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Criteria For Coal Tar Seal Coats On Airport Pavements

Volume I—State of the Art

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March 1987

Final Report

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16. Abstract

Because coal tars are resistant to gasoline and jet fuel, they have been used for many years as a protective coating on asphalt pavements used for airport parking areas, ramps, taxiways and runways. Applications include both ...al tar emulsions and ...ubberized coal tar emulsions, generally applied with ...d added to provide skid resistance and stability to the seal coats.

Th... report describes typical coal tar emulsion seal coat formulations ... ...tion practices, and lists major distress manifestations reported by ag... ...ntacted in the first year of the study. Also described are the results of site visits to several airports where problems have been encountered, the results of limited laboratory tests conducted by outside agencies, and the basic laboratory study being conducted as part of this research effort.

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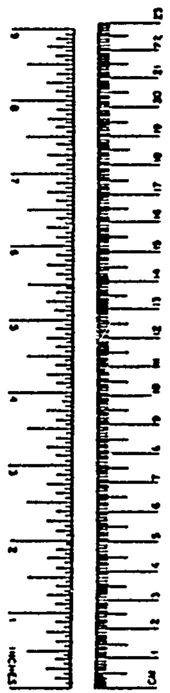
METRIC CONVERSION FACTORS

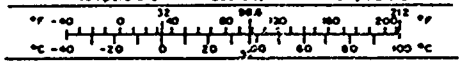
APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This report resulted from a one-year effort to accumulate information on the use of coal tar emulsion seal coats on airport pavements, as part of a study for the Federal Aviation Administration, "Criteria for Coal Tar Emulsion Seal Coats on Airport Pavements," Contract No. DTFA-86-C-00023. Dr. Aston McLaughlin is the Project Manager for FAA, and his assistance and advice are gratefully acknowledged.

Volume II of the report will include field and laboratory test data obtained as part of the same project.

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SCOPE AND OBJECTIVE

Because coal tars are resistant to gasoline and jet fuel they have been used for many years as a protective coating on asphalt pavements used for airport parking areas, ramps, taxiways and runways. Applications include both coal tar emulsions and rubberized coal tar emulsions, generally applied with sand added to provide skid resistance and stability to the seal coats. FAA specifications for coal tar pitch emulsion seal coats are contained in change 20 to Standards For Specifying Construction of Airports, FAA AC No: 150/537-10, Item P-625 (Ref. 1).

This project was programmed because of a need to update and improve the existing P-625 specifications. It has been observed that under certain conditions, coal tar pitch emulsions used as sealants have peeled from base pavements, have exhibited signs of scuffing, cracking and reemulsification, and in many cases appear to have aged prematurely with a useful service life of as little as three years. The objectives of this research are (1) to update or develop new materials and construction criteria for coal tar seals on airport pavements; and (2) to predict their performance on airport pavements based on the proportions and characteristics of ingredients in the coating mix. These criteria will be influenced by such factors as the effects of water, temperature variations, and the amount of exposure to sunlight.

BACKGROUND INFORMATION

The published literature contains very little useful information on the use of coal tar emulsions on airport pavements. References (2) through (7) indicate that coal tar emulsions have been used fairly extensively on concrete bridge decks for protection against the action of de-icing salts, a related application. Unpublished reports, and surveys of FAA Regional offices, State Aviation Administrations, Industry and other sources indicate fairly wide use of coal tar emulsion seal coats for fuel protection, to protect underlying asphalt pavements from weathering, and as a pavement maintenance and rehabilitation procedure. However, coal tar pitch emulsions have low resistance to abrasion, and, therefore, have not, in general, served well for heavy traffic conditions. For aircraft parking areas, aprons and other areas with low traffic conditions, they appear to work well, although sharp turning movements may produce scuffing. They also are used extensively as a surface dressing for automobile parking areas.

Results of surveys of users and producers of coal tar emulsion seal coats have been summarized and are reported elsewhere in this report.

CRITERIA FOR COAL TAR SEAL COATS ON AIRPORT PAVEMENTS

I. INTRODUCTION

SCOPE AND OBJECTIVE

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COAL TAR EMULSION SEAL COAT FORMULATIONS AND SPECIFICATIONS

Coal tar emulsions are classified as clay emulsions, generally consisting of:

30 - 35% coal tar pitch
20% clay, including bentonite
45 - 50% water.

There are three general categories of coal tar emulsions: the grade meeting Federal Specifications R-P 355d(8), containing approximately 54% residue; the domestic grade, cut back with water to approximately 47% residue; and the low residue grade with 35% or less solid residue. The grade meeting Federal Specification R-P 355d* is used for the pavement sealers that are considered in this research. Up to 10% latex rubber may be added to retard weathering and cracking, and up to 16 lbs of sand per gallon of sealer may be added, usually at the job-site, to improve skid resistance properties. They may be winterized by adding a glycol anti-freeze preparation.

ASTM D3320, Standard Specification for Emulsified Coal Tar Pitch (Mineral Colloid Type), (Ref. 9), is often used but is considered by many experts consulted to permit too low residue content for airport applications. Minimum residue contents indicated by the specifications cited are:

ASTM D3320	42%
R-P-355d	47%
P-625	50%

FAA requirements for coal tar emulsion seal coats, with or without rubber latex additives or sand, are included in AC 150/5370-10 CHG 20, Item P-625 (Ref. 1). Item P-625 is included in this report in Appendix A. Formulations permitted by P-625 are summarized in Table 1.

U.S. Air Force guide specifications for airfield pavements, "Guide Specification for Coal Tar Pitch Emulsion Protective Seal Coat (for Airfield Pavement)" (Ref. 10) and "Guide Specification for Coal Tar Pitch Emulsion Sand Slurry Seal Coat for Airfield Pavements" also are included in Appendix A (Ref. 11). These specifications differ in some respects from FAA P-625, but are included for reference purposes.

It was indicated that the formulation in the Air Force "Guide Specification for Sand Seals" will support 5 to 6 lbs of sand, and that in many cases this will provide sufficient skid resistance properties. FAA Item P-625, FAA AC 150/5370-10 CHG 20, permits sand loadings up to 14 lbs, and a recent draft modification permits up to 16 lbs of sand per gallon of emulsion.

* At the time of this report, Federal Specification R-P-355D is being revised. The new version will be designated R-P-355e.

Table 1 FAA Item P-625 Coal Tar Pitch Emulsion Seal Coat Formulatior

Type of Seal Coat	Composition and Quantities			
	Water gal/gal of emuls.	Sand lbs/gal of emuls.	Rubber gal/gal of emuls.	Application Rate gal/sq yd (Per Application)
Rubberized Sand Slurry	0.70 - 1.00	6 - 14	0.07 - 0.12	0.25 - 0.55
Rubberized Emulsion	0.70 - 1.00	---	0.03 - 0.05	0.10 - 0.25
Sand Slurry	0.10 (max)	5 - 7	---	0.15 - 0.25
Emulsion	0.10 (max)	---	---	0.10 - 0.15

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Sand Slurry	0.10 (max)	5 - 7	---	0.15 - 0.25
Emulsion	0.10 (max)	---	---	0.10 - 0.15

A number of additives to the basic P355d coal tar emulsion are used, or have been proposed, to improve their use as seal coats for airport pavements. FAA Item P625 permits the use of a latex additive containing 51-70 part butadiene and 30-49 parts acrylonitrile with the possible addition of a silicone up to 3% of the rubber content. The rubber additives are added to increase the life of these coatings and to permit use of higher sand loadings. Silicones are added to provide better handling characteristics and to provide longer life. The particle size of the latex has been cited as an important factor in supporting high sand contents. Other polymers have been proposed by manufacturers to provide additional improvements, and the use of chemical emulsifying agents to reduce or eliminate the use of clay, has been proposed.

It is generally conceded that sand is required to impart skid resistance properties to coal tar emulsion sealers. Differences of opinion arise over the quantity of sand, sand gradation and type of sand to be used. Table 2 shows several different gradation ranges that indicate the major differences between sand gradations used in coal tar emulsion seals. FAA Item P625 permits use of sand loadings up to 14 lbs per gallon of emulsion. Some suppliers argue that not more than 8 lbs are required to provide skid resistance, and that higher rates decrease fuel resistance of the coatings.

ASTM is considering a proposed Standard for aggregate filled pavement sealers, "Performance Standard for Coal Tar Pitch Emulsion Pavement Sealer Mix Formulations Containing Mineral Aggregates and Optional Polymeric Additives". This proposed standard differs from the FAA and Air Force Specifications cited above in that it is based on the use of performance tests instead of prescribed formulas to control mix properties. The proposed standard could be applied to samples of coal tar emulsion sealers both in the formulation stage, and as a post-construction test on samples collected on the job-site.

Construction procedures are considered critical. References (10) and (11) have been cited as sources of good construction practice. It was recommended that a light coating of diluted emulsion be applied as a first coat to be followed after drying by an emulsion sand coat. The Air Force Guide Specification recommends an initial spray coat followed by two or three sand coats.

Good construction practice also requires that the raw pavement be damp when the initial coat is applied. Most important is the cure period between coats and before traffic is allowed to use the pavement. Periods not less than 4 hours and up to 24 hours may be required; although this could create problems with air traffic interruptions. Construction quality control procedures are not well established, and construction control test procedures are not available. Usually, subjectively defined characteristics, such as color and tackiness, are used for construction quality control purposes.

Table 2 Aggregate Gradations

Sieve Size or No.	Percent Passing by Weight		
	FAA P625 & Air Force Guide Specs.	(1)	(2)
No. 16 (1.18 mm)	100	100	
No. 20 (0.85 mm)	85-100	95-100	
No. 30 (0.60 mm)	15-85	5-15	98-100
No. 40 (0.40 mm)	2-15	1-5	90-98
No. 50 (0.30 mm)			44-75
No. 100 (0.15 mm)	0-2	0-2	5-24
No. 200 (0.074 mm)			0-3

(1) Proposed in FAA Engineering Brief No. 22 (Ref. 12)
(2) Recommended by some suppliers. (Note, this is a range, not a typical gradation).

ADVANTAGES AND DISADVANTAGES OF COAL TAR SEAL COATS

Coal tar sealers have traditionally been marketed as proprietary products and, except for Federal and ASTM specifications, have not been the subject of extensive technical discussions as have other bituminous products. Major companies discontinued marketing coal tar emulsions during the oil embargo of the early 70's. However, the products are available from several sources at this time.

Coal tars, in some respects, are similar to asphalts, but they are more temperature susceptible than asphalts, and require some modifications in construction procedures. However, they are less permeable, provide a better seal, and, particularly, have good resistance to fuel spillage.

Coal tar emulsions have been reported to have good storage characteristics, are easy to make, and are relatively simple to handle and apply, when formulated for home use. They are petroleum and water resistant. Disadvantages include embrittlement and cracking with time, poor adhesion characteristics, poor resistance to traffic and wear on the surface of pavement exposed to heavy traffic, and poor skid resistance, except in the form of a sand slurry.

Coal tar weathers differently than asphalts. Asphalts weather through the effects of oxidation and sunlight, whereas coal tar appears to weather through the evaporation of oils. Reference (13) reports some of the early research done on these type of mixes. Coal tar emulsion also differ from asphalt emulsions in that they cure by water evaporation. Thus, curing time is influenced by humidity and similar environmental factors.

MAJOR DISTRESS MANIFESTATIONS

Major forms of distress associated with the use of coal tar emulsion seal coats include cracking, loss of adhesion or wear, and low friction values. Some of the factors involved in distress are listed below.

Cracking

1. Incompatibility between certain asphalts and coal tar.

2. Shrinkage of the underlying pavement.

3. Shrinkage and brittleness of the coating.

4. Sand content.

5. Thickness of the application.

6. Lack of prime coat.

Poor Adhesion

1. Poorly cleaned surface of pavement before sealing.

2. Mix proportions not correct.

3. Poor mixing and placement (construction).

4. Type of latex additive.

5. Poor fuel or water resistance.

Low Friction Values

1. Sand loading.

2. Type of sand.

3. Type and application rate of top coat.

4. Use of silicone.

SUMMARY

It has been observed that under certain circumstances coal tar emulsion seal coats meeting FAA P-625 specifications have exhibited signs of scuffing, cracking, premature aging and reduced service life. This study was designed to obtain information on the performance of these fuel resistant coatings from various agencies, including FAA, aviation authorities and industry representatives; and to conduct laboratory and field studies to determine if P-625 mix formulations and construction guidelines should be modified to produce better performance.

This chapter describes typical coal tar emulsion seal coat formulations and construction practices, and lists major distress manifestations reported by agencies contacted in the first year of the study. Subsequent chapters describe the results of site visits to several airports where problems have been encountered, reviews the results of limited laboratory tests conducted by outside agencies, and describes the basic laboratory study being conducted as part of this research effort.

II. SURVEYS OF FIELD EXPERIENCE

INTRODUCTION

Letter and telephone requests were made to the following groups to obtain research reports or references to documented field experience with coal tar emulsion seal coats: (1) FAA Regional Offices, (2) State Aviation Administrations, (3) producers of coal tar emulsion seal coats, (4) The U.S. Army, Corps of Engineers, Waterways Experiment Station, and (5) miscellaneous other sources.

Information and reports received from these contacts have been compiled for use as background material and for planning the laboratory study. Unfortunately, very little research data was located.

Several replies were received from letters sent to FAA regional offices. One reply, for example, included reports on a reported failure at the Bradford, PA airport. The consultant's report on this project indicated possible effects of sand loadings on fuel resistance of coal tar emulsion seal coats. Other replies related observations on the performance of coal tar emulsion seal coats in general; and results of a recent survey of seal coat performance were obtained, and summarized in later paragraphs.

Most industry representatives supplied promotional material. This has been useful in defining the range of coal tar emulsion seal coat formulas that are being used on airport pavements. In addition, construction practices and test procedures recommended by industry have beeen useful in establishing the testing program and subsequent recommendations on good construction practices.

Industrial agencies that were written to or that have contacted us include Ark-La-Tx Coatings, Inc.; Engineering Industries; Gem Seal (Mariani Asphalt); Gulf States Asphalt Co.; Koppers Company; Maintenance Incorporated; Merritt Sealing Co.; Monsey Products Co.; National Coal Tar Institute (letter returned); NEYRA Industries; Reichold Chemicals, Inc.; Reilly Tar & Chemical Corp.; U.S. Steel; Walaschek & Associates, Inc.; Western Colloid Products; and Wikel Manufacturing Co.

REPORTS

Very few extensive reports on seal coat performance were discovered in the survey. However, useful test data were obtained from a few sources. Further discussion of these reports are included in separate sections of this report.

Test data from an Arthur D. Little study for Engineering Industries, Inc. were supplied by Engineering Industries, Inc. for use in this study. The data were used in planning the laboratory test program, and have been useful in indicating how mix formulation can affect certain laboratory test properties.

The State of Wisconsin Department of Transportation, Bureau of Aeronautics, has supplied two useful sets of ski data obtained on coal tar emulsion seal coats applied to airport runways. One set contains skid data on 23 runways of different surface type. An analysis was made of these data to compare dry and wet friction values on coal tar emulsion sealers and other pavement surfaces. The second set is from a special study of different formulations of coal tar emulsion sealer. These data will be useful in comparing the effect of different sand loadings on friction values.

Other reports include, "Evaluation of Rubberized Coal Tar Sand Slurry Seal Coat on the Lafayette Airport General Aviation Airports", by Philip J. Arena, Jr. (Ref. 14). This report concerns the application of a coal tar emulsion seal coat to pavements having a variety of different surface textures. Mu Meter friction values were obtained on the old pavement before application of the seal coat, and after the seal coat was applied.

Two formal reports of laboratory studies were obtained from the U.S. Army Corps of Engineers Waterways Experiment Station: "Fuel Resistant Coatings and Binders for Porous Friction Surface Pavements: Tests and Analyses" (Ref. 15), and "Fuel-Resistant Pavement Sealers," (Ref. 16), both reports by J.E. Shoenberger. These reports are reviewed in subsequent chapters. Also received was a copy of a "Test Procedure for Evaluating the Quality of Fuel Resistant Sealers in the Laboratory" (Ref. 17). The work at WES was useful in establishing the laboratory test program for this study.

Field observations by the Waterways Experiment Station have been reported by WES, also. The most recent report is "Facilities Technology Application Tests; Fuel-Resistant Pavement Sealers," by J. E. Shoenberger and E. R. Brown (Ref. 18).

OBSERVATIONS

Federal

The Western-Pacific Region of the Federal Aviation Administration (FAA) conducted a survey of airport operations regarding the use of 3 types of seal coats (Items P-609, P-625 and P-626). Of the 250 questionnaires sent out responses were received from 36 operators. Of these, 27 replies stated that one or more types of seal coats had been used on 63 projects at 42 locations. Several of the replies indicated that close supervision by a qualified inspector on the job is necessary to insure proper application of the seal coat and to obtain a good job. The responses are summarized below for each type of seal coat.

Item P-609, Seal Coats and Bituminous Surface Treatment, was used by 17 of the respondents on 23 projects. The performance of the seal coat was rated good to excellent on 20 of the projects, fair on 2 projects and poor on 1 project.

Item P-625, Coal Tar Pitch Emulsion Seal Coat, was generally rated good to excellent by 8 of the respondents for 9 projects. Resistance to fuels, wear and weather, skid and adhesion to pavement was mostly rated good. FAA specifications were used on 5 of the projects, State specifications on 1 project and others on the remaining 3 projects.

Item P-626, Emulsified Asphalt Slurry Seal Surface Treatment, was used by 18 of the respondents on 31 projects and is by far the most commonly used type of surface treatment. The performance of the seal coat was rated good to excellent. FAA specifications were used on 6 projects, State specifications on 14 projects and other specifications on the remaining 11 projects.

States

Letters were sent to state aviation administrations requesting research data, consultant reports, or their experiences with the use of coal tar emulsion seal coats on airport pavements. Replies were received from 15 agencies. These replies are reviewed briefly below.

The State of Hawaii reported limited experience with coal tar sealers. A general aviation runway was seal coated recently and could be evaluated fairly. Previously, an aircraft apron and a roadway were treated with a coal tar sealer. The fuel resistance property of the sealer was excellent. It was reported, however, that since the coal tar sealer did not allow petroleum contaminants from equipment to penetrate the asphalt, the pavement became slick whenever it rained. It was determined that it was cheaper to repair the asphalt than to assume the potential liability for a slick surface, and the coal tar sealer was removed. Other than sales and promotional literature, no literature relating to coal tar seal coats were found by the State of Hawaii.

The State of Michigan has done a number of seal coat projects over the last few years using Federal Specification P-625. Copies of the plans and the individual specifications used for each project were received. The results of friction tests at two airports were also received and are presented in Section IV of this report.

Results from friction tests at five general aviation airports in Tennessee were received, along with the standard construction specifications used.

The Minnesota Department of Transportation reported that its experiences with coal tar seal coats have been limited to areas around fueling facilities on airport aprons. No reports were available for these projects.

Four Kentucky airport projects used coal tar sealers and two additional projects are being contemplated. One failure was cited due to improper application or insufficient latex content. No formal records of performance are available.

Industry

Suppliers of coal tar emulsions were contacted and given the opportunity to contribute any beneficial information. Literature was received from Engineering Industries, Inc., Maintenance, Inc., Neyra Industries, Inc., Walaschek and Associates, Inc., and Wikel Manufacturing Co. Studies of the literature and discussions with industry representatives indicate that sand gradation, sand loading, latex particle size, and the use of silicones are matters of disagreement among major suppliers of latex additives and coal tar emulsion sealers.

Some suppliers argue that the current specification allows too coarse a sand gradation. It is believed that larger sand particles in the range of the #20 and #30 sieves have a tendency to roll out of the coating under traffic. Problems with keeping the larger sand particles in suspension have also been cited. Other suppliers argue that using the 20-30 sand produces a seal coat that is more flexible and that has better adhesion and fuel resistance properties.

Another major point addressed in the replies was the sand loading. The current FAA specification allows up to 14 lbs per gallon of coal tar emulsion. One supplier has stated that his material can support up to 16 lbs per gallon. Another supplier argues that adding more than 8 to 10 lbs per gallon is detrimental to the performance of the seal coat, and that in mixes with higher sand loadings there is insufficient binder to coat the sand particles, causing loss of adhesion.

The FAA P-625 specification allows for a copolymer latex additive containing 51 to 70 parts butadiene and 30 to 49 parts acrylonitrile or styrene. The average particle size specified is between 300 and 1500 angstroms. One supplier argues that latex particles over 1000 angstroms cause the coal tar emulsion to conglomerate, and that latex materials with particle sizes below 1000 angstroms reduce voids in the seal coat and accomodate higher sand loadings.

There is also a question of the usefulness of a silicone additive. It is claimed that silicones change the viscosity of the mixture and provide for a more even distribution of the materials.

VISITS

Visits were made to a number of public sites and industry laboratories. These visits included:

- Waterways Experiment Station to discuss their testing program, which includes coal tar emulsion and other seal coat materials.

- Davison Army Airfield, Ft. Belvoir, VA to observe a fuel-resistant sealer demonstration site.

- Meetings of ASTM Subcommittee D08.09, "Bituminous Emulsions", which has been considering a proposal for an aggregate filled pavement sealer specification of possible use as a performance - based specification. The proposed specification includes test procedures that are included in the University of Nevada test program.

- Neyra Industries, Cincinnati, to observe coal tar emulsion test procedures and to obtain the Neyra view on coal tar emulsion seal coat specifications, perfo~ nce, test procedures, etc.

- Wisconsin DOT, Madison and LaCrosse airports, to review experiences and to obtain test reports on one study conducted at LaCrosse and another study of skid tests made on different Wisconsin airport runways. Test data are summarized in Chapter IV.

- Orlando Executive, Merrit Island and Titusville airports in Florida with the airport engineering representative.

- Airport at Stuart, Florida where a coal tar emulsion seal coat was to be placed over surfaces with different textures. No test data, but observations are planned after one year of use.

- Cambridge, MA to review results of a laboratory study conducted by Arthur D. Little for Engineering Industries. The data obtained during this visit are summarized in Chapter III.

- Laboratory facilities of Maintenance Incorporated, Wooster, Ohio, for demonstration of properties of coal tar emulsion formulations.

- The FAA office at Willow Run, Michigan, to meet with Mr. Robert Conrad, FAA District Engineer for Ohio, to discuss a failure by cracking and curling in a coal tar emulsion seal coat applied to two parking aprons at the Greene County, Ohio, airport.

Results of the visits to Florida, Ohio and Wisconsin are summarized in Chapter IV.

SUMMARY

Information on the properties, use and performance of coal tar emulsion seal coats were obtained from several sources, including review of literature, letter requests, telephone requests and personal visits. Very few reports of tests or documented observations of performance under actual field conditions were obtained, however.

Replies from both industry and user agencies indicate that coal tar emulsion seal coats perform satisfactorily when formulated and placed properly. However, poor performance has been observed. Industry suppliers of coal tar emulsion seal coats agree that both good and bad performance has been observed, and cite various reasons for both. There appears to be, however, major disagreements between industry suppliers on desirable formulations and the adequacy of FAA P-625 specifications to insure a satisfactory product.

III. LABORATORY STUDIES

INTRODUCTION

A search for useful laboratory data that could be used in this study revealed only two sources of existing data: the U.S. Army Corps of Engineers, and Arthur D. Little, Inc. A substantial part of this study, accordingly, involves a separate laboratory investigation to be conducted at the University of Nevada at Reno. Both the U.S. Army and Arthur D. Little studies are summarized in this chapter. The University of Nevada study, at the time of preparing this interim report, was just getting underway, and only the results of preliminary planning activities are reported.

UNIVERSITY OF NEVADA-RENO LABORATORY STUDY

A planning meeting for the project laboratory study was held at the University of Nevada at Reno on August 1 and 2, 1986. The basic decisions from this meeting were (1) to invite suppliers of coal tar emulsion sealers to place small test sections of their product on roadways in University parking lots; (2) to have the University laboratory supervisor in charge of this project visit two different industry laboratories, and the Corps of Engineers, Waterways Experiment Station research facility, where some corollary work is underway; and (3) to develop test procedures and acquire laboratory test equipment to be used in this study. The objective was to provide the laboratory personnel with exposure to coal tar emulsion technology and to develop a basic approach for the laboratory testing program.

Four suppliers applied six different products to locations on roadways at the University of Reno during September 1986. Formulations and other data for these mixes are given in Table 3. Samples of these materials were obtained for use in the laboratory test program. Visual observations of condition, but no physical tests, are planned for the field test pads at this time.

The first series of tests are being limited to the coal tar emulsions used for the field test pads placed on the University parking lots. The results of this series of tests will be used to make final plans for a factorially designed follow-up experiment.

In addition to the expressed need for locally available field test patches of typical sealers, the University research staff felt the need to conduct an exploratory investigation before planning any type of study involving an elaborate factorial experiment design. However, most variables that need to be included in a factorial experiment have been identified.

The first series will be grouped into five separate sub-experiments: (1) tests on the coal tar emulsion only; (2) tests on coal tar emulsion, latex and water formulations; (3) tests on coal tar emulsion, latex, water

Table 3 University of Nevada Reno Test Sections

Section	Supplier	Prime coat	No. of base coats	Top coat w/o sand	Quantity Coal tar (gal)	Quantity Water (gal)	Additive Quantity & type (gal)	Sand loading (lb/gal coal tar)
1	WC	No	2	Yes	100	80	8.2 latex with silicone	13
2	WC	No	1	Yes	100	80	8.2 latex with silicone	13
3	WC	Poly oil & water	2	Yes	100	80	8.2 latex with silicone	--
4	WC	Yes	2	No	80 80	20 20	-- --	4 5
5	WC	No	2	No	-------------Asphalt Emulsion (20% cut)----------------			
6	WC	No	2	No	-----------15% coal tar, 85% asphalt emulsion-------------			
7	MI	No	2&3	No	--	--	Fass-Dri	5.4 lb/gal Fass-Dri
8	MI	No	2	Yes Top coat	100 100	25 25	25 F.S.A. 10 F.S.A.	10 --
9	MI	Water	2	Yes Top coat	100 100	20 25	10 F.S.A. 10 F.S.A.	5 --
10	MI	J220	2	No	100	20	10 F.S.A.	5
11	MI	No	2	No	100	20	10 F.S.A.	5
12	EI	No	2	Yes†	100	40	4 Tarmax	2
13	EI	No	2	Yes†	100	50	6 Tarmax	6
14	EI	No	2	Yes†	100	40	5 Tarmax	4
15	EI	No	2	Yes†	100	50	7 Tarmax	8
16	NE	Yes	2	No	100	45	15 Armoflex	7
17	NE	Yes	2	No	100	90	10 Tarco plus	6.2

Notes: WC= Western Colloid
MI= Maintenance, Inc
EI= Engineering Industries, Inc
NE= Neyra Industries, Inc

† Top coat on EI sections consisted of: 100 gal coal tar
40 gal water
4 gal Tarmax

Sand used by WC was #20 sand.
Sand used by MI was 2040.
Sand used by EI was silica sand #30.
Sand used by NE was Wedrin 5-30.

Sections 1 to 9 were applied with a squeegee.
Sections 12 to 15 were applied with a brush.
Sections 16 and 17 were applied with a sprayer.

and sand formulations; (4) tests on coal tar emulsion, water and sand formulations without latex; and (5) tests on various formulations applied to different types of surfaces.

Table 4 presents an overview of this planned series of tests.

ARTHUR D. LITTLE LABORATORY STUDY

The aging process of coal tars is believed to be governed by the evaporation of volatiles and moisture in the emulsion, unlike that of asphalt where the aging process is characterized by the oxidation of the bitumen. In November and December of 1984, Arthur D. Little Co. conducted a laboratory testing program on several mixtures of coal tar emulsion seal coats for Engineering Industries, Inc.* The objective of this study was to evaluate the adhesive characteristics of the sealers over time. In this study a weatherometer was used to simulate the aging process of the coal tar samples.

The coal tar emulsions included in this series of tests were obtained from three different sources. Fourteen mix formulations were tested. Table 7 shows the formulations that were tested. Three coats of the emulsion mixture were brushed on 6 in by [illegible] in aluminum panels at an application rate of 0.15 gallons per sqare yard (0.0267 in or 0.679 mm layer thickness).

Each panel was placed in the weatherometer to age. The weatherometer ran at a dry bulb temperature of 112F (44C) and a wet bulb temperature of 96F (36C). Sunlight was simulated at all times and the relative humidity was kept at 55 percent. Nine minutes of every hour rain was imitated. One day inside the weatherometer was considered equivalent to fourteen days outside. Each panel was covered with strips of masking tape prior to being placed in the weatherometer. Two inch strips of tape were removed at various times to expose new material, and to simulate different weathering ages.

The laboratory testing program consisted of three tests: the cross-hatch test, the mandrel bend test, and the ball drop test. Each test was evaluated on a subjective rating scale of one to five, one being very good and five indicating failure. (See footnote, Table 6).

The cross-hatch test is used in the painting and coatings industry to measure adhesive properties. The test consists of coating a metal plate with the coal tar emulsion. After curing, two sets of parallel cuts are made perpendicular to each other. Failure is a subjective evaluation of the coating becoming detached.

In the mandrel bend test a coated metal plate is bent around an axle; in this case, having an oval-shaped cross section. This test primarily measures the flexibility characteristics but will show adhesion loss if cross-hatched.

*Results of this study were made available to this project by Engineering Industries, Inc., which sponsored the study.

and sand formulations; (4) tests on coal tar emulsion, water and sand formulations without latex; and (5) tests on various formulations applied to different types of surfaces.

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The coal tar emulsions included in this series of tests were obtained from three different sources. Fourteen mix formulations were tested. Table 7 shows the formulations that were tested. Three coats of the emulsion mixture were brushed on 6 in by 18 in aluminum panels at an application rate of 0.15 gallons per sqare yard (0.0267 in or 0.679 mm layer thickness).

Each panel was placed in the weatherometer to age. The weatherometer ran at a dry bulb temperature of 112F (44C) and a wet bulb temperature of 96F (36C). Sunlight was simulated at all times and the relative humidity was kept at 55 percent. Nine minutes of every hour rain was imitated. One day inside the weatherometer was considered equivalent to fourteen days outside. Each panel was covered with strips of masking tape prior to being placed in the weatherometer. Two inch strips of tape were removed at various times to expose new material, and to simulate different weathering ages.

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*Results of this study were made available to this project by Engineering Industries, Inc., which sponsored the study.

Table 4 Overview of Planned University of Nevada Laboratory Testing Program

Test Series No 1. Coal tar emulsions (four suppliers)

(a) Viscosity (3 temperatures) - Brookfield viscometer
(b) Coal tar particle size - microscope for visual examination and photographs
(c) Density - ASTM D 2939
(d) Residue by evaporation - ASTM D 2939
(e) Flexibility - ASTM D 2939 (using metal panels)

Test Series No 2. Coal tar emulsion/latex/water

Same five tests as in part 1, but with variable levels as follows:

(a) latex type - 2 types for two coal tar emulsions; 1 type for other two coal tar emulsions
(b) latex quantity - 3 levels
(c) water quantity - 3 levels

Test Series No 3. Coal tar emulsion/latex/water/sand

Preliminary screening tests on all formulations with variable levels as follows:

(1) latex type - 2 types for two coal tar emulsions; 1 type for other two coal tar emulsions

(2) latex quantity - 3 levels

(3) water quantity - 3 levels

(4) sand type - 2 types

(5) sand gradations - 2 gradations

(6) sand quantity - 3 levels

Tests -

(1) viscosity (3 temperatures) - Brookfield viscometer

(2) settling test

(3) "scuff" test - adapted from ISSA cohesion test (TB 139) using one layer and one thickness

Table 4 (continued)

Test Series No 4. Coal tar emulsion/latex/water

Additional tests on formulations selected from results of preliminary screening tests with variable levels as follows:

(1) prime surface - 2 levels ("yes" or "no")

(2) number of layers with sand - 2 levels (1 or 2 layers)

(3) top coat with no sand - 2 levels ("yes" or "no")

(4) thickness of layers containing sand - 2 levels

Tests -

(1) Fuel drip test followed by wet track abrasion test - Corps of Engineers (adapted from ASTM D 3910 for slurry seals)

(2) Fuel resistance using ceramic tiles - ASTM D 466 (modified according to ASTM D 3320)

(3) Wet track abrasion test (no fuel)

(4) Flexibility - ASTM D 2939 (using metal panels)

(5) Cyclic freeze-thaw for crack monitoring

(6) Shrinkage - curing
  (1) Drying for 24 hours at 77F
  (2) Freezing for 24 hours at -20F
  (3) Heating for 24 hours at 140F

Test Series No 5. Coal tar emulsion/water/sand

Same testing sequence as in part 3, except without variable levels for latex type and quantity.

Test Series No 6. Tests for effect of existing surface on bonding with coal-tar emulsion seal coat (using standard application rates and techniques). Formulations will be same as those selected for second phase of testing in parts 3 and 4.

Surfaces:
(a) New Asphalt concrete
(b) Aged Asphalt concrete
(c) Metal
(d) Roofing shingles
(e) Release-paper

Tests:
(a) Shrinkage-curing
(b) Cyclic freeze-thaw

Table 4 (continued)

Test Series No 4. Coal tar emulsion/latex/water

Additional tests on formulations selected from results of preliminary screening tests with variable levels as follows:

(1) prime surface - 2 levels ("yes" or "no")

(2) number of layers with sand - 2 levels (1 or 2 layers)

(3) top coat with no sand - 2 levels ("yes" or "no")

(4) thickness of layers containing sand - 2 levels

Tests -

(1) Fuel drip test followed by wet track abrasion test - Corps of Engineers (adapted from ASTM D 3910 for slurry seals)

(2) Fuel resistance using ceramic tiles - ASTM D 466 (modified according to ASTM D 3320)

(3) Wet track abrasion test (no fuel)

(4) Flexibility - ASTM D 2939 (using metal panels)

(5) Cyclic freeze-thaw for crack monitoring

(6) Shrinkage - curing
 (1) Drying for 24 hours at 77F
 (2) Freezing for 24 hours at -20F
 (3) Heating for 24 hours at 140F

Test Series No 5. Coal tar emulsion/water/sand

Same testing sequence as in part 3, except without variable levels for latex type and quantity.

Test Series No 6. Tests for effect of existing surface on bonding with coal-tar emulsion seal coat (using standard application rates and techniques). Formulations will be same as those selected for second phase of testing in parts 3 and 4.

Surfaces: (a) New Asphalt concrete
 (b) Aged Asphalt concrete
 (c) Metal
 (d) Roofing shingles
 (e) Release-paper

Tests: (a) Shrinkage-curing
 (b) Cyclic freeze-thaw

Table 5 Mix Formulations Tested

Panel	CTPE gallons	Water gallons	Additive gallons	Sand lbs
A	100	80	10	1600
B	100	70	5	600
C	100	60	6	800
D	100	50	3	---
E	100	70	8	1000
F	100	50	5	600
G	100	70	5	---
H	100	30	---	---
J	100	30	---	200
K	100	50	3	300
L	100	50	3	400
M	100	50	3	500
OC	100	60	6	800
OE	100	70	3	1000

Panels OC and OE were primed with additive.

For the ball drop test a 66.7 gram ball is dropped 23 inches above a coated metal plate. After 7 hits the adhesion loss is observed and judged on a subjective basis.

The results of the test series are summarized in Table 6 and in Figure 1. Table 6 presents the results of the visual ratings obtained from the Weatherometer panels at various equivalent exposure time periods. In these tests increasing rating scores indicate poorer performance. Most test panels exhibited some deterioration during the exposure period. In the most severe cases, a rating score of 5 (= failed) was observed after only a slight amount of exposure. In the least severe cases, a score of 2 (= good) was reached after an equivalent 6-month exposure period. In general, increasing scores, indicating an increasing tendency to crack, were observed to progress uniformly over the entire exposure period, from 0.5 to 6 months.

From discussions with various people, and from observations of the test data summarized in Table 6, it seemed reasonable to study the data for any possible effects of differences in source of additive, water content, or sand loading on the test scores. Although no complete statistical study of the data was made, it appears that the major effect on the rating score was the sand loading used. This is illustrated in Figure 1. Scores obtained by averaging the third- and six-month scores from the Cross Hatch and Mandrel Bend tests are plotted in Figure 1 vs. sand loading in lbs per gallon. Two clusters of data can be noted, separated approximately into those with scores of fair to good and those with scores of poor to fail.

Conclusion

Data have been obtained from a study conducted by the Arthur D. Little Co. for a supplier of latex additives for coal tar emulsion seal coats. In these studies, samples consisting of coated aluminum panels were subjected to periods of exposure in a Weatherometer and tested using a Ball drop test, a Cross Hatch test and a Mandrel bend test. A visual rating score was used to indicate resistance to cracking or fracture. Results of the tests indicate that test panels with coal tar emulsion seal coats and high sand loadings (lbs/gal) exhibited a greater tendency to fail than did those having lower sand loadings. It was not possible from the data to relate the tendency to fracture to either the source of latex additive or to how the same materials would behave under actual conditions in the field.

U.S. ARMY CORPS OF ENGINEERS

Results of two laboratory studies conducted by the U.S. Engineer Waterways Experiment Station on the fuel-resistant properties of pavement seal coats have been reported (Refs. 15 and 16).

Table 6. Results of the Arthur D. Little Tests Sorted by Test Average.

Mix	Test (1)	0	0.5	1.3	2.7	3	3.7	4.4	4.6	6	Avg
		Weathered Age (months)									
		Visual Rating Scores(2)									
A	BD	5									5.0
A	MB	5				5					5.0
OE	CH			5		5		5		5	5.0
A	CH	5		5		5					5.0
OC	CH			3		5		5		5	4.5
E	CH	1		4		5		5		5	4.0
B	BD	2	5		5						4.0
OC	MB					3				5	4.0
M	MB					3				4	3.5
E	MB	1				4				5	3.3
F	MB	1				4				5	3.3
C	MB	1				4				5	3.3
B	CH	1		2		5		4		4	3.2
C	BD	2	3		4		3		4		3.2
B	MB	1				3				5	3.0
F	CH	1		1		4		4		5	3.0
D	BD	2	3		3		3		3		2.8
C	CH	1		2		4		4			2.8
G	BD	2	2				3		3		2.5
H	BD	1	2		2		3		4		2.4
F	BD	1	2		2		3		4		2.4
E	BD	1	2		3		3		3		2.4
M	CH			1		2		3		3	2.3
L	CH			1		2		3		3	2.3
J	MB	1				2				3	2.0
L	MB					2				2	2.0
J	CH	1				2		2		2	1.8
K	CH	1				2		2		2	1.8
G	MB	1				2				2	1.7
H	MB	1				2				2	1.7
K	MB	1				2				2	1.7
H	CH	1		1		1		2		3	1.6
D	CH	1		1		1		2		3	1.6
D	MB	1				2					1.5
G	CH	1		1		1		2		2	1.4

(1) BD = Ball drop test
CH = Cross hatch test
MB = Mandrill bend test

(2) 1 = Very good
2 = Good
3 = Fair
4 = Poor
5 = Fail

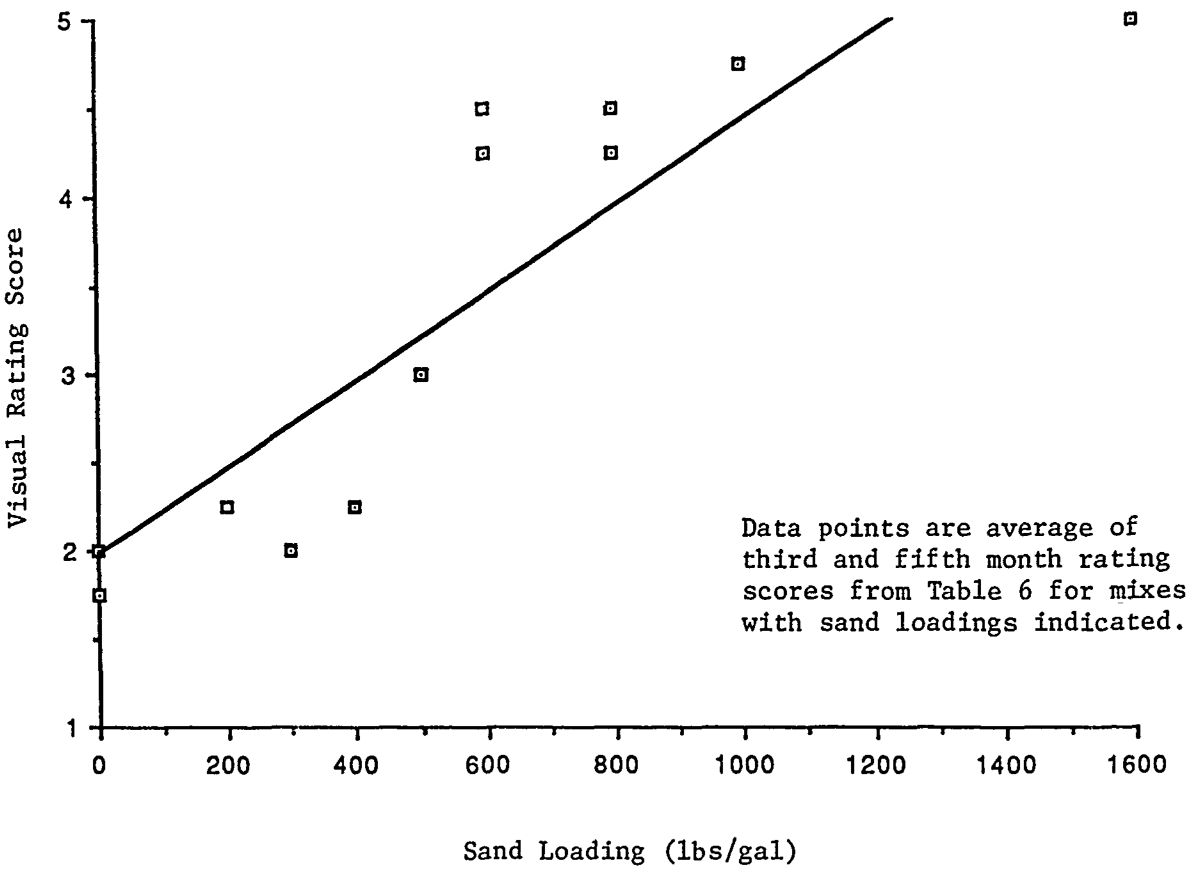

Figure 1 Effects of Sand Loading on Rating Score
(Arthur D. Little Study)

Fuel Resistant Coatings and Binders for Porous Friction Surface Pavements

The investigation reported in Reference 15 was conducted at the U.S. Army Engineers Waterways Experiment Station to evaluate the fuel resistant properties of several materials used as coatings for existing porous friction surfaces (PFS) and as binders for constructing new PFS. A porous friction surface is an open-graded, free draining, bituminous mixture used to prevent hydroplaning, water splashing, and loss of wet traction.

A review of available products on the market was made and material producers were requested to submit products believed to be useful for this application. Table 7 lists the products that were tested. Products F, G, I and K are coal tar emulsions.

The testing program was conducted in two phases. Phase I evaluated the products as coatings for PFS pavements. In Phase II they were evaluated as binders for new PFS construction. A laboratory investigation was used as a screening test to select materials for a field test. The laboratory tests included a permeability test, a fuel-drip test, a hydraulic fluid test, and an abrasion test.

The permeability of laboratory prepared test specimen was measured to insure that the coated samples maintained a satisfactory permeability to fit the requirements of a PFS. Any product which caused the permeability to fall below 1000 ml/min was considered unacceptable as a coating.

The hydraulic fluid test specimens were 6 inch diameter cylinders consisting of a 1 inch thick concrete base and a 3/4 inch porous friction coarse surface. This specimen was coated with the coating materials to be evaluated, and the specimen placed in a 1/2 inch depth of hydraulic fluid with the PFS side down. The specimen was examined periodically for damage by the fluid.

The same type of specimens were exposed to dripping of a standard ASTM reference fuel (Ref. 19) for 10 minutes. The specimens were then exposed to a modified version of the ASTM Method of Test D 3910, commonly called the wet-track abrasion test (Ref. 20).

Product J, RT-14, was then included as a test series under moving vehicles. Observations from both the laboratory and traffic tests are summarized in Table 8.

The authors of this report concluded that as a group, the coal tar emulsions showed some resistance to fuel. However, they did not perform as well as the epoxy coatings. Several products appeared to have failed to protect the samples from fuel penetrating the surface because not enough material could be applied to the open graded material to protect it without reducing the permeability below the recommended level. The relatively short pot-life of the epoxy coatings, however, casts doubts as to their usefulness in general construction, it was concluded.

Table 7 Summary of Products Tested (Ref. 15)

Symbol	Manafacturer	Product	Type of Material	Mixture
A	Adhesive Engineering Co. San Carlos, CA	AEX - 1480	Epoxy resin	1 part A to 5 parts B
B	Adhesive Engineering Co. San Carlos, CA	Concresive epoxy asphalt (A)1152 + (B)1179	Epoxy asphalt	14.6 parts A to 85.4 parts B
C†	American Protective Coatings Corp. Cleveland, OH	No. 21 Epoxy	Coal tar epoxy	1 part binder to 2 parts activator
D†	American Protective Coatings Corp. Cleveland, OH	No. 21 Epoxy (penetrating type)	Coal tar epoxy	1 part binder to 2 parts activator
E	Dural International Corp. Deer Park, NY	No. 306 Epoxy	Coal tar epoxy	1 part base to 1 part binder
F	Emulsified Asphalt Inc. Chicago, IL	GRS-R	Coal tar emulsion	Water added as required
G	Emulsified Asphalt Inc. Chicago, IL	GRS-IL	Coal tar emulsion	Water added as required
H	Isochem Resins Co. Lincoln, RI	Sol epoxy	Epoxy resin	4 parts hardener to 10 parts resin
I	Koppers Co., Inc. Monroeville, PA	Coal tar emulsion	Coal tar emulsion	Water added as required
J	Koppers Co., Inc. Monroeville, PA	RT-14	Tar	No admixtures required
K	Midwest Industrial Products Corp. Chicago, IL	Z-40	Coal tar pitch emulsion	Water added as required
L	Rub-R-Road, Inc. Akron, OH	(A)R-526B + (B)R-607	Rubberized sealant	1 part thinner (B) to 3 parts binder (A)
M	Sahuaro Petroleum and Asphalt Co. Phoenix, AZ	Plastic seal	Plastic-asphalt	1 part water to 2 parts emulsion
N	Union Carbide Corp. Indianapolis, IN	EC-A70	Polyvinyl acetate	Water added as required
O	Uniroyal, Inc. Mishawaka, Iowa	M-6249	Rubberized adhesive	2 parts acetone to 3 parts adhesive (coating) 1 part acetone to 2 parts adhesive (binder)
P	Uniroyal, Inc. Mishawaka, Iowa	M-6136	Rubberized adhesive	2 parts acetone to 3 parts adhesive (coating) 1 part acetone to 2 parts adhesive (binder)

† Products C and D , manufactured by same company, are similar products; however, D is formulated with a lower viscosity.

Table 8 Summary of Products as Fuel-Resistant Coatings and Binders (Ref. 15)

Satisfactory Product Symbol	Marginal* Product Symbol	Unsatisfactory** Product Symbol
	FUEL-RESISTANT COATINGS	
A	F	B
L	G	C
D	I	E
O	K	H
P		J
		M
		N
	FUEL-RESISTANT BINDERS	
L	F	A
E	G	M
C	H	N
O	I	D
P		K
B		
J		

*Marginal includes products tested that exhibit some fuel resistance but fall below the effectiveness of the satisfactory products.

**Unsatisfactory includes products which failed or were unusable for a wide variety of reasons.

Fuel-Resistant Pavement Sealers

In the study reported in Reference (16) the seven products listed in Table 9 were tested in the laboratory in a similar manner. The selection of materials for this project was influenced by the previous laboratory study, and three of the products were the same ones that were examined in the previous study.

Asphalt concrete cores were prepared and sealed with each of the products being evaluated. Both ends and sides of the asphalt cores were sealed. The coal tar emulsions were applied to the specimens in several coats as required to assure a good seal. Three materials, Cheme-Crete coal tar, RT-14, and Sulphlex 233A, which required heating before application, were difficult to apply due to rapid cooling.

The sealed asphalt concrete cores were subjected to the same wet-track abrasion test used previously. In this test, 0.26 gallons of fuel were allowed to drip on each specimen for approximately 10 minutes. Test results are summarized in Table 10. The authors of the report concluded that product No. 21 performed well in the laboratory; no signs of distress were noted during the fuel drip and abrasion tests. The coal tar emulsions resisted the effects of fuel to some extent; however, the fuel gradually penetrated the tar film and affected its bond to the asphalt concrete core.

The results from the above studies were used to select five fuel-resistant sealers to be applied in a field demonstration. This field demonstration is reported in Reference 22 and is discussed in Chapter VI of this report.

SUMMARY

Field test pads were placed on parking lots at the University of Nevada at Reno as a preliminary step for planning an extensive laboratory study. Most of the variables to be included in the experiment have been identified and are summarized in this chapter.

Previous laboratory investigations by outside agencies also were summarized. A study in which Arthur D. Little, Inc. investigated the adhesive characteristics of coal tar emulsions using an artificial weathering procedure indicated differences in the behavior of several commercial formulations. Two laboratory studies conducted by the U.S. Engineer Waterways Experiment Station evaluated and compared the fuel-resistant properties of several different types of pavement seal coats, including coal tar emulsions.

Table 9 Products Tested as Fuel-Resistant Sealers (Ref. 16)

Product	Manufacturer	Material	Mixture	Application rate (gal/sq yd)*	Price per gallon	Approximate Material cost per sq yd**
No. 21 Epoxy	American Protective Coating Corp. Cleveland, OH	Coal tar epoxy	1 part binder to 2 parts activator†	0.1	$18.52	$1.85
Tar	Chem-Crete Corp. San Francisco, CA	Tar	None required	0.2	> $2.00	$0.40
Coal tar emulsion (nonwinterized)	Koppers Inc. Pittsburg, PA	Coal tar emulsion	No water added	(0.1 to 0.3) 0.2	$0.92	$0.18
Coal tar emulsion (winterized)	Koppers Inc. Pittsburg, PA	Coal tar emulsion	1 part emulsion to 1 part water	0.4	$0.92	$0.18
Super Seal coal tar emulsion	Koppers Inc. Pittsburg, PA	Coal tar emulsion with rubber	No water added	0.2	$0.95	$0.19
RT-14	Koppers Inc. Pittsburg, PA	Tar	None required	0.2	> $2.00	$0.40
Sulphex 233A	Southwest Research Institute San Antonio, TX	Plasticized sulpher	None required	0.2	††	

* The application rates given are estimates of those rates applied to the test specimens.

** These price estimates are not directly comparable due to unknowns concerning the life of the sealers.

† The manufacturer now suggests a 1-to-1 mixture.

†† No price available but probably $3.00 to $4.00 per gallon.

Table 10 Results of the Wet-Track Abrasion Test on Fuel-Resistant Sealers (Ref. 16)

Product	Original Weight of Sample (g)	Weight After Sealing (g)	Weight of Material Applied (g)	Weight After First Cycle (g)	Weight After Second Cycle (g)	Remarks
No. 21 Epoxy	2557.8	2273.0	15.2	2273.2	2272.8	Specimen received two fuel drip tests before first abrasion test.
Cheme-Crete* processed coal tar	2250.2	--	--	--	--	Weight not recorded; fuel penetrated specimen where sealer separated from core.
Koppers coal tar emulsion (nonwinterized)	2247.8	2259.2	11.4	2258.2	2191.0	Some material dislodged by abrasion head.
Koppers coal tar emulsion (winterized)	2271.0	2282.6	11.6	2196.8	--	Failed after one cycle.
Koppers** coal tar Super Seal Emulsion	2256.5	2288.2	26.3	--	2294.1	Applied in four coats; test surface marked or indented by abrasion head.
RT-14*	2234.8	2325.3	90.5	2325.6	--	No apparent damage to specimen after testing.
Sulphex 233A*	2244.8	2342.9	98.1	--	--	Weight not recorded; fuel penetrated specimen where sealer separated from core.
Untreated Specimen	2225.5	--	--	Failed		During abrasion test aggregate dislodged

* These products had to be heated for application. The application technique used (brushing) prevented a satisfactory sealing of the specimens, except by obtaining extremely thick coats.

** Contains 3 percent rubber by weight of coal tar.

IV. FIELD FRICTION STUDIES

INTRODUCTION

Reports describing limited field studies, primarily involving pavement friction measurements, were obtained from several agencies. The most extensive series were obtained from the state of Wisconsin. Additional friction data were obtained from studies made in Louisiana, Michigan, Tennessee and Texas. Only one study, by the Corps of Engineers included an assessment of fuel resistance.

Brief descriptions of these studies are given in the following paragraphs.

WISCONSIN RUNWAY STUDY

Extensive runway friction data were obtained from Mu-meter tests on 23 runways at 15 airports in Wisconsin. The runway pavements included coal tar emulsion seal coats, asphalt concrete and portland cement concrete surfaces. The attached Table 11 contains a summary of these data.

The data in Table 11 were subjected to a statistical analysis by Dr. Paul Irick, statistical consultant to the project. Since the different types seemed to have similar characteristics, they were combined into groups for analysis. Mean values from Table 11 have been reproduced in Table 12, along with values that can be used to test for significance between surface types. The value given at the bottom of each column in Table 12 is the magnitude of the difference between mean values for any two surface types required to conclude that the difference is statistically significant.

The data in Tables 11 and 12 indicate that wet friction values are lower than dry friction values for all surface types, and that two surface types, coal tar B and portland cement concrete without grooves, had the lowest wet friction values. For wet conditions friction values for coal tar B was significantly lower than coal tar A, or any other surface type. The wet friction values of the portland cement concrete surface without grooves were significantly higher than coal tar B and were significantly lower than all other surface types.

LOUISIANA, MICHIGAN AND TENNESSEE STUDIES

Mu-meter friction data from measurements made in Louisiana, Michigan and Tennessee are summarized in Table 13. Also in Table 13 are average data from the 1980 FAA National Runway Friction Measurement Program (Ref. 21) that can be used for comparison to the data obtained in this study. Where comparisons can be made, wet friction values are lower than dry values; however, there is no clear evidence that coal tar produced appreciably lower wet friction values than the other pavement sealers tested.

Table 11 Results of the Wisconsin Friction Study

Surface type	Airport	Runway	Dry Mu Value		Wet Mu Value		N	Comments
			Mean	Std Dev	Mean	Std Dev		
AC	OSH	27	77.5	1.695	65.5	5.106	12	Part grooved
AC	OSH	9	76.8	1.055	64.7	5.228	12	Part grooved
AC	MJN	31	74.4	0.535	55.9	5.210	7	
AC	MJN	13	75.3	1.380	59.7	4.461	7	
AC	JVL	31	81.1	0.601	72.1	4.197	9	
AC	JVL	13	83.3	1.500	66.9	7.721	9	
AC	JVL	22	81.3	0.651	69.3	2.570	12	
AC	JVL	4	82.8	1.193	66.4	6.374	12	
AC	MSN	8	81.3	0.957	53.5	6.137	4	Fairly new surface
AC	MSN	26	81.3	1.708	55.8	1.500	4	Fairly new surface
AC	MSN	4	82.1	0.641	65.8	3.227	8	Considerable cracking
AC	MSN	22	82.0	0.750	75.4	4.627	8	Considerable cracking
AC	RHI	5	80.4	1.130	61.6	2.698	9	AC over PCC
AC	RHI	23	79.9	0.782	65.0	2.550	9	AC over PCC
AC	EAU	32	82.6	2.066	48.8	4.559	8	Combination AC & PCC
AC	EAU	14	81.6	1.061	52.8	5.776	8	Combination AC & PCC
Weighted mean			80.2		63.6			
Pooled Std Dev				1.178		4.824		
AESS	HAYW	20	73.3	0.707	71.9	0.991	8	Latex slurry seal
AESS	HAYW	2	73.0	0.535	73.3	0.886	8	Latex slurry seal
AESS	AIG	16	82.6	1.817	75.0	2.345	5	"Black Beauty" aggregate
AESS	AIG	34	82.4	0.548	77.0	1.414	5	"Black Beauty" aggregate
AESS	SUE	1	81.3	1.380	62.9	2.545	7	"Black Beauty" aggregate
AESS	SUE	19	80.1	0.690	66.7	1.976	7	"Black Beauty" aggregate
AESS	UNU	2	81.2	0.408	69.5	1.643	6	"Black Beauty" aggregate
AESS	UNU	20	82.2	983.000	70.3	0.816	6	"Black Beauty" aggregate
Weighted mean			79.0		70.5			
Pooled Std Dev				0.952		1.662		
Coal tar A	LSE	13	81.8	0.463	62.9	0 835	8	4th coat w/latex, no silicone, angular aggregate
Coal tar A	LSE	31	81.3	0.463	59.5	3 207	8	4th coat w/latex, no silicone, angular aggregate
Coal tar A	LSE	18	84.9	0.799	62.5	3 662	15	4th coat w/latex, no silicone, angular aggregate
Coal tar A	LSE	36	83.1	0 641	61.7	6 997	15	4th coat w/latex, no silicone, angular aggregate
Weighted mean			83.1		63.6			
Pooled Std Dev				0.650		4.820		
Coal tar B	AUW	12	77.7	0.488	43.9	1.345	7	Latex, silicone, 12# sand loading, sprayed on
Coal tar B	AUW	30	77.3	0.756	45.9	2.410	7	Latex, silicone, 12# sand loading, sprayed on
Coal tar B	MSN	13	82.6	1.014	36.7	4.528	9	Latex, silicone, 8# sand in 2 coats , 1 clear coat
Coal tar B	MSN	31	80.6	0.882	33.6	5.434	9	Latex, silicone, 8# sand in 2 coats , 1 clear coat
Coal tar B	ENW	14	78.3	0.756	47.3	2.138	7	Latex, silicone, 16# sand loading, sprayed on
Coal tar B	ENW	32	79.0	0.816	38.0	3.559	7	Latex, silicone, 16# sand loading, sprayed on
Weighted mean			79.5		40.4			
Pooled Std Dev				0.820		3.710		
PCC w/ g	MSN	36	79.6	1.151	68.5	6.584	14	Rough broom texture
PCC w/ g	MSN	18	78.4	1.505	60.2	8 657	14	Rough broom texture
PCC w/ g	OSH	2	78.6	0.515	65.2	1.850	12	
PCC w/ g	OSH	20	80.2	2.517	64.7	5.228	12	
PCC w/ g	EAU	4	77.3	0 480	66.5	4 666	13	Rough texture
PCC w/ g	EAU	22	77.8	1.633	62.8	6 902	13	Rough texture
PCC w/ g	GRB	24L	77.1	1.387	62.0	2 878	15	Rough broom finish
PCC w/ g	GRB	6R	78.5	1.506	62.1	5 855	14	Rough broom finish
Weighted mean			78.4		63.9			
Pooled Std Dev				1 487		5 748		
PCC w/o g	ATW	21	83.8	0.754	53 9	3 630	12	Normal finish
PCC w/o g	ATW	3	83 4	1.084	52.8	3 010	12	Normal finish
PCC w/o g	GRB	36	80.4	1.647	53.2	2 201	10	Normal finish
PCC w/o g	GRB	18	79.9	1.729	47.8	3.994	10	Normal finish
Weighted mean			82.0		52.1			
Pooled Std Dev				1.328		3.285		

AC = Asphalt concrete
AESS = Asphalt emulsion slurry seal
PCC w/ g = Portland cement concrete with grooves
PCC w/o g = Portland cement concrete without grooves

Table 12 Significant Differences From Analysis of Variance - Wisconsin Friction Study

Surface Type	Average Friction Values			
	Dry	Wet	Average Dry & Wet	Dry Minus Wet
AC	80.2	63.6	71.9	16.6
AESS	79.0	70.5	74.9	8.4
Coal Tar A	83.1	61.8	72.5	21.4
Coal Tar B	79.5	40.4	59.9	39.1
PCCW/G	78.4	63.9	71.2	14.5
PCCW/OG	82.0	52.0	67.0	30.0
Differences Between Means That are Significant at The 0.05 probability level:				
All Types	5.9	11.2	9.1	8.9

Table 13 Friction Test Data From Louisiana, Michigan and Tennessee

Location	Surface Type or Identification	Average Friction Value	
		Dry	Wet
Lafayette, Louisiana, Airport, general aviation aprons	Old asphalt concrete surface before sealing	86	62
	After sealing with coal tar emulsion	86	60
Marquett County, Michigan, Airport	Coal tar emulstion test strip top coat, no sand	80	53
Iron Mountain, Michigan, Municipal Airport	Coal tar emulsion surfaces: 11 lbs. sand, light top coat		58
	11 lbs. sand, heavy top coat		53
	16 lbs. sand, light top coat		56
	16 lbs. sand, heavy top coat		55
Lafayette Airport Tennessee	Coal Tar Emulsion sprayed on 6 months earlier		34
Portland Airport Tennessee	Coal Tar Emulsion squeegeed on 6 months earlier		61
Gallatin Airport Tennessee	Unprotected Pavement 10 Years Old		39

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Lafayette, Louisiana, Airport, general aviation aprons	Old asphalt concrete surface before sealing	86	62
	After sealing with coal tar emulsion	86	60
Marquett County, Michigan, Airport	Coal tar emulstion test strip top coat, no sand	80	53
Iron Mountain, Michigan, Municipal Airport	Coal tar emulsion surfaces:		
	11 lbs. sand, light top coat		58
	11 lbs. sand, heavy top coat		53
	16 lbs. sand, light top coat		56
	16 lbs. sand, heavy top coat		55
Lafayette Airport Tennessee	Coal Tar Emulsion sprayed on 6 months earlier		34
Portland Airport Tennessee	Coal Tar Emulsion squeegeed on 6 months earlier		61
Gallatin Airport Tennessee	Unprotected Pavement 10 Years Old		39

Table 13 Friction Test Data From Louisiana, Michigan and Tennessee (cont)

Location	Surface Type or Identification	Average Friction Value	
		Dry	Wet
Lebanon Airport Tennessee	Unprotected Pavement 3 Years Old		76
Crossville Airport Tennessee	Coal Tar Emulsion Sprayed on 6 months earlier		43
Comparative Data from National Runway Friction Measurement Program (FAA Report dated December 1980)	Asphalt, not grooved, no rubber accumulation		70
	Asphalt, not grooved, with rubber accumulation		55
	Asphalt, grooved, nc rubber accumulation		74
	Asphalt, grooved, with rubber accumulation		66
	Concrete, not grooved, no rubber accumulation		64
	Concrete, not grooved, with rubber accumulation		55
	Concrete, grooved, no rubber accumulation		71
	Concrete, grooved, with rubber accumulation		63

TEXAS TRANSPORTATION INSTITUTE FRICTION TESTS

A friction measurement program was reported by Gallaway in Reference 22. In this program fifteen pavement surface types were tested (see Table 14). Friction tests were conducted at 20, 40 and 60 mph on wet and dry pavements. Each pavement surface was tested by a Mu-meter and a Texas Highway Department research skid trailer. The tests were conducted using two tire inflation pressures.

Results of the Mu-meter friction tests are summarized in Figure 2. When the pavement surface is dry, the friction values tend to cluster together. However, when the surface is wet, significant differences occur. The coal tar emulsion without latex or sand, surface T-4, consistently displayed lower friction values when wet than the other surfaces.

SUMMARY

Results of friction tests were obtained from several agencies and compared to data from the 1980 FAA National Friction Measurement Program. Friction data from the state of Wisconsin were subjected to a statistical analysis and significant differences between different pavement types were reported. A previously published friction study conducted by the Texas Transportation Institute was discussed. In many cases wet friction values were substantially lower than dry values, but there was no clear evidence that coal tar emulsion sealers always produce substantially lower friction values than other pavement surfaces.

Table 14 Description of the Fifteen Surfaces Tested

Surface Number	Surface Type	Average Daily Traffic(1968)	Construction Date
3	Lignite boiler slag hot mix, 3/16 inch top size	4200	1965
4	Rounded river gravel hot mix 5/8 inch top size	1420	1968
11	Crushed river gravel hot mix 1/2 inch top size	3655	1967
13	Crushed sandstone hot mix 3/8 inch top size	1310	1965
17	Open graded lightweight aggregate hot mix, 3/8 inch top size	700	1968
18	Open graded light-weight aggregate hot mix, 5/8 inch top size	700	1968
22	Rounded river gravel portland cement concrete 1/2 inch top size	920	1936
28	Rounded river gravel surface treatment, 5/8 inch top size	135	1968
31	Crushed limestone surface treatment, 3/8 inch top size	820	1968
33	Lightweight aggregate surface treatment, 1/2 inch top size	100	1964
T-1	Rounded river gravel hot mix 5/8 inch top size	none	1968
T-2	Crushed river gravel hot mix 1/4 inch top size	none	1968
T-3	Crushed limestone hot mix 1/2 inch top size, Terrazzo finish	none	1968
T-4	Clay-filled tar emulsion seal (Jennite)	none	1968
T-5	Rounded river gravel portland cement concrete 1-1/2 inch top size	none	1953

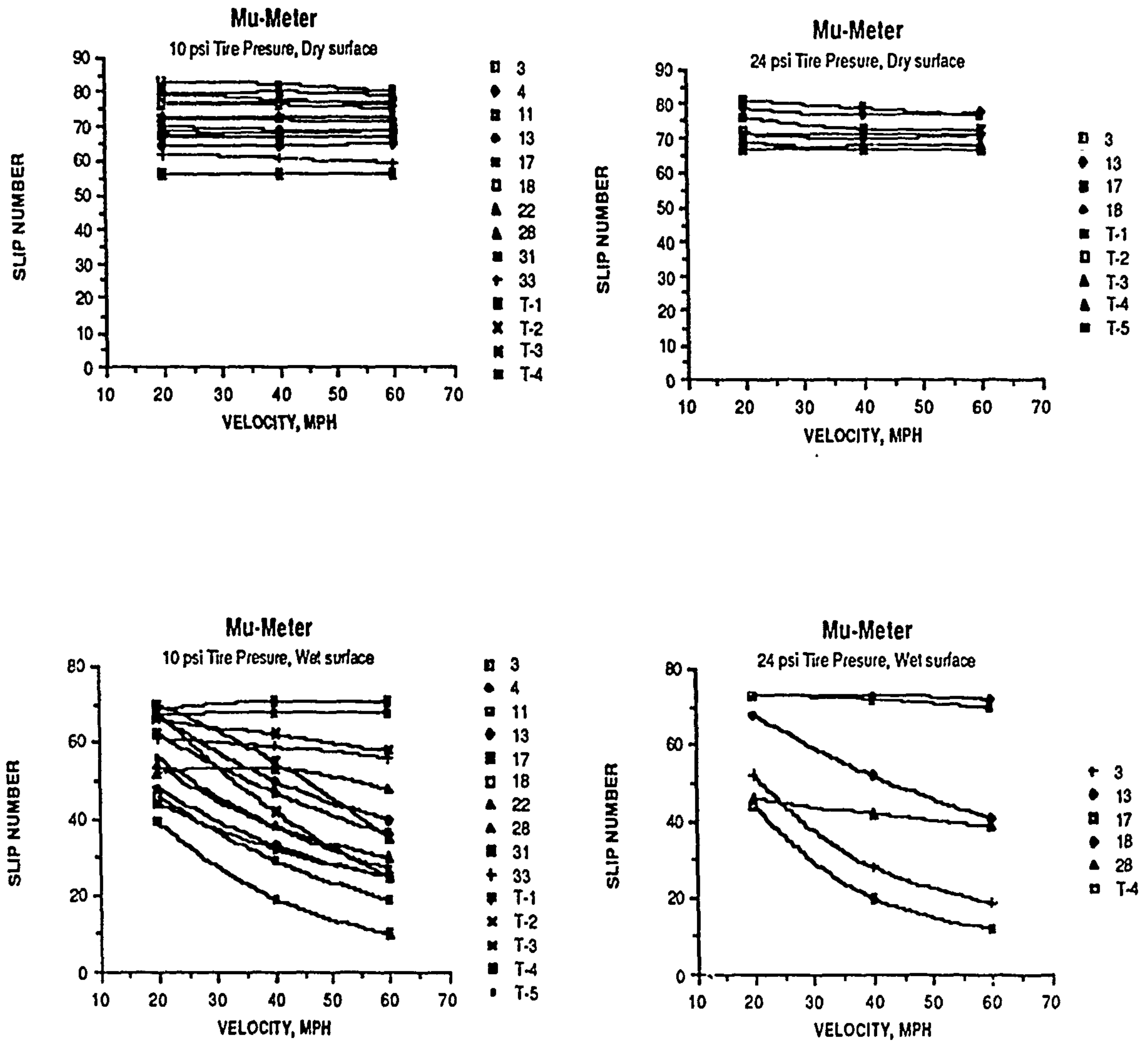

Figure 2 - Effect of Pavement Type on Friction Values

V. FIELD PERFORMANCE OBSERVATIONS

Visits were made to six different airports to observe coal tar emulsion seal coats that had been in place for periods of from a few months to three and one-half years. Three airports were located in Florida, two in Wisconsin and one in Ohio. Undesirable performance was noted or had been reported to have been a problem at four of the six locations.

FLORIDA

Site visits and field inspection trips were made to four Florida general aviation airports, Orlando Executive, Merritt Island, TICO/SCEA (Titusville) and Grumman Field, Stuart, Florida. Coal tar emulsion sealers were being used at the first three airports primarily to rehabilitate older parking aprons, but also had been applied to newly paved surfaces. One experimental application had been made at the TICO airport, and an application to permit changing paint stripes was planned for a runway at the Stuart Airport.

Various formulations had been placed at the Orlando, Merritt Island and Titusville airports. Generally, these meet FAA P-625 specifications, except that up to 16 lb of sand per gal of emulsion were used in some places. Most installations on older surfaces were 2 1/2 to 3 1/2 years old. More recent installations, less than 1 to about 1 1/2 years old, had been placed on surfaces that were recently given an asphalt concrete overlay before applying the sealer. A 5 to 7 year life is expected from both applications.

Almost all of the older sealed areas exhibited block cracking. These can be seen in photos 1 through 4. Blocks are generally 3 to 12 in across. Similar cracking patterns were observed in the newer sealed areas, but these were less extensive or were just beginning to appear. Adhesion appeared good, except in a few areas where there appeared to have been construction problems. In one area the seal coat was "sandy" looking, some loose sand was observed, and was coming loose from the pavement. Construction problems were cited as probable causes for the poor coating, but no test data or other documentary evidence was available to support the construction.

In many cases where high sand loading coal tar emulsion seal coats were used to rehabilitate older parking aprons the original pavement exhibited wide cracks which had been filled with coal tar emulsion sealer using a squeegee application procedure before applying the final coats. In some cases the filler was loose, and cracking was evident in most instances. In the most recent applications, either a hot or cold applied crack filler were being used to fill cracks prior to sealing.

Two test strips had been applied to a taxiway at the TICO (Titusville) airport. Applications of sealers using conventional A-B rubbers and an epoxy reinforced polymer were placed side by side. The test strips were only one week old, and no observations of performance could be made.

Photo 1 Coal tar emulsion seal coat with heavy sand loading used to fill cracks and coat old asphalt pavement (Florida)

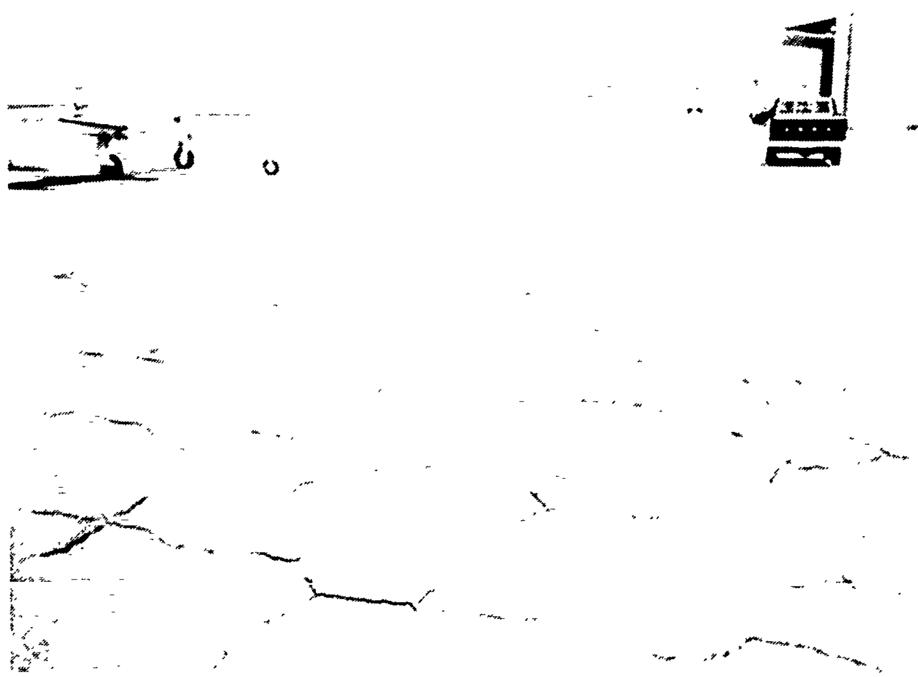

Photo 2 Same as above showing crack pattern (Florida)

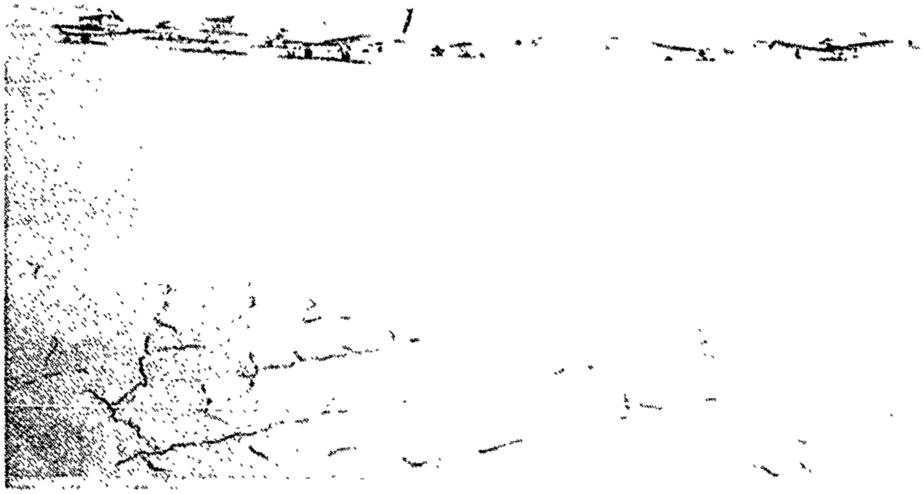

Photo 3 Coal tar emulsion seal coat using heavy sand loading on new asphalt pavement showing crack pattern developing (Florida)

Photo 4 Fuel spill on coal tar emulsion seal coat (Florida)

The application to the Stuart airport runway had not been placed at the time of the visit, but was scheduled for the following week.

GREENE COUNTY, OHIO

A trip was made to observe cracking and curling in a coal tar emulsion seal coat applied to two parking aprons at the Greene County, Ohio airport. New asphalt surfaces had been placed in October 1985 and left unsealed until the following May. The pavements were then sealed with a rubberized coal tar emulsion sealer meeting FAA P-625 specifications.

Shortly after application, the seal coat showed extensive cracking and curling. Cracks were about 4 inches in size, as can be seen in photos 5 through 10. During the following summer most of the curling disappeared, but the cracking persisted. Checks indicated that there was good adhesion between the coal tar sealer and the asphalt pavement surface in most areas. Curling remained, even at the end of the summer, in areas that had been patched with an asphalt sand mix and sealed immediately after patching.

No test data were available, but it was speculated that the curling was caused by the release of volatile oils in the underlying asphalt, or some other incompatibility problems related to the asphalt. It was related that similar problems have been encountered where new asphalt mixes have not been permitted to weather under summer-time conditions. In this regard, applications placed on weathered pavements on adjacent roadways did not exhibit cracking or curling.

WISCONSIN

Two airports were inspected in Wisconsin, at Madison and LaCrosse. High sand content rubberized coal tar emulsion sealers had been placed at both airports on old, cracked asphalt runways. All materials conformed to FAA P-625 specification materials with A-B rubber and silicone additives. Because of severe slippery conditions at the LaCrosse airport, a series of test sections were constructed and subjected to skid resistance testing. The results of these tests are summarized in Chapter IV. Other formulations and sand types were also used.

Some spalling of the asphalt surface was noted at the Madison airport, and it was reported that daily sweeping was necessary to remove loose particles. It was not clear, however, that this indicated any problems with the coal tar sealer. Beading of water during rains was noted and was considered a potential hazard. It was reported that keeping the 16 lb sand loading in suspension during construction had been a problem. A 200 gal fuel spill caused no damage to an apron where the same material had been used. The sealer on the apron looked good after about 1 year, and the coating was described as tough. Some wear was observed on the runways, but this was ascribed to the action of snow plows. The black color was described as an aid to snow removal because it promoted melting.

The runways at LaCrosse were grooved and showed considerable wear from snow plows. In some places the layers of rubberized coal tar emulsion sealer were separating, but it was not clear if this was the result of snow plow

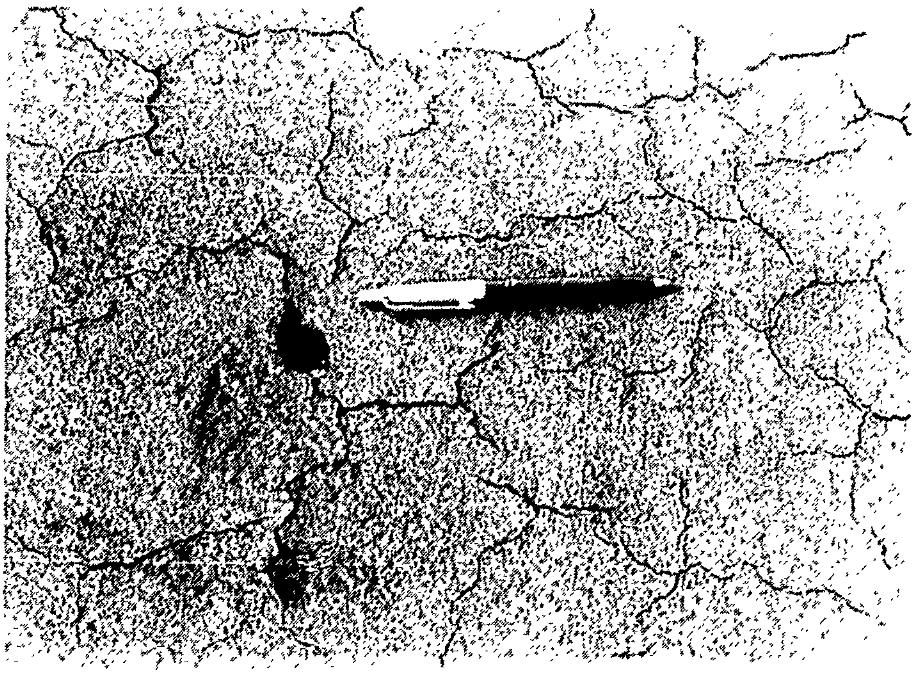

Photo 5 Coal tar emulsion seal coat showing cracking, curling and flaking (Ohio)

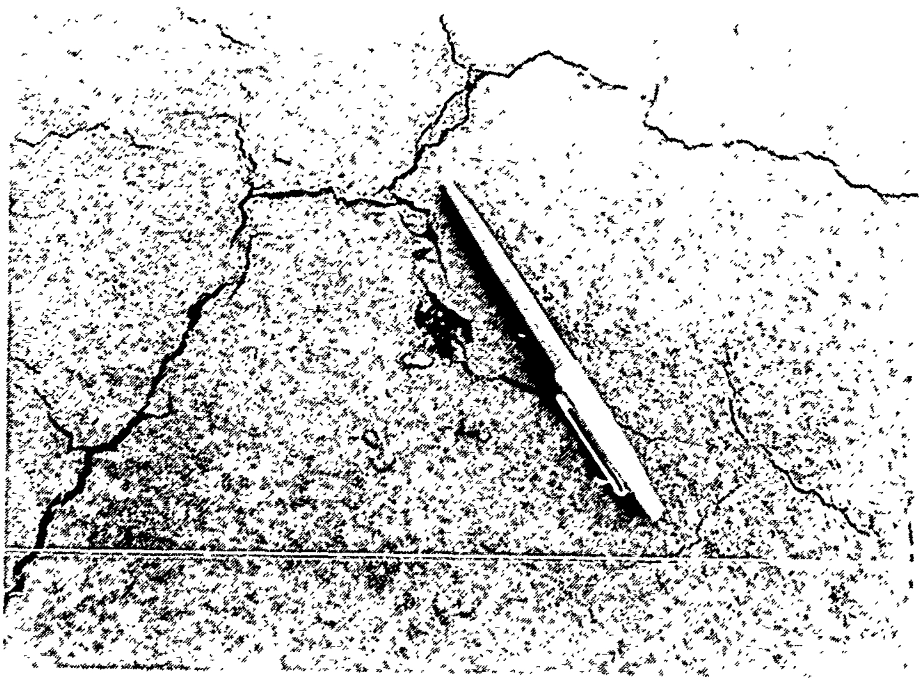

Photo 6 Same as above

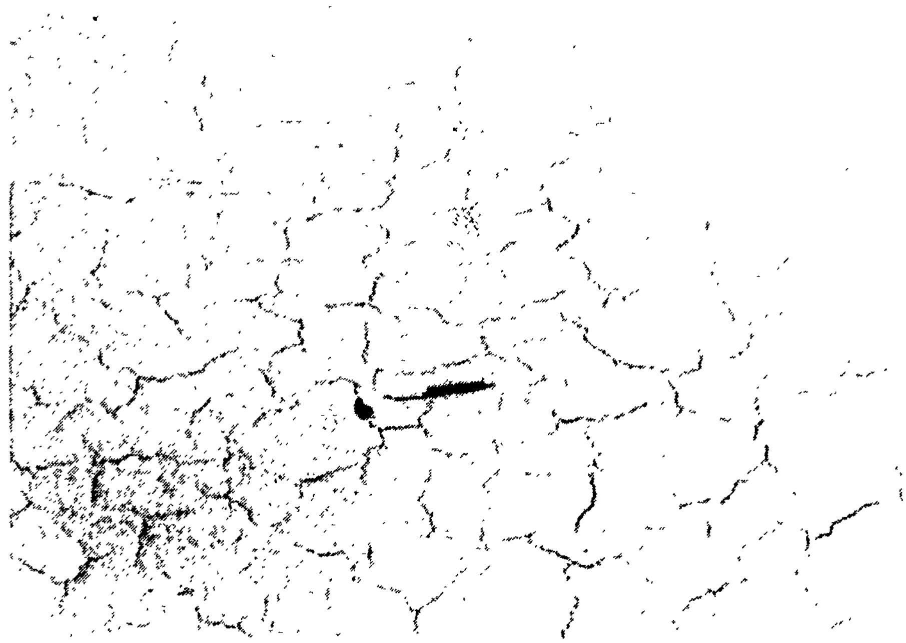

Photo 7 Coal tar emulsion seal coat showing cracking, curling, and loss of adhesion on new pavement (Ohio)

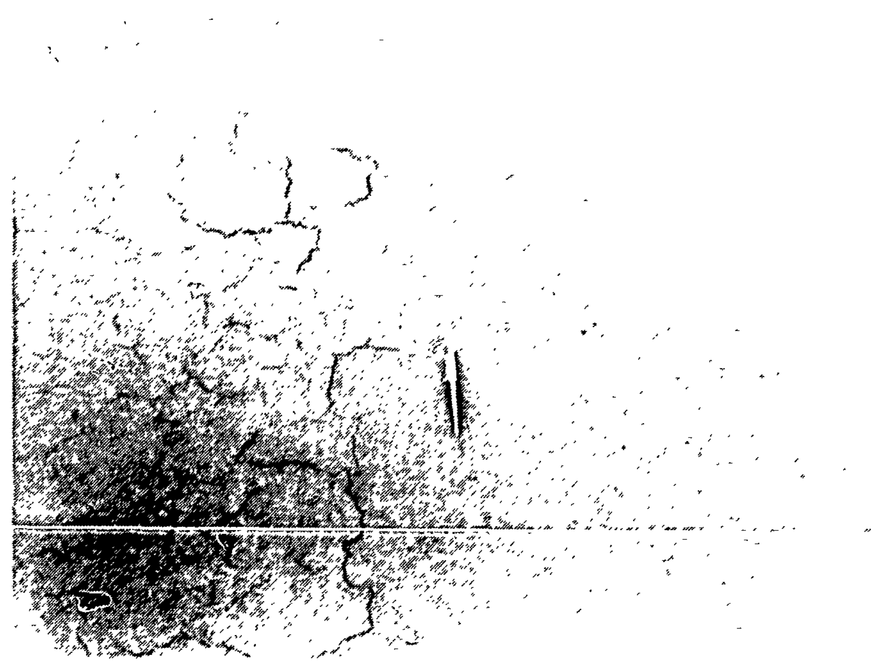

Photo 8 Different crack patterns on new pavement than an old pavement (Ohio)

Photo 9 Fuel spill (Ohio)

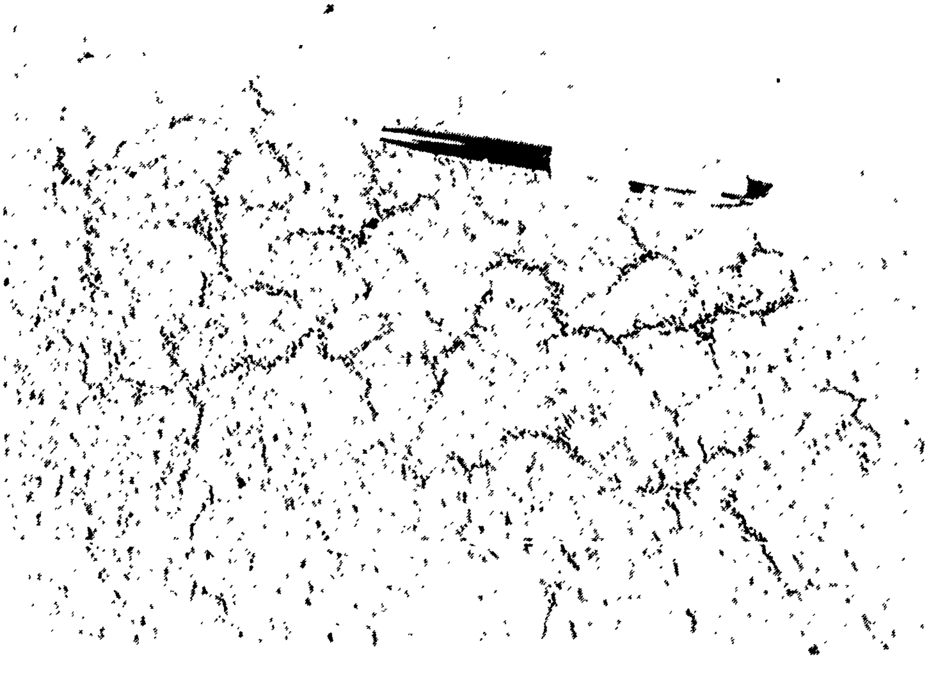

Photo 10 Fuel spill (Ohio)

action, or if it was a separation caused by the earlier application that had proved slippery and which had been covered by a new coating.

U. S. ARMY CORPS OF ENGINEERS

The results from two previous studies conducted by the WES, References 15 and 16, were used to select five fuel resistant sealers for a field investigation. This field investigation is reported in Reference 22.

Ft. Rucker, Alabama, and Ft. Belvoir, Virginia, were the demonstration sites selected. These locations regularly receive aircraft traffic that expose their asphalt parking aprons to fuel spillage.

Construction Procedures

The sealers used for this project are listed in Table 15. The sealers included two types of epoxies, a rubberized sealant, a rubber adhesive, and a coal tar emulsion with rubber.

The asphalt concrete pavements were sealed at Ft. Rucker on May 26 and 27, 1984. They were in reasonably good condition prior to sealing, and required only sweeping and cleaning with compressed air for the surface preparation. The sealers were combined and/or thinned in accordance to manufacturers' recommendations. Concrete sand was added to the mix to provide a skid-resistant surface. The amount of sand added varied with the type of sealer and ranged from approximately 0.6 to 2.2 lbs per gallon of sealer.

The sealer mixture was spread using two types of hand squeegees - a stiff wooden-supported rubber squeegee and a more flexible metal-supported rubber squeegee. Two coatings of each sealer were applied on succesive days. Table 16 shows the sand content of each mixture and the application rate for each layer. The weather was warm and sunny during the entire demonstration period. The sealed area for each test pad was approximately 140 sq yd.

The pavements sealed at Ft. Belvoir were parking aprons used by C-12 airplanes. Two of the six parking areas selected were in satisfactory condition for sealing without repairs. The remaining four parking areas had been damaged by previous fuel spillage and were repaired shortly before sealing. Scheduling difficulties did not allow the recommended cure time of the asphalt patches before sealing. The areas were sealed one day after they were patched.

Mixing and the application of the sealers were performed in the same manner as described for Ft. Rucker, except that sand was added to the top coat only. Table 17 gives the amount of sand and sealer added to each coating. The sealers were placed on dry pavement during generally overcast

Table 15. Fuel-Resistant Sealers Used in Demonstrations (Ref. 19)

Product Name	Manufacturer	Type of Sealer
AEX-1480	Adhesive Engineering Co. San Carlos, California	Resin epoxy
No. 21 Epoxy	American Protective Coating Corp. Cleveland, Ohio	Coal tar epoxy
Super Seal	Koppers Co., Inc. Monroeville, Pennsylvania	Coal tar emulsion with rubber
R-526B and R-607	Rub-R-Road, Inc. Akron, Ohio	Rubberized sealant
M-6249	Uniroyal, Inc. Mishewaka, Iowa	Nitrile rubber adhesive

Table 16. Ft. Rucker Demonstration (Ref. 19)

Material	Layer	Sand Content* lbs per sq yd	Application Rate ** gal per sq yd
AEX-1480	1	0.9	0.17
	2	0.7	0.15
No. 21 Epoxy	1	0.9	0.16
	2	0.6	0.14
Super Seal	1	1.2	0.18
	2	1.0-2.2***	0.14
R-526B and R-607	1	0.9	0.13
	2	0.7	0.11
M-6249	1	1.1	0.18
	2	1.0	0.14

*Sand content, except for Super Seal and to a lesser extent M-6249, is limited by the ability of the sealer to hold sand in suspension.

**Application rates for the first layer are generally higher due to sealer absorption and pavement defects (filling in cracks, etc.).

***The larger amount of sand was added to part of one pad. It mixed and applied well, and even more could have been added.

Table 17 Ft. Belvoir Demonstration (Ref. 19)

Material	Layer	Sand Content* lb/sq yd	Application Rate** gal/sq yd	Sand Content lb/gal
AEX-1480	1	None	0.15	None
	2	0.8	0.13	6.2
No. 21 Epoxy	1†	1.0	0.12	8.3
Super Seal	1	None	0.18	None
	2	1.5	0.13	11.5
R-526B and R-607	1	None	0.15	None
	2	0.9	0.12	7.5
M-6249	1	None	0.18	None
	2	1.0	0.16	6.3

* Sand was not applied in the first layer except for No. 21 Epoxy. Sand content, except for Super Seal and to a lesser extent M-6249, is limited by the sealers ability to hold sand in suspension.

** Application rates for the first layer are generally higher due to sealer absorption and pavement defects (filling in cracks, etc.)

† No. 21 Epoxy was placed in one layer only.

Table 18 Material Costs of Sealer Per Square Yard (Ref. 19)

Material	Ft. Rucker cost/sq yd	Ft. Belvoir cost/sq yd
AEX-1480	$10.88	$9.52
No. 21 Epoxy	$5.97	$2.39
Super Seal	$0.46	$0.45
R-526B and R-607	$3.95	$4.44
M-6249	$4.78	$5.08

Table 17 Ft. Belvoir Demonstration (Ref. 19)

Material	Layer	Sand Content* lb/sq yd	Application Rate** gal/sq yd	Sand Content lb/gal
AEX-1480	1	None	0.15	None
	2	0.8	0.13	6.2
No. 21 Epoxy	1†	1.0	0.12	8.3
Super Seal	1	None	0.18	None
	2	1.5	0.13	11.5
R-526B and R-607	1	None	0.15	None
	2	0.9	0.12	7.5
M-6249	1	None	0.18	None
	2	1.0	0.16	6.3

* Sand was not applied in the first layer except for No. 21 Epoxy. Sand content, except for Super Seal and to a lesser extent M-6249, is limited by the sealers ability to hold sand in suspension.

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R-526B and R-607	$3.95	$4.44
M-6249	$4.78	$5.08

conditions and in between rain showers. The individual parking areas which were sealed measured approximately 60 by 50 ft.

Table 18 gives the material costs per square yard for both of the project sites.

Inspections

The field test sections were inspected in November 1985, and in May 1986. The findings from these inspections are discussed below.

At Ft. Rucker, the November inspection revealed that the AEX-1480 epoxy resin sealer effectively sealed some cracks in the asphalt concrete. The area where this material was applied had not been used and thus had not been subjected to fuel spillage. The material had remained slightly flexible. In some places there was much more sand than in other areas, indicating that segregation had occured during application.

The Super Seal rubberized coal tar emulsion sealer was placed in an area that had been subjected to fuel spillage. Much closely spaced block cracking had occured, although it appeared that the cracks were confined to the sealer and that they did not occur in the underlying asphalt concrete. The material was brittle. The overall condition of this sealer was rated fair to poor.

The Rub-R-Road sealer was placed in an area that had been subjected to fuel spillage. No cracks had occured in the sealer except for cracks reflecting up from the underlying asphalt concrete. The material remained flexible and was judged to be in very good condition.

The No. 21 Epoxy was placed in an area that had been subjected to fuel spillage. Much cracking had occured in the sealer and the material had raveled back from the cracks. This section was judged to be in a failed condition.

The M-6249 nitrile rubber sealer was placed in an area that had been subjected to fuel spillage. No cracks had occured in the sealer except for cracks reflecting up from the underlying asphalt concrete. The material did a good job of sealing the cracks. Problems occured when placing this material, causing an uneven coating. According to personnel involved in placing the material, it was sticky and stringy when placed. The overall condition of material was judged as good except for its appearance.

At Ft Belvoir, the November inspection revealed that the AEX-1480 epoxy resin had become brittle, but was still bonded to the underlying pavement. The Super Seal had been eroded from the surface in some places. This material had become brittle and showed hairline cracking. The Rub-R-Road sealer was in good condition as well as the M-6249. The No. 21 Epoxy had hairline cracks in areas where the material was applied in thicker applications.

At Ft. Belvoir, the May inspection revealed that the AEX-1480 experienced a large amount of hairline cracking. A small amount of wear or scuffing had occured. Fuel damage was not observed on this section. The overall appearance was judged as fair.

The Super Seal experienced a large amount of hairline cracking. The cracks were not wide, but surface crazing could be seen throughout the section. There was some wear or scuffing in a few isolated areas which seemed to be caused by snow removal equipment. The overall appearance of this section was judged as fair.

The Rub-R-Road experienced very little cracking. The small amount of cracking that had occured was hairline. A small amount of wear or scuffing, probably caused by snow removal equipment, was observed. Fuel damage had not occured on this section and there was no delamination. The overall appearance of this section was judged as very good.

No. 21 Epoxy experienced a large amount of cracking. Many of the cracks were as wide as 1/2 inch. It is believed that the crack was caused by differences in the amounts of material applied, or thickness of the coating. There was a small amount of fuel damage adjacent to some of the cracks but no damage was observed in other areas. No delamination was observed. The overall appearance was judged as good except for the cracks.

M-6249 had experienced no cracking except for a few small cracks that had reflected from the underlying material. Some of the cracks from the underlying material had been effectively sealed. Some wear or scuffing had occured, again apparently caused by snow removal equipment. Fuel damage had not occured and there was no delamination between the sealer and the asphalt concrete. The surface texture was not consistent , indicating some difficulty in placing the material. The overall appearance was judged as good except for the rust color and the surface texture.

Conclusions

Based on the two site visits to Ft. Rucker and the two to Ft. Belvoir, the following conclusions were made by the authors of Reference 19; however, they are not to be considered as recommendations by the authors of this report, or of the Federal Aviation Administration.

1. "No. 21 epoxy should not be used as a fuel-resistant sealer. It tends to crack and deteriorate adjacent to the crack."

2. "Super Seal should be allowed for use as fuel resistant sealer. It does develop hairline cracks and wear from the surface; however, it is relatively inexpensive. To be used succesfully, it must be used periodically to reseal the asphalt concrete. It is recommended that treated areas be resealed after 1 to 2 years."

3. "Rub-R-Road should be allowed for use as fuel resistant sealer. It does effectively seal the surface and does not readily crack. However, it may wear quickly under traffic with very high tire pressure. Treated areas should be resealed after 3 to 4 years."

4. "AEX-1480 should not be used as a fuel-resistant sealer. It tends to devlop hairline cracks. Its performance is similar to coal tar but it is much more expensive."

5. "M-6249 should be allowed to be used as a fuel-resistant sealer. It effectively seals the surface and does not readily crack. It may wear quickly under traffic with very high tire pressure. Treated areas should be resealed after 3 to 4 years."

SUMMARY

Site visits were made by project personnel to airports in Florida, Ohio and Wisconsin. In general, cracking in the coal tar emulsion seal coats was observed at all locations, and extensive curling at one. Most applications were applied to older pavements as a rehabilitation alternative; however, examples of applications to new asphalt pavements also were seen.

Also included in this chapter is a summary of observations made by the US Army Corps of Engineers of various materials for use as fuel-resistant coatings. A rubberized coal tar emulsion sealer included in the study exhibited closely spaced block cracks and the overall condition was rated fair to poor.

Snow plow damage to sealers was noted at several installations.

VI. SUMMARY AND CONCLUSIONS

SUMMARY

It has been observed that under certain circumstances coal tar emulsion seal coats meeting FAA P-625 specifications have exhibited signs of scuffing, cracking, premature aging and reduced service life. This study was designed to obtain information on the performance of these fuel resistant coatings from various agencies, including FAA, aviation authorities and industry representatives; and to conduct laboratory and field studies to determine if P-625 mix formulations and construction guidelines should be modified to produce better performance. This report describes typical formulations and construction practices, and lists major distress manifestations reported by agencies contacted in the first year of the study. Also described are the results of site visits to several airports where problems have been encountered, the results of limited laboratory tests conducted by outside agencies, and the basic laboratory study being conducted as part of this research effort.

Information on the properties, use and performance of coal tar emulsion seal coats was obtained from several sources during the study. However, very few reports of tests or documented observations of performance under actual field conditions were obtained.

Replies from both industry and user agencies indicated that coal tar emulsion seal coats perform satisfactorily when formulated and placed properly. However, poor performance has been observed. Industry suppliers of coal tar emulsion seal coats agree that both good and bad performance has been observed, and cite various reasons for both. There appears to be, however, major disagreements between industry suppliers as to desirable formulations and the adequacy of FAA P-625 specifications to insure a satisfactory product.

Results of friction tests conducted at general aviation airports were obtained from several agencies and compared to data from the 1980 FAA National Friction Measurement Program. Friction data obtained from the state of Wisconsin were subjected to a statistical analysis, in which significant differences between different pavement types were reported. Friction data from several sources indicated that wet friction values were substantially lower than dry values, but there was no clear evidence that coal tar emulsion sealers always produce substantially lower friction values than other pavement surfaces.

Site visits made by project personnel to airports in Florida, Ohio and Wisconsin found cracking in the coal tar emulsion seal coats at all locations, and extensive curling at one. Most applications were applied to older pavements as a rehabilitation alternative; however, examples of applications to new asphalt pavements were seen. Snow plow damage to sealers was noted at several installations.

Field test pads have been placed on parking lots at the University of Nevada at Reno as a preliminary step for planning an extensive laboratory study. Most of the variables to be included in the experiment have been identified.

Previous laboratory investigations by outside agencies were summarized. A study in which Arthur D. Little, Inc. investigated the adhesive characteristics of coal tar emulsions using an artificial weathering procedure indicated differences in the behavior of several commercial formulations. Two laboratory studies conducted by the U.S. Engineer Waterways Experiment Station evaluated and compared the fuel-resistant properties of several different types of pavement seal coats, including coal tar emulsions.

CONCLUSIONS

One of the primary conclusions to be drawn from the first year of this study is that there are substantial differences of opinion among suppliers, in particular, and some users, as to what formulations of coal tar emulsions, water, latex and sand willl produce acceptable seal coats. There is general agreement that good construction practices should be followed, and that formulations that produce acceptable coatings are available.

The study has shown that coal tar emulsion seal coats are being used quite frequently to rehabilitate old airport parking aprons, taxiways and runways, and that they often are placed on new parking aprons as a protection against fuel spillage and weathering of the new asphalt surface. Examples of both good and poor applications have been observed.

Major issues were raised during the study regarding seal coat formulations; primarily involving sand gradation, sand loading, type and quantity of latex (or similar) additive, latex particle size, latex solids content, and use of silicones. Preliminary laboratory data indicate that an A-B rubber latex can be incompatible with an RP-355 clay emulsion when used in certain proportions, and that sand grading, sand type, and sand quantity may not influence many mixture properties to any great extent.

Another issue concerned possible causes of cracking and curling, such as shrinkage of the coating, shrinkage of the underlying asphalt pavement, incompatibility with certain asphalt cements, use of high sand loadings, lack of a prime coat on old and rough surfaces, and thick coatings.

Concern has been expressed also about skid resistance properties of coatings, primarily from use of silicones and use of top coats without sand.

VII. RECOMMENDATIONS

Based on the information collected so far in this study, the following tentative recommendations are offered for consideration.

A number of cases of severe cracking in coal tar emulsion seal coats were cited in the survey conducted as part of this study. Such cracking has been attributed to reflection of both visible and invisible cracks in the underlying asphalt pavement, shrinkage of the coal tar emulsion seal coat, placing the seal coat on insufficiently cured new asphalt pavement, use of coatings that are too thick, or incorrect formulations. Sometimes the cracks appear within a few weeks of placing the seal coat, or they may not become evident for several months.

In addition to cracking, cases of low skid resistance and poor adhesion were cited. In general, these problems appear to have been related to incorrect formulations or incorrect construction practices.

Item P-625, Article 3.3, TEST SECTION, stipulates that prior to full production a test section of approximately 50 square yards of mixture in the proportions specified for the job shall be placed and evaluated to verify the adequacy of the proposed mix composition, application rate, placement operations, and equipment. Indications are that in many cases the placement and evaluation of test sections prior to construction of the seal coat would have helped determine whether or not problems of cracking, poor adhesion, or other difficulties would have occurred. Therefore, it is recommended that test sections be placed on a representative section of all pavements for which sealing is scheduled and that these test sections be observed for at least one month before construction of the seal coat on the remaining pavement. In many cases it may be necessary to construct test sections with different application rates, different formulations, and with and without a prime coat or top coat (without sand) to determine the optimum composition and application rate for the particular conditions applying to a given pavement surface.

Several replies to a survey conducted by an FAA regional office, and private conversations with engineers responsible for seal coat construction, have indicated that close supervision by a qualified inspector on the job may be required to insure proper application of coal tar emulsion seal coats. Item P-625 is somewhat vague regarding requirements for contractor certification of the final mixture, as applied, and does not include any requirement for on-site inspection. Pending development of applicable quality control testing procedures for coal tar emulsion seal coats, it is recommended that on-site inspection and contractor certification be required to insure that the mixture as applied meets the specified composition and application rates. Pre-certification of contractors also should be considered.

A number of conflicting claims were made by industry representatives and others regarding the adequacy of seal coat formulations and application rates specified in Item P-625. In addition, new polymer additives that do not meet

P-625 requirements are being introduced. One of the objectives of this research project is to develop tests and applicable criteria that might be used to specify coal tar emulsion sealers for airport pavements. Pending development of such procedures and criteria, it is recommended that deviations from P-625 requirements for materials be permitted provided the supplier can produce documented evidence, satisfactory to the FAA, that the proposed product has been applied and performed satisfactorily under similar conditions for a period of four to five years.

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APPENDIX

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Change 20 to STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS--Updates Coal Tar Pitch Emulsion Specification	Date: 7/14/83 Initiated by: AAS-200	AC No: 150/5370-10 Change: 20

1. PURPOSE. Item P-625, Coal Tar Pitch Emulsion Sealcoat, has been updated and rewritten in guide specification format. An option to use a rubberized sealcoat has been included.

The Change number and date of change are carried at the top of each page.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
419-426	10/29/74	419-426	7/14/83

Leonard E. Mudd
LEONARD E. MUDD
Director, Office of Airport Standards

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT 1.5
1.6

1. DESCRIPTION 3

1.1 This item shall consist of an application of a [rubberized] 6
coal-tar emulsion sealcoat, with or without mineral aggregate, 8
[and with the use of a latex rubber, which may or may not contain 10
a silicone additive] applied on an existing, previously prepared 12
bituminous surface, in accordance with these specifications for 13
the area shown on the plans or as designated by the Engineer. 13

** 14.4.1

a. Use of a rubberized sealcoat may be specified by the 15
Engineer by incorporating the words enclosed in brackets. 16

b. Silicones increase the viscosity of the mixture and 18
provide for a more even distribution of the materials. 19

** 20.1.1

2. MATERIALS 22

2.1 AGGREGATE. The aggregate shall either be a natural or 25
manufactured product and shall be composed of clean, hard, 26
durable, uncoated particles, free from lumps of clay and all 29
organic matter. The aggregate shall meet the gradation in Table 30
1, when tested in accordance with ASTM C136. 31

TABLE 1. GRADATION OF AGGREGATES 33

35

Sieve Size	Percentage By Weight Passing Sieves	
		36
		37
No. 16 (1.18 mm)	100	39
No. 20 (0.85 mm)	85-100	40
No. 30 (0.60 mm)	15-85	41
No. 40 (0.40 mm)	2-15	42
No. 100 (0.15 mm)	0-2	43
		44

2.2 BITUMINOUS MATERIALS. The bituminous material shall be a 48
coal-tar pitch emulsion prepared from a high-temperature, coal- 50
tar pitch conforming to the requirements of Federal Specification 50
R-T-143. Oil and water gas tar shall not be used even though 51
they comply with R-T-143. The coal-tar pitch emulsion shall 52
conform to all requirements of Federal Specification R-P-355 53
except the water content shall not exceed 50 percent. 53

2.3 WATER. The water used in mixing shall be potable and free 56
from harmful soluble salts. The temperature of the water shall 57
be at least 50 degrees F (10 degrees C). 57

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT 1.5
1.6

2.4 LATEX RUBBER. The rubber shall be a copolymer latex 60
containing 51-70 parts butadiene and 30-49 parts acrylonitrile or 61
styrene[.] [with silicones at 3 percent of the rubber content.] 62
The average particle size shall be between 300 and 1500 angstroms 63
and the rubber shall be compatible with the coal-tar pitch 64
emulsion used by the Contractor. The rubber must mix 65
homogeneously with the coal-tar emulsion, water, and sand in the 67
proportions specified to produce a mixture that will adequately 67
suspend the sand. 67

*** 68.4.1

The Engineer shall delete paragraph 2.4 if a rubberized 69
coal-tar pitch emulsion is not specified. 70

*** 71.1.2

3. COMPOSITION AND APPLICATION 73

3.1 COMPOSITION. The [rubberized] coal-tar pitch emulsion 78
sealcoat shall consist of a mixture of coal-tar pitch emulsion, 78
water, [latex rubber] and aggregate in the proportions shown in 81
Table 2. [The amount of water added to the rubberized coal-tar 82
pitch emulsion or to the rubberized coal-tar pitch emulsion sand 83
slurry, to achieve application consistency, shall not exceed 100 85
percent of the coal-tar pitch emulsion.] [The amount of water 86
added to the coal-tar pitch emulsion sand slurry or to the 86
emulsion shall not exceed 10 percent of the coal-tar pitch 87
emulsion.] The final composition shall be determined by the 89
Engineer within the limitations of Table 2. 90

*** 91.4.1

The Engineer shall incorporate the appropriate sentence in 92
the project specifications, depending on whether the 93
sealcoat is to be rubberized or non-rubberized. 93

The composition of the sealcoat applicable to a project 95
(rubberized or non-rubberized) shall be specified by the 96
Engineer from the information contained in this note. The 97
composition and application rates shall be inserted into 97
Table 2. Insert points are denoted by asterisks. 98

The proportions of water, sand and rubber and the 101
application rate are a function of the condition of the 102
pavement surface texture desired. A highly oxidized 103
pavement or a pavement with substantial cracks will require 103
more sand and rubber as well as a heavier application rate 104
than a newly placed pavement. 104

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT

Type of Sealcoat	Water gal./gal. of emul.	Sand lbs/gal. of emul.	Rubber gal./gal. of emul.	Application Rate gal./sq. yd. (Per Application)
	Composition and Quantities			
Rubberized Sand Slurry	0.70-1.00	6-14	0.07-0.12	0.25-0.55
Rubberized Emulsion	0.70-1.00	-	0.03-0.05	0.10-0.25
Sand Slurry	0.10 (max)	5-7	-	0.15-0.25
Emulsion	0.10 (max)	-	-	0.10-0.15

****

TABLE 2. COMPOSITION OF MIXTURE

Type of Sealcoat	Water gal./gal. of emul.	Sand lbs/gal. of emul.	Rubber gal./gal. of emul.	Application Rate gal./sq. yd. (Per Application)
	Composition and Quantities			
*	*	*	*	*

3.2 APPLICATION. [The rubberized coal-tar emulsion sealcoat shall be applied in three coats at the rate specified in Table 2. The first and second coats shall consist of a rubberized sand slurry; the third coat shall consist of a rubberized emulsion.] [The sand slurry coal-tar emulsion sealcoat shall consist of two coats applied at the rate specified in Table 2.] [The emulsion sealcoat shall consist of two coats of emulsion applied at the rate specified in Table 2.]

****

The Engineer shall incorporate the appropriate sentence in the project specifications, depending on whether the sealcoat is rubberized, non-rubberized or emulsion only. When, in the opinion of the Engineer, an area will be subjected to heavy fuel spillage, a final application of straight emulsion, on a sand slurry sealcoat, may be made at the rate of 0.075 to 0.10 gallons per square yard (0.36 to 0.5 liters per square meter).

****

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT

Type of Sealcoat	Composition and Quantities			
	Water gal./gal. of emul.	Sand lbs/gal. of emul.	Rubber gal./gal. of emul.	Application Rate gal./sq. yd. (Per Application)
Rubberized Sand Slurry	0.70-1.00	6-14	0.07-0.12	0.25-0.55
Rubberized Emulsion	0.70-1.00	-	0.03-0.05	0.10-0.25
Sand Slurry	0.10 (max)	5-7	-	0.15-0.25
Emulsion	0.10 (max)	-	-	0.10-0.15

****

TABLE 2. COMPOSITION OF MIXTURE

Type of Sealcoat	Composition and Quantities			
	Water gal./gal. of emul.	Sand lbs/gal. of emul.	Rubber gal./gal. of emul.	Application Rate gal./sq. yd. (Per Application)
*	*	*	*	*

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****

The Engineer shall incorporate the appropriate sentence in the project specifications, depending on whether the sealcoat is rubberized, non-rubberized or emulsion only. When, in the opinion of the Engineer, an area will be subjected to heavy fuel spillage, a final application of straight emulsion, on a sand slurry sealcoat, may be made at the rate of 0.075 to 0.10 gallons per square yard (0.36 to 0.5 liters per square meter).

****

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT

3.3 TEST SECTION. Prior to full production, the Contractor shall prepare a quantity of mixture in the proportions shown in Table 2. The amount of mixture shall be sufficient to place a test section of approximately 50 square yards (45 square meters) at the application rate shown in Table 2. The area to be tested will be designated by the Engineer and will be located on the existing pavement.

The test section shall be used to verify the adequacy of the mixuture and to determine the exact application rate. The same equipment and method of operations shall be used on the test section as will be used on the remainder of the work.

If the test section should prove to be unsatisfactory, the necessary adjustments to the mix composition, application rate, placement operations, and equipment shall be made. Additional test sections shall be placed and evaluated, if required.

****

The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place as well as the performance of the equipment.

****

4. CONSTRUCTION METHODS

4.1 WEATHER LIMITATIONS. The sealcoat shall not be applied when the surface is wet or when the humidity or impending weather conditions will not allow proper curing nor when the atmospheric or pavement temperature is below 50 degrees F (10 degrees C), unless otherwise directed by the Engineer.

4.2 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.

(1) Distributors. Distributors used for the application of the tar emulsion shall be self-propelled, equipped with pneumatic tires, and capable of uniformly applying 0.15 to 0.50 gallon per square yard (0.69 to 2.3 liter per square meter) of tar emulsion over the required width of application. Distributors shall be equipped with removable manhole covers, tachometers, pressure gauges, and volume-measuring devices.

(2) Mixing Equipment. The mixing machine shall have a continuous flow mixing unit capable of accurately delivering a predetermined proportion of aggregate, water, emulsion [and rubber] and of discharging the thoroughly mixed product on a continuous basis. The mixing unit shall be capable of thoroughly blending all ingredients together.

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT 1.5
1.6

(3) Spreading Equipment. Attached to the mixing 219
machine shall be a mechanical-type squeegee distributor, equipped 220
with flexible material in contact with the surface to prevent 220
loss of slurry from the distributor. It shall be maintained to 222
prevent loss of slurry on varying grades and adjusted to assure 223
uniform spread. 223

There shall be a lateral control device and a flexible strike-off 225
capable of being adjusted to lay the slurry at the specified rate 226
of application. The spreader box shall have an adjustable width. 227
The box shall be kept clean; asphalt and aggregate build-up on 229
the box shall not be permitted. 229

4.3 PREPARATION OF PAVEMENT SURFACE. Bituminous pavement 232
surfaces which have been softened by petroleum derivatives or 232
have failed due to any other cause shall be removed to the full 233
depth of the damage and replaced with new bituminous concrete 234
similar to that of the existing pavement. Areas of the pavement 235
surface to be treated shall be in a firm consolidated condition. 236
They shall be sufficiently cured so that there is no 237
concentration of oils on the surface. This can usually be 239
determined by pouring water on the surface to be treated. If the 240
water, after standing for a short period, picks up a film of oil, 242
then that surface is not sufficiently cured for the application 243
of the sealcoat. 243

A period of [**_____] days shall elapse between the placement of 247
a bituminous surface course and the application of the sealcoat. 248
** 249.4

The Engineer shall specify the time period. In order to 251
allow adequate curing of the pavement surface prior to 251
applying the sealcoat, a 30 day period is recommended. 252

** 253.1

4.4 CLEANING EXISTING SURFACE. Prior to placing the sealcoat, 256
the surface of the pavement shall be clean and free from dust, 257
dirt, or other loose foreign matter, grease, oil, or any type of 262
objectionable surface film. When directed by the Engineer, the 264
existing surface shall be cleaned with a power blower and wire 264
brushes. 264

Where vegetation exists in cracks, the vegetation shall be 267
removed and the cracks cleaned to depth of two inches where 267
practical. Those cracks shall be treated with a concentrated 268
solution of a herbicide approved by the Engineer. Cracks wider 269
than 3/4 inch (18 mm) shall be filled with compatible crack 269
filler, prior to placing the sealcoat. Areas that have been 271
subjected to fuel or oil spillage shall be wire brushed to remove 272
any dirt accumulations. The area shall then be primed with 273
shellac or a synthetic resin to prevent the sealcoat from 273
debonding. 273

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT

****

If a rubberized sealcoat is included in the specifications, all cracks may be filled with the slurry at the time it is applied to the pavement. However, application must be made with a squeegee as specified in paragraph 4.2(c).

****

4.5 APPLICATION OF EMULSION. The emulsion shall be applied at a uniform rate with a distributor at the rate specified in Table 2. When it is necessary to dilute the emulsion in order to aid application, the emulsion may be diluted with clean water but not more than 10 percent.

4.6 APPLICATION OF SLURRY. When the emulsion, aggregate, water [and rubber] are blended, the material shall be premixed to produce a homogeneous mixture of uniform consistency. The quantities of materials to be combined in each batch shall be in accordance with the proportions shown in Table 2.

Before application, the materials shall be proportioned accurately and mixed by suitable mixing equipment. The emulsion and the water shall first be 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. [The latex rubber 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. The slurry shall be applied at a uniform rate to provide the desired amount. A sufficient amount of slurry shall be fed in the spreader box to keep a full supply against the full width of the squeegee, so that complete coverage of all surface voids and cracks is obtained.

In areas where a spreader box cannot be used, the slurry shall be applied by means of a hand squeegee.

Upon completion of the work, the sealcoat shall have no pin holes, bare spots, or cracks through which liquids or foreign matter could penetrate to the underlying pavement. The finished surface shall present a uniform texture.

Each application shall be allowed to dry thoroughly before the next coat is applied.

4.7 CURING. The mixture shall be permitted to dry for a minimum of [**_____] hours after the final application before opening to traffic and shall be sufficiently cured to drive over without damage to the sealcoat. Any damage to the uncured mixture will be the responsibility of the Contractor to repair.

****

A minimum of 24 hours is recommended.

****

4.8 HANDLING. The mixture shall be continuously agitated from the time it had 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.

4.9 CONTRACTOR'S CERTIFICATION. The Contractor shall furnish the manufacturer's certification that each consignment of emulsion shipped to the project meets the requirements of Federal Specification R-P-355, except the water content shall not exceed 50 percent. [The Contractor shall furnish certification to the Engineer that the latex rubber shipped to the project meets the requirements of the material specified in paragraph 2.4.] The [certification] [certifications] shall be delivered to the Engineer prior to the beginning of work. The manufacturer's certification for the emulsion [and rubber] shall not be interpreted as a basis for final acceptance. Any certification received shall be subject to verification by testing samples received for project use.

5. METHOD OF MEASUREMENT

5.1 The coal-tar pitch emulsion shall be measured by the gallon (liter) of undiluted emulsion.

5.2 The mineral aggregate shall be measured by the ton (kilogram).

5.3 The latex rubber shall be measured by the gallon (liter).

****

Paragraph 5.3 shall be deleted if a rubberized sealcoat is not specified.

****

ITEM P-625 COAL-TAR PITCH EMULSION SEALCOAT 1.5 1.6

6. BASIS OF PAYMENT 384

6.1 Payment shall be made at the contract unit price per gallon 386
(liter) for the coal-tar pitch emulsion, per ton (kilogram) for 388
the mineral aggregate[,][.] [and per gallon (liter) for the latex 389
rubber.] These prices shall fully compensate the Contractor for 390
furnishing all materials; and for all labor, equipment, tools, 393
and incidentals necessary to complete the items. 394

Payment will be made under: 396
Item P-625-5.1 Coal-Tar Pitch Emulsion - per gallon (liter) 397
Item P-625-5.2 Aggregate - per ton (kilogram) 398
Item P-625-5.3 Latex Rubber - per gallon (liter) 399

*** 400.4.

Item P-625-5.3 shall be deleted of a rubberized sealcoat is 401
not specified. 401

*** 402.1.

7. TESTING REQUIREMENTS 404

ASTM 136	Sieve or Screen Analysis of Fine and Coarse Aggregates	406 407 408

8. MATERIAL REQUIREMENTS 411

Federal Specification R-P-355	Pitch, Coal-Tar Emulsion (Coating for Bituminous Pavements)	413 414 415
Federal Specification R-T-143	Tars, (for use in) Road Construction	417 418

+ + END OF ITEM P-625 + + 419.3

DEPARTMENT OF THE AIR FORCE
Headquarters, United States Air Force
Washington 25, D.C.

GUIDE SPECIFICATIONS

****

RUBBERIZED COAL TAR PITCH EMUSLION SAND SLURRY SEAL COAT (FOR AIRFIELD PAVEMENTS)

1 February 1961

RUBBERIZED COAL TAR PITCH EMULSION SAND SLURRY SEAL COAT

TECHNICAL PROVISIONS

TABLE OF CONTENTS

TECHNICAL PROVISIONS

01 - SCOPE

The work covered by this section of the Specification consists of furnishing all labor, equipment, and materials, and in performing all operations in connection with the application of rubberized coal tar pitch emulsion slurry seal coat on bituminous pavements, complete, in strict accordance with this section of the Specifications and the applicable drawings, and subject to the terms and conditions of this contract.

02 - APPLICABLE SPECIFICATIONS

The following Federal Specifications and standards in effect on the date of advertising, form a part of this specification:

A. Federal Specifications

R-P-00355b - Pitch, Coal Tar Emulsion (for) Coating Bituminous Pavements

SS-R-406 - Road and Paving Materials; Methods of Sampling and Testing

SS-S-164 - Sealer; Hot-poured Type, For Joints in Concrete

SS-S-00200a- Sealing Compound, Two Component Elastomeric, Polymer-Type, Jet-Fuel Resistant, Cold-Applied Concrete Paving

R-T-143 - Tars; (for use in) Road Construction

B. American Society for Testing Materials Serial Designations:

C-136-46 - Standard Method for Test for Sieve Analysis of Fine and Coarse Aggregates

D-75-48 - Tentatie Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for use as Highway Materials

D-140-55 - Tentative Method of Sampling Bituminous Materials

D-244-55 - Tests for Emulsified Asphalts

D-466-42 - Testing Films Deposited by Bituminous Emulsions

D-1010-58 - Asphalt Emulsion for Metal Protective Coatings

COAL TAR PITCH EMULSION PROTECTIVE SEAL COAT

04 - MATERIALS

A. Bituminous Materials: The bituminous materials shall be homogeneous and show no separation or coagulation of components that cannot be overcome by moderate stirring. It shall be capable of application and complete coverage, by squeegee, brush, or by approved mechanical methods, to the surface of bituminous pavements at a spreading rate of 1.5 to 2.5 gallons per 100 square feet in two coats. The tar emulsion shall be prepared from a high temperature coal tar conforming to 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 material shall conform to all requirements of Federal Specification R-P-00355b, prior to fortification with anti-freeze, and meet the Contracting Officer's approval in all respects.

B. Water and Additives: Water used for blending, and for rinsing or wetting the pavement surface, shall be potable. When additives are used to fortify the emulsion against freezing, they shall be non-harmful to the bituminous components, and shall meet the Contracting Officer's approval in all respects.

05 - SAMPLING

Samples shall be taken in accordance with Federal Specifications SS-R-406.

06 - QUANTITIES OF MATERIALS

The coal tar pitch emulsion shall be applied in two coats, providing a minimum total coverage of 0.2 gallon per square yard. Each coat shall be applied uniformly over the entire area. The total quantity applied per square yard may be increased, as directed by the Contracting Officer, to meet specific field conditions.

07 - EQUIPMENT

All equipment, machines, and tools used in performance of the required work shall be of types and capacities approved by the Contracting Officer, and shall be maintained in satisfactory working conditios at all times.

A. Cleaning Equipment: Cleaning equipment shall be capable of effectively removing oil, grease, paint, clay, dust, rubber deposits, and other objectionable materials from the pavement surface.

B. Mixing Equipment: Mechanical equipment used for blending shall be of adequate capacity and suitably powered, and shall meet the Contracting Officer's approval in all respects.

C. Watting Equipment: A distributor truck or other method approved by the Contracting Officer shall be used to dampen pavement surfaces prior to application.

D. Application Equipment: Application equipment shall be a combination or individual use of spray bar equipment, squeegees, mechanical brushes, nylon or plastic bristled brooms, and related hand tools, and shall be of adequate types and sizes to satisfactorily perform the required work.

08 - WEATHER LIMITATION

Emulsion shall be applied in dry weather and only when the pavement and atmospheric temperatures are 50°F or above. Application shall not be permitted when precipitation is anticipated before the film dries to a rain-resistant condition or when temperature and humidity conditions are such that the coal tar pitch emulsion could not dry thoroughly before a minimum pavement temperature of 45°F occurs.

09 - PREPARATION OF SURFACE

Pavement surfaces to be seal coated shall be free of oil and grease spots, paint, clay, dust, rubber deposits, and other objectionable materials which might adversely affect bonding of the coal tar pitch emulsion. Solvents shall not be used for cleaning. If detergents are used for this purpose the pavement must be thoroughly rinsed prior to application of the coal tar pitch emulsion. Cracks wider than 1/8" but less than 1/2" in width shall be widened to a minimum of 1/2" and to a minimum depth of 1/2" and shall be cleaned of all dirt and loose or foreign material by the use of comprressed air at a pressure of not less than 90 p.s.i. at the nozzle. The cleaned cracks shall then be filled flish with crack sealer conforming to the requirements of Federal Specification S-S-164 for asphaltic concrete or Federal Specification SS-S-00200a for tar and tar-rubber pavements. Cracks wider than 1/2" shall be repaired as directed by the Contracting Officer. Badly oxidized or weathered pavement surface should be rejuvenated before sealing at the Contracting Officer's direction, in which case an appropriate adjustment in the contract price will be negotiated. Tie-down anch recesses will be filled with sand or otherwise protected to prevent clogging with bituminous materials. Immediately prior to application of the coal tar pitch emulsion the pavement surface shall be dampened.

10 - APPLICATION OF COAL TAR PITCH EMULSION

Coal tar pitch emulsion shall be applied to the pretreated and dampened pavement surface as previously specified. Each application shall be so applied that uniform distribution is obtained at all points on the surface to be sealed. Applications shall be made in accordance with the manufacturer's recommendations where such is practicable and compatible with these specifications. Each operation shall be approved by the Contracting Officer prior to beginning any subsequent phase of the work. Pinholes or areas left unsealed shall be touched up to the satisfaction of the Contracting Officer.

11 - CURING TIME

Adequate time shall be allowed for each application to dry thoroughly prior to placement of the next, and in no case shall a curing period of less than 4 hours be permissable. Upon completion of seal coating, all traffic shall be excluded from the area for a minimum period of 24 hours, and longer if the Contracting Officer so directs.

12 - INSPECTION

Rigid inspection shall be maintained throughout progress of the work. All pinholes, voids, and uncoated areas shall be sealed to the satisfaction of the Contracting Officer prior to acceptance.

13 - WAYBILLS AND DELIVERY TICKETS

Waybills and delivery tickets shall be regularly submitted to the Contracting Officer during progress of the work. Prior to acceptance and final payment, the Contractor shall be required to furnish certified proof that all materials used comply with specified requirements.

14 - METHODS OF MEASUREMENT

A. Patching: Surface repair materials to be paid for shall be the tons of hot bituminous plant-mix, as weighed after mixing, used in the completed and accepted work. Separate payment will not be made for tack coat material.

B. Crack Sealing: The sealant to be paid for shall be the number of pounds used in the completed and accepted work.

C. Coal Tar Pitch Emulsion: The coal tar pitch emulsion to be paid for shall be the number of gallons used in the completed and accepted work.

D. Rejuvenating Pre-Treatment Material: This shall be considered a separate pay item, and will be determined by gallons used in the completed and accepted work.

15 - BASIS OF PAYMENT

Payment shall be made on the basis of unit costs for the contract item listed, and quantities verified by the Contracting Officer. Payment so determined shall constitute full compensation for furnishing all materials and performing all required work, in accordance with these specifications and the contract drawings.

06 - QUANTITIES OF MATERIALS

The following quantities shall apply to mixing and application of the slurry, unless otherwise directed in writing by the Contracting Officer to comply with specific field conditions.

TABLE II

Materials	Emulsion Gals/Sq. Yd. *(1)	Mineral Aggregate Lbs/Gal *(2)
	FIRST (PRIME) APPLICATION	*(3)
Rubberized Coal Tar Pitch Emulsion	0.075-0.10	--
	SECOND APPLICATION	
Rubberized Coal Tar Pitch Emulsion	0.10-0.15	--
Mineral Aggregate	--	3 to 5
	THIRD APPLICATION	
Rubberized Coal Tar Pitch Emulsion	0.10-0.15	--
Mineral Aggregate	--	4 to 6
	FOURTH APPLICATION *(4)	
Rubberized Coal Tar Pitch Emulsion	0.075-0.10	--
Mineral Aggregate	--	0 to 2

*(1) Undiluted Rubberized Coal-Tar pitch emulsion
*(2) Oven dry weight
*(3) Adjustments to be approved in writing by the Contracting Officer
*(4) To be applied only at the direction of the Contracting Officer

07 - EQUIPMENT

All equipment, machines, and tools used in performance of the required work shall be of types and capacities approved by the Contracting Officer, and shall be maintained in satisfactory working conditios at all times.

DEPARTMENT OF THE AIR FORCE
Headquarters, United States Air Force
Washington 25, D.C.

GUIDE SPECIFICATIONS

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COAL TAR PITCH EMULSION PROTECTIVE SEAL COAT (FOR AIRFIELD PAVEMENTS)

1 February 1961

GUIDE SPECIFICATION: COAL TAR PITCH EMULSION
PROTECTIVE SEAL COAT

TECHNICAL PROVISIONS

TABLE OF CONTENTS

TECHNICAL PROVISIONS

01 - SCOPE

The work covered by this section of the Specification consists of furnishing all labor, equipment, and materials, and in performing all operations in connection with the application of coal tar pitch emulsion fuel and weather resistant seal coat on bituminous pavements, complete, in strict accordance with this section of the Specifications and the applicable drawings, and subject to the terms and conditions of this contract.

02 - APPLICABLE SPECIFICATIONS

The following Federal Specifications and standards in effect on the date of publishing the Invitation to Bid, form a part of this specification:

A. Federal Specifications

R-P-00355b - Pitch, Coal Tar Emulsion (for) Coating Bituminous Pavements

R-T-143 - Tars; (for use in road construction, August 3, 1940)

SS-R-406 - Road and Paving Materials; Methods of Sampling and Testing

SS-S-164 - Sealer; Hot-poured Type, For Joints in Concrete

SS-S-00200a- Sealing Compound, Two Component Elastomeric, Polymer-Type, Jet-Fuel Resistant, Cold-Applied Concrete Paving

B. American Society for Testing Materials Serial Designations:

D-140-55 - Tentative Method of Sampling Bituminous Materials

D-244-55 - Tests for Emulsified Asphalts

D-466-42 - Testing Films Deposited by Bituminous Emulsions

D-1010-58 - Asphalt Emulsion for Metal Protective Coatings

03 - DESCRIPTION

The seal coat covered by this section of the specification shall consist of an application of coal tar pitch emulsion on a bituminous wearing course, previously prepared as hereinafter specified.

RUBBERIZED COAL TAR PITCH EMULSION SAND SLURRY SEAL COAT

03 - DESCRIPTION

The bituminous slurry seal coat covered herein shall consist of consecutive applications of rubberized coal tar pitch emulsion, mixed with mineral aggregates, on a previously prepared bituminous pavement surface.

04 - MATERIALS

A. Mineral Aggregates: The mineral aggregate shall be either a natural or manufactured product composed of clean, hard, durable, uncoated particles free from dirt, organic matter, and other objectionable substances. Gradation shall meet the following requirements when tested according to ASTM C-136-46.

TABLE 1

Sieve Designation U.S. Standard Square Mesh	Percent By Weight Passing
# 16	100
20	85-100
30	15-85
40	2-15
100	0-2

In locations where the mineral aggregate gradations are not practicable, alternate gradations will be established by the Contracting Officer to comply with field conditions.

B. Bituminous Materials: Bituminous materials used for prime and subsequent seal coats shall be rubberized coal tar pitch emulsion, suitable to attain the rates of coverage shown in Table II of this specification. The rubberized coal tar pitch emulsion shall be homogeneous and show no separation or coagulation of components which cannot be overcome by moderate stirring and shall be prepared from straight run coal tar conforming to Federal Specification R-T-143, except that oil-gas and water-gas tars shall be excluded. The coal tar pitch shall have been blended, prior to emulsification, with a minimum of three percent by weight of unvulcanized rubber which is resistant to petroleum oils and distillates. Upon curing the rubberized coal tar pitch emulsion shall provide a continuous, unbroken, adherent coating which is resistant to jet fuel, gasoline and other petroleum derivatives, water, volatilization, oxidation and weathering. Where shipping during freezing weather is anticipated, the rubberized coal tar pitch emulsion shall be fortified with an appropriate commercial anti-freeze solution, in such manner as to not be harmful to the rubberized coal tar pitch emulsion or its components. Manufacturer's certificates shall be furnished to the Contracting Officer, certifying that all materials delivered conform to the specified requirements. Materials shall also be subject to the following requirements:

(1) The composition shall be determined in accordance with ASTM Serial Designation D-1010-58, Sections 3,6,7,8, and 9, and conform to the minimum requirements of Federal Specification R-P-00355b which are:

	Maximum	Minimum
Water %	53	--
Non-Volatile Matter %	--	47
Ash on Non-Volatile Matter %	40	30
Solubility on Non-Volatile Matter in CS_2%	--	20
Specific Gravity	--	1.20

(2) Drying time shall be determined in accordance with ASTM Serial Designation D-1010-58, Section II, and shall exhibit final set within 8 hours at 25°C (±20) and 50 (± 2%) relative humidity.

(3) Resistance to volatilization shall be determined in accordance with ASTM Serial Designation D-1010-58, except that the residue from the procedure outlined in Section 6 shall be heated in an over at 270°C for 30 minutes. The lost in weight shall not exceed 15%.

(4) Resistance to heat shall be determined in accordance with ASTM Serial Designation D-1010-58, Section 12, except that the oven shall be maintained at a temperature of 80°C (±2°). The coated panel shall be removed from the oven after a period of at least one hour, but not to exceed 1-1/2 hours, and then shall be place immediately in the flexing box (Figure 1). Within a period of 2 to 3 seconds the panel shall then be flexed rapidly five times in succession to a depth of 1-1/2 inches. The coating shall be considered satisfactory if it does not crack to its full depth, flake, or separate from the metal panel.

(5) Resistance to low temperature shall be determined with test panels prepared in accordance with Section 10 of ASTM Serial Designation D-1010-58. The rubberized coal tar pitch emulsion coating shall be cured for at least 48 hours at 25°C (±2°) and 50°C (±2%) relative humidity. The panel shall then be placed in a freezer maitained at 0°C (±2°), for a period of at least one hour but not more than 1-1/2 hours. Immediately upon removal it shall be placed in the flexing box (Figure 1). Within a period of 6 to 10 seconds the panel shall be flexed five times in succession to a depth of 1/2 inch. The coating shall be considered satisfactory if it does not crack to its full depth, flake, or separate from the metal panel.

(6) Resistance to freezing shall be determined in accordance with Section 36 of ASTM Serial Designation D-244-55. Wet samples of rubberized coal tar pitch emulsion containing anti-freeze in accordance with paragraph 04, B shall be exposed to a temperature of -17°C (±2°) for a period of 24 hours. After thawing at a laboratory temperature of 25°C (±2°) the material shall be considered satisfactory if it returns to an emulsion state with stirring.

(7) Resistance to field service fluids shall be determined with the aid of tile panels coated with adequately cured rubberized coal tar pitch emulsion prepared in accordance with procedures outlined in ASTM Serial

11 - CURING TIME

Adequate time shall be allowed for each application to dry thoroughly prior to placement of the next, and in no case shall a curing period of less than 4 hours be permissable. Upon completion of seal coating, all traffic shall be excluded from the area for a minimum period of 24 hours, and longer if the Contracting Officer so directs.

12 - INSPECTION

Rigid inspection shall be maintained throughout progress of the work. All pinholes, voids, and uncoated areas shall be sealed to the satisfaction of the Contracting Officer prior to acceptance.

13 - WAYBILLS AND DELIVERY TICKETS

Waybills and delivery tickets shall be regularly submitted to the Contracting Officer during progress of the work. Prior to acceptance and final payment, the Contractor shall be required to furnish certified proof that all materials used comply with specified requirements.

14 - METHODS OF MEASUREMENT

A. Patching: Surface repair materials to be paid for shall be the ons of hot bituminous plant-mix, as weighed after mixing, used in the completed and accepted work. Separate payment will not be made for tack coat material.

B. Crack Sealing: The sealant to be paid for shall be the number of pounds used in the completed and accepted work.

C. Coal Tar Pitch Emulsion: The coal tar pitch emulsion to be paid for shall be the number of gallons used in the completed and accepted work.

D. Rejuvenating Pre-Treatment Material: This shall be considered a separate pay item, and will be determined by gallons used in the completed and accepted work.

15 - BASIS OF PAYMENT

Payment shall be made on the basis of unit costs for the contract item listed, and quantities verified by the Contracting Officer. Payment so determined shall constitute full compensation for furnishing all materials and performing all required work, in accordance with these specifications and the contract drawings.

16 - NOTES FOR CONTRACTING OFFICER

1. Coordination of Activities: Work shall be so scheduled by the Contractor, and coordinated by the Contracting Officer, that interruption of operational activity will be kept to a minimum, and the pavement made available for use at the earliest practicable time.

2. Base Regulations: The Contractor shall comply with all safety, fire, and security regulations and shall provide for the protection of all Government property affected by his operations. Any damage shall be repaired and paid for by the Contractor at no expense to the Government.

3. Storage of Materials: Materials and equipment shall be stored in areas designated by the Contracting Officer Both unfortified and fortified coal tar pitch emulsion must be protected from freezing.

4. Cleanup: The project site and adjacent areas shall be kept clean, neat, and free of debris at all times, and upon completion of the work these areas must be left in a condition satisfactory to the Contracting Officer.

A. Cleaning Equipment: Cleaning equipment shall be capable of effectively removing oil, grease, paint, clay, dust, rubber deposits, and other objectionable materials from the pavement surface prior to priming.

B. Mixing Equipment: Mechanical equipment used for blending and mixing slurry shall be of adequate capacity and suitably powered, and shall meet the Contracting Officer's approval in all respects.

C. Wetting Equipment: A distributor truck or other method approved by the Contracting Officer shall be used to dampen pavement surfaces prior to application of the slurry.

D. Application Equipment: Application equipment shall be a combination of, or individual use of spray bar equipment, squeegees, mechanical brushes, nylon or plastic bristled brooms, and related hand tools, and shall be of adequate types and sizes to satisfactorily perform the required work in accordance with the application rates shown in Table II.

08 - WEATHER LIMITATION

Emulsion shall be applied in dry weather and only when the pavement and atmospheric temperatures are 50°F or above. Application shall not be permitted when precipitation is anticipated before the film dries to a rain-resistant condition or when temperature and humidity conditions are such that the rubberized coal tar pitch emulsion could not dry thoroughly before a minimum pavement temperature of 45°F occurs.

09 - PREPARATION OF SURFACE

Pavement surfaces to be seal coated shall be free of oil and grease spots, paint, clay, dust, rubber deposits, and other objectionable materials which might adversely affect bonding of the rubberized coal tar pitch emulsion. Solvents shall not be used for cleaning. If detergents are used for this purpose the pavement must be thoroughly rinsed prior to application of the rubberized coal tar pitch emulsion. Areas saturated with fuel or oil shall be cut out and replaced with new paving material to match adjacent areas. Surface defects shall be repaired or patched at least one week prior to application of rubberized coal tar pitch emulsion. Cracks wider than 1/8" but less than 1/2" in width shall be widened to a minimum of 1/2" and to a minimum depth of 1/2" and shall be cleaned of all dirt and loose or foreign material by the use of comprressed air at a pressure of not less than 90 p.s.i. at the nozzle. The cleaned cracks shall then be filled flish with crack sealer conforming to the requirements of Federal Specification S-S-164 for asphaltic concrete or Federal Specification SS-S-00200a for tar and tar-rubber pavements. Cracks wider than 1/2" shall be repaired as directed by the Contracting Officer. Badly oxidized or weathered pavement surface should be rejuvenated before sealing at the Contracting Officer's direction, in which case an appropriate adjustment in the contract price will be negotiated. Tie-down anch recesses will be filled with sand or otherwise protected to prevent clogging with bituminous materials. Immediately prior to application of the rubberized coal tar pitch emulsion the pavement surface shall be dampened.

10 - APPLICATION OF SLURRY

A. General: The pavement surfaces shall be primed before slurry is applied in accordance with Table II of these specifications. Each application will be adequately cured before the next coat is applied. Each coat shall be so applied that coverage is uniform, and any pinholes or unsealed areas shall be touched up to the satisfaction of the Contracting Officer. Treated areas shall be inspected prior to each subsequent slurry application to insure proper coverage.

B. First (Prime) Application shall be made with suitable equipment, on the previously prepared and dampened surface, at the rate shown in Table II.

C. Second Application containing mineral aggregates shall be made with suitable equipment on the previously primed, cured and dampened (if required) surface, at the rate shown in Table II.

D. Third Application containing mineral aggregates shall be made with suitable equipment on the previously cured and dampened (if required) surface, at the rate shown in Table II.

E. Fourth Application shall be made only upon written direction of the Contracting Officer, in critical areas subject to intensive fuel spillage. Application shall be made at the rate shown in Table II.

11 - CURING TIME

Adequate time shall be allowed for each application to dry thoroughly prior to the next application and in no case shall a curing period of less than 4 hours be permissable. Upon completion of seal coating, all traffic shall be excluded from the area for a minimum period of 24 hours, and longer if the Contracting Officer so directs.

12 - INSPECTION

Rigid inspection shall be maintained throughout progress of the work. All pinholes, voids, and uncoated areas shall be sealed to the satisfaction of the Contracting Officer prior to acceptance.

13 - WAYBILLS AND DELIVERY TICKETS

Waybills and delivery tickets shall be regularly submitted to the Contracting Officer during progress of the work. Prior to acceptance and final payment, the Contractor shall be required to furnish certified proof that all materials used comply with specified requirements.

14 - METHODS OF MEASUREMENT

A. Patching: Surface repair materials to be paid for shall be the tons of hot bituminous plant-mix, as weighed after mixing, used in the completed and accepted work. Separate payment will not be made for tack coat material.

B. Crack Sealing: The sealant to be paid for shall be the number of pounds used in the completed and accepted work.

C. Bituminous Material: The rubberized coal tar pitch emulsion to be paid for shall be the number of undiluted gallons used in the completed and accepted work.

D. Mineral Aggregates: Mineral aggregates to be paid for shall be the number of tons used in the completed and accepted work.

15 - BASIS OF PAYMENT

Payment shall be made on the basis of unit costs for the contract item listed, and quantities verified by the Contracting Officer. Payment so determined shall constitute full compensation for furnishing all materials and performing all required work, in accordance with these specifications and the contract drawings.

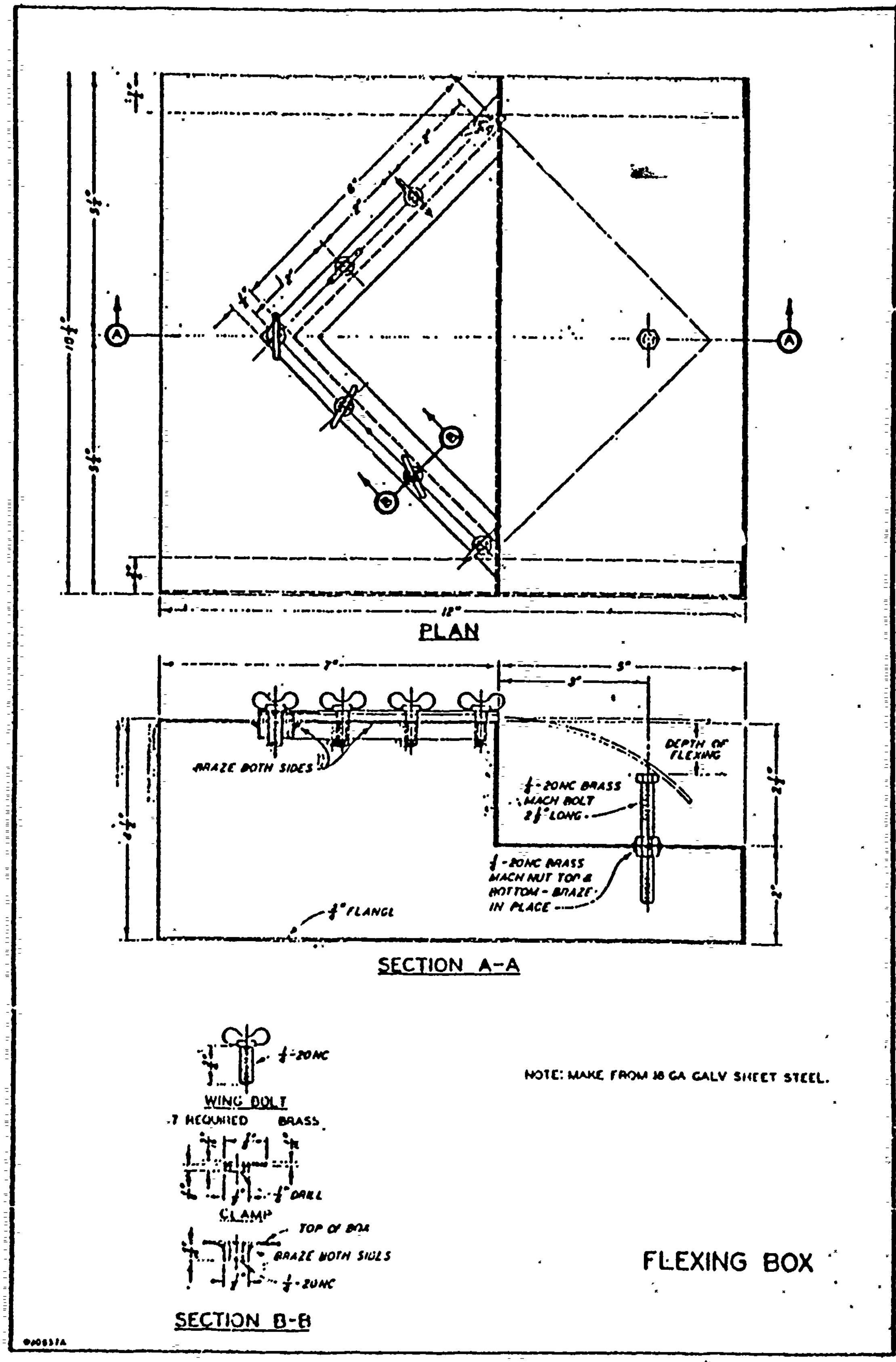
16 - NOTES FOR CONTRACTING OFFICER

1. Coordination of Activities: Work shall be so scheduled by the Contractor, and coordinated by the Contracting Officer, that interruption of operational activity will be kept to a minimum, and the pavement made available for use at the earliest practicable time.

2. Base Regulations: The Contractor shall comply with all safety, fire, and security regulations and shall provide for the protection of all Government property affected by his operations. Any damage shall be repaired and paid for by the Contractor at no expense to the Government.

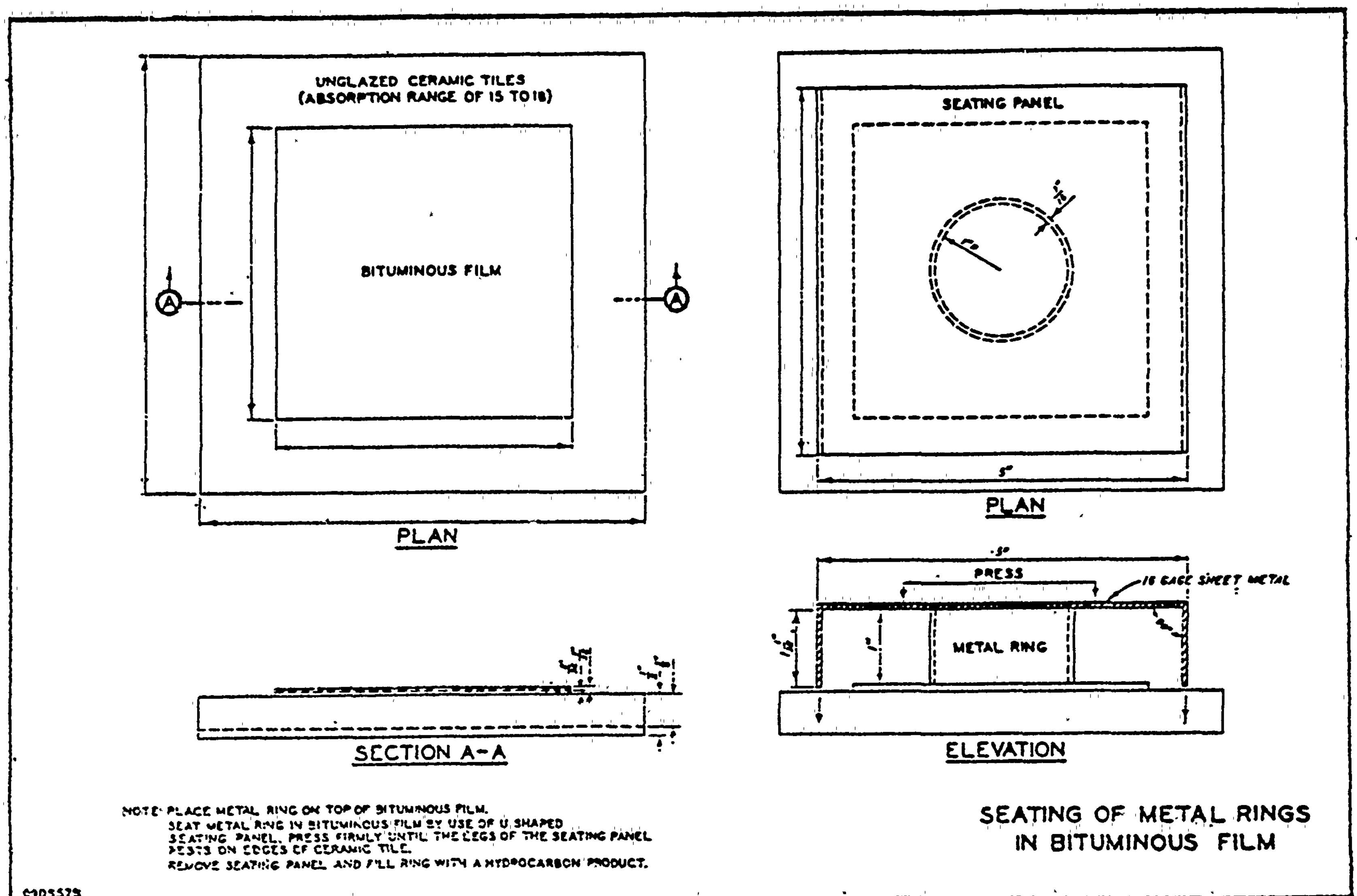
3. Storage of Materials: Materials and equipment shall be stored in areas designated by the Contracting Officer. Both unfortified and fortified rubberized coal tar pitch emulsion must be protected from freezing.

4. Cleanup: The project site and adjacent areas shall be kept clean, neat, and free of debris at all times, and upon completion of the work these areas must be left in a condition satisfactory to the Contracting Officer.



PLAN
SECTION A-A
BRAZE BOTH SIDES
DEPTH OF FLEXING
1/4-20NC BRASS MACH BOLT 2 1/2" LONG
1/4-20NC BRASS MACH NUT TOP & BOTTOM - BRAZE IN PLACE
1/4" FLANGE
WING BOLT
7 REQUIRED BRASS
CLAMP
TOP OF BOX
BRAZE BOTH SIDES
1/4-20NC
SECTION B-B
NOTE: MAKE FROM 18 GA GALV SHEET STEEL.
FLEXING BOX

FIG. 1



UNGLAZED CERAMIC TILES
(ABSORPTION RANGE OF 15 TO 18)
BITUMINOUS FILM
PLAN
SEATING PANEL
5"
PLAN
PRESS
16 GAGE SHEET METAL
METAL RING
ELEVATION
SECTION A-A
NOTE: PLACE METAL RING ON TOP OF BITUMINOUS FILM.
SEAT METAL RING IN BITUMINOUS FILM BY USE OF U SHAPED
SEATING PANEL. PRESS FIRMLY UNTIL THE LEGS OF THE SEATING PANEL
RESTS ON EDGES OF CERAMIC TILE.
REMOVE SEATING PANEL AND FILL RING WITH A HYDROCARBON PRODUCT.
SEATING OF METAL RINGS
IN BITUMINOUS FILM

FIG. 2