

Engineering Brief # 22

ASPHALT RUBBER AND RUBBERIZED COAL TAR PITCH EMULSION

Introduction

During the past few years, two new asphaltic products have been introduced to the construction industry. Both products are a modification of existing materials and incorporate some form of rubber to provide increased elasticity and flexibility.

Asphalt-rubber is essentially a chip seal with up to 25 percent reclaimed rubber replacing the asphalt cement. The coal tar pitch emulsion is basically a tar emulsion seal coat with a latex rubber additive and greater sand content.

ASPHALT-RUBBER

Background

In recent years asphalt-rubber has received considerable attention for use as a paving material. Asphalt-rubber may be defined as heavy concentrations or reclaimed rubber reacted in hot asphalt. The mix is composed of 20-25 percent reclaimed rubber by weight as opposed to "rubberized asphalt" which contains approximately 3 percent latex type rubber. Rubberized asphalt appears smooth and homogeneous, whereas asphalt rubber mixtures appear chunky with rubber particles that are clearly visible.

Considerable research has been undertaken by various agencies and suppliers and more will be necessary before asphalt-rubber mixes can be incorporated into our construction standards. The technology is sufficiently advanced, however, to use the material on a case by case basis for the following applications:

1. Surface treatments such as seal coats and chip coats.
2. Membranes between existing pavements and overlays to reduce reflection cracking
3. Binders for open-graded mixes (PFC)

A unique feature of asphalt-rubber is its elasticity and flexibility which allows the material to resist reflective cracking.

Composition of Asphalt-Rubber Binders

Asphalt-Rubber binders are formulated using approximately 25 percent rubber by weight of mixture. The formulation will differ slightly depending on the supplier, the rubber type, and the application. The rubber is obtained from processing old tires from which metal and cord reinforcement have been removed. Particles are then reduced to size by one or a combination of methods that include shredders, opposed rollers, grinders and hammermills. The rubber may be frozen to facilitate reduction to size.

Another method of processing rubber is by "devulcanization". This method involves some chemical processing of the rubber together with heat and digestion during processing.

Properties of both rubber and asphalt will affect the properties of the asphalt-rubber mixture. Tread rubber is different from sidewalls. Radial tires are a different compound than conventional tires and both are different compounds than truck tires. For example, sorting before processing can affect crumb rubber if the percentage of truck tires that contain a higher natural rubber content varies. Particle size, shape, and texture of rubber will also affect the properties of asphalt-rubber mixes.

Based on the above, it is apparent that considerable variability may exist, particularly between sources. However, individual suppliers are capable of producing a product of good uniformity in regards to meeting present specifications.

Uses of Asphalt-Rubber

Asphalt-rubber mixes are used chiefly for surface treatments and stress absorbing membranes. Both of these mixtures are essentially the same material and are constructed in the same manner. They consist of a relatively thick layer of asphalt-rubber into which aggregate is rolled.

Preparation of asphalt-rubber depends on the system being used. The system using "devulcanized" rubber reacts with asphalt and rubber in a separate tank and transfers the material to a conventional distributor for application. The system using vulcanized rubber uses a special distributor for both reaction and distribution.

When the asphalt has reached the reaction temperature (350-425 degrees F) rubber is added over a period of 30 minutes. The system using vulcanized rubber adds up to 7.5 percent kerosene to adjust the mixture to spraying viscosity and to improve cover aggregate wetting.

The following conditions are necessary to achieve a good application:

1. Air temperature above 65 degrees F
2. Dry surface
3. Wind conditions satisfactory for obtaining a uniform spread.

The asphalt-rubber is applied by a pressure distributor truck within a temperature range of 375-425 degrees F at a rate of approximately 0.6 gallons per square yard. Application is by conventional spraying, however, there is occasionally a problem with rubber particles plugging the nozzles. The aggregate is applied directly behind the distributor in order to insure good, embedment. Pneumatic rollers are recommended for rolling in order to prevent breaking the particles.

Specification

Present specifications are of the "how to do it" type based on experience rather than specifying properties. The reasons for this type of specification are as follows:

1. Standard tests have not been adequately developed for routine quality control.
2. Asphalt-rubber properties necessary for specific applications have not been fully established.

An interim specification is contained in Appendix A.

RUBBERIZED COAL TAR PITCH EMULSION

Another product that uses rubber as an additive is a rubberized coal tar pitch emulsion sealcoat. This product is a combination of coal tar pitch emulsion, sand, and a latex rubber additive. The sealcoat is applied to existing bituminous surfaces in two or three coats and is intended to prevent erosion due to fuel spillage or dripping and to provide increased frictional characteristics.

Conventional coal tar pitch emulsions offer a relatively soft coating which is subject to wear. With the use of a latex rubber additive the tensile strength of the coating is increased to where it will hold more sand per gallon of coal tar pitch emulsion thereby providing a harder coating and greater skid resistance.

The sand used in this formulation generally passes the #20 sieve and is retained on the #30 sieve. The rubber additive is an acrylonitrile/butadine copolymer latex with a particle size between 400 and 1000 angstroms.

An interim specification is contained in Appendix B.

CONCLUSION

Based on research already completed we feel that asphalt-rubber mixes for surface treatments and stress absorbing membranes and rubberized coal tar pitch emulsion sealcoats for fuel spillage protection and to increase the skid resistance of pavements are feasible for use on airport pavements.

We suggest that demonstration projects be undertaken so that we may evaluate the use of these products on airport pavements. In such instances evidence should be provided by the engineer or sponsor to show that equal or better performance than conventional sealcoats can be achieved, commensurate with any added costs.

Approval will be required by the Office of Airport Standards prior

to use since we do not have standards for them and their use on ADAP construction projects has been limited.

ORIGINAL SIGNED BY:
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Civil Engineer

APPENDIX A

ASPHALT-RUBBER WEARING SURFACE

1. DESCRIPTION

1.1 This item shall consist of a bituminous surface treatment as a wearing course composed of a single or multiple application of asphalt-rubber material and aggregate cover.

2. MATERIALS

2.1 Asphalt-Rubber (Vulcanized). Bitumen shall be asphalt-rubber consisting of a blend of asphalt cement and ground rubber.

a. Asphalt Cement. Asphalt cement shall meet the requirements of ASTM D 3381.

b. Granulated Rubber. Granulated rubber shall meet the following requirements:

Passing sieve	Percent
No. 8	100
No. 50	0-15

The rubber shall have a specific gravity of 1.15 ± 0.02 and shall be free of fabric, wire or other contaminating materials, except that up to four percent of calcium carbonate may be included to prevent the particles from sticking together.

2.2 Asphalt-Rubber (Devulcanized). Bitumen shall be asphalt-rubber consisting of a blend of asphalt cement, extender oil, and ground rubber.

a. Asphalt Cement. Asphalt cement shall meet the requirements of ASTM D 3381.

b. Extender Oil. The extender oil shall be a resinous, high flash point aromatic hydrocarbon meeting the following requirements:

Viscosity SSU at 100 degrees F (ASTM D-88) 2500 min.
Flash Point, C.O.C., degrees F (ASTM D-92) 392 min.
Molecular Analysis (ASTM D-2007)
Asphaltenes, percent by weight 0.1 max.
Aromatics, percent by weight 55 min.

c. Ground Rubber. The ground rubber shall meet the following requirements:

(1). Composition. The rubber shall be a dry, free flowing blend of 40 percent powdered reclaimed (i.e., devulcanized) rubber and 60 percent ground vulcanized rubber scrap selected to have a high material rubber content. It shall be free from fabric, wire or other contaminants except that up to four percent calcium carbonate may be included to prevent the particles from sticking together.

(2). Sieve Analysis

Passing Sieve	Percent
No. 8	100
No. 30	60-80
No. 50	15-40
No. 100	0-15

(3) Mill test. When 40 to 50 grams of rubber retained on the No. 30 sieve are added to a tight set six-inch rubber mill, the material shall band on the mill roll in one pass.

NOTE TO THE ENGINEER : This test is to establish that a sufficient quantity of reclaimed devulcanized rubber is present. END NOTE
Natural rubber shall be a minimum of 30 percent, by weight when tested in accordance with ASTM D-297.

2.3 Aggregate. Aggregate shall consist of a hard, clean aggregate such as crushed rock, crushed gravel, or crushed slag. It shall be of uniform quality throughout and shall be free from dirt and other deleterious substances. It shall also be essentially dry, with a water content less than 0.5 percent when tested in accordance with ASTM C-70. It shall show no more wear than 10 percent, after 100 revolutions, when tested in accordance with ASTM C 131. At least 75 percent by weight of the material retained on the No. 4 sieve shall have at least one rough angular surface produced by crushing.

The aggregate shall conform to one of the gradations shown in Table 1.

Table 1 Aggregate Gradation

Sieve Size	% Passing	% Passing
3/4 in	100	-
1/2 in	70-100	100
3/8 in	0-40	70-90
No.4	0-10	0-10
No. 20	0-2	0-2

3. COMPOSITION OF ASPHALT-RUBBER BLEND

3.1 Asphalt-Rubber (Vulcanized). The proportions of the asphalt and the granulated rubber, by weight, of the total

asphalt-rubber blend shall be 78 percent + 1 percent asphalt and 22 percent + 1 percent granulated rubber.

The materials shall be combined as rapidly as possible for such a time and at such a temperature that the consistency of the mix approaches that of a semi-fluid material. The temperature of the asphalt shall be between 350 degrees F and 450 degrees F. The necessary reaction time required to achieve this semi-fluid state is a time-temperature relationship. The time may vary from a minimum of 10 minutes at 450 degrees F to as much as one hour at 350 degrees F.

To obtain optimum spraying and wetting viscosity it may be necessary to add kerosene. A high boiling point kerosene may be used in an amount not to exceed 74 percent, by volume, of the hot asphalt-rubber composition. The kerosene used shall have a boiling point of not less than 350 degrees F and the temperature of the asphalt-rubber shall not exceed 350 degrees F at the time the kerosene is added.

3.2 Asphalt-Rubber (Devulcanized). The asphalt-rubber blend shall be a combination of the asphalt cement, extender oil, and ground rubber mixed together at elevated temperatures in accordance with the following proportions and procedures:

(a) Preparation of Asphalt-Extender Oil Mix. The asphalt cement shall be heated to between 250 and 400 degrees F and combined with from two to six percent of the rubber extender oil to reduce the viscosity of the asphalt cement to within the range of 600 to 1800 poises at 140 degrees F when tested in accordance with AASHTO T-202. The mixture shall be thoroughly mixed by recirculation, stirring air agitation, or other means.

(b) Addition of Rubber. The temperature of the asphalt cement-extender oil blend shall be increased to within the range of 350-425 degrees F and an amount of ground rubber equal to 22 percent, plus or minus one percent by weight of the total asphalt-rubber blend shall be added. The rubber shall be added as rapidly as possible and the mixture shall be recirculated for a period of not less than 30 minutes after incorporation of all the rubber. Recirculation and stirring of the total combined material shall be maintained to provide good mixing and dispersion. Sufficient heat should be applied to keep the temperature of the total blend: to between 350-425 degrees F while mixing.

4. CONSTRUCTION METHODS

4.1 Weather Limitations. The asphalt-rubber surface coat shall be applied only when the existing surface is absolutely dry and the ambient air temperature is above 65 degrees F.

4.2 Equipment. All equipment, tools, and machines used in the performance of this work shall be maintained in satisfactory working order at all times.

(a) Distributor Truck. At least one pressure-type bituminous distributor truck in good condition will be required. The distributor shall be equipped with an internal heating device capable of even heating of the material up to 425 degrees F; have adequate pump capacity to maintain a high rate of circulation in the tank and have adequate pressure devices and suitable manifolds to provide constant positive cut-off to prevent dripping from the nozzles. The distribution bar on the distributor shall be fully circulating. Any distributor that produces a streaked or irregular distribution of the material shall be promptly repaired or removed from the project.

Distributor equipment shall include a tachometer, pressure gauges, volume measuring devices, and a thermometer for reading temperature of tank contents.

It shall be constructed so that uniform applications may be made at the specified rate per square yard within a tolerance of plus or minus 0.05 gal./sq. yd.

(b) Chip Spreader. A self-propelled; chip spreader in good condition and of sufficient capacity to apply the aggregate within the time period specified will be required. The spreader shall be constructed so that it can be accurately gauged and set to uniformly distribute the required amount of aggregate at regulated speed.

(c) Brooms. Revolving brooms shall be constructed so as to sweep clean or redistribute aggregate without damage to the asphalt-rubber membrane or surface treatment.

(d) Pneumatic-Tired Roller. There shall be at least two multiple wheel self-propelled pneumatic-tired rollers with provisions for loading to eight to twelve tons as deemed necessary. Pneumatic-tired rollers shall carry a minimum of 4000 pounds on each wheel and shall have a minimum tire pressure of 100 pounds per square inch.

4.3 Cleaning Existing Surface. Prior to application of the tack coat and asphalt-rubber surface seal, the surface of the pavement shall be clean and free from any dust, dirt, or other loose foreign matter, grease, oil, or any type of objectionable surface film.

4.4. Application of Tack Coat. Following the preparation for sealing, asphalt cement shall be applied at the rate of 0.05 gallon per square yard. If emulsified asphalt is used it shall be applied at the rate of 0.07 gallon per square yard. If devulcanized asphalt-rubber is used no tack coat will be required.

4.5 Application of Asphalt-Rubber. The asphalt-rubber shall be applied by a pressure distributor within the temperature range of 375-425 degrees F and at a rate of 0.55 + 0.05 gallon per square yard. The Engineer may vary the application rate

depending on the surface texture.

All transverse joints shall be made by placing building paper over the end of the previous application. The adjoining application shall begin on the building paper. The paper shall be removed immediately after use. Longitudinal joints shall be lapped approximately 4 inches.

4.6 Application of Aggregate. The application of aggregate shall follow as closely as possible behind the application of the hot asphalt-rubber, but in no instance should the distance be greater than 100 feet.

Construction equipment shall not drive on the uncovered asphalt-rubber.

The dry aggregate shall be spread uniformly by a spreader at the rate of 30-50 pounds per square yard as directed by the Engineer.

4.7 Rolling. Rolling shall commence immediately following the application of the aggregate. Sufficient rollers shall be furnished to cover the width of the spread with one pass. The first pass must be made immediately behind the spreader. If the spreading is stopped for any reason, the spreader shall be moved ahead so that all cover material spread may be immediately rolled. The rolling shall continue until a minimum of four complete cover-ages have been made.

All loose aggregate shall be swept off the surface and removed.

5. METHOD OF MEASUREMENT

5.1 The asphalt-rubber mixture shall be measured by the number of tons or gallons of mixture used in the accepted work.

5.2 Aggregate shall be measured by the number of tons used in the accepted work.

6. BASIS OF PAYMENT

6.1 Payment shall be made at the contract unit price per ton or gallon for the asphalt-rubber mixture and at the contract unit price per ton for mineral aggregate. These prices shall be full compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Asphalt-Rubber Mixture--per ton (gallon)
Mineral Aggregate--per ton
Bituminous Tack Coat--per gallon

APPENDIX B

RUBBERIZED COAL TAR PITCH EMULSION SEALCOAT
(For Bituminous Pavements)

Description

1.1 This item shall consist of an application of a coal tar pitch emulsion sealcoat, with or without mineral aggregate, and with the use of a latex rubber, applied, on an existing previously prepared bituminous wearing course, in accordance with these specifications for the areas shown on the plans or as designated by the engineer.

1.2 QUANTITIES AND COMPOSITION OF MATERIALS PER SQUARE YARD.
The approximate amounts and compositions of materials per square yard for the sealcoat shall be as provided in Table 1. The exact amounts to be used shall be determined by the engineer.

TABLE 1. Quantities and Composition of Materials

Gallons of coal tar pitch emulsion	Gallons of water	Pounds of Sand	Gallons of Additive	Application Rate Per Square Yard
First Application:				
100	100	1600	10	0.35 - 0.45
Second Application:				
100	100	1600	10	0.35 - 0.45
Third Application:				
100	100	-0-	4	0.15 - 0.20

MATERIALS

The Rubberized Coal Tar Pitch Emulsion Sand Slurry Protective Coating shall consist of basic coal tar pitch emulsion containing not more than 50 percent water and not less than 50 percent non-volatile material content and conform to Federal Specification R-P 355. In addition, the following additives shall be used: Rubber as will provide a thixotropic composition as a copolymer being present by, 9 to 11 percent of the coal tar pitch emulsion and having an average particle size between 400 and 1000 angstroms, said latex comprising an acrylonitrile/butadine copolymer containing 30-49 acrylonitrile and 7-51 parts butadine and sand, No. 3 sand blasting sand, generally passing U.S. sieve 20 and retained on U.S. sieve 30, 16 pounds per gallon, or 80 percent by volume of the coal tar pitch emulsion, water as needed for application consistency (not exceeding equal parts of coal tar pitch emulsion and water), to assure uniform sand coverage on each coat. This composition shall be used for the first two coats. The third coat shall consist of the same materials except that no sand shall be present and the latex reduced to 4 percent of the coal tar pitch emulsion.

2.1 BITUMINOUS MATERIAL. The bituminous materials shall be a coal tar pitch emulsion prepared from a high-temperature coal tar pitch

conforming to the requirements of Federal Specification R-T-143. Oil and water gas tars shall not be used even though they comply with R-T-143. The coal tar pitch emulsion shall conform to all the requirements of Federal Specification RP-0355 with the exception that the ash of Non-Volatile shall be 50 percent + and the water content shall not exceed 50 percent.

2.2 WATER: The water used in the mix design shall be clear fresh potable water having a temperature of 50 degrees F or higher. The amount of water added to the coal tar pitch emulsion shall not exceed 100 percent.

2.3 AGGREGATES: The mineral aggregate shall be either a natural or a manufactured angular product and shall be composed of clean, hard, durable, uncoated particles, free from lumps of clay and all organic matter. The mineral aggregate shall meet the gradation given in Table 2. The test for gradation shall be made in accordance with ASTM C 136.

TABLE 2 REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designations (Square openings)	Percentage by weight Passing sieves
No. 16	100
No. 20	95 - 100
No. 30	5 - 15
No. 40	2 - 5
No. 100	0 - 2

CONSTRUCTION METHODS

3.1 WEATHER LIMITATIONS: The tar emulsion seal coat shall not be applied when the weather is foggy or when rain threatens, nor when the atmospheric or pavement temperature is below 50 degrees F, unless otherwise directed by the engineer.

3. 2 EQUIPMENT AND TOOLS: All methods employed in performing the work and all equipment, tools, and machinery used for handling materials and executing any part of the work shall be subject to the approval of the engineer before the work is started.

Spray distributors used for the application of the tar emulsion shall be self-propelled, equipped with pneumatic tires, and be capable of applying 0.10 to 2.0 gallon per square yard of tar emulsion over the required width of application. Distributors shall be equipped with removable manhole covers, tachometers, pressure gauges, and volume-measuring devices.

Mixing or agitating equipment furnished shall be a tank-type power mixer. Mixing in tanks may be done in horizontal, round-bottom tanks equipped with a power driven full-sweep mixer of sufficient capacity to maintain the mineral content of the emulsion in complete suspension.

Suitable types and Sizes of pumping equipment shall be available for pumping water and for handling or applying the emulsion. When compressed-air spray equipment is used for application of the emulsion, heavy-duty air compressors shall be furnished.

Mixing machines for preparing the slurry may be central plant mixers, a transit mixer, or any type mixer, approved by the engineer, capable of producing a uniform mixture of emulsion and aggregate.

When a transit mixer or other type mixer is used for preparing the slurry, the slurry may be applied with a spreader box into which the slurry is conveyed by a chute. The spreader box shall consist of a rectangular frame 10 feet or more in width and not less than 8 feet long, equipped for towing, and with a squeegee screed across the inside of the box about three-quarters toward the rear which is adjustable for thickness of application and crown of pavement. The squeegee on the spreader box may be neoprene rubber belting, 1/2-inch thick and 6 to 8 inches in width, held vertically across the width of the box (preferable with 4 inches of "free rubber" for aggregate flexibility) and anchored to an adjustable frame. The front and sides of the box shall be lined with 1/4-inch thick belting to prevent slurry leakage and to assure proper spreading. The slurry box shall be equipped with wheels in order that it may be raised off the pavement and quickly towed into position for use on adjacent lanes.

A suitable spray-type applicator or distributor approved by the engineer may be used for applying the slurry. This equipment shall be equipped with an agitator to keep the slurry uniformly mixed before and during application and so designed to uniformly spread the slurry on the pavement surface at the specified rate of application.

Other tools or equipment, such as brushes, hand squeegees, hose equipment, aggregate batchers, sand spreaders, tank trucks, water distributors and flushers, power sweepers, power blowers, barricades, etc., shall be provided as required.

3.3 PREPARATION OF PAVEMENT SURFACE: Bituminous pavement surfaces which have been softened by petroleum derivatives or have failed due to any other cause shall be removed to the full depth of the damage and replaced with new bituminous concrete similar to that of the existing pavement. Areas of the pavement surface to be treated shall be in a firm consolidated condition and sufficiently cured so that there is no concentration of oils on the surface. Areas that have been subjected to fuel or oil spillages shall be wire brushed to remove any accumulations, the accumulations removed by air blowing and the area primed with shellac or a synthetic resin which will not allow the oil in the pavement to bleed through to prevent disbonding of the protective coating.

3.4 CLEANING EXISTING SURFACE: Prior to placing the seal coat, the surface of the pavement shall be clean and free from dust, dirt, or other loose foreign matter, grease, oil, or any type of objectionable surface film. When directed by the engineer, the existing surface shall be cleaned with a power blower and wire

brushes.

Where vegetation exists in cracks, the vegetation shall be removed and the cracks cleaned to a depth of two inches where practical. Those cracks shall be treated with a concentrated solution of an approval herbicide.

3.5 APPLICATION OF EMULSION After the pavement surface has been inspected, and layers by the engineer, the coating shall be applied over the pavement in three layers in accordance with the method described below in sub-paragraph (a) Hand Method or (b) Distributor or Applicator. Due to the settling that may take place in transit, the emulsion shall be thoroughly agitated before use so that a homogeneous consistency is assured for proper and uniform application.

(a) Hand Method. The emulsion shall be applied in two or three coats in the amounts per square yard as stated in Table 1. The material shall be poured in strips on the pavement and spread with a squeegee or brush. This procedure shall be continued until the entire area is covered. The first coat shall be allowed to dry and cure sufficiently to prevent pickup before the second coat is applied.

(b) Distributor or Applicator. When applied by distributor or approved type of applicator, the emulsion shall be applied uniformly to the surface of the pavement at the prescribed pressures and in the amounts per square yard as specified in Table 1. The emulsion shall be thoroughly mixed before use.

The first application shall be cured sufficiently to drive over without damage before the second application is applied. During the application, surfaces of adjacent structures shall be protected to prevent them from being spattered or marred, In areas inaccessible to the distributor application may be by the hand method.

3.6 APPLICATION OF SAND SLURRY: When the emulsion and aggregate are blended, the material shall be premixed to produce a slurry seal coat. The quantities of materials to be combined in each batch shall be in accordance with the proportions shown in Table 1.

Before application, the materials shall be proportioned, accurately and mixed by suitable mixing equipment. The emulsion and the water are first charged into the mixer and blended to a desired consistency. Aggregate shall then be added at a slow and uniform rate while the mixing is continued, mineral aggregate and the latex rubber additive shall then be added. After all the constituents are in the mixer, the mixing shall continue for approximately five minutes or longer, if necessary. The mixing shall produce a smooth, free flowing, homogeneous mixture- of uniform consistency. Slow mixing shall be continuous from the time the bitumen is placed into the mixer until the slurry is applied by distributor truck or poured into the spreading equipment. During the entire mixing process, no breaking, segregating, or hardening of the emulsion, nor balling, lumping, or swelling of the aggregate shall be permitted. When transit mixers are used, the drum shall be rotated

at its slowest possible speed.

The application of the slurry shall be either by hand methods using rubber squeegees for spreading, by spreader boxes, or distributor equipment, as specified in 625-3.2, or by any other suitable method approved by the engineer. The slurry shall be applied at a uniform rate to provide the desired amount. Care shall be taken not to overload the box with slurry, but a sufficient quantity shall be maintained to supply a feed against the full width of the squeegee.

Each application shall be allowed to dry thoroughly, and in no case shall the curing period be less than four hours.

3.7 CURING: The applied emulsion seal coat shall be allowed to cure for not less than four hours, during which time all traffic shall be excluded from the area that has been sealed.

3.8 HANDLING: The emulsion shall be continuously circulated or agitated from the time it has been mixed until its application on the pavement surface. The distributor or applicator, pumps, and all tools shall be maintained in satisfactory working condition. Spray bar nozzles, pumps, or other equipment can be cleaned with coal-tar toluene or xylene.

3.9 EMULSION MATERIAL CONTRACTOR'S RESPONSIBILITY: Samples of the emulsion that the contractor proposed to use, together with a statement as to its source, must be submitted and approved before use of such material begins. The contractor shall furnish manufacturer's certification that each consignment of the emulsion shipped for the work meets the requirements of Fed. Spec. R-P-355, with the exception that the volatile material shall not exceed 50 percent and the non-volatile be 50 percent minimum. The report shall be delivered to the engineer. The manufacturer's certification for the emulsion and rubber additive shall not be interpreted as a basis for final acceptance. All such reports shall be subject to verification by testing samples of the emulsion received for use on the project.

Method of Measurement

4.1 The unit of measurement of coal-tar pitch emulsion and the rubber latex additive shall be the U.S. gallon. The gallonage to be paid for shall be the number of gallons of undiluted emulsion used as ordered in the accepted work.

4.2 The unit of measurement of the mineral aggregate shall be the ton. The tonnage to be paid for shall be the number of tons of mineral aggregate used as ordered in the accepted work.

Basis of Payment

5.1 Payment shall be made at the contract unit price per gallon for coal-tar pitch emulsion, at the contract unit per ton for mineral aggregate and the contract unit price per gallon for rubber latex additive. These prices shall be full compensation for furnishing all materials and for all preparation, mixing, and applying of these materials, and for all labor, equipment, tools, and

incidentals necessary to complete the item.

Payment will be made under:

Coal-Tar Pitch Emulsion - per gallon

Mineral Aggregate - per ton

Rubber Latex Additive - per gallon

APPENDIX C

ADDITIONAL INFORMATION

Additional information may be obtained from the following companies:

Sahuaro Petroleum and Asphalt Company
731 North 19th Avenue
P.O. Box 6536
Phoenix, Arizona 85005
602-252-3061

Arizona Refining Company
P.O. Box 1453
Phoenix, Arizona 85001
602-256-4843

Walaschek and Associates Inc.
P.O. Box 9566
Fort Lauderdale, Florida 33310
305-771-0014