Marathon Petroleum Company LP

PG+ MaSsaCRe

Asphalt Technology Group

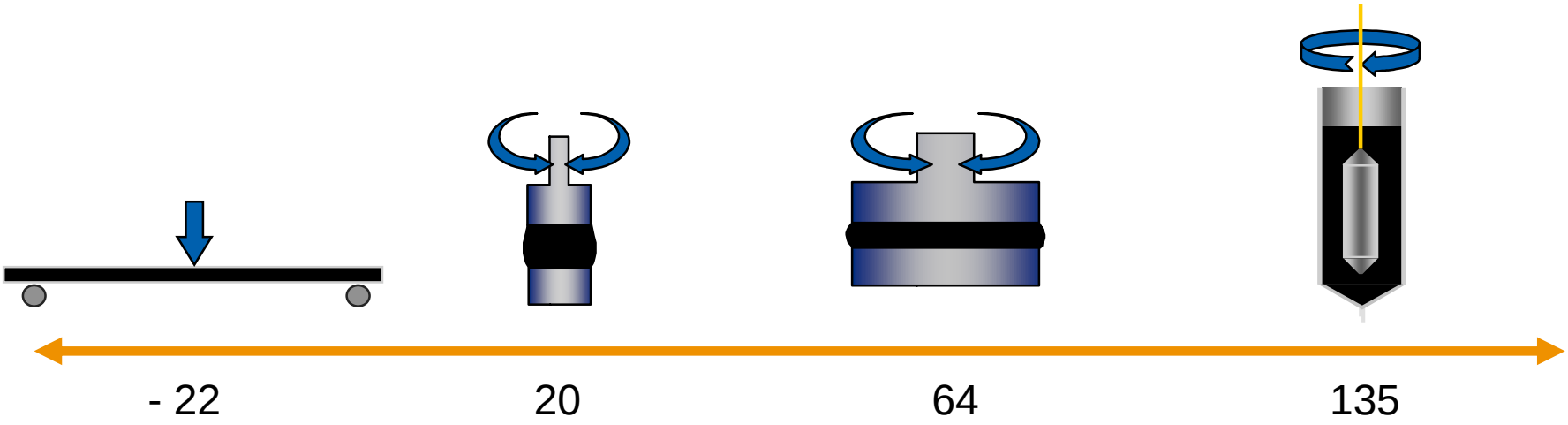
February 2019

Agenda

- History of PG+ specifications
- Path Forward
- What is MSCR
- Implementation

History

- Performance-Based Physical Properties Measured by
  - Rotational Viscometer (RV) (high temps)
  - Dynamic Shear Rheometer (DSR) (high, intermediate temps)
  - Bending Beam Rheometer (BBR) (low temps)
  - Direct Tension Tester (DTT) (low temps)



History

Performance Grades

Max. Design Temp.	PG 46			PG 52						PG 58					PG 64						PG 70						PG 76					PG 82				
Min. Design Temp.	-34	-40	-46	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-10	-16	-22	-28	-34
Original																																					
≥230 °C	**Flash Point**																																				
≤ 3 Pa-s @ 135 °C	**Rotational Viscosity**																																				
≥ 1.00 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)																																				
	46			52						58					64						70						76					82				
(Rolling Thin Film Oven) RTFO, Mass Change ≤ 1.00%																																					
≥ 2.20 kPa	**DSR G*/sin δ** (Dynamic Shear Rheometer)																																				
	46			52						58					64						70						76					82				
(Pressure Aging Vessel) PAV																																					
20 hours, 2.10 MPa	90			90						100					100						100(110)						100(110)					100(110)				
≤ 5000 kPa	**DSR G*sin δ** (Dynamic Shear Rheometer) Intermediate Temp. = [(Max. + Min.)/2] + 4																																				
	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	31	28	25	22	19	16	34	31	28	25	22	19	37	34	31	28	25	40	37	34	31	28
S ≤ 300 MPa m ≥ 0.300	**BBR S (creep stiffness) & m-value** (Bending Beam Rheometer)																																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24
If BBR m-value ≥ 0.300 and creep stiffness is between 300 and 600, the Direct Tension failure strain requirement can be used in lieu of the creep stiffness requirement.																																					
ε_f ≥ 1.00%	**DTT** (Direct Tension Tester)																																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24

History

- Shearing resistance to resist traffic loads
  - Upper specification temperature
  - $G^*/\sin\delta \geq 1.00$ kPa OB
  - $G^*/\sin\delta \geq 2.20$ kPa RTFO residue

History

Table 1—Binder Selection on the Basis of Traffic Speed and Traffic Level

	Adjustment to the High-Temperature Grade of the Binder[a]		
	Traffic Load Rate		
Design ESALs[b] (Million)	Standing[c]	Slow[d]	Standard[e]
< 0.3	—[f]	—	—
0.3 to < 3	2	1	—
3 to < 10	2	1	—
10 to < 30	2	1	—[f]
≥ 30	2	1	1

[a] Increase the high-temperature grade by the number of grade equivalents indicated (one grade is equivalent to 6°C). Use the low-temperature grade as determined in Section 5.

[b] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[c] *Standing Traffic*—where the average traffic speed is less than 20 km/h.

[d] *Slow Traffic*—where the average traffic speed ranges from 20 to 70 km/h.

[e] *Standard Traffic*—where the average traffic speed is greater than 70 km/h.

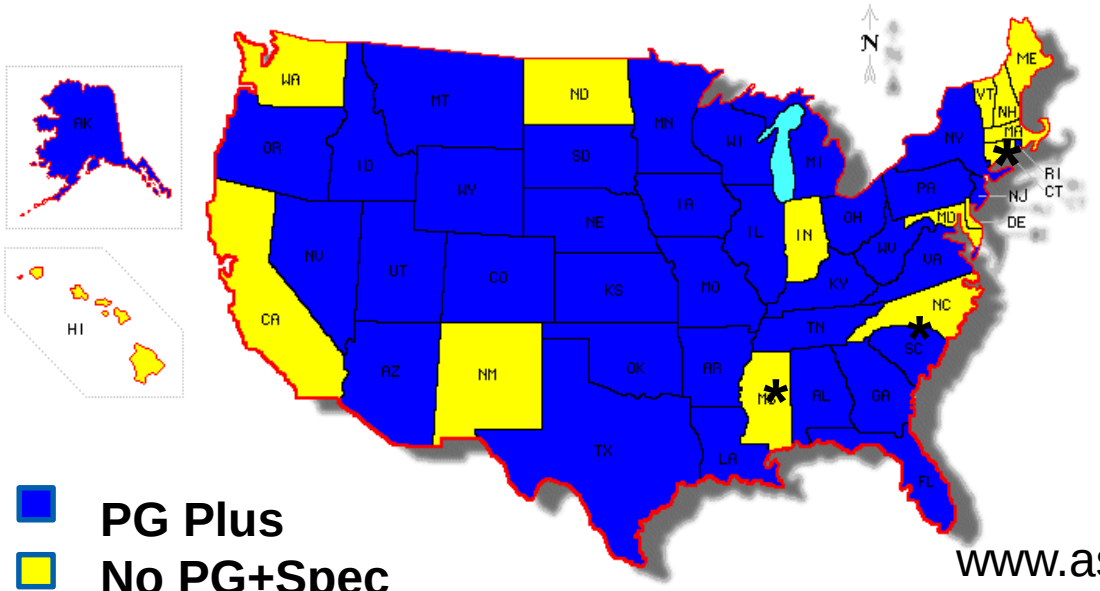
[f] Consideration should be given to increasing the high-temperature grade by one grade equivalent.

History

- Why doesn't AASHTO M320 properly characterize polymer-modified binders?
  - G* and δ are measured in the linear viscoelastic range.
  - For neat asphalts, flow is linear and not sensitive to the stress level of the test.
  - For polymer-modified binders, the response is not linear and sensitive to the stress level of the test. The polymer chains can be rearranged substantially as the stress increases.

History

- Most states began requiring additional tests to the ones required in AASHTO M320
  - 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



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Path Forward

- Any new specification must be blind to modification.
- A new specification must identify the rutting potential of all binder types under multiple conditions.

Path Forward

- 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

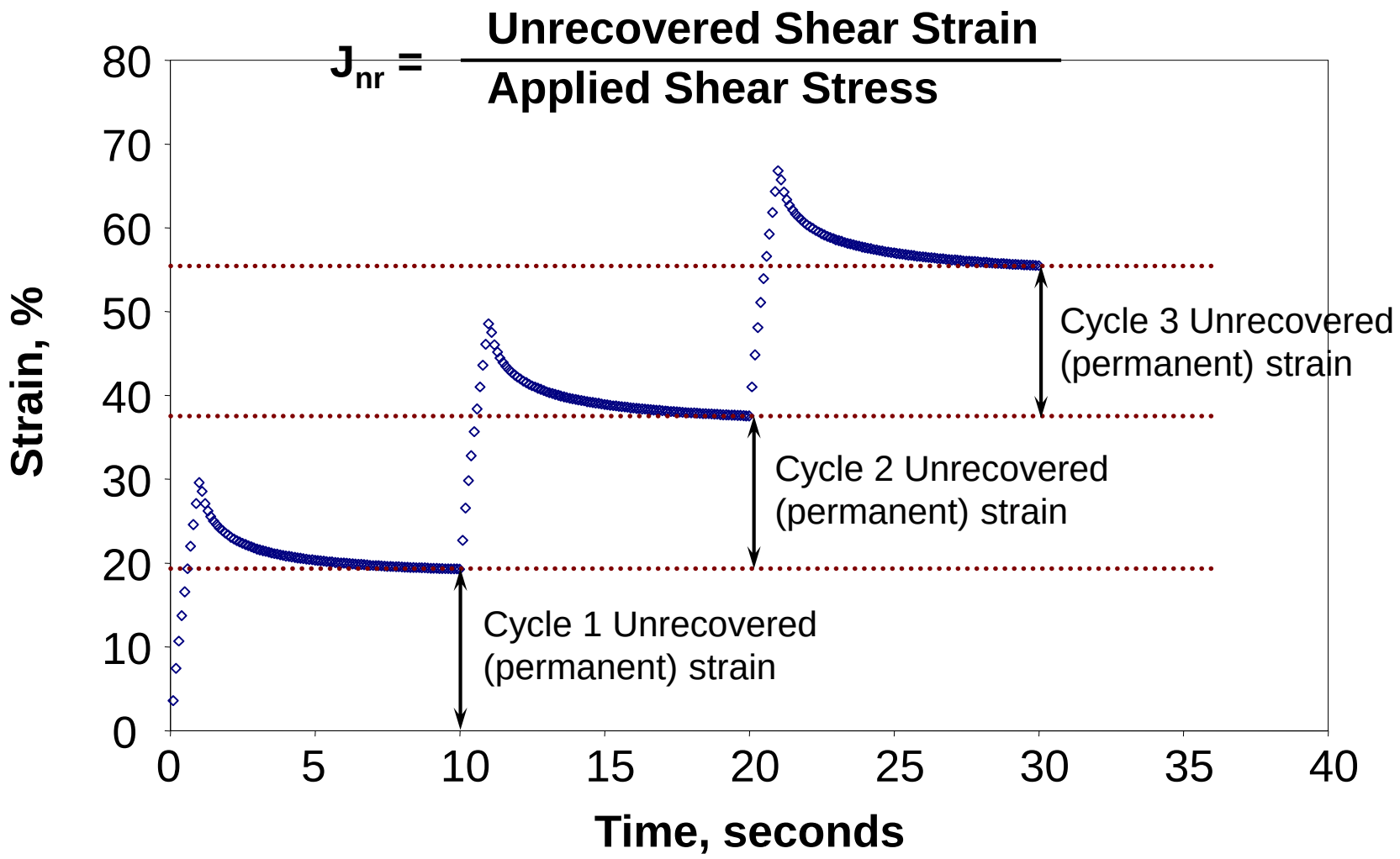
Path Forward

- **Creep and recovery** – a standard test protocol whereby a specimen is subjected to a constant load for a fixed time period and then allowed to relax (recover) at a zero load for a fixed time period

- **Percent Recovery** – A measure of how much the sample returns to its previous shape after being repeatedly stretched and then relaxed

- **Non-Recoverable Creep Compliance (J_{nr})** – a measure of the amount of residual strain left in the specimen after repeated creep and recovery, relative to the amount of stress applied

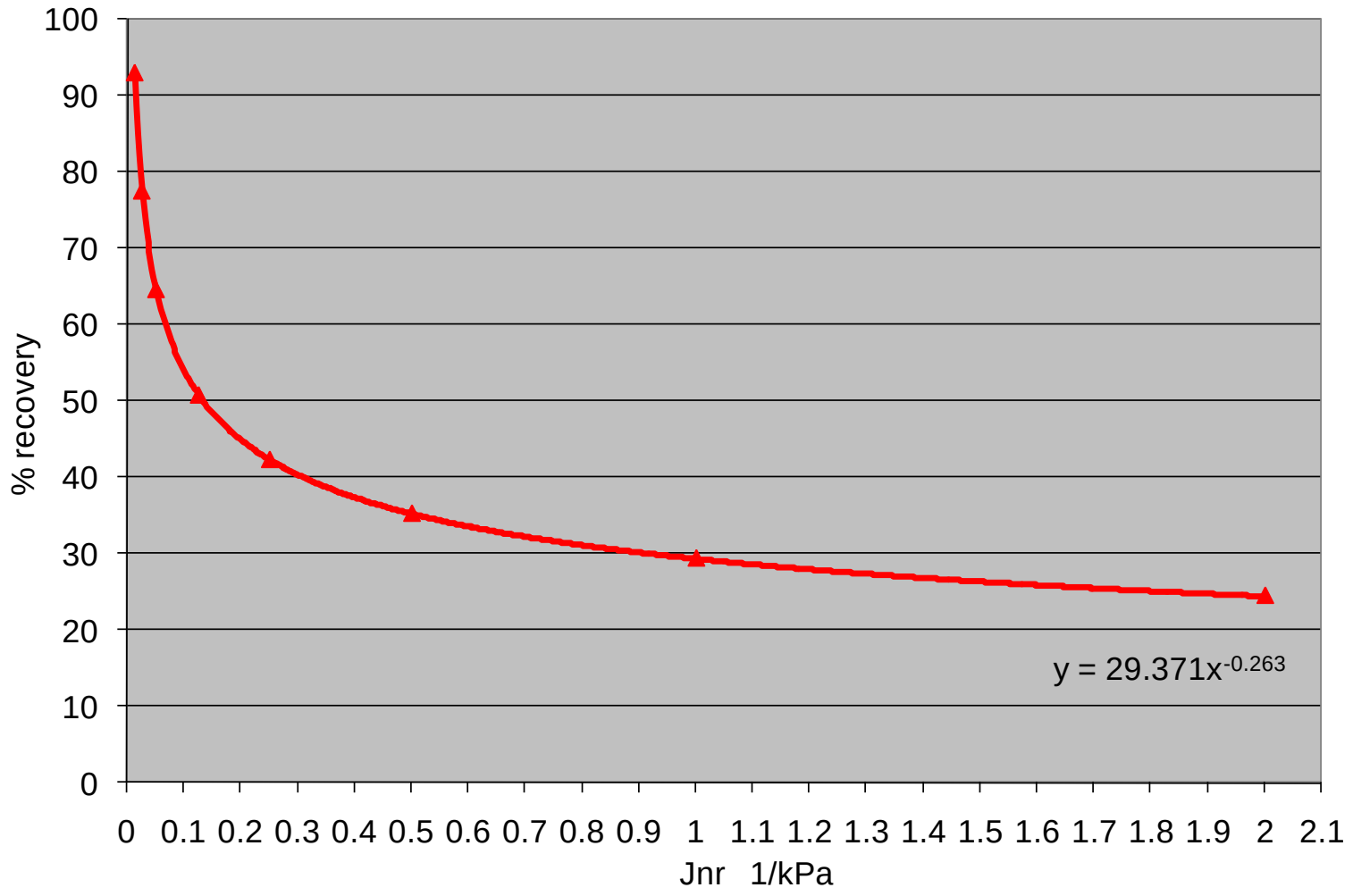
Jnr


J_{nr} = Unrecovered Shear Strain / Applied Shear Stress
Strain, %
Time, seconds
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
35
40
Cycle 3 Unrecovered (permanent) strain
Cycle 2 Unrecovered (permanent) strain
Cycle 1 Unrecovered (permanent) strain

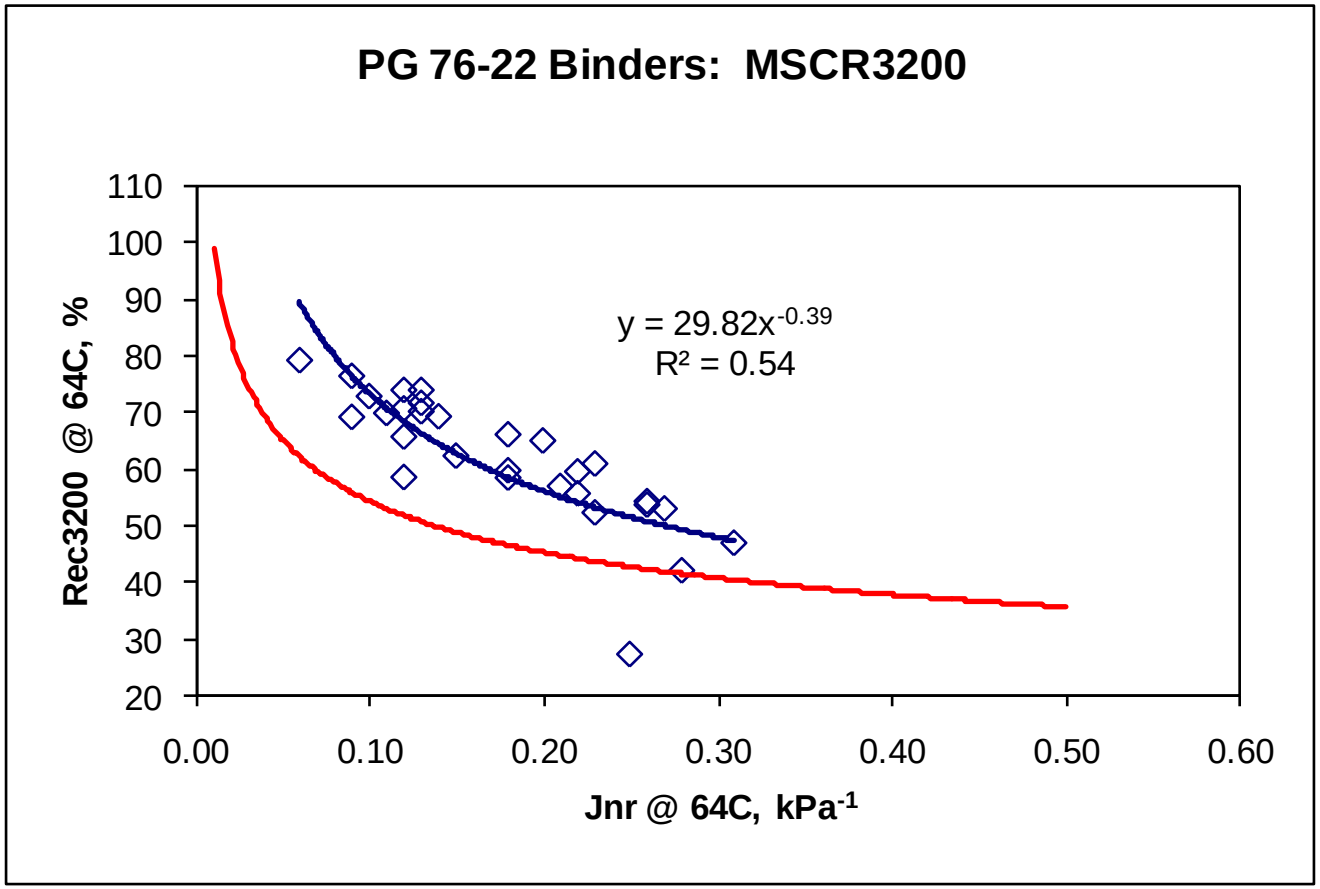
New Names

- PG 64 (Standard, Heavy, Very Heavy, Extreme) traffic based
  - PG 64-xxS J_{nr} =< 4.0
  - PG 64-xxH J_{nr} =< 2.0
  - PG 64-xxV J_{nr} =< 1.0
  - PG 64-xxE J_{nr} =< 0.5

%Rec – Validates Polymer



% Rec.



States are using the curve differently based on the products they were already receiving.

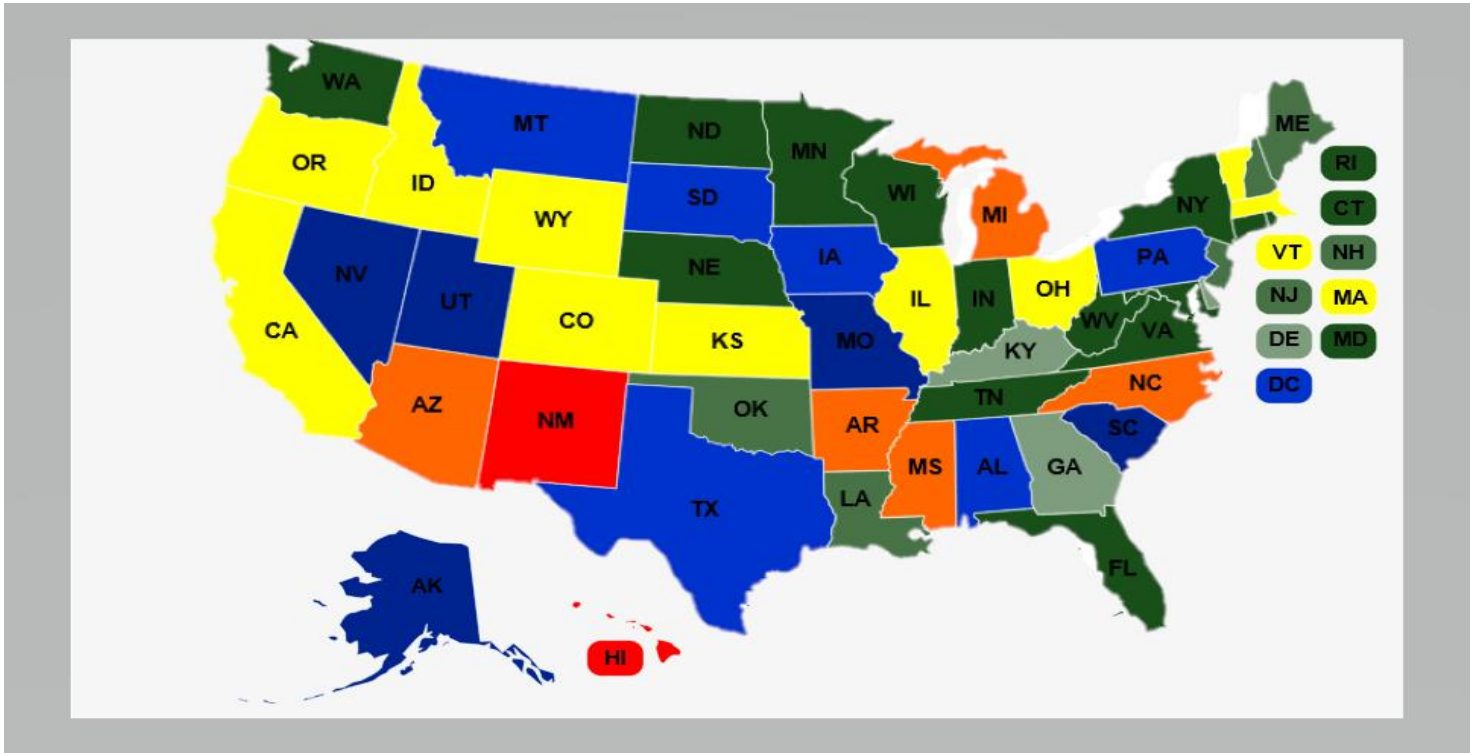
Take Away

WVDOH 2019 PG Binder Updates		
M320 Old Grade	**M332 New Grade**	**Meaning**
PG58-28	PG58S-28	"S" Standard Traffic
PG64-22	PG64S-22	"S" Standard Traffic
PG70-22	PG64H-22	"H" Heavy Traffic
PG76-22	PG64E-22	"E" Extremely Heavy Traffic

No Recovery

Requires % recovery curve

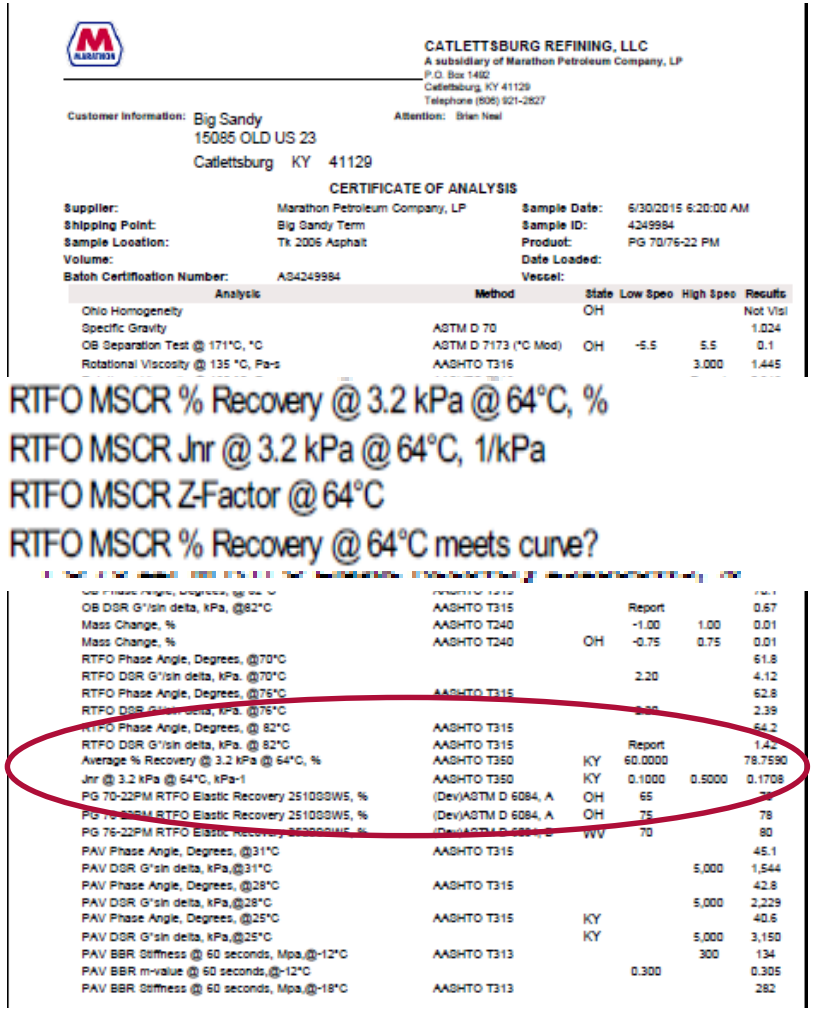
MSCR State Map



State Color Key

- Full Implementation
- Full Implementation Modified Grades Only
- Planned Full Implementation (12 months)
- Partial Implementation
- Planned Partial Implementation (12 months)
- Considering Implementation (No Time Frame)
- Testing/Evaluation
- No Activity
- To Be Posted Soon

COA



CATLETTSBURG REFINING, LLC
A subsidiary of Marathon Petroleum Company, LP
P.O. Box 1492
Catlettsburg, KY 41129
Telephone (606) 921-2627

Customer Information: Big Sandy
15085 OLD US 23
Catlettsburg KY 41129

Attention: Brian Neal

CERTIFICATE OF ANALYSIS

Supplier:	Marathon Petroleum Company, LP	Sample Date:	6/30/2015 6:20:00 AM
Shipping Point:	Big Sandy Term	Sample ID:	4249984
Sample Location:	Tk 2006 Asphalt	Product:	PG 70/76-22 PM
Volume:		Date Loaded:	
Batch Certification Number:	AB4249984	Vessel:	

Analysis	Method	State	Low Spec	High Spec	Results
Ohio Homogeneity		OH			Not Visi
Specific Gravity	ASTM D 70				1.024
OB Separation Test @ 171°C, °C	ASTM D 7173 (°C Mod)	OH	-5.5	5.5	0.1
Rotational Viscosity @ 135 °C, Pa-s	AASHTO T316			3.000	1.445

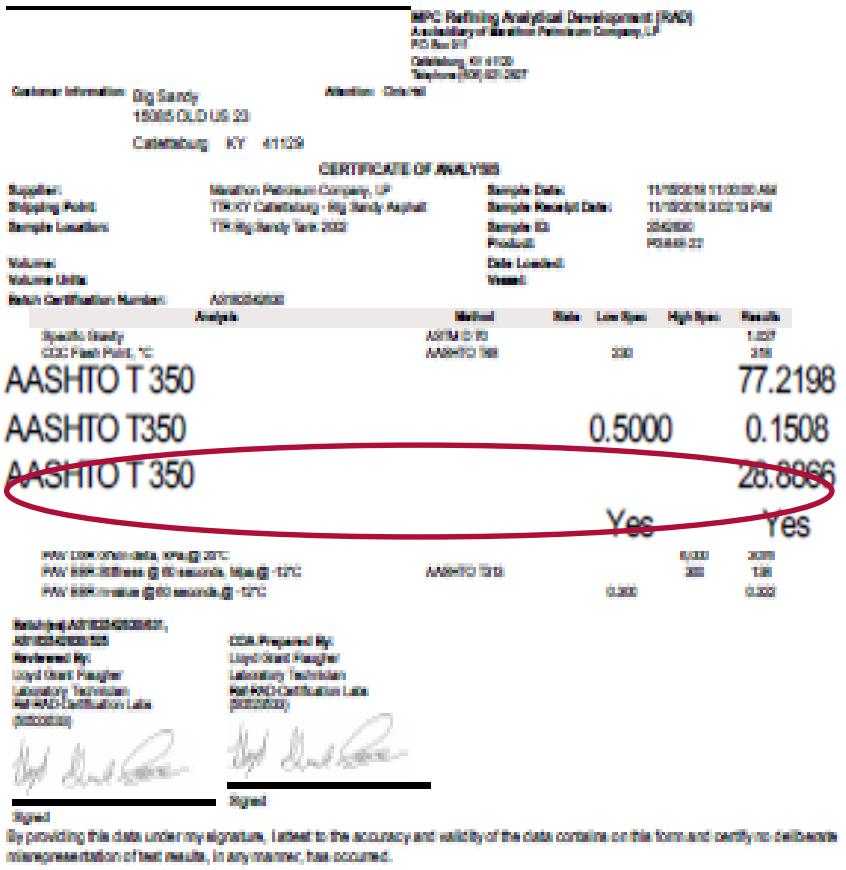
RTFO MSCR % Recovery @ 3.2 kPa @ 64°C, %

RTFO MSCR Jnr @ 3.2 kPa @ 64°C, 1/kPa

RTFO MSCR Z-Factor @ 64°C

RTFO MSCR % Recovery @ 64°C meets curve?

OB DSR G*/sin delta, kPa, @82°C	AASHTO T315		Report		0.67
Mass Change, %	AASHTO T240		-1.00	1.00	0.01
Mass Change, %	AASHTO T240	OH	-0.75	0.75	0.01
RTFO Phase Angle, Degrees, @70°C					61.8
RTFO DSR G*/sin delta, kPa, @70°C			2.20		4.12
RTFO Phase Angle, Degrees, @76°C	AASHTO T315				62.8
RTFO DSR G*/sin delta, kPa, @76°C					2.39
RTFO Phase Angle, Degrees, @ 82°C	AASHTO T315				64.2
RTFO DSR G*/sin delta, kPa, @ 82°C	AASHTO T315		Report		1.42
Average % Recovery @ 3.2 kPa @ 64°C, %	AASHTO T350	KY	60.0000		78.7590
Jnr @ 3.2 kPa @ 64°C, kPa-1	AASHTO T350	KY	0.1000	0.5000	0.1708
PG 70-22PM RTFO Elastic Recovery 251008W5, %	(Dev)ASTM D 6084, A	OH	65		78
PG 76-22PM RTFO Elastic Recovery 251008W5, %	(Dev)ASTM D 6084, A	OH	75		78
PG 76-22PM RTFO Elastic Recovery [illegible]	[illegible]	WV	70		80
PAV Phase Angle, Degrees, @31°C	AASHTO T315				45.1
PAV DSR G*/sin delta, kPa,@31°C				5,000	1,544
PAV Phase Angle, Degrees, @28°C	AASHTO T315				42.8
PAV DSR G*/sin delta, kPa,@28°C				5,000	2,229
PAV Phase Angle, Degrees, @25°C	AASHTO T315	KY			40.6
PAV DSR G*/sin delta, kPa,@25°C		KY		5,000	3,150
PAV BBR Stiffness @ 60 seconds, Mpa,@-12°C	AASHTO T313			300	134
PAV BBR m-value @ 60 seconds,@-12°C			0.300		0.305
PAV BBR Stiffness @ 60 seconds, Mpa,@-18°C	AASHTO T313				282



MPC Refining Analytical Development (RAD)
A subsidiary of Marathon Petroleum Company, LP
P.O. Box 911
Catlettsburg, KY 41129
Telephone (606) 921-2627

Customer Information: Big Sandy
15085 OLD US 23
Catlettsburg KY 41129

Attention: Chris Hall

CERTIFICATE OF ANALYSIS

Supplier:	Marathon Petroleum Company, LP	Sample Date:	11/1/2018 11:00:00 AM
Shipping Point:	TBUKY Catlettsburg - Big Sandy Asphalt	Sample Receipt Date:	11/1/2018 3:02:13 PM
Sample Location:	TK Big Sandy Tank 2002	Sample ID:	2542500
		Product:	PG 64-22
Volume:		Date Loaded:	
Volume Units:		Vessel:	
Batch Certification Number:	AB1825425000		

Analysis	Method	State	Low Spec	High Spec	Results
Specific Gravity	ASTM D 70				1.027
COC Flash Point, °C	AASHTO T48		230		318

AASHTO T 350 77.2198

AASHTO T350 0.5000 0.1508

AASHTO T 350 28.8866

Yes Yes

PAV DSR G*/sin delta, kPa,@ 25°C			5,000	3,029
PAV BBR Stiffness @ 60 seconds, Mpa,@ -12°C	AASHTO T313		300	136
PAV BBR m-value @ 60 seconds,@ -12°C		0.300		0.309

Batch [illegible] AB1825425000001,
AB1825425000005

Reviewed By:
Lloyd Grant Faugher
Laboratory Technician
Ref RAD Certification Lab
(5000000)

COA Prepared By:
Lloyd Grant Faugher
Laboratory Technician
Ref RAD Certification Lab
(5000000)

Signed

Signed

By providing this data under my signature, I attest to the accuracy and validity of the data contains on this form and certify no deliberate misrepresentation of test results, in any manner, has occurred.

Questions

- Thank You!
- This info and much more available at:

http://www.asphaltinstitute.org/training/webinars/using-the-mscr-test-in-asphalt-binder-specifications/