SCR

27

Introduced: 5/13/83
Referred: Transportation

IN THE SENATE BY THE TRANSPORTATION COMMITTEE

# SENATE CONCURRENT RESOLUTION NO. 27 am

## IN THE LEGISLATURE OF THE STATE OF ALASKA

## THIRTEENTH LEGISLATURE - FIRST SESSION

Relating to the designation of three sites for the application of high float emulsion asphalt.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

WHEREAS a substantial portion of the state's money is spent on the rehabilitation and rebuilding of our highways; and

WHEREAS the present road building techniques are (extremely) expensive and may not be the most cost effective method for northern climate highways; and

WHEREAS the Yukon Territory Department of Highways and Transportation has had success with a less expensive and more durable surfacing technique known as high float emulsion asphalt; and

WHEREAS the climate and highway demands of Alaska are very similar to the climate and highway demands of the Yukon Territory; and

WHEREAS there are highway surfaces in the Interior region, the ~~South-~~central region, and the Southeast region that are in need of rehabilitation and could therefore be designated as test sites for an alternate surfacing technique;

BE IT RESOLVED by the Alaska State Legislature that the governor is respectfully requested to direct the commissioner of transportation and public facilities to designate a representative site in each of the Interior, the ~~South~~central and the Southeast regions to be used as a test application site for high float emulsion asphalt; and be it

FURTHER RESOLVED that the Department of Transportation and Public Facilities document the and cost effectiveness of the test applications and

engineering & construction
considerations

# STATE OF ALASKA
# FISCAL NOTE

## I. REQUEST

Bill/Resolution No.: SR 6/SCR 27
Title: Re. designation of 3 sites/asphalt
Sponsor: Transportation Committee
Requestor: Ray

## II. FISCAL DETAIL

Agency Affected: DOT&PF
Program Category Affected: Research
BRU, Program or Subprogram(s) Affected: Interior Region

EXPENDITURES/REVENUES: (Thousands of Dollars)

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| OPERATING | | | | | | |
| 100 PERSONAL SERVICES | | 8.0 | 2.5 | 2.5 | 2.5 | 2.5 |
| 200 TRAVEL | | 2.6 | .9 | .9 | .9 | .9 |
| 300 CONTRACTUAL | | | | | | |
| 400 COMMODITIES | | | | | | |
| 500 EQUIPMENT | | | | | | |
| 600 LAND & STRUCTURES | | | | | | |
| 700 GRANTS, CLAIMS, ETC | | | | | | |
| TOTAL OPERATING | | 10.6 | 3.4 | 3.4 | 3.4 | 3.4 |
| CAPITAL | | 80.0 | | | | |
| REVENUE | | | | | | |

FUNDING: (Thousands of Dollars)

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| GENERAL FUND | | 90.6 | 3.4 | 3.4 | 3.4 | 3.4 |
| FEDERAL FUNDS | | | | | | |
| OTHER (Specify Source) | | | | | | |

POSITIONS:

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| FULL-TIME | | | | | | |
| PART-TIME | | | | | | |
| TEMPORARY | | | | | | |

## III. SOURCE OF FUNDS TO OFFSET FISCAL IMPACT OF BILL:

## IV. ANALYSIS: Attach a separate page for any Analysis

Prepared By: Billy Connor Phone: 479-2281
Division: Research Date: 5/17/83

Approved by Commissioner: H. Gienzer, Jr. Date: 5/17/83
Department: DOT&PF

Distribution:
Original to Legislative Finance
Copy to Office of Management and Budget (for Legislature introduced bills)
Copy to Department (for Governor introduced bills)
Copy to Sponsor
Copy to Requestor (if different from Sponsor)

## IV ANALYSIS

### Operating Funds

FY 84

| | | |
|---|---|---|
| 100 personal services | | |
| 2 researchers 10 days $800/day | | $ 3,000 |
| 200 travel | | |
| 1 trip to Haines | $1,600 | |
| 1 trip to Soldotna | 1,000 | |
| | | 2,600 |
| TOTAL FY 84 | | $10,600 |

FY85-88

1 trip to each location

| | |
|---|---|
| 100 personal services | $ 2,500 |
| 200 travel | 850 |
| TOTAL | $ 3,350 |

### Estimate of Costs

| | | |
|---|---|---|
| Central | | |
| Asphalt: 35 X $250 | $8,750 | |
| Aggregate: 328 X $12 | 3,940 | |
| Reconditioning: | 7,920 | |
| Subtotal | | $20,610 |
| Interior | | |
| Asphalt: 35 X $250 | 8,750 | |
| Aggregate: 328 X $18 | 5,900 | |
| Reconditioning: | 7,920 | |
| Subtotal | | $22,570 |
| SE | | |
| Asphalt: 35 X $250 | 8,750 | |
| Aggregate: 328 X $18 | 5,900 | |
| Reconditioning: | 7,920 | |
| Subtotal | | $22,570 |
| | | $65,750 |
| 20% mobilization | | 13,150 |
| TOTAL | | $78,900 |

## STATE OF ALASKA
## FISCAL NOTE

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BRU, Program or Subprogram(s) Affected:
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EXPENDITURES/REVENUES: (Thousand's of Dollars)

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| OPERATING | | | | | | |
| 100 PERSONAL SERVICES | | 8.0 | 2.5 | 2.5 | 2.5 | 2.5 |
| 200 TRAVEL | | 2.6 | .9 | .9 | .9 | .9 |
| 300 CONTRACTUAL | | | | | | |
| 400 COMMODITIES | | | | | | |
| 500 EQUIPMENT | | | | | | |
| 600 LAND & STRUCTURES | | | | | | |
| 700 GRANTS, CLAIMS, ETC | | | | | | |
| TOTAL OPERATING | | 10.6 | 3.4 | 3.4 | 3.4 | 3.4 |
| CAPITAL | | 80.0 | | | | |
| REVENUE | | | | | | |

FUNDING: (Thousands of Dollars)

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| GENERAL FUND | | 90.6 | 3.4 | 3.4 | 3.4 | 3.4 |
| FEDERAL FUNDS | | | | | | |
| OTHER (Specify Source) | | | | | | |

POSITIONS:

| | FY 83 | FY 84 | FY 85 | FY 86 | FY 87 | FY 88 |
|---|---|---|---|---|---|---|
| FULL-TIME | | | | | | |
| PART-TIME | | | | | | |
| TEMPORARY | | | | | | |

III. SOURCE OF FUNDS TO OFFSET FISCAL IMPACT OF BILL:

IV. ANALYSIS: Attach a separate page for any Analysis

Prepared By: Billy Connor
Phone: 479-2281
Division: Research
Date: 5/17/83

Approved by Commissioner: H. Glenzer, Jr.
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3/8/83

## IV ANALYSIS

Operating Funds

FY 84

| | | |
|---|---|---|
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FY85-88

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| | | $65,750 |
| 20% mobilization | | 13,150 |
| TOTAL | | $78,900 |

STATE OF ALASKA

BILL SHEFFIELD, GOVERNOR

DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES

P. O. BOX 1467
JUNEAU, ALASKA 99802

April 29, 1983

RE: Meeting with Yukon Territory
Highway and Transportation
Officials

FILE: 1802

Honorable Randy E. Phillips
Representative
Alaska State Legislature
Transportation Committee
Pouch V
Juneau, AK 99811

THROUGH: Fred Seeger, Deputy Commissioner

Dear Representative Phillips:

Attached for your information is a copy of the trip report by Department representatives who visited Yukon Territory highway officials on April 21 and April 22, 1983.

Although I was originally scheduled to make the trip, I was unable to go for medical reasons. I have talked to Mr. Larry Blackman in Whitehorse over the telephone several times. We have extended to him the courtesy of reciprocating information exchange trips whenever he sees the need. In fact, since the meeting in Whitehorse, Mr. Blackman has asked for copies of our truck size and weight statutes and regulations. Apparently, they intend to require the same limitations on the Canadian portion of the Klondike Highway from Whitehorse to Skagway that we do.

In regard to the High Float Emulsion Surface treatments that were investigated during the trip, I have also spoken to Mr. Tom Neunaber of the local Federal Highway Administration and Mr. Coley Wycoff of Chevron, USA.

Mr. Neunaber was one of the FHWA representative on the "Shakwak" project on which the Alaska Highway in Canada is being upgraded and surfaced. He has personal experience with High Float emulsion surface treatments that were done on the highway by contractor forces. He has a slide show which reveals many of the "tricks of the trade" in placing this material.

After viewing these slides as narrated by Mr. Neunaber, I am convinced that we could place this material successfully _if_ we can utilize his experience and/or that of Yukon Territory representatives to get the contractor started off right.

Mr. Wycoff is somewhat skeptical of our chances of success with this material. He stated that Chevron made High Float emulsion several years ago. This practice was discontinued because of the lack of success with it. He also cites several failures with it in British Columbia and claims that they have discontinued its use in favor of a cationic medium-set emulsion (CMS) which has given excellent results.

I think that one of the keys to success with High Float emulsion may be strict compliance to temperature and weather limitations and a knowledge of the "do's" and "don'ts" in placing the material. Another is experience, which is pointed out in the report.

My recommendation would be that we try two projects in different Regions with the High Float emulsion and a CMS emulsion for comparison. We are arranging to have Mr. Wycoff travel to Juneau and Fairbanks to discuss his product now.

As a final note, Mr. Neunaber's slides and the on-site inspection confirm the fact that many of the road sections in the Yukon where High Float emulsion was used have very shallow side ditches. Some are on the order of one foot or less. Our standards require a minimum of a three-foot ditch which would provide vastly improved drainage. Hardly anything is worse for a paved surface than water in the subgrade, so we should have some advantage in this respect.

Sincerely,

John J. Simpson, Acting Director
Standards and Technical Services Division

cc: Fred Seeger, Deputy Commissioner, Standards and Statewide Programs
Jon Scribner, Acting Deputy Commissioner, Southeast Region
H. Glen Glenzer, Deputy Commissioner, Interior Region
Dave Haugen, Deputy Commissioner, Central Region
Ray Miller, Materials Engineer, Southeast Region
Paul Misterek, Materials Engineer, Interior Region
Ben Harding, Special Staff Assistant, Office of the Governor
Emil Notti, Legislative Liaison, Office of the Governor
Representative Mitch Abood
Representative Bob Bettisworth
Representative Bette Cato
Representative Milo Fritz
Senator Don Gilman
Representative Niilo Koponen
Representative Jack McBride
Senator Pappy Moss
Representative Richard Schultz

# MEMORANDUM

State of Alaska
Department of Transportation & Public Facilities
SOUTHEASTERN REGION

TO: John Simpson
Director, S & TS
Southeastern Region

DATE: April 26, 1983

FILE NO: 244E-1802

TELEPHONE NO. (907) 789-0841, Ext. 215
(907) 452-1911

FROM: Ray D. Miller
Materials Engineer
Southeastern Region

Paul Misterek
Materials Engineer
Southeastern Region

SUBJECT: Surface Treatments,
Yukon Territory

Presented, herewith, are the observations made by the writers during their April 21 and 22 visit to Whitehorse, Yukon Territory, the purpose of which was to meet with officials of the Yukon Department of Highways and Transportation and discuss primarily their use of High Float Emulsion Asphalt with well graded aggregate on surface treatments.

A meeting was held in the office of the Department of Highways and Transportation at Whitehorse on the afternoon of April 21, 1983. Those in attendance were:

L.W. Blackman, P.E. Deputy Minister, Yukon Territory
Colin Farr, Director of Highways, Yukon Territory
Raymond Magnuson, Manager of Maintenance Branch, Yukon Territory
Ray Miller, Alaska Department of Transportation
Paul Misterek, Alaska Department of Transportation

The meeting was very cordial and discussion centered around Yukon Territory's use of High Float Emulsion Surface Treatments, typical projects where used, problems associated with and possible avoidance of same. A schedule was set up for the following day to visit typical projects where this type surface treatment has been used. Following is a summary of observations noted during the discussion and site visits:

## I. DESCRIPTION OF PROCESS

High float (HF) is a medium setting anionic emulsion that has a quality imparted by the addition of certain chemicals that prevent the emulsion from breaking immediately on contact with the aggregate. The surface treatment reacts to surface rolling by allowing the emulsion to migrate within the aggregate. While the regular asphalts have a tendency to flow, or migrate, at 60° C (140° the high floats are designed to stay in place up to 70° C (160° F). As a result, the HF residues are less susceptible to changes in temperature and are harder in the summer and do not harden as much in the winter. The high content of petroleum solvent enables the HF to penetrate through a heavy application of sand and gravel. Consequently, the final surface may be many stones thick while it provides the advantage of resisting flushing or bleeding better than a standard emulsion.

The fact that HF emulsions set up a slower rate can be a disadvantage when it is necessary to get the road back into service as soon as possible, such as in the case on major highways.

While HF asphalts are being used for the treatment of a large number of roads in areas of scattered populations with low traffic volumes, there is a general feeling within the industry that they are not adequate for Bituminous Surface Treatment's carrying high traffic volumes on major main roads.

## II. TYPICAL USES BY YUKON TERRITORY

1. The process is used as an interim surfacing on new construction where the subgrade has been reconstructed to current standards

2. The application is used with minimal upgrading of the existing roadway where traffic volume does not warrant a higher level of surfacing, such as pavement. Generally a base course is placed prior to application of the surface treatment.

3. It is used as a substitution for other dust palliatives until reconstruction. The treatment is applied on the existing surface materials, which have been reshaped and re-compacted.

It should be noted that this application has not been placed over existing pavement, but this is being contemplated, using a smaller size (½ inch minus) aggregate.

## III. COST ESTIMATES

During the 1982 season, Yukon Territory incurred costs of $22,500* (Canadian) for surface treatments with a twenty-six foot width. This includes costs for labor, equipment, and materials and utilizing their own forces. It does not include any base preparation costs.

During 1981, Public Works of Canada awarded contracts for work of this type. Costs were approximately 25 percent higher than those incurred using their own forces. This higher cost recognizes the risk factor, as well as the fact that the State forces worked continuously on the same type of work all season and gained a high degree of proficiency.

*Cost per mile in length

## IV. DESIGN CONSIDERATIONS

1. Yukon Territory officials consider this treatment to have a five year life expectancy, although in low traffic problem areas over a good base, a longer use period is anticipated.

2. A four percent crown is recommended. Experience in Yukon Territory has shown that the texture of the surface slows drainage, and the greater crown is desirable, especially at near-freezing temperatures.

3. Yukon Territory does not use a prime coat, but officials there feel it would be beneficial, especially for maintaining a surface prior to application of the treatment.

4. Gradation of the surfacing aggregate used by Yukon Territory approximates our Base Course D-1 specification, and it is felt that this gradation could be used.

5. The surfacing aggregate should be slightly moist at the time of application. Specifications should require moisture content of two percent minimum to four percent maximum.

6. Only emulsified asphalt of grade HF-350S has been used by Yukon Territory. For initial projects, specifications should be developed using that grade of asphalt or a product very similar.

7. Weather limitations noted in the example specifications from Yukon Territory should be strictly enforced. Yukon Territory officials credit this with their high success rate. During adverse or marginal weather, the crew can be diverted to advance preparation activities such as aggregate stockpiling. A copy of the Canadian specifications are attached for your information.

8. Application rates found to be desirable are:

| | |
|---|---|
| Asphalt | 0.50 gal./sq. yd. |
| Aggregate | 40 lb./sq. yd. max. |

It has been found that too much aggregate can have an adverse effect on the product.

## V. CONSTRUCTION TECHNIQUES

1. Experienced personnel are mandatory for a high degree of succes Mr. Blackman emphasized that he felt that surfacing treatment is 80 percent art and 20 percent science.

2. Adequate equipment is essential. Yukon Territory has new equipment with duplication to assure a continuous operation (i.e., two distributors, adequate trucks, etc.)

3. Specifications regarding traffic control and opening of the newly constructed roadway to traffic should be strictly observed.

Initially, Yukon Territory crews placed approximately two miles of 26 foot width surface treatment per day. As the techniques improv this increased to a maximum of approximately ten miles of 26 foot width under very good conditions.

## VI. PERFORMANCE AND MAINTENANCE EVALUATION

1. During 1982, Yukon Territory incurred costs of $6000 per kilometer without the surfacing and $4000 per kilometer with the treatment for maintaining roadway sections.

2. Maintenance of the surface is critical. Small holes must be patched as they develop. Asphalt emulsion and chips can be used, but a cold mix is preferable for small areas and potholes.

3. The surface texture is rougher than normal pavement or a two coat surface treatment. At regular highway speeds, there is a noticeable increase in noise level and a somewhat rougher ride, however, not so much as to be objectionable. At reduced speeds, neither is noticeable.

Traffic tends to knead the aggregate and with time produces a tight compact surface.

4. Most of the surface treatments observed during this visit were relatively new in age, that is, less than five years old. Conditions varied from excellent to poor with poor subgrade and inadequate drainage most likely a contributing factor in those areas appearing less than acceptable. Again, as stated in the Design Considerations, this process is interim in nature and life expectancy is five years.

## VII. SUMMARY

Yukon Territory will have projects under construction adjacent to the Alaska border on the Klondike and Alaska Highways. It is recommended that personnel of Alaska Department of Transportation involved in design, construction, and maintenance should be allowe to observe these projects. A copy of Yukon's surface treatment schedule is attached.

It is recommended that a project should be designed and constructe using this process in Alaska. The initial project should be monit and necessary revisions made to project specifications prior to pr ceeding with additional contracts. The Interior Region has tentat selected a road project; Southeast might consider its use on a sma airport, possibly Haines or Skagway.

Yukon officials have expressed an interest in our adoption of this surfacing method and may be available to advise us during construction and it is recommended they be extended an invitation to participate.

Also, it should be noted that discussions with Chevron Asphalt Company (USA) have indicated that Anionic Emulsified Asphalt products are not now available nor have they been available for quite some time (± 15 years). Consequently, the HF350S may be difficult to obtain in the United States.

The visit, we believe, will prove very beneficial to both Yukon and Alaska as many items of mutual interest were discussed. The communication door is now open and a closer association between the two departments will provide both with the opportunity to exchange ideas in the field of highway design, construction and maintenance. Should you have any further questions regarding this process, please feel free to contact Mr. Misterek or Mr. Miller.

RDM/PM/cln

Attachments: As stated

cc: Charles Matlock
Director/S.E. Region
Design & Construction

Steve Sisk
Director/Interior Region
Design & Construction

## PART 1 - GENERAL

### 1.1 Description

.1 This section specifies requirements for applying si application of emulsified asphalt and aggregate to a granular base in accordance with these specification

### 1.2 Related Work Specified Elsewhere

.1 Weight Scales: Section HC01155
.2 Aggregates - General: Section HC02225
.3 Granular Base: Section HC02229

### 1.3 Samples

.1 Submit to Engineer following material samples at lea 4 weeks prior to commencement of work:

  .1 10 kg of aggregate

  .2 Two 4 litres plastic containers of Asphalt Mater

### 1.4 Measurement for Payment

.1 Asphalt Surface Treatment Aggregate - Production, Hauling and Application: To be measured in tonnes of material incorporated into work.

.2 Asphalt Surface Treatment Aggregate - Hauling and Application: To be measured in tonnes of material incorporated into work.

.3 Asphalt Material: To be measured in litres at 15 deg. C., supply and delivery according to Prime Cost Sum (General Instructions, Section 01015, Article 13). Application will be paid for in litres separately under applicable Unit Price Item.

## PART 2 - PRODUCTS

### 2.1 Materials

.1 Asphalt Material: To CGSB 16-GP-5M grade HF-350S. Transported, stored and handled in accordance with Asphalt Institute Publication CL-21.

.2 Aggregates:

  .1 General Requirements: Crushed stone or gravel, clean, tough, durable fragements, free from an excess of flat, elongated, soft or disintegrate pieces and free from stone coated with dirt or other objectionable matter. Flat and elongated particles are those whose greatest dimension exceeds four times their least dimension

## PART 2 - PRODUCTS CONT'D

### 2.1 Materials (Cont'd)

.2 Aggregates: (Cont'd)

.2 Physical Properties:

AGGREGATE GRADING

| Sieve Size | | % Passing by Ma |
|---|---|---|
| ASTM | METRIC EQUIVALENT | |
| 3/4 inch | 19.0 mm | 100 |
| 1/2 inch | 12.7 mm | 65 - 90 |
| 3/8 inch | 9.51 mm | 55 - 80 |
| No. 4 | 4.76 mm | 35 - 55 |
| No. 10 | 2.00 mm | 15 - 35 |
| No. 40 | 0.420 mm | 5 - 20 |
| No. 200 | 0.074 mm | 0 - 5 |

.3 Los Angeles Abrasion AASHTO T96-70: Max. loss by mass 45%.

.4 Crushed fragments: Material reta on No. 4 (4.760 mm) sieve to have least 1 fractured face: percent by weight 60.

.5 Thin and elongated particles: max mass 5%.

## PART 3 - EXECUTION

### 3.1 Equipment

.1 Pressure distributor:

.1 Distributor to be so designed, equippe maintained, and operated that asphalt material at even heat may be applied uniformly on variable widths of surfac to 5 m at readily determined and contr led rates from 0.3 to 5.5 litres per square metre, with uniform pressure,

## PART 3 - EXECUTION (CONT'D)

### 3.1 Equipment (Cont'd)

.1 Cont'd

.2 Capable of distributing asphalt material in a uniform spray without atomization at rate specified and at temperature require

.3 Equipped with a tachometer registering metres per minute visibly located enablin truck driver to maintain constant speed required for application at specified ra

.4 Pump equipped with a tachometer registeri litres per minute passing through nozzles and readily visible to operator. Pump to operate by a separate power unit independent of truck power unit. Have full circulating system that includes spray ba

.5 Equipped with an easily read, accurate an sensitive device which registers temperature of liquid in reservoir. Equipped with heating system to bring emulsion to proper spray application temperature.

.2 Mechanical aggregate spreader: A self-propelled unit of approved design, supported b at least four wheels equipped with pneumatic tires on two axles. Aggregate spreader to be equipped with positive controls so that requir amount of material will be deposited uniforml over full width of asphalt material.

.3 Rollers: Self-propelled pneumatic tired rolle weighing not less than 11 tonnes, equipped wit not less than seven wheels staggered back and front, and tires inflated to 415 kPa.

.4 Power Broom: Self-propelled pneumatic tired unit, capable of vertical and horizontal angular adjustment.

### 3.2 Preparation

.1 Grade granular base to specified grade and cross-section. Blade smooth, and compact. Remove foreign material as necessary immediately before asphalt binder is applied.

.2

## 3.3 Application

.1 Apply treatment only when existing surface is slightly damp, when atmospheric temperature in shade is above 10 deg. C and rising or about 15 deg C if falling, and when weather is not foggy or rainy. Apply light spray application of water to surface before treatment when requested by Engineer.

.2 Schedule work to approval of Engineer. If directed, treat one lane at a time.

.3 Spread a protective covering of building paper or other acceptable material over width of surface, and for a sufficient distance back so that spraying nozzles are fully operative when surface to be treated is reached.

.4 Apply materials within following ranges. Engineer will direct quantities of asphalt material and aggregate to be supplied.

.1 Single Surface Treatment:

| | |
|---|---|
| Asphalt binder, litres per square metre | 2.77 to 3.75 |
| Kg. of aggregate per square metre | 34.0 46.0<br>~~[illegible]~~ to ~~[illegible]~~ |

Note: 40 Kg/m² worked very well. JA

.5 Apply liquid asphalt at spraying temperature specified in applicable CGSB standard for gra used and at rate specified per square metre using approved pressure distributor.

3.3 Application (Cont'd)

.6 Remove used protective covering and dispose of by acceptable means.

.7 Apply aggregate immediately following applicat of asphalt material. Apply no more aggregate than can be thoroughly incorporated into and absorbed by asphalt. Local areas of excess asphalt to be spread uniformly by hand or remo prior to aggregate application. Aggregate to be applied at a rate and manner that shall min mize the displacement of asphalt material.

.8 Rates of application of asphalt and aggregate will be adjusted by Engineer, if needed, durin course of work.

.9 Apply aggregate in such a manner that tires of approved aggregate spreader at no time contact uncovered and newly applied asphalt material.

.10 Immediately after aggregate is spread, cover any deficient areas with additional material.

.11 Roll immediately after aggregate is spread, making at least 6 passes with pneumatic tired roller, until cover material is tied, or to approval of Engineer.

.12 After completing rolling, lightly broom or otherwise maintain as directed for a period of 4 days. Maintenance to include distribution o aggregate, to absorb free asphalt and to cover any areas deficient in aggregate material. Repair to satisfaction of Engineer areas of improper or deficient surface treatment produc

.13 Conduct maintenance in manner not to displace imbedded material. Sweep loose material from entire surface by rotary brooms at time determined by Engineer.

3.4 Traffic Control

.1 Direct traffic through project with warning signs, flagpersons and pilot truck in a manner that provides maximum safety for workmen and least interruption of work.

.2 Keep traffic off freshly sprayed asphalt.

.3 If necessary to route traffic over new treatment, restrict speed to 10 km/h or less, until rolling is completed and asphalt has taken initial set.

.4 After initial set, restrict traffic to 40 km/h or less, until Engineer directs end of traffic control.

# 1983 - 84 B.S.T. SCHEDULE

| PLACE | DATE |
|---|---|
| Watson Lake - km 1045.9 - 1055 | June 1st - 4th |
| Swift River - km 1203 - 1240 | June 7th - 17th |
| Teslin - km 1265 - 1273 | June 20th - 21st |
| Beaver Creek - km 1886 - 1968.7 | June 28th - July 22nd |
| Teslin - km 1293 - 1308 | Aug. 23rd - 26th |
| Patching - Alaska Highway | July 23rd - 29th |
| **Capital Projects** | |
| Klondike Hwy. - km 146 - 159 (Skagway Road) | June 22nd - 24th |
| Klondike Hwy. - km 701 - 716 (Dawson) | Aug. 1st - 5th |
| Stewart Crossing - 1 km | Aug. 8th |
| Pelly - 1 km | Aug. 9th |
| Carmacks - km 308 - 346 | Aug. 10th - 22nd |
| **Resurfacing** | |
| Swift River | April 26th - May 27th |
| Beaver Creek | April 26th - June 24th |
| Mule Creek | June 27th - July 22th |
| Carcross | June 27th - July 15th |
| Carmacks | July 18th - Aug. 5th |
| Dawson | June 6th - July 15th |
| Stewart/Mayo | July 18th - Aug. 30th |
| Dempster (4-1 HC) | June 1st - Sept. 30th |

# PART ONE:

# UNDERSTANDING ASPHALT EMULSIONS

## CHAPTER I

# INTRODUCTION

### 1.01 BASIC TYPES OF PAVING ASPHALTS

Virtually all asphalts used in the United States are products of the distillation of crude petroleum. Asphalt is produced in a variety of types and grades ranging from hard and brittle solids to almost water-thin liquids. Asphalt cement is the basis of all of these products. It can be made fluid for construction uses by heating, by adding a solvent, or by emulsifying it. When a petroleum solvent, such as naphtha or kerosene, is added to the base asphalt to make it fluid, the product is called a cutback. When asphalt is broken into minute particles and dispersed in water with an emulsifier it becomes an asphalt emulsion. The tiny droplets of asphalt remain uniformly suspended until the emulsion is used for its intended purpose.

When combined with a cutback, the asphalt is dissolved in the liquefying agent. In an emulsion, an electrochemical action keeps the particles in suspension in the liquid phase. When either type is used in the field, the liquefying agent evaporates. In the case of the emulsion, the remaining chemicals combine with the base asphalt to enhance its properties so it will perform its functions of cementing and waterproofing.

### 1.02 ASPHALT EMULSION IN THE PAST

The use of asphalt emulsions for road construction and maintenance is not new. Emulsions were first developed in the early 1900s. It was not until the 1920s, however, that emulsions, as we know them today, came into being. Their early use was confined largely to spray applications and use as a dust palliative. The growth in the use of asphalt emulsions was relatively slow. It was limited by the types available and a lack of knowledge as to how they should be used. Continuing development of new types and grades, coupled with improved construction equipment and practices, now gives a broad range of choices, with which virtually any roadway requirement can be met. Judicious selection and use can yield significant economic benefits.

Use records reveal a slow but steady increase in the amount of emulsions used between 1930 and the mid 1950s. Following World War II, traffic loads and volumes increased so much that roadway designers began to curtail the use of these materials. Instead, they specified high-type hot plant mixes requiring the use of asphalt cement. While the volume of asphalt cement used has shown a rapid increase since 1953, the combined use of other asphalt products has remained almost constant. But one interesting trend is worthy of note—there has been a steady rise in the volume of asphalt emulsions used.

The major uses of asphalt emulsion in the United States are:

- Surface treatments
- Patching and thin overlays
- Stabilization
- Slurry sealing

Asphalt emulsions also are used in base and surface course mixes.

In the past few years several factors have contributed to a nationwide interest in the use of asphalt emulsions, namely:

- The energy crisis of the early 1970s that prompted conservation measures by the Federal Energy Administration. Asphalt emulsion does not require a petroleum solvent to make it liquid. (However, some medium-setting grades contain limited amounts of solvent to enhance mixing qualities.) Also, asphalt emulsion can be used (in most cases) without additional heat. Both of these contribute to energy savings.
- Reduced atmospheric pollution. There are little or no hydrocarbon emissions from asphalt emulsions.
- The ability of certain types of asphalt emulsion to coat damp aggregate surfaces, which is another energy saving feature.
- Availability of a greater number of emulsion types, coupled with improved laboratory procedures, to satisfy design and construction requirements.
- Potential cost savings by the use of less fuel.

Two major environmental factors—energy conservation and atmospheric pollution—caused grave concern and a realization that some type of Federal action was needed. Our nation suddenly became aware that energy needs soon could exceed supply unless conservation laws were enacted promptly. In one of the early actions, the Federal Highway Administration issued FHWA Notices N5080.2 and N5080.5, respectively. These notices directed attention to fuel savings that can be realized by using asphalt emulsions instead of cutback asphalts. They estimated that a huge amount of petroleum solvents could be saved annually by such substitution. While the substitution was not mandatory, it was strongly suggested that it be considered. At that time at least 42 states were substituting, or allowing the substitution of, asphalt emulsions for other types of asphalts. It is probable that the number of agencies permitting this substitution has increased since that time.

## 1.03 LOOKING AHEAD

Despite conservation pressures, the demand for energy-related materials—especially asphalts — will remain. An American Association of State Highway and Transportation Officials (AASHTO) survey has revealed that the United States has about 3.8 million miles (6.1 million km) in the roadway network. The survey also showed that of the 1.8 million miles (2.9 million km) of paved highways, about 93 percent have asphalt paved surfaces. A 1977 survey made by the Federal Highway Administration estimated that 285,000 miles (459,000 km) of highways and streets needed resurfacing. Another 140,000 miles (225,000 km) needed widening, and almost 500,000 miles (805,000 km) required either reconstruction or widening. In addition, most of the remaining 2 million miles (3.2 million km) were in need of some type of improvement. Any attempt to meet these highway needs will require a large amount of energy-related paving materials.

The number of registered vehicles and number of licensed drivers have shown a sharp increase yearly for the past 30 years. Highway planners predict that by 1990 we will have 170 million vehicles on the highways. There will be 161 million licensed drivers—85 percent of everyone over 15 years of age. Thus the need for an extensive and well-maintained roadway network will remain high, and the demand for asphalt materials will remain correspondingly high. Yet, at the same time, every attempt should be made toward energy conservation. The forecast, therefore, is for a sharp increase in the use of asphalt emulsions.

A clear understanding of the ''why and how'' of using asphalt emulsions offers a promise of reduced energy consumption and less atmospheric pollution. The proper use of these materials can result in high performance pavements and thrifty, but versatile, maintenance systems. This manual is directed toward those ends.

As an aid in understanding technical terms that may not be familiar, a glossary is provided as Appendix A.

## CHAPTER II

# THE CHEMISTRY OF ASPHALT EMULSIONS

## A. GENERAL

### 2.01 EMULSIONS

There are many types of emulsion products that we use in our daily lives. Some of the more common are mayonnaise, paints, hair dyes and ice cream. In each case, certain mechanical and chemical processes are involved that permit the combining of two or more materials that, under normal conditions, will not mix. An entire scientific field is devoted to the study of emulsification. You don't have to understand how an internal combustion engine works to operate an automobile. Neither do you have to understand complex emulsion chemistry to obtain high quality results with asphalt emulsion. The key is to select the right emulsion for the aggregate and construction system involved. Throughout this text when the term "emulsion" is used it is intended to mean "asphalt emulsion."

### 2.02 COMPOSITION OF ASPHALT EMULSIONS

An asphalt emulsion consists of three basic ingredients: asphalt, water, and an emulsifying agent. On some occasions the emulsifying agent may contain a stabilizer.

It is well known that water and asphalt will not mix, except under carefully controlled conditions using highly specialized equipment and chemical additives. The blending of asphalt cement and water is somewhat akin to an auto mechanic trying to wash grease from his hands with water only. It is not until a detergent or soapy agent of some type is used that grease can be successfully removed. The soap particles surround the globules of grease, break the surface tension that holds them, and allow them to be washed away. Some of the same physical and chemical principles apply in the formulation, production, and use of asphalt emulsion.

The object is to make a dispersion of the asphalt cement in water, stable enough for pumping, prolonged storage, and mixing. Furthermore, the emulsion should break down quickly after contact with aggregate in a mixer, or after spraying on the roadbed. Upon curing, the residual asphalt retains all of the adhesive, durability, and water-resistant properties of the asphalt cement from which it was produced.

### 2.03 CLASSIFICATION

Asphalt emulsions are divided into three categories: anionic, cationic, and nonionic. In practice, the first two types are ordinarily used in roadway construction and maintenance. Nonionics, however, may be more widely used as emulsion technology advances. The anionic and cationic classes refer to the electrical charges surrounding the asphalt particles. This identification system stems from one of the basic laws of electricity — like charges repel one another and unlike charges attract. When two poles (an anode and a cathode) are immersed in a liquid and an electric current is passed through, the anode becomes positively charged and the cathode becomes negatively charged. If a current is passed through an emulsion containing negatively charged particles of asphalt they will migrate to the anode. Hence, the emulsion is referred to as anionic. Conversely, positively charged asphalt particles will move to the cathode and the emulsion is known as cationic. With nonionic emulsions, the asphalt particles are neutral and, therefore, do not migrate to either pole.

Emulsions are further classified on the basis of how quickly the asphalt will coalesce; i.e., revert to asphalt cement. The terms RS, MS, and SS have been adopted to simplify and standardize this classification. They are relative terms only and mean rapid-setting, medium-setting, and slow-setting. The tendency to coalesce is closely related to the mixing of an emulsion. An RS emulsion has little or no ability to mix with an aggregate, an MS emulsion is expected to mix with coarse but not fine aggregate, and an SS emulsion is designed to mix with fine aggregate.

The emulsions are further subdivided by a series of numbers related to viscosity of the emulsions and hardness of the base asphalt cements. The letter "C" in front of the emulsion type denotes cationic. The absence of the "C" denotes anionic or nonionic. For example, RS-1 is anionic or nonionic and CRS-1 is cationic.

Three grades of high-float medium-setting anionic emulsions, designated HFMS, have been added to standard ASTM specifications. These grades are used primarily in cold and hot plant mixes, coarse aggregate seal coats, and road mixes. High float emulsions have a specific quality that permits a thicker film coating without danger of runoff.

A quick-set type of emulsion (QS) has been developed for slurry seals. Its use is rapidly increasing as the unique quick-setting property solves one of the major problems associated with the use of slurry seals.

Standard specifications for quick-set emulsions are under development. Additionally, some emulsions are made with the water dispersed in asphalt, usually a cutback. As these so-called "inverted emulsions" are seldom used, they are not discussed at all.

## 2.04 SPECIFICATIONS

AASHTO and ASTM have developed standard specifications for the following grades of emulsions:

| EMULSIFIED ASPHALT | CATIONIC EMULSIFIED ASPHALT |
|---|---|
| RS-1 | CRS-1 |
| RS-2 | CRS-2 |
| MS-1 | — |
| MS-2 | CMS-2 |
| MS-2h | CMS-2h |
| HFMS-1 | — |
| HFMS-2 | — |
| HFMS-2h | — |
| SS-1 | CSS-1 |
| SS-1h | CSS-1h |

The "h" that follows certain grades simply means that a harder base asphalt is used. The "HF" preceding some of the MS grades indicates high-float, as measured by the Float Test (AASHTO T 50 or ASTM D 139). High-float emulsions have a quality, imparted by the addition of certain chemicals, that permits a thicker asphalt film on the aggregate particles with minimum probability of drainage. Some user agencies specify an additional cationic sand-mixing grade designated CMS-2s, which contains more solvent than other cationic grades. All grades in this lengthy list of emulsions cannot be stocked by most producers. Communication and planning between user and producer helps facilitate service and supply of a given grade.

The specifications for emulsified asphalts (AASHTO M 140 and ASTM D 977) make no mention of a solvent in the emulsion. CRS- and CMS- cationic emulsion specifications (AASHTO M 208, ASTM D 2397), on the other hand, permit solvent but restrict the amount.

General guidelines for use as contained in "Standard Practice for Selection and Use of Emulsified Asphalts," ASTM D 3628, are given in Table V-1, Chapter V. Standard specifications for emulsified asphalts carry AASHTO Designations M 140 and M 208 and ASTM Designations D 977 and D 2397. For convenience, the basic requirements of these specifications are given in Tables II-1 and II-2.

### 2.05 VARIABLES AFFECTING ASPHALT EMULSION

There are many factors that affect the production, storage, use, and performance of an asphalt emulsion. It would be hard to single out any one as being most significant. But, among the variables having a significant effect are:

- — Chemical properties of the base asphalt cement
- — Hardness and quantity of the base asphalt cement
- — Asphalt particle size in the emulsion
- — Type and concentration of the emulsifying agent
- — Manufacturing conditions such as temperatures, pressures, and shear
- — The ionic charge on the emulsion particles
- — The order of addition of the ingredients
- — The type of equipment used in manufacturing the emulsion
- — The property of the emulsifying agent
- — The addition of chemical modifiers.

The above factors can be varied to suit the available aggregates or to suit construction conditions. It is always advisable to consult the emulsion supplier with respect to a particular asphalt-aggregate combination as there are few absolute rules that will work the same under all conditions. Therefore, making asphalt emulsions appears to be a combination of art and science.

An examination of the three main constituents—asphalt, water, and emulsifier—is essential to an understanding of why asphalt emulsions work as they do.

## B. EMULSION INGREDIENTS

### 2.06 ASPHALT

Asphalt cement is the basic ingredient of asphalt emulsion and, in most cases, it makes up from 55 to 70 percent of the emulsion. Tables II-1 and II-2 show the asphalt content specified for various types of emulsions.

Because asphalt cement is such a complex material, only those properties that significantly affect emulsions are discussed. There is not an exact correlation, however, between the properties and the ease with which the asphalt can be emulsified. Although hardness of base asphalt cements may be varied as desired, most emulsions are made with asphalts in the 100—250 penetration range. On occasion, climatic conditions may dictate that a harder or softer base asphalt be used. In any case, compatibility of the emulsifying agent with the asphalt cement is essential for production of a stable emulsion.

Asphalt is a colloid composed of several fractions, the major ones being asphaltenes and maltenes. The colloidal make-up of the asphalt depends on the chemical nature and percentage of these fractions and their relationship to each other.

# TABLE II-1 REQUIREMENTS AND TYPICAL APPLICATIONS FOR EMULSIFIED ASPHALT

D 977

| Type | Rapid-Setting | | | | Medium-Setting | | | | | | Medium-Setting | | | | | | Slow-Setting | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS-1 | | RS-2 | | MS-1 | | MS-2 | | MS-2h | | HFMS-1 | | HFMS-2 | | HFMS-2h | | SS-1 | | SS-1h | |
| Grade | min | max | min | max | min | max | min | max | min | max | min | max | min | max | min | max | min | max | min | max |
| Tests on emulsions: | | | | | | | | | | | | | | | | | | | | |
| Viscosity, Saybolt Furol at 77°F (25°C), s | 20 | 100 | | | 20 | 100 | 100 | | 100 | | 20 | 100 | 100 | | 100 | | 20 | 100 | 20 | 100 |
| Viscosity, Saybolt Furol at 122°F (50°C), s | | | 75 | 400 | | | | | | | | | | | | | | | | |
| Settlement,[a] 5-day, % | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 |
| Storage stability test,[b] 24-h, % | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 |
| Demulsibility,[c] 35 ml, 0.02 $N$ $CaCl_2$, % | 60 | | 60 | | | | | | | | | | | | | | | | | |
| Coating ability and water resistance: | | | | | | | | | | | | | | | | | | | | |
| Coating, dry aggregate | | | | | good | | good | | good | | good | | good | | good | | | | | |
| Coating, after spraying | | | | | fair | | fair | | fair | | fair | | fair | | fair | | | | | |
| Coating, wet aggregate | | | | | fair | | fair | | fair | | fair | | fair | | fair | | | | | |
| Coating, after spraying | | | | | fair | | fair | | fair | | fair | | fair | | fair | | | | | |
| Cement mixing test, % | | | | | | | | | | | | | | | | | | 2.0 | | 2.0 |
| Sieve test, % | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 |
| Residue by distillation, % | 55 | | 63 | | 55 | | 65 | | 65 | | 55 | | 65 | | 65 | | 57 | | 57 | |
| Tests on residue from distillation test: | | | | | | | | | | | | | | | | | | | | |
| Penetration, 77°F (25°C), 100 g, 5 s | 100 | 200 | 100 | 200 | 100 | 200 | 100 | 200 | 40 | 90 | 100 | 200 | 100 | 200 | 40 | 90 | 100 | 200 | 40 | 90 |
| Ductility, 77°F, (25°C), 5 cm/min, cm | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | |
| Solubility in trichloroethylene, % | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | |
| Float test, 140°F (60°C), s | | | | | | | | | | | 1200 | | 1200 | | 1200 | | | | | |
| Typical applications[d] | surface treatment, penetration macadam, sand seal coat, tack coat, mulch | | surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple) | | cold plant mix, road mix, sand seal coat, crack treatment, tack coat | | cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat | | cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat | | cold plant mix, road mix, sand seal coat, crack treatment, tack coat | | cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment road mix, tack coat, and seal | | cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment road mix, tack coat | | cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch | | | |

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[a] The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until the emulsified asphalt is used, if the elapsed time is less than 5 days.

[b] The 24-h storage stability test may be used instead of the 5-day settlement test.

[c] The demulsibility test shall be made within 30 days from date of shipment.

[d] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

# TABLE II-2 REQUIREMENTS AND TYPICAL APPLICATIONS FOR CATIONIC EMULSIFIED ASPHALT

ASTM D 2397

| Type | Rapid-Setting | | | | Medium-Setting | | | | Slow-Setting | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Grade | CRS-1 | | CRS-2 | | CMS-2 | | CMS-2h | | CSS-1 | | CSS-1h | |
| | min | max | min | max | min | max | min | max | min | max | min | max |
| Test on emulsions: | | | | | | | | | | | | |
| Viscosity, Saybolt Furol at 77°F (25°C), s | | | | | | | | | 20 | 100 | 20 | 100 |
| Viscosity, Saybolt Furol at 122°F (50°C), s | 20 | 100 | 100 | 400 | 50 | 450 | 50 | 450 | | | | |
| Settlement,[A] 5-day, % | | 5 | | 5 | | 5 | | 5 | | 5 | | 5 |
| Storage stability test,[B] 24-h, % | | 1 | | 1 | | 1 | | 1 | | 1 | | 1 |
| Classification test[C] | passes | | passes | | | | | | | | | |
| or | | | | | | | | | | | | |
| Demulsibility,[D] 35 ml 0.8 % sodium dioctylsulfosuccinate, % | 40 | | 40 | | | | | | | | | |
| Coating, ability and water resistance: | | | | | | | | | | | | |
| Coating, dry aggregate | | | | | good | | good | | | | | |
| Coating, after spraying | | | | | fair | | fair | | | | | |
| Coating, wet aggregate | | | | | fair | | fair | | | | | |
| Coating, after spraying | | | | | fair | | fair | | | | | |
| Particle charge test | positive | | positive | | positive | | positive | | positive | | positive | |
| Sieve test, % | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 | | 0.10 |
| Cement mixing test, % | | | | | | | | | | 2.0 | | 2.0 |
| Distillation: | | | | | | | | | | | | |
| Oil distillate, by volume of emulsion, % | | 3 | | 3 | | 12 | | 12 | | | | |
| Residue, % | 60 | | 65 | | 65 | | 65 | | 57 | | 57 | |
| Tests on residue from distillation test: | | | | | | | | | | | | |
| Penetration, 77°F (25°C), 100 g, 5 s | 100 | 250 | 100 | 250 | 100 | 250 | 40 | 90 | 100 | 250 | 40 | 90 |
| Ductility, 77°F (25°C), 5 cm/min, cm | 40 | | 40 | | 40 | | 40 | | 40 | | 40 | |
| Solubility in trichloroethylene, % | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | | 97.5 | |
| Typical applications[E] | surface treatment, penetration macadam, sand seal coat, tack coat, mulch | | surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple) | | cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat | | cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat | | cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch | | | |

[A] The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days time; or the purchaser may require that the settlement test be run from the time the sample is received until the emulsified asphalt is used, if the elapsed time is less than 5 days.

[B] The 24-h storage stability test may be used instead of the 5-day settlement test.

[C] Material failing the classification test will be considered acceptable if it passes the demulsibility test.

[D] The demulsibility test shall be made within 30 days from date of shipment.

[E] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

The asphaltenes are the dispersed phase in the asphalt whereas the maltenes are the continuous phase. The asphaltenes are thought to furnish hardness while the maltenes are believed to provide the adhesive and ductile properties of the asphalt. The maltenes present have an influence on the viscosity, or flow properties, of the asphalt. The complex interaction of the different fractions makes it almost impossible to predict accurately the behavior of an asphalt to be emulsified. For this reason, constant quality control is maintained on emulsion production to detect and correct any tendency of the asphalt to affect adversely the performance of the resulting emulsion.

Several systems of asphalt analysis are in use today to separate and evaluate the fractions. There is no absolute agreement among technologists as to how each fraction affects field performance. Nor is there total agreement about the ease with which an asphalt cement can be emulsified.

Each emulsion manufacturer has his own formulations and production techniques. They have been developed to achieve optimum results with the asphalt cement and emulsifying chemicals that he uses.

## 2.07 WATER

The second largest ingredient in an asphalt emulsion is water. Its contribution to the desired properties of the finished product cannot be minimized. Water wets and dissolves; it adheres to other substances; and, it moderates chemical reactions. These are all important factors that can be favorable to the production of a satisfactory emulsion. On the other hand, water may contain minerals or other matter that affect the production of stable asphalt emulsions.

Water found in nature may be unfit because of impurities, either in solution or colloidal suspension. Of particular concern is the presence of calcium and magnesium ions, which can affect the properties of the emulsion.

Water containing foreign matter should not be used in emulsion production. It may result in an imbalance of the emulsion components that can adversely affect performance or cause premature breaking.

In summary, water used to produce asphalt emulsions should be reasonably pure and free from foreign matter and should be considered an important item.

## 2.08 EMULSIFYING AGENTS

Properties of an asphalt emulsion depend greatly upon the chemical used as the emulsifier. That chemical is a surface-active agent, commonly called surfactant, that determines whether the emulsion will be classified as anionic, cationic, or nonionic. The emulsifier also keeps the asphalt droplets in stable suspension and permits breaking at the proper time. The surfactant changes the surface tension at the interface, i.e., the area of contact between the asphalt droplets and the water. A great many chemical emulsifiers are available. Each must be appraised for compatibility with the asphalt cement being used.

In the early days of asphalt emulsion production, such materials as ox-blood, clays, and soaps were used as emulsifying agents. As the demand for emulsions increased, new and more efficient emulsifying agents were found. Several chemical emulsifiers now are commercially available.

The most often used anionic emulsifiers are fatty acids, which are wood-product derivatives such as tall oils, rosins, and lignins. Anionic emulsifiers are saponified (turned into soap) by reacting with sodium hydroxide or potassium hydroxide.

Most cationic emulsifiers are fatty amines (diamines, imidazolines, amidoamines, to name three). The amines are converted into soap by reacting with acid, usually hydrochloric. Another type of emulsifying agent, fatty quarternary ammonium salts, is used to produce cationic emulsions. They are water-soluble salts as produced and do not require the addition of acid to make them water-soluble. They are stable, effective cationic (positively charged) emulsifiers.

It is important to remember that the pH value of the asphalt emulsion is unrelated to its identification as cationic or anionic. Acidity or alkalinity does not determine the sign of the charge. This sign is determined only by the type of emulsifier.

see page 26 F.M.

Each manufacturer has his own procedure for using his agent in asphalt emulsion production. In most cases, the agent is combined with the water before introduction into the colloid mill. In other cases, however, it may be combined with the asphalt cement just before it goes into the colloid mill.

## C. PRODUCING THE EMULSION

### 2.09 EMULSIFYING EQUIPMENT

Basic equipment to prepare an emulsion includes a high-speed, high-shear mechanical device (usually a colloid mill) to divide the asphalt into tiny droplets. Also needed are an emulsifier solution tank, heated asphalt tank, pumps, and flow-metering gauges. The colloid mill has a high-speed rotor that revolves at 1,000–6,000 rpm (17—100 Hz) with mill-clearance settings in the range of about 0.01 to 0.02 in. (0.25 to 0.50 mm). Such settings yield emulsions with asphalt droplet sizes smaller than the diameter of a human hair [about 0.001 to 0.005 in. (0.025 to 0.125 mm)]. There is a slight variation in mill clearance settings and, thus, asphalt droplet sizes depend upon the equipment used. Some emulsion mills have fixed clearances with no latitude for variation. Although simple mixers can be used to produce low viscosity cutback asphalt, normally they are not used to produce emulsions.

Separate pumps are used to meter asphalt and the emulsifier solution into the colloid mill. Because the emulsifier solution can be highly corrosive, it is necessary to use a pump made of corrosion resistant materials.

A schematic diagram of a typical asphalt emulsion manufacturing plant is shown in Figure II-1.

### 2.10 THE EMULSIFYING PROCESS

In the general method of emulsifying asphalts, concurrent streams of molten asphalt cement and treated water are directed by positive displacement pumps into the intake of the colloid mill. The asphalt and emulsifying water are subjected to intensive shear stresses as they pass through the colloid mill. The newly-formed emulsion may then be pumped through a heat exchanger. The excess heat is used to raise the temperature of the incoming emulsifying water just before it reaches the colloid mill. From the heat exchanger the emulsion is pumped into bulk storage tanks. These tanks sometimes are equipped with some type of stirring device to keep the product uniformly blended.

Heated asphalt cement the base of the asphalt emulsion, is fed into the colloid mill where it is divided into tiny droplets. At the same time, water containing the emulsifying agent is fed into the colloid mill. The asphalt, as it enters the colloid mill, is heated to ensure a low viscosity, and the water temperature is adjusted accordingly. These temperatures vary; they depend upon the emulsification traits of the asphalt cement and the compatibility between the asphalt and the emulsifying agent. Extremely high asphalt temperatures are not used because the temperature of the emulsion leaving the mill must be below the boiling point of water.

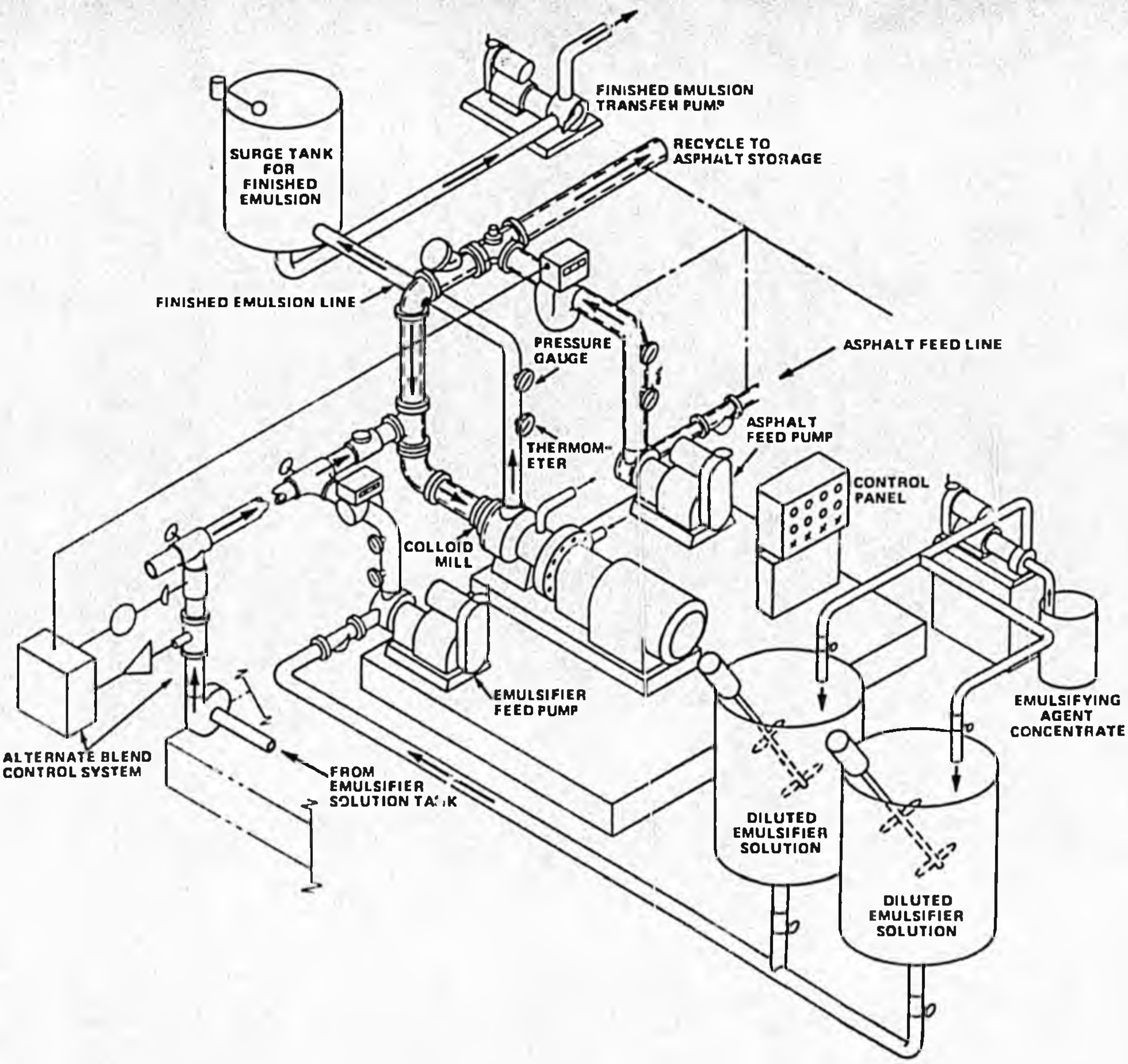


**Figure II-1. Diagram of an asphalt emulsion manufacturing plant.**

Courtesy Chemicolloid Laboratories, Inc.

The method of adding the emulsifier to the water varies according to the maker's procedure. Some emulsifiers, such as amines, must be mixed and reacted with an acid, such as hydrochloric, to attain water solubility. Others, such as fatty acids, must be mixed and reacted with an alkali, such as sodium hydroxide, to attain water solubility. Mixing is most typically done in a batch mixer. The emulsifier is introduced into warm water containing acid or alkali and agitated until completely dissolved.

Asphalt and emulsifier solution can be proportioned accurately. It can be done by monitoring the temperature of each phase and the mill discharge, or with meters. If the temperature regulation method of proportioning is used, the outlet temperature of the finished emulsion can be calculated from the temperatures of the various emulsion ingredients.

Asphalt particle size is a vital factor in making a stable emulsion. A microscopic photograph of a typical emulsion reveals the following average particle sizes:

| | |
|---|---|
| Smaller than 0.001 mm (1$\mu$m) | 28 percent |
| 0.001–0.005 mm (1–5$\mu$m) | 57 percent |
| 0.005–0.010 mm (5–10$\mu$m) | 15 percent |

These microscopic-sized asphalt droplets are dispersed in water in the presence of the chemical surface-active emulsifier (surfactant). The surfactant causes a change in the surface tension at the contact area between the asphalt droplets and the surrounding water, and this permits the asphalt to remain in a suspended state. The particles, all having a similar electrical charge, repel each other, which also aids in their remaining in a suspended state. Figure II-2 is a photomicrograph showing the sizes and distribution of the asphalt particles.

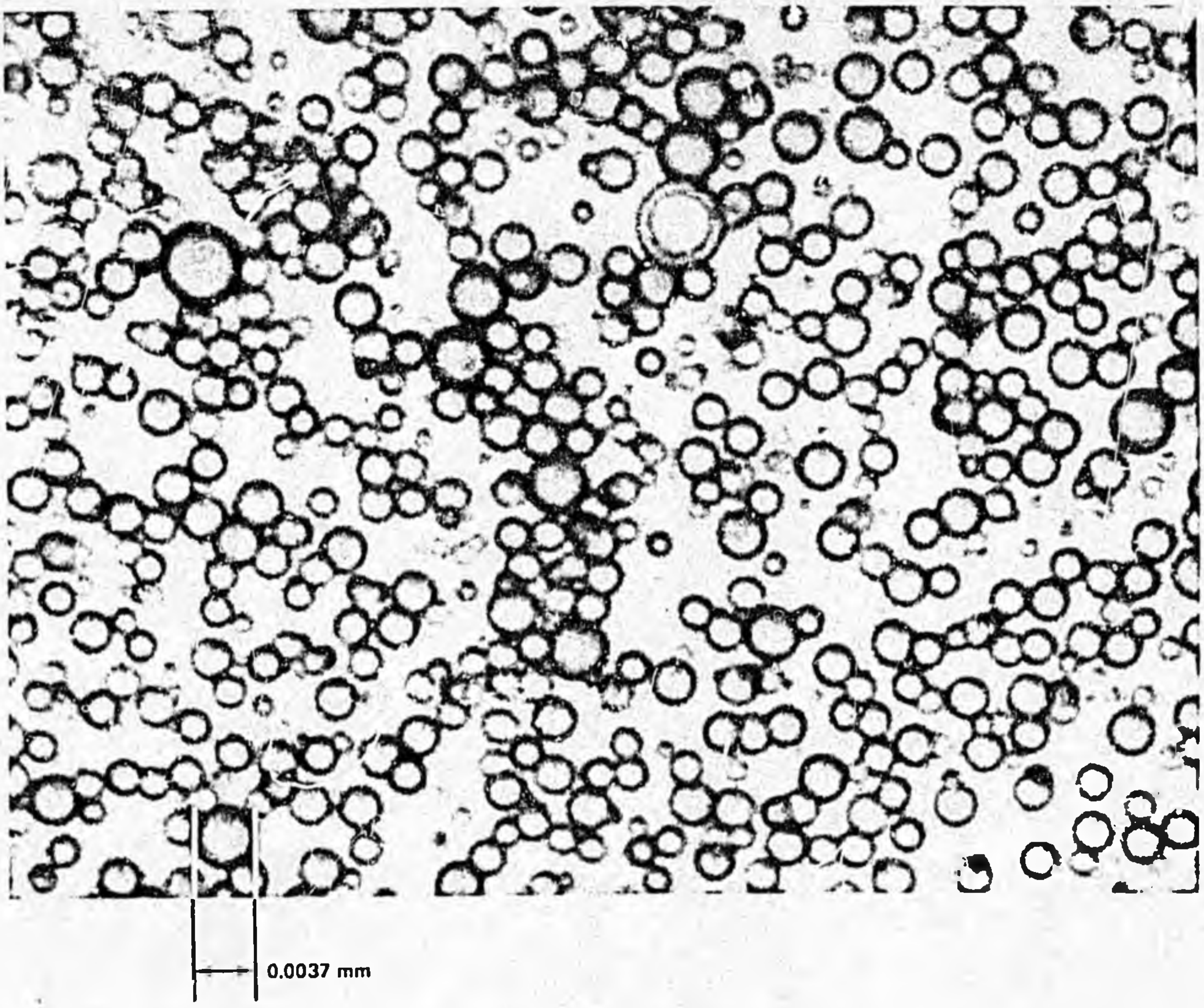


**Figure II-2. Relative sizes and distribution of asphalt particles in an emulsion.**

Courtesy Chevron U.S.A. Inc.

## D. BREAKING AND CURING

### 2.11 BREAKING

If the asphalt emulsion is to perform its ultimate function of cementing and waterproofing, the asphalt must separate from the water phase. For surface treatments and seals, emulsions are formulated to break upon contact with a foreign substance such as aggregate or a pavement surface. The asphalt droplets coalesce and produce a continuous film of asphalt on the aggregate or pavement. For dense mixtures, more time is needed to allow for mixing and laydown. Therefore, emulsions used for mixtures are formulated for delayed breaking. Asphalt coalescence is commonly referred to as breaking, or setting. The rate at which the asphalt globules separate from the water phase is referred to as breaking or setting time. For example, a rapid-set emulsion will break within one to five minutes after being applied, whereas a medium- or slow-set material may take considerably longer.

The rate of breaking is controlled primarily by the specific type and concentration of the emulsifying agent used, as well as atmospheric conditions.

The fact that different aggregate types have different rates of absorption means that breaking is also related to the relative absorption characteristics of the aggregate used. Those with higher absorption rates tend to accelerate the breaking of the emulsion due to the more rapid removal of the emulsifying water.

In asphalt emulsion-aggregate mixtures, gradation and surface area of the aggregate also are significant factors in the rate of breaking. As the surface area changes, the breaking characteristic of the medium also changes because of the altered adsorption of the emulsifying agent by the aggregate. In order to achieve optimum results, it is necessary to control the sizing of the aggregate or to adjust the emulsion formulation to meet the specific requirements of the aggregate.

### 2.12 CURING

For paving uses, both anionic and cationic asphalt emulsions depend on the evaporation of water for development of their curing and adhesion characteristics. Water displacement can be fairly rapid under favorable weather conditions but high humidity, low temperatures, or rainfall soon after application can deter proper curing. Although surface and atmospheric conditions are less critical for cationic emulsions, these types still depend somewhat on weather conditions for optimum results. Perhaps the principal advantage of the cationics is their willingness to give up their water a little faster.

Traditional theory holds that anionic emulsions (with a negative charge on the asphalt droplets) perform best with aggregates having mostly positive surface charges — limestone and dolomite are examples. The theory also holds that cationic emulsions (with a positive charge on the asphalt droplets) perform best with aggregates having mostly negative surface charges—some examples are siliceous or granitic aggregates. Presently, there is not complete agreement on the subject of electrical charges on aggregate surfaces. Recent studies have challenged the traditional theories. The theories presented in this manual follow the line of traditional usage, which may change in the future.

When using either the anionic or cationic rapid-set emulsion the initial deposition of asphalt develops through an electrochemical phenomenon. But the main bond of strength between the asphalt film and the aggregates comes after the loss of emulsifying water. This water film can be displaced by evaporation, pressure (rolling), or by absorption. In actual use, breaking is usually a function of the combination of these three factors.

Medium- and slow-set emulsions, being more heavily stabilized, depend less on the aggregate type although the same basic principles of electrical charges with respect to selection of emulsion type still apply. When the MS and SS grades are used for paving mixes, the use of slightly damp aggregates facilitates the mixing and coating process. The development of strength in the SS types depends mainly on dehydration and absorption with removal of water by either of these mechanisms breaking the emulsion. Solvent-free CMS and CSS emulsions require that the moisture on the aggregate be at or near optimum for proper mixing and coating.

Some types of emulsions contain slight amounts of petroleum solvent to aid in the mixing and coating process. While the solvent does not enter directly into the breaking mechanism, provisions must be made for the evaporation of the solvent in order for the mixture to be properly cured. Where multiple courses are to be placed, a successive course should not be applied until the water (and solvent, if applicable) has been removed from the preceding course.

## 2.13 FACTORS AFFECTING SETTING RATE

In general, some of the factors that affect setting rate of an asphalt emulsion are as follows:

1. The rate that water is absorbed by the aggregate. A rough-textured, porous aggregate speeds the setting time by absorbing water from the emulsion.
2. Moisture content of the aggregate prior to mixing.
3. Weather conditions—temperature, humidity, and wind velocity all have a bearing on rate of set.
4. Mechanical forces brought to bear by rolling and by traffic. Roller pressure, to a limited extent, forces the water from the materials.
5. Size distribution and mineral composition of aggregate. Fine aggregate mixes tend to break faster because they possess greater surface area than an equal weight of coarse aggregate. The mineral composition also affects the speed at which the asphalt emulsion breaks. There may be some type of chemical reaction between the emulsifier and the aggregate surface. Also, dirty aggregate or excessive fines may accelerate breaking and retard curing.
6. The type and amount of emulsifying agent used.
7. Intensity of charge on aggregate versus intensity of emulsifier charge, in combination with surface area, is a major setting-rate determinant.
8. Chemical coagulation. The emulsion becomes unstable because of a decreased water content.

The above factors must be considered in determining working time after the emulsion has been sprayed or mixed with the aggregate in the field.

## CHAPTER III

# STORING, HANDLING, AND SAMPLING ASPHALT EMULSIONS

### 3.01 GENERAL

The storage and handling of asphalt emulsions require precaution beyond that used for other types of asphalt materials. Improper handling or storage of the emulsion, or both, may cause premature breaking, thereby making it useless. The Asphalt Institute, in recognition of these necessary precautions, has issued a Construction Leaflet, *Storing and Handling of Emulsified Asphalts* (CL-21), outlining some of the safeguards that must be followed. Failure to follow even a single one of them may cause the material to be unsatisfactory at the time of use. Careful study of each item is therefore suggested. Sticking to these simple rules will save time and money by having the material ready for use when needed. The safeguards listed in the Asphalt Institute leaflet are repeated below to help those who have had little or no experience with asphalt emulsions. However, it is not intended to give the impression that asphalt emulsions are so delicate as to limit their field use. The use of almost any other material would have a long list of admonitions for the uninitiated.

### 3.02 STORING ASPHALT EMULSIONS

Emulsified asphalt, being a dispersion of fine droplets of asphalt cement in water, has both the advantages and disadvantages of the carrier medium, water. When storing emulsified asphalts:

*DO* store as you would fluid water—between 50° F (10° C) and 185° F (85° C), depending on the use.

*DO* use hot water as the heating medium for storage tanks with heating coils. Low pressure or waste steam also may be used, with temperature controlled on the coil surface to not more than 185° F (85° C).

*DO* store at the temperature specified for the particular grade. For spray applications, the emulsions are stored at higher temperatures than for mixing with aggregate. For example, the higher viscosity rapid-set spray grades are stored at 125° F to 185° F (50° C to 85° C) since they are usually applied in this temperature range. The lower viscosity grades are stored at lower temperatures. Table III-1 shows the normal storage temperature ranges. Store the mixing grades at the lower end of the temperature ranges as shown in Table III-1.

*DO NOT* permit the emulsified asphalt to be heated above 185° F (85° C). Elevated temperatures evaporate the water, resulting in an increase in viscosity and an asphalt layer in the tank. The materials can no longer be used as intended and it will be difficult to empty the tank.

*DO NOT* let the emulsion freeze. This breaks the emulsion, separating the asphalt from the water. The result will be two layers in the tank, neither suited for the intended use, and the tank will be difficult to clean.

*DO NOT* allow the temperature of the heating surface to exceed 205° F (96° C). This will cause premature breakdown of the emulsion on the heating surface.

*DO NOT* use forced air to agitate the emulsion. It may cause the emulsion to break.

### TABLE III-1 STORAGE TEMPERATURES FOR EMULSIFIED ASPHALTS

| Grade | Temperature, °F (°C) | |
|---|---|---|
| | Minimum | Maximum |
| RS-1 | 70° (20°) | 140° (60°) |
| RS-2, CRS-1, CRS-2 | 125° (50°) | 185° (85°) |
| SS-1, SS-1h, CSS-1, CSS-1h, MS-1, HFMS-1 | 50° (10°) | 140° (60°) |
| CMS-2, CMS-2h, MS-2, MS-2h, HFMS-2, HFMS-2h | 125° (50°) | 185° (85°) |

## 3.03 STORAGE FACILITIES

For protection from freezing and best utilization of heat, storage tanks should be insulated. A skin of asphalt can form on the surface of emulsions when exposed to air. It is best, therefore, to use tall, vertical tanks as they expose the least amount of surface area to the air. Most fixed storage tanks are vertical but horizontal tanks are often used for short-term field storage. Skinning can be reduced by keeping horizontal tanks full to minimize the area exposed to air.

Side-entering propellers located about three feet (one metre) up from the tank bottom may be used to prevent surface skin formation. Large diameter, slow-turning propellers are best and should be used to roll the material over. Avoid overmixing. Secondly, tanks may be circulated top to bottom with a pump. Avoid over-pumping. In tanks not equipped with propellers, or a circulating system, a very light film of kerosene or oil on the surface can reduce skin formation. Emulsions that are rolled or circulated generally do not require a layer of kerosene or oil on the surface. Cathodic protection should be provided to avoid possible corrosion of tank walls and heating coils.

## 3.04 HANDLING EMULSIFIED ASPHALTS

*DO* when heating emulsified asphalt agitate it to eliminate or reduce skin formation.

*DO* protect pumps, valves, and lines from freezing in winter. Drain pumps or fill them with anti-freeze according to the manufacturer's recommendations.

*DO* blow out lines and leave drain plugs open when they are not in service.

*DO* use pumps with proper clearances for handling emulsified asphalt. Tightly fitting pumps can cause binding and seizing.

*DO* use a mild heating method to apply heat to the pump packing or casing to free a seized pump. Discourage the use of propane torches.

*DO* warm the pump to about 150° F (65° C) to ease start-up.

*DO* when a pump is to be out of service for even a short period of time, fill it with No. 1 fuel oil to ensure a free start-up.

*DO* when diluting grades of emulsified asphalt, check the compatibility of the water with the emulsion.

*DO* if possible, use warm water for diluting and always add the water slowly to the emulsion (not the emulsion to the water).

*DO* avoid repeated pumping and recycling, if possible, as the viscosity may drop and air may become entrained, causing the emulsion to be unstable.

*DO* guard against mixing different classes, types, and grades of emulsified asphalt in storage tanks, transports, and distributors. For example, if cationic and anionic emulsified asphalts are mixed, the blend will break and separate into water and coagulated asphalt that will be difficult to remove. Because it is hard to determine visually the difference between various emulsified asphalts, always make a trial blend of the newly-delivered emulsion and the stored emulsion before pumping off. Check the trial blend for compatibility.

*DO* place inlet pipes and return lines at the bottom of tanks to prevent foaming.

*DO* pump from the bottom of the tank to minimize contamination from skinning that may have formed.

*DO* remember that emulsions with the same grade designation can be very different chemically and in performance.

*DO* haul emulsion in truck transports with baffle plates to prevent sloshing.

*DO* mix by circulation, or otherwise, emulsions that have been in prolonged storage.

*DO NOT* use tight-fitting pumps for pumping emulsified asphalt; they may "freeze."

*DO NOT* apply severe heat to pump packing glands or pump casings. The pump may be damaged and the asphalt may become even harder.

*DO NOT* dilute rapid-setting grades of emulsified asphalt with water. Medium and slow setting grades may be diluted, but always add water slowly to the asphalt emulsion. Never add the asphalt emulsion to a tank of water when diluting.

*DO NOT* recirculate emulsified asphalts for too many cycles. They tend to lose viscosity when subjected to pumping. Also, air bubbles may become entrained which would render the emulsion unstable.

*DO NOT* load emulsified asphalt into storage tanks, tank cars, tank transports, or distributors containing remains of incompatible materials. See Tables III-2 and III-3.

## TABLE III-2 GUIDE FOR CONDITION OF EMPTIED TANKS BEFORE LOADING EMULSIFIED ASPHALTS

| | *LAST PRODUCT IN TANK* | | | | | |
|---|---|---|---|---|---|---|
| PRODUCT TO BE LOADED | Asphalt Cement (includes Industrial Asphalt) | Cutback Asphalt | Cationic Emulsion | Anionic Emulsion | Crude petroleum and residual fuel oils | Any product not listed above |
| Cationic Emulsion | Empty to no Measurable Quantity | Empty to no Measurable Quantity | OK to load | Empty to no Measurable Quantity | Empty to no Measurable Quantity | Tank must be cleaned |
| Anionic Emulsion | Empty to no Measurable Quantity | Empty to no Measurable Quantity | Empty to no Measurable Quantity | OK to load | Empty to no Measurable Quantity | Tank must be cleaned |

*NOTE: All tanks to be emptied to 0.5 percent or less of capacity. Pump section, unloading line, and all piping must be drained.*

## TABLE III-3 POSSIBLE CAUSES OF CONTAMINATION OF ASPHALT MATERIAL OR SAMPLES AND SUGGESTED PRECAUTIONS

HAULERS AND HAULING VEHICLES

Field observations and studies of test results have indicated that contamination of materials during transportation often occurs.

| *Possible Causes* | *Precautions* |
|---|---|
| (a) Previous load not compatible with material being loaded. | Examine the log of loads hauled or check with the supplier to determine if previous material hauled is detrimental.<br>If it is, make sure vehicle tanks, unloading lines, and pump are properly cleaned and drained before being presented for loading. Provide a ramp at the unloading point at the plant that will ensure complete drainage of vehicle tank while material is still fluid. |
| (b) Remains of diesel oil or solvents used for cleaning and flushing of tanks, lines, and pump. | When this is necessary, make sure all solvents are completely drained. |
| (c) Flushing of solvents into receiving storage tank or equipment tanks. | Do not allow even small amounts to flush into storage tank as entire contents may be contaminated |

(Continued on next page)

## TABLE III-3 (con't.)

MIX PLANT STORAGE TANK AND EQUIPMENT

Many investigations and test results point to mix plant storage tanks and associated equipment as the source of contamination.

| Possible Causes | Precautions |
|---|---|
| (a) Previous material left over in tank when changing to another material | Any material allowed to remain must be compatible with new material; and the amount remaining in the tank must be insufficient to cause new material to become out-of-specification.<br>If in doubt, check with your supplier.<br>To be on the safe side, tank should be drained or cleaned prior to using tank for each different type or grade of asphalt.<br>Be sure discharge line connects at low point of storage tank to ensure complete emptying when changing type or grades of asphalt or cleaning tank. |
| (b) Solvents used to flush hauling vehicle tank discharged into storage tank. | Observe unloading operations, caution driver about flushing cleaning materials into storage tank.<br>If possible, provide place for hauler to discharge cleaning materials. |
| (c) Flushing of lines and pump between storage tank and hot-plant with solvents and then allowing this material to return to tank. | If necessary to flush lines and pump, suggest providing bypass valves and lines to prevent solvents from returning to tank. A better solution is to provide insulated, heated lines and pump, thereby eliminating the necessity of flushing. |
| (d) Cleaning of distributor tank, pump, spray bar, and nozzles with solvents. | Be sure all possible cleaning material is drained off or removed prior to loading.<br>Do not take sample from nozzle until sufficient material has been discharged to guard against taking a contaminated sample. |
| (e) Dilutions from hot oil heating systems. | Check reservoir on hot oil heating system. If oil level is low, or oil has been added, check system for leakage into the asphalt supply. |

NON-REPRESENTATIVE OR CONTAMINATED SAMPLE

Test results are greatly dependent upon proper sampling techniques. Extra care, on the part of the sampler, to obtain samples that are truly representative of the material being sampled will do much to eliminate the possibility of erroneous test results by reason of improper sampling. Make sure samples are taken only by those authorized persons who are trained in sampling procedures.

| Possible Causes | Precautions |
|---|---|
| (a) Contaminated sampling device (commonly called a "sample thief"). | If sampling device (of type described in AASHTO T 40 or ASTM D 140) is cleaned with diesel oil or solvent, make sure that it is thoroughly drained and then rinsed out several times with material being sampled prior to taking sample. |
| (b) Samples taken with sampling device from top of tank where, under certain conditions, contaminants can collect on the surface. | In taking a sample from the top of a tank lower sampling device below the extreme top before opening. Note: This sample may come from the top one-third of the tank. |

*(Continued on next page)*

TABLE III-3 (Con't.)

| *Possible Causes* | *Precautions* |
|---|---|
| (c) Contaminated sample container. | Use only new clean containers. Never wash or rinse a sample container with solvent. Glass or polyethylene containers should be used. |
| (d) Sample contaminated after taking. | **DO NOT** submerge container in solvent or even wipe outside of container with solvent-saturated rag.<br>If necessary to clean spilled material from outside of container, use a clean dry rag.<br>Make sure container lid is tightly sealed prior to storage or shipment. Ship to testing laboratory promptly. |
| (e) Samples taken from spigot in lines between storage tank and hot-plant. | If sampling spigot is in suction line between tank and pump, this necessitates stopping pump prior to taking sample. Samples thus taken are by gravity and only representative of material localized in the pipe area of the spigot.<br>Rather, the spigot should be in lines between pump and return line discharge, thereby allowing slow withdrawal of material during circulation.<br>**DO NOT** take sample while hauling vehicle is pumping into storage tank.<br>**DO NOT** take sample without allowing sufficient time for circulation and thorough mixing of material.<br>**DO** drain off sufficient material through spigot prior to taking sample to ensure removal of any contaminant lodged in spigot.<br>**DO** take sample slowly during circulation to be more representative of material being used. |
| (f) Samples taken from unloading line of hauling vehicle. | Drain off sufficient material through spigot prior to taking sample to ensure removal of any contaminant lodged there. Sample should be taken after one-third and not more than two-thirds of the load has been removed. Take sample slowly to be sure it is representative of the material being used. |

## 3.05 SAMPLING ASPHALT EMULSIONS

The purpose of any sampling method is to obtain samples that will show the true nature and condition of the material. The general procedure is described in the following articles. The standard procedure is detailed in "Standard Methods of Sampling Bituminous Materials," AASHTO T 40 or ASTM D 140.

## 3.06 SAMPLE CONTAINERS

(1) Containers for anionic emulsified asphalt samples shall be one-gallon wide-mouth jars or bottles made of glass or plastic.

(2) Containers for cationic emulsified asphalt samples shall be one-gallon wide-mouth jars or bottles made of plastic or wide-mouth plastic-lined cans with lined screw caps, or plastic-lined triple-seal friction-top cans.

(Bare metal cans are corroded by emulsified asphalts, particularly the cationic type. They also may cause the emulsion to break.)

### 3.07 SIZE OF SAMPLES

The size of samples shall correspond to the required sample containers.

### 3.08 SAMPLES

Whenever practicable, the emulsified asphalt shall be sampled at the point of manufacture or storage. If that is not practicable, samples shall be taken from the shipment immediately upon delivery. Three samples of the emulsified asphalt shall be taken. The samples shall be sent to the laboratory for testing as soon as possible.

### 3.09 SAMPLING PRECAUTIONS

(1) Sample containers shall be new. They shall not be washed or rinsed. If they contain evidence of solder flux or if they are not clean and dry they shall be discarded. Top and container shall fit together tightly.

(2) Care shall be taken to prevent the samples from becoming contaminated. The sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. Any residual material on the outside of the container shall be wiped with a clean, dry cloth immediately after the container is sealed and removed from the sampling device.

(3) The sample shall not be transferred into another container.

(4) The filled sample container shall be tightly and positively sealed immediately after the sample is taken.

### 3.10 SAFETY PRECAUTIONS

(1) Safety precautions are mandatory at all times when handling asphalt materials. These safety precautions include, but are not limited to, the ones that follow.

(2) Gloves shall be worn and sleeves shall be rolled down and fastened over the gloves at the wrist while sampling and while sealing containers.

(3) Face shields should be worn while sampling.

(4) There shall be no smoking while sampling asphalts.

(5) The sampler shall stand on the windward side when taking the sample.

(6) During sealing and wiping the container shall be placed on a firm level surface to prevent splashing, dropping or spilling the material.

### 3.11 PROTECTION AND PRESERVATION OF SAMPLES

(1) Immediately after filling, sealing, and cleaning the sample containers shall be properly marked for identification with a wick marking pencil on the container itself, not on the lid. Linen tags also may be used for identification if they can be securely fastened to the container in such a manner as to ensure that they will not be lost in transit.

Linen tags shall not be attached to containers by using the lids to secure them.

(2) Samples of emulsions shall be packaged, labeled, and shipped in such a manner as to protect them from freezing.

(3) All samples should be packaged and shipped to the laboratory the same day they are taken. The containers, tightly sealed, should be packed in absorbent material, such as sawdust, excelsior, or vermiculite, to reduce the probability of damage during shipment.

(4) Each sample shall be identified with at least the following information:

(a) Shipper's name and bill of lading or loading slip number

(b) Date sampled.

(c) Sampler's name.

(d) Product grade.

## CHAPTER IV

# EMULSIFIED ASPHALT TESTS

### 4.01 REASONS FOR TESTING ASPHALT EMULSIONS

Proper interpretation of laboratory test results can greatly aid in determining the traits of an asphalt emulsion. As advances in asphalt emulsion technology have been made through the years, corresponding advances in emulsion testing have evolved. Some of these tests are designed to measure performance qualities. Others deal mainly with the manufacturing process.

Laboratory tests are normally performed for one of four purposes:

1. To measure properties related to handling, storage, and field use.
2. To control the quality and uniformity of the product during manufacturing and use.
3. To provide reference procedures for specifications.
4. To predict or control field performance.

Table IV-1 is a useful summary of most of the tests.

A review of emulsion specifications used across the United States reveals a wide variety of requirements. Many are directly related to the emulsions produced by specific manufacturers. Because it is impracticable to discuss the multitude of requirements and test methods, this chapter is confined to the methods in AASHTO Test Method T 59 and ASTM Method D 244.

### 4.02 ASPHALT EMULSION TESTS

Asphalt emulsions are made by taking asphalt cement, and by special formulation, converting it to a liquid form. That makes the asphalt easy to apply, mix, or handle before it reverts to its original state. Test methods for evaluating properties of asphalt cement are well known. Among them are penetration, ductility, and solubility in trichloroethylene, tests that apply also to the residual asphalt in the emulsion after the water has evaporated. The primary purpose of this chapter is to consider the tests that apply to asphalt emulsion, rather than the base asphalt cement. The major emulsion tests are briefly discussed, with details of each test method presented in Appendix B. Most of the tests are standard procedures and are outlined in "Testing Emulsified Asphalts," AASHTO Method T 59 and ASTM Method of Test D 244.

### 4.03 RESIDUE BY DISTILLATION

The relative proportions of asphalt cement and water in the emulsion can be determined by a distillation test. Additional tests may be made on the asphalt cement residue when the emulsifed asphalt contains an oil distillate. A micro-distillation test or residue-by-evaporation test also can be performed to determine the amount of this material in the emulsion.

The distillation test procedure for asphalt emulsion is closely akin to that for cutback asphalt. The main difference is that an aluminum alloy still and ring burners are used instead of the glass flask and Bunsen Burner (note Figure IV-1). The equipment is designed to prevent trouble from

## TABLE IV-1 SUMMARY OF EMULSION TESTS

| *Property* | *Factor* | *Requirement* | *Test* | |
|---|---|---|---|---|
| CONSTANCY | A) Uniformity | Product must have the same handling, mixing and setting characteristics from shipment to shipment. | *Residue: | Proportions of asphalt & water. (Indication of uniformity of manufacture.) Residue is measured by dehydrating the emulsion by evaporation or distillation. |
| | B) Storage Stability | Product must be capable of storage without excessive damage or change. | *Sieve: | Amount of oversize particles, shot and slugs retained on #20 mesh sieve. |
| | | | *Settlement:<br>*Storage Stability: | Amount of settlement of asphalt particles in 5 days — one day for storage stability test. The difference in residue between top and bottom is measured. |
| | | | Freeze-Thaw: | Most emulsions are damaged by freezing. |
| CLASSIFICATION | A) Differentiate mixing grade product from rapid set types. (Select proper grade) | | *Demulsibility: | Amount of coagulation on addition of a salt-calcium chloride with anionic emulsion; Aerosol OT with cationic emulsion. |
| | B) Differentiate cationic from anionic emulsions. (Prevent mixing of grades which could result in breakdown) | | *Particle Charge Test: | Deposition of asphalt on an electrode. |
| | | | pH: | Cationics are acid with a pH of less than 7. Anionics are alkaline with a pH greater than 7. Water has a pH=7.<br>see page 11 fn. |
| CONSTRUCTION CHARACTERISTICS | A) Handling | Product must be safe to handle and capable of being pumped and sprayed without breakdown or run-off. | *Consistency: | Emulsion viscosity. |
| | | | Pumping Stability: | No test in current specifications. |
| | B) Rate of Set | The product must break rapidly and hold aggregate under the action of traffic. | Dehydration: | Amount of water lost in 96 hours at 100°F.<br>(Note: Improved test method for Rate of Set is needed.) |
| | C) Mixing Stability | The product must mix with water and aggregate without balling or breakdown. Once mixed, the mix must cure rapidly to an asphalt film. | *Cement Mixing: | Emulsion mixed with cement. |
| | | | *Stone Coating-Water Resistance: | Job (or reference) aggregate is mixed with the emulsion to determine coating and early rain resistance. |
| | | | Miscibility With Water: | Ability to mix with water without coagulation. |
| DURABILITY | A) Traffic Densification | Properly designed pavements must not bleed under repeated load application by heavy traffic. | *Penetration:<br>*Float Test:<br>*Residue: | Consistency of base asphalt after laboratory distillation. |
| | B) Resistance to Stripping | Mixes must not strip when in prolonged contact with water. | Adhesion Test: | Made on job aggregate or a reference aggregate. |
| | C) Long-Term Service Life | Asphalt must remain flexible at cold temperatures and not deteriorate on long-term weathering in a pavement. | *Penetration & Ductility After Laboratory Distillation:<br>Specification Tests On Original Asphalt: | |
| ASPHALT PURITY | A) Ensure Presence of Asphalt | Keep to a minimum the additives, emulsifiers and fillers used to emulsify the asphalt. | *Solubility Of The Asphalt After Laboratory Distillation: | |

*Included in AASHTO T 59 and ASTM D 244

Courtesy Chevron U.S.A., Inc.

foaming of the emulsified asphalt as it is being heated to a maximum of 500°F (260°C).

The usual test method, however, is not necessarily preferred for recovery of the asphaltic residue and for defining the properties of the asphalt base stock used in the emulsion. Properties of the asphalt base can be altered substantially by:

— Concentration of inorganic salts from the aqueous phase in the asphaltic residue.

— Concentration of emulsifying agents and stabilizers (if present) in the asphaltic residue. These materials frequently undergo thermal decomposition during the distillation test and the resulting degradation products may or may not be soluble in the asphalt. This alters the asphalt properties by increasing the percentage of insoluble matter, thus lowering ductility and increasing or decreasing the penetration and viscosity of the asphalt base.

Thermally-induced changes do not occur in actual usage because the applied emulsion is allowed to break either electrochemically or by evaporation of the water. In field use, the temperature of the system never approaches that observed in the distillation test. Therefore, the real purpose of the test—to determine accurately the amount of asphalt cement in the emulsion—is not always realized. Evaporation of the water at subatmospheric pressure and at lower temperatures (AASHTO T 59 or ASTM D 244) provides a more realistic means for defining the properties of the asphalt after it is cured on the pavement surface. Similar procedures are now recognized and used by many agencies and emulsified asphalt producers.

### 4.04 OIL DISTILLATE

The oil distillate, percent by volume of the original emulsion sample, is obtained from the amount of oil in the cylinder at the end of the test for residue by distillation.

### 4.05 RESIDUE BY EVAPORATION

This test is designed to measure the percentage of asphalt cement in the emulsion by evaporating the water. The residue derived from this procedure can be used for other tests but lower penetration and ductility than in the residue from distillation usually results.

### 4.06 PARTICLE CHARGE TEST

The particle charge test is made to identify cationic emulsions. It is performed by immersing a positive electrode (anode) and a negative electrode (cathode) into a sample emulsion and connecting them to a controlled direct-current electrical source, Figure IV-2. At the end of a specified period, the electrodes are observed to determine if the cathode has an appreciable layer of asphalt deposited on it. Most cationic asphalt emulsion particles will be attracted by the cathode.

### 4.07 VISCOSITY

Viscosity is defined as a fluid's resistance to flow. In the case of emulsified asphalts the Saybolt Furol viscosity test (Figure IV-3) is used as a measure of consistency. Results are reported in Saybolt Furol seconds. For convenience and for testing accuracy, two testing temperatures, which cover the normal working range, are used. These temperatures are 77°F (25°C) and 122°F (50°C).

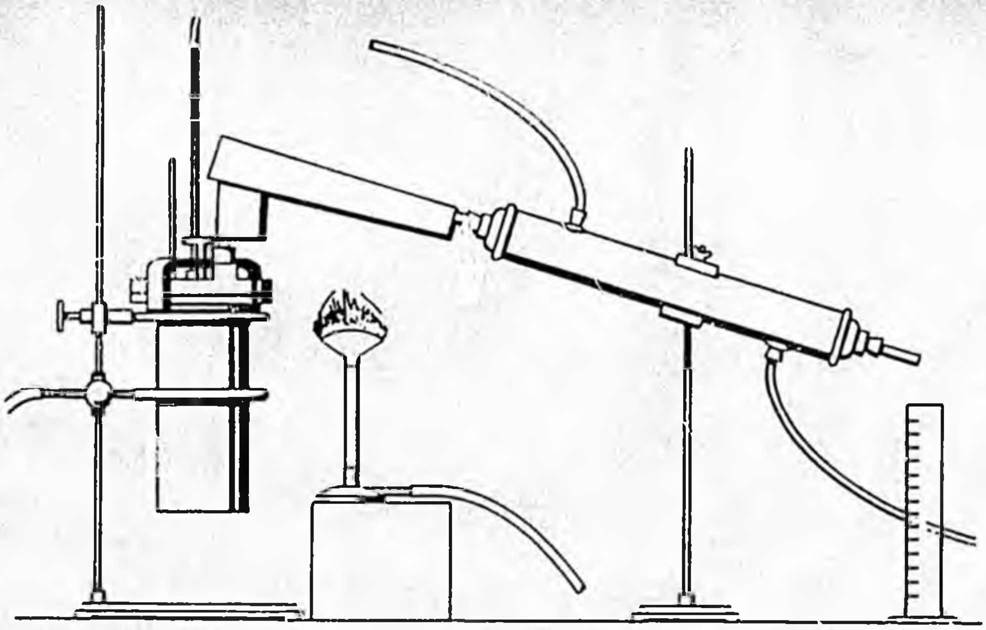


Figure IV-1. Distillation test for emulsified asphalts.

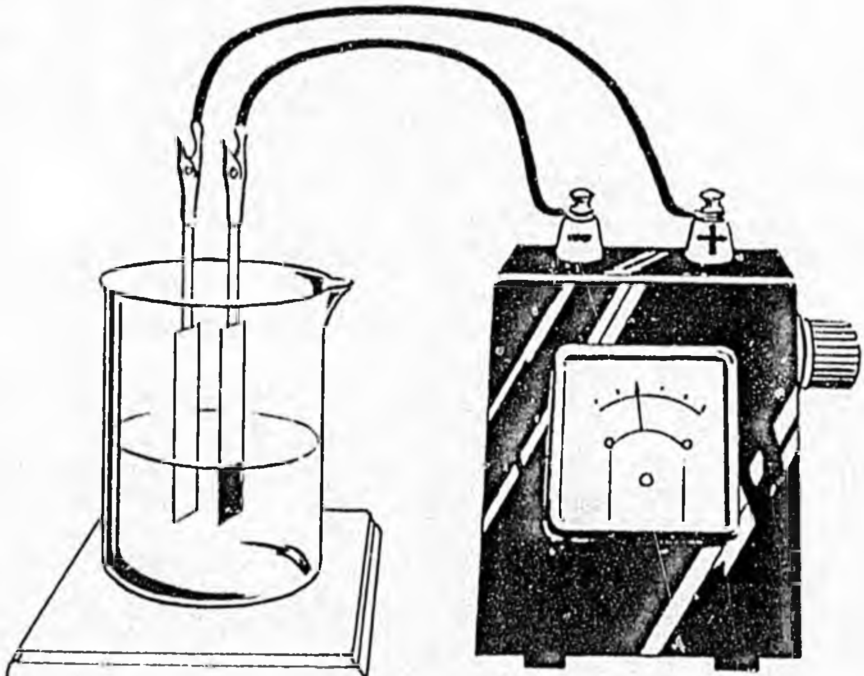
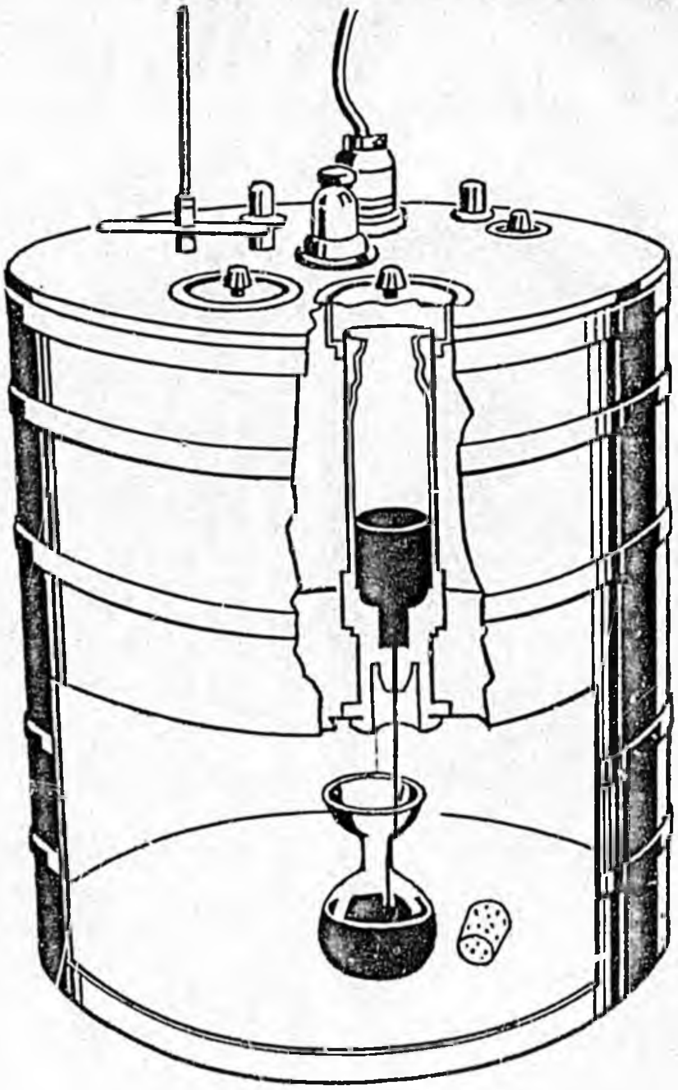


Figure IV-2. Particle charge test.

Figure IV-3.
Saybolt Furol viscosity test.



### 4.08 DEMULSIBILITY

The demulsibility test indicates the relative rate at which the colloidal asphalt globules in the rapid-setting type of emulsified asphalts will break when spread in thin films on soil or aggregate. Calcium chloride causes the minute asphalt globules present in these emulsified asphalts to coalesce. In the test, a solution of calcium chloride and water is thoroughly mixed with emulsified asphalt; then it is poured over a sieve to determine how much the asphalt globules coalesce.

In testing rapid-setting (RS) emulsions, a very weak solution of calcium chloride and water is employed. But, in testing cationic rapid-setting (CRS) emulsions, dioctyl sodium sulfosuccinate solution is used instead of calcium chloride. Specifications prescribe the concentration of the solution and the minimum amount of asphalt to be retained on the sieve. A high degree of "demulsibility" is required of this type of emulsified asphalt. It is expected to break almost immediately upon contact with the aggregate on which it is applied.

## 4.09 SETTLEMENT

The settlement test indicates the emulsion's stability in storage. It detects the tendency of asphalt globules to settle during storage. This test also serves as an indicator of quality even if the emulsion is not to be stored for a period of time. Failure of the settlement test indicates that something is wrong or out of balance in the emulsification process.

A prescribed volume of emulsion is allowed to stand in a graduated cylinder for a specified number of days (usually five). Small samples are then taken from the top and bottom parts. Each sample is placed in a beaker and weighed. The sample is then heated until all water evaporates; then the residue is weighed. The weights obtained are used to find the difference, if any, between the asphalt cement content in the upper and lower portions of the cylinder. This provides a measure of settlement.

When the asphalt emulsion is to be used promptly, most agencies will accept the storage stability test (one-day settlement), Article 4.14, in lieu of the settlement test.

## 4.10 CEMENT MIXING

The cement mixing test does the same for slow-setting (SS) emulsified asphalts as the demulsibility test for rapid-setting grades. The SS grades are used with fine materials and dusty aggregates. They are normally unaffected by calcium chloride solution as used in the demulsibility test.

In the cement mixing test, a sample of emulsified asphalt is mixed with finely-ground portland cement and the mixture washed over a 1.40 mm (No. 14) sieve. Specifications usually limit the amount of material that may be retained on the sieve.

The cement mixing reaction for cationic and noncationic emulsions is quite different. The cationic emulsion reacts to portland cement because of surface area; the noncationic, particularly the anionic type, reacts chemically with portland cement constituents, forming a water-insoluble salt.

## 4.11 SIEVE TEST

The sieve test complements the settlement test and has a somewhat similar purpose. It is used to find the amount of asphalt in the form of rather large globules that may not have been detected in the settlement test and could clog the spraying equipment. Such globules will not provide thin and uniform coatings of asphalt on the aggregate particles.

In the sieve test, a representative sample of emulsified asphalt is poured through a 850 $\mu$m (No. 20) sieve. For anionic emulsions, the sieve and retained asphalt are then rinsed with a mild sodium oleate solution and finally with distilled water. For cationic emulsions, distilled water only is used for rinsing. After rinsing, the sieve and asphalt are dried in an oven and the amount of retained asphalt determined by weighing.

## 4.12 MISCIBILITY WITH WATER

This test finds if medium-setting or slow-setting emulsions can be mixed with water. It is *not* applicable to rapid-setting asphalt emulsions. After adding and stirring distilled water, the emulsion sample is allowed to stand for two hours. It is then examined for any appreciable coagulation of the asphalt droplets in the emulsion.

The test is a quality measure in addition to indicating whether the emulsion is capable of mixing with, or being diluted with, water. Quite often there will be a deposit of heavy emulsion in the bottom of the beaker. If the deposit in the beaker is minimal, it signifies that the emulsion is properly formulated and that the dispersed particles are in the desired size range.

### 4.13 COATING ABILITY AND WATER RESISTANCE

This test has a threefold purpose. It determines the ability of an asphalt emulsion to: (1) coat the aggregate thoroughly, (2) withstand mixing action while remaining as a film on the aggregates and (3) resist the washing action of water after completion of mixing. The test is primarily intended to identify medium-setting asphalt emulsions suitable for mixing with coarse-graded calcareous aggregates. Other aggregates may be used in the test if calcium carbonate is omitted throughout the method. This test is *not* adaptable to rapid-setting or slow-setting asphalt emulsions.

The job aggregate is coated with calcium carbonate dust and then mixed with the emulsified asphalt. About one-half of the mixture is then placed on absorbent paper for a visual inspection of the surface area of aggregate coated by the emulsified asphalt. The remainder of the mixture is sprayed with water and rinsed until the rinse water runs clear. This material is then placed on absorbent paper and inspected for coating.

Another sample of job aggregate is similarly coated with calcium carbonate dust. A given quantity of water is then mixed with the dust-coated aggregate. Emulsified asphalt is added and thoroughly mixed. Inspections are made as described above for the dry-coated aggregates.

### 4.14 STORAGE STABILITY

The storage stability test is used to determine the ability of an emulsified asphalt to remain as a uniform dispersion during storage. It is a measure of the permanence of the dispersion as related to time.

A measured representative sample is placed in each of two glass cylinders. They are stoppered and allowed to stand at laboratory temperature for 24 hours. A 50g sample from each cylinder is siphoned from the top. The samples are placed for a set time in an oven heated to a prescribed temperature. Then they are removed, allowed to cool, and weighed. After the top sample is removed, all but a small portion of the asphalt emulsion remaining in each cylinder is siphoned off. A 50g sample of the portion that is left is put through the same procedure as for the top samples.

The storage stability is expressed as the numerical difference between the average percentage of residue in the top samples and the bottom samples.

### 4.15 EXAMINATION OF RESIDUE

The same desirable characteristics in the base asphalt cement should show up in the residual asphalt after emulsification and coalescence. The most common tests run on the residue include penetration, solubility, ductility, float test, and specific gravity. These tests are described in detail in AASHTO Methods T 49, T 44, T 51, T 50, and T 228 (ASTM Methods D 5, D 2042, D 113, D 139 and D 70) respectively.

The penetration test is an empirical test of consistency. It has been carried over in some viscosity-based asphalt specifications to ensure that materials of an undesirably low penetration are precluded from use. This test measures the depth of penetration in units of 0.1 mm of a standard needle under a load of 100g for exactly five (5) seconds when the asphalt sample is at a temperature of 77°F (25°C). Lower test temperatures are sometimes checked when the asphalt is to be used in an area where very low temperatures are prevalent.

The solubility test is a measure of the "purity" of the asphalt cement. The portion of the asphalt cement that is soluble in specified solvents represents the active cementing constituents.

Only such inert matter as salts, free carbon, or nonorganic contaminants, such as clay or finely divided mineral matter, are insoluble. Solubility is determined by dissolving the asphalt cement in the solvent and separating the soluble and insoluble portions by filtering.

The ductility of an asphalt cement is its ability to be extended or pulled into a narrow thread. In many applications, it is an important characteristic of asphalt cements. The presence or absence of ductility, however, is usually of more significance than the actual degree of ductility. This test is made by molding a briquette of asphalt cement under standard conditions and dimensions. The asphalt briquette is then brought to a standard test temperature in a water bath. It is pulled at a specified rate of speed until the thread connecting the two ends breaks. The elongation, in centimeters, at which the thread of material breaks is designated as ductility.

The float test is performed on the residue from distillation of HFMS emulsified asphalts. The test is a measure of consistency of the material being examined.

In the test, illustrated in Figure IV-4, a plug of asphalt residue is solidified in a brass collar by cooling to 41° F (5° C). The collar is then screwed into the bottom of an aluminum float which is placed into a testing bath of water heated to 140° F (60° C). The time required for the water to break through the plug is determined. Values are limited by specifications for the HFMS emulsified asphalts (see Table II-1, Chapter II). The test is prescribed in AASHTO Method of Test T 50 and ASTM Method of Test D 139.

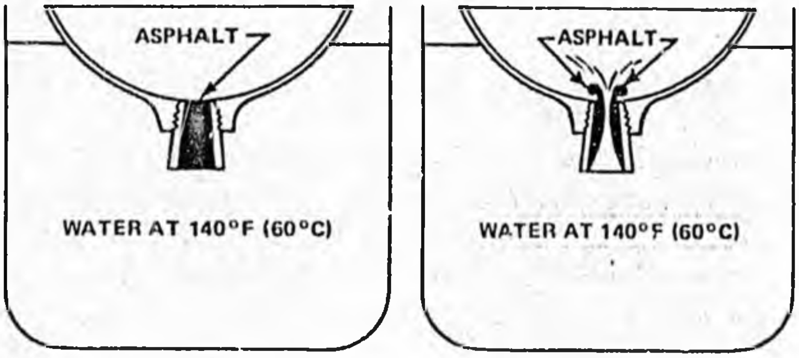


Figure IV-4. Float test.

## 4.16 CLASSIFICATION TEST FOR RAPID-SETTING CATIONIC ASPHALT EMULSIONS

This test identifies rapid-setting cationic asphalt emulsions by their failure to coat a specific Ottawa sand-portland cement (Type III) mixture. Following a 2½ minute mixing period, an estimate is made of the amount of uncoated and coated areas in the mixture. An excess of uncoated area over a coated area is considered as a passing rating for rapid-setting cationic emulsions.

## 4.17 FIELD COATING TEST

This test is used at the project site to determine:

- — The ability of an asphalt emulsion to coat the job aggregate.
- — The ability of the emulsion to withstand mixing.
- — The water resistance of the emulsion-coated aggregate.

Measured amounts of the job aggregate and job emulsion are hand mixed. The ability of the emulsion to remain as a coating during a five-minute cycle is observed. The resistance of the coating to wash-off is determined by repeated filling with water and emptying a container of the coated aggregate five times. The coating of the aggregate is visually rated as good, fair, or poor. A rating of good means that the aggregate is fully coated (except for pinholes and sharp edges). A rating of fair indicates an excess of coated over uncoated aggregate area. A rating of poor indicates an excess of uncoated aggregate over coated area.

## 4.18 WEIGHT PER GALLON

This test is used to determine the weight per gallon (litre) of asphalt emulsion. This unit weight is computed by finding the weight of an asphalt emulsion in a standard measure of known volume. Results are reported in pounds per gallon (kilograms per litre) to the nearest 0.01 lb (0.005 kg) at 77°F (25°C).

## 4.19 SPECIFIC GRAVITY

Finding the specific gravity of asphalt cement is not normally a specification item. It can be helpful, however, in making volume corrections at elevated temperatures and determining necessary quantities. Asphalt cements fall within a specific gravity range of about 1.0 to 1.05. This means that they weigh 1.0 to 1.05 times as much as the same volume of water under the same test conditions. The specific gravity is usually determined with a pycnometer.

## 4.20 SPECIAL TEST — ZETA POTENTIAL

The measurement of zeta potential is a relatively new test for evaluating asphalt emulsions and is not an AASHTO or ASTM test. It measures stability in a colloid system with a laboratory device known as a zeta meter. The zeta meter measures the speed of movement of individual asphalt droplets of an emulsion that is placed in an electrical field. This test has particular value in evaluating cationic emulsions. The level of zeta potential is a general indication of the setting characteristics of the emulsion.

# PART TWO:

# USING ASPHALT EMULSIONS

# CHAPTER V

# SELECTING THE RIGHT TYPE OF ASPHALT EMULSION

## 5.01 GENERAL

Asphalt emulsions can be used for almost any purpose for which cutback asphalts are used. Furthermore, they have a broader range of uses that include many not suited to cutbacks. That does not mean that they can be used indiscriminately. Successful performance of asphalt emulsions requires selecting the proper type for the intended use. Guidelines presented in this chapter should help select the specific grade and type of emulsion to be used.

## 5.02 CONSIDERATIONS FOR SELECTION

The first consideration in picking the right type of emulsion is the type of construction in which it will be used. Is it a seal coat or a plant mix (central or mixed-in-place)? Is it some type of surface application only? Is it for maintenance? Once this decision is made other project variables must then be considered. Some other factors that affect the selection are:

- — Climatic conditions anticipated during construction: The selection of emulsion grade, design of mix or treatment, and construction equipment depend upon this factor.
- — Aggregate type and availability.
- — Construction equipment availability.
- — Geographical location: hauling distance, and in some cases, water availability.
- — Traffic control: can traffic be detoured?
- — Environmental considerations.

While general guidelines can be given for selecting emulsions, laboratory testing is strongly recommended. There is no good substitute for a laboratory evaluation of the emulsion and the aggregate to be used. Different types and quantities of emulsion should be tried with the aggregate to find the best combination for the intended use. An experienced technician can determine the type and amount of emulsion to be used. He can also determine if additional water must be added, and the amount of time for breaking to occur.

## 5.03 GENERAL USES

Each grade of asphalt emulsion is designed for specific uses. They are described in general terms in the following paragraphs.

- — *Rapid-Setting Emulsions:*

  The rapid-setting grades are designed to react quickly with aggregate and revert from the emulsion state to asphalt. The RS grades produce a relatively heavy film. They are used primarily for spray applications, such as aggregate (chip) seals, sand seals, surface treatments, and asphalt penetration macadam. The RS-2 and CRS-2 grades have high viscosities to prevent runoff.

— *Medium-Setting Emulsions:*

The medium-setting grades are designed for mixing with coarse aggregate. Because these grades do not break immediately upon contact with aggregate, mixes using them remain workable for a few minutes. They are used extensively in travel plants. The CMS grades have high viscosities to prevent runoff.

A newly standardized type of medium-setting asphalt emulsion, identified as high float, is anionic in nature. The major difference between this emulsion and the conventional medium-setting type is the high float characteristic, measured on the asphalt residue by the Float Test, AASHTO T 50 or ASTM D 139. It reportedly gives better aggregate coating and asphalt retention under extreme temperature conditions. While regular asphalts have a tendency to flow, or migrate, at about 140°F (60°C), the high float residues are designed to stay in place up to about 160°F (71°C). Therefore, high float residues are less susceptible to changes in temperature. They soften less in summer and do not harden as much in winter.

In 1977, the American Society for Testing and Materials standardized three types of high-float emulsions — HFMS-1, HFMS-2, and HFMS-2h. Their specifications are contained in ASTM D 977 (see Table II-1).

— *Slow-Setting Emulsions:*

The slow-setting grades are designed for maximum mixing stability. They are used with high fines content, dense-graded aggregates. The SS grades have long workability times to ensure good mixing with dense-graded aggregates. All slow-setting grades have low viscosities that can be further reduced by adding water. These grades, when diluted, can also be used for tack coats, fog seals, and dust palliatives. The SS type of emulsion depends entirely upon evaporation of the water for coalescence of the asphalt particles. If a faster setting rate is needed in mixtures, portland cement or hydrated lime can be added. The SS emulsions are generally used for dense-graded aggregate-emulsion bases, soil-asphalt stabilization, asphalt surface mixes, and slurry seals.

Table V-1 shows the general uses of standard emulsion types and grades.

## 5.04 ADHESIVE PROPERTIES

Success with any aggregate-emulsion combination depends greatly on the electrical surface charges of the asphalt droplets and the aggregate. The probability of good adhesion is diminished if the charges are similar. Conversely, the probability of good adhesion is greatly improved if the charges are different. The predominating charge on the aggregate surface determines whether anionic or cationic emulsion will produce the best results. The only way to be sure is to test in the laboratory.

## 5.05 GUIDELINES FOR SELECTION

In summary, success with any type of asphalt emulsion system is best ensured by adherence to each of the following steps:

1. Laboratory testing using the actual aggregate and emulsion that is to be used on the project.
2. Selection of grades in conformance with Table V-1 and Article 5.02. Table V-2 may be helpful also.
3. Strict adherence to the specifications and guides for usage.
4. Careful handling of the emulsion to prevent contamination, settlement of the asphalt droplets, or premature coalescence.
5. Consultation with the emulsion manufacturer's representative when special or unusual problems occur.

Asphalt emulsions as an alternative for use in paving and maintenance operations are now a reality. Following proper procedures will produce a system that should provide a high level of service.

## TABLE V-1 GENERAL USES OF EMULSIFIED ASPHALT

**D 3628**

NOTE—Only those grades of emulsified asphalt in general use have been indicated herein. It is possible that under certain variations of aggregates, or climatic conditions, or both, additional selections might be appropriate. Where the use of emulsified asphalt for applications other than those listed in the table are contemplated, the emulsion supplier should be consulted.

| Type of Construction[A] | Specification D 977 | | | | | | | Specification D 2397 (Cationic) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS-1 | RS-2 | MS-1, HFMS-1 | MS-2, HFMS-2 | MS-2h, HFMS-2h | SS-1 | SS-1h | CRS-1 | CRS-2 | CMS-2 | CMS-2h | CSS-1 | CSS-1h |
| *Bituminous-aggregate mixtures:* | | | | | | | | | | | | | |
| For pavement bases and surfaces: | | | | | | | | | | | | | |
| Plant mix (hot) (D 3515) | ... | ... | ... | ... | X[B] | ... | ... | ... | ... | ... | ... | ... | ... |
| Plant mix (cold) | | | | | | | | | | | | | |
| Open-graded aggregate | ... | ... | ... | X | X | ... | ... | ... | ... | X | X | ... | ... |
| Dense-graded aggregate | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| Sand | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| Mixed-in-place: | | | | | | | | | | | | | |
| Open-graded aggregate | ... | ... | X | X | X | ... | ... | ... | ... | X | X | ... | ... |
| Dense-graded aggregate | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| Sand | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| Sandy soil | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| Slurry seal | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... | X | X |
| *Bituminous-aggregate applications:* | | | | | | | | | | | | | |
| Treatments and seals: | | | | | | | | | | | | | |
| Single surface treatment (Chip Seal) | X | X | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... |
| Multiple surface treatment | X | X | ... | ... | ... | ... | ... | X | X | ... | ... | ... | ... |
| Sand seal | X | X | X | ... | ... | ... | ... | X | X | ... | ... | ... | ... |
| Penetration macadam: | | | | | | | | | | | | | |
| Large voids | ... | X | ... | ... | ... | ... | ... | ... | X | ... | ... | ... | ... |
| Small voids | X | ... | ... | ... | ... | ... | ... | X | ... | ... | ... | ... | ... |
| *Bituminous applications:* | | | | | | | | | | | | | |
| Fog seal | ... | ... | X[C] | ... | | X[D] | X[D] | ... | ... | ... | ... | X[D] | X[D] |
| Prime coat—penetrable surface | ... | ... | ... | ... | ... | X[D] | X[D] | ... | ... | ... | ... | X[D] | X[D] |
| Tack coat | ... | ... | X[C] | ... | ... | X[D] | X[D] | ... | ... | ... | ... | X[D] | X[D] |
| Dust binder | ... | ... | ... | ... | ... | X[D] | X[D] | ... | ... | ... | ... | X[D] | X[D] |
| Mulch treatment | ... | ... | ... | ... | ... | X[D] | X[D] | ... | ... | ... | ... | X[D] | X[D] |
| Crack filler | ... | ... | ... | X | X | X | X | ... | ... | X | X | X | X |
| *Maintenance mix:* | | | | | | | | | | | | | |
| Immediate use | ... | ... | X | X | X | ... | ... | ... | ... | X | X | ... | ... |

[A] For definitions of terms used in this table, refer to Section 2.

[B] Specification D 3515 permits the use of other emulsion grades by note, "Grades of emulsion other than MS-2h may be used where experience has shown that they give satisfactory performance."

[C] Diluted with water by the manufacturer.

[D] Diluted with water.

## TABLE V-2 EMULSIFIED ASPHALT SEAL COATS AND SURFACE TREATMENTS

| *System* | *Description and Uses* | *Emulsified Asphalt* | *Construction Hints* |
|---|---|---|---|
| SAND SEAL | Restores uniform cover. In city street work, improves street sweeping, traffic line visibility. Enriches dry, weathered pavements; reduces raveling. | CRS-1 or RS-1 | Spray-applied with sand cover. Roll with pneumatic roller. Avoid excess binder. |
| CHIP SEAL | Single most important low cost maintenance method. Produces an all-weather surface, renews weathered pavements, improves skid resistance, lane demarcation, seals pavement. | CRS-2 or RS-2 | Spray-applied. Many types of textures available. Key to success: Coordinate construction, use hard, bulky grained, clean aggregate, and have properly calibrated spray equipment. |
| DOUBLE SEAL | Similar to chip seal except the second chip application uses a small sized stone. Durable, provides some leveling, available in a number of textures. | CRS-2 or RS-2 | See Chip Seal. |
| TRIPLE SEAL | Three applications of binder and 3 sizes of chips are applied. Provides up to a 2 cm thick, flexible pavement. Levels as well as providing a seal, tough wearing surface. | CRS-2 or RS-2 | Spray-applied in three lifts. Drag broom between lifts to provide leveling. |
| DRAG SEAL | Low cost method of improving the riding quality of rough pavements. A rain-resistant medium-set emulsified asphalt is applied followed by chips. The pavement is drag-broomed to level spots and depressions. A second application of binder followed by a choke aggregate or sand is applied. | CMS-2 | The CMS-2 tolerates more mixing and drag-brooming than the rapid-set emulsions. Use a wetting agent in the steel wheel roller to reduce pickup. |
| SLURRY SEAL | Used in airport and city street maintenance where loose aggregate cannot be tolerated. Seals, fills minor depressions, provides an easy-to-sweep surface. Made with crushed aggregate mixed with quick-set emulsified asphalt. The liquid slurry is machine-applied with a sled-type box containing a rubber-edged strike-off blade. | QS* grades | Pretest the aggregate and emulsion mix to achieve desired workability, setting rate, and durability. Calibrate equipment prior to starting the project. |
| CAPE SEAL | Combines a single chip seal with a slurry seal. Provides the rough, knobby surface of a chip seal to reduce hydroplaning yet has a tough sand matrix for durability.<br>Test track data indicate better studded tire damage resistance than a chip seal. | CRS-2 and QS* grades, SS-1, SS-1h, CSS-1, or CSS-1h | Apply a large aggregate single chip seal. Broom and apply slurry seal. Have the strike-off ride on the rock surface to form the matrix.<br>Avoid excess slurry as this destroys the knobby stone texture desired. |

*Not Standardized*