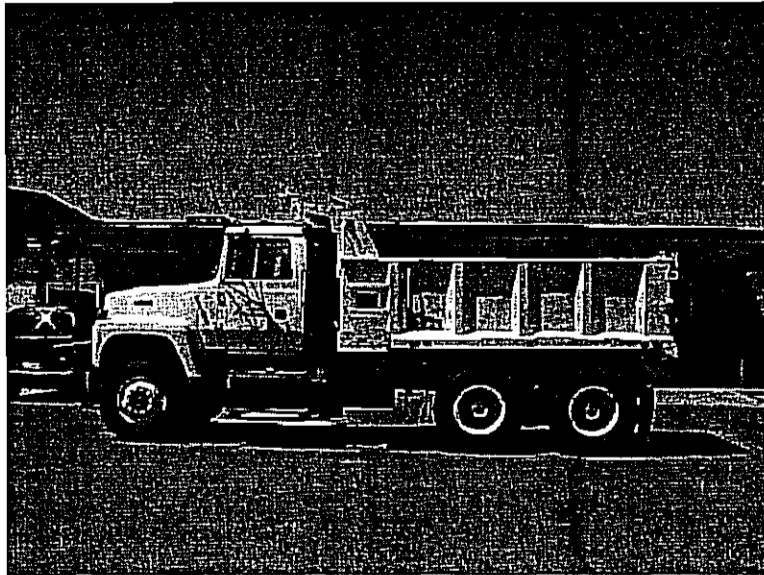


Figure 8: Haul Truck

All trucks used on a seal coat project should be in reasonably good mechanical condition. They should be free from leaking fuel, crankcase or transmission oil, engine coolant, and hydraulic fluid. Any of these fluids leaking onto a fresh seal coat would probably prevent proper bonding of the asphalt and aggregate.

All trucks must be legally registered to operate on the public highway and have appropriate safety equipment. All trucks must have a hoist mechanism to enable the bed to be raised in order to dump the load into the spreader box. The hoist mechanism should operate properly, and be free of hydraulic leaks.

The tailgate should be hinged at the top, and have the capability of being latched closed at the bottom. This prevents the aggregate from spilling out until the tailgate is unlatched. It should open smoothly when unlatched and the bed is raised. Every truck should be equipped with a hitch that matches the one on the spreader box. This is very important, since the spreader box tows the truck as the load is being emptied. If the hitch does not hold the truck and spreader together securely, it could ruin the whole project.

#### HAUL TRUCK INSPECTION:

Haul trucks used on a seal coat project do not have as many parts to inspect as does the asphalt distributor. The items that must be checked, however, are extremely important.

#### *Visual Inspection:*

All trucks to be used on a seal coat project must be checked visually for leaks. Remember that this is true of all equipment used on seal coat work.

Each truck must also have its own unique number permanently affixed where it is clearly visible.

*Identifying Data:*

The model and serial number of each truck may be recorded for entry in the project folder, along with the truck bed measurements.

*Bed Measurements:*

The measurements of the bed of each truck must be taken and converted to cubic yards. The requirement for these measurements comes from the aggregate being a pay item. The Contractor is paid for the number of cubic yards of aggregate actually placed on the roadway. Each truck is measured and the number of full loads is counted to arrive at the amount of aggregate the Contractor is paid for. Obviously, the measurements must be precise.

One important point to always remember is that all trucks used on the project must be the same size. Only in this way can you accurately compute the cubic yards of aggregate applied on the road. If the Contractor has an odd-sized truck, it cannot be used on the job. There is no one size that works best, as long as they are all the same.

The bed should be measured in feet and hundredths of feet. Begin by measuring the length of the inside of the truck bed, then measure width and depth. You then multiply the Length times Width times Depth. Divide the product by 27, the number of feet in one cubic yard (CY).

Here is an example:

The Dimensions of the Bed:

LENGTH=9.13'

WIDTH =6.17

HEIGHT =2.95'

$$9.13 \times 6.17 \times 2.95 = 166.18$$

$$166.18 / 27 = 6.15 \text{ CY}$$

*Deduction for Hoist Housing:*

Some trucks have the hoist mechanism recessed into the truck bed, with a housing in the bottom front of the bed.

If the trucks on the project have these, their area must be deducted from the total area of the truck bed.

#### *Acceptable Size:*

In our example, the capacity of the truck bed, 5.93 CY, is less than an even number of cubic yards, which is not acceptable. They should be an even number of cubic yards, or just over, such as 6.1 CY, 12.15 CY, etc.

To enable us to keep an accurate count of the number of cubic yards of aggregate the Contractor is paid for, the bed capacity must be expanded. The obvious way to accomplish this is to add side-boards.

By adding a standard "2 X 4" on top of the metal truck bed sides, the capacity is increased to 6.54 CY, but there should be an upper limit above the nearest whole yard. This would be acceptable as a 6 cubic yard truck. The addition of boards (2 X 4's or 2 X 6's) is common practice. It is acceptable as long as it does not permit the trucks to carry more than the gross vehicle weight established by law.

#### *Hoist:*

Always have the truck operator raise and lower the bed, so you can check the operation of the hoist. Visually check to see that it operates correctly, and check for hydraulic leaks as the hoist is in operation.

#### *Tailgate Release:*

As the bed is raised, check the locking mechanism on the tailgate. Make certain it locks securely when the bed is in the down position, and ensure that it unlocks smoothly as the bed begins to rise.

#### *Truck Hitch:*

Every truck must be equipped with a hitch that is compatible with the hitch on the aggregate spreader box. In most, if not all, cases this amounts to a bar-type hitch as seen in this photo.

### **AGGREGATE SPREADER:**

Another piece of equipment used in seal coat work, and one of primary concern to the Inspector, is the aggregate spreader. This is commonly called the "spreader box" and is used to distribute aggregate evenly over a film of asphalt being sprayed by the asphalt distributor.

The specifications require aggregate spreaders to be self-propelled and have a continuous feed feature. The photo below shows a typical aggregate spreader.

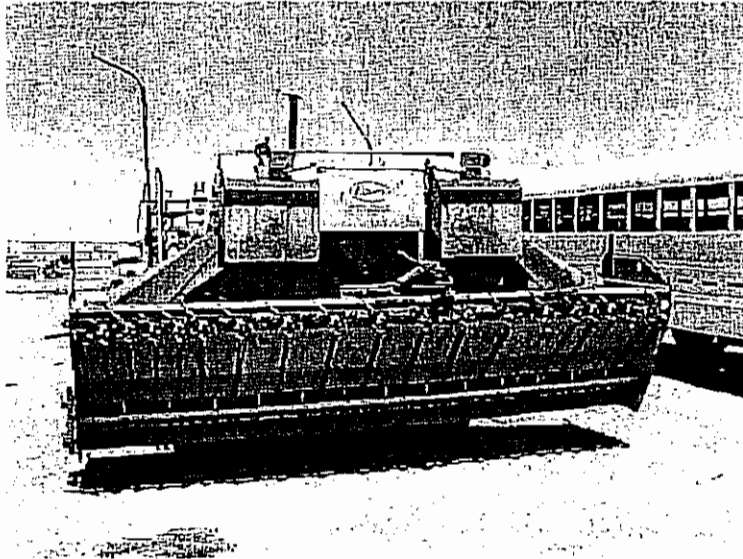


Figure 9: Aggregate Spreader

The spreader box receives aggregate from a haul truck, which dumps the aggregate into a receiving hopper at the rear of the spreader. A conveyor system transports the aggregate to another bin at the front of the vehicle. Gravity spreads the aggregate evenly across adjustable gates. The gates allow precise amounts of aggregate to pass through.

The major components that you should be familiar with are the:

- Truck hitch
- Receiving hopper
- Belt conveyors
- Spreading hopper
- Discharge gates
- Discharge roller

The spreader box must be able to distribute the aggregate evenly and uniformly over fresh asphalt. For a clear understanding of how this is done, let's look at each of the components.

#### TRUCK HITCH:

To be operated properly, the haul truck should back up to the spreader; a coupling on the spreader should engage one on the rear of the truck; the coupling should lock securely together; and the spreader box should pull the truck behind it. The truck should not push the spreader box.

This is very important, because the amount of aggregate covering the asphalt depends partially on the traveling speed of the spreader. Thus, to maintain a constant speed and ensure a uniform aggregate application rate, the spreader must regulate its own speed.

The hitch must be able to lock securely with the truck hitch, and the spreader box operator must be able to release the hitch easily and quickly.

This photo is of a typical spreader box truck hitch arrangement.

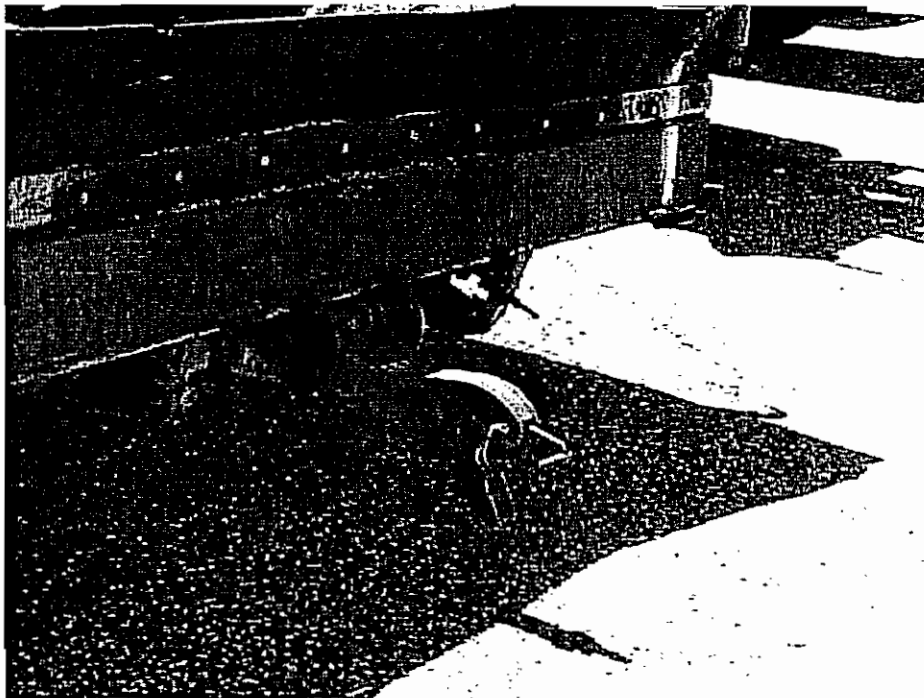


Figure 10: Truck Hitch

#### RECEIVING HOPPER:

After the truck has engaged the hitch on the spreader, the truck bed is raised and aggregate is dumped into the receiving hopper.



The receiving hopper is seen in this photo.



Figure 11: Receiving Hopper

Its only function is to receive the aggregate from the truck. At the bottom of the receiving hopper, there are openings through which the belt conveyors must pass in a continuous loop. You will note in the photo below, a rubber shield around the parts. This prevents aggregate from piling up on the belt, being carried ahead of the-receiving hopper and being spilled onto the ground. This shield must be in good condition to function properly.

#### BELT CONVEYORS:

There are two belt conveyors which transport the aggregate. These belts must be in good condition, and not frayed enough to allow aggregate to spill over the sides onto the roadway.

#### SPREADING HOPPER:

The spreading hopper receives the aggregate from the belt conveyors and distributes it laterally in the hopper. This is done by the aggregate falling over two angular (pyramid-shaped) devices at the top of the spreading hopper.

There is a scalping device, either a series of bars or a coarse mesh, to separate any large rocks, dirt clods, or weeds from the aggregate.

#### DISCHARGE GATE:

On the bottom of the discharge hopper are a series of discharge gates that can be opened by operator control, to discharge the aggregate. Each gate can also be opened or closed individually by levers located at the top and in the front of the discharge hopper.

#### DISCHARGE ROLLER:

A roller at the bottom of the discharge gates spins to assure an even flow of aggregate onto the asphalt. This roller ensures that an even amount of aggregate is spread laterally across the pavement. The roller must be straight, and not warped, in order for the aggregate to be distributed evenly.

#### DEFLECTOR SCREEN:

Some of the newer spreader boxes are equipped with an additional deflector screen under the discharge roller. It allows the normal-sized aggregate to drop through, but "kicks" large rock particles out in front. This is a good feature when using some of the coarser-graded aggregate, because the larger particles are pushed out in front and the finer particles placed on top. It will also enable undesirably large rock particles or dirt clods that have passed through the scalping screen to be separated. By being deflected out in front, there would be time to remove these particles before the rest of the aggregate covered them up.

#### AGGREGATE SPREADER INSPECTION:

Inspection of the aggregate spreader or "spreader box" must also be thorough. The spreader must distribute an even quantity of cover aggregate over the entire width and length of the lane or lanes being sealed. Not only must it be evenly spread, it must also be precisely the right amount. Only through careful inspection can we have a reasonable assurance that this will happen.

##### *Visual Inspection:*

Part of the visual inspection should be directed at the overall condition of the power train, primarily directed at detecting evidence of leaks in the engine and transmissions.

##### *Identifying Data:*

The manufacturer's name, spreader model number and serial number, may be recorded and kept in the project file.

### *Receiving Hopper:*

Visually check the receiving hopper for overall condition. There should be no holes or large gaps that would allow aggregate to fall through. The conveyor belt system should have rubber, neoprene, or fabric cowling (or flaps) around it to prevent aggregate loss. There should also be a flap on top of the receiving hopper to ensure a tight fit against haul trucks as the aggregate is being dumped into the receiving hopper.

### *Truck Hitch:*

Check the truck hitch visually, to look for anything broken or bent.

Pull up on the locking portion to ensure that it locks securely. Have the operator manipulate the release to be sure it will disengage the truck cleanly.

### *Conveyor Belts:*

Inspect the conveyors to ensure the belts are in good condition. Have the operator start the conveyors and demonstrate the speed control. The speed should be variable to ensure that the supply of aggregate reaching the front hopper can be increased or decreased as needed.

There should not be an excessive amount of slack in the belts; this will cause them to sag and you may lose some aggregate off the sides. If there is too much slack, the belts must be tightened.

### *Discharge Hopper:*

Visually check the front hopper to ensure that it is clean and does not contain any aggregate particles from a previous project. Check the scalping grate to ensure that it covers the entire top of the hopper. This grate performs the very important function of keeping large clay balls and other foreign matter out of the fresh asphalt binder. Also, check to be certain there are no holes or cracks in the hopper, where aggregate can fall through and cause a ridge or row of excess aggregate.

### *Discharge Gates:*

The discharge gates have control handles to enable the operators to open and close the gates individually. Check the operation of the manual controls to ensure that they function properly.

Also check to see that they are correctly adjusted to close the gates fully. You will not be able to judge whether the adjustment is correct when the gates are open, until the spreader is actually dispensing aggregate. There is another adjustment that increases or decreases the space between the gate and roller.

### *Discharge Roller:*

The steel discharge roller at the bottom of the hopper must be checked visually to ensure there is nothing caked on its surface. Also, using a stringline, check the roller for warpage.

When checking the roller, have another person assist you., Use a length of heavy twine string and have your assistant hold one end against the front of the roller. You hold the other end of the string against the opposite end of the roller, stretching it as tight as possible.

Sight down the string to the opposite end. The string should be in contact with the roller the entire distance. if the roller is warped, it will be readily apparent, because there will be a gap between the roller and string, or else the string will bulge under an outward warp.

Once you have checked the roller with a stringline, have the operator turn it on so you can check the end bearings for excessive wear. if they are badly worn, the roller will probably wobble, or you may be able to hear noise coming from the bearings as they turn.

#### *Discharge Hopper Exterior:*

Check the exterior of the discharge hopper, looking for damage. Occasionally, a spreader will be carelessly driven over a large rock or other object. Which damages the lower front corners. Damage of this sort may be critical, because the roller bearings are held in a casing in this section of the hopper. Damage can cause the roller to wobble, which will result in an uneven flow of aggregate.

#### *Wheels and Tires:*

With the spreader in motion, closely observe the wheels. Look for any indication of wheel wobble or excessive "toe-in" or "toe-out." This is important, because any of these conditions will tend to cause the tires to scuff the aggregate. Remember that the spreader box is the first vehicle to drive over the freshly laid aggregate. When the spreader's tires pass over the aggregate, the aggregate particles will still be in unarranged positions. Any scuffing by the spreader's tires may shove the aggregate sideways rather than straight downward. Scuffing will appear as a dark, ragged-looking strip. It could easily cause asphalt to be picked up on the tires of the pneumatic rollers.

Also, you should give the tires a visual check to detect any gouges that might adversely affect the aggregate arrangement. Gouges that may weaken the sidewall should be noted, as well. Don't take a chance on a spreader box tire having a blowout while in operation. it would be better to bring it to the Contractor's attention so he can have it changed before the project starts. Otherwise, he may be repairing a large section of ruined seal coat if a faulty tire were to blow out during operation.

#### *Brakes and Clutch:*

Have the operator stop and start the spreader a few times so you can check the operation of the clutch and brakes. Remember that the spreader box can ruin a seal coat 'ob as quickly as any other vehicle can.

## **ROLLERS:**

Once the asphalt has been sprayed and covered with a layer of aggregate, the seal coat must be rolled. This is done to orient the aggregate in its flattest dimension and seat it firmly into the asphalt binder. Rolling equipment is important to the final outcome of the project.

Numerous types of rollers are used throughout the State on seal coat and surface treatment projects. They are:

- Pneumatic tired rollers
- Steel-wheeled tandem rollers
- Single drum steel wheeled rollers
- Three-wheeled rollers

There is some difference of opinion on the use of rollers, from one District to another. Some Districts do not allow contractors to use steel-wheeled rollers at all; other Districts permit it.

The rationale behind not allowing steel-wheeled rollers is the belief that the flat, steel drum will tend to crush the aggregate on the high spots.

This would probably be true where the old pavement is rutted considerably, especially when light-weight aggregate is used. Another factor is that if the old pavement is rutted enough to cause the aggregate to be crushed on the high spots, it would probably not seat the aggregate firmly in the lower wheel paths.

Without being judgmental, we can safely say that on rutted or uneven pavement, a pneumatic roller will probably seat the aggregate better than a steel-wheeled roller can. However, if the old pavement is not rutted and unevenness is not a problem, then a steel-wheel will undoubtedly do an adequate job unless lightweight or soft aggregate is used.

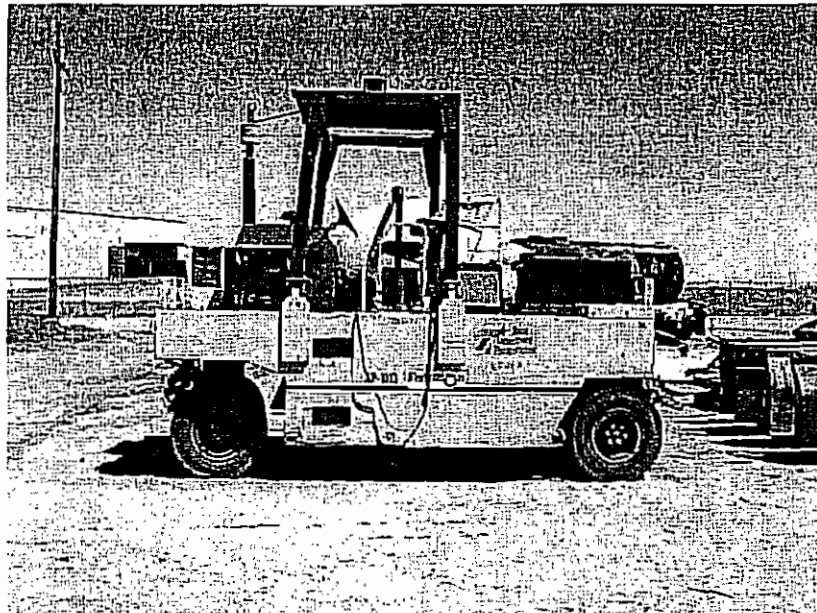
Steel-wheeled rollers are used in some Districts, we will also include a description of these machines. They are also used in conjunction with other types of surface treatments.

Any roller used on seal coat or surface treatment projects must be in acceptable mechanical condition and free of leaks.

### **PNEUMATIC TIRED ROLLERS:**

Pneumatic rollers operate on rubber air-inflated (pneumatic) tires. The tires, themselves, provide the forces needed to seat the aggregate firmly in the asphalt binder in a uniform arrangement.

This photo shows a pneumatic roller typical of those used in seal coat work.



*Figure 12: Pneumatic-Tired Roller*

The Standard Specifications Item 213.2(1) require that all pneumatic rollers used on seal coats and asphaltic surface treatments be self-propelled. They must also be capable of operating in both forward and reverse.

Many project plans will call for light pneumatic rollers, which are described in Standard Specifications Item 213.2(2). This Item requires that the roller be capable of ballast loading, to uniformly vary the total vehicle weight from 9,000 pounds or less to 18,000 pounds or more." Wet sand or aggregate may be used for ballast.

A more accurate measure of the forces exerted than the total vehicle weight, is the contact pressure exerted by each tire on the roller. Contact pressure is a function of the following combination of factors.

- Total vehicle weight
- Number of tires on the roller
- Tire size and ply rating
- Tire inflation pressure

Item 213.2(2) requires a minimum contact pressure of 45 pounds per square inch (PSI) of tire area, as a minimum All tires must be smooth surfaced.

Our specifications require that all tires be inflated so that there is no more than 5 pounds PSI variation from one tire to the next. We cannot overemphasize the importance of maintaining correct tire pressures. If one tire is soft, it will not seat the aggregate as firmly as the other tires, and this could result in the aggregate in that path stripping away under traffic.

*Number of Tires:*

Specifications require that light pneumatic rollers have a minimum of nine tires. Most are manufactured with 5 wheels on the front and 4 on the rear. The rear wheels are the drive wheels; the front are the steering mechanism.

*Area of Coverage:*

Light rollers are required to cover an area approximately 60 inches wide on each pass. The rear tires must be offset to provide coverage of the areas between the front wheels.

*Wheel Wobble:*

The wheels must not wobble when the roller is in operation. This would cause the aggregate to be displaced, and could ruin the whole seal coat job. If any wheel on any of the rollers can be seen wobbling, it is too much, and the roller should not be allowed on the project until it is repaired.

*Smooth Operation:*

All rollers must be capable of smooth operation, especially when turning, stopping, or starting. If the brakes or drive train are faulty and cause jerking or excessive vibration when the roller is stopped or started, it must not be allowed to continue operation. If one of the wheels is out of alignment, it may cause "scuffing" when the roller is turned. None of these conditions can be permitted on the job, since premature failure of the seal coat will almost certainly be the result.

*Free of Leaks:*

Like all other pieces of equipment on any construction project, rollers must not leak engine coolant, fuel, hydraulic fluid, or anything else that might contaminate the asphalt binder or aggregate. If any leaks are detected, the roller must immediately be removed from the fresh seal coat, or the whole project could be ruined.

*Medium Rollers:*

Medium pneumatic rollers may be used on some projects. The information given for light pneumatics is also true for medium-weight rollers, with the exception of the weight; number

of wheels; contact pressure; and width. Medium rollers must be capable of varying the weight, by adding ballast, from 23,500 pounds or less to 50,000 pounds or more." There must be no less than 7 wheels, with contact pressure specified at either 85 or 90 pounds PSI, depending on type. The effective rolling width must be approximately 84 inches.

#### STEEL-WHEELED ROLLER:

Steel-wheeled rollers, often called "flat-wheel," use a smooth-surfaced, cylindrical drum to exert compactive force. There are three types of steel-wheeled rollers used on seal coat and surface treatment projects:

- Single drum
- Two-axle tandem
- Three wheeled roller

This photo shows a typical steel-wheeled roller.

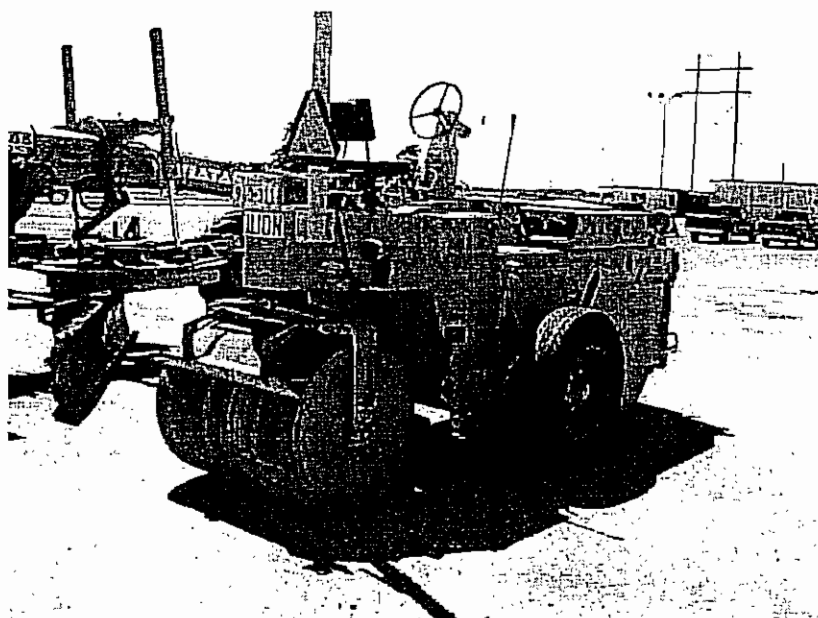


Figure 13: Steel-Wheeled Roller

Steel wheeled rollers used for surface treatments may not weigh less than 3 nor more than 6 tons. These are light rollers by comparison to the machines used for base courses or hot mix projects. It is not necessary to compact a seal coat or even a multiple-course surface treatment, in the same sense that a base course or hot mix overlay is compacted. If a heavier roller is used, it is quite probable that degradation (crushing) of the aggregate would occur, especially on a seal coat. If the aggregate did not break apart, it would probably be forced down into the old asphalt pavement, which would not be desirable, either. Particular attention must be paid to the maximum allowable weight, to ensure that a steel wheeled roller does not exceed 6 tons.



Like pneumatic rollers, steel-wheeled rollers must be self-propelled and must be capable of operating in both forward and reverse. All wheels must be flat and the surfaces of the drum and wheels must be free of gouges or pits. The drums and rear wheels must be free of any visible wobble or excessive vibration.

These machines use a steel drum as the compaction roller, and rubber pneumatic tires on the rear drive wheels. The front roller serves as the tiller (steering) roller on most models. The size of the front drum varies, but most models in this weight range have rollers from 4 to 5 feet in diameter and from 5 to 6 feet wide.

#### ROLLER INSPECTION:

The primary purpose of rollers in seal coat projects is to orient the cover aggregate particles in their "average least dimension.", This simply means to turn the particles to their lowest silhouette. By doing so, the surface texture of the cover aggregate is closed, or more simply arranged closer together. The condition of the rollers, however, determines how well they can do this job. Also, rollers must meet certain specifications to ensure they can do the job adequately, and to ensure that the new cover aggregate is not further degraded (crushed) in the process.

#### *Roller Types:*

We mentioned earlier that both pneumatic and steel-wheeled rollers are used in various parts of the State. Pneumatic rollers may be either light or medium, as permitted by Items 213.2 and 316.3. Of the Districts which locally permit the use of steel wheeled rollers, the majority (if not all) use steel wheeled rollers in conjunction with pneumatic rollers.

Since pneumatic rollers are used in just about all Districts, we will discuss the inspection of pneumatic-tired rollers first, and flat-wheeled rollers last. If your District does not permit the use of flat-wheeled rollers on seal coat projects, simply skip over those pages concerned with flat-wheeled rollers.

#### *Identifying Data:*

The manufacturer's name (or brand name), model number, and serial number of all rollers used on the project may be recorded and entered in the project folder. This applies to all types of rollers.

#### *Weight Certification:*

Sometimes it is not possible to determine from the manufacturer's specifications whether the rollers used on a project meet the Specifications in terms of weight. Manufacturers publish the gross weights of their product with water and wet sand maximum ballast. If either of these materials is used and the ballast tanks are full, the Inspector can safely certify whether or not it meets the weight requirements.

If, however, the Contractor uses another material, such as aggregate for ballast, it may be impossible for the inspector to determine with certainty whether the rollers meet the weight requirements or not. In this case, it would be wise and certainly justified to require the Contractor to have the rollers weighed. A weight ticket will be issued with a certified vehicle weight, and can be included in the project folder.

*Visual Inspection:*

All of the rollers to be used on the project should be given a thorough overall visual inspection. This visual check should include:

- Overall condition of the equipment.
- Presence of leaks of any kind.
- Smooth tires (no tread pattern).
- All tires the same sizes and ply rating.
- The rollers should start and stop smoothly.
- The roller must be self-propelled and operate in both forward and reverse.
- There should be no wheel wobble, since this will scuff the cover aggregate and require major repairs.
- Check tire stability on turns. If there is unusual scuffing, it may mean a bad bearing or king pin which might not be detectable when the roller is moving in a straight line.
- Roller tires should have no large gouges or chunks missing that would alter the contact pressure of the tire.

*Tire Pressure:*

Tire pressure is probably the most critical inspection point for pneumatic rollers. In the 1982 Standard Specifications (Item 213.2), a new requirement was added. The variation in the pressure cannot exceed 5 pounds per square inch (PSI) from one tire to another.

The correct tire pressure is a function of these variables.

- Gross operating vehicle weight.
- Number of wheels (either 7 or 9 are required for this class of roller. Most used on seal coats have 9).
- Tire size and ply.
- Required ground contact pressure, as specified in Item 213.2. For light pneumatic rollers contact pressure of 45 PSI is required. For medium (Type A), 80 is required; for medium (Type B), 90 PSI. These are the minimum amounts; higher contact pressures are allowed.

*Computation:*

Assume that you are inspecting a light pneumatic roller. You have a certified weight ticket showing the gross weight of the roller as 17,700 pounds. It is a nine-wheeled roller. The

tires are 7.50 X 15, 6 ply. Standard Specifications call for a minimum of 45 PSI contact pressure per wheel.

First divide the number of wheels into the gross vehicle weight, to determine the weight on each tire (wheel load).

$$\frac{17700}{9} = 1,967 \text{ lbs. wheel load}$$

Next, turn to the Pneumatic Tire Pressure Table. Look in the left-hand column which gives tire size and ply. Find the block which applies to 7.50 X 15, 6 ply tires. The next column gives wheel load. Since the blocks are broken down into 250 pound increments, the chart shows 1,750, then 2,000 pound wheel loads. Since the 1,750 block is less than the 1,967 pound wheel load on our roller, go to the 2,000 pound block.

The next column to the right is Inflation Pressure. Skip over this column and go to the one titled Contact Pressure. The Specifications call for a minimum of 45 PSI Contact Pressure. Again, there is a division of only 43 and 46 PSI, so you must use the higher number. Reading back to the left one column (Inflation Pressure), you find that 40 PSI is the minimum inflation pressure for the size tires used on our example roller.

#### *Checking Inflation Pressure:*

Have the roller operator check the inflation pressure of all tires on the roller, in your presence. Remember that there cannot be more than 5 PSI variation between any of the tires.

#### *Steel-Wheeled Rollers:*

If a steel-wheeled roller is used on the project, it must be inspected in the same manner as pneumatic rollers. The only difference is that a steel-wheeled roller must be inspected visually for excessive pits or gouges in the drums. Additionally, you must use a straightedge to check the roller drums to ensure constant and even contact pressure across the entire width of the drum. The drum or drums must also be checked for wobble on both straight paths and on turns.

### **ROTARY BROOM:**

Before asphalt is sprayed in a seal coat project, the roadway surface must be thoroughly cleaned. Power rotary brooms are used for this purpose.

This photo shows one of the power brooms commonly used:

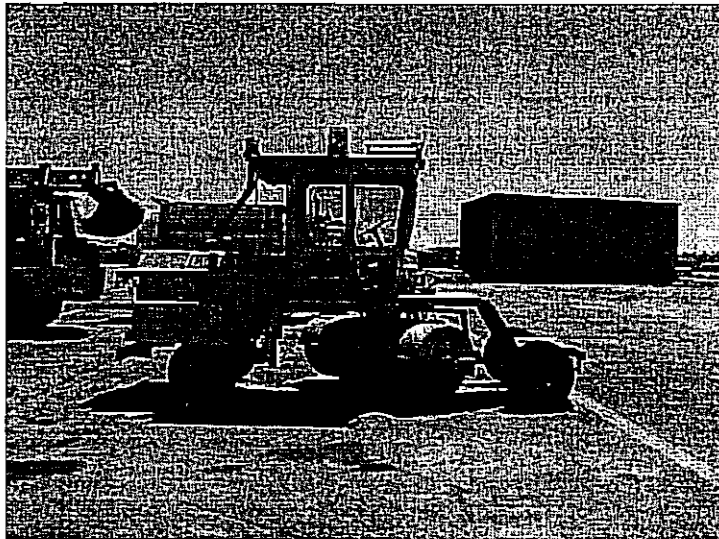


Figure 14: Rotary Broom

Most power brooms are self-propelled. They are powered by either a gasoline or diesel engine. Most are four wheeled, light vehicles capable of operating in both forward and reverse.

You may, however, encounter a power broom that is towed behind a pickup truck. Standard Specifications do not prohibit the use of this type of broom, but the project plans may. They are more awkward to maneuver, and the results are probably not as good as a self-propelled broom.

The rotary broom should be capable of being raised and lowered. This is usually done hydraulically on brooms manufactured in recent years. The bristles may be nylon or fiber. Some use a combination of nylon and steel bristles, which give excellent results. Our primary concern with the rotary broom is that the bristles are in good condition. They should not be excessively worn, or worn unevenly. Uneven wear may prevent thorough cleaning of part of the pavement surface. If it is excessively worn, it should be replaced.

The power broom should, as all equipment used on the project, be free of leaks. This includes crankcase oil, hydraulic fluid, engine coolant, and gearbox lubricant. Any of this material leaking onto the pavement will prevent the asphalt from bonding to the pavement surface.

## ROTARY BROOM INSPECTION:

One of the simplest pieces of equipment to inspect is the rotary broom. Yet, it is very important, because it must adequately clean the pavement before asphalt is shot. Unless this is done thoroughly, the asphalt will not stick to the pavement. Also, a finished seal coat will often be broomed to remove excess aggregate particles. This must be done without gouging out the aggregate that is bonded in place.

### *Identifying Data:*

As with other pieces of equipment, the manufacturer's name, model number, and serial number must be recorded and entered in the project folder. Many Districts have developed a form for this purpose, which includes a statement by the Inspector that the equipment was inspected and found acceptable for use on the project.

### *Visual Inspection:*

Visually check the power train and hydraulic lines and couplings for leaks. Give the broom an overall visual check for its general condition.

### *Safety Markings:*

The rotary broom, or sweeper as it is often called, operates well ahead of the rest of the equipment. This puts it in a very vulnerable position on many roads, due to traffic. If required on the project, safety markings, signs, and flags must be checked for the benefit of the motoring public as well as the sweeper operator.

### *Bristles:*

Check the bristles on the sweeper to ensure they are in good condition. Also, sight down the width of the brush to check for evenness. If the bristles are worn off unevenly, too much pressure will be exerted in one spot and the bristles may not even make contact in another. If there is a readily visible unevenness, the bristle assembly should be replaced.

### *Brush Controls:*

Check to ascertain that the brush can be raised and lowered and that it can be rotated from one angle to another. It should rotate fully from left-side to right-side discharge. Check also that the brush controls start it rotating and stop it properly.

## ASPHALT TRANSPORTER:

On some seal coat projects, it may be necessary to transport the asphalt a considerable distance from the heater unit or storage tanks to where it is being sprayed on the roadway. In Texas, it is not at all unusual to have seal coat projects of 20 to 30 miles. It would be

illogical for the asphalt distributor to return to the heater unit to refill after every shot. An asphalt transporter is usually used in these situations.

An asphalt transporter is simply a large truck mounted, insulated tank. It usually contains approximately 6,000 to 6,500 gallons of asphalt. It is equipped with a valve and hose system through which asphalt is pumped into and out of the tank.

Transporters do not contain any type of heater unit, nor do they have any spray capability. Their only purpose is to transport a large quantity of asphalt from the heater unit or storage tank, and fill up the asphalt distributors as close to where they are spraying as possible.

Asphalt transporters are used to carry various types of asphalt. Before one is used on a project, it should be completely drained and if necessary, cleaned. Although this is the contractor's responsibility, it has caused real problems on past projects. The wrong type of asphalt might have been shipped from the supplier, or contamination may have occurred from previous loads of different types of asphalt and the tank not completely emptied.

These are things that have happened. If a good inspector checks the manifest carefully, he or she can sometimes avoid a disaster. If there is evidence that something is wrong with the load, it must be rejected.

#### TRANSPORTER AND BOOSTER INSPECTION:

Transporters sometimes belong to the Contractor; sometimes to the petroleum company which supplies the asphalt to the Contractor; and sometimes to independent truckers. Booster tanks are not used on all jobs, but are frequently used on projects that cover 6 to 10 miles or more. This cuts down on the amount of time the distributor is tied up being refilled.

##### *Identifying Data:*

If the transporter and boosters belong to the Contractor, it would be safe to record the standard vehicle identification information and include it in the project file. This would also apply if the Contractor has leased the equipment.

If the transporter belongs to the petroleum company or to an independent trucker, it would be wise to jot down the company name and the truck license or other unique number. Although this may not be required, it is a good practice, in case there is a problem with the asphalt.

##### *Manifest:*

Check the transporter's manifest before it is unloaded to make certain the asphalt in the truck is the right type for the project. Unfortunately, some inspectors have found out too late that the wrong asphalt was pumped into the heater unit. once again, this is the Contractor's

responsibility, but it will delay the project and can be easily prevented. A copy of the manifest of each load of asphalt delivered on the job must be retained in the project folder.

#### *Cleanliness:*

If the transporter belongs to or is leased by the Contractor, it should be cleaned if a different type of asphalt was transported on a previous project. It is not usually possible for you to determine exactly what type of asphalt had been hauled previously, so a good rule of thumb is to be certain it is clean before it hauls asphalt to the current project.

#### *Contamination:*

Besides guarding against contamination from previous asphalts, you should ensure that the transporter tank and piping protect the asphalt from contamination during off-loading to the heater unit.

Sometimes a transporter is used as a booster tank on the job, transporting asphalt from the heater unit to where the distributors are operating. In this case the distributors are filled directly from the transporter. If asphalt cement (AC) is being shot on the project, it must be shot in the vicinity of 300' F. This would necessitate having an insulated transporter, in order to keep the asphalt hot between the heater unit and the distributor.

#### *Booster Tanks:*

On some jobs, booster tanks are used to refill the distributors close to where they are shooting the asphalt. These vehicles should be inspected for cleanliness; to guard against contamination; and have the identifying data recorded. Their piping and shut-off valves should be checked for leaks to guard against puddles of asphalt being left behind after they have refilled an asphalt distributor. This is especially important if the distributors are to be filled while parked on the pavement, which will be sealed.

#### *Insulation:*

Like the transporter, it may be necessary to ensure that booster tanks, if used to carry AC at high temperatures, are adequately insulated. Without proper insulation, the asphalt may cool enough to raise the viscosity above the limits for being pumped into the distributor, especially if there are any unexpected delays.

#### *Disposing of Excess Asphalt:*

A problem sometimes occurs with transporter drivers, especially when they do not work directly for the Contractor, and are being paid by the gallon shipped from the refinery. There may be as much as 150 or 200 gallons of asphalt remaining in their tank after the heater unit or storage tank has been filled. If they return to the refinery with this asphalt in their tank, it costs them money.

Some of the less considerate drivers have been known to pull over to the side of the road and dump the remaining asphalt on the right-of-way. If it is done outside the barricade area, the local police or Department of Public Safety patrolmen can and will ticket them for littering. To avoid getting a ticket, some drivers have pulled over to the side inside the barricade area, which is the Contractor's area, and dump their excess asphalt. This makes an incredible mess. You have limited power to prevent this from happening, but you should bring it to the Contractor's attention. Let the Contractor use his influence to stop this practice.

### **HEATER AND STORAGE UNIT:**

On most large projects, the contractor will set up a heater and storage unit. The asphalt is hauled from the source by truck and pumped into the heater and storage unit. When it is used, it is pumped either into another transporter or directly into the asphalt distributor.

There is no standard configuration for storage and heater units. They may be a single tank with heating and circulating equipment, or they may be an insulated tank and a separate heater unit with interconnecting piping. Storage capacity and size vary according to the needs of the project.

This photo shows one type of heater and storage unit together.

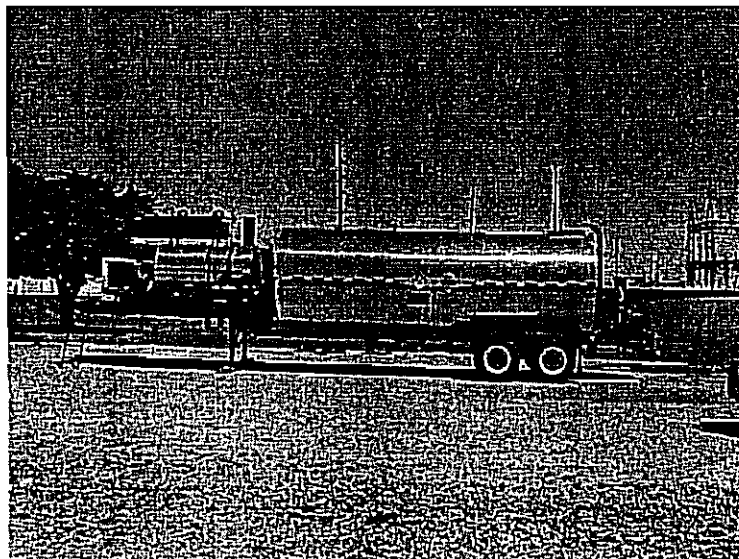


Figure 15: Heater and Storage Unit

Asphalt must be stored at specific temperatures, which are usually somewhat higher than the temperatures at which the asphalt is applied. The asphalts used in seal coat work are stored at the following approximate temperatures:



- Asphalt cement - 325<sup>o</sup>- 400<sup>o</sup>F,
- Cutback asphalt - 150<sup>o</sup> - 200<sup>o</sup>F
- Emulsions - 150<sup>o</sup> - 170<sup>o</sup>F

The higher temperatures are the maximum allowable storage and heating temperatures. In order for these asphalts to be sprayed properly, with the desired results, the temperature must be closely controlled in order to maintain the correct viscosity for spraying. The heater unit operator must clearly understand the importance of his job in terms of the viscosity temperature relationship. So that the temperature of the asphalt may be closely monitored, the heating and storage unit must be equipped with a continuous recording thermometer. The operator must also be aware of the flash point of whatever type of asphalt is being used. It is his responsibility to ensure that all necessary safety precautions are taken, but this can never be assumed. This point is especially critical with cutback asphalts. As an example, RC-250 has a flash point of 80<sup>o</sup>F.

As you can see, with this type of asphalt, you are well into the danger range any time that you work with it. Besides the danger of fire, there is an additional danger around the heater and storage unit, especially if you're using asphalt cement. Storage tanks, pipes, and valves are extremely hot. Adequate safety precautions should be taken to insulate any part that might be touched, but don't take chances.

Extreme care must be taken if you are required to take a sample. Getting splattered with 350<sup>o</sup>F asphalt is no laughing matter. Wear proper safety equipment and clothing, but above all, be careful. The heater and storage unit must be assembled and maintained in good condition and kept clean. All components of the unit must assist in preventing the contamination of the asphalt. Contaminants might include water, dirt, or fluids such as fuel, which would ruin many gallons of asphalt.

#### HEATER UNIT INSPECTION:

The heater and storage unit, usually called a "heater unit," is inspected at the beginning of a project, along with the other equipment. Quite often, the Contractor has manufactured his own heater unit, so there may or may not be any identifying data. The only numbers on the equipment may be an engine serial number on the pump unit.

#### *Storage Tank:*

The storage tank must be inspected for cleanliness and the presence of any condition which would permit contamination of the asphalt. There should be a continuous-recording thermometer on the tank, which records any and all fluctuations in asphalt temperature.

#### *Heater:*

In some cases, the heater unit is a part of the storage tank. In others, it is a separate unit, consisting of a smaller tank with pump and heater. Regardless of the system used, the heater unit must be inspected.

It should have a burner that can be regulated to alter the intensity of heat. The burner should direct the flame into flues, similar to the arrangement in an asphalt distributor. The pump should circulate the asphalt through the heater unit sufficiently to prevent the asphalt from burning next to the flues and from sticking (from cooling) near the outside of the tank.

#### *Pump Unit:*

The pump unit should be checked for proper operation, but your primary concern is to ensure that the pump and associated piping protects the asphalt from contamination. It should be assembled so that no dirt or fuel can enter the piping or pump unit.

#### *Location:*

Although the location of the heater unit is the Contractor's responsibility, you should consider the location of the unit from the standpoint of safety for the motorists. The Contractor may situate the pump unit where it is most convenient for his distributor or booster tank drivers, and may overlook the safety of motorists using the road.

The heater unit will have transporters moving to and from it, as well as asphalt distributors or boosters pulling onto and off the highway in the vicinity of the heater. This traffic must be clearly visible to motorists driving through the construction area. Therefore, it should not be situated on or near blind curves, and probably well clear of intersections.

If the heater unit is situated in the vicinity of the aggregate stockpile, it should be separated far enough away to ensure that no contamination of the aggregate occurs. Asphalt is often spilled around heater units, so it is best that the heater be situated well away from aggregate stockpiles, if possible.

#### *Recording Thermometer:*

When the project begins, the inspector must pick up the record card from the continuous recording thermometer each day. A new card is installed when the old one is removed.

### **EQUIPMENT PERFORMANCE:**

Three of the equipments discussed above determine the sustained production of the seal coat system. These are the asphalt distributor, the spreader, and the rollers. To achieve maximum sustained production, the production rates of the spreader and the rollers must be greater than that of the distributor. The distributor controls the overall production because no other piece of equipment can begin to produce its function until the distributor has applied the binder to the surface. Therefore, to ensure a high standard of quality control, all other equipment systems must be able to keep up with the production of the distributor. Observations in the field confirm that the distributor sets the pace for the rest of the

equipment spread. If one link's production rate is inherently less than that of the distributor, it will be forced to keep up at the expense of quality.

The rollers may not be spending the specified amount of rolling time on each shot since their primary objective would be to keep up with the distributor. General notes varied on the required amount of rolling time from a high of 1000 square yards per hour to a low of 5000 square yards per hour. The number of rollers in a specific project becomes a critical quality parameter. If the number of rollers that will attain the rollers to keep up with distributor and still spend the specified amount of rolling time on each shot were calculated, this problem would be solved.

Here is an analysis done to calculate the number of rollers needed in a shot. Average equipment spread contained three medium pneumatic rollers. Using an equipment data sheet for a Dynapac Model CP132 nine-wheel roller that is approved by TxDOT as an acceptable medium pneumatic roller, the effective width of the roller is found to be 69.3 inches. Assuming that the critical shot width is that of a standard 12-foot lane, the following analysis was conducted to calculate the production rate comparison between the distributor and the roller fleet.

In this analysis production rates of the aggregate spreader and binder sprayer are taken to be equal as observed in practice. Therefore, the combined production rate of the system is expressed as the sprayer production rate. If there is a stipulated minimum rolling time requirement in a seal coat project, the rollers are observed to be lagging behind the asphalt distributor and aggregate spreader. When the equipment spread moves up to the next shot the rollers catch up, and fail to provide the minimum rolling time called for in the contract. The computations below prove that rollers cannot keep up with the distributor under the mentioned assumptions. Figure 42 shows the plan view of a roadway section to be seal coated. The roadway is a two-lane highway with the dimensions described.

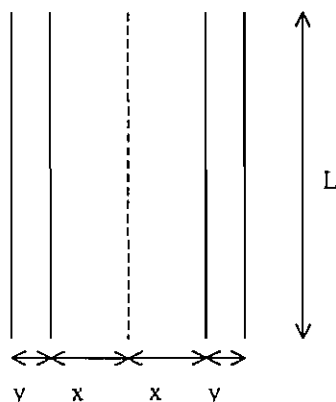


Figure 16: Typical Seal Coat Roadway Geometry

Where  $x$  = lane width  
 $y$  = shoulder width  
 $L$  = length of the seal coat shot

Given the required rolling time of 1 hour per a specified area of A, rolling time of each roller, t, for a calculated length of shot length, L (see Equation 1), can be found to depend on the application width, x, as shown in Equation 2.  $V_r$  is the roller speed. Rollers have dual gears that in practice limit the roller speed to only two values. The rolling time requirement implies that some minimum number of rollers traveling at a fixed speed must be present to meet the minimum rolling time criteria.

$$A = xL \quad \text{Eq. 1}$$

$$t = \frac{L}{V_r} \quad \text{Eq. 2}$$

Knowing the rolling time spent by a roller to travel a distance of L at the traveling speed of  $V_r$ , the total time spent by all rollers per each pass, T (the rolling time), can be calculated by simply multiplying the rolling time for one roller, t, by the number of rollers, N, that are utilized in the rolling process (Equation 3).

$$T = tN \quad \text{Eq. 3}$$

The required number of passes, NP will be easily calculated once the time spent by all of the rollers per one pass is determined from Equation 3. This calculation is formulated in Equation 4. 1 hour is divided by T to obtain necessary passes required by N number of rollers.

$$NP = \frac{H}{T} \quad \text{Eq. 4}$$

Where: H is normally taken to be 1 hour as in 1 hour per 5000 yd<sup>2</sup> rolling time.

Production rate of the rollers,  $P_r$ , can be defined as the linear mile of seal coat section rolled per hour. This will be a function of the passes made by the rollers as shown in Equation 5.

$$P_r = \frac{V_r}{NP} \quad \text{Eq. 5}$$

By algebraically combining Equations 1, 2, 3, 4, and 5, the roller production rate,  $P_r$ , can be expressed as a function of the number of rollers, N, as shown in Equation 6.

$$\text{From Eq. 5} \quad P_r = \frac{V_r}{NP} \quad \text{and} \quad \text{Eq. 4} \quad NP = \frac{H}{T}$$

$$P_r = \frac{V_r T}{H} \quad \text{and} \quad \text{Eq. 3} \quad T = tN$$

$$P_r = \frac{V_r t N}{H} \quad \text{and} \quad \text{Eq.2} \quad t = \frac{L}{V_r}$$

$$P_r = \frac{V_r L N}{H V_r} = \frac{L N}{H} \quad \text{and} \quad \text{Eq.1} \quad L = \frac{A}{x}$$

$$P_r = \frac{A N}{x H} \quad \text{Eq. 6}$$

### Distributor Speed ( $S_f$ ) (ft/min)

Distributor speed for the desired asphalt rate can be calculated from Equation 7. Spray bar output is dependent on the type of the binder sprayer used. R is the width of the shot and is used interchangeably with x value in this calculation as  $x = R$ .

$$S_f = \frac{9G_t}{WR} \quad \text{Eq. 7}$$

Where  $G_t$  = spray bar output (gal/min)

W = sprayed width (ft)

R = rate of binder application (gal/sy)

Distributor speed,  $S_f$ , can be modeled as the distributor production rate if production is considered to be a function of lineal miles per hour. This works well for matching the roller production rates to compute system production. In practice, the distributor controls the production of all other components of the system. Therefore, to ensure that quality control is maintained, both the chip spreader's production and the roller fleet production must be greater than or equal to the production of the distributor. If this is not the case, either the distributor will have to reduce its production or the other equipment will not be able to produce the required level of quality. Observations in the field confirm that the distributor actually sets the pace for the entire system.

For seal coat projects, the asphalt distributor is the controlling piece. To maximize system production, the production rate of all other links in the equipment system had to be greater than or equal to the production of the controlling piece. The relationship for production of the rollers with respect to the production of the distributor can be expressed as Equation 8.

- $P_r \geq P_D$  Eq. 8

- If the system production is defined in terms of lineal miles per hour, distributor production,  $P_D$ , equals distributor speed,  $S_f$ . It should be noted that the production rates shown in Equation 8 are instantaneous production. In other words, this is an ideal

condition for both the distributor and the roller. Using instantaneous production as the parameter of comparison yields a conservative solution by ensuring that the “best” production of the roller is greater than or equal to the “best” production of the distributor.

### A Case Study for Required No. of Rollers:

The following case study exemplifies the above equations, in accordance to the practical values for each variable. The following assumptions are made:

Dynapac CP 132 type roller is selected. The roller has two gears that enables one lower and one higher speed of 6.2mph and 12.4 mph, respectively. The width of the roller is 69.3 inches. The lower speed of 6.2 mph is used in the calculations because it reduces the number of rollers needed to meet the minimum rolling time requirement.

$$V_r = 6.2 \text{ mph}$$

The roadway geometry is as follows.

$$x = 12 \text{ ft.}$$

$$y = 10 \text{ ft.}$$

A minimum 1 hr of rolling time is required per 5000 square yards. This value the least restrictive rolling time requirement found on TxDOT general notes for actual projects surveyed in this study. In practice, this value tends to be the maximum area per 1 hour rolling time. This makes the following analysis more conservative.

Number of rollers used in the rolling process is taken to be three reflecting common practice.

The production rate of binder sprayer is calculated with the assumption of 90 gal/min value for the  $G_1$  parameter.

Rate of binder application is selected to be 0.33 gal/sy.

$$A = xL$$

$$L = \frac{5000}{4}$$

$$L = 1250 \text{ yd.}$$

$$t = \frac{L}{V_r}$$

$$t = \frac{1250(yd)}{6.2(mph)1760 \frac{yd}{mile}}$$

$$t = 0.115 \text{ hr.}$$

$$T = tN$$

$$T = (0.115)(3)$$

$$T = 0.345 \text{ hr.}$$

$$NP = \frac{H}{T}$$

$$NP = \frac{1(hr)}{0.345(hr)}$$

NP = 2.17 passes; therefore NP = 3 because you must have an odd number of complete passes

$$P_r = \frac{V_r}{NP}$$

$$P_r = \frac{6.2}{3}$$

$$P_r = 2.07 \text{ lineal miles per hour}$$

Hence the production rate rollers, rolling a seal coat section of 12 feet wide is calculated as 2.07 linear miles per hour. It should be noted that, at this production rate 3 rollers making 3 passes on the sealed section will realize the required 1 hour of rolling time per 5000 square yards of surface area. Knowing this, the production rate of the distributor can be calculated as shown below.

$$S_f = \frac{9G_t}{WR}$$

$$S_f = \frac{(9)(90)}{(12)(0.33)}$$

$$S_f = 2.33 \text{ lineal mile per hour}$$

$$P_r < S_f$$

$$2.07 < 2.33$$

If we take equation 11 and isolate the number of rollers, N, and use the distributor production rate as the minimum required production of the rollers, N becomes the required number of rollers to achieve the distributor's production.

$$N = \frac{P_x}{A} = \frac{2.33 \text{ lmp/h} (4 \text{ yd}) (1760 \text{ yd/mi})}{5000 \text{ yd}^2/\text{hr}} = 3.28 \text{ rollers} \Rightarrow 4 \text{ rollers}$$

Thus, four rollers would be required to keep up with the distributor. The production rate of three medium pneumatic rollers is less than the production rate of the distributor (both are expressed in linear miles per hour of a 12-ft seal coat section). The comparison of the roller production rate,  $P_r$ , and distributor production rate,  $S_f$ , reveals that three rollers should lag behind the distributor since it has a higher production rate. This situation will be observed if the rollers strictly travel at 6.2 mph in order to comply with the required rolling requirement. On the other hand, rollers may accelerate to keep up with the distributor by shifting to the higher gear. However, this means the minimum rolling time criteria is violated and adequate aggregate embedment is not achieved. This will possibly cause loss of aggregate due to inadequate rolling.

Looking at this production mismatch in another manner, every hour the rollers should fall behind the distributor by about a quarter mile. At the end of a typical 12 hour day, the rollers should be three miles behind the rest of the equipment if they are strictly adhering to the rolling time requirement, and they would have to continue to roll for another hour and a half before they could shut down for the night. Obviously, this is not happening in the field. The rollers are expected to keep up with the distributor, and the distributor is allowed to achieve its maximum sustained production.

The other equipment production match that could potentially cause quality control problems is the dump truck/chip spreader relationship. As the chip spreader generally follows the distributor, its production can easily match the distributor's if sufficient trucks are available to feed it. If there are not enough trucks, the chip spreader will lag the distributor allowing the binder to cool before application of aggregate and potential shelling due to lack of sufficient adhesion between the aggregate and the binder. The required number of trucks to maintain maximum sustained production can be calculated as follows.

*Length of Shot,  $L_A$  (TTI, 1981)*



Length of a seal coat shot is a function of the binder sprayer capacity, T, width of the lane, W, and the design asphalt application rate, R. Equation 9 gives the shot length.

$$L_A = \frac{9T}{WR} \quad \text{Eq. 9}$$

*Aggregate Spreading (Rock Land), L<sub>R</sub> (TTI, 1981)*

To check the aggregate application rates rock lands are calculated in practice. The length of the seal coat section spread by a single truck load is a function of the truck capacity, Q, aggregate spread rate, S, and lane width, W, as expressed in Equation 10.

$$L_R = \frac{9QS}{W} \quad \text{Eq. 10}$$

Where Q = truck capacity (cy)

S = spread rate (sy/cy)

#### *A Case Study for Required No. of Trucks for a Shot:*

The length of the seal coat shot is dependent on capacity of the asphalt distributor rather than the aggregate truck capacity. All asphalt in the distributor is sprayed (some is left in the distributor to avoid mechanical problems) and enough aggregate is spread over to cover all the sprayed asphalt. Therefore, when number of required trucks to cover a given amount of sprayed asphalt is being calculated (Equation 11), the resulting decimal number of trucks is rounded to the next greater integer. This means, unless the shot is the last shot of the project, the left over aggregate in the truck is used with the asphalt sprayed from the following distributor. If the shot is the last shot, then some amount of rock is put in the last truck just enough to cover the remaining asphalt in the sprayer.

$$NT = \frac{L_A}{L_R} \quad \text{Eq.11}$$

The figure simplifies the model established for the calculation of the adequate number of trucks in a seal coat project. The scheme model is designed to be repeating itself along the roadway section that is sealed. Aggregate stockpile is located at the beginning of the section with the capacity that can serve the number of trucks used. At the beginning of the work all trucks wait loaded with rock with an equal separation of Rock Land distance, L<sub>R</sub>. Each truck (from 1 to 5 in Figure 2) returns to the stockpile as soon as it unloads its rock load. Each successor truck has to travel farther than the preceding truck as the construction proceeds. On the other hand as the number of trucks increase, the maximum time that a truck should spend on the way (from the time it unloads till it reaches its new location where the distributor needs it) increases to the favor of the truck. This varying distance traveled by each truck, X<sub>i</sub>, is calculated in Equation 12.

$$X_i = NTL_R + (2i - 1)L_R$$

Eq. 12

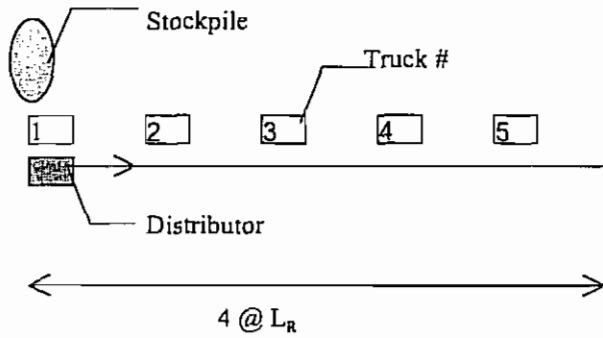


Figure 17: Layout of Typical Shot

Time elapses between a truck unload its rock load and the distributor needs the truck again,  $T_{\max}$ , can be calculated from Equation 13. As shown in Equation 13, this value is a function of the number of trucks, rock land, and production rate of distributor (lineal distributor speed).

$$T_{\max} = \frac{(NT - 1)L_R}{S_f} \quad \text{Eq. 13}$$

For a seal coat production without any interruption, travel time of each truck plus its loading time,  $T_{\text{loading}}$ , at the stockpile should be less than or equal to  $T_{\max}$  as expressed in Equation 14. From Equation 11 one can see that the last truck in the line travels the longest path. Hence, Equation 14 is directly calculated for the last truck,  $X_{NT}$  being the most critical distance to be traveled. Travel speed of the truck to the stockpile and from the stockpile is shown with  $V_{tr}$  in the following equation.

$$T_{\max} \geq \frac{X_{NT}}{V_{tr}} + T_{\text{loading}} \quad \text{Eq. 14}$$

From the substitution of Equation 12 into Equation 14, number of trucks,  $NT_{\min}$ , can be solved from Equation 15. Hence, the maximum number of trucks is a function of truck speed, distributor production rate, rock land, and loading time of the truck at the stockpile. It should be noted that constant loading time is assumed for every level of truck number, which is valid, if the bucket loader capacity at the stockpile allows that.

$$NT_{\min} = \frac{L_R(V_{tr} - S_f) + T_{\text{loading}}(S_f)(V_{tr})}{L_R(V_{tr} - 3S_f)} \quad \text{Eq. 15}$$

These equations can be used to ensure that quality control is not sacrificed through a lack of equipment on site. The rule that must be remembered is that all equipment must have the

ability to equal or exceed the sustained production of the distributor. Field observations show that insufficient dump trucks are not a common problem. However, as shots get farther from the stockpile, the required number of trucks increases. Therefore, it behooves inspection personnel to check to see if the trucks are able to adequately feed the chip spreader.

#### *Roller Patterns:*

The above analysis showed that a minimum of four medium rollers were required to match the distributor's production rate if the rolling time requirement was 1 hour/5000 square yards. This leads us to a discussion of rolling patterns. The structured interview showed that the most common number of medium rollers was three. The pattern was described as a staggered pattern with one roller on the centerline, one roller on the outside edge, and the third bringing up the center. Using the Dynpac CP132 from the previous examples, the resultant roller pattern for three rollers in a staggered formation is shown in Figure 44. One can see that there are three areas that only receive three passes. Two are roughly 37 inches wide on the outsides of the lane and the third is about five inches wide between the wheel paths. The area where the wheel paths lie receives six passes. Observations at the test sections show that shelling is most prevalent between and out side of the wheel paths.

Additionally, when one considers the staggered pattern, the first two rollers will tend to work excess aggregate to the center where the third roller flattens it out. This further encourages shelling between the wheel paths by accumulating a greater quantity of aggregate in a smaller area discouraging full embedment. On the other hand, a diagonal roller pattern working from the centerline outwards will work excess aggregate toward the shoulder of the road, and thus, should keep shelling between the wheel paths due to an accumulation of excess aggregate to a minimum.

As four rollers are required to achieve required production rates, it is interesting to see the change in roller coverage. Figure 45 shows that by carefully stationing the four rollers, the coverage can be dramatically increased. In fact, it can be made by six uniform passes virtually across the entire width of the lane. It only drops to three passes for two 5.4-inch strips at the centerline and the outside edge of pavement. Thus, not only does the addition of a roller increase the probability that sufficient rolling time will be achieved without a loss of distributor production, but it also produces a superior roller pattern which virtually doubles the average number of passes across the width of the section. Analysis is ongoing to determine if shelling problems are less in those districts that require four rollers.

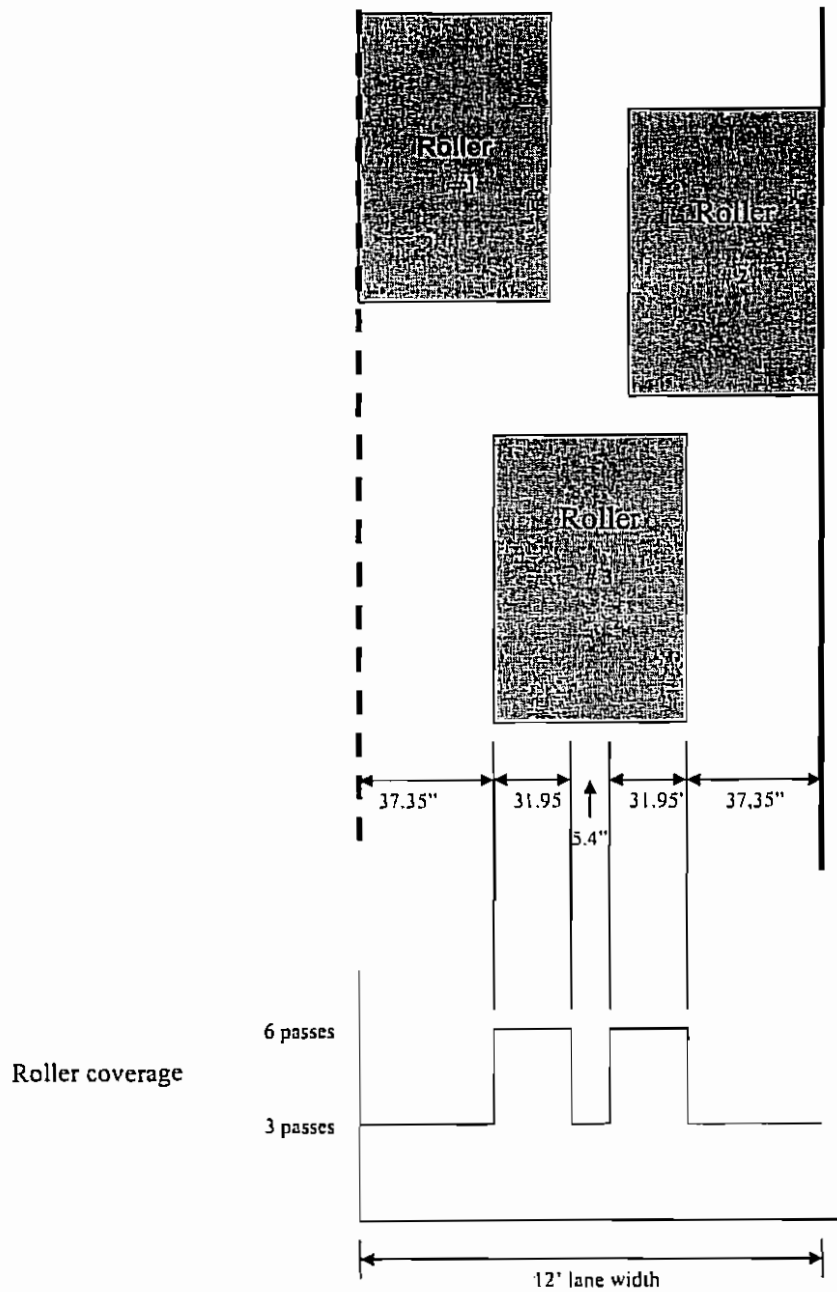


Figure 18: Staggered Pattern and Coverage for Three Medium Rollers

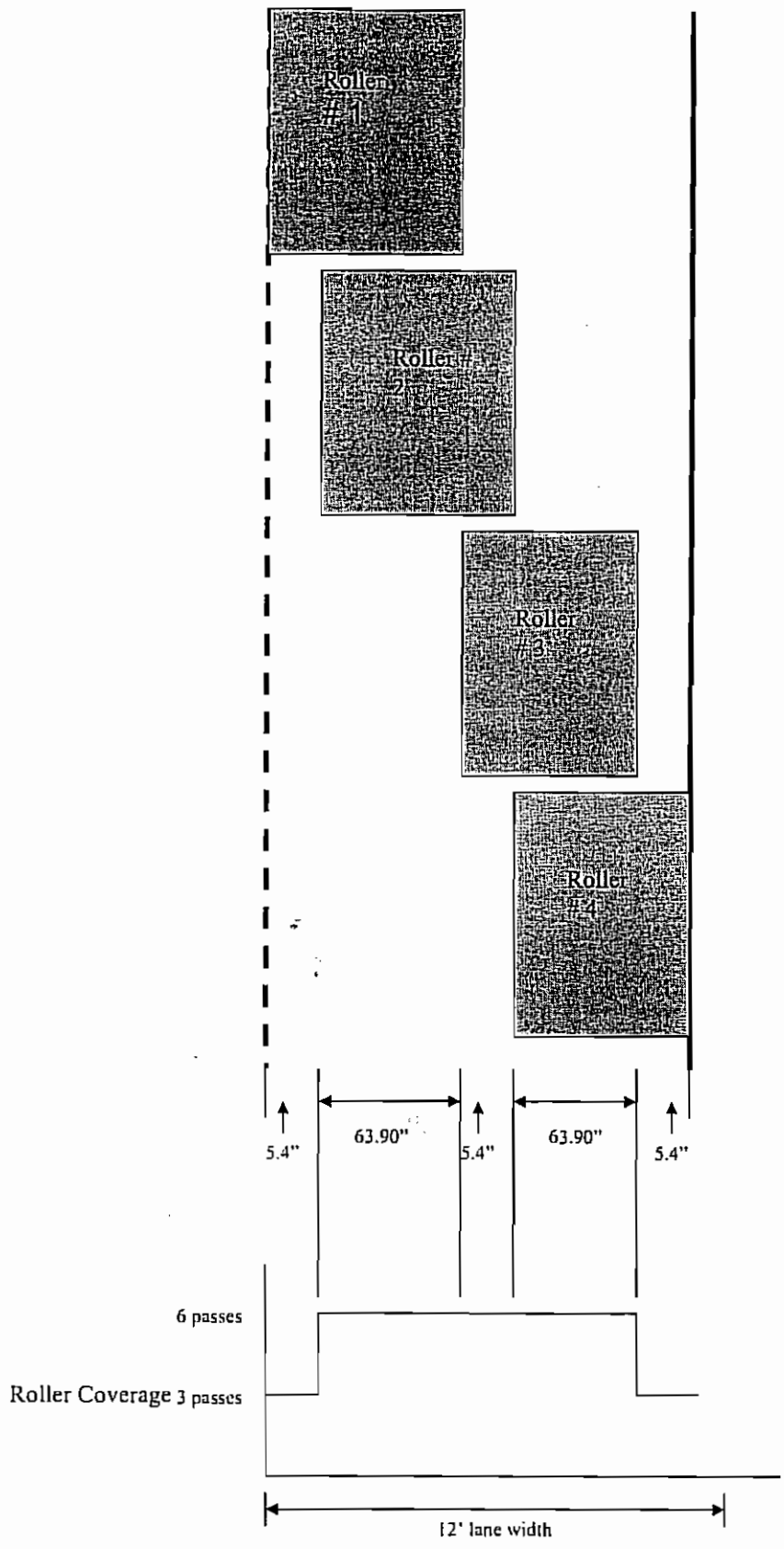


Figure 19: Roller Pattern and Coverage for Four Medium Rollers

The preceding analysis on rolling clearly presents how important it is to specify a minimum number of rollers in order to attain the required production level with the desired seal coat quality. If roller numbers are not specified, then either the rollers may lag the distributor in order to attain the desired rolling time or for the sake of keeping up with the distributors, they roll less amount of time on the roadway section.

Rolling is particularly important because it ensures the seating of the aggregate in place. It is evident that shelling is observed in the regions where aggregate embedment is poor such as between the wheel paths where rolling effort is lesser. With the diagrams that show three and four roller coverage, it was delineated that four lightweight rollers produce a more uniform rolling effort distribution across the lane. The use of four rollers give twice as much rolling than the use of three rollers as depicted in Figures 44 and 45.

Therefore, the district personnel, in order not to sacrifice from quality and production rate, should calculate equipment requirements such as minimum number of rollers and aggregate trucks. This can be easily handled during pre-construction meeting in close coordination with the contractor.

### **SEAL COAT APPLICATION:**

After all plans have been finalized; the aggregate stockpiled; the preconstruction meeting held; and the equipment assembled and inspected; the next major aspect Of the project is to apply the seal coat on the roadway.

In order for the seal coat to be applied as planned, it usually requires three good Inspectors who "stay on top of" every part of the seal coat operation. The application of the seal coat is a fast-paced process, and requires totally alert Inspectors to ensure that it is done properly. The Inspectors must work together as a tightly-knit team, because it is so difficult to catch every detail. If one inspect-or misses a detail one of the others must pick it up. Communications and coordination must be excellent. And on top of it all, the days are long, hot, and tiring. This is one of the most difficult jobs a State Inspector can have.

### **WEATHER:**

Weather plays an extremely important role in seal coat operations. There are many things that can happen with a sudden change of weather, most of which are undesirable in seal coat work.

The ideal conditions for applying a seal coat are hot temperatures with relatively low humidity, and little or no wind. This is a difficult order to fill in many parts of the State. There are, however, periods when weather patterns are more likely to follow these

requirements than at other times. For most parts of the State, the period from June through September tends to be the best time for seal coat work. Too early in the spring or too late in the Fall brings temperature and wind problems. Always check the extended forecast.

Our Standard Specifications require that seal coats be applied when the roadway surface is 60° F or higher. During the summer months, roadway temperatures are commonly 100° F or higher by 9:00 or 10:00 A.M. In most cases, temperature is not a major problem. You must, however, record the surface temperature every morning before any asphalt is shot. This is done by placing a surface-type dial thermometer on the roadway.

The temperature reading should be taken under conditions which are as typical as possible of those under which the asphalt will be shot.

#### HUMIDITY:

It is best if the humidity is 50 percent or lower when the asphalt is shot, especially if you are shooting emulsions. With any asphalt, however, the lower the humidity, the better. High humidity will cause an invisible film of moisture to collect on the roadway surface, which can only detract from the asphalt sticking properly to the surface. With emulsified asphalts, the emulsion will be slower breaking in high humidity. With asphalt cement (AC), which is shot at much higher temperatures than emulsions, you will see steam rising in a thick cloud as the hot asphalt hits the moisture on the roadway. Some of this steam is trapped under the asphalt. You will often see small bubbles forming and breaking as the air and moisture works its way to the asphalt surface.

#### WIND:

Wind may work partially in your favor and against you at the same time. A gentle wind, if it is constant in speed and direction, can help to cool AC or help to break the emulsion sooner, if you are shooting that type asphalt. In either case, it will generally allow you to apply the cover aggregate closer behind the asphalt distributor. This can reduce some of the potential for problems that usually comes when the distributor gets far ahead. The farther ahead the distributor gets, the higher the chance of traffic crossing the fresh asphalt, which always seems to happen. On the other hand, if the wind is too strong, it causes problems. It will distort the fan pattern as the asphalt is forced, under pressure, out of the spray nozzles. This may cause streaking and uneven distribution. Many contractors install a piece of wide conveyor belting material in front of the spray bar to cut down the wind effects on the spray pattern. This helps somewhat, but does not totally eliminate the problem.

Wind always tends to help "decorate" passing automobiles with asphalt specks. You have to be very careful of wind direction especially when spraying AC with Latex. It is a very sticky substance, and as it is sprayed, small "cobwebs" of the mixture are blown around. They are almost invisible until they land on a light-colored automobile, at which time they become very obvious.



Wind may, in fact, force a change in plans, as to which lane is shot first, and the direction of work, in order to minimize the effects of blowing asphalt.

#### **RAIN:**

It is probably safe to say that asphalt should never be shot during rain. If rains are in the vicinity and predicted for the area, you probably should suspend operations until it clears. It is better to be safe than to have 12,000 square yards washed off the road into the ditch.

Sudden, unexpected showers are common. Sometimes they appear with no hint of rain and pass very quickly. In this case, it is probably wise to shut off the asphalt distributor immediately, and wait until the shower is gone and the pavement dries. But it is usually best to continue operation of the aggregate spreader until the asphalt already shot is completely covered.

After a rain, always suspend operations until the pavement has had ample opportunity to dry completely.

#### **TRAFFIC CONTROL:**

We have said repeatedly that safety is one of the Inspector's many concerns, and probably the most important one. The Contractor must supply all of the barricades, signs, and other traffic control devices specified in the plans. You must ensure that he has all the correct required devices, and that they are installed properly.

For the operation to begin efficiently the Contractor should have the required barricades and signs in their proper locations no later than the night before the sealing begins. The most efficient Contractors have one person in charge of a crew of other people whose sole responsibility is traffic control. Their duties include erecting signs and barricades; placing traffic cones; serving as flaggers; and moving the traffic control devices down the roadway as close as possible behind the seal coat equipment.

When the signs and barricades are placed in position on the afternoon or evening before the seal coat begins, they must be turned away from approaching traffic, covered, or laid flat on the ground. This will prevent passing motorists from thinking that the construction has already begun, heeding the warnings, and causing an unnecessary traffic delay.

#### **EXPOSING SIGNS:**

The first thing that occurs on the morning of start-up should be the correct positioning of signs and barricades. The timing is critical, because motorists should come under control of the warning signs before any equipment is moved onto the highway. As soon as the signs are exposed, they must be checked by one of the Inspectors.

Check to ensure that all barricades and signs specified in the plans and the Traffic Control Plan (TCP) are:

- In the proper sequence
- The correct distance apart
- Clearly visible to motorists
- Positioned correctly, so the devices themselves do not pose a hazard to traffic.

#### TRAFIC CONES:

Traffic cones are almost always used to keep traffic routed around the seal coat equipment. As soon as the signs and barricades are exposed, the traffic cones should be put in place. These must also be checked to ensure:

- They are spaced properly.
- There are enough cones in position to keep traffic away from the start-up point and down the roadway far enough to include at least the distance of the first asphalt shot.
- The cones are positioned outside of the operating path of the asphalt distributor and aggregate spreader.

#### FLAGGERS:

As soon as the first traffic cones are placed in position, a flagger should also be in position. You should watch to ensure the flagger is using the correct signals. If the flagger is required to verbally explain the situation to vehicle operators, listen to what he or she tells a few of the drivers, to make certain it is clean and accurate.

If there are flaggers at both ends of the project, which there usually will be on a two-lane road, make certain they have whatever communications are deemed necessary. Also ensure that the communications are properly used. Always remember that the flaggers are vital to the safety of motorists in the construction area. If they are not performing some element of their duties properly, they must be corrected promptly.

#### MOVING CONTROL DEVICES:

Later in the day, after some distance has been covered, the flagger and cones will probably be moved closer to the operations and the first part sealed opened to traffic. The project barriers and signs will not be moved. Check the flagging and cones again to ensure proper placement and procedures after they are repositioned.

If the seal coat operation crosses numerous intersections, extreme care must be taken. The TCP must be followed carefully, in the interest of safety. Care must be taken to prevent vehicles from crossing the wet asphalt between the asphalt distributor and the aggregate spreader. It may mean positioning another member of the traffic control crew at the intersection.

Sometimes flashing arrows are used, as seen in the photos below, to move traffic into the opposite lane. This is best on four lane highways and especially where there is a large volume of high-speed traffic.

## MARKING THE ASPHALT SHOTS:

While the traffic control devices are being set up and the sweeper is working, one or two of the Inspectors may be assigned the task of marking asphalt shots. Not all Districts use the method described below, and this is not to be interpreted as the only or right way. It is one method which may have certain advantages over others.

### ASPHALT APPLICATION RATE:

Before any asphalt shots are measured, other factors must be considered. First is the seal coat design. Looking first at asphalt, what is the average rate of application called for on the plans?

Let's assume that on the main lane we're sealing, the average application rate is 0.32 gallons per square yard (0.32 GAL/SY). If AC asphalt is being shot, this is the quantity that will be sprayed from the distributor and the amount that will bind the cover aggregate to the pavement.

If, however, emulsions are being used, our figure of 0.32 GAL/SY is only the amount of basic asphalt we desire in the end, not the amount shot from the distributor. Remember that emulsions are made up of asphalt cement mixed with water and a chemical emulsifying agent. After the emulsion is sprayed on the road, the water and emulsifying agent evaporate (the emulsion "breaks"), leaving only the asphalt cement.

Also, various types of emulsions contain different amounts of water and emulsifiers. Typically, emulsifying agents and water make up 35 to 40 percent of each gallon sprayed. Therefore, you may be spraying emulsions at 0.45 to 0.60 GAL/SY in order to leave the desired amount of residual asphalt.

### DISTRIBUTOR CAPACITY:

You must also consider the capacity of the asphalt distributor in use. The distributor may be capable of holding, for example, 2,000 gallons. This does not mean that all 2,000 gallons will be sprayed onto the roadway in one shot. The distributor should never be run until the asphalt runs out. Especially when shooting emulsions, there should be some asphalt remaining in the tank when the sprayer is turned off. Emulsions tend to foam more than other types of asphalt. The operator should not spray until the foam is reached, because the asphalt rate will not be correct. It is wise to plan on leaving perhaps 200 gallons in the distributor at the end of each shot if emulsions are shot, and perhaps 100 gallons if AC is used. This also reduces the chance that the thin film of asphalt which remains inside the pipes and spray nozzles will harden due to rapid cooling.

## AREA CALCULATION:

If you were to seal one 12-foot-wide area of roadway with AC at .32 GAL/SY using a 2,000 gallon distributor, you would first determine the maximum amount to spray at one shot. Let's assume you have determined 1,800 gallons per shot will be safe.

At .32 GAL/SY, 1,800 gallons will cover 5,625 SY of roadway (Divide 1,800 by .32). Since the pavement is 12 feet wide (4 yards), you should be able to cover an area 1,406.25 yards along the highway. This equates to 4,218.75 feet, which will be the length of each shot. Check your calculations this way:

Linear feet of roadway:	4,218.75 feet
Multiply by width:	12 feet
Area:	50,625.00 sq. feet

Divide by square feet per square yard (9):  $\frac{50\ 625}{9} = 5,625$  square yards of roadway

Rate asphalt is to be sprayed: .32 GAL/SY Multiply area by rate:  
 $5,625 \times .32 = 1,800$  gallons

As long as the application rate and the roadway width remain constant, each shot will be 4,218.75 feet long.

## MARKING THE SHOT:

The Inspector who is assigned to mark the shots should be equipped with a vehicle with a bitometer gauge, which has been properly calibrated. This is the simplest way of measuring the roadway length. He simply sets the odometer on the gauge to zero at the spot where the first shot will begin. He drives down the roadway until the odometer registers 49219 (4,218.75 rounded upward to the nearest whole foot). He stops at that point and marks the highway, resets his odometer to zero, and measures the next shot.

Each shot should be marked so that the spot is clearly visible. It can be done with a fluorescent shade of spray paint from an aerosol can, or with a small, bright-colored wire flag stuck in the earth next to the pavement surface. By marking each spot, the Contractor's personnel will know where to form the paper joint, which will be discussed later.

We may have given the impression that the length of each asphalt shot is determined by the capacity of the asphalt distributor. This is not really the case, although capacity is a factor. The real emphasis for asphalt shots should be placed on the rock lands, which are governed by the number and size of trucks available. The importance here is that the asphalt must be covered as quickly as possible. If the aggregate is not available in the right amount at the

right time, the whole operation held up. The last thing you want to happen is to have an asphalt shot laid on the roadway and no aggregate to cover it.

### **SETTING THE ROCK LANDS:**

As with asphalt shots, some of the Districts mark the rock lands in advance; others do not. The advantage of doing so comes mainly from the ability to more precisely control the application rate of aggregate on each load

A rock land is the area covered by one predetermined size truckload of aggregate. The area of the rock land is calculated in advance and marked either on the pavement with paint, or on the side of the road with flags. Rock lands are marked in advance, to enable the aggregate spreader operator and the Inspectors to determine whether the desired application rate is actually being spread on the road. If a rock land is established and a truckload of aggregate is fed through the spreader, there should be no aggregate left in the spreader if it is being applied at the correct rate. If the aggregate runs out before reaching the marker at the end of the rock land, it is being applied too heavily. If there is some aggregate left over at the end, it is not being applied heavily enough.

All of this assumes, of course, that the truck was carrying precisely the right amount of material. That is, a 14-yard truck would contain exactly 14 yards of aggregate.

### **APPLICATION RATE:**

It is quite common to specify, in the project plans, the desired rate of application as one cubic yard of aggregate to a given number of square yards of roadway. An example would be: 1 CY/145 SY.

### **CALCULATION:**

Let's assume that the lane we are sealing, from an earlier example, is 12 feet wide. All of the haul trucks used on the job are 14-yard trucks (will carry 14 cubic yards of aggregate). Our rate, as given in the example above, is 1 CY/145 SY.

First, we would compute the area, in square yards, that would be covered by each truckload of aggregate. Simply multiply the number of cubic yards in the truckload by the number of square yards to be covered by each cubic yard of material. In this case:

$$14 \times 145 = 2,030 \text{ square feet}$$

*Roadway Area:*

Since the lane we are sealing is 12 feet (4 yards) wide, we would divide 2,030 by 4,

$$\frac{2030}{4} = 507.5 \text{ yards}$$

Since we want to mark the rock land based on a measurement from a truck odometer which measures the number of feet traveled, we would multiply this figure by 3 (feet per yard).

$$507.5 \times 3 = 1,522.5 \text{ feet}$$

Check your calculation in this manner:

Linear feet of roadway: 1,522.5

Multiply by lane width: 12

$$1,522.5 \times 12 = 18,270 \text{ (roadway area in square feet)}$$

Divide the number of square feet per square yard:

$$\frac{18,270}{9} = 2,030$$

#### MARKING THE LANDS:

The easiest method of measurement, like the asphalt shot, is to use a truck with a calibrated odometer. Start at the beginning of the first shot, with the odometer set at zero. Drive down the roadway until the odometer reads 1,523 feet (1,522.5 rounded up to the nearest whole foot). Stop and mark the spot with either paint or bright-colored flags.

Make certain that the markings for rock lands are either a different color or are distinguishable from the markers used for asphalt shots.

Reset the counter at the end of each rock land, and repeat the process.

#### CONSTRUCTING PAPER JOINTS:

To ensure an even, straight, and sharp beginning and end of each asphalt shot, paper joints should be constructed. If you have marked each shot in advance, the placement of each joint is easy. The joint is placed exactly on the spot where the shots have been measured.

The most efficient method of constructing paper joints is for the Contractor's supervisor to assign at least two people and a pickup truck to this responsibility. They will need a pickup-load of aggregate, shovels, and pushbrooms. They will also need a large roll of heavy-weight brown wrapping paper or joint paper, 36 to 48 inches wide.

#### STARTING POINT:

This is the easiest joint to construct. All that is necessary is to lay a strip of the paper across the full width of the lane being sealed, and anchor it down with a thin layer of aggregate spread over the paper. If a hydrostatic distributor is used on the project, or if the distributor spray operator is inexperienced you may want to have a wider mask. Simply lay a second or third sheet of paper beside the first, overlapping each one by at least two or three inches. Anchor the paper securely in place by spreading a few shovelfuls of aggregate on top of the paper. Sweep away any aggregate that has spilled on the surface to be sealed, and the starting joint is complete. As soon as the distributor has started the shot, the paper should be removed. This photo shows a typical paper joint on a recent project.

#### END OF THE SHOT:

At the end of the shot, another joint exactly like the first must be constructed. It is constructed just like the first, except that the rear edge of the paper is placed on the marker for the end of the shot. This simply means that the sprayer will be turned off as the spray bar passes over the paper.

#### START OF SECOND

As soon as the distributor has moved away, the paper is removed. It should be pulled to the side of the road, out of the way, and disposed of later. Aggregate is spread over the asphalt. To save time, especially when two distributors are used, the joint crew often does this by hand. They shovel aggregate from their pickup truck over the end of the fresh asphalt. Then, another layer of the joint paper is placed over the end to form a starting joint for the second shot.

Care must be taken to clean all excess aggregate off the unsealed pavement, to preserve the clean, sharp end. The edge of the paper should be positioned exactly above the end of the asphalt shot.

#### SHOOTING THE ASPHALT:

Shooting the asphalt is certainly one of the most critical parts of the operation. It is also the part which presents the most problems. The asphalt distributor is a complex piece of equipment and numerous things can go wrong. If correct procedures are followed, however, the equipment is in good working condition, and everything goes smoothly, it looks like a simple operation.

#### DISTRIBUTOR PREPARATIONS:

The distributor must be filled from the heater unit, booster tank, or transporter. When the distributor is full, it must be strapped and the number of gallons recorded. The asphalt temperature must be checked to ensure that it is at proper shooting temperature. If the temperature is low, have the operator light the burners of the heater unit and start the pump to circulate the asphalt through the pipes.

It is important for the spray bar to also be hot. In hot weather, circulating the asphalt through the system may heat the bar adequately. During cooler weather, however, it may be necessary to preheat the spray bar with a torch or other device.

Have the operator increase the pump speed to make certain the correct pressure can be achieved. This is important on the first shot of the project, even though the distributor was inspected perhaps the day before. It should also be done on the first shot each morning.

#### BLOW THE NOZZLES:

Have the driver move the distributor to the side of the road, where correct shooting temperature is reached. Have him back the truck to the edge so that the spray bar is completely off the pavement and in a grassy area. Have the spray operator turn the sprayer on momentarily to "blow out" the nozzles. As it is spraying, visually check each nozzle to make certain it is not clogged and the spray pattern looks correct.

If any nozzles are clogged, have it removed and cleaned out with diesel fuel. Do not let the operator try to unplug it by inserting a wire into the nozzle. After it has been cleaned, repeat the inspection process.

When all nozzles are working correctly, have the driver move the distributor onto the pavement a few feet in front of the starting point.

#### RECHECK BAR HEIGHT:

To be on the safe side, once again measure the spray bar height above the pavement. Make certain the distributor is parked on a level spot and the pavement is representative of the rest of the shot. If the bar height is still correct, double check the spray system for leaking asphalt. If no leaks are apparent, the distributor is ready for the first shot. Have the distributor stand by in ready position while other checks are being made.

#### FINAL EQUIPMENT CHECK:

Make a final check to ensure that all the other equipment is in position and ready, before allowing any asphalt to be sprayed. Make certain the spreader box is in position and ready to begin. Check to see that at least one or two haul trucks are full and waiting to begin.

If a patching crew will be used on the job, they should be ready to follow the haul trucks as closely as possible. All the rollers should be ready to begin. It is important to make a last minute check with the Contractor's supervisor to make certain that all of his equipment operators and support personnel are on the job. If he is missing any personnel, discuss with him his alternate plans for covering the absences.



## PAPER JOINT:

Make certain the paper joint is in place for the beginning of the shot. Make sure it is adequate for the type of distributor being used and the skill of the operator. Remember that a hydrostatic distributor may require a wider paper than a distributor having a separate pump motor.

Have the distributor operator back the distributor to where the spray bar is over or behind the paper joints. This will enable the sprayer operator to open the spray valve as the distributor reaches spraying speed. This photo shows the correct position for a distributor with separate pump motor.

## TRANSVERSE ALIGNMENT:

When the distributor is in position over the paper, check the transverse alignment by sight. The end nozzle should be directly over the line which the operator will use as a guide. As soon as the transverse alignment is correct, have the operator set his guide bar so that his alignment device is in position over the reference line.

## BEGINNING THE SHOT:

As soon as all the preceding checks have been made, give the operator the signal to begin. Make sure you are in position to be able to closely observe the early part of this shot. Check to see that all nozzles are spraying correctly. The desired fan pattern should be easily visible. Closely inspect the asphalt film on the roadway to detect any variation. It should appear as a uniform sheet of asphalt across the entire width of the shot. Look for any visible signs of streaking or skipping.

Watch the spray pattern as long as you can clearly see it on the shot. If anything goes wrong, such as some of the nozzles stopping up or clogging, you will need to make a rapid decision to stop the spraying or to continue. If it continues, it will need to be patched later, but at times, it is the only logical decision. These decisions can only be made on the basis of good judgment, evaluation of the consequences, experience, and the specific situation. Always remember, however, that you have the authority to stop the shot if you are convinced it is the best choice.

## CHECK THE ASPHALT:

Before any aggregate is placed on the asphalt binder, check the asphalt to see that it is ready. This is another case where a call is made. Different types of will be treated differently.

With AC asphalt, the speed with which it cools will be the deciding factor. Remember that AC is shot at high temperatures, often over 300 degrees. Cool ground temperature will dictate that the aggregate be spread quickly. To test AC, take a handful of aggregate particles and toss a few into the asphalt. Watch what happens when the aggregate particles hit the asphalt film. If they bounce and roll as they hit, it will be better to wait a few

minutes to allow the asphalt to cool a little more. If, when the aggregate particles strike the asphalt, they stick to the spot where they first hit, it is time to begin spreading the aggregate.

Emulsified asphalt looks different from AC when it is sprayed. AC is a clear glossy black, but emulsions are dark brown. Emulsions remain this color until the emulsion breaks, at which time, they begin to turn black. As the shade begins to turn black on the surface, you can check for readiness to spread the aggregate. Some experienced people say that the aggregate should be spread before the emulsion breaks.

One way to check it is to use a small stick or rock, and scratch a line in the surface of the asphalt. Watch the line closely. If the asphalt under the surface is a lighter, muddy brown and the mark begins to fill in immediately, the emulsion has not completely broken. If the asphalt under the surface is already dark brown or black and the edges of the scratched line are holding firm and not filling in rapidly, it is ready for the aggregate to be applied. You can also toss a few aggregate particles into the asphalt, and at this stage, they will tend to stick in place. They may bounce once, but when they stop, they will tend not to turn over.

The best rule of thumb is to put the aggregate on the asphalt as soon as possible without causing problems. If the rock begins to turn or asphalt is being picked up on spreader box tires, you will need to wait longer to spread the cover aggregate.

#### END JOINT:

Always make sure, there is a paper joint constructed at the end of each shot, as well as at the beginning. This will minimize the patchwork; prevent loss of aggregate due to uneven asphalt application; better ensure against "fat" spots of aggregate; and enable you to get a more precise measurement of the amount of asphalt shot.

If two distributors are used on the project, the first one will be strapped and refilled after the first shot. The second distributor will be brought up for the second shot. Make certain that the same checks are performed on the second distributor that were performed on the first. It is also desirable that they be numbered on the rear, so that they can be easily distinguished later in the job. This may only be necessary if the distributors are identical as they sometimes are.

#### TRAFFIC RESTRICTIONS:

No traffic of any type should be allowed on the fresh asphalt. This sounds as though it should be easy to avoid, but it is not always.

#### STRAPPING THE DISTRIBUTOR:

Before and after each distributor load of asphalt is sprayed, the asphalt distributor must be strapped. This term means that the amount remaining in the tank is measured to determine precisely how much asphalt was used on every shot.

The Contractor is paid by the State for the amount of asphalt by the gallon. Therefore, it is necessary for us, as representatives of the State, to ensure that an accurate record is kept of every gallon of asphalt used on the project.

As mentioned in our description of the equipment, each distributor must have a calibrated measuring stick or "dip stick." The stick is used to measure the quantity of asphalt in the tank after the shot. This quantity is subtracted from the total amount that was in the tank at the beginning of the shot.

For example, a full 2,000 gallons of asphalt was pumped into the tank before the shot. By measuring the asphalt remaining, we determine that there are 225 gallons in the tank after the shot. So 1,775 gallons were sprayed over a known area.

#### APPLICATION RATE:

Besides being important for pay purposes, strapping the distributor serves another important purpose of immediate concern. It allows us to determine what our average application rate was over each shot applied. This allows us immediate information that enables us to have adjustments made from one shot to the next.

Strapping the distributor allows us to determine what our average application rate was over each shot applied. An example of calculating application rate is shown below.

Given:

Shot Width in linear feet = 12 LF

Shot Length in linear feet = 468.75 LF

Calculate:

$$\text{Total Shot Area} = \frac{12 \text{ LF} (468.75 \text{ LF})}{9 \text{ SF/SY}} = 5,625 \text{ SY}$$

$$\text{Application Rate} = \frac{1,775 \text{ gallons used for the total area}}{5,625 \text{ total area shot in square yards}} = .315 \text{ GAL/SY}$$

To strap the distributor, the following procedure is used:

- Immediately before and after the shot, have the operator stop the distributor on a level spot.
- The tank must be as level as possible. Some distributors have a level attached to the tank. If not, a 3- or 4- foot carpenter's level will work just as well.
- Have the spray operator make certain the dip stick is wiped clean before he puts it in the tank.
- Open the manhole cover at the top of the tank and put the dip stick in the tank, making certain it is held as nearly vertical as possible.
- Push the stick down into the asphalt until it touches the bottom of the tank.

- Pull the stick out and read the number of gallons at the top of the line covered by asphalt, or, on other models, hold the stick up against the scale mounted on the side of the tank as seen here.
- Subtract the gallons remaining from the number of gallons at the beginning.

## **SPREADING THE AGGREGATE:**

As you will recall from the chapter covering materials, the aggregate used in a seal coat provides the load-bearing element, the skid resistance, and creates a uniform appearance. If the aggregate is applied properly, all of these things happen and the roadway is pleasant to drive on. If it is improperly applied, it can become a nightmare.

Before the distributor begins to spray the first shot of the project, the aggregate spreader must be in position and ready to begin. In your last-minute equipment check, be certain to check with the spreader operator to make certain his machine is ready. Also be certain that his assistant, who controls the aggregate flow and gate adjustment, is present and ready.

There should be one haul truck behind the aggregate spreader, loaded with aggregate with which to fill the spreader. There should be at least 2 or 3 more trucks loaded and standing by.

### **SPREADER ALIGNMENT:**

As the distributor begins to spray the first shot, the spreader should move up to within a few feet of the starting point. While the joint paper is being removed, the operator should align the spreader. He should position it so that the left corner of his spreading hopper is in line with the inside edge of the freshly sprayed asphalt film.

As soon as the operator has the spreader in position, the assistant checks all the discharge gates. He makes certain that all the gates needed are open, to ensure complete coverage of the asphalt shot. If the discharge hopper is wider than the asphalt, some of the gates on the right-hand side would be closed. He should be sure that complete coverage will result, but aggregate should not be wasted.

### **TRUCK HOOK-UP**

When all is ready, the waiting truck backs up to the spreader and stops slightly short of coming in contact with the spreader. This allows the spreader operator to back the spreader into the truck, so that the hitches connect. A spotter should be used to ensure correct connection.

The truck driver then shifts his transmission into neutral to allow the spreader to tow the truck backwards as the aggregate is spread. Upon a signal from the spreader operator or his assistant, the truck driver releases the tailgate latch. He raises truck bed as he is told and

allows the aggregate to fill the receiving hopper. He must remain ready to lower the bed on signal to prevent the hopper from overflowing.

#### RECEIVING AGGREGATE:

As soon as the aggregate begins to pour into the receiving hopper, the conveyor belts are turned on. The aggregate begins to flow into the discharge hopper and is distributed across the discharge gates.

When both the receiving and discharge hoppers are nearly full, the operator or his assistant signals the truck driver to lower the truck bed. This stops the flow of aggregate into the spreader.

#### DISENGAGEMENT:

A careful and experienced spreader operator will, at this point, take one extra precaution. He will disengage the truck hitch and have the truck driver move a few feet forward, away from the spreader. This allows the spreader operator to test his equipment for a few feet without the truck being attached. He will still have enough aggregate in the spreader to run perhaps a 50-foot test strip.

#### TEST STRIP

The operator must begin the dispensing of aggregate at the same speed which he will maintain throughout. Consequently, both he and his assistant must be ready to have the spreading fully underway as the front of the discharge hopper crosses the edge of the asphalt strip.

The operator must start his forward roll and maintain alignment of the spreader while reaching the correct forward speed. An instant before reaching the asphalt strip, he opens all the discharge gates. His assistant watches the flow of aggregate over the top of the discharge hopper. If any gates are not functioning correctly, he must immediately signal the operator to stop, unless the assistant can correct the problem immediately. If the problem can be corrected within the first few feet, the patching crew can fill in the bare spot easily.

As soon as the operator and his assistant are satisfied that the gate settings are correct and the equipment is functioning properly, they should terminate the test.

#### LIVE SPREADING:

When the test is finished and any needed adjustments made, the spreader operator backs the spreader a few feet from the spot where he ended the test. There he waits while the haul truck backs toward the spreader. The truck and spreader are joined together by the hitch again. This time the spreader operator has the truck driver raise the bed enough to keep the receiving hopper full for the entire truckload.

As the spreader and truck move forward, the gates are opened just before reaching the bare asphalt. Excess aggregate at the point of double coverage will be swept off later or dislodged by traffic, so will do no harm. The operator continues to spread until the truck bed is empty.

When the last of the aggregate has left the truck and entered the receiving hopper, the spreader assistant signals the truck driver to lower his truck bed. This will allow the truck to separate from the spreader without allowing the tailgate or rear of the truck bed to strike the top of the receiving hopper.

#### SEPERATION:

The spreader operator will normally continue to move forward while the truck bed is being lowered. Before the spreader is completely empty, the operator should stop the spreader and release the truck hitch. Most hitches can be released without stopping the spreader first, but the spreader will have to stop within a few feet, anyway. When he stops the spreader, the operator should back up a few feet to allow the second truck to link up. The process is repeated.

#### ROCKLAND MARKER:

After linking up with the second truck and resuming the spreading for just a few feet, the spreader should pass the marker for the end of the first rock land. It should be slightly farther than the truck link up, because there was still some aggregate from the first truckload in the spreader when they separated.

If the spreader passes the rock land marker before the first truck separates, the aggregate is being applied too thinly. If the spreader does not pass the marker within about 25 feet from where the second truck was picked up, the aggregate is being applied too heavily. In either case, gate openings must be adjusted accordingly.

#### VISUAL CHECKS:

The Inspector that is assigned to watch the aggregate application should have a good view of the aggregate as it leaves the discharge hopper. He or she should watch closely to see that there is a thin "curtain" of aggregate dropping through the gates. The curtain should be uniform across the entire width of the discharge hopper. If the curtain of aggregate is only one aggregate thick, as it should be, light can easily be seen through the curtain. Any dark stream suggests a gate that is open too widely. Any unusual light streak means that not enough aggregate is being released.

You should also watch the aggregate as it hits the fresh asphalt. There should be only a small bouncing action visible in front of the curtain of aggregate. If a "wave" of aggregate forms in front of the curtain, the aggregate is being applied too heavily.

Keep an eye on the scalping grate on top of the discharge hopper. If everything is going well, there should only be a steady flow of aggregate passing through it. An accumulation of clay balls, grass, or rocks on top of the grate indicates that the loader operator is picking up contaminating materials. The Chief Inspector or Contractor's foreman should be notified immediately.

Also look closely behind the spreader to check for contaminants and streaking of thin or thick rows of aggregate. Check for a ripple effect, as well. If there is evidence of thick and thin alternating streaks running transversely (across the pavement), it indicates that the spreader speed is too high and should be slowed down.

#### RECORDING TRUCK LOADS:

One important job of the Inspector assigned to watch the aggregate is to also keep records of the number of truck loads of aggregate placed on the roadway. The best way to do this is to write down the identification numbers of each truck on the project. Each time the truck finishes emptying a load into the spreader, put a mark beside that truck's number. Where load tickets are issued for each truck load, you will have your own copy of the ticket.

#### PATCHING:

Regardless of how much care is taken to apply a seal coat perfectly, at one point or another, something will go wrong. It may be something as minor as a spot where the aggregate truck separated from the spreader, and excess aggregate fell on the pavement. Or, it may be something as major as the "hot rodder" spinning his wheels across the entire width of the lane he crosses, just behind the rollers. Any and all of these problems require some hand work.

#### PATCHING CREWS:

Some of the more conscientious contractors assign two or three people to a patching crew, and making repairs is their sole responsibility. They are equipped with a three-quarter ton pickup, up to an 1 1/2-ton truck. The truck will contain a supply of aggregate, shovels, pushbrooms, and sometimes buckets with patching asphalt and swabs or mops to apply it. They usually follow behind the chain of haul trucks and make repairs before the rollers reach the trouble spot.

#### IMMEDIATE REPAIRS:

The patching crew may be required to make minor, on-the-spot repairs that will not interrupt the seal coat process. These repairs may include, but are not limited to:

- Removing and brooding smooth, small mounds of excess spilled aggregate on top of the sealed surface. The majority may be shoveled back into the truck and the remainder swept off to the side of the shoulder.

- Covering "fat" joints. Occasionally a double layer of asphalt may be sprayed on a joint. This usually happens because the joint paper was not exactly at the edge of the aggregate when a joint was made. Asphalt usually moves up through the aggregate at this point. For the moment, about all the patching crew can do is cover the asphalt with additional aggregate to prevent it from sticking to the roller tires.

Later, it should be cleaned off and the section replaced. Otherwise, there will be a noticeable bump.

- Covering oversprayed asphalt on the lane edges. Quite often, asphalt splashes outside the coverage of the spreader. These streaks of asphalt must be covered with aggregate, or it will stick to roller tires.
- Removal of grass or clay balls. It is very difficult, if not impossible, to keep all grass and clay out of the aggregate. If the patching crew finds any that has passed through the spreader, it is their responsibility to remove it and replace it with aggregate, if necessary.
- If a spot has been missed by the asphalt distributor because of a nozzle being momentarily clogged, or any other reason, the patching crew may be called ahead of the aggregate spreader to manually swab asphalt onto the bare spot.

#### DELAYED REPAIRS:

Some repairs are beyond the capability of the patching crew, and must be delayed until later. These are usually large areas that have failed due to an accident or through carelessness or negligence.

One example could be haul trucks bringing a load of aggregate to the spreader sometimes turn around to back into the spreader, and turn too sharply on the fresh seal coat. This scuffs the aggregate. Once the aggregate has been scuffed and turned over, the asphalt begins to stick to vehicle tires. It then tracks onto more aggregate, which also turns over. The more asphalt that comes to the top, the more the aggregate will be picked up by tires.

The only way to adequately repair something this extensive is to clean it off and redo it. Sometimes, it is possible to broom it off, if the binder has not hardened yet. If it has hardened, it may be necessary to use a scraper to remove the aggregate that is left. It is likely that any attempt to merely patch the bare spots would be futile.

#### TURNING THE TRAFFIC:

Since seal coats are applied on many 2-lane Farm to Market roads, the usual pattern is to start at one end and shoot that lane straight through to the opposite end. The operation is turned around, and the opposite lane is sealed continuously back to the starting point. Then,



any irregular areas such as shoulders, intersections, and transitions are done last. Traffic, however, cannot usually be kept off the fresh seal coat until the application is finished. The question is, at what point should the traffic be allowed on the fresh seal coat, and how should the turn-around be handled? (Note: in some cases, it is better to do the crossovers and irregular areas before shooting the main lanes. However, the turn-around considerations are generally the same.)

#### VOLUME OF TRAFFIC:

If the road being sealed has a low volume of traffic, it is sometimes possible to open the freshly-sealed lane as soon as possible after the rollers have finished rolling. A high traffic volume normally should be held off the fresh seal coat longer, if possible. This is not always possible, however, because the higher the traffic volume, the higher the need to reopen the closed lane as quickly as possible.

#### TYPE OF TRAFFIC:

If the traffic consists mainly of light passenger vehicles, it is usually safer to open the lane to traffic soon after the rollers are finished. With a large number of heavily-laden trucks, however, you would want the asphalt to set longer to give it a chance to "firm up." Heavy trucks with multiple axles are a natural enemy of a fresh seal coat. Tandem axles will scuff aggregate on turns, with almost absolute certainty.

Although not always possible, it is highly desirable to hold heavy truck traffic off the seal coat as long as possible.

#### TRAFFIC SPEED:

The higher the traffic speed, the harder it is on a seal coat. If traffic can be slowed to below about 20 MPH, it may be possible to reopen the traffic lane as soon as all the equipment is clear. If you are sealing a straight, open highway where traffic speeds are high despite warning signs and flaggers, it is best to wait to reopen the lane to traffic. High speed traffic tends to "whip" the aggregate loose.

#### HIGHWAY FEATURES:

The features of the roadway itself may influence how quickly you open the lane to traffic. If the highway is a four-lane (or more) road, you may be able to confine traffic to a different lane long enough for the asphalt to set adequately.

Some two-lane roads have shoulders as wide as ten feet. This is wide enough to accommodate traffic at fairly high speeds, and may enable you to keep the freshly sealed lanes closed longer. Climbing lanes may enable you to keep traffic off the fresh seal longer, if your District is in a hilly region where climbing lanes are present.

Numerous intersections on the highway being sealed will present special problems. Roads with numerous intersections mean a lot of "stop-and-go" traffic, which is hard on a fresh seal coat. It would be nice to keep intersections closed for longer periods, but it is just not feasible.

#### TYPE OF ASPHALT AND WEATHER:

The type asphalt used as the binder will also affect the amount of time before opening the lane to traffic.

When shooting AC, remember that temperature is the major factor in the asphalt's hardening. The cooler the pavement temperature, the quicker it hardens. Even in the middle of the summer, when pavement temperatures reach 150° F or more, the asphalt cools rapidly from the 300° F or higher at which it is sprayed. It will drop to the pavement temperature within just a few minutes.

With emulsions, temperature is a factor, but not as much as with AC. Emulsions are normally shot at about 150° F and will also reach the ground temperature very quickly. The ground temperature is often close to 150° F, so there is little change. Humidity, however, plays a much bigger role with emulsions than it does with AC. As the humidity rises, it takes longer for the emulsion to break. Any amount of humidity over 50 percent should be a warning to keep traffic off as long as possible.

Rain showers are not controllable, and often are not predictable. If clouds start building up and it looks certain to rain, it is best to suspend the operation until it either rains or the clouds pass. If it does rain and you are shooting emulsions, you must keep the traffic off the fresh seal or you are certain to lose most of the aggregate, and possibly a good share of the asphalt binder.

#### CHANGE TO OTHER LANE:

When the first lane is finished, and you are ready to turn the traffic onto the fresh seal, extreme care must be taken to avoid confusion and ensure the safety of motorists and construction personnel.

Before the second lane is closed, make certain that all equipment is safely out of the lane to be used. Not only should the equipment be out of the lane, it should be moved off the shoulder and a safe distance onto the right-of-way. It may be feasible to move it onto the opposite side of the road where it will be most convenient to start sealing the second lane.

Extreme care must be taken to get the equipment across the road without causing an accident. If possible, it is best to stop the traffic at both ends and move all the equipment across at once. This, of course, will depend on the volume of traffic, road features, and other factors. The traffic cones should be moved last, and you must be certain that all flaggers are prepared before the traffic is turned onto the lane that has just been sealed. The critical issue

is that complete and positive control is exercised over the traffic; movement of equipment onto the opposite side; and the resetting of traffic cones.

## APPENDIX A:

**Table 1. Binder Base Rates (AC)**

Aggregate Gradation	GR3	GR4	GR5
<b>Binder Rate</b>	0.37	0.32	0.22

**Table 2. Binder Rate Adjustment Factors for Traffic Level**

ADT per Lane	GR3	GR4	GR5
0-50	+0.07	+0.05	+0.04
50-100	+0.06	+0.04	+0.02
100-300	+0.04	+0.03	0
300-500	+0.03	+0.02	* -0.02
500-700	0	0	N/A
700-1000	-0.01	-0.01	N/A
1000-1500	-0.02	-0.02	N/A
1500-2000	-0.03	* -0.03	N/A
>2000	-0.04	* -0.04	N/A

\* This grade aggregate not recommended for traffic volumes shown

**Table 3. Alternate Binder Rate Adjustment Factors for Traffic Level**

ADT/Lane	Adjustment	Highway Description
0	+ .10	Shldrs
0-100	+ .05	Very low vol FM
100-250	+ .04	Low vol FM
250-400	+ .03	Med vol FM or
400-600	+ .01	Low vol US or SH
600-800	0	Med vol US or SH or High vol FM
800-1000	- .02	High vol US or SH
1000-1500	- .03	High vol US or SH
1500-2000	- .04	Very high vol US
>2000	- .06	Key ave etc...

**Table 4. Binder Rate Adjustment Factors for Truck Traffic**

% Trucks	GR3	GR4	GR5
5%	0	0	0
15%	-0.01	-0.01	N/A
30%	-0.02	-0.02	N/A
40%	-0.03	-0.02	N/A

**Table 5. Alternate Binder Rate Adjustment Factors for Truck Traffic**

	GR5	GR4	GR3
High %	- .02	- .04	- .05
Medium %	- .01	- .02	- .03
Low %	0	0	0

**Table 6. Binder Rate Adjustment Factors for Pavement Condition  
(existing or new pavement-wheel path conditions)**

Surface Type	Surface Condition	GR3	GR4	GR5
ACP	Very dry ACP with many cracks	+0.08	+0.06	+0.05
	Dry ACP with some cracks	+0.05	+0.04	+0.03
	Good ACP with few cracks	+0.02	+0.02	+0.01
	Flushed seal	-0.02	-0.02	-0.01
	Bleeding ACP	-0.04	-0.04	-0.03
SEAL	Very dry seal with many cracks	+0.06	+0.06	+0.04
	Dry seal with few cracks	+0.03	+0.03	+0.02
	Good seal with few cracks	0	0	0
	Flushed Seal	-0.02	-0.02	-0.01
	Bleeding seal	-0.04	-0.04	-0.02
PATCHES	Dry or fresh patch	+0.03	+0.03	+0.02
	Flogged patch	0	0	0
	Flushed patch	-0.03	-0.03	-0.03
PRIME	Dry surface, light rate	+0.02	+0.02	+0.02

Penetrated well, good rate	0	0	0
Waxy and wet, not penetrated well	-0.03	-0.03	-0.02

**Table 7. Alternate Binder Rate Adjustment Factors for Pavement Condition on wheel path  
(Hunger Factor)**

Surface Condition	Adjustment
Very dry ACP with many cracks	+ .10
Dry ACP with some cracks	+ .06
Good ACP with few cracks	0
Flushed ACP	- .05
Bleeding surface	- .10
Dry seal with many cracks	+ .08
Dry seal with few cracks	+ .05
Good seal with few cracks	0
Flushed seal	- .05
Fogged patch	0
Dry patch	+ .08
Flushed patch	- .06

**Table 8. Alternate Binder Rate Adjustment Factors for Pavement Texture  
(wheel path only)**

	AGGREGATE GRADATION		
	GR5	GR4	GR3
Very coarse seal		+ .04	
Coarse seal or premix patch		+ .02	
Good seal or premix patch; texture with little or no flushing		+ .01	
Flushed or smooth surface	0	0	0

**Table 9. Binder Rate Adjustment Factors for Aggregate Gradation**

	GR5	GR4	GR3
Coarse	+ .02	+ .05	+ .08
Fine	- .02	- .03	- .05

**Table 10. Binder Rate Adjustment Factors Based on Type of Rock**

Type of Aggregate	Binder Rate Adjustment
Light weight	+ .02
Limestone, etc...	0

**Table 11. Suggested Nozzle Configurations**

Lane Width (ft)	Nozzle Configuration								Total Nozzle (BIG) s	Comments	Uniform Binder	Uniform Binder
	DEFL (BIG)	BIG	SM	BIG	SM	BIG	DEFL (BIG)	Rate Factor (20% Variance)			Rate Factor (30% Variance)	
9	1	0	9	6	9	2	1	28		1.072	1.108	
10	1	2	9	6	9	3	1	31		1.084	1.126	
11	1	4	9	6	9	4	1	34		1.094	1.141	
12	1	5	9	8	9	4	1	37		1.102	1.153	
13	1	6	9	8	9	6	1	40		1.110	1.165	
14	1	6	9	8	9	9	1	43	Outside shoulder	1.117	1.175	
14	1	9	9	8	9	6	1	43	Inside shoulder	1.117	1.175	
15	1	6	9	8	9	12	1	46	Outside shoulder	1.121	1.182	
16	1	6	9	8	9	15	1	49	Outside shoulder	1.126	1.189	
16	1	16	9	8	9	5	1	49	Inside shoulder	1.126	1.189	

\* Configuration of 1-5-9-8-9-4-1 may be shown as 6-9-8-5 etc. on design and application reports

**Table 12. Lane Traffic Distribution Factors**

Total Number of Lanes	Lane Traffic Distribution Factor
2 lane	ADT x 0.5

4 lane rural outside ln	ADT x 0.35
4 lane rural inside ln	ADT x 0.15
4 lane urban (all) ln	ADT x 0.25
Shoulder	0

**Table 13. Typical Truck Percentages**

<b>Highway Description</b>	<b>Typical Truck Traffic Level (Percent of ADT)</b>
Low volume FM's, ADT 250 or less	5
Moderate volume FM/SH/US Highways	15
High Volume US Highways	30
Interstate Highways	40

Note: Seal coat not recommended for 40% truck volumes