

Chapter 2

Materials

From... Maintenance Technical
Advisory Guide (MTAG)

Outline

- Asphalt Binders
- Asphalt Emulsions
- Cutback Asphalts
- Polymer Modified Binders and Performance Based Asphalt
- Asphalt Rubber
- Aggregates
- Storage and Handling
- Sampling Guidelines and Delivery

Asphalt Binders

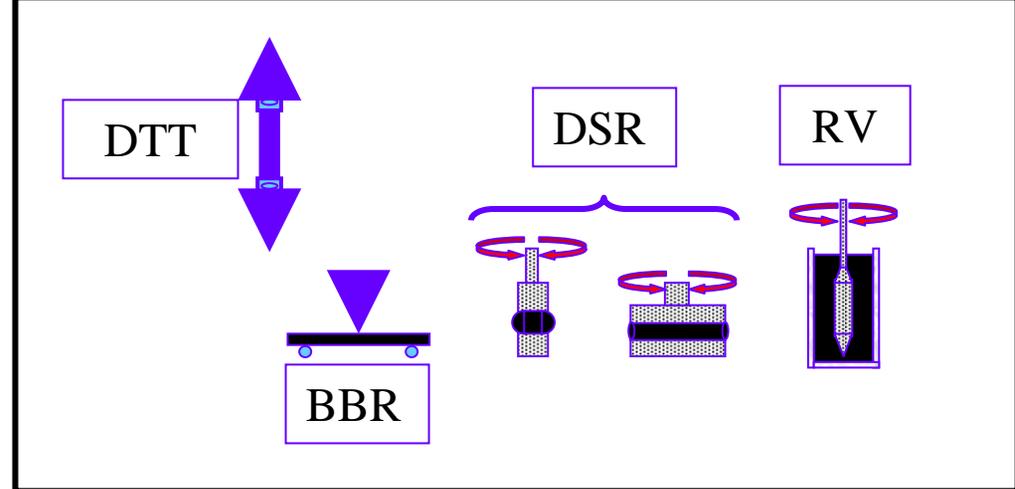
- Paving Asphalt Constituent
 - A refined material from crude oil
 - Asphalt properties depend on its chemical composition, crude source and type
 - Highly temperature dependent
- Caltrans requirements for asphalt binders – Section 92 of the Standard Specifications



Asphalt Binders – Specifications

Caltrans adopted the Performance Graded (PG) system for asphalt binder since 2006 for conventional binders and 2007 for modified binders

Asphalt Binders – Specifications

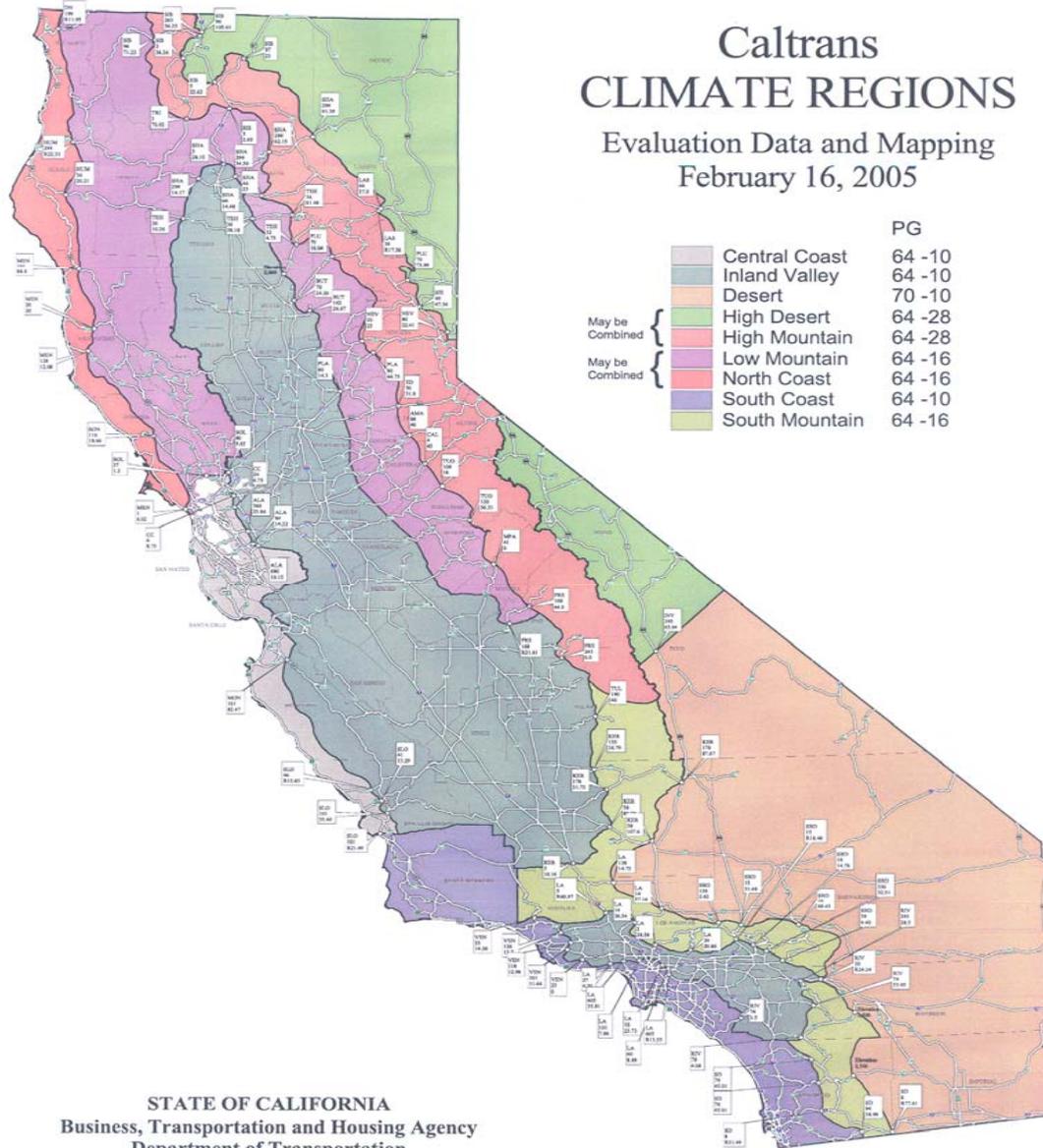


- In the PG system, asphalt is specified by:
 - Dynamic Shear Rheometer (DSR) for performance at high and intermediate temperatures
 - Bending Beam Rheometer (BBR) for performance at cold temperatures
 - Aging Characteristics
 - Purity and Safety

Asphalt Binders – Specifications

Equipment	Purpose	Performance Parameter
Rolling Thin Film Oven, RTFO	Simulate binder aging during HMA production & construction	Resistance to aging during and immediately after construction
Pressure Aging Vessel, PAV	Simulate binder aging during HMA life	Resistance to aging over the length of pavement service life
Rotational Viscometer, RV	Measure binder properties at high construction temperature	Handling & pumping
Dynamic Shear Rheometer, DSR	Measure binder properties (stiffness and elasticity) at high and intermediate service temperatures	Resistance to permanent deformation (rutting) and fatigue cracking
Bending Beam Rheometer, BBR	Measure binder properties at low service temperatures	Resistance to thermal cracking

Asphalt Binders – Where to Use?



STATE OF CALIFORNIA
Business, Transportation and Housing Agency
Department of Transportation

Asphalt Binders – Where to Use?

Binder Climatic Region	Conventional Hot Mixed Asphalt				RAC
	Dense Graded HMA		Open Graded		Base Stock for RAC-O and RAC-G
	Typical	Special ¹	Placement Temperature		
			>70°F	<70°F	
South Coast Central Coast Inland Valleys	PG 64-10	PG 70-10 PG 64-28 PM	PG 64-10	PG 58-34 PM	PG 64-16
North Coast	PG 64-16	PG 64-28 PM	PG 64-16	PG 58-34 PM	PG 64-16
Low Mountain South Mountain	PG 64-16	PG 64-28 PM	PG 64-16	PG 58-34 PM	PG 64-16
High Mountain High Desert	PG 64-28	PG 58-34 PM ²	PG 64-28	PG 58-34 PM	PG 58-22
Desert	PG 70-10	PG 64-28 PM	PG 70-10	See Note 3	PG 64-16

Notes:

1. PG 76-22PM may be specified for conventional dense graded hot mixed asphalt for special conditions in all climatic region when specifically requested by the District Materials Engineer.
2. PG 64-28 PM may be specified when specifically requested by the District Materials Engineer.
3. Consult the District Materials Engineer for appropriate binder grade.

Asphalt Emulsions

- Emulsion Constituent
 - An asphalt dispersed in water
- Breaking
 - The process of separating the asphalt and water
- Curing
 - The process by which the asphalt expels water and dries to a film on the aggregate or surface

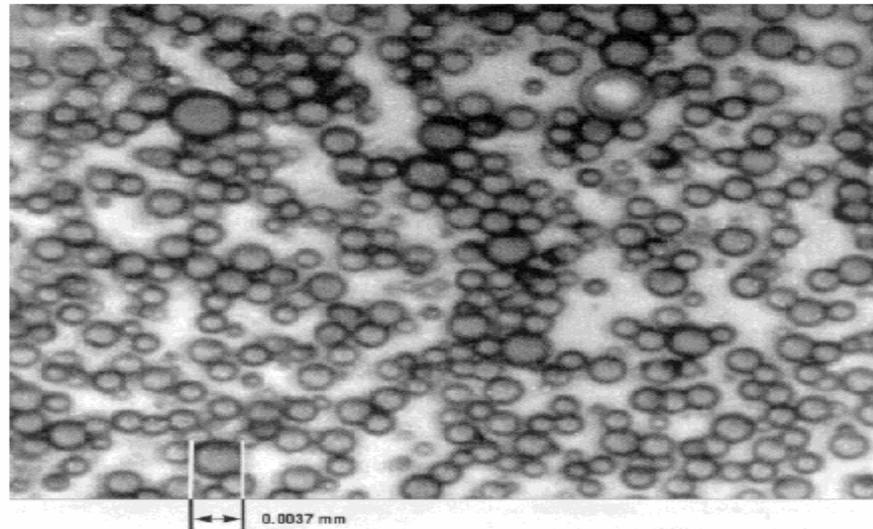


Figure 2.6-1 Relative Sizes and Distribution of Asphalt Particles in an Emulsion

Asphalt Emulsions



Asphalt



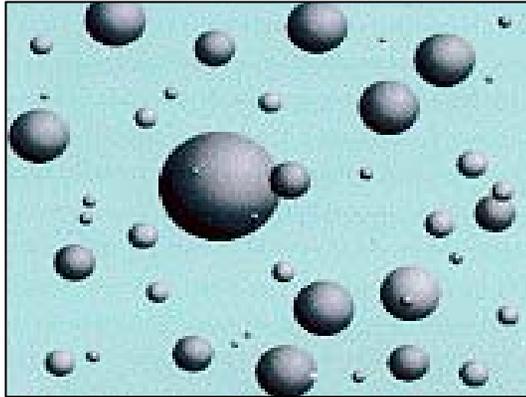
Asphalt and Water



Asphalt Emulsion

Asphalt Emulsions

Asphalt emulsion illustration



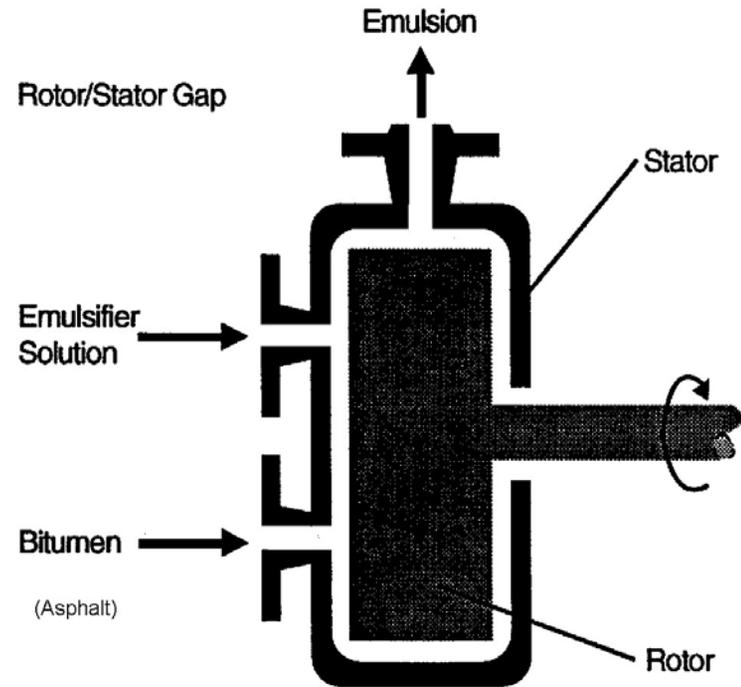
Emulsion schematic



Emulsion micrograph

Asphalt Emulsions

- Emulsion Manufacture
 - Asphalt is sheared into small droplets and coated/ reacted with a chemical stabilizer or emulsifier
- Emulsion must be stored at right pressure and temperature to prevent from damaging



A device used to shear the asphalt – Colloid Mill Cross

Asphalt Emulsions

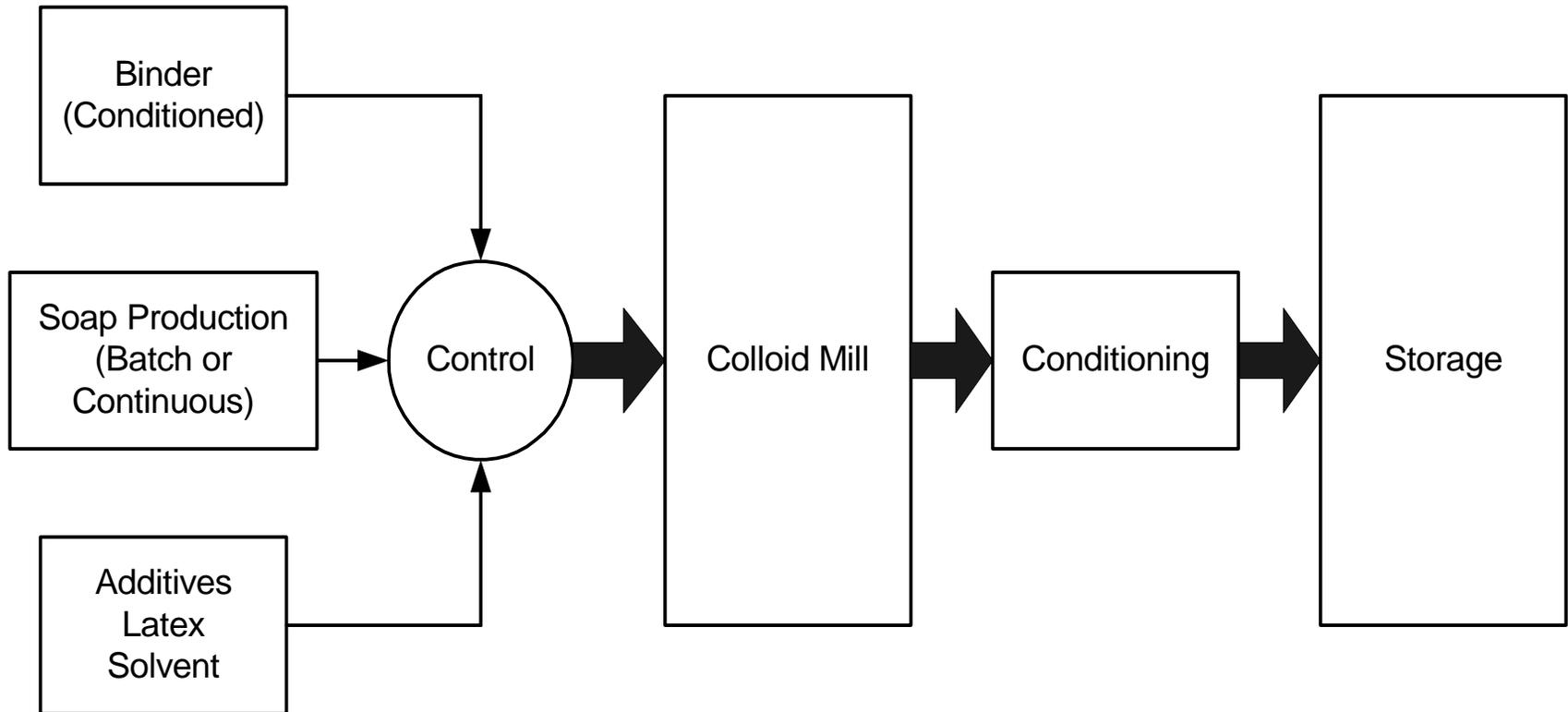


Emulsions Mill



**Emulsions Mill
Control Panel**

Asphalt Emulsions



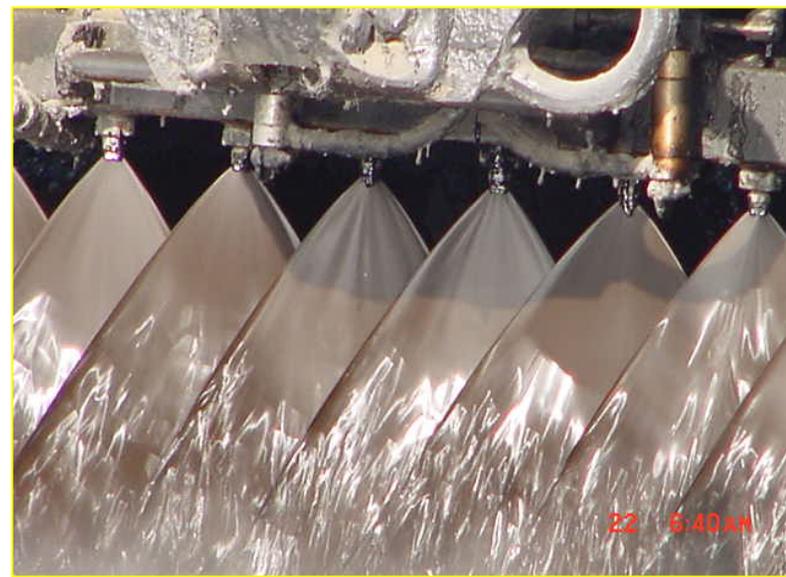
Emulsion plant operations

Chapter 2 - Materials

Asphalt Emulsions

- Emulsifiers
 - Anionic emulsifiers are based on fatty acids
 - Cationic emulsifiers are based on various types of amines. Cationic emulsifiers are used for slow set, rapid, quick sets and micro surfacing of various types of amines depending on the application.
- Caltrans uses both, mostly Cationic. The choice between anionic and cationic is based on the application requirements and the characteristics of the aggregate to be used in the mix

Asphalt Emulsions

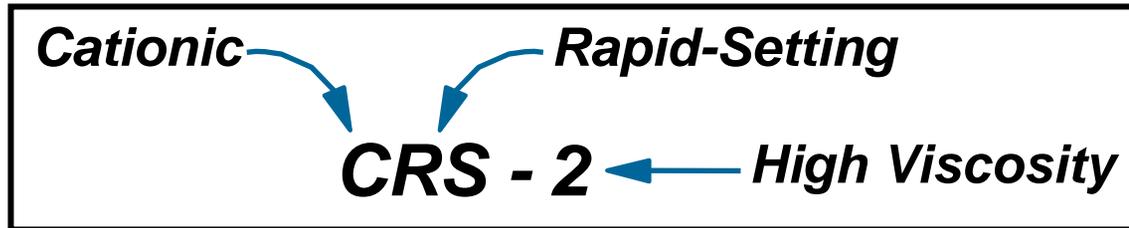


- **Caltrans Specifications**

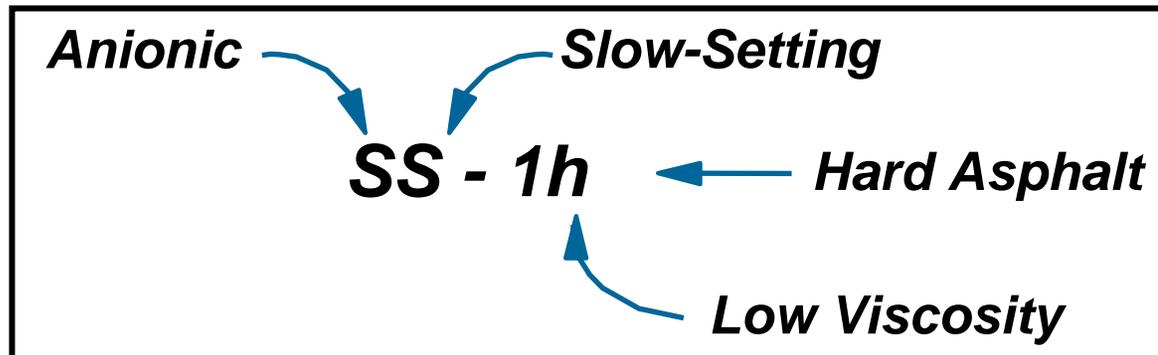
- Anionic emulsions: rapid set (RS), Medium Set (MS), and Slow Set (SS)
- Cationic emulsions: rapid set (CRS), Medium Set (CMS), and Slow Set (CSS)
- Polymer modified emulsions
- Quickset slurry emulsion

Asphalt Emulsions

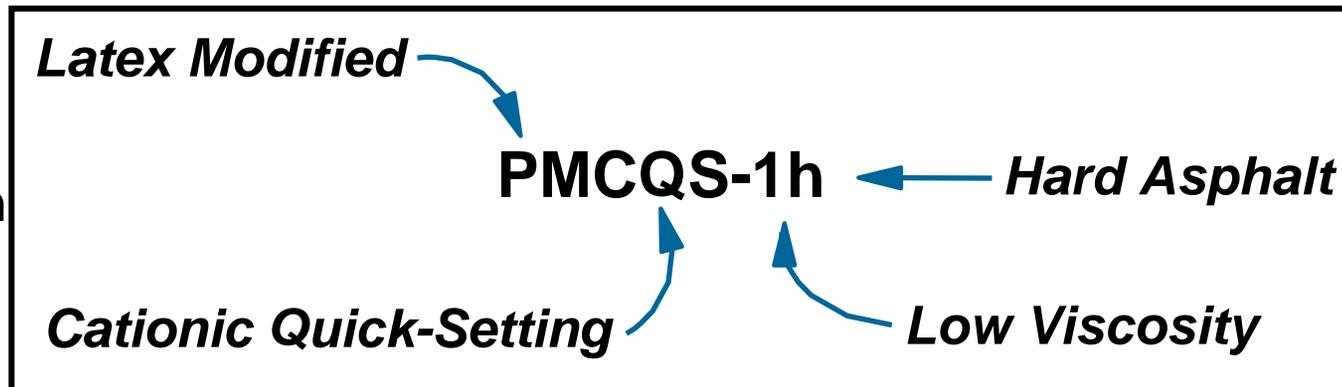
Chip Seal
Emulsion



Tack Coat



Slurry
Emulsion



Cutback Asphalts

- In California, only slow cure cutbacks are still made and used
- The main use for cutbacks is prime coats over aggregate base materials prior to placement of an asphalt-wearing course in new construction

Cutback Asphalts

- Manufacture
 - Easy
 - Manufactured on site by circulation in a tank
 - In refinery
- Specifications and Testing
 - Standard specifications Section 93 “Liquid Asphalts”
 - Flash point and water content, viscosity, and boiling range of the solvent

Polymer Modified Binder

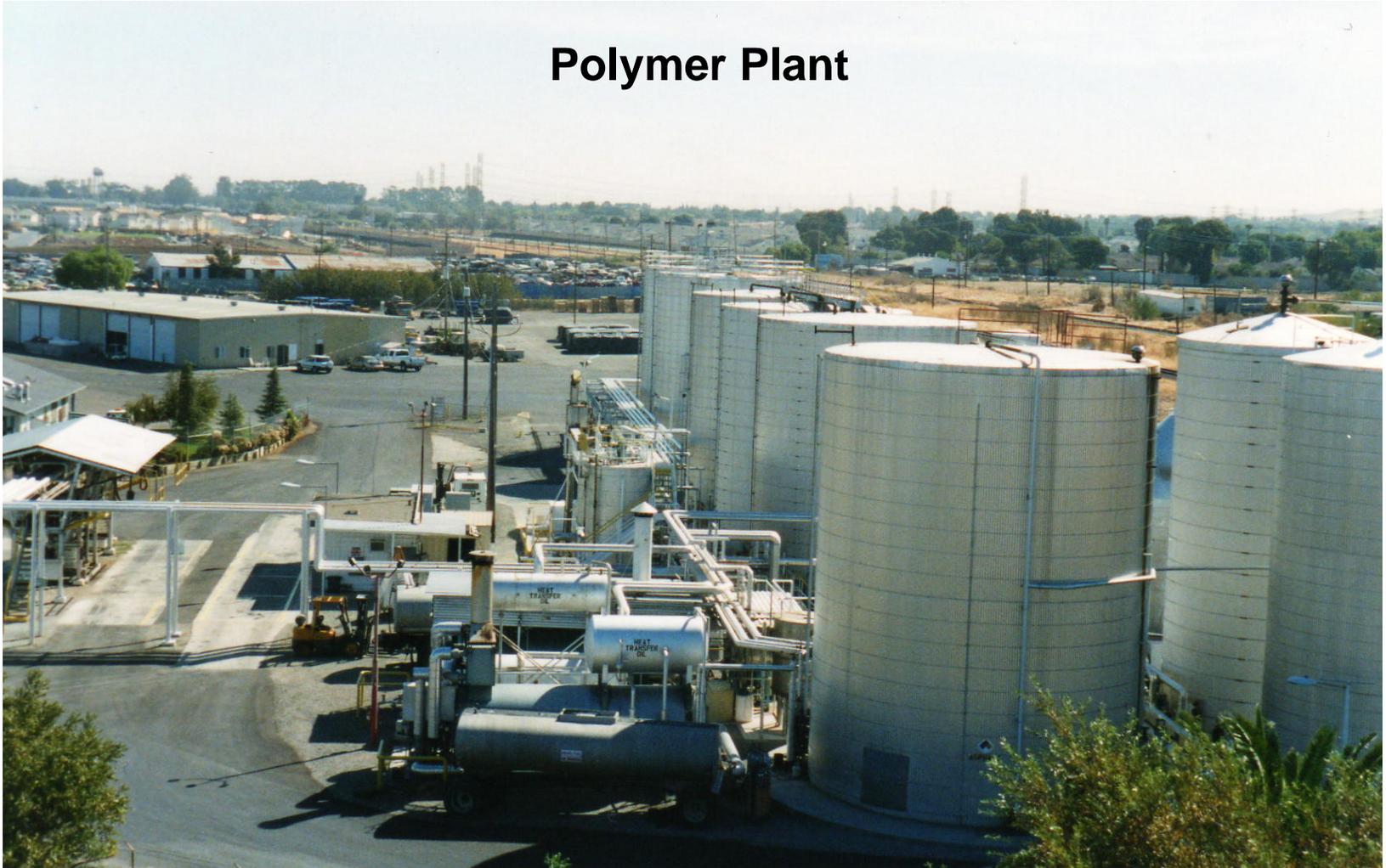
- Polymers are large molecule additives that are used to enhance the performances of asphalt cement and asphalt concrete pavement, particularly at high temperatures
- Some purposes of polymers
 - Increase serviceable temperature range
 - Improve durability at all temperatures
 - Reduce moisture damage
 - More forgiving binder

Polymer Modified Binder

- **Manufacture Procedures**
 - Metering of polymer, asphalt, and additives.
 - Wetting of the polymer by the asphalt/additive blend.
 - Dispersion of the polymer.
 - Allowance for any interaction (reaction) of the polymer with the asphalt.
 - Storage and transportation
- Most important steps are dispersion and reaction

Polymer Modified Binder

Polymer Plant



Polymer Modified Binder

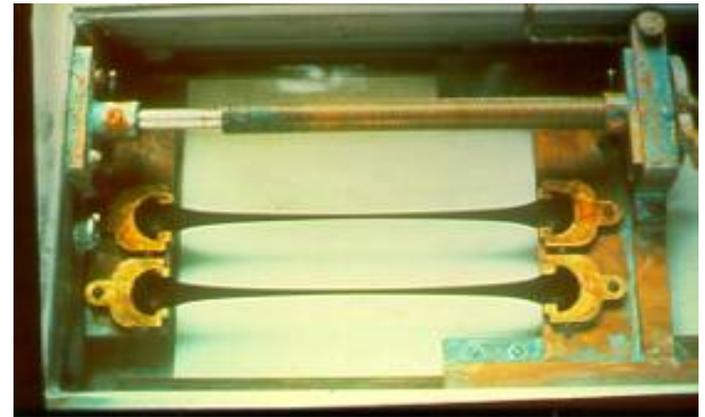
Polymer Mill System



Polymer Modified Binder



SBR Latex



Elastic Recovery

Polymer Modified Binder

PROPERTY	AASHTO TEST METHOD	SPECIFICATION GRADE		
		PG 58-34PM	PG 64-28PM	PG 76-22PM
Original Binder				
Flash Point, Minimum °C	T48	230	230	230
Solubility, Minimum % ^b	T44	99	99	99
Viscosity at 135°C, ^c Maximum, Pa·s	T316	3.0	3.0	3.0
Dynamic Shear, Test Temp. at 10 rad/s, °C Minimum G*/sin(delta), kPa	T315	58 1.00	64 1.00	76 1.00
RTFO Test ^e , Mass Loss, Maximum, %	T240	0.6	0.6	0.6

Complete table available in MTAG Vol. I Chapter 2

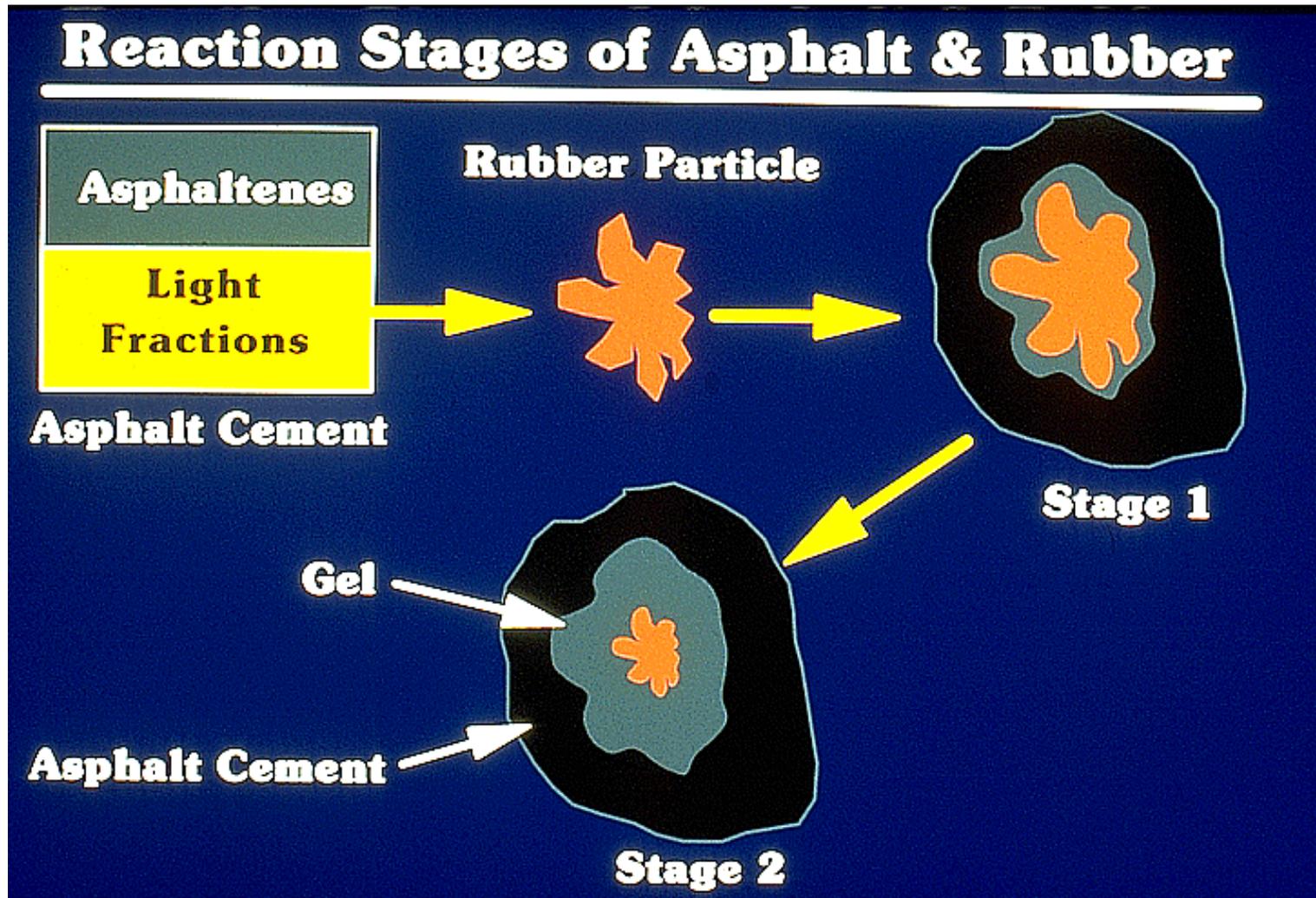
Asphalt Rubber

- Asphalt Rubber Constituent
 - Crumb Rubber Modifier (CRM)
 - Scrap Tire Rubber
 - High Natural Rubber Content Scrap Rubber
 - Asphalt Cement
 - Extender oil - Caltrans
- Asphalt rubber manufacture
 - Heat asphalt cement to ~ 375 to 440°F
 - Add CRM into a pre-wet tank
 - Asphalt contacts and wets CRM particles
 - Asphalt reacts with rubber particles to form a gel coated particle

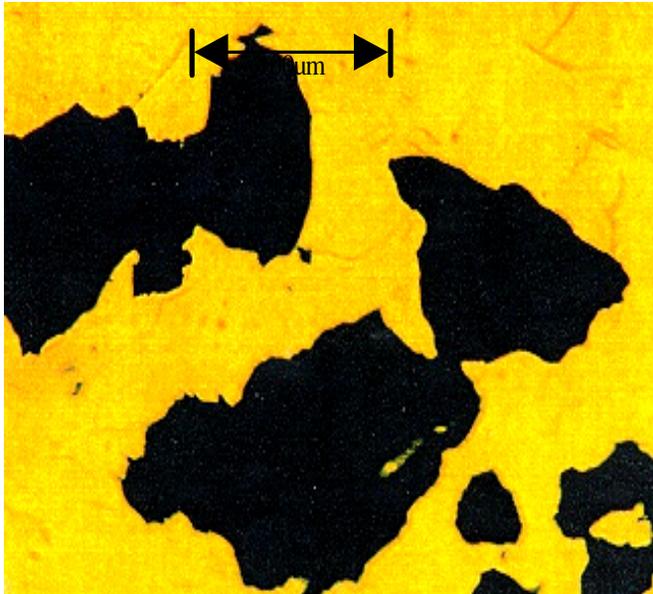
Crumb Rubber Modifier (CRM)



Asphalt Rubber



Asphalt Rubber



Without extender oil



With extender oil

AR PG Asphalt Cements

- For high mountain and high desert areas, use PG 58-22 as the base asphalt.
- For other areas (coastal, inland valleys, low and south mountain, and low desert) use PG 64-16 as base asphalt.

AR Binder Specification

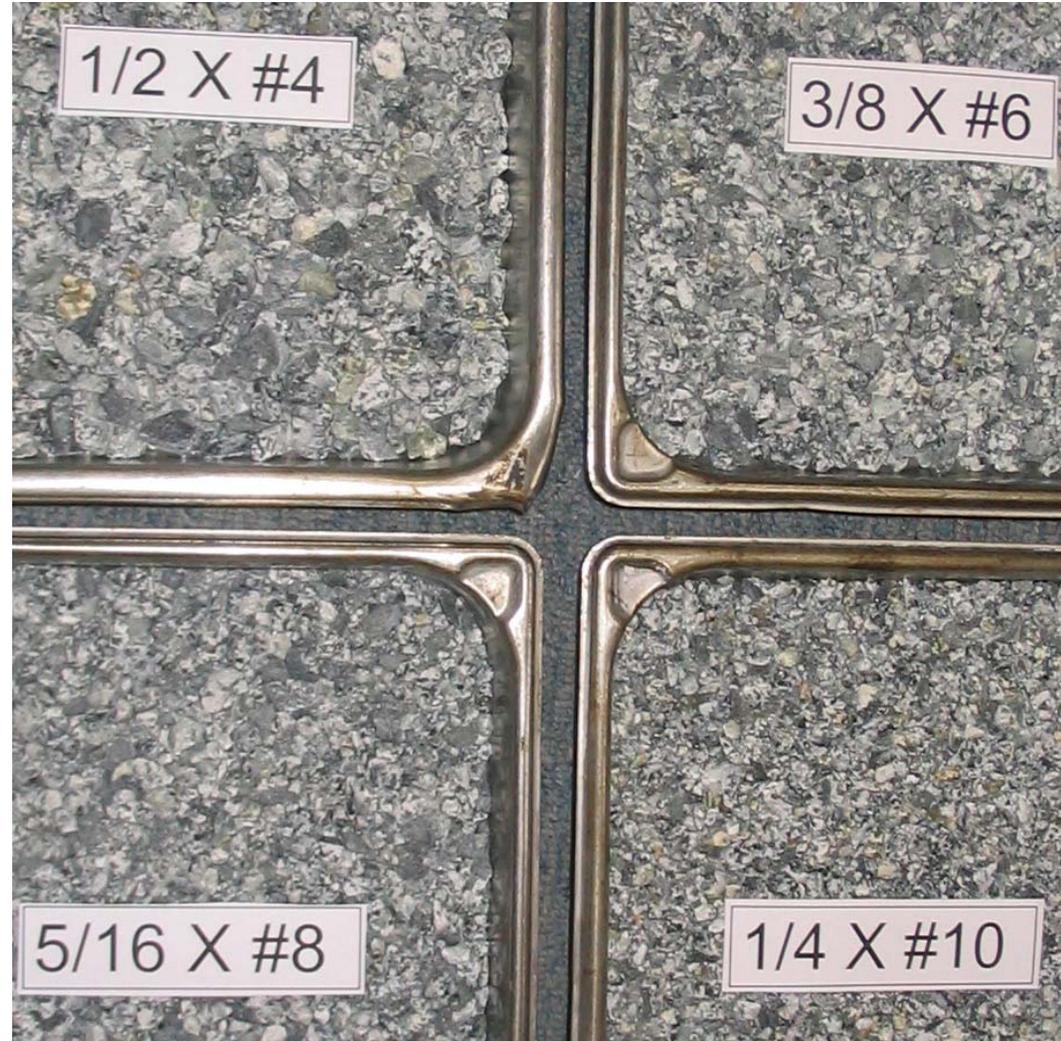
- ARB: $20 \pm 2\%$ CRM content by total binder mass. The CRM must include $25 \pm 2\%$ by mass of high natural rubber CRM and $75 \pm 2\%$ scrap tire CRM.
- The scrap tire CRM consists primarily of No. 10 to No. 30 sized particles (2 mm to 600 μm sieve sizes). The high natural rubber CRM is somewhat finer, mostly No. 16 to No. 50 (1.18 mm to 300 μm sieve sizes).

AR Binder Specification

- The extender oil dosage for chip seals ranges from 2.5 to 6% by mass of the asphalt cement. However, the minimum extender oil content for use in RAC mixes may be reduced to one percent to minimize potential for flushing and bleeding for hot climate, high traffic index (TI) locations.

Aggregates

- The major building material for pavements
- Form the structural matrix in HMA mix
- Types
 - Igneous
 - Sedimentary rocks
 - Gravel
 - Sands
 - Slag



Aggregate Properties

- Chemical
 - Affinity to asphalt
- Physical
 - Grading or particle size distribution
 - Cleanliness or presence of deleterious materials
 - Hardness or abrasion resistance
 - Durability or soundness
 - Particle shape and surface texture
 - Absorption characteristics

Aggregate

- Manufacture
 - Quarry operations
 - Gravel deposits

Storage and Handling

- Conventional asphalt
- Modified asphalts, including asphalt rubber and MB)
- Asphalt emulsions
- Aggregate

Storage and Handling

- Conventional asphalt
- Avoiding Problems during Storage
 - Minimizing the risk of overheating
 - Minimizing oxidation and loss of volatiles
 - Maintaining asphalt homogeneity
 - Minimizing heat loss
- Storage and Handling Temperatures and Times are product specific

Storage and Handling

- Asphalt Emulsion
- Handling
 - Pumping – use of appropriate pump to avoid changing the properties of emulsion
 - Temperature – affects the behavior of asphalt droplets
 - Transport – avoid air enters the emulsion since air can break the emulsion
 - Do not mix cationic and anionic emulsions
- Storage
 - The key is to prevent asphalt particles from settling

Storage

Product	Mixing Temperature °F (°C)	Spraying Temperature °F (°C)	Storage Temperature °F (°C)
RS-1	N/A	68-140 (20-60)	68-140 (20-60)
RS-2	N/A	68-140 (20-60)	122-185 (50-85)
MS-1	50-158 (10-70)	68-158 (20-70)	68-140 (20-60)
MS-2	50-158 (10-70)	N/A	122-185 (50-85)
MS-2h	50-158 (10-70)	N/A	122-185 (50-85)
SS-1	50-158 (10-70)	50-140 (10-60)	50-140 (10-60)
SS-1h	50-158 (10-70)	50-140 (10-60)	50-140 (10-60)

Storage

Product	Mixing Temperature °F (°C)	Spraying Temperature °F (°C)	Storage Temperature °F (°C)
CRS-1	N/A	68-140 (20-60)	50-140 (10-60)
CRS-2	N/A	122-185 (50-85)	122-185 (50-85)
CMS-2s	50-158 (10-70)	N/A	122-185 (50-85)
CMS-2	50-158 (10-70)	N/A	122-185 (50-85)
CMS-2h	50-158 (10-70)	N/A	122-185 (50-85)
CSS-1	50-158 (10-70)	68-140 (20-60)	50-140 (10-60)
CSS-1h	50-158 (10-70)	68-140 (20-60)	50-140 (10-60)

Storage

Product	Mixing Temperature °F (°C)	Spraying Temperature °F (°C)	Storage Temperature °F (°C)
PMRS-2	N/A	122-185 (50-85)	122-185 (50-85)
PMRS-2h	N/A	122-185 (50-85)	122-185 (50-85)
PMCRS-2	N/A	122-185 (50-85)	122-185 (50-85)
PMCRS-2h	N/A	122-185 (50-85)	122-185 (50-85)
QS-1	50-104 (10-40)	N/A	50-140 (10-60)
QS-1h	50-104 (10-40)	N/A	50-140 (10-60)
CQS-1	50-104 (10-40)	N/A	50-140 (10-60)
CQS-1h	50-104 (10-40)	N/A	50-140 (10-60)
LMCQS-1h	50-104 (10-40)	N/A	50-140 (10-60)
MSE	50-104 (10-40)	N/A	50-140 (10-60)

Storage and Handling

- Tankage Guidelines
 - Bulk tanks should be circulated at regular intervals. Circulation should be done slowly.
 - The frequency of circulation will depend on the weather and how long the emulsion has spent in storage.
 - Most emulsions only require circulation once a week in summer and once every five days during the winter.
 - Circulation should be performed in the middle of the day, not first thing in the morning due to the colder temperatures.

Storage and Handling

- Tankage Guidelines
 - The time of circulation is based on the size of the tank; a 1320 gal (5000 L) tank should be circulated for 15 minutes while a 2640 gal (10,000 L) tank requires 20 minutes.
 - Pumps must be flushed after use, but never into the emulsion tank.
 - Lines and pumps should be able to be warmed before use.
 - Lines should not be left part full of emulsion.

Storage and Handling

- Cleaning Procedures
 - Flush equipment including hoses thoroughly with WATER.
 - Flush equipment and hoses with kerosene, NOT diesel, distillate or other solvent. These materials may dissolve asphalt but they are also incompatible with the emulsion and may cause the emulsion to break rather than flush it away. *NEVER FLUSH INTO THE EMULSION TANK.*

Storage and Handling

- Cleaning Procedures (cont.)
 - Finish with a second flush with water.
 - If a pump or line is already clogged with bitumen gentle heat may be applied at the blockage. Do not apply heat to the lines, as this will break the emulsion.
 - Soak pumps with kerosene for an hour or more.
 - Flush again with water after blockage is removed.

Acceptable Switch Load Combination

Last Product in Tank	Product to be Loaded			
	Asphalt Cement	Cutback Asphalt	Cationic Emulsion	Anionic Emulsion
Asphalt Cement	OK to Load	OK to Load	Empty to No Measurable Quantity	Empty to No Measurable Quantity
Cutback Asphalt	Empty to No Measurable Quantity	OK to Load	Empty to No Measurable Quantity	Empty to No Measurable Quantity
Cationic Emulsion	Empty to No Measurable Quantity	Empty to No Measurable Quantity	OK to Load	Empty to No Measurable Quantity
Anionic Emulsion	Empty to No Measurable Quantity	Empty to No Measurable Quantity	Empty to No Measurable Quantity	OK to Load
Crude Petroleum and Residual Fuel Oils	Empty to No Measurable Quantity			
Any Product Not Listed Above	Tank Must be Cleaned			

Aggregate Storage and Handling

- Stockpile areas should be clean and stable to avoid contamination from the surrounding area.
- Stockpiles should be on free draining grades to avoid moisture entrapment.
- Stockpiles should be separated for different aggregate sizes to prevent inter-mingling.

Aggregate Storage and Handling

- Segregation may be avoided by avoiding stockpiling in a cone shape. Acceptable stockpile shapes are either horizontal or radial. Making each end dump load a separate pile, each adjacent to the next, makes horizontal stockpiles. Radial stockpiles are made with a radial stacker.
- Degradation of the aggregate creating fines can be avoided by handling the stockpile as little as possible. In chip seal or slurry surfacing applications, re-screening may be considered.

Sampling Guidelines

- Samples of emulsion and binder shall be taken in conformance with the requirements in AASHTO T 40, “Sampling Bituminous Materials,” and Section 8-01 and 8-02 of the Construction Manual and California Test Method 125
- Observe safety procedures
- Sample binders daily using new, clean, dry 0.26 gal (1 L) cans with screw lids
- Samples are normally taken from the application lance at the rear of the distributor. Drain off sufficient material through the nozzle to ensure removal of any material lodged there

Sampling Guidelines

- Samples should be taken after one-third and not more than two-thirds of the load has been removed
- Do not submerge sample containers in solvent or wipe containers with solvent saturated cloths. Use a clean, dry cloth, only immediately after sampling, to clean containers
- Attach a Sample Identification Form (TL-0101) to each material sample in accordance with Section 8-01 of the Construction Manual and instructions printed on the TL-0101 booklet
- Provide the e-mail address of the Resident Engineer on the TL-0101

Sampling Guidelines

- Emulsions have a shelf life; therefore, it is important that all samples be sent to the Transportation Laboratory daily
- Aggregates should be sampled according to the contractual requirements
- Samples of aggregate shall be taken according to Section 39-3.03 “Proportioning” of the Standard Specifications
- Samples may be taken from a conveyor belt or sampling chute.
- Field samples must be taken from the stockpile. AASHTO T 2 and Section 39 3.03 of the Standard Specifications (9) describe the method

Sample Delivery

- Samples for testing are to be delivered to the Transportation Laboratory:

**Materials Engineering and Testing Services
Flexible Pavement Materials Branch, MS #5
5900 Folsom Boulevard
Sacramento, California 95819-4612**

Summary

- Asphalt Binders
- Asphalt Emulsions
- Cutback Asphalts
- Polymer Modified Binders and Performance Based Asphalt
- Asphalt Rubber
- Aggregates
- Storage and Handling
- Sampling Guidelines and Delivery

Thank You

Questions?