Virginia Department of Transportation

Materials Division

SLURRY SURFACING CERTIFICATION STUDY GUIDE

ACKNOWLEDGEMENT

The Virginia Department of Transportation, Materials Division is grateful for permission from the International Slurry Surfacing Association to use their *Inspector's Manual* for Slurry Surfacing certification training. It should be noted that photographs and VDOT specifications and requirements have been added to the manual.

INTRODUCTION

During the 1930's a new technique for maintaining road surfaces was developed. It consisted of a coating of very fine aggregate, asphalt emulsion and water. This was the beginning of slurry surfacing. In early attempts, a concrete truck was used for mixing the materials and a truck or tractor used for spreading, creating unpredictable results.

Experimentation continued to refine the process with a breakthrough in the 1960's as improved emulsifiers, set-control additives, and continuous flow machines were developed. This created an increased interest for using slurry for a wide variety of applications.

DESCRIPTION

GENERAL

The principle materials in a slurry surfacing are crushed aggregate, asphalt emulsion, water and special purpose additives such as mineral fillers and liquid or dry set control additives. These are mixed together according to a laboratory's mix design formula. Advanced and specialized slurries may include polymers, fibers, or other materials. Each change or added material is designed to enhance a feature of the slurry for a particular end need such as rut filling or crack resistance.

Slurry surfacing is mixed in specially designed equipment, either truck mounted or self-propelled. This equipment carries a quantity of unmixed materials which are blended together in a continuous flow pugmill. Mixing and spreading are accomplished in one continuous operation with the new pavement surface normally re-opened to traffic within a few hours or less. Technologically advanced machinery insures a high degree of quality control and consistency in the mix.

USES

Slurry surfacing qualities make it a good choice for pavement resurfacing when used on deteriorated roadways that are still structurally sound. The slurry mix fills surface voids, small or fine cracks and minor depressions sealing the pavement against the infiltration of moisture. It used to provide an anti-skid surface to pavement with poor skid resistance. Resurfacing asphalt shoulders of highways with a slurry surfacing application eliminates build-up of the pavement thickness. It also is used for rut filling and provides a surface that is uniform and smooth in appearance.

TYPES OF SLURRY SURFACING

The generic term slurry surfacing or slurry is used throughout this manual to reference Slurry Seal and Micro-Surfacing. VDOT currently distinguishes the two categories as follows:

Slurry Seal – A mixture of aggregate, emulsified asphalt, water, and additives properly proportioned, mixed and spread over a properly prepared surface. Slurry seal is applied in a single layer. It is generally used on low traffic primary and secondary roads.

Micro-Surfacing (Latex-modified Emulsion Treatment) – A mixture of cationic polymer modified asphalt emulsion, crushed aggregate, water and other additives, properly proportioned and spread over a prepared surface. The special purpose polymers and additives used in micro-surfacing allow higher than normal rates of application and multi-layer applications for projects such as rut filling, higher traffic primary roads and highway resurfacing.

MATERIALS & SPECIFICATIONS

AGGREGATE

Aggregate Quality – For a high performance slurry surfacing, quality aggregate is mandatory. Quality is more than the actual properties of the parent rock. Quality also includes proper gradation, fractured faces and cleanliness or sand equivalent.

Aggregate Gradation – In most cases the aggregate from a single source will not vary substantially during the course of a project. However, unusual changes can be brought about by:

- Different phases of the project occurring over a long period of time.
- Changes in the area aggregates are harvested from within the quarry or pit.
- Gradation fluctuation (especially on the fine aggregate sizes).

Aggregate within specification but on the coarse side, i.e. made up of greater percentage of larger size aggregates, and must be applied thicker. If not, inadequate embedment of the largest aggregate within the emulsified asphalt binder will occur, causing streaking where larger stones are caught by the strike-off rubber and/or raveling can occur. Conversely, aggregate on the fine side, i.e. made up of a greater percentage of smaller size aggregates, must be applied thinner.

Standard slurry seals are designed to be applied **one stone thick** (based on the placing of multiple layers to increase thickness will create an unstable seal and may lead to raveling, bleeding, rutting and/or washboarding).

Crushed aggregate is important as the fractured faces allow the particles to seat and lock together to better resist movement. Where available, 100% crushed aggregate should be used. Large round rock particles will ravel out of the constructed slurry.

Aggregates generally used for slurry surfacing come in three standard gradations, each with a designed use selected for the surface condition to be repaired:
(VDOT Designations)

Type A aggregate is the smallest size, and is most often used to fill surface voids, cracks and correct moderate surface conditions when protection from the elements is the main reason for resurfacing. It is used frequently on airfields and residential streets in mild climate areas.

Type B aggregate is used to fill surface voids and correct moderate surface conditions. It is often used on pavements with medium- textured surfaces that would require this size aggregate to fill the cracks and correct weathering and raveling while producing an adequate wearing surface for medium to heavy traffic.

Type C aggregate, the coarsest size, gives maximum coefficient of friction and an improved durability due to the depth of the application as the larger aggregate size increases the thickness of the mat placed. Type C is best-suited to higher traffic pavements such as highways and arterials. When used with a micro-surfacing emulsion, stability is also increased which makes the Type C micro-surfacing an excellent method of rut filling and minor surface reprofiling.

VDOT Design Range Table
Aggregate Gradations for Slurry Surfacing

Sieve Sizes	Type A % Passing	Type B % Passing	Type C % Passing	Rutfilling % Passing
3/8 (9.5mm)	100	100	100	100
No. 4 (4.75mm)	100	90-100	70-95	70-95
No. 8 (2.36mm)	65-90	65-90	45-70	45-70
No. 16 (1.18mm)	45-70	45-70	32-54	32-54
No. 30 (600µm)	30-50	30-50	23-38	23-38
No. 50 (300µm)	18-33	18-33	16-29	16-29
No. 100 (150µm)	10-21	10-21	9-20	9-20
No. 200 (75µm)	5-15	5-15	5-12	5-12

(Ref. VDOT Special Provision for Emulsified Asphalt Slurry Seal and SP for Latex Modified Emulsion Treatment - Micro-Surfacing)

Aggregate Composition – An average loose unit weight for aggregate is 108 pounds per cubic foot. Unit weight varies from 80 to 115 pounds per cubic foot. Since all mix designs and slurry formulations are based on aggregate unit weight, equipment must be calibrated for each aggregate source and type. Aggregates are composed of many different types of minerals.

NOTE: Aggregate for slurry surfacing is approved at the plant source under the Virginia Department of Transportation Quality Assurance Program.

Aggregates must be durable and clean to insure the asphalt bonds to the aggregate. Requirements will vary depending on the form of slurry (slurry seal or micro-surfacing) and the type (A, B, C). Listed below are the laboratory tests used to check the aggregate for suitability in a slurry mix.

Sieve Analysis Test – AASHTO T11 and T27 – This test measures aggregate size and distribution.

Sand Equivalent Test – AASHTO T176 – This test evaluates cleanliness of the aggregate by measuring the amount of expansive clays or organic materials.

Abrasion Resistance – AASHTO T96 - This test measures aggregate degradation under wear conditions.

Soundness of Aggregate – AASHTO T104 – The results of this test provides a preliminary estimate of the soundness of aggregates.

Other aggregate tests may include apparent specific gravity and moisture effect on unit weight. Aggregates must also be mixed with the emulsified asphalt and additives to determine compatibility before accepting them for use.

Aggregate gradation directly affects the amount of emulsified asphalt required for a slurry surfacing. Variations in aggregate gradation, even within the allowable specified ranges will change the total aggregate surface area to be coated by emulsified asphalt. Thus the importance of consistence in the aggregate selected for a project.
In summary the aggregate used should be:

- Clean
- Crushed
- Durable
- Properly graded and
- Consistent

ASPHALT EMULSIONS

Manufacturing Process – An asphalt emulsion is a colloid of water, an emulsifier, and asphalt bitumen. In making an asphalt emulsion, the asphalt and uniformly diluted emulsifier solution are pumped at proper temperature into a colloid mill. The mill includes a high speed rotor that turns at a very close tolerance within a stator. The asphalt is sheared into micron-sized particles. Each particle is surrounded by the emulsifier and emulsion is formed.

NOTE: VDOT specifications require the use of cationic quick-set asphalt emulsions in slurry seal and micro-surfacing. It must meet the physical properties of a CSS-1h emulsion (*VDOT Spec. Section 210 – Specifications*).

Special emulsifiers are added in order to suspend the asphalt particles. The particles remain in suspension because all emulsifier layers have the same electrical charge, which makes them repel each other. These charges are a characteristic of the emulsifier used. A negative charge denotes an anionic emulsifier, while a positive charge is found in a cationic emulsifier. Anionic and cationic are the two types of emulsion commonly used for slurry surfacing. Cationic emulsions have an acid or neutral pH while anionic emulsions are alkaline. The emulsions are at ambient or slightly higher temperature, brown in color and have a low viscosity. For high performance Slurry emulsions and those using additives, the type, condition, and tolerances of the actual mill used to make the emulsion may be critical concern as particle size in the emulsion becomes a more precise requirement.

Slurry emulsions contain 60-65 percent asphalt, 0.5-2.5 percent emulsifier, 0.0-2.0 percent caustic or acid (to adjust pH) and water to make up 100 percent. An emulsion is brown as long as the particles remain in true suspension. As the emulsion “breaks”, the particles of asphalt start to deposit themselves on the nearest aggregate particle or

and the characteristic black color of the asphalt starts to show. This is known as coalescence.

How Asphalt Emulsion Works -

Once on the roadway, the slurry mixture begins to change from a slurry state to a solid state. The process begins with the slurry surfacing mixture “breaking”. An emulsion “breaks” when the asphalt drops begin to re-combine. Visually observed when the material changes from brown to black and can no longer be handworked. The break time for slurry seal mixtures is usually 2 minutes or longer and for micro-surfacing mixtures less than 2 minutes.

As the aggregate is coated by the asphalt, the slurry mixture “sets”. This is when the initial expulsion of water takes place. At this point the material is rain safe and will support foot traffic. Set time for slurry seal can take up to an hour while micro-surfacing takes typically 30 minutes or less.

Not all of the water is expelled during the breaking and setting. Curing is the term used for the expulsion of most of the water from the mat through evaporation or chemical reaction. Curing is not the same as traffic time. Traffic time is when traffic can be allowed on the mat without damaging it. Traffic time for slurry seal is normally 2-3 hours and 1 hour or less for micro-surfacing, depending on weather conditions. It should be noted that final cure (total dehydration) can take periods of up to two weeks, however, most of the water is expelled within 24 hours after application. At this time the aggregate is totally covered with asphalt.

Handling and Storage of Emulsions – Emulsions can be sensitive to excessive shear caused by pumping or high speed agitation. They can also have poor stability during freezing conditions. Such conditions result in agglomeration of the fine, micron-size asphalt drops, into larger particles of asphalt, forming streaks, shots or skin on the emulsion. The emulsion is often acceptable when small quantities of broken emulsion are present if carefully screened before being blended with the aggregate.

Emulsions containing polymers can show a special form of separation problem. The polymer particles normally have a different density than the asphalt, and may show up either as a thin white layer on top of or at the bottom of the emulsion, especially if the emulsion is stored for extended time without circulation or agitation. Such emulsion can be used after homogenization by gentle agitation.

Transportation of emulsion may result in contamination if the transport tanker is not properly cleaned prior to loading the slurry emulsion. A minor residue left in a transport that has carried any cut-back asphalt, any opposite type (cationic versus anionic) grade

emulsion, magnesium chloride, or other incompatible material may set off a chain reaction that will destroy a whole load of slurry emulsion.

Inspector's Note: Emulsions within specification when they arrive at the job may develop problems if not used soon enough. Emulsion that sits for more than 2 to 3 days could start to develop asphalt pellets or a skin over the surface that will continue to get thicker. If a question arises on length of storage, check the tanker for sieve problems. Shot or strings of asphalt in the slurry mat are indicative of this. For minor problems, the emulsion can be filtered (screened) and circulated.

SAMPLING AND TESTING

Approval of asphalt emulsion is from the producer certification under the VDOT Asphalt Acceptance Program. The table below shows the specific tests and requirements for slurry seal and micro-surfacing.

Emulsion Tests	VDOT Requirement
• **Saybolt-Furol Viscosity Test -** provides control of consistency in the range of temperatures associated with field operations.	20-100 sec.
• **Sieve Test** - identifies oversized or coagulated particles.	0.1% maximum
• **Electrical Charge Test**- identifies anionic or cationic charge.	Positive
• **Settlement Test -** evaluates storage ability (setting time).	1 hour maximum
Residue Tests	
• **Penetration Test on Residue -** defines the hardness of the asphalt.	40 - 90
• **Residual Asphalt Content** determines the percentage of asphalt in solution.	
- **SLURRY SEAL – by Distillation**	57% minimum
- **MICRO-SURFACING – by Evaporation (VTM -78)**	62% minimum
• **Ring & Ball Test -** identifies the softening point of the asphalt **- MICRO-SURFACING only**	140°F minimum

WATER

Water forms an important part of a stable slurry and it percentage of the total mix is a major factor determining consistency of the mix. It is introduced three ways, as moisture already in the aggregate, as pre-wet water, and as one of the two major constituents of the emulsion.

Water to fill the tank of the slurry machine may be obtained form any source that is potable, free from oil, acid, salt, alkali, organic matter, or other deleterious substances. Water obtained from any source other than that approved for drinking must be approved by the Engineer. The pH must be tested since it will affect the behavior of the emulsion. VDOT requires a pH range from 4.5 – 8.5. *(Ref. VDOT Rd. & Bridge Spec. 216)*

For any given combination of aggregate and emulsion, stable Slurries can be formed over a limited range of pre-wet water concentrations; e.g. from 6 to 11 percent of the weight of the dry aggregate. Slurries containing less than 6 percent of pre-wet water could be too stiff to spread, and those containing more than 11 percent could become unstable, as evidenced by setting of the aggregate and floating of the asphalt and fines. Control of the total pre-wet water present while not often a problem, is very important, and machine operation at about the middle of the permissible range, or at 9 percent in our example, is recommended. Operation at more than 11 percent should be avoided.

In addition to its subsequent effect upon the slurry, the moisture present in the aggregate supplied to the mixer has a significant effect upon the mass rate at which the aggregate is delivered. Emulsified asphalt also adds water to the slurries. Since the emulsion is 35 -43% water, the total water content of stable slurries are normally within the approximate range of 12 – 20% of the weight of the dry aggregate.

ADDITIVES

Additives are added to the slurry surfacing to adjust the workability of the slurry and/or to modify the setting and curing characteristics. Additives may come in the form of dry additives, liquid additives, and mineral fillers.

Dry Additives – Aluminum sulfate crystals, ammonium sulfate and other inorganic salts are the most common types used. These materials are fed through the fine feeders of the machines at levels up to 1 percent of dry aggregate weight.

Liquid Additives – Liquid aluminum sulfate, amines and other liquid materials are the most common used. These materials are added at a rate up to 1 percent of the dry aggregate weight depending on the delivered concentration of the material.

Mineral Fillers – The mineral filler can be hydrated lime, flyash, or non-air entraining Type I Portland cement. Lime is typically used with quick-set slurry seal at

concentrations of 0.1 – 0.3%. Type I Portland cement is required for micro-surfacing systems and is normally used at concentrations of 0.5 – 1.5%.

A mineral filler is always a dry additive, but not all dry additives are mineral fillers as some dissolve in water. This distinction is important because any mineral filler must be added to the weight of the dry aggregate for the purpose of determining asphalt requirements. **Mineral fillers are included as part of the aggregate weight, and the concentration of each of the other ingredients of a slurry is usually expressed as a percentage of the combined weight of the dry aggregate and the mineral filler. It is important to use exactly the same quality of filler in the actual field work as in the mix design.**

Fillers, if used, could be an important part in the chemical reactions that determine the setting and final properties of the slurry, and the chemical composition of similar fillers can be quite different.

Inspector's Note: The percent of mineral filler and/or set control additives can change during daily operations when using a quick set slurry surfacing system.

SLURRY SURFACING

THE SYSTEM

A slurry consists of aggregate, emulsion, water, and additives (if used). Slow set/slow traffic slurry systems break and set mainly by the evaporation of water. Quick set/slow traffic slurry systems break mainly by chemical reaction and set mainly by evaporation. Quick set/quick traffic and micro-surfacing systems both break and set mainly by chemical reaction.

In all cases, when the emulsion is mixed with aggregate and mineral filler, the emulsifiers are migrated from the asphalt drops to be adsorbed onto the aggregate surfaces. When this happens, the drops lose their stability and combine into an asphalt film. For the Quick set slurries, the pH may be changed by addition of alkaline fillers such as hydrated lime or Portland cement. This change in the pH reduces the emulsion stability and promotes a faster set.

The setting and curing characteristics of slurries can be controlled by use of chemical additives. They are normally added to the pre-wet water and are adsorbed onto the aggregate to make it less reactive and enable prolonged workability before the Slurry sets. The strength and water resistance of the asphalt aggregate bond determines the durability of the slurry and the adhesion to the existing pavement surface.

Temperature is perhaps the most important factor for setting and curing of slurry surfacing. Sufficient temperature and time is needed for the final curing of the material

into a durable product although the temperature/time requirements may vary with different emulsifier or additive systems.

Higher temperatures increase the reactivity of the components and create a more rapid set. Temperature increases may come in the form of higher component temperatures, outside air temperatures, or pavement temperatures, any of which may shorten mix times and accelerate the set.

LABORATORY MIX DESIGN

Each of the Slurry components, aggregate, emulsion, water, and additives, must meet all job specifications and test requirements. Once individual materials have been qualified through testing through an approved lab, further tests will be performed to determine the compatibility of all materials and to evaluate the performance of this mix under simulated wear conditions. Laboratory tests conducted on mixed materials are:

Slurry Seal	Micro-Surfacing
Compatibility Test VTM -60	Certification of compatibility of Latex, Aggregate and Emulsion
Wet-Track Abrasion VTM-14 (WTAT) Wear loss not greater than 75 gr/ft^2	Marshall Test Stability: 1800 lbs minimum Minimum Flow: 6 – 16 units VTM: 4.7% leveling and finish, 6.5% rutfill

Proportioning – Aggregate gradation directly affects the amount of emulsified asphalt required for a Slurry Surfacing. Fine aggregates have larger surface area per unit weight. More surface area requires more emulsified asphalt to adequately coat the aggregate. Asphalt content varies significantly among the three standard aggregate sizes. It can also vary within a single standard aggregate size as the gradation changes from the larger to the smaller size within allowable tolerances, especially at the smaller size fractions, e.g. the number 100 and number 200 sieve. Thus the mix must be done with samples that are representative of actual materials to be used.

The Contractor must submit to the engineer for approval, a signed original laboratory report of a mix design on a VDOT test log (TL-127), results of the Compatibility Test and the Wet Track Abrasion Test, all of which must be performed by an approved testing laboratory. These should be submitted at least seven working days before the slurry surfacing commences.

Inspector's Note: The laboratory mix design that you receive should detail the optimum/recommended proportions of aggregate, emulsion and additives as well as summarizing the test results on the material submitted. This information becomes the final guideline for the construction of the slurry. (See Job-mix on next page.)

Form TL-127 (Rev. 11/05)

VIRGINIA DEPARTMENT OF TRANSPORTATION

MATERIALS DIVISION

STATEMENT OF ASPHALT CONCRETE OR CENTRAL-MIX AGGREGATE JOB-MIX FORMULA

Submit to the District Administrator, Virginia Department of Transportation. Approval must be received by the contractor from the Materials Division before work is begun. This job-mix design is approved for all projects of the Department for the type of mix and the calendar year shown below.

Contractor Design Mix No. 3 Design Lab No. D60-0857T

Date 3-22-2007 Job Mix ID No. SS-8A-07 Calendar Yr. 2007 TSR Test No. None

Type Mix / Size Aggregate Slurry Seal Type B

Producer Name & Plant Location Slurry Pavers, Inc Phone (804) 264-0707

Materials					Kind	Source
Approval Phase	A	B*	C			
Aggregate				%		
Aggregate				%		
Rap				%		
Sand				%		
Screening	99.0			%	Granite	Luck Stone, Goose Creek Plant, Leesburg, VA
Lime	1			%	Hydrated Lime	Greer Lime, Riverton, WV
Asphalt Cement						
Asphalt Prime/Tack						
Additives: Water						
Water	As needed				Potable	Local Sources
Asphalt Emulsion					CQS -1h	Asphalt Emulsion, Inc, Richmond, VA/ Manassas

Job-Mix Sieves	Total % Passing		Tolerance % + or -	Acceptance Range Average of ___ Test(s)		End of Year Average	Design/Spec. Range
	Lab JMF	Production JMF					
Approval Phase	A	B*		A	B	C	
3/8	100			100			Same
4	98.5			90-100			Same
8	79.4			65-90			Same
16	61.2			45-70			Same
30	46.0			30-50			Same
50	32.8			18-33			Same
100	20.9			10-21			Same
200	12.5			5-15			Same
Asphalt (%)	7.5		± 1.5	6.0 – 9.0			8.0 – 10.5

Lay Down Temperatures	____ - ____ °F(°C)	Muffle Furnace Correction Factor:	
		Field Correction Factor ($G_{se} - G_{sb}$):	.13
Lab Compaction Temperatures	____ - ____ °F (°C)	Pill Weight:	
		SMA Mixes	
		VCA_{DRC}:	
Producer Technician's Certification Number	123-45-6789	G_{CA}:	

MATERIALS DIVISION USE ONLY

Remarks	All materials have been tested and approved according to VAAP.						
Nominal Max. Size Aggregate		Application Rates:	Min.	lb/yd² (kg/m²)	Max.	lb/yd² (kg/m²)	
Mix Properties at the Job-Mix Asphalt Content:	Compacted Unit Weight	lb/ft³ (kg/m³)	VTM:		G_{mm}:		
Checked By:							

Approved tentatively subject to the production of material meeting all other applicable requirements of the specification.
* Note: Part B 'Production JMF' and corresponding Material percentages will be filled out by the DME upon receipt of the additional requirements of the HMA producer within the first three lots under Section 502.01(b)

Copies:	Approvals			
State Materials Engineer District Materials Engineer Project Inspector Sub-Contractor and/or Producer			Part A:	Date:
			Part B:	Date:
			Part C:	Date:

EQUIPMENT

Both the slurry seal and micro-surfacing application machines are mobile “plants” which blend the components to produce the mix application. These machines have some features in common, but there are differences which prevent the slurry seal from mixing and applying a micro-surfacing mix. However, the micro-surfacing machine can be used to mix and apply slurry seal.

Application machines can be either truck-mount or continuous application. Truck-mounted machines must return to the stockpile to reload materials which slows the application, unless more than one truck-mount machine is used.

Continuous application machines are supplied by nurse trucks which provide a constant flow of materials in the application machine. There is no interruption in the mixing and placement of Slurry.

CALIBRATION OF THE SLURRY APPLICATION MACHINE

To insure that the slurry surfacing mix is composed of the proper proportions developed in the mix design, the equipment must be calibrated using the actual project materials. The calibration process provides data that allows the operator to accurately set each machine for the material proportions developed in the mix design. Current year data must be kept with each slurry machine.

Calibration Theory – In slurry surfacing, all mix designs and formulations are based on the combined weight of dry aggregate and the weight of any mineral filler. To set the machines to a given mix design and to produce a consistent material, accurate information on the machine feed rates of aggregate, emulsified asphalt, water, and additives is necessary. The mix design is based on dry aggregate and dry mineral filler. Corrections for moisture in the aggregate could be necessary.

The reasons for calibration include:

1. To set a machine to a given mix design.
2. To maintain mix design consistency on all machines when using 2 or more machines on a project.
3. To have a database on a given machine.

A proper calibration is predicted on:

- All weights are based on the combined weight of dry aggregate and the weight of mineral filler (if used). The aggregate in the field or at the calibration site may include moisture and the weights must be corrected to account for it.
- The emulsified asphalt and aggregate must be mixed in the desired proportions which means calibrating to a common unit such as the aggregate belt, head pulley, or jack shaft. The industry prefers to use the head pulley because the machines have a counter that is very accurate and readable at this location.
- Three runs for each component should be made. The runs for testing have to be long enough to allow a sufficient amount of the different materials to pass through each system. Larger samples provide more accurate results.

For further information - See Calibration Procedure beginning on page 44.

SAMPLING/TESTING OF MATERIALS ON THE JOB SITE

During the process of producing, hauling and stockpiling of materials, good quality control procedures require tests to:

- Ensure that only satisfactory material is used in the slurry surfacing mixture and
- Provide a permanent record as evidence that the materials meet job specifications.

Inspector's Note: All materials used in the application of slurry surfacing should have first been tested in a laboratory during the mix design procedure. Since these materials have all passed contract specifications and exhibited system compatibility; the inspector's workload is reduced to verifying that the materials delivered to the job site all have the same characteristics.

TEST	FREQUENCY
Asphalt Content – Tested by VTM-102 ignition Method or VTM-90 Nuclear gauge as directed by the engineer	**Micro-Surfacing** -One test per 500 tons of aggregate unless problems arise requiring more frequent tests. **Slurry** – Sample representing a maximum of 25,000 square yards from each mixing unit until consistent, then reduce to minimum of 50,000 square yards.
Consistency – ISSA Tech. Bulletin 106 Cone Test	Contractor tests minimum of 2 tests for each day's production or as directed by the engineer. Performed during test strip and production.
Wet Track Abrasion – VTM-14	Materials from job site according to VDOT Acceptance Plan
The emulsion should be checked for "sieve" (oversized asphalt particles) using the standard No.20 sieve.	One test per day or one for each transport load that is delivered to the job site.
The pH of the job site water should be checked to be sure it is in the same range as the system emulsion/aggregate mix.	Once at the beginning of the job and again if the water source changes.

INSPECTION RESPONSIBILITIES AND PROCEDURES

Note: The Contractor must have a VDOT certified Slurry Surfacing Technician on the job site to control the work.

Successful construction requires continuous checking, coordination, planning, good judgment, and an overlapping of efforts by informed and qualified parties. This responsibility demands that the inspector be honest, knowledgeable, and courteous. It demands developing the skill of observation and common sense to do the job effectively.

During construction, the inspector has the authority to identify and point out to the contractor situations in which job plans and specifications are not being followed. The inspector has the authority to reject or suspend payment for any work that does not meet job requirements. However, the inspector does not have the authority to supervise the contractor's workers or to give orders.

Central to maintaining work quality and conditions, the inspector must have a friendly, workable relationship with the contractor, a relationship in which both parties understand and respect each other's viewpoint.

CONSTRUCION PHASE CHECKLIST:

- Source of materials is sampled and approved by testing laboratory or certified upon receipt.
- Pavement surfaces are clean and prepared for the slurry surfacing.
- Utility covers are protected.
- Weather limitations are observed.
- A copy of all truck delivery tags is collected on a daily basis. If payment is made by weight of material.
- Certificates of compliance are received.
- Beginning of slurry is properly made with building paper.
- Tie-ins to adjacent surfaces are as required

CONSTRUCTION PROCEDURES

BEGINNING WORK

The contractor must perform ignition oven calibrations and submit them with the job-mix formula to VDOT two weeks prior to the beginning of the work. Upon request by VDOT, the contractor will provide six quarts of liquid emulsion and 50,000 grams of aggregate material for use to determine asphalt content. The contractor must notify the engineer at least three work days prior to beginning work.

Test Strip – Prior to beginning work, the contractor must place a test strip for approval by the Engineer. The mix consistency shall be determined by the contractor in accordance with the International Slurry Seal Association Technical Bulletin Number 106 and shall be 2.5 cm, ± 0.5 cm. Calibration data for the slurry machine must be provided prior to placing the test strip. The slurry mixture should form a creamy textured slurry that when spread will "roll" in the spreader box ahead of the strike-off squeegee. Slurry that does not roll is sufficient reason to reject the test strip.

STOCKPILE

The contractor will need to set up one or more staging areas for the stockpiling of aggregates, emulsion and additives, and to use for equipment storage and maintenance. The ground at the stockpile site should be kept clean

and free from vegetation or deleterious materials. The ground must be firm enough so that even when wet the tankers will not sink in or topple over. Adequate space must be provided for loading slurry machines or support units. Ideally the location should be a fenced and gated area, and close to the project work to minimize the transportation time. Locks should be placed on emulsion tank quick-connect caps or valves to prevent vandals from releasing the emulsion onto the ground.

Avoid segregation and contamination at stockpile sites. When loading the aggregate, always keep the crane or front-end loader bucket at least 6 inches from the base of the stockpile to avoid scraping up deleterious material which may effect slurry surfacing application. Any oversized aggregate should be removed by a screening unit which may be located at the plant or stockpile. Small oversized aggregate will cause drag marks in the mat while large oversized aggregates will damage the mixer or pugmill on the application machine.

The foreman and the operator should watch the material for any change in the gradation, color, or behavior of the mix, which could indicate that the aggregate source was changed or the wrong material was delivered.

SURFACE PREPARATION Prior to the slurry operation all cracks, base failures or other required repairs should be completed.

Cleaning the Surface – The entire surface scheduled for coating with slurry should be cleaned of all vegetation, loose material, silt spots and any other objectionable matter. For this purpose, conventional methods such as power sweeping and air blasts are effective. Washing with water should be avoided.

Sweeping with a mechanical broom usually works the best, although recent improvements in vacuum sweepers have allowed successful use of this type as well. The important factor is that the broom must be designed for street sweeping, a parking lot sweeper will not do. A pickup broom is necessary where the road has curbs and gutters whereas a kick broom is sufficient if moving the dirt off the side of the roadway is acceptable (such as most highways). Grass and weeds thrive on asphalt and will need to be removed (dug out) or destroyed by a chemical weed killer before the slurry is applied.

No asphalt surface will adhere properly to extensive grease spots or oil saturated surface and these should be removed or treated before applying slurry. Using industrial detergents will assist in scrubbing such spots away. For severe problems, acrylic sealers are available for oil spot treatment.

Unpaved areas require a heavy prime coat of asphalt to water-proof and toughen the surface of the base. Light tack coats of diluted asphalt emulsion are effective in improving the adhesion of slurry to existing concrete and brick pavement and to asphalt pavements that are excessively dusty or have polished aggregate that is extensively exposed. Material for an effective tack coat consists of three parts of water and one part of an emulsion. An application rate of from 0.05 to 0.10 gallon per square yard is recommended. The actual rate depends somewhat on the actual residual asphalt content after dilution, but primarily upon the texture and absorption characteristics of the old surface.

Utility and Casting Protection – Manhole covers catch basins, and valve boxes need to be protected. This may be done by using several methods:

- Cut a piece of roofing paper to fit the cover and stick it in place, using a spray glue.
- Remove the covers, put them in plastic bags and replace them in their original position.

Each procedure requires removal of the protective device at the end of each day.

To insure that all utility covers are located and accounted for, the covers should be counted and a sketch of locations or reference each cover with a temporary marker on the adjacent curb.

Pavement Markings

Water-based Paint Markings - Unless the striping is very new, or has substantial buildup, there is not normally any need for special treatment, slurry will adhere to normal, worn water-based paint traffic stripes.

Traffic tape – Traffic tape should be removed

Thermoplastic Markings - Thermoplastic pavement markings must be removed prior to placing a slurry mix. Slurry will not stick to thermoplastic unless it is well worn and rough. The box tends to skin the material from the surface. There are several approaches to handling this situation. An alternative to removal is protecting the thermoplastic with tape and paper during the slurry operation. This is very labor intensive and presents problems with the spreader box tearing the paper. Referencing with temporary markers or reference stakes may be needed.

Another alternative entails squaring off a block of area around the pavement marking (Stop, Rail Road Crossing, School Zone, etc.) and use tape or building paper to keep the Slurry away from the thermoplastic. This method is favored since it not only preserves the markings but also prevents the slurry from tracking onto the thermoplastic.

Raised Markers - Plastic covers are available that will protect the markers. These are often not successful as the spreader box tends to pull the covers off. The markers may be taped and then uncovered afterwards. This is very time consuming and labor intensive but may be acceptable if the number of markers are small. Another option is to remove the markers and replace them after the resurfacing is completed.

Street Gutters - Concrete valley gutters are occasionally found on residential streets. These are normally not a problem for the crew to work around and the slurry is not placed on the concrete.

Railroad Tracks – Intersecting railroad tracks are normally handled by stopping the slurry at the edge of the railroad right of way. Never allow the slurry to enter the track area itself without a permit issued by the railroad.

Traffic Control - All highway traffic control should be done in accordance with the applicable agency standards for traffic control and safety.

City/county roads: The application of slurry requires that the area being surfaced be closed temporarily to all traffic, both pedestrian and vehicular. Any kind of traffic on uncured slurry will cause unsightly tracks.

Notification should be given to residents and businesses at least 24 hours prior to the beginning of slurry surfacing from damage by traffic until such time that the mixture has cured sufficiently and will support traffic without damage. Law enforcement officers should be available to arrange towing of vehicles not moved from areas to be slurried and to apprehend willful violators of the barricades.

Temperature/Weather Guidelines

Pavement temperatures play an important part in the curing of the slurry mixes as all mixes rely in some part on the evaporation of water from the cured product. Nearly all slurries in use today are “quick set” and form a chemical set at early stages: evaporation then dries the final product. Advanced slurries and micro-surfacing actually “push” the water out of the mix to allow evaporation to begin earlier. Humidity can effect set times by delaying the evaporation process.

Although slurries may be traffic ready in a short amount of time, some water may remain in the mix for a few hours. Freezing could cause a problem if this occurs. **All asphalt emulsions are ruined if the water in the emulsion is allowed to freeze**. No slurry should be placed when there is danger that the finished product will freeze within 24 hours of placement.

Whereas low temperatures will extend the set times of the slurry, hot temperatures will accelerate the set. During warm days the crew will increase the use of spray bars to fog the pavement as the road temperature increases.

The spray of water helps cool the surface and prevent the emulsion from breaking on contact with the pavement. Elevated temperature may require additional water in the mix to counteract the higher pavement temperatures and dehydration in the spreader box.

Slurry is generally softer during the first few weeks of hot weather and at elevated temperatures will take a longer time to form the final cure, sometimes several weeks. During hot periods, vehicles may peel or scuff the slurry under heavy torsional or lateral loading. Power steering abrasion is normal for all slurry surfacing and will be most prevalent in cul-de-sacs, parking lots, or any areas where vehicle turning is restricted.

Application:

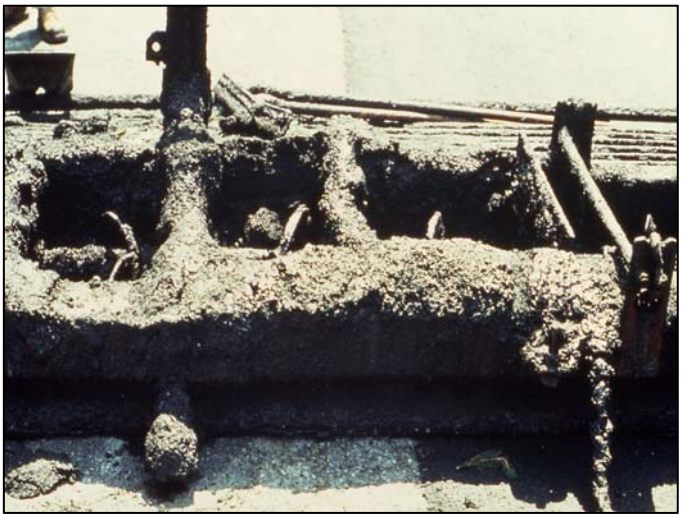
The slurry surfacing surface course should not be applied if puddles of water are on the surface. It should not be applied if the pavement surface temperature is below 50°F, but may be applied when both pavement and air temperature are above 40°F and rising, and the ambient temperature is expected to be above 60°F. An additional requirement is that there is no forecast of the ambient temperature dropping below 32°F within 24 hours from the time the material is applied.

Slurries that cure by evaporation should not be placed during periods of abnormal high humidity, or when rain is expected within a few hours. Slurries that cure by chemical ejection of water are much less effected by humidity. No slurry surfacing should be placed if the weather is foggy or rainy.

Spreader Box: There are many types and variations of spreader boxes but they all perform the same function: the spreading of the slurry mixture in a uniform manner onto the pavement. Spreader boxes range from simple, light, non-adjustable units to large boxes equipped with augers, special runners, and hydraulic controls. Specialized boxes are used for rut filling and may be used for special shoulder work, and variable width spreading. The box which should be used for a slurry surfacing project depends on the type and spread rate of the slurry but often comes down to personal preference. The contractor will provide the appropriate box for your project.

1. Cleanliness is mandatory in a spreader box. The box must be cleaned at the end of every work period and may require cleaning (especially the rear rubber) during the work day if excessive buildup of slurry takes place to the point it causes streaking in the mix.

2. The spreader box should not leak slurry. Side rubbers (where appropriate) should be installed so that edges are kept neat. The rear box rubber (or steel) should leave a uniform thickness and strike off the slurry material so that there are no uneven ridges or longitudinal ripples left in the mat. The rear rubber may be changed in thickness, width, and hardness to achieve desired results.



3. The spreader box should pull smoothly and evenly without vibrations. Machine speed should be kept uniform. Excess speed can cause the box to vibrate or jump leaving transverse ripple lines in the slurry. If using a drag (typically a short length of burlap) excess speed can cause it to leave a rippled and uneven mat.

Proper Strike Off Rubber: The correct rear flexible screed helps allow the mix to be applied at proper depth. Strike- off material too thick or hard will segregate the material and hold the larger aggregate in the spreader box while material too soft or thin will allow multiple layers of slurry to pass under the screed. Various rubber or synthetic materials are available at different levels of stiffness. Some micro-surfacing applications may even require a steel strike off.

Drag Types and Uses: A drag is often used to produce a uniform textured mat. A drag may consist of canvas, burlap, carpet or other materials chosen to produce a particular texture. For heavy materials such as Type C and micro-surfacing, a second rubber strike off may be used in place of a drag for beneficial mat texture. If a drag is used on the spreader box, the same material should be attached to the squeegees (or used separately) to have handwork duplicate the results produced with the spreader box.

A drag used improperly can cause large stones to be rolled into a position where they are not properly imbedded in the mat. The drag length, height, and thickness should be adjusted for each specific aggregate gradation or slurry system. Drags need to be replaced when they become torn or stiff as with asphalt.

Handwork: Most slurry surfacing projects will include areas that are not accessible to the spreader box. There areas are covered by the use of squeegees (asphalt lutes are often used for very heavy slurries). If drag mops are being used on the spreader box, drag mops must be used on the squeegees as well to give matching texture.

The cardinal rule for handwork is "<u>least is best.</u>" The more the slurry mix is worked the more segregation takes place. As the squeegee moves the matrix back and forth the larger aggregate is worked to the surface while the fines may be lost and the mix can dehydrate. The coarse aggregate is then inadequately embedded and may ravel.

When handwork is being done, care should be taken to wet the existing asphalt surface first and to be sure the finished slurry surface is uniform. Water in the mix reduces pavement surface tension and helps the squeegee persons to move and work with the slurry. Slurry that has set during handwork should be removed.

Lateral Joints: Lateral joints are best controlled by placing tar paper on the surface being slurried. This is normally only required at the start and end of each street and not at the joints between. Heavier application rates such as a Type C may require a butt joint procedure to assure a smooth transition.

Longitudinal Joints: This is critical in highway and high speed applications where slurries such as a course Type B or a Type C require minimizing overlaps. Micro-surfacing shall not overlap more than 4 inches, except on irregular roadway widths when approved by the engineer. Areas of overlap may cause problems with bleeding, displacement, and may leave an uneven surface. Suitable width spreading equipment should be provided to produce a minimum number of longitudinal joints on a project. When possible these joints should be placed on the lane lines. Half passes and odd width passes should be used only in minimum amounts. Residential and low volume streets slurried with a Type B normally do not require special treatment of longitudinal joints.

Application: The surface should be pre-wetted by fogging through the spray bars of the slurry machine, ahead of the spreader box when required by local conditions. The rate of application of the fog spray should be adjusted during the day to suit temperatures, surface texture, humidity and dryness of the pavement surface. Water used in the pre-wetting of the surface should be applied such that the entire surface is damp with no pooling of water in front of the slurry box.

The surfacing mixture should be of the desired consistency upon leaving the mixer and no additional materials should be added. The mixture should roll in a continuous mass in the spreader box. A sufficient amount of material should be carried in all parts of the spreader so that a complete coverage is obtained. There should be no lumping, balling or unmixed aggregate in the mixture.

No streaks or grooves, such as those caused by oversized aggregates, should be left in the finished surface. The mixture should be uniform and homogeneous after application and should not show separation of the emulsion and the aggregate after setting.

Application Rates:

One of the primary advantages of slurry surfacing is the ability of the application process to automatically address the surface demand requirements. The correct

application rate of the slurry surfacing can have a pronounced affect on the success of the project. Excessive thickness can result in rippling, displacement, and segregation. Inadequate thickness can cause excessive raveling and reduced life. Application rates may vary during the project due to changes in the existing pavement surface demand. This variance is more pronounced in thinner lifts. Two primary factors determine optimum rate of application, aggregate gradation and existing surface texture.

VDOT Application rate for slurry seal is 16 pounds per square yard for Type A and Type B. For Type C the application rate is 20 pounds per square yard.

Latex modified emulsion treatment for leveling course shall consist of an initial application to prepare for the surface course. The minimum application rates shall be 16 pounds per square yard for Type B and 20 pounds per square yard for Type C.

Latex modified emulsion treatment (LMET) for surface course shall consist of the final application which serves as the pavement surface. The LMET shall be placed at an application rate of 16 to 20 pounds of mix per square yard for Type B and 18 to 22 pounds per square yard for Type C.

Where neither rutfilling nor leveling is used, the mix application rates shall be 18 to 22 pounds per square yard for Type B and 20 to 24 pounds per square yard for Type C.

Aggregate gradation: Aggregate within specification but on the coarse side, i.e. made up of greater percentage of larger size, must be applied thicker. If not, inadequate embedment of the largest aggregate within the emulsified asphalt binder will occur, causing streaking where larger stones are caught by the strike-off rubber and/or raveling. Conversely, aggregate on the fine side, i.e. made up of a greater percentage of smaller size aggregates, must be applied thinner. Slurry seals are designed to be applied one stone thick (based on the largest stone in the gradation) and forcing the slurry to be placed thinner, thicker or the placing of multiple layers to increase thickness will create an unstable seal and may lead to reveling, bleeding, rutting and/or wash-boarding. Multi-stone depth thickness requires the use of micro-surfacing.

Existing Surface Texture: The existing surface void content will directly affect the lay down rate of the slurry surfacing. The more porous the surface the more material must be placed to satisfy the surface demand. The amount and size of voids on the surface of the existing pavement is affected by many factors: size of aggregate in the existing asphalt, percent of fines in original mix or loss thereof since placement, percentage of compaction at lay down, and type and coarseness of seal coats previously placed on the original surface.

A slurry placed over a badly raveled asphalt may require the material to be properly applied as a tight surface of very low voids with the same gradation of material.

Properly applied Slurry will have the largest stone embedded at least 75 percent. Slurry placed too thin may have drag marks and possibly even bare areas where the spreader box has pulled all but the finest aggregate and emulsion off of high areas in the pavement. During placement under this condition the larger aggregate can be seen accumulation the spreader box as the unit proceeds down the street. This will make handwork at the end of the street difficult and unsightly.

Inspector's Note: A review of the key points in determining application rates should include:

1. Aggregates may vary in distribution of particles in various sieve sizes. A Type B aggregate from one supplier may be finer than a Type B from another supplier and thus would be applied lighter. Aggregates produced by different types of crushers from the same parent rock may produced different shape particles. For instance a cone crusher will produce nugget shaped particles while an impact crusher will produce long flat slivers.
2. Aggregates may vary in unit weight and a thicker application of one rock may actually weigh less than a thinner application of another.
3. Surface texture will affect the application rate. A smooth surface does not have as many voids to fill and thus keeps the spread rate at a minimum. A weathered, raveled, open surface will increase the spread rate as the material fills the voids at the same time it is covering the surface.
4. Surface textures will often vary on the same road between traffic areas and shoulders or centerline areas. Application rates will vary with surface texture and thus may vary across any given cross section of a pavement.
5. Ruts not filled under a separate procedure will affect application rate. A single rut of even minor deformation will increase the total average application rate as the rut must be filled to the level of the existing pavement during the application process. See the section on Ruts for additional information.

Monitoring Application Rates: The inspector should monitor the project daily to track the amount of materials being placed. This may be accomplished by keeping a list of the quantities of material on each truck as it is placed or tracking deliveries of material to the project and deducting waste. When available, another method is to use calibrated counters on each unit and tabulate total materials from those counters. Dividing the weight of materials by the area slurried gives the actual application rates. Backup data may be obtained by tracking materials delivered less any materials left at the end of the project.

Proper Moisture Content: A proper slurry mix will have consistency similar to that of fresh Portland cement concrete. Adequate water must be in the slurry surfacing mix to

provide “free emulsion” for tack coating. If the mixture is too wet the emulsion will run into the gutter. If it is too dry the mixture cannot be mixed uniformly throughout. If too wet, the mixture has inadequate viscosity to remain homogeneous, so the large aggregate falls to the bottom and the emulsion and fines float to the surface. This could produce a surface that will be very black and shiny.

A dry slurry has inadequate “free emulsion” to properly coat the aggregate or bond to the pavement. Very dry mixes will normally allow the slurry to “break” or “set” in the spreader box before it can be applied.

Slurry Applied Too Dry

Slurry Applied Too Wet

Uniform Emulsion Content: Adjustments may be necessary in the field within the limits of the mix design. Different emulsion percentages may be required for the same aggregate when applied under different traffic and/or weather conditions. With a mix design, the inspector's focus is to verify that the Slurry is being placed in accordance with that design. Since the mix design tells what percentage of emulsion is optimum and the calibration chart for each machine tells what gate setting will produce that percentage, the inspector needs only to verify the gate setting of the machine to know that the proper percentage is being placed. That may be cross-checked by tabulating total tons of aggregate and total tons of emulsion placed each day. This comparison is a simple means to see that all machines are remaining in calibration and are, in fact, producing at the percentages previously calibrated.

Color Variations: Uniformity from one machine to another is important. Machines producing at different percentages will result in a color variation of the finished product. This color variation is normally not discernable to the eye until the slurry is totally set, usually the next day.

There can be color differentiation between slurries placed when the temperature varies substantially. Slurry placed at or near 50°F may be somewhat "rusty" in color as opposed to the same materials laid at 80°F or above. This condition is very different from emulsion percentage not being consistent.

The two can be distinguished in that color differentiation due to temperature will be uniform from one pass to the next and is usually magnified on pavement areas that were shaded at the time of application. This color difference will dissipate as the slurry is exposed to traffic and elevated temperatures. It does not affect the quality of life of the slurry.

Rut-Filling: When ruts have a cross section that is deformed ½ inch or more they should be treated with micro-surfacing and rut box. Ruts overfilled with normal slurry seal, or with full width micro-surfacing applications can compact, displace, washboard, or become slick.

Rut filling with a depth of 1/2 inch or greater must be constructed using a special rut box specifically designed for the purpose. Rut boxes are designed as a double chambered box with adjustable screeds to regulate depth. Hydraulic augers set at an angle move the mixed material from the rear to the front of the filling chamber. The augers serve to push the larger stone into the center deeper section of the rut and send the fine material toward the edges of the pass to act as mastic and for feathering down the longitudinal joint.

Rut boxes are manufactured in both a 5-foot and a 6-foot width. The five foot box will leave a gap in the existing pavement coverage when applied to a 12 foot lane width with dual ruts. The 5 foot box is normally used when full width surface application is specified in addition to the rut filling work. The six foot box will fill both ruts and provide complete coverage of the lane. A 5 or 6 foot box can also be used for single rut application in a lane where only one rut may exist.

Rut repair requires the contractor to slightly overfill the rut to allow for traffic compaction of the mix. A guideline is to overfill the rut 1/8 or 1/4 of an inch per inch of rut depth.

If the depth of a rut is in excess of 1-1/2 inches, it may be advisable to go to a larger aggregate than the rest of the project requires. Deep lifts may be constructed on the low side of the optimum asphalt content range. Normally desired, this may not always be true it the existing pavement condition is dry and absorptive.

Power Steering Abrasion: Slurry seals will abrade and tear under high torsional or lateral loads in the early weeks after placement. High pavement and ambient temperatures will compound these occurrences until the slurry stabilizes at the higher temperature. If the temperatures continue to increase, the marks will continue to occur. Asphalt in relation to aggregate is a lubricant; therefore the problem will be heightened if the mix has a high percentage of asphalt. Power steering turn marks are to be expected when the slurry is in abrasion. These marks generally “roll out” with traffic.

Quality Control: Achieving the highest possible quality in slurry is the primary responsibility of the contractor and it is also the key to his continued success in the slurry surfacing business. To the customer, quality is of prime concern, and the knowledge, skill and attention which his inspector applies to a slurry project are a major importance in precluding errors.
A summary of the more important items to watch for:

1. Select and use only aggregate and emulsion which have been found to meet existing specifications individually and which are known to be compatible with one another. Select aggregate of the gradation type best suited to the condition of the existing pavement.
2. Always keep all parts of the slurry machine and of the spreader box clean and in good working condition.
3. Place the slurry at the proper thickness determined by aggregate size and surface conditions.
4. The slurry machine should be calibrated using materials selected for the job. Previous calibration data covering the same materials to be used may be

acceptable providing they were made during that calendar year. Calibration should be spot checked periodically or when any material is changed significantly.

5. The pavement to be slurried must be sound, clean and moistened by water fogging from the slurry machine, but free of puddles of water.
6. Adjust the rate at which water is supplied to the mixer so that a stable homogeneous slurry is produced. To this end the percentage of pre-wet water should be kept at about the midpoint of the range which the laboratory has found to be permissible. Keep in mind that the water content varies according to pavement and climatic demands.
7. Unless pulling partial width passes, slurry discharged from the mixer should be distributed so that each front compartment of the spreader box is covered completely. Slurry in the box should appear to roll as the box moves forward.
8. The forward speed of the machine or the flow of slurry into the spreader box should be adjusted so that the total quantity of slurry in the spreader box remains essentially constant.
9. Adhere to the proportions specified in the mix design.

Keeping the Job Clean: During and at the completion of a slurry project, it is important that all areas involved be kept clean and orderly. Daily inspection of the loading area is suggested, with particular emphasis on the emulsion loading area. Final acceptance of the job should be deferred until the inspector is satisfied that all areas involved have been restored to their original state of cleanliness.

CONSTRUCTION CLOSE OUT:

The inspector and contractor should cooperate in accomplishing the following objectives:

1. Agree on and accomplish any final punch list items.
2. Perform a final inspection.
3. Prepare a final pay estimate.

In summary the components necessary for a user to procure a quality slurry surfacing project include:

1. A mix design by a qualified laboratory.
2. High quality materials.
3. Quality, well maintained equipment.
4. Quality inspection.
5. A quality contractor with trained knowledgeable personnel.

PROBLEMS, SOLUTIONS and SUGGESTIONS:

Appearance: Normal slurry surfacing looks its very worst immediately after being constructed. It needs traffic to seat the aggregate and to iron out the mat.

Raveling: All slurry will shed some aggregate during the first few days of traffic. This is normal but should also be minimal. Aggregate particles may be loosened from the slurry for many reasons:

1. Natural process where traffic dislodges larger particles that do not have sufficient embedment in the matrix.
2. Cooler temperatures may result in increased raveling due to slowing of the cure prior to initial traffic.
3. Application rate is not sufficient to hold larger aggregate particles in place.
4. Asphalt quantity is too low to bind the aggregate in place.
5. Poor quality aggregates may disband from the slurry.
6. A lack of fines in any aggregate – fails to fill voids between larger particles.
7. Premature opening to traffic.
8. Rain prior to complete setting of the material.

On residential streets and parking lots where traffic is very light it may take weeks for traffic to mat out the finished slurry.

Improperly mixed materials at the beginning and end of passes: Older machines that require each mix component to be engaged by the operator can be started improperly or out of sequence. Newer machine having automatic sequenced starts, once properly set, will automatically proportion each material as required.

If the material is too wet, the water was being started too soon. If the material is too rich in asphalt, the emulsion was started too soon.

Bleeding or fat spots: Too much emulsion in the mix or floating of asphalt to the surface – caused by too much water or emulsion or due to heavy overlapping.
Possible solutions would be to verify machine calibration and/or minimize overlaps.

Hot Emulsion: Hot emulsion can cause the mix to break too fast or cause false slurries. Emulsion is manufactured at temperatures ranging from 170 to 190 °F and is usually delivered to the job site at temperatures from ambient to 120 °F. On cool days the extra heat (over 100 °F) helps promote set, but on hot days this additional heat may present problems.

To help workability and allow emulsion to be used under these conditions the operator could add more water and/or more additives to slow the break of mix. The easiest, but

often not the most practical solution, is to let the emulsion cool down to a workable temperature.

Road Temperature Too Hot: The effect of road temperature will vary depending on the emulsion/aggregate system being used. Hot surface temperatures accelerate set and reduce available mixing time. Wetting the surface with water from spray bars and hand hoses helps keep pavement temperatures down. Slightly less slurry in the box cuts down on box time. On very hot days start to place the slurry during early morning hours when road temperatures are at minimum. See also: False Break.

Power Steering Marks: Although primarily a parking lot problem you may also see occurrences of “scuffing” along curbs where parallel parking is allowed. This tearing of the surface is unsightly but normally is not a matter for concern. Most “scuffed” areas will mat back in place as traffic rolls over them although some surface blemishes might remain. Slurry is susceptible to scuffing for the first few weeks after it has been placed, although reoccurrences may appear during periods of hot weather.

Parking lots have a real potential for power steering marks. Tight turning and congested parking aggravate the situation as cars need to turn their wheels when the car is not moving. The bond of the slurry to the pavement verses the bond between the slurry and the tire produces a real challenge to the laws of physics.

Scuffing can be reduced by a number of means:

1. Using a harder asphalt
2. Adding latex or polymer additives for strength.
3. Rolling of the slurry with rubber tired roller.
4. Placing the slurry during the cooler months of the year. Allowing the asphalt to cure prior to the next hot season.
5. Broadcasting of sand on a new surface will help break the bond between the slurry and the tires although this is unsightly and may discolor the slurry.

Rolling of Slurry: Seldom required for most slurries, rolling is used for some airport projects and parking lots that may not receive the desired traffic rolling or where loose aggregate may cause foreign object damage. If rolling is specified, a rubber tired roller should be used. This will allow the tires to knead the surface and compact all areas. Steel wheel rollers tend to bridge on the high spots, do not compact the low areas, and will search and mark the surface as well as crush the larger aggregates.

A common 10 to 12 ton nine-wheel rubber tired roller is adequate. Roll about two coverages. Rolling should be done as soon as slurry is set up enough to support the roller and will not pick up on the tires.

Hand Work – Large Areas: Usually a parking lot problem, areas such as drive-up windows, multi-parking carport areas and areas too tight for the machine to pull have to be done by hand. Hand work in these areas require special attention to produce a satisfactory finish that matches the slurry placed by machine.

Work in these areas is best done early in the day when cooler ambient and pavement temperatures allow extra time for the mix to be worked before the set begins. Squeegees should have mops that closely match the one used on the box. Water should be sprayed on the surface first to be sure the material does not dehydrate while being placed. Any material that breaks prior to being placed must be removed.

POTENTIAL CAUSES OF UNSATISFACTORY SLURRY

Slurry Surfacing Over Crack Seal Materials: Placing slurry on a pavement that has been crack sealed has potential problems. Some of the common problems associated with slurry over crack fillers are:

1. Incompatible materials, Crack fillers that use rejuvenation agents or solvents will bleed through the slurry.
2. Flexible materials such as rubber based crack fillers will not remain bonded with slurry. As the rubber flexes with traffic the slurry will disband.
3. Crack fillers that have not properly cured or have been sprayed with a tack coat will adhere to the tires of the slurry machine and will be dislodged.
4. Crack filled using the “overfill” technique, where a band of material is placed above the crack 3 to 4 inches wide as part of the crack filling process, create problems when the spreader box skids run into these ridges.
    - The skids can hook onto the material and pull out pieces as it moves along or, worse yet, may pull out the whole string of material placed it the crack.
    - Pieces of material torn loose or dislodged may leave a gouge or streak in the mat or protrude out of the mat leaving it unsightly.
    - Hard ridges will force the box skids to ride up over the ridge which changes the amount of material placed by the box, possibly leading to an uneven surface.

The best preventions for slurry surfacing/crack filler problems are:

1. An understanding of the potential problems.
2. Compatible materials.
3. No overfilling of the cracks.
4. Proper curing time prior to the slurry.

B. Color Variations in the Slurry Surface: Slurry can cure in color variations from tan to grey to black. These variations, while not usually detrimental to the performance of the slurry may occur. Variations in color may be caused by various mix and climatic conditions.

1. Cement – When cement is used the slurry could set up with a dull black color and could be grey on the surface.
2. Sulfate – Aluminum sulfate tends to promote a darker black color than cement systems although the sulfate can show outline stains on cured Slurry where water has stood. Water from rain and irrigation systems can cause these stains. The higher the mineral content of the water, the worse the stain. Fortunately these are temporary and disappear in a short time.
3. Additives – Additives used to promote adhesion, control the set, or otherwise enhance the mix may leave a sheen on the surface. This condition usually disappears with time.
4. Water – Excess water can cause the asphalt to float giving a slick black appearance. If water from a hand hose is incorrectly applied to placed slurry, emulsion can be washed off the surface and the slurry assumes the color of the rock. Rain on a fresh slurry, when a cement or lime was used as a mineral filler, may turn grey or ashen.
5. Temperature – The same slurry mix placed on adjacent surfaces of different temperatures (such as shaded verses unshaded) may dry slightly different colors. This usually disappears with traffic and elevated temperatures.
6. On a multiple machine operation, color differences may occur from machine to machine. If they are not set to deliver the same proportions.

C. Leaks from Equipment: Any material (sulfate, aggregate, hydraulic oil, diesel, etc) will cause adhesion problems.

D. Loader operator can contaminate aggregate while loading: If rocks, dirt or other contamination are seen in the mix you should check the stockpile. Improper loader operation may have dug into the dirt or otherwise picked up objectionable materials. Loader operators must leave a floor or a pad underneath the aggregate pile when loading.

E. Shaded Areas/Cool Weather: Shade is not normally a problem but in early spring or late fall when temperatures are low, shaded areas must dry without the benefit of sun or warm temperatures. Placing these areas early in the day will help the curing and promote adhesion. In extreme causes it may be necessary to stop work in these areas earlier in the day to allow time for curing.

F. Rain on Fresh Slurry: Many factors come into play: how much rain, how long has the slurry been down, temperature, traffic, etc. Damage can vary from simply extending the drying time to washing all of the emulsion out of the mix. In general, assuming light traffic, if the slurry has chemically set, the rainfall is light and the duration is short, the slurry may be slightly discolored but will remain sound. A chemical set may take place in as little as five minutes with the fast setting material and within 15 or 30 minutes for a normal quick-set.

Light Rain: Keep the road closed until dry then turn traffic loose.

Moderate Rain: Slurry that has had the emulsion washed off the top of the rock can be allowed to set up and then sweep off any loose rock. If the damage is severe, a new application can be placed over the remaining material.

Heavy Rain: Slurry that has suffered a major loss of emulsion can be swept and re-slurried. Cleanup of emulsion in the gutters may have to be addressed.

G. Slurry on Tires: Machine tires can pickup and track freshly placed slurry. The units may have to drive on fresh slurry while placing and may often have a coating of slurry on their tires. Tires can not be allowed to pull large patties of broken slurry off the pavement and deposit them somewhere they are not wanted such as the surface yet to be slurried; where they are mixed with the slurry and produce lumps in the finished surface or dragged into the box and leave gouges and/or streaks in the mat. These problems can be eliminated by the operator using the hand hose or spray bars to wet the slurry, The tires, or the pavement surface so the tires do not stick. Water will cool the pavement and form a barrier between the slurry and the tries.

H. Previously Sealed Surfaces: Slurry may be used over most asphalt-based sealcoats. Sealcoats such as coal tar, however, do not allow the slurry to adhere to the existing seal and the slurry will fail unless the coal tar is old, well worn or the existing surface is very course. Very fine sealcoats may present another problem, the slurry may stick, but the surface is so smooth that power steering marks are more of a problem.

Unwanted Slurry on Concrete: Slurry spilled or tracked onto concrete should receive immediate attention. Depending on the situation, squeegee persons should squeegee or shovel excess material off the concrete before it sets. Prompt attention and a hand hose usually leaves no stain on the concrete. If the spill is no treated promptly, it can usually be taken care of by dusting with cement or making a fine cement mix and brooming it on the affected area. In extreme cases, water or sand blasting may be necessary.

Trucks leaving the slurry seal area with slurry emulsion on the tires can leave tracks across concrete valley gutters or sidewalks. Here are several methods to prevent this from happening.

1. Sand valley gutters/sidewalks with slurry aggregate.
2. Dust valley gutters/sidewalks with cement.
3. Pre-wet the gutters/sidewalks with water.
4. Wash off as soon as truck drives over the waterway.
5. Apply felt paper where tire tracks would be and throw a few shovelfuls of aggregate on the felt paper to keep it from moving.

False Break: Under unusually intense summer conditions. Evaporation of moisture from an exposed slurry surface can become so rapid that a blanketing film or “skin” of semi-solid asphalt is formed. Such a film seals in the moisture remaining in the balance of the mix and tends to extend the time required for complete cure. This problem is called “tender mix” or “false break” and occurs most often under a combination of high and low humidity conditions which promote rapid evaporation of the water in the slurry mix and a faster chemical break.

False Slurry: A false slurry occurs when extensive agglomeration of asphalt takes place on the fine aggregate during the mixing process. When the material cures, the asphalt will be unable to create an even film on larger aggregate particles. This could create an adhesion problem.

A false slurry is often difficult to recognize. Excessive foaming or grey color of the wet mixture of emulsion and aggregate usually indicate the problem. Sometimes an excess of uncoated large aggregate particles indicates false slurry.
A simple field test can often assist in identifying false slurry. Mix fresh materials, taken immediately after release from the box in a beaker with water. True slurry will turn the water brown indicating a high content of “free” or unbroken emulsion. In extreme case, false slurries will mot appreciably discolor the water with free emulsion.

Control of the Water Content: There is a strong tendency to add too much water because this makes mixing and distribution go more smoothly, especially when a wide spreader box is used. The use of augers in the spreader box has reduced this problem.

A simple test to determine if excessive water is used is to draw a line in the slurry with a stick. If the depression fills with fluid, the slurry contains too much water.

Oversized Rocks and Agglomerated Lumps of Aggregate: In spite of normal precautions at the original source of the aggregate, and in its subsequent handling and stockpiling, an occasional piece of rock having dimensions greater than the thickness of the slurry Layer may get into the aggregate bin. If large enough, such oversized

pieces may cause mechanical damage to the slurry machine. When such pieces pass through the mixer and into the spreader box they may eventually become lodged under the lower edge of the rear squeegee, and there produce unsightly longitudinal grooves in the finished Slurry surface.

Some types of aggregates, when exposed to heavy rain, tend to dry in lumps or balls. The drier these become, the more difficult it is to disintegrate them again. The tendency to lump is greater in materials having a low sand equivalent, which indicates high content of clay or silt. Under some conditions such agglomerated balls of aggregate may pass through the mixer without being broken up. Once in the spreader box, they may cause longitudinal streaks, similar to the defects caused by oversized rocks. The lumps may also disintegrate under the rear squeegee, which then drags out the uncoated material into light colored streaks in the exposed surface.

Depending upon the consistency of the slurry being placed, pulling a burlap drag behind the spreader box may be effective in obscuring the streaks due to oversized rocks or balls of aggregate. Quality control in the aggregate supply procedures is the best preventative measure. If the problem is severe, the aggregate will need to be screened or some other method used to remove or break up the clumps.

High Crowns and Banked Curves: In the absence of mechanical means for distributing slurry in the spreader box, it will flow by gravity toward the low end of the box. Partial compensation can be made for this if the operator diverts the slurry from the mixer entirely to the higher compartment. However, the only complete solution to this problem is to distribute the slurry mechanically in all compartments of the box. A successful means of doing this involves the installation of spiral or auger type devices in the box driven by hydraulic motors to force the slurry laterally as desired by the operator. Box designs vary and box requirements change for different types of slurry applications. In general, most augured (spiral or paddle type) boxes allow the operator to activate the augers on either right or left side, separately or in unison. He can also control the direction of rotation and the speed of each pair of augers. With proper use of the augers, a uniform mat can be placed regardless of the degree of crown or bank.

Steep Grades: As a result of the gravity flow of the slurry in the spreader box, some relatively minor problems are involved in laying slurry on grades steeper than about 8 percent. For an uphill operation application of a slightly more fluid slurry is recommended. This counteracts the tendency of the pressure of the Slurry on the strike-off squeegee to allow the deposited layer of slurry to be thicker than desired. On the other hand, use of a somewhat stiffer slurry during downhill operation will counteract the tendency of the Slurry to escape under the front squeegee.

Curbs and Gutters: The rubber on the spreader box are positioned so as to retain the Slurry within the box, with two purposeful exceptions. The rear of strike-off rubber

allows the slurry to escape at a desired thickness. A small opening is often purposely left between the side and back rubber to allow escape of a small amount of Slurry on both the right and left-hand ends of the box. This nominal amount aids in making joints and in handwork adjacent to curbs, but is not great enough to cause any run-off into gutters. Sealing the joint between pavement and curbs or gutters against moisture is very important.

In slurrying adjacent to either a gutter or a curb a skillful driver can simplify the task of the operator in moving the spreader laterally as required.

Cul-de-sacs: A cul-de-sac is a street that dead ends in a traffic circle from which there is no other outlet. Smaller slurry machines, and those mounted on cab-over-engine trucks are usually capable of following sharper curves. When the machine cannot follow a particular curve, hand work preceding machine operation is recommended over sufficient area that the machine will subsequently cover any remaining irregular edges.

Partial Width Passes: Occasionally it is not possible to slurry a width utilizing all full width passes. To avoid overlap in such cases, partial width passes may be used, the operator simply sets the diverter to supply that portion of the box being used, using the augers to assist in its distribution. A partial pass should never be the final pass.

PROBLEMS, SOLUTIONS and SUGGESTIONS: Micro-Surfacing

Material Sets Too Quickly: By design the micro-surfacing material will change or “break” from a liquid homogeneous mixture to a cold mix asphalt state very quickly. A problem occurs when this break takes place too quickly and broken mix or cold mix is actually placed rather than a liquid mix. The resulting cold mix will not bond to the pavement surface and will quickly come off. Therefore, it’s important to keep the material in the spreader box in a liquid state.

Several methods to help control this are:

1. Insure that the emulsion manufacturer has put enough emulsion during the manufacturing process.
2. Have the emulsion go through a curing stage to increase its stability. By allowing the emulsion to sit in storage for a period of time you not only facilitate stabilization of the molecules but you also allow for cooling. A high emulsion temperature (over 115°F) increases the reactivity of the material.
3. Keep the micro-surfacing mix in constant movement. Spreader boxes must be equipped with flight interrupted augers or paddles to keep the mix in motion.

4. All micro-surface systems allow the contractor to help control the mix break time by adding additional chemical to help slow it down, Each micro-surfacing machine should be equipped to do this.

Joint Overlap: The micro-surface is normally applied at a much thicker rate than slurry seal and extra care must be taken to minimize overlaps. When laying a mix from 3/8 to 1/2 inch thick, overlaps create a high point that is subject to increased abrasion from snow removal equipment and will create a water retention problem.

When working on highways or city streets, each lane should be placed full width with all joints on the traveled surface being constructed as butt joints placed on centerline or lane line.

Hand Work Areas: Due to the rapid “break” of micro-surfacing the operator should over-stabilize the mix with chemical additive for hand work to insure the material is in a liquid state for application. The micro-surfacing foreman should insure the area to be covered has been dampened by a water spray and enough people are available to spread and finish the mix before it breaks.

SPECIAL SITUATIONS ON PROJECTS

Freeway shoulders and ramps: Traffic is a concern on these types of projects due to the high speeds and extended work zone lengths. On and off ramps create a need for special traffic control and crew awareness. Motorists are preoccupied with entering the freeway and their attention is already divided. All crew members need to be aware of the higher requirements for a safe operation. Equipment drivers need to be aware of the high speed traffic when entering and exiting the work zone with slow moving slurry machines.

Due to the odd shapes and sizes, ramps need special planning to avoid large areas of overlap. Attention is also needed to assure that the seam lines are straight and uniform. Short passes with tapers or the use of an expandable box can aid in eliminating overlap.

Filling large cracks: Due to the economics of filling large cracks with conventional crack sealers some projects may require the use of slurry as a crack filling material separate from the normal slurry operation. There are different ways to apply slurry for this purpose.

Two methods are:

1. Build a small box with a holding compartment for the slurry. The box then be filled on one side of the road from a parked slurry truck then manually pulled transversely across the road over the crack.
2. Parking the slurry truck over the top of the crack and dropping material onto the crack. The material can then be squeegees across the crack with a conventional slurry squeegee or “V” shaped squeegees.

When slurry is used as a crack filler, the crack will eventually migrate through the slurry, usually at a smaller width than was originally present. It is then practical and cost effective to seal it with an effective crack sealant.

Protecting special markings and stencils: Stencils and markings, if not too extensive, can be covered by cutting fiber paper to size and/or taping them if they are not too extensive. If they are too numerous, remove and replace them. Use tape on the outside edges and keep it tightly bonded so as to prevent leaks.

These areas should be referenced so they can be found later. This eliminates problems with relocating the cover to be removed if the slurry erases its outline.

SPECIAL SITUATIONS: Micro-Surfacing

Profiling of Roadway: Minor rutting (under 1/2 inch depth), surface depressions and cross sectional irregularities may be such that a “scratch coat” would be recommended for effective repair prior to the actual micro-surfacing. The “scratch coat” is constructed using a micro-surfacing spreader box but with an adjustable rear strike-off mad of steel plate. The steel plate is set to drag off material from any high points in the road and fill low spots, ruts and irregularities.

By striking off the high point in a road, these areas will not have a uniform layer of material on them. This is corrected when the second or finish coat is placed using a standard strike off of rubber or steel to cover the whole width with a uniform pass of evenly textured material.

Grinding/Milling of Pavement: Micro-surfacing is a very effective method of covering a cold milled section of pavement. The liquid nature of the micro-surfacing will allow it to flow into the grooves for tight bonding. It will also smoothly flow over the top of the grooved pavement.

It is advisable to consider milling pavements that have asphalt rolled up at the edge line before re-profiling either with rut filling or a scratch coat. If the outside edge of the pavement is pushed up and the micro-surface is sued to re-profile, the road may lose

its crown and even become an inverted crown. Proper rot milling techniques should be used.

High Quarter Points: High quarter points (that area between wheel paths) can create a special area for concern. When applying the micro-surface with a full width lane surfacing box, care needs to be taken to insure that the area at the quarter point of the road has an ample amount of material covering it. This is easily accomplished by allowing the lay down box to flex or move at its center point. Also, roads with a high quarter point will in most cases require a flexible rear strike off be used rather than a rigid steel strike off.

Excessively rich, flushed, or bleeding asphalt surfaces create the need for special application techniques when applying a micro-surface. The flushed area makes it difficult to apply the correct application rate of material as the box rear strike off tends to pull the micro-surface in place; the material pulled along with the box and not deposited as evenly as it would be in non flushed areas. To correct this flexible rear strike off needs to be used, not a rigid strike off.

A double application may be preferred. The first application can be very thin and used much like a scratch coat. The second application will then adhere well to the scratch coat at the correct application rate. Also, when the application is made with two lifts, the second lift may be applied with the rigid strike off to maximize the materials re-profiling.

Raised Pavement Markers: The normal procedure is to remove and reset or replace these markers. Since the micro-surface is normally applied at a thick application rate, most of the markers would not be exposed enough to be functional. Also, the semi-liquid nature of the mix will stain the markers.

Thermo Plastic Markings/Plastic Tape Markings: It is important to remove the plastic lane delineation markings before applying a micro-surface. The micro-surface will not adhere properly to the plastic markings and amounts that do adhere will very quickly wear off. Even if the new marking is to be placed over the micro-surface at the same location as the original marking, it is recommended that the original be removed.

Existing conventional pained lines that have been repainted many times and have a thick paint buildup may also present an adhesion problem. Consideration should be given to removal or roughing up these areas as well.

Application Rates/Multiple Lifts: The micro-surface material allows construction in thick lifts but it does have a maximum depth limit when placed unconfined or with a surface box, using the existing ISSA gradations we would suggest that a Type C be placed on heavier than 30 pounds per square yard. When micro-surfacing is applied in

rates that are excessive, the mix may segregate leaving a flushed or excessively smooth surface texture.

If application rates in excess of those stated above are desired, multiple applications of micro-surfacing should be considered. Once again, multiple applications of slurry seals/polymer modified slurry are not normally recommended whereas micro-surfacing has the added strength and stability to allow this.

For Acceptance and Price Adjustment - See VDOT Special Provision for Latex Modified Emulsion Treatment (Micro-Surfacing) and Special Provision for Emulsified Asphalt Slurry Seal, located in the back of this manual.

GLOSSARY

Emulsions – Defined as a mixture of two immersible liquids. One of which is dispersed in the other in the form of very fine droplets usually in the presence of a third component, the surface active agent.

Asphalt Emulsions – Defined by the most common type of system in which the asphalt is the dispersed liquid or the internal phase, and water is the dispersing liquid or the external phase. Commonly called oil-in-water emulsion. In asphalt emulsion manufacture the emulsifying agent promotes emulsification during manufacture and keeps it stable thereafter.

Emulsifiers (See Surface Active Agent)

Set Control Additives - Defined as small amounts of materials (mineral fillers or chemical) that when added to a slurry/micro-surfacing mixture speed or retard the setting characteristics of that mix.

Pugmill – An aggregate-asphalt mixing device that proportions and mixes aggregates and emulsified asphalts to yield a uniformly coated mixture. The pugmill consists of a chamber in which shafts rotate. These shafts have paddles spaced along their length that are capable of being angled to advance or retard the movement of the mix through the mixing chamber. Spraybars for asphalt emulsion and/or water/set coat additives are usually mounted in the mining chamber near the aggregate feed end.

Colloid – Any fine suspension of finely divided particles in a continuous medium.

Surfactant (Surface Active Agent) – Any substance that alters the energy relationship at interfaces: organic compounds displaying surface activity such as detergents, wetting agents, dispersing agents and emulsifiers.

Stator – The fixed or stationary plate of a colloid mill. Emulsions are formed when two immersible liquids are introduced into a small clearance cavity between the stator and a high speed rotor creating a high sheer forces.

Breaking – The initial separation of the water from the emulsion, which can be detected by a marked color change from brown to black, and often by the release of fairly clear to straw-brown water. This results in the deposition of the base asphalt on an aggregate or paved surface.

Set – The point at which the breaking process has advanced to the point the asphalt aggregate mix will no longer track when blotted with white paper. (The mix may be too tender for traffic at this point.)

Cure – The entire process of breaking and set until the final mixture of emulsion and aggregate has lost all moistures due to evaporation or dehydration.

Slow Set Emulsions - Asphalt emulsions which demonstrate very stable properties. These emulsions must be stable to dilution in addition to having a high resistance to chemical breakdown. The ability of the emulsion to mix with cement is an indication of its suitability for use with aggregates of high surface area.

Quick Set Emulsions – Asphalt emulsions (normally used in slurry seal application) in which the set of the mixture may be controlled by the use of small amounts of additives.

Polymer Modified Emulsions – An emulsion formed with an asphalt previously modified with a polymer or an emulsion formed with a latex in the continuous phase during emulsification.

Particle Charge Test - The particle charge test is made to identify cationic emulsion. It is performed by immersing a positive electrode (anode) and negative electrode (cathode) into a sample of emulsion and connecting them to a controlled direct-current electrical source. At the end of a specified period the electrodes are observed to determine which pole has an appreciable layer of asphalt deposited on it. Cationic emulsions will migrate towards the cathode.

Viscosity – The Saybolt Furol Viscosity test as described for asphalt cements is used both for the anionic and cationic emulsified asphalts to measure and specify consistency properties. As a matter of testing convenience and also to achieve suitable testing accuracy, tow testing the specific type and grade of emulsified asphalts. These temperatures are 77° F and 122 °F.

Residue From Distillation – The distillation test provides a means for determining the relative proportion of asphalt cement and water in the emulsified asphalt. Some grades of emulsified asphalt also contain an oil distillate and the distillation test provides information on the amount of this material in the emulsion. Also, the distillation test provides an asphalt cement residue on which additional test may be made.

Settlement – The settlement test detects the tendency of asphalt globules to settle during storage of emulsified asphalt. A prescribed volume of material is allowed to stand in a graduated cylinder for a specified number of days. Small samples are then taken from the top and bottom parts in the cylinder. Each sample is placed in a beaker and weighed. The sample is then heated until water evaporates and the residue is then weighed. The Weights obtained provide the basis for determining the difference, if any, between asphalt cement content in the upper and lower portions of the graduated cylinder, thus providing a measure of settlement.

Sieve Test –The sieve test complements the settlement test and has a somewhat similar purpose. It is used to determine quantitatively the percent of asphalt present in the form of relatively large globules. Each globules do not provide thin and uniform

coatings of asphalt on the aggregate particles and may or may not be detected by the settlement test. In the sieve test, a representative sample of emulsified asphalt is poured through a No. 20 sieve. For anionic emulsions the sieve and retained asphalt are then rinsed with a mild sodium oleate solution and finally with distilled water. For cationic emulsions distilled water is used instead of sodium oleate solution. After rinsing, the sieve and asphalt are dried in an oven and the amount of retained asphalt determined.

Penetration – An empirical measure of consistency in which a container of asphalt cement is brought to test temperature of 77F in a water bath. A needle of prescribed dimension, loaded to a weight of 100 grams, is allowed to bear on the surface of the asphalt cement for 5 seconds. The unit of 0.1 mm which the needle penetrates into the sample is defined as the penetration.

Ring & Bell Softening Point - Used as a measure of consistency for asphalts. Samples of asphalt loaded with steel balls are confined in brass rings suspended in a beaker of water one inch above a metal plate. The liquid is heated at the prescribed rate. As the asphalt softens, the balls and asphalt gradually sink toward the plate. At the moment the asphalt touches the plate, the temperature of the water is recorded and this is designated as the Ring & Ball Softening Point.

CALIBRATION PROCEDURES

Inspectors Note: Since all calibrations require the use of the head pulley which turns the aggregate belt, it is easiest to start with no aggregate on the machine and calibrate other items first. This eliminates the need to clean out the aggregate hopper after calibration.

EMULISON CALIBRATION

Emulsion pumps vary among machine manufacturers. Pumps are either a fixed positive displacement pump or a variable positive displacement pump that can be mechanically set to various rates of flow. Since a variable volume pump will normally not be changed during the project, a calibration is necessary only for the setting that the contractor intends to use. Variable volume pumps should be equipped with a lock to avoid accidental changes and should be locked in place once calibration is completed. Calibrate emulsion to the head pulley count.

Procedure:

1. Empty machine of all aggregate. Fill the Slurry machine with emulsion and determine gross weight.
2. Hook pump outlet to a second container (tanker).
3. Run desired number of turns in head pulley counter.
4. Determine the weight of emulsion pumped by reweighing the machine.
5. Determine the weight of emulsion pumped per count on the head pulley.
6. Run three tests to ensure accuracy of results. If variable pumps are used and will be reset during the project, calibration will have to be done for enough settings to establish a straight line graph.
7. The emulsion pump should deliver emulsion to the pugmill with such volumetric consistency that the deviation for any individual delivery rate check run shall be within 2 percent of the mathematical average of three runs of at least 300 gallons each.

EMULSION CALIBRATION WORKSHEET

Pump Setting: ____________ % Machine No. ____________

Full Weight: ____________

Empty Weight: ____________ = Tons ____________ x 2000 = lbs ____________

Lbs/ Emulsion: ____________ /No. of Revs ____________ = lbs per Rev: ____________

Pump Setting: ____________ % Machine No. ____________

Full Weight: ____________

Empty Weight: ____________ = Tons ____________ x 2000 = lbs ____________

Lbs/ Emulsion: ____________ /No. of Revs ____________ = lbs per Rev: ____________

Pump Setting: ____________ % Machine No. ____________

Full Weight: ____________

Empty Weight: ____________ = Tons ____________ x 2000 = lbs ____________

Lbs/ Emulsion: ____________ /No. of Revs ____________ = lbs per Rev: ____________

Pump Setting: ____________ % Machine No. ____________

Full Weight: ____________

Empty Weight: ____________ = Tons ____________ x 2000 = lbs ____________

Lbs/ Emulsion: ____________ /No. of Revs ____________ = lbs per Rev: ____________

Pump Setting: ____________ % Machine No. ____________

Full Weight: ____________

Empty Weight: ____________ = Tons ____________ x 2000 = lbs ____________

Lbs/ Emulsion: ____________ /No. of Revs ____________ = lbs per Rev: ____________

Notes:

DRY ADDITIVE/MINERAL FILLER CALIBRATION

Various types of machines use different methods of supplying dry additives. Some are mechanically connected to the head pulley while others hydraulically matched through a ratio meter. Mechanical feeders have a gate setting similar to that of the aggregate belt. Hydraulic units have a hydraulic flow adjustment.

Procedure:

1. Check that all aggregate is remove from the machine as the conveyor belt must turn while calibrating the fines feeder.
2. Use a small pan or box to catch the mineral filler that falls from the feeder. Weigh this container prior to performing the next steps.
3. Using a count of the turns of the head pulley or the fines feeder auger, run out approximately 20 pounds of material into the box.
4. Weigh the container of material and subtract the weight of the container. Weight of material divided by the count of ht head pulley or the fines feeder gives weight per turn.
5. Repeat at three settings to develop a curve for the material at various gate settings.
6. Calculate the desired setting to meet mix design requirements, set the gate or hydraulic controls and verify the delivery rate.

AGGREGATE CALIBRATION

Notes:

1. Determine moisture content of aggregate used in calibration test to obtain dry weight.
2. Select and record three or more gate openings.
3. Run at least 3 tons of aggregate per gate setting.
4. The machine should deliver such volumetric consistency that the deviation for any individual aggregate delivery rate check-run shall not exceed 2 percent of the mathematical average of three runs of at least 3 tons in duration each.
5. The results should produce a straight line on an arithmetic graph.

Procedure:

1) Set gate to desired setting.
2) Run a small amount of material past the gate to establish the flow and fill the gate, remove excess material.
3) Weigh the machine. (Note all weights and counts.)
4) Reset head pulley counter to zero.
5) Run material out of machine and stop the belt just as the counter changes to a new count. (To avoid partial counts.).
6) Remove excess material on the belt that is past the gate but may not have fallen into the pugmill. Reweigh the machine. Net weight of run divided by the count provides pounds of aggregate per revolution of the head pulley.

AGGREGATE CALIBRATION WORKSHEET

Gate Setting: ______________ Machine No. ______________

Full Weight: ______________

Empty Weight: ______________ = Tons ______________ x 2000 = lbs ______________

Lbs of Rock: ______________ /No. of Revs ________ = lbs/Rev: ____________ = lbs/Dry ____________

Gate Setting: ______________ Machine No. ______________

Full Weight: ______________

Empty Weight: ______________ = Tons ______________ x 2000 = lbs ______________

Lbs of Rock: ______________ /No. of Revs ________ = lbs/Rev: ____________ = lbs/Dry ____________

Gate Setting: ______________ Machine No. ______________

Full Weight: ______________

Empty Weight: ______________ = Tons ______________ x 2000 = lbs ______________

Lbs of Rock: ______________ /No. of Revs ________ = lbs/Rev: ____________ = lbs/Dry ____________

Gate Setting: ______________ Machine No. ______________

Full Weight: ______________

Empty Weight: ______________ = Tons ______________ x 2000 = lbs ______________

Lbs of Rock: ______________ /No. of Revs ________ = lbs/Rev: ____________ = lbs/Dry ____________

Gate Setting: ______________ Machine No. ______________

Full Weight: ______________

Empty Weight: ______________ = Tons ______________ x 2000 = lbs ______________

Lbs of Rock: ______________ /No. of Revs ________ = lbs/Rev: ____________ = lbs/Dry ____________

Moisture Content of Rock = ______________________ % = Moisture Factor ______________________

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
EMULSIFIED ASPHALT SLURRY SEAL
(Maintenance)

August, 2008

I. DESCRIPTION

This work shall consist of furnishing and applying an emulsified asphalt slurry seal as specified herein and as directed by the Engineer.

II. MATERIALS

A. **Asphalt Emulsion**: Emulsified asphalt shall conform to the requirements of Section 210 of the Specifications; except it shall be a quick setting emulsion and the following requirements shall apply:

1. The emulsion shall be designated CQS-1h cationic quick setting emulsion and shall conform to the requirements of Cationic Type CSS-1h.

2. The Cement Mixing Test is waived.

3. Emulsion Setting Time - Prior to shipment of each new formulation of emulsified asphalt, the Contractor shall perform a towel test to verify that the emulsion will set sufficiently quick for early release of traffic. Testing for setting time shall be in accordance with VTM-89.

B. **Aggregate**: Aggregate shall be crushed stone and except for locations where the posted speed limit is 15 miles per hour or less and for roadways in Traffic Groups I through VII; it shall be non-polishing. The quality of aggregate shall conform to the requirements of Section 202 of the Specifications except that the loss on soundness shall not exceed 18 percent. The sand equivalent value shall not be less than 40.

Gradation shall be as follows for the type mix specified:

DESIGN RANGE TABLE

SIEVE SIZE	TYPE A (% Passing)	TYPE B (% Passing)	TYPE C (% Passing)
No.3/8	100	100	100
No.4	100	90-100	70-95
No.8	65-90	65-90	45-70
No.16	45-70	45-70	32-54
No.30	30-50	30-50	23-38
No.50	18-33	18-33	16-29
No.100	10-21	10-21	9-20
No.200	5-15	5-15	5-12
Design Asphalt Content Range*	8.0 – 10.5%	8.0 - 10.5%	7.0 - 9.5%

*Residual Asphalt content by weight of dry aggregate.

C. **Mineral Filler**: Mineral filler shall conform to the requirements of Section 201 of the Specifications.

D. **Water**: Water used in the mix shall conform to the requirements of Section 216 of the Specifications.

E. **Mix Design**: The Contractor shall submit for the Engineer's approval a mix design for each type slurry on Form TL-127, results of the Compatibility Test as per VTM-60, and wear loss by the Wet Track Abrasion Test (WTAT) as prepared by an approved testing laboratory. The WTAT shall be performed in accordance with VTM-14. The wear loss shall not be greater than 75 grams per square foot. The wear loss shall apply to the asphalt content limits designated on the job mix formula. Such limits shall be determined by selecting the optimum asphalt content from the WTAT loss curve and within the ranges shown in the Design Range Table in II.B herein and applying a tolerance of plus or minus 1.5 percent. WTATs shall then be taken only once per mix type per aggregate type.

F. **Test Strip**: The Contractor shall place a test strip for approval by the Engineer prior to beginning the work. The mix consistency shall be determined by the Contractor in accordance with current International Slurry Seal Association Technical Bulletin Number 106 and shall be 2.5 cm, plus or minus 0.5 cm. Calibration data as specified in III.B of herein shall be provided prior to placing the test strip.

G. **Mix Sampling and Testing Requirements**: Testing for gradation shall be based on an approved aggregate producer's modified acceptance production control plan. Gradation shall conform to the ranges specified in II.B herein.

Samples for asphalt content shall be taken from the completed mix and will be tested by the Department. The frequency of sampling and testing will be established by the Engineer based upon the Department's current acceptance program. The asphalt content will be determined by the Ignition Method (VTM-102) or nuclear gauge (VTM-90), as determined by the Engineer.

Samples representing a maximum of 25,000 square yards will be taken from material produced by each mixing unit for asphalt content determination in the beginning. Upon establishing consistency, testing frequency shall be reduced to a minimum of one test per 50,000 square yards.

At the discretion of the Engineer, the Contractor shall perform a minimum of two consistency tests for each day's production as specified in F herein, and shall conduct additional tests as requested.

Materials from the job site will be tested for Wet Track Abrasion in accordance with VTM-14 and the Department's current acceptance program. The WTAT loss shall not be greater than 75 grams per square foot.

H. **Personnel**

The Contractor shall have a Department certified Slurry Surfacing Technician on the job site to control the work.

III. EQUIPMENT

A. **General**: All equipment, including hand tools, shall be designed or suitable for the application of slurry and be in good working order. A mobile unit is required and shall be equipped with an accurate mineral filler feeder, a fog type spray bar, be capable of an operation speed of 60 feet per minute, and have capacity to store mix components to produce a minimum of five tons of slurry seal. The equipment shall be capable of delivering a continuous uniform and homogeneous mixture of aggregate, emulsion, water, and mineral filler to the spreader box. Mixing aid additive dispensers, if used, shall be capable of uniformly adding the additive to the water line prior to entering the mixing chamber.

B. **Equipment Calibration**: The Contractor shall provide current year data for each mixing unit utilizing materials from the same sources as those to be used on the project. Data for each unit shall be in the form of a graphic scale indicating the stone gate setting required to obtain the residual asphalt content as determined in the mix design. Such data shall be maintained with each unit.

C. **Spreader**: The spreader shall be equipped with a flexible type squeegee positioned in contact with the pavement surface. The spreader shall be designed to apply a uniform spread with a minimum loss of slurry. The spreader box shall be equipped with augers extending its full width which shall uniformly distribute the slurry mixture across the entire width of the box. The box shall be equipped with an approximately 18-inch wide burlap drag to smooth the slurry surface.

D. **Suspension of Work**: If during the life of this project excessive loss of cover aggregate occurs, the Engineer may suspend the work in accordance with Section 108 of the Specifications until the cause of the loss of cover material is corrected.

IV. PROCEDURES

A. **Beginning Work**: The Contractor shall notify the Engineer at least three work days prior to beginning work. Upon request by the Department, the Contractor shall provide 6 quarts of liquid emulsion and 50,000 grams of aggregate material for the Department's use in determining asphalt content. The contractor shall perform ignition oven calibrations and submit them with the job-mix formula (JMF) to the Department two weeks prior to the beginning of the work.

B. **Preparation of Surface**: The surface upon which slurry seal is to be applied shall be thoroughly cleaned of all loose material, vegetation, silt spots, and other objectionable materials by either brooming or the use of compressed air.

C. **Application**: When warranted by local conditions or when the pavement temperature is above 90 degrees F, the surface of the pavement shall be fogged with water at a rate of 0.05 gallons per square yard immediately preceding the pass of the spreader. The slurry mixture shall be of a consistency such that it "rolls" in the spreader box in a continuous mass. Slurry that segregates in the spreader box, so that flowing of liquids (water and emulsion) is evident, is not acceptable and shall not be applied. The liquid portion of a slurry mixture shall not flow from either the spreader box or the applied slurry. Evidence of such flow shall be sufficient cause for rejection of the applied material. A mixing aid additive may be used when necessary to accommodate slow placements or high temperatures.

The slurry shall be uniformly placed on the road in full lane widths up to and including 12 feet. Excess buildup of slurry on longitudinal and transverse joints shall be corrected.

Treated areas shall not be opened to traffic until such time as the slurry seal has cured to the extent that it will no longer be damaged by traffic. Where earlier opening to traffic is necessary, such as at entrances, the contractor may lightly sand the surface using the same aggregate as in the mix and may be required to remove excess aggregate from the roadway in curb and gutter

sections. The applied slurry mixture shall be uniform in texture and shall not flush under traffic. In the event a failure occurs prior to acceptance, the Contractor shall repair or replace the failed treatment as directed by the Engineer.

Slurry Seal surface course shall not be applied on surfaces containing puddled water and on surfaces less than 50 degrees F, except that in the early "AM" the minimum surface temperature will be 40 degrees F provided the ambient temperature is expected to be above 60 degrees F and there is no forecast of ambient temperature below 32 degrees F within 24 hours from the time the material is applied.

Should oversize aggregate be encountered, the Contractor shall immediately cease operation until approved corrective measures have been taken.

D. **Rate of Application**: The minimum aggregate application rate shall be 16 pounds per square yard for Type A and Type B and 20 pounds per square yard for Type C.

The Contractor shall provide to the Engineer aggregate weight tickets, a daily delivery summary, and an estimate of aggregate lost and otherwise not used in the work for each stockpile location. Where disagreements occur, the Engineer shall have the final judgment of such loss.

E. **Test Failure**:

1. Asphalt Content - Samples representing a maximum of 25,000 or 50,000 square yards will be taken from material produced by each mixing unit for asphalt content determination. The asphalt content of such samples shall be within plus or minus 1.5 percent of the approved job mix. When two successive tests from a mixing unit fail or one test fails by more than two percent, that mixing unit shall be removed from service until approved by the Engineer.

2. Consistency Test - Upon failure, adjustment shall be made in the mix immediately and rechecked. If more than two consecutive tests fail, work shall cease. The equipment and/or materials shall be adjusted and approved by the Engineer before proceeding.

3. Wet Track Abrasion Test (WTAT) - Upon failure, adjustment shall be made in the mix and/or process immediately and rechecked. If two or more consecutive tests fail, work shall cease until the cause is determined and remedied and approved by the Engineer.

F. **Price Adjustment:**

1. Emulsified asphalt certified weight tickets showing the residual asphalt content shall be provided to the Engineer. Asphalt not used shall be

documented and considered in determining the percent of asphalt used on the total project. Upon completion of the project, the percent of asphalt shall be determined by dividing the calculated weight of residual asphalt by the delivery ticket weight of aggregate used in the work. A one percent reduction in the unit price per square yard will be applied for each one-tenth of a percent the residual asphalt content is more than one percent below the approved job mix formula (JMF).

2. Application Rate - a three percent reduction in price per square yard will be applied for each pound of aggregate per square yard less than the specified application rate. The square yards retreated, if any, shall be added to the total square yards retreated, if any, shall be added to the total square yards for calculation of application rate. The price adjustment will be applied to the total square yards for which payment is made. Material applied over the specified application rate will not be considered for extra payment.

   Price adjustments under 1 and 2 herein shall apply concurrently.

V. MEASUREMENT AND PAYMENT

Emulsified asphalt slurry seal will be measured and paid for in square yards on a plan quantity basis for the type specified. Authorized increases and decreases to plan quantities will be adjusted in accordance with Section 109.02 of the Specifications. Payment shall be full compensation for furnishing, applying, testing, and maintenance of traffic.

The Contractor will be paid at the rate of $*(fill in per District)* per hour for vegetation removal as required, which price shall include each operator and the necessary equipment, maintenance, and all incidentals necessary to perform this operation.

When vacuuming is required by the Engineer, the Contractor will be paid $*(fill in per District)* per hour for loose particle removal, by mobile vacuum unit with no less than an eight cubic yard capacity, which price shall include each operator and the necessary equipment, maintenance and all incidentals necessary to perform this operation.

Payment will be made under:

Pay Item	**Pay Unit**
Emulsified asphalt slurry seal, (Type)	Square yard

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
LATEX MODIFIED EMULSION TREATMENT (MICRO-SURFACING)
(Maintenance)

August, 2008

I. DESCRIPTION

This work shall include furnishing and placing a latex modified emulsion to existing roadway surfaces as specified herein and as directed by the Engineer.

II. MATERIALS

A. **Emulsified asphalt** shall be a quick set latex modified cationic emulsion conforming to the requirements of Section 210 of the Specifications and the following:

1. The emulsion shall be designated CQS-1h cationic quick setting emulsion and shall conform to the requirements of Cationic Type CSS-1h.
2. Ring and ball softening point of the residue, minimum = 140 degrees °F.
3. Pass towel test (VTM-89) in the 30 minutes at room temperature with job materials.
4. Residue, percent by evaporation, minimum 62 percent as determined by VTM-78.
5. Material shall be furnished in accordance with the Departments Asphalt Acceptance Program.

B. **Aggregate** shall be non-polishing crushed stone conforming to the requirements Section 202 of the Specifications, except the soundness loss shall not exceed 18 percent.

Gradation of the aggregate shall be in accordance with the following:

SCREEN SIZE	TYPE A (% Passing)	TYPE B (% Passing)	TYPE C (% Passing)	RUTFILLING (% Passing)
No.3/8	100	100	100	100
No.4	100	90-100	70-95	70-95
No.8	65-90	65-90	45-70	45-70
No.16	45-70	45-70	32-54	32-54
No.30	30-50	30-50	23-38	23-38
No.50	18-33	18-33	16-29	16-29
No.100	10-21	10-21	9-20	9-20
No.200	5-15	5-15	5-12	5-12

C. **Mineral filler** shall be non-air entrained hydraulic cement, Type I, conforming to the requirements of Section 214 of the Specifications or hydrated lime conforming to the requirements of Section 240.02(a) of the Specifications. When requested by the Engineer a manufacturers Certification will be required.

D. **Water** shall conform to the requirements of Section 216 of the Specifications.

E. **Latex modifier** along with emulsifiers shall be milled into the asphalt emulsion by an approved emulsion manufacturer.

F. **Additives** may be used by the Contractor to provide control of the break/set time in the field. The type of additive shall be specified in the mix design.

G. **Sampling requirements** for gradation shall be taken from aggregate stockpiles designated by the Contractor. These stockpiles shall be located in the aggregate producer's quarry and acceptance for gradation will be based on an approved aggregate Producer's modified acceptance production control plan. Samples for Marshall tests and asphalt content shall be taken from the completed mix for testing by the Department. The frequency of sampling and testing will be established by the Engineer based upon the Department's acceptance program. The asphalt content will be determined by the Ignition Method (VTM-102) or nuclear gauge (VTM-90), as determined by the Engineer.

III. MIX DESIGN

A. The mixture shall be designed in a Department approved lab by the Contractor for the Engineer's approval and the job mix formula shall provide the following:

1. Compatibility of latex, aggregate and emulsion in accordance with the Schulze-Breuer Test procedure. Other procedures approved by the Engineer may be used. The test shall be run at the design stage and when requested by the Engineer.

2. A minimum Marshall Stability of 1800 pounds when tested in accordance with VTM-95.

3. A flow of between 6 and 16 units when tested in accordance with VTM-95.

4. An asphalt content that produces 4.7 percent voids in total mix for surface and 6.5 percent voids for rutfilling when tested in accordance with VTM-95.

Aggregate used in the job mix formula shall be from the same source and representative of the material proposed by the Contractor for use on the project.

B. Proportioning of the mix design shall be within the following limits:

	Type A	Type B	Type C	Rutfilling
% Residual Asphalt (by wt. of dry aggr.)	6.5-8.5	6.5-8.5	5.0-7.5	4.5-6.5
% Mineral Filler	0.26-3.00	0.26-3.00	0.25-3.00	0.25-3.00
% Latex Modified-Solids (by wt. of residual asp.)	3.0 Min.	3.0 Min.	3.0 Min.	3.0 Min.
Additive	As Required	As Required	As Required	As Required

IV. EQUIPMENT

All equipment, including hand tools, shall be designed or suitable for the application of micro-surfacing and in good working condition.

A. **Mixing equipment** shall produce the asphalt mixture in a self-propelled, front feed, continuous loading, and mixing machine. The unit shall deliver and proportion the aggregate, emulsion, mineral filler, control setting additive and water to a revolving multi-blade shafted mixer and discharge the mixture on a continuous and uniform basis. A mobile unit will be permitted on areas less than 15,000 square yards provided a sufficient number of units are used to promote an efficient continuous type operation which minimizes disruption to traffic and provided the units are equipped with a twin shaft mixer capable of an operational speed of 60 feet per minute and have a capacity to store and mix components to produce a minimum of 5 tons of mix. All equipment shall be capable of delivering a continuous, uniform, properly proportioned, and homogenous mixture to the spreading unit.

   Individual volume or weight controls for proportioning each material shall be provided and meters or counters shall be such that the Engineer may readily and accurately determine the amount of each material used at anytime.

   The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box when required.

B. **Equipment calibration** shall be provided by the Contractor stating the current year data for each mixing unit using materials from the same sources as those to be used on the project. Data for each unit shall be in the form of a graphic scale indicating the proportioning controls settings required to obtain the residual asphalt content as determined in the mix design. Such data shall be maintained with each unit.

C. **Spreading equipment** shall uniformly spread the paving mixture by means of a mechanical type spreader box attached to the mixer and equipped to agitate and spread the materials throughout the box. The box shall be designed and

operated so all the mixed material will be kept homogenous and moving with no evidence of premature breaking during laydown. A front seal shall be provided to ensure no loss of the mixture at the road contact surface. The rear flexible seal shall act as a final strike off and shall be adjustable. The spreader shall be maintained to prevent the loss of the paving mixture in the surfacing super-elevated curves. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved and produces a free flow of material to the rear strike-off without causing skips, lumps, ripples or tears in the finished surface. A secondary strike-off may be used to improve surface texture.

Rutfilling, when required, shall be accomplished by means of a box specifically designed for that purpose. The box shall be of one-half lane width and have a dual chamber with an inner v configuration of augers to channel the large aggregate to the center of the rut and the fines to the edges of the rut fill pass. The box shall be equipped with dual steel strike-off to control both the width and depth of the rutfill.

D. **Pneumatic roller** may be required by the Engineer, at no cost to the Department, if excessive loss of aggregate is observed. The roller shall be equipped with treaded tries having an air pressure of 40 – 60 pounds per square inch (psi).

V. PROCEDURES

A. **Beginning work**, The Contractor shall notify the Engineer at least three work days prior to beginning work. Up on request by the Department, the Contractor shall provide 6 quarts of liquid emulsion and 50,000 grams of aggregate material for the Department's use in determining asphalt content. The contractor shall perform ignition oven calibrations and submit them with the job-mix formula (JMF) to the Department two weeks prior to the beginning of the work.

B. **Surface preparation**, prior to applying the paving mixture, the surface shall be thoroughly cleaned of all vegetation, loose materials, dirt, mud and other objectionable materials. Prior to paving, an asphalt tack coat Type CSS-1h diluted three parts water to one part asphalt shall be applied at a rate 0.05 gallons per square yard. When required by field conditions prewetting of the tacked surface shall be applied evenly at a rate that will uniformly dampen the entire roadway surface.

All cost for furnishing and applying the tack coat and prewetting shall be included in the price bid for "Latex Modified Emulsion Treatment".

C. **Application types and rates**

1. Rutfilling shall be placed by means of a specially designed rutfilling box that will leave the surface crowned between 1/8 and 1/4 inch per inch depth to allow for traffic compaction to approximately a level surface. The Contractor

shall provide and use a ten foot straight edge to control the depth and crown.

2. Latex Modified Emulsion Treatment for leveling course shall consist of an initial application to prepare for the surface course. The minimum application rates shall be 16 pounds per square yard for Type B and 20 pounds per square yard for Type C.

3. Latex Modified Emulsion Treatment (LMET) for surface course shall consist of the final application which serves as the pavement surface. The LMET shall be placed at an application rate of 16 to 20 pounds of mix per square yard for Type B and 18 to 22 pounds per square yard for Type C.

   Where neither rutfilling nor leveling is used, the mix application rates shall be 18 to 22 pounds per square yard for Type B and 20 to 24 pounds per square yard for Type C.

   The Contractor shall provide to the Engineer aggregate weight tickets, a daily delivery summary, and an estimate of aggregate lost and otherwise not used in the work for each stockpile location (rutfilling aggregate shall be stockpiled and inventoried separately). When disagreements occur, the Engineer will make the final determination of such loss.

D. **Application**

The mixture shall be spread to fill minor cracks and shallow potholes and leave a high-skid resistant surface uniform in texture and appearance. Longitudinal joints shall not overlap more than four inches, except on irregular roadway widths when approved by the Engineer; however the joints shall be neat in appearance. Pavement edges shall be reasonably straight and shall be tapered to tie in neatly at gutters, entrances, and connections. When possible, longitudinal joints shall be placed on lane lines.

During night paving operations sufficient lighting shall be provided by the Contractor to insure proper application of micro-surfacing.

Rutfilling must be compacted by traffic or by a minimum of three passes with a pneumatic tire roller not in excess of 5 miles per hour (mph) prior to application of the surface course and must be cured such that applied material is totally free of detectable water. Rutfilling or scratch courses placed at night shall not be overlaid the same night or until such time that the materials totally free of detectable water.

Any oversized aggregate or foreign materials shall be screened from the aggregate stockpile prior to delivery to the mixing machine. A mixing aid additive shall be used to accommodate spreading due to slow placements or high temperatures. Additionally, water in a very limited quantity may be sprayed into the sprayed box to prevent build-up on the blades. All excess material shall be removed immediately from the ends of each run. Loose

aggregate that is determined to be objectionable by the Engineer shall be immediately removed without damaging the surface.

Based upon a visual examination or test results the Engineer may reject any work due to poor workmanship, loss of texture, raveling or apparent instability.

The entire area specified shall be treated and the contract quantity shall not be exceeded.

E. **Test requirements**

Samples representing a maximum of 500 tons will be taken from material produced by each mixing unit for asphalt content determination. The residual asphalt content of such samples shall be within plus or minus 1.5 percent of the approved job mix. When successive tests from a mixing unit fail or one test fails by more than two percent, that unit shall be removed from service until approved by the Engineer.

F. **Price Adjustment**

Emulsified asphalt certified weight tickets showing the residual asphalt content shall be provided to the Engineer. Asphalt not used shall be documented and considered in determining the percent of asphalt used on the total project. Upon completion of the project, the percent of asphalt shall be determined by dividing the calculated weight of residual asphalt by the delivery ticket weight of aggregate used in the work. A one percent reduction in the unit price per ton will be applied for each one tenth of a percent the residual asphalt content is more than one percent below the approved job mix formula.

The price adjustment will be applied to the total tons for which payment is made.

G. **Weather Limitations**

Micro-surfacing shall not be applied on surfaces containing puddle water and on surfaces less than 50 degrees F, except that in the early morning the minimum surface temperature may be 40 degrees F provided the ambient temperature is expected to be above 60 degrees F and there is no forecast of ambient temperature below 32 degrees F within 24 hours from the time the material is applied.

H. **Personnel**

The Contractor shall have a Department certified Slurry Surfacing Technician on the job site to control the work.

VI. MEASUREMENT AND PAYMENT

The quantity of latex modified emulsion treatment used in the accepted portions of the work will be measured by net ticket weight of aggregate, latex modified emulsion and mineral filler delivered and incorporated in the accepted work. No

deduction will be made for moisture naturally occurring in the aggregate and mineral filler.

The accepted quantity of **latex modified emulsion rutfilling** will be paid for at the contract unit price per ton.

The accepted quantity of **latex modified emulsion treatment** will be paid for at the contract unit price per ton for the type material specified.

The Contractor will be paid at a rate of $*(fill in per District)* per hour for vegetation removal, when required. The contract price shall include each operator and the equipment necessary to remove and dispose of vegetation.

Payment will be made under:

Pay Item	**Pay Unit**
Latex modified emulsion rutfilling	Ton
*Latex modified emulsion treatment, (Type)	Ton

*(For asphalt schedule work projects the leveling and surfacing courses are shown as separate line items in the schedule of work but combine into one bid item in the schedule of items.)

Virginia Test Method - 14

Wet Track Abrasion

November 1, 2000

1. Scope

The wet track abrasion is intended for measuring the wearing qualities of thin, fine aggregate bituminous surfacings, such as slurry seal, under wet abrasion conditions. It may be used for design purposes to establish the optimum quality and type of binder consistent with wear resistance of the surfacing.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Apparatus

1. Balance

   a. Capable of weighing 5,000 grams to within ± 1.0 gm.

2. Planetary Type Mechanical Stirrer

   a. (Such as the Hobart C-100 made by Hobart Mfg. Co., Troy Ohio) equipped with an abrasion head weighing 5 lbs. (including rubber hose) ± .05 lbs.
   b. Has 1/2 in. up and down movement in the shaft sleeve.

3. Has 1/8 in. Flat Bottom Metal Pan

   a. 13 in. diameter.
   b. 2 in. vertical side walls (20 gage or heavier).
   c. 4 equally spaced screw clamps capable of securing 11.75 in. diameter sample to bottom of pan.

4. Suitable Heavy Gage Round Bottom Bowl to be used for mixing sample.

5. Long Handled Serving Spoon should project 4 in. or more from bottom of round bottom mixing bowl.

6. Disk

   a. 11.75 in. diameter or larger circular cut from 40 - 60 lbs. roofing felt.

7. Metal Plates

   a. 15 in. square with 4 rods space 14 in. center to center.
   b. Rods 1 in. tall and 1/4 in. in diameter.

8. Plastic Templates

a. 15 in. square 1/4 in. thick with 4 holes spaced 14 in. center to center.
b. Holes 3/16 in. diameter.
c. 11 in. circle cut into center of template.

9. Window Squeegee

a. 12 in. to 14 in. long with short handle (rubber edge).

10. Funnel

a. Metal or nalgene with top diameter opening minimum 5 in. to maximum 7.0 in.
b. To tubular opening minimum 3/4 in. to maximum 1.0 in.
c. Bottom tubular opening 1/2 inch.

11. Oven

a. Forced draft constant temperature.
b. Thermostatically controlled at 140ºF (60ºC).

12. Water Bath

a. Constant temperature controlled 77ºF ± 2ºF (25ºC ± 1ºC).
b. 1 in. water above top sample.
c. Will hold minimum of 3 samples at a time.

13. Reinforced Rubber Hose

a. 3/4 in. inside diameter (2 braid, Oil-Resistant Cover, equivalent to Parker 3292 OZEX general purpose hose).
b. Cut into 5 inch lengths.
c. 2 holes drilled on 4 inch center to center.
d. Diameter of holes should be 3/8 in.

NOTE: Do not drill through concave or convex sides.

14. Thermometers

a. ASTM 49ºC range 20ºC to 70ºF (140ºF oven).
b. ASTM 17ºF range 66ºF to 80ºF (77ºF water bath).

15. Sample Rack

a. Should be large enough to place sample without any overhang.
b. 1 in. spacers between samples.
c. Rack should be secured together without any movement.

16. Support for Flat Bottom Metal Pan should be secured to machine.

17. Squares for Towel Test (VTM-60)

a. 8 in. square.
b. 40 - 60 lbs. roofing felt.

18. Paper Towel for Test

a. White hand towel.

3. Procedure

PART I - PREPARATION OF TEST SPECIMEN

1. Making Specimens:

   a Air dry (May be oven dried not to exceed 140ºF) a sufficient quantity of aggregate to obtain the required number of batches. Sieve material over the #4 sieve. (Filler to be considered as part of the aggregate).

   NOTE:Three test specimens to be made for each percent residual asphalt content.

   b. Weigh 800 grams of aggregate into the mixing bowl. Dry mix the sample wiith the spoon, a minimum of one minute. Add all the predetermined amount of water and mix for one minute or until all aggregate particles are uniformly wetted.

   c. Add the predetermined amount of emulsion (For example 13, 15, and 17% emulsion based on the weight of aggregate). Stir with a spoon using a circular, combined with a back and forth, motion for a period of three minutes (± 5 seconds).

   NOTE: After 3 minutes if compatibility fails part A or part B from VTM-60, design test will not be run. Check funnel flow mix consistency by testing the ability of the slurry to flow through the one-half inch opening on the bottom of the funnel. (Trial batches should be run prior to making specimens for lowest possible water content)

   NOTE: Mixtures which segregate will not flow through the funnel. They are unsuitable for slurry work unless this segregation can be overcome by additions of hydrated lime or Portland Cement or by a change of gradation (Blending). If free flowing consistency is unattainable without segregation discard the batch. Repeat Steps b and c with the addition of hydrated lime or Portland Cement to the aggregate. (Suggest 0.5% increments based on the weight of the aggregate). All subsequent mixtures would include the lowest amount of hydrated lime or Portland Cement to overcome segregation.

   d. Place the opening in the lucite template over the 11.75 in. diameter disc or roofing felt. Pour the slurry onto the top part of the felt.

   e. Squeegee the slurry level with the top of the lucite template with a minimum of manipulation (Excessive squeegeeing contributes to segregation). Scrape off excess material and discard

   f. After one hour (± 5 min.) remove the lucite template. Place the molded specimen the 140ºF oven and dry to constant weight (Minimum 24 hours drying time).

PART II - WET TRACK ABRASION TEST

a. Remove the dried specimen from the 140ºF oven, allow to cool to room temperature and weigh.

b. After weighing, place the specimen in the 77ºF water batch for 1 to 1 l/4 hours

c. Remove the specimen from the water bath and place in the 13 in. diameter flat bottom pan. Secure the specimen to the pan bottom by tightening the four wing-nut washers.

d. Completely cover the specimen with at least 0.25 in. depth of distilled water (Temperature 77ºF ± 5ºF).

e. Secure the pan, so as to avoid movement during testing, containing the specimen on the platform of the Hobart Machine. Lock the rubber hose abrasion head on the shaft of the Hobart Machine. Elevate the platform of the Hobart Machine until the rubber hose bears on the surface on the specimen. Use the prop block or other device to support the platform assembly during testing.

f. Switch to the low speed of the Hobart Machine and run for 5 minutes.

NOTE: Install a fresh section of hose after completion of each test.

g. Remove the specimen from the pan after the abrasion cycle and wash off debris. Place the washed test specimen in the 140ºF oven and dry to constant weight.

h. The dried specimen is removed from the 140ºF oven, allowed to reach room temperature, and weighed. The difference between this weight and the weight obtained in Step(a) Part II is multiplied by 3.06 to express the loss in grams per square foot (Wear Value).

NOTE: The factor 3.06 is used to convert the loss for the actual abraded area, 0.327 sq. ft. to a one square foot basis. <u>(The 3.06 value only applies to the Hobart C-100 Machine with a 5 in. rubber hose).</u>

i. To compensate for the +4 material in a slurry mixture, the optimum residual asphalt content (As determined by the WTAT) may be reduced as follows :For each 1% of +4 material, (Not to exceed 15.0%) reduce the optimum residual asphalt content by 0.1%. However, in no case should the asphalt content be lower than the specification limits.

Example:

10.0 Percent Residual Asphalt for Mix
15.0 Percent +4 material
0.1% x 15.0% = 1.5%
10.0%
-1.5%
8.5% Adjusted Residual Asphalt Content

PART III - DESIGN CHECK

On design check tests, the lower limit of the job mix design residual asphalt content acceptance range will be used. (Three test specimens). If compatibility fails part A or part B from VTM-60, design check test
will not be run.

NOTE: For each 1% of +4 material, not to exceed 15%, the residual asphalt content may be increased by 0.1%.

Example:

8.5 Percent Residual Asphalt Content
15.0 Percent +4 Material
0.1% X 15.0% = 1.5%
8.5%
+ 1.5%
10.0% Adjusted Residual Asphalt Content for Design Check Test

4. COMPATIBILITY

Materials must be checked for compatibility in accordance with VTM-60.

5. REPORT

a. The average wear value (WTAT Loss) in grams, to the nearest whole number for each percentage of emulsified asphalt.
b. Total water added.
c. Percent emulsion.
d. Percent residual asphalt in emulsion (actual or estimated).
e. Percent hydrated lime or Portland Cement.
f. Description of texture.
    1. poor - Surface skinning or tackiness.
    2. good - Freedom from surface skinning or tackiness.
g. Gradation of aggregate.
h. Pass or fail compatibility (VTM-60).

NOTE: Report separately for Part A and Part B of VTM-60.

Virginia Test Method - 60
Compatibility Test of Slurry Seal Mixtures

November 1, 2000

1. Scope

The compatibility test is used to determine the minimum mixing time and maximum setting time of a slurry seal mixture.

This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Apparatus

a. Scale, capable of weighing 5000 g to within ±1.0 g.

b. Suitable heavy gauge round bottom bowl to contain the sample during mixing.

c. Long-handled spoon of sufficient length to project 4 in. (100 mm) or more out of round bottom bowl during stirring.

d. Supply of 6 in. (152 mm) (approximately) squares cut from smooth (40-60 lb.) (18 – 27 kg) roofing felt.

e. Supply of white paper towels.

3. Procedure

PART A - MINIMUM MIXING TIME

To a total of 200 g of aggregate and hydrated lime or Portland Cement, add the percentage of water and quick-setting emulsion (at 68-80°F) (20-27˚C), as established by the job mix formula, and mix for minimum of 3 minutes. This mixture shall form a free flowing, smooth, homogeneous slurry with no segregation, no balling, and no stiffening to pass the test requirement.

PART B - MAXIMUM SETTING TIME

Slurry seal setting time - Spread about half of the mix from Part A on a section of asphalt-saturated roofing felt to a thickness of approximately 0.25 in. (6 mm) and cure for one hour at 68-80°F (20-27°C). A piece of white paper towel, when pressed lightly on the surface of the slurry after the curing period, shall show no brown stain (black particles of asphalt shall be disregarded) to pass the test requirement.

NOTE: If a slow-set emulsion is specified, Part B will be voided.

4. Report

a. Pass or fail Part A
b. Pass or fail Part B

Cone Consistency Test

Taken from the ISSA Technical Bulletin 106

The cone test is use to determine the amount of water required to form a stable, workable mixture. This test uses the sand absorption cone described in ASTM C- 128 or AASHTO T-84 and a base flow scale. The cone is a hollow .8 mm metal frustrum, 75 mm high with 40 mm top and 90 mm bottom diameters. The flow scale has 7 concentric circles inscribed on an industrial tile or metal sheet or paper in one centimeter increasing radii from the circle formed by the large end of the cone.

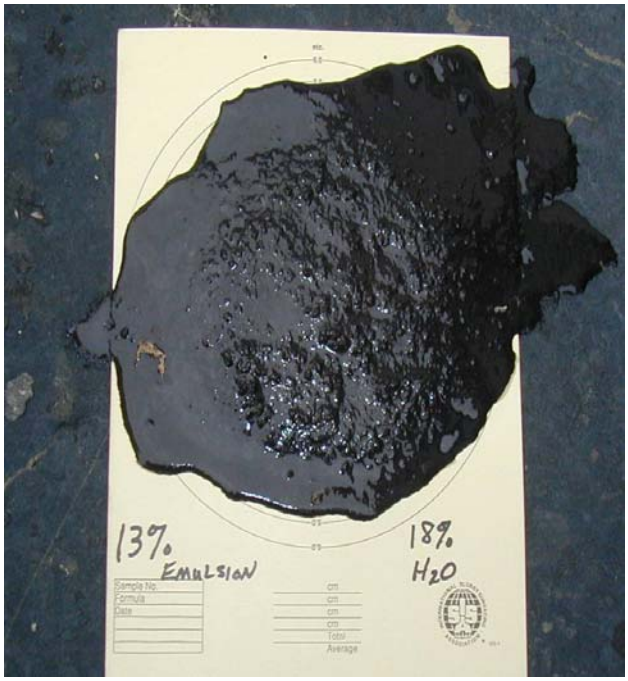
Several trial mixtures are made using 400 grams of combined aggregate at ambient temperature, optimum emulsion and varied water contents. The cone is centered on the flow scale and after 30 seconds of thorough mixing the cone is loosely filled, struck off and immediately removed with a smooth vertical motion. The outflow of the slurry is measured at four points 90° apart, averaged and recorded as "___ cm flow @ ____% added mix water."

Optimum is considered as 2.5cm. radial flow with limits of 2.9 cm to 3.0 cm. and a reproducibility of ± cm. Design work should be performed with all the actual project materials and should simulate field conditions of temperature and stockpile moisture expected.

Note: This test may not applicable to certain Quick-Set and Quick –Traffic Systems because of erratic results due to their setting characteristics.

Cone and metric consistency flow scale.

Slight slump – no flow, too dry



Extreme drainage – too wet
Requires reformulation

Optimum formulation

Study Questions

1. Slurry Surfacing is used to:

   A. Fills large potholes
   B. Improve drainage
   C. Makes a pavement structurally sound
   D. Prolongs the life of the pavement

2. Emulsion tanker lids should be tightly closed to:

   A. Keep air entrapped in the tank
   B. Prevent rainwater from entering the tank and diluting the emulsion.
   C. Prevent pressure from building in the tank
   D. Ensure the emulsion hasn't been tampered with

3. The application machine should be calibrated:

   A. At least every two years when in service
   B. using the same source of materials as those to be used on the project
   C. At the beginning of each work day.
   D. using multiple sources of materials and averaging the results

4. Lightly sanding the surface with the same aggregate as used in the Slurry Surfacing mix can aid in:
   A) in allowing traffic on a new mat sooner at intersections
   B) Nothing
   C) .
   D) Lightly sprinkle emulsion over the surface.

5. Manhole and valve covers must be protected during a Slurry Surfacing application by:

   A) coating them with diesel fuel
   B) applying a control additive to them
   C) covering with roofing paper (tarpaper)
   D) coating them with a heavy oil.

6. What can be done to help produce a uniform surface texture?

A) use a burlap drag on the paver
B) make sure to keep the spreader box full of mix
C) Prevent slurry from spilling into gutter pans
D) Fog the freshly applied mat.

7. Where are samples for asphalt content of the mixture taken?

A) From the completed mix at the discharge chute
B) From the applied mix on the road
C) Only taken at the lab
D) Samples are not needed

8. Generally, Slurry Seal is placed on a roadway with a higher volume of traffic.

A) True
B) False

9. Which weather condition would be acceptable for placing a Slurry Surfacing application?

A. Puddles of water on the road surface.
B. The morning temperature is 48°F and the high is expected to be 54°F.
C. The temperature is 50°F, but the overnight low is expected to be 30 °F
D. The morning temperature is 43 °F and the expected high is 65°F, with an overnight low of 50 °F

10. Oversized aggregate in a mix can cause _____ on the Slurry Surfacing mat.

A) the mix to flow into the gutter
B) speed up the break of the slurry mixture
C) drag marks
C) the mix to separate

11. What should the consistency of the Slurry Surfacing mixture be in the spreader box?

A) It should roll in a continuous mass
B) It should be thin and run out of spreader box
C) It should be stiff with some chunks in it
D) The mix should be segregated

12. Prior to any Slurry Surfacing application, why should storm drain gratings be covered before applying Slurry?

A) To save on slurry material and recycle what is ends up on the cover
B) So the applied mix is more visually pleasing in that area
C) Prevents material or emulsion from entering the water drainage system
D) To prevent water from the drainage system flowing into the slurry mixture

13. Quick-set slurry application machines may not be used to mix and apply Micro-surfacing
A) True
B) False

14. What equipment calibration information is required to be kept with the micro-surfacing application machine and slurry application machine?

A) Current year calibration from any asphalt source.
B) Monthly calibration data.
C) Current year data using the same materials as those to be used on the project.
D) Manufacturers calibration at time of purchase.

15. The Asphalt Content of the samples of material produced by each mixing unit shall be within:

A) ± 1.5 percent of the average of two tests.
B) ± 2 percent of the minimum of test averages for the day.
C) ± 1.5 percent of the approved job mix.
D) ± 1.5 percent of the average of three tests.

16. Latex modified emulsion treatment (micro-surfacing) joints should not overlap more than _____ , except on irregular roadway widths when approved by the Engineer.

A) 4 inches
B) 6 inches
C) 1 foot
D) there should be no overlap

17. When should a Slurry Surfacing mixing unit be removed from a job site?

A) If a slick spot is noticed on the mat.
B) Two successive asphalt content tests from a mixing unit fail by ± 1.5% or one test fails by more than 2%.
C) One test fails by 1.5%.
D) None of the above

18. Slurry Surfacing shall not be applied if within the next 24 hours after the material is applied:

A) The ambient temperature will drop below 32°F
B) The ambient temperature will exceed 90°F
C) The surface temperature will exceed 90°F
D) The ambient temperature will drop below 60°F

19. Which picture shows the correct consistency for a Slurry mix?

A)

B)

20. When water fogging is necessary before applying Slurry, always allow at least 2 to 3 hours drying time and proceed with paving

A) True
B) False

21. Course aggregate may not be embeded properly because of too much handwork.

A) True
B) False

22. The Contractor must notify the Engineer at least _____prior to beginning work.

A) Five days
B) Five work days
C) Three work days
D) Seven work days

23. When rutfilling, how much of a surface crown should be in place?

A) 1/8 and 1/4 inch per inch depth
B) 1/4 to 1/2 inch depth
C) 1/2 inch
D) At least ½ inch per inch depth

24. How should the road surface be prepared before just before Slurry Surfacing is applied?

A) Heating the existing surface with a blower if the temperature is below 50°F
B) Fill all potholes with aggregate
C) Clean with high pressure water
D) Clean of all vegetation, dirt, and loose materials

25. When is the Mix Consistency Test (Cone Test) performed on an emulsified asphalt Slurry Seal?

A) Only during the test strip
B) Only during production
C) During both the test strip and production
D) Is not performed on slurry seal