Construction of Quality Hot Mix Asphalt Pavements - 1 Day Course

Asphalt Materials

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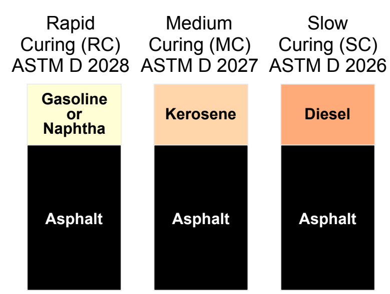
Classifications of Asphalt

- **Cutbacks**
- **Emulsions**
- **Asphalt Cement (Binder)**

Cutback Asphalt

- Paving asphalt liquefied by blending with petroleum solvents
- Resulting material can be sprayed/mixed at lower temperatures
- Primary uses:
  - penetrating prime coat
  - binders for storable cold mix asphalt

Types of Cutback Asphalt

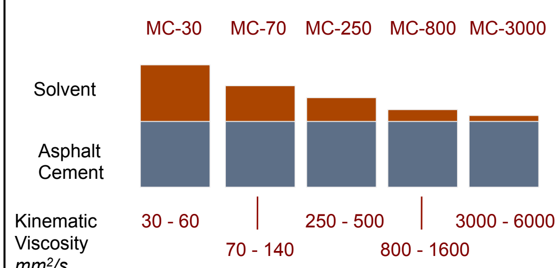


Cutbacks are further divided by viscosity. *For example:*

MC-30: Kinematic Viscosity Min. 30 mm²/sec @ 140°F

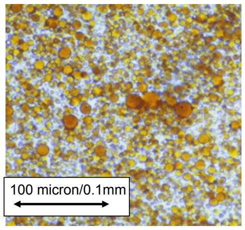
MC-70: Kinematic Viscosity Min. 70 mm²/sec @ 140°F

Grades of Cutback Asphalt



Asphalt Emulsions

- Microscopic asphalt droplets suspended in water.
- Mostly 1-5 μm diameter
- Emulsifiers or surfactants hold these droplets in suspension.



Asphalt Emulsions

The purpose of diluting the binder with water is to lower the viscosity.

This allows the emulsion to be shot onto the roadway surface at much lower temperatures than straight binder.

If the emulsifying agent causes the particles to bear a negative charge, the emulsion is said to be *anionic*.

If the emulsifying agent causes the particles to bear a positive charge, the emulsion is said to be *cationic*.

Asphalt Emulsions

Anionic emulsions (negatively charged) typically bond best with positively charged aggregates (limestones, dolomites).

Cationic emulsions (positively charged) typically bond best with negatively charged aggregates (granites, sandstones).

Asphalt Emulsions

The process in which the binder globules begin to coalesce and the water evaporates is called *breaking*.

The amount of binder left after the water evaporates is called the *residual asphalt*.

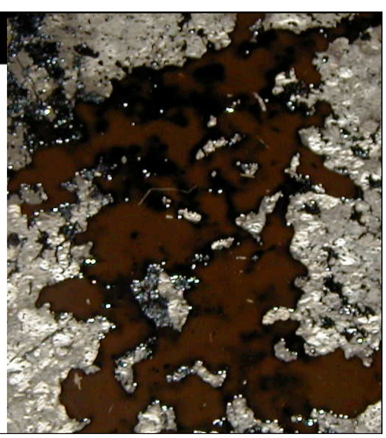
The residual asphalt is expressed as a percentage of the emulsion.

Both the amount and type of water and emulsifying agent mixed with the binder affect the evaporation rate.

Emulsion

"Un-broken" emulsion is brown

"Broken" emulsion is black



Negatively- Charged Emulsions are classified into 3 types

RS (Rapid Setting)

MS (Medium Setting)

SS (Slow Setting)

Positively- Charged Emulsions are also classified into 3 types

CRS (Rapid Setting)

CMS (Medium Setting)

CSS (Slow Setting)

Additional Nomenclature

QS = Quick Set
HF = High Float
1 = Binder residue = 60% Minimum
2 = Binder Residue = 65% Minimum
h = Hard Pen Asphalt Base
s = Soft Pen Asphalt Base or sometimes Solvent
l and/or p = Latex and/or Polymer

Asphalt Emulsions

The most common uses of emulsions are for chip seals, tack coats, and fog seals.

Asphalt Binders

The term "binder" covers both neat (unmodified) and modified asphalt cements, but doesn't include emulsions and cutbacks.

Binders are the "glue" that holds the aggregate together in HMA.

Unlike emulsions and cutbacks, binders are typically required to be heated to over 300°F for use, unless modified for use as Warm Mix Asphalt (WMA).

Polymers can be added to the binder to enhance their high temperature performance.

Superpave Asphalt Binder Specifications

The grading system is based on Climate

PG 64 - 22

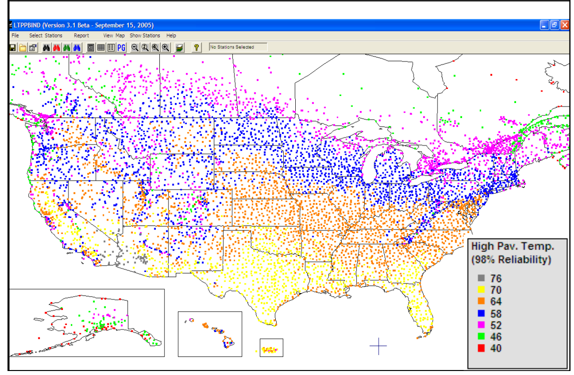
Performance Grade

Meets all requirements up to this temperature (°C)

Meets all requirements down to this temperature (°C)

Note: These grades are specified in 6° increments

High Temperature @ 98% Reliability



Low Temperature @ 98% Reliability

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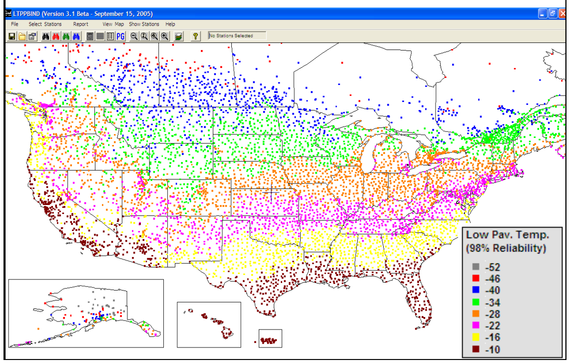
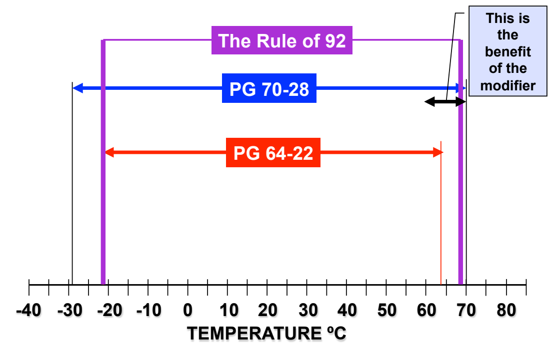


PG Binder Grades

PG 64-22 Probably Unmodified
PG 70-28 Probably Modified



Asphalt Description and Sources

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Asphalt Cement or Asphalt Binder

- Black, cementitious, waterproof material
- Originally mined from a natural lake (still operating today: Lake Asphalt of Trinidad and Tobago)
- Most asphalt today comes from the refining process

Not All Crudes Are The Same

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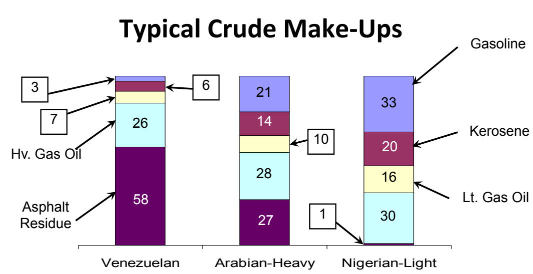

Basic Refining Concepts

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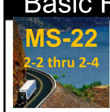

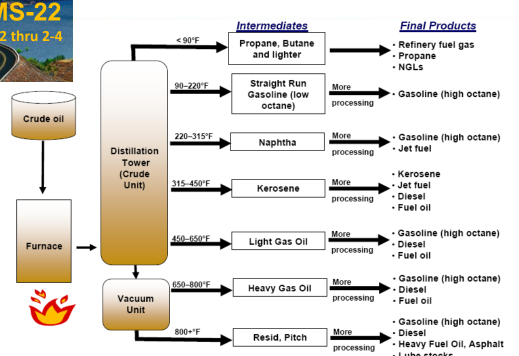

Asphalt Behavior Depends On:

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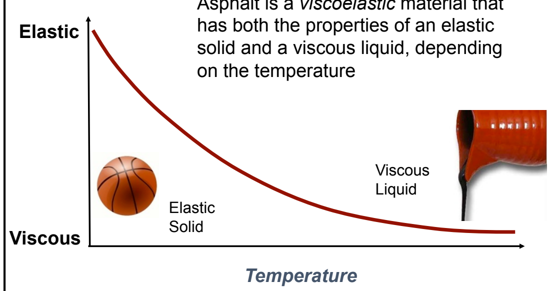
- **Temperature**
- **Time of Loading**
- **Aging (properties change with time)**

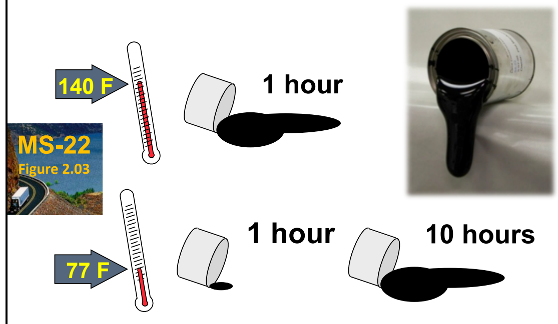
Asphalt Behavior at Varying Temperatures

MS-22 Figure 2.04

Asphalt is a *viscoelastic* material that has both the properties of an elastic solid and a viscous liquid, depending on the temperature



Asphalt Flow Behavior



Effect of Loading Rate on Binder Selection

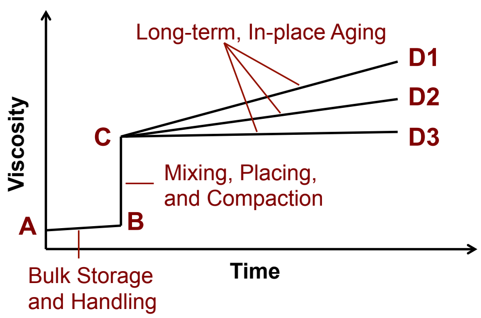
Example
- Toll road
  PG 64-22 ← **90 kph (55 MPH)**
- Toll booth
  PG 70-22 ← **Slow**
- Weigh stations
  PG 76-22 ← **Stopping**

Effect of Traffic on Binder Selection

- 10 to 30 million ESALs
  - Consider increasing one high temperature grade
- > 30 million ESALs
  - Increase one high temperature grade
- Newer recommendations are based on more gradual bumping in LTPPBind version 3.0+

NOTE: Multiple Stress Creep Recovery (MSCR) test specification will replace traffic grade bumping.

Asphalt aging over the pavement life



High Temperature Behavior

- **High in-service temperature**
  – Desert climates
  – Summer temperatures
- **Sustained loads**
  – Slow moving trucks
  – Intersections

→ *Viscous Liquid*

MS-22
2-4

Low Temperature Behavior

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- **Low Temperature**
  - Cold climates
  - Winter
- **Rapid Loads**
  - Fast moving trucks

→ *Elastic Solid*

"Ideal" Asphalt Binder

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- **Low stiffness at construction temperature**
- **High stiffness at high in-service temperature**
- **Low stiffness at low in-service temperature**
- **Excellent long-term durability**

Polymer-modified Asphalt Binder

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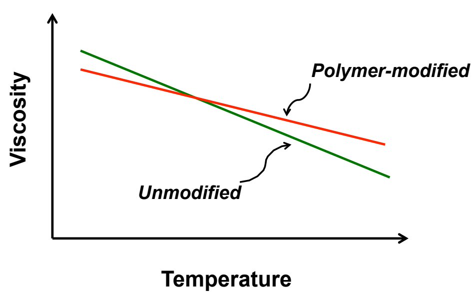
General Performance



Polymers

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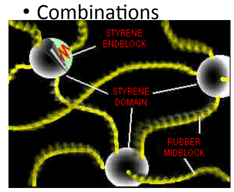
- Elastomers
- Plastomers
- Combinations



poly • mer

"many parts"

Image courtesy Infrapave

Elastomers

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- Natural Latex Rubber
- Synthetic Latex
  - Styrene-butadiene (SB)
- Block Copolymer
  - Styrene-butadiene-styrene (SBS)
- Reclaimed Rubber

Image courtesy Injectec.com

Plastomers

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- Polyethylene
- Polypropylene
- Ethyl-vinyl-acetate (EVA)
- Polyvinyl-chloride (PVC)

PVC Pipe

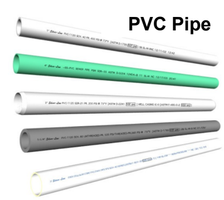
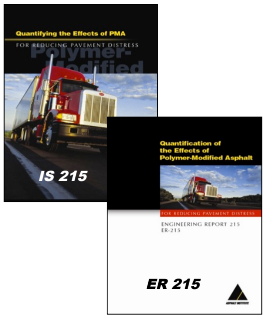


Image courtesy sbpipe.com

EVA is a plastic that is used to create stiffer insoles for your shoes

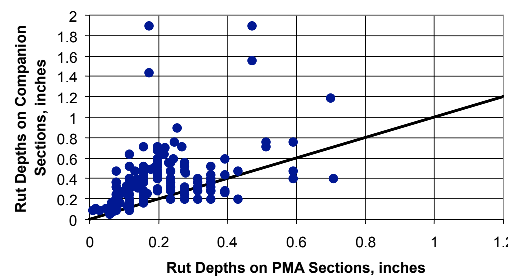
Image courtesy cyclingfitness.com

Quantifying the Effects of PMA for Reducing Pavement Distress

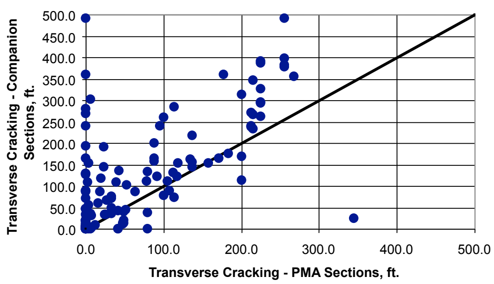


This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

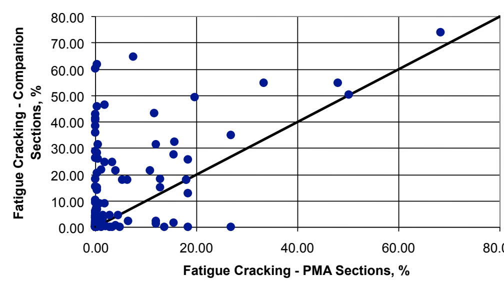
Direct Comparisons – Rutting



Distress Comparisons – Transverse Cracking



Distress Comparisons – Fatigue Cracking



MSCR Implementation

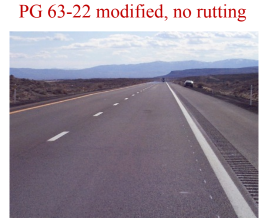
The use of polymer modified binders has grown tremendously over the past several years

However, the most widely used binder specification in the U.S., AASHTO M 320, was based on a study of neat (unmodified) binders, and may not properly characterize polymer modified binders

PG Grading Alone Does Not Always Predict Performance

- Study of the two mixes with the same aggregate structure, but different binders.

PG 63-22 modified, no rutting



PG 67-22 unmodified, 15mm rut

Why doesn't M 320 properly characterize polymer-modified binders?

- Current spec, G* and δ are measured in the linear visco-elastic range.
- For **neat binders**, flow is linear*(strain increases in a constant proportion to stress)* and therefore not sensitive to the stress level of the test.
- For **polymer-modified binders**, the response is not linear and very sensitive to the stress level of the test. The polymer chains can be rearranged substantially as the stress increases.

Why Do We Need New Binder Test?

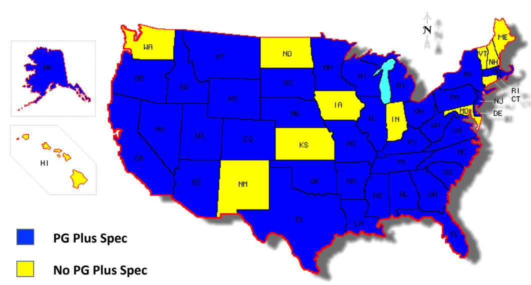
- **PG Binders**
  - **Most Common "Neat" Binder Grades**
    - **PG 64-22**
    - **PG 67-22** — **Works OK for neat binders**
  - **Most Common "Modified" Binder Grade**
    - **PG 76-22**

Doesn't work as well for modified binders

What happened as a result of M 320's inability to fully characterize polymer-modified binders?

- **Most states began requiring additional tests to the ones required in AASHTO M 320**
- **These mostly empirical tests are commonly referred to as "PG Plus" tests**
- **These tests are not standard across the states – difficult for suppliers**
- **Even some of the tests that are the most common, e.g. Elastic Recovery, are not run the same way from state to state**

States with a "PG Plus" Specification



ER Information and Test Time

- The Elastic Recovery Test is an excellent tool to establish the *presence* of polymer modification.
  - It takes about 4 hours to prepare and test samples for this information.
- However, it is a poor tool to evaluate the rutting *performance* of polymer-modified binders.
  - The MSCR test can use the same sample already being run in the DSR to give more information in a few extra minutes.

Multiple Stress Creep Recovery Test

- Performed on RTFO-aged Binder
- Test Temperature
  - Environmental Temperature
  - Not Grade-Bumped
- 10 cycles per stress level
  - 1-second loading at specified shear stress
    - 0.1 kPa
    - 3.2 kPa
  - 9-second rest period

Multiple Stress Creep Recovery Test

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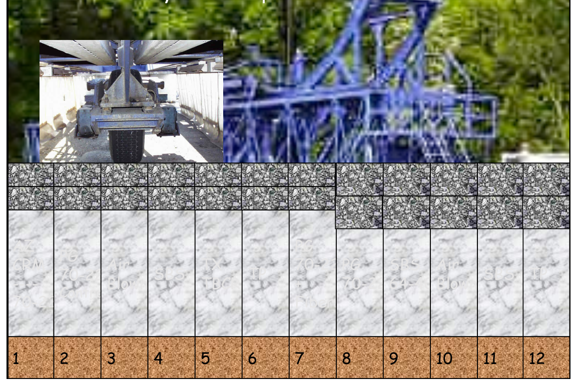
- Calculate Recovery for each Cycle, Stress
  - Difference between strain at end of recovery period and peak strain after creep loading
- Calculate Non-recoverable Creep Compliance (J_{nr})
  - Non-recoverable shear strain divided by applied shear stress
    - "J" = "compliance"
    - "nr" = "non-recoverable"

ALF Study - 7 Asphalt Binders



ALF Loading

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- The pavement was heated to a constant 64ºC.
- The FHWA ALF uses an 18,000 lbs wheel load with no wheel wander.
- The speed is 12 MPH.
  - This is a extreme loading condition far more sever than any actual highway.

Relationship between G*/ sinδ and ALF rutting

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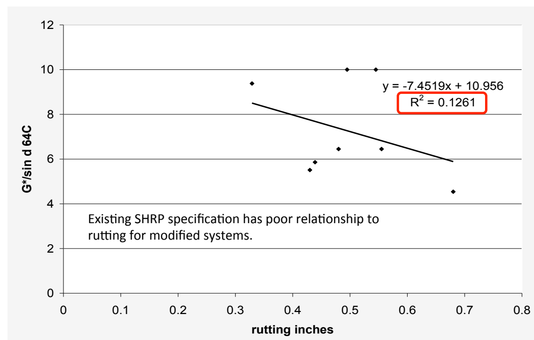

Relationship between Jnr and ALF rutting

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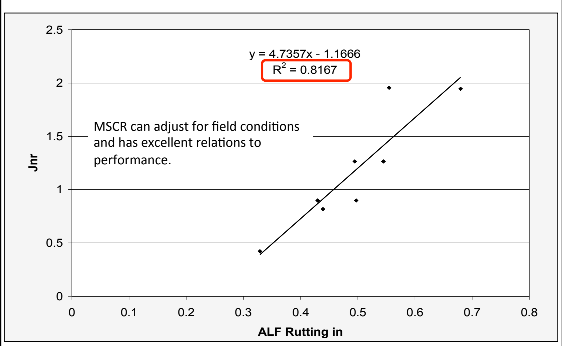

New PG Grading System (MSCR)

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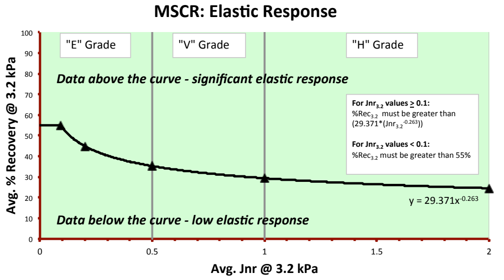
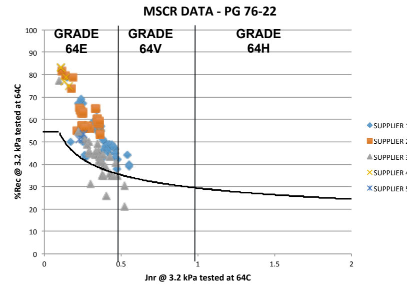
Requirements

- S = Standard: $J_{nr} \leq 4.5\ kPa^{-1}$
- H = Heavy: $J_{nr} \leq 2.0\ kPa^{-1}$
- V = Very Heavy: $J_{nr} \leq 1.0\ kPa^{-1}$
- E = Extreme: $J_{nr} \leq 0.5\ kPa^{-1}$

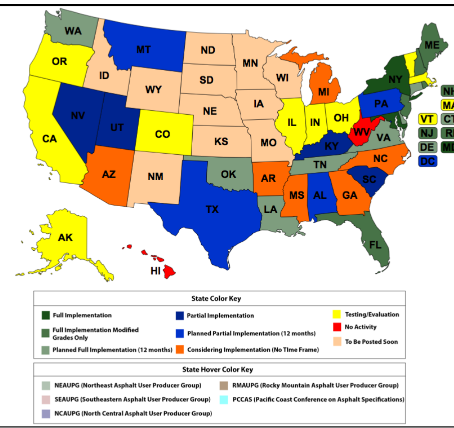


WHAT IS CURRENTLY BEING SUPPLIED?



MODIFIED GRADES IN THE NORTHEAST

CURRENT GRADE – M320	NEW GRADE – M332
PG 76-22	PG 64E-22
PG 76-28	PG 64E-28
PG 70-28	PG 64V-28
PG 64-22P	PG 64V-22
PG 58-34	PG 58H-34



State: New Jersey	**Materials:** Re: Section 902.01.01 - Asphalt Binder
Date Last Reviewed: 3/6/14	**Web Address:** www.state.nj.us
Materials Engineer: Eileen Sheehy	**Contact Info:** eileen.sheehy@dot.state.nj.us
Reviewed By: Gregory A. Harder, P.E., AI Regional Engineer	**AI Contact Info:** gharder@asphaltinstitute.org

Status:	**Full Implementation:**	All Grades Modified Grades Only	No plans yet May 2014
	Partial Implementation:	% Recovery - Modified Grades Substitution Allowed	n/a Jan. 2014
	Evaluation:	Testing/Data Collection	On-going

Details: NJDOT has been testing their binders using MSCR since 2011. They currently allow the substitution of M332 MSCR graded binder PG 64E-22 for PG 76-22 on all new and all existing contracts (provided there is no additional cost to the dept). NJDOT should have PG 64E-22 included into their specs (full implementation) by May 2014. The NEAUPG states have begun discussing full implementation of MSCR (M332) grading for all unmodified binders but no plans or dates have been determined. In 2014, the states and suppliers will collect and share MSCR data on all unmodified binders in the region.

	MSCR				
Current M320 Grade	**M332 Grade *or (Test Temp. °C)***	**Requirement**			**Implementation**
		$Jnr_{3.2}$ (kPa^{-1})	**Jnr_{diff} (%)**	**% $Rec_{3.2}$**	
PG 76-22	PG 64E-22	0.5 max.	75 max.	*see note below*	Anticipated May 2014
PG 64-22	PG 64S-22	4.5 max.	75 max.	n/a	No plans yet

Notes: % $Rec_{3.2} \geq 29.371\ Jnr_{3.2}^{-0.263}$

Disclaimer: To ensure the most accurate and current information, the specific agency should be contacted

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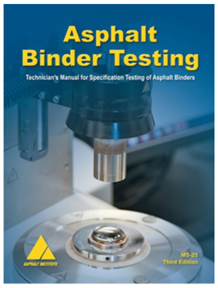
When would a polymer-modified asphalt typically be used?

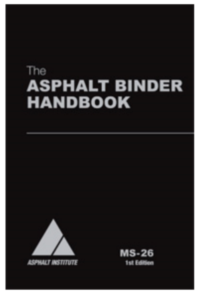
AASHTO M 323 - Table 1

	Adjustment to High-Temp Grade		
	Traffic Load Rate		
ESALs (M)	Standing	Slow	Standard
< 0.3	-	-	-
0.3 - < 3	2	1	-
3 - < 10	2	1	-
10 - < 30	2	1	-
≥ 30	2	1	1

For More Binder Information



MS-25



MS-26