Multiple Stress Creep and Recovery (MSCR)- Binder Limits

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Introduction

- Current Binder Specifications:

  AASHTO M 320 - Standard Specification for Performance-Graded Asphalt Binder – "PG Binder Specification"

  AASHTO M 332 - Standard Specification for Performance-Graded Asphalt Binder Using Multiple Stress Creep and Recovery (MSCR) Test – "MSCR PG Binder Specification" (Affectionately known as Massacre Spec)

- Federal Highway Administration (FHWA) project: "Deployment and Development of Innovative Asphalt Pavement Technologies. (DDIAPT)"
  - ***Deployment and Technical Support of MSCR Binder Specifications***
  - ***Technical Brief -***

Background

- **AASHTO M 320 – "PG Binder Specification"**
  - Product of the Strategic Highway Research Program (SHRP)
  - Introduced via Provisional Specification in early 1990's
  - Implementation, User/Producer Groups early 1990's
  - AASHTO Specification – late 1990's
  - **Primary parameter G*/sinδ**
- **AASHTO M 332 – "MSCR PG Binder Specification"**
  - Enhancement to M 320 to address issues PG issues with Permanent Deformation
  - AASHTO T 350 - Standard Method of Test for Multiple Stress Creep and Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR) - employs a well-established creep and recovery concept.
  - Captures the non-recoverable creep compliance (J_{nr}) and percentage of recovery.
  - Introduced via Provisional Specification ~ 2009 (M 320 Table 2 – MP 19)
  - AASHTO Specification ~ 2011
  - **Primary parameter J_{nr}**

Similarities of M 320 and M332

- Both specifications cover asphalt binders graded by performance-related criteria.
- Specification limiting parameters are based on rheological properties of the asphalt binder measured over a range of temperatures and aging conditions.
- Grading designations are established based on the accumulated degree days above 10°C to determine the high pavement design temperature, and minimum pavement design temperature.
- Typical PG binder grades are specified for climatic conditions ranging from high temperature grades of PG 46 to PG 82 and low temperature grades of -10 to -40.

Traffic speed and loading parameters are addressed differently.

- **M 320 Temp Grade Bumping**

	Adjustment to the High-Temperature Grade of the Binder		
	Traffic Load Rate		
Design ESALs (millions)	Standard	Slow	Standing
< 0.3	------	------	------
0.3 to < 3	------	1	2
3 to < 10	------	1	2
10 to < 30	------	1	2
≥ 30	1	1	2

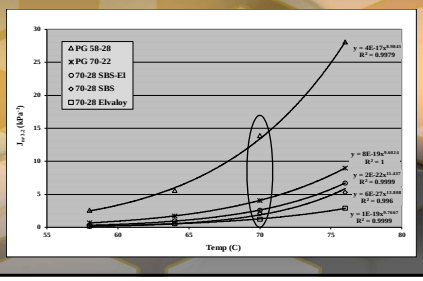
"Climate Temperature" does not change, only the DSR test temperature with DSR testing being performed at the higher (bumped) PG grade temperatures to account for traffic.

- **M 332 J_{nr} Grade Bumping**

MSCR J_{nr} Parameter Value	Design Traffic Level
Less than or Equal to 4.5	Standard < 3 million ESALs
Less than or Equal to 2.0	Heavy > 3 million ESALs
Less than or Equal to 1.0	Very Heavy > 10 million EASLs
Less than or Equal to 0.5	Extreme > 30 million ESALs

With M 332 the value of J_{nr} determines whether a PG binder is suitable for standard, heavy, very heavy, or extreme traffic loadings

J_{nr} Determines S, H, V, or E Grade



General Comparison M 320 vs. M 332 Nomenclature

	M 320	M 332
Performance Grade Nomenclature	PG XX - XX	PG XX(S, H, V or E) - XX
Maximum Pavement Design Temp, °C	< LTPPbind Regional Climate Temp	< LTPPbind Regional Climate Temp
Minimum Pavement Design Temp, °C	> LTPPbind Regional Climate Temp	> LTPPbind Regional Climate Temp

General Comparison – M 320 vs. M 332 Original Binder Properties

	M 320	M 332
Dynamic shear, T 315: G*/sinδ, min 1.00 kPa test temp @ 10 rad/s, °C	LTPPbind Regional Climate Temp with Temp Grade Bump as Required by M 323	LTPPbind Regional Climate Temp (No Temperature Bumping)

Original DSR limits, for the DSR specification parameter G*/sinδ, remain at a minimum of 1.0 kPa for both specifications.

Since ALL M 332 testing is performed at the LTPPBind™ regional climate temperature, important to note and understand that ODSR results from M 332 H, V, and E grades will be considerably higher than results from M 320 temperature grade bumped grades approximately two-, to four-, to eight -fold respectively.

Do not combine temperature bumping and J_{nr} grade bumping.

General Comparison – M 320 vs. M 332 RTFO (T 240) Aged Binder Properties

	M 320	M 332
Dynamic shear, T 315: G*/sinδ, min 2.20 kPa test temp @ 10 rad/s, °C	LTPPbind Regional Climate Temp with Temp Grade Bump as Required by M 323	N/A
MSCR, T 350: Standard Traffic "S" $J_{nr\ 3.2}$, max 4.5 kPa^{-1} $J_{nr\ diff}$, max 75% test temp, °C	N/A	LTPPbind Regional Climate Temp (No Temperature Bumping)
MSCR, T 350: Heavy Traffic "H" $J_{nr\ 3.2}$, max 2.0 kPa^{-1} $J_{nr\ diff}$, max 75% test temp, °C	N/A	LTPPbind Regional Climate Temp (No Temperature Bumping)
MSCR, T 350: Very Heavy Traffic "V" $J_{nr\ 3.2}$, max 1.0 kPa^{-1} $J_{nr\ diff}$, max 75% test temp, °C	N/A	LTPPbind Regional Climate Temp (No Temperatur Bumping)
MSCR, T 350: Extremely Heavy Traffic "E" $J_{nr\ 3.2}$, max 0.5 kPa^{-1} $J_{nr\ diff}$, max 75% test temp, °C	N/A	LTPPbind Regional Climate Temp (No Temperature Bumping)

General Comparison – M 320 vs. M 332 PAV (R 28) Aged Binder Properties

	M 320	M 332
PAV Aging Temp, °C	Based on Regional Simulated Climate Conditions, either 90, 100 or 110°C	Based on Regional Simulated Climate Conditions, either 90, 100 or 110°C
Dynamic shear, T 315: G* sinδ, max 5000 kPa test temp @ 10 rad/s, °C	Half the Differential of Maximum and Minimum Pavement Design Temps plus 4°C	N/A
Dynamic shear, T 315: "S" G* sinδ, max 5000 kPa test temp @ 10 rad/s, °C	N/A	Half the Differential of Maximum and Minimum Pavement Design Temps plus 4°C
Dynamic shear, T 315: "H," "V," "E" G* sinδ, max 6000 kPa test temp @ 10 rad/s, °C	N/A	Half the Differential of Maximum and Minimum Pavement Design Temps plus 4°C
Creep stiffness, T 313: S, max 300 Mpa m-value, min 0.300 test temp @ 60 s, °C	10°C Below the LTPPbind Mimimum Pavement Design Temp	10°C Below the LTPPbind Mimimum Pavement Design Temp

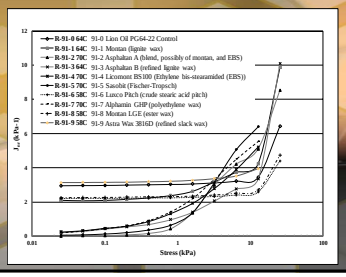
Improvements Offered by M 332

- J_{nr} is better correlated with rutting potential than G*/sinδ.
- MSCR test results for modified and unmodified asphalt binders can be determined with the same test procedure, eliminating the need for additional tests, e.g. PG plus tests, to characterize high temperature performance of modified asphalt binders.
- Criteria are available to eliminate rutting-susceptible overly stress sensitive binders which were not captured by M320.
- MSCR % recovery does a better job of characterizing polymer modified asphalt binders as well as being faster/easier compared to other "PG Plus" tests like Elastic Recovery (ER)
- MSCR testing is conducted at the actual pavement temperature, regardless of traffic loading, no artificial temperature bumping.

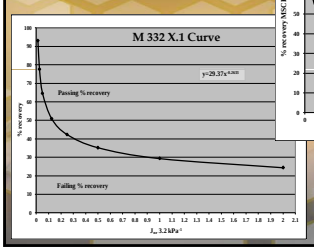
Non-recoverable Creep Compliance (J_{nr})

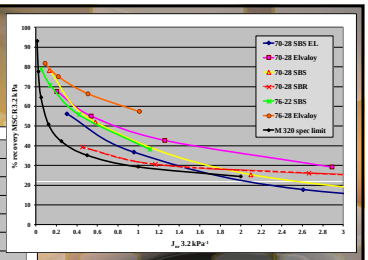
Modifier	Continuous grade	Modification	Jnr 800Pa 64C	6 yr rut mm
Ultrapave	70-27	SBR/3.0%	0.055	4.5
Styrelf	77 29	SB/6.0%	0.013	2
GTR 80	75-29	80 mesh GTR/10%	0.039	1.5
Sealoflex	82-27	SBS/4.25%	0.008	3
Multigrade	72-24	Chemical Process	0.079	5
Cryo Rubber	75-28	80 mesh GTR/10%	0.052	7
Control	70-24	neat	0.142	11

$J_{nr\ diff}$ – Stress Sensitive Binders

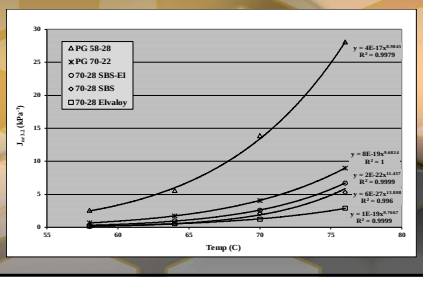


% Recovery

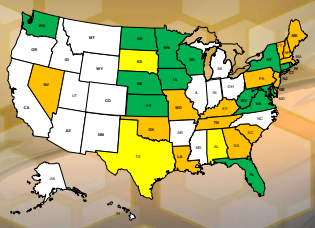




No Temperature Bumping

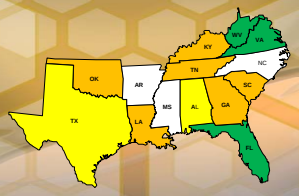


FHWA Technical Brief – Implementation/Transition



- Fourteen States Using M332.
  - CT, FL, IA, MD, MN, NE, ND, NY, RI, TN, VA, WA, WI, WV (28%)
- Fifteen States Using M332 for PMB only or in addition to M 320.
  - DE, GA, KY, LA, MA, ME, MO, NH, NJ, NV, OK, PA, SC, TN, VT (30%)
- Three States Using M320 with M332 as a "Plus" test.
  - AL, SD, TX (6%)
- Eighteen States Using M320 and other Plus tests.
  - AK, AR, AZ, CA, CO, DC, HI, ID, IL, IN, MI MS, MT, NC, NM, OH, OR, UT, WY (36%)

SEAUPG States - Implementation/Transition



- Three States Using M332.
  - FL, VA, WV
- Six States Using M332 for PMB only or in addition to M 320.
  - GA, KY, LA, OK, SC, TN
- Two States Using M320 with M332 as a "Plus" test.
  - AL, TX
- Three States Using M320 and other Plus tests.
  - AR, MS, NC

Barriers to Implementation and Transition

- Status Quo – Satisfied with what we have now.
- Fear of change, we want to get the same products used historically.
- Specification name change and training.
- We will have to re-write specifications.
- Loss of grade bumping option.
- Industry fear of grade proliferation.

SEAUPG States – Let's make it Green!

Six Simple Steps

- Familiarize with the MSCR Test
- Familiarize with the M 332 Specification
- Perform Transitional Testing as Necessary
- Transition Regionally and Uniformly
- Apply MSCR % Recovery as Necessary
- Eliminate Existing "PG Plus" Tests

Thank You!