Implementation of the MSCR Test and Specification:
Questions, Clarifications, and Emphasis

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Implementation of the MSCR Test and Specification

- Acknowledgments
  - Federal Highway Administration
    - DTFH61-11-H-00033, “Deployment of Innovative Asphalt Binder and Construction Technologies”
      - Michael Arasteh, AOTR
      - John Bukowski, Tom Harman, Matt Corrigan, Jeff Withee, Tim Aschenbrener, Jason Dietz
  - Member Companies of the Asphalt Institute
    - Technical Advisory Committee

Implementation of the MSCR Test and Specification

- MSCR Test
  - AASHTO T350
- Performance-Graded (PG) Specification using MSCR
  - AASHTO M332
- Practice for Evaluating the Elastic Behavior of Asphalt Binders Using the MSCR Test
  - Draft practice not yet sent to AASHTO for review

Implementation of the MSCR Test and Specification

- Concerns/Questions/Challenges
  - Inconsistent implementation by specifying agencies
  - Grade names in AASHTO M332
  - Variability of MSCR test
  - Selection of appropriate test temperature
  - Leadership/champion
  - Use of recovery-Jnr curve for evaluating elastic response

Implementation of the MSCR Test and Specification

- Concerns/Questions/Challenges
  - Use and relevance of Jnr-Diff as a specification requirement
  - Use and criterion for intermediate temperature binder parameter (G*sin δ)
  - Criterion for unmodified asphalt binders (“S” grades)
  - Original DSR criterion
  - Quick QC testing on original binder

Implementation of the MSCR Test and Specification

- ASTM Standard
  - Standard Specification for Performance Graded Asphalt Binder Using the Multiple Stress Creep and Recovery Test
  - Bob Kluttz (Kraton), Chair
- Negative Votes (Summary of Key Points)
  - There's some confusion on the language that a few folks are interpreting to mean binders must be modified. Action - reword Section 5.7.
  - There's still fear of grade proliferation. Is there any solid data from any of the implementing states or UPGs to naysay this?

Implementation of the MSCR Test and Specification

- Negative Votes (Summary of Key Points)
  - AASHTO T350 and ASTM D7405 are different (now fixed)
  - There's still unhappiness with 5000 kPa for S and 6000 for all other grades.
  - And the one that drew the most flack—The R3.2 vs. Jnr3.2 curve for selecting R3.2 criteria. The implication from the language in the spec is that the figure is a yes/no determination on whether or not a binder is modified. Action – needs clarification (currently using M332 language).

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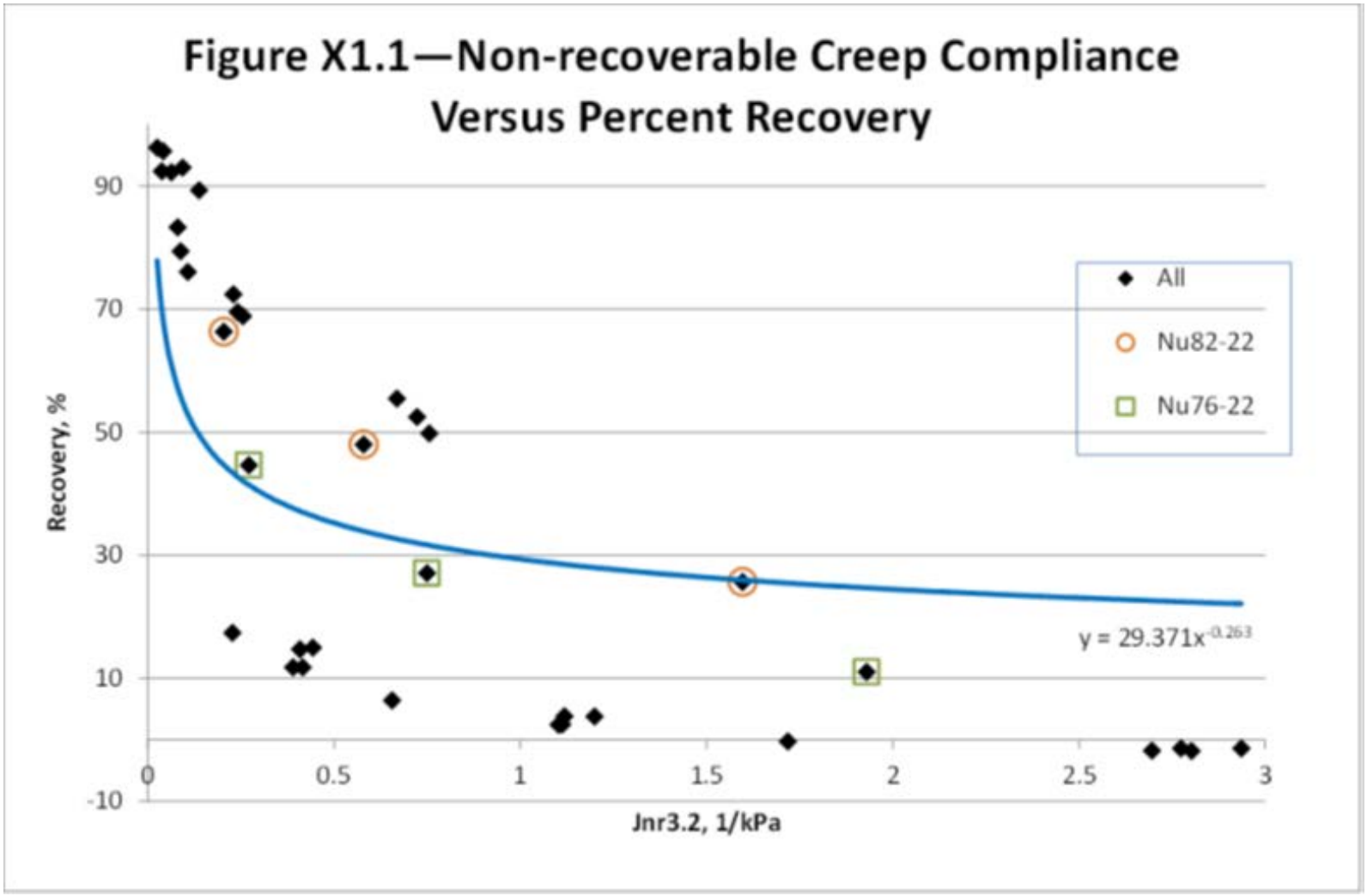
- Negative Votes (Summary of Key Points)

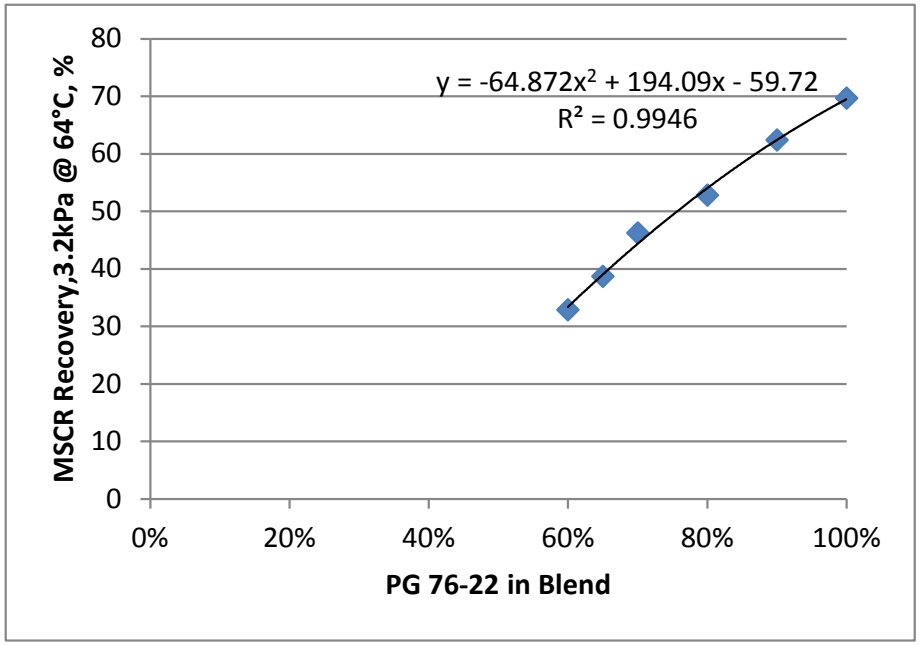


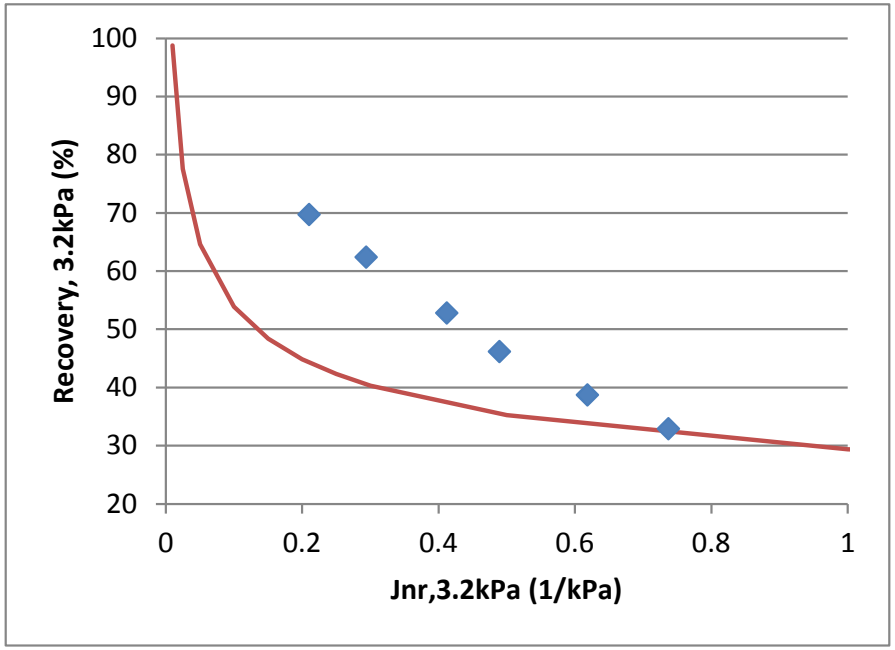
Implementation of the MSCR Test and Specification

- Use of recovery-Jnr curve for evaluating elastic response
  - Some agencies are using the curve as-is
  - Some agencies are specifying a minimum Rec-3.2 value
    - Kentucky has a requirement of Rec-3.2 ≥ 60% for their PG 76-22 asphalt binders (M320) when tested at 64°C
      - Replaces ER
  - Rec-3.2 is determining factor
  - Is curve even needed?
    - Replacement for PG Plus Tests
    - Maximum phase angle

Implementation of the MSCR Test and Specification

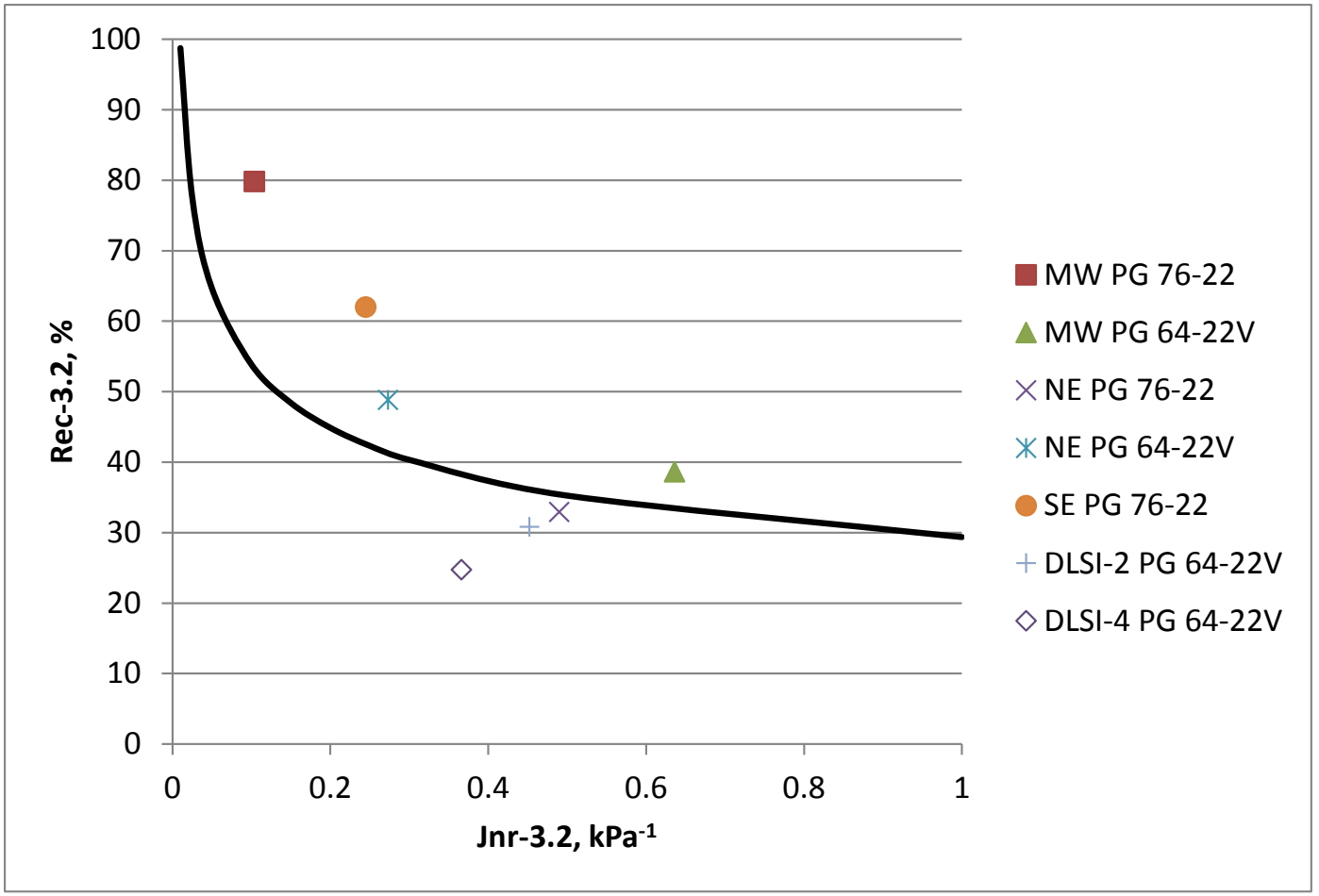
- Use of recovery-Jnr curve for evaluating elastic response





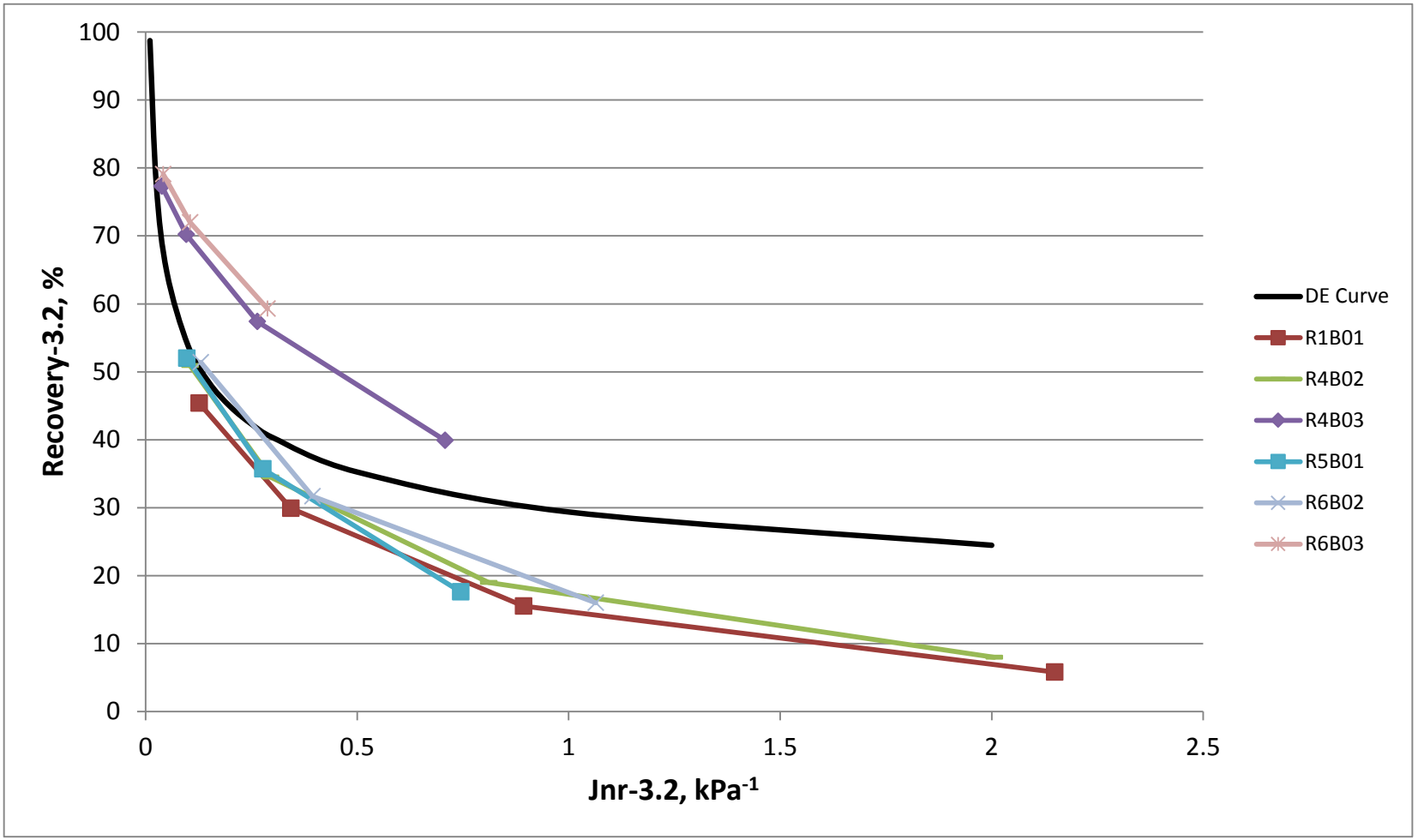
Implementation of the MSCR Test and Specification

- Use of recovery-Jnr curve for evaluating elastic response



Implementation of the MSCR Test and Specification

- Use of recovery-Jnr curve for evaluating elastic response



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- Selection of appropriate test temperature
  - "Standard" environmental temperature
    - Selection of environmental temperature based on LTPPBind 3.1
    - Guidance on the appropriate assumptions needed
      - Similar to AMPT Flow Number
    - Locations that choose "standard" temperature that is different than environmental temperature
      - e.g., choosing 64°C when LTPPBind would suggest that the climate is 58°C
    - Southeastern states that use 67°C as standard temperature

Implementation of the MSCR Test and Specification

- Selection of appropriate test temperature
  - Standard environmental temperature with grade bumping (higher traffic)
  - Standard environmental temperature with grade dumping (RAP and RAS use)
    - Use of a softer grade due to RAP and/or RAS use
    - What temperature for testing?
      - i.e., PG 58-28 is used in a RAP-RAS mix in a 64°C climate
      - Test the PG 58-28 at environmental temperature (64°C)? If so what grade would this be ("R"?) Or test as PG 58S-28 (at 58°C)?

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- Original DSR Criterion
  - Testing at environmental temperature with no change in criterion
  - H, V, and E grades will easily meet criterion at environmental grade
    - $G^*/\sin\delta \geq 1.00$ kPa

Implementation of the MSCR Test and Specification

- Criterion for unmodified asphalt binders ("S" grades)
  - Original criterion was J_{nr} at 3.2 kPa shear stress (Jnr-3.2) ≤ 4.0 kPa^{-1}
  - Changed to ≤ 4.5 kPa^{-1} based on recommendation from Asphalt Binder ETG
    - Asphalt Institute report dated 26 April 2013
    - Presentation at Asphalt Binder ETG Meeting in May 2013 (Raleigh, NC)
  - Concern that change still allows some currently acceptable unmodified asphalt binders (M320) to fail M332.

Implementation of the MSCR Test and Specification

- Criterion for unmodified asphalt binders ("S" grades)

Table 15: Calculated Values of Jnr-3.2 at AASHTO T315 T_c and G*/sin δ at AASHTO TP70 T_c

	Figure 1 (Source A, PG 64-22)	Figure 2 (AI Miscellaneous)	Figure 4 (SHRP MRL)	Figure 31 (SHRP MRL, Multiple Labs)
Jnr-3.2 at AASHTO T315 T_c (where G*/sin δ = 2.20 kPa)	4.70 kPa^{-1}	4.65 kPa^{-1}	4.52 kPa^{-1}	4.65 kPa^{-1}
G*/sin δ at AASHTO TP70 T_c (where Jnr-3.2 = 4.00 kPa^{-1})	2.53 kPa	2.52 kPa	2.46 kPa	2.52 kPa

G*/sin δ at T350 T_c (where Jnr-3.2 = 4.50 kPa^{-1})	2.285 kPa	2.267 kPa	2.209 kPa	2.267 kPa

2.257 kPa

Implementation of the MSCR Test and Specification

- Use and relevance of Jnr-Diff as a specification requirement
  - Indicative of stress-sensitive binders
  - Problem for some current formulations
  - Not a problem for the majority of modified binders
  - Is it needed?

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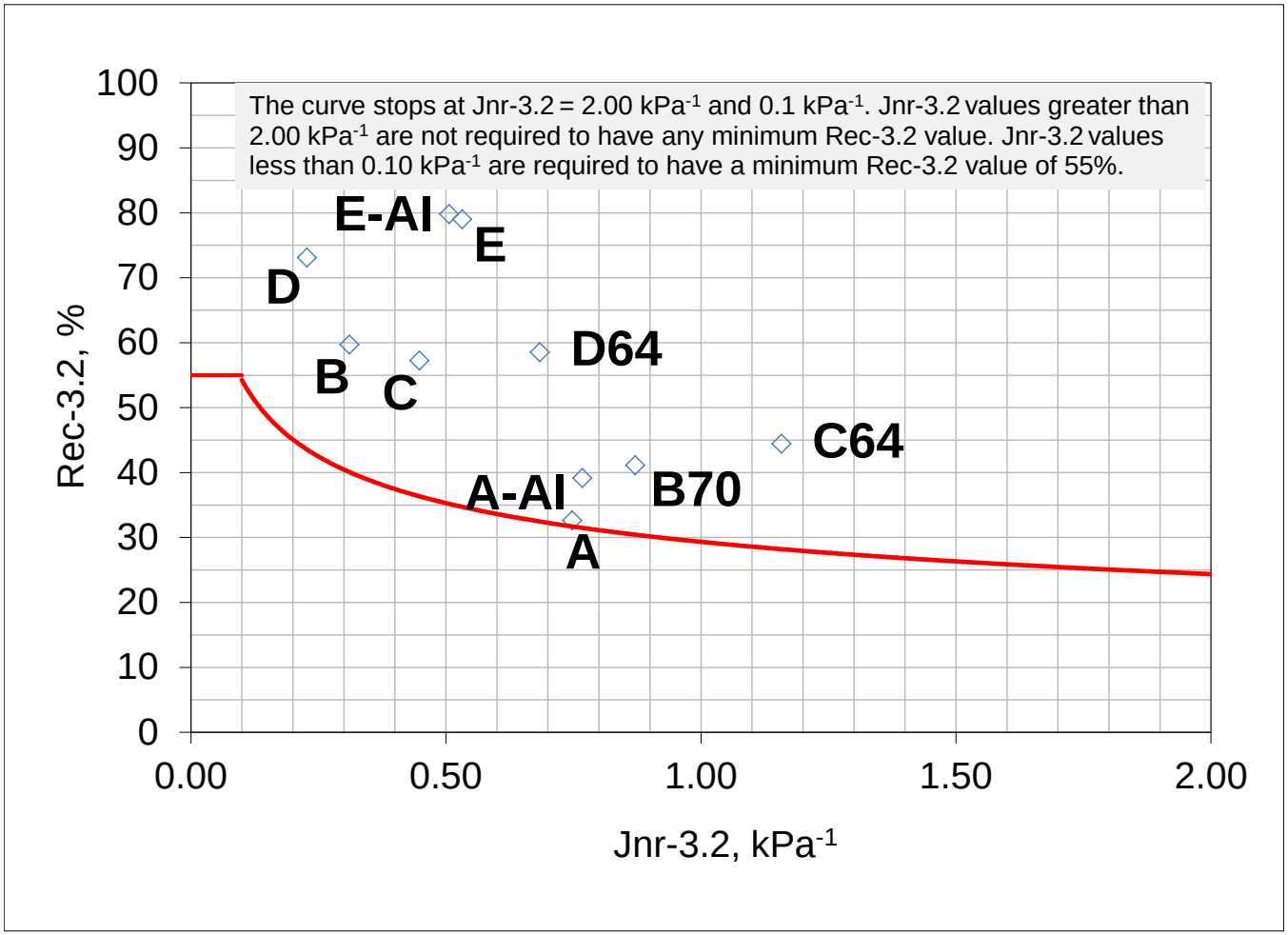
- Use and relevance of Jnr-Diff as a specification requirement

ID	Grade	Temp. (°C)	Jnr-3.2 (kPa^{-1})	Rec-3.2 (%)	Jnr-Diff (%)
A	PG 76-28	64	0.748	32.6	1157
B	PG 70-22ER	64	0.311	59.7	20
C	PG 64-28NV	58	0.448	57.2	42
D	PG 64-28PM	58	0.227	73.1	14
E	PG 58-34PM	58	0.532	79.0	38

Implementation of the MSCR Test and Specification

- Use and relevance of Jnr-Diff as a specification requirement



Implementation of the MSCR Test and Specification

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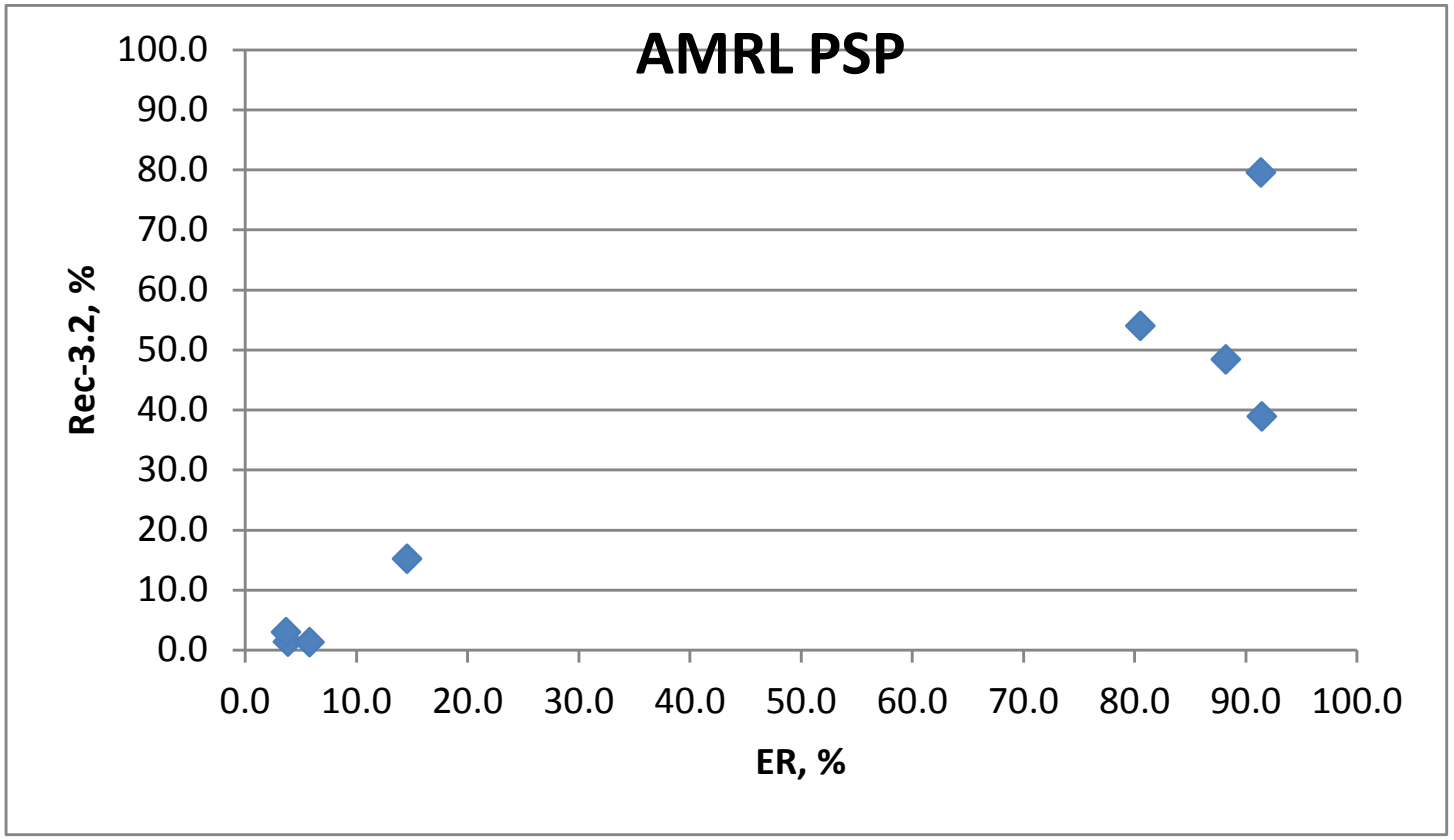

Implementation of the MSCR Test and Specification

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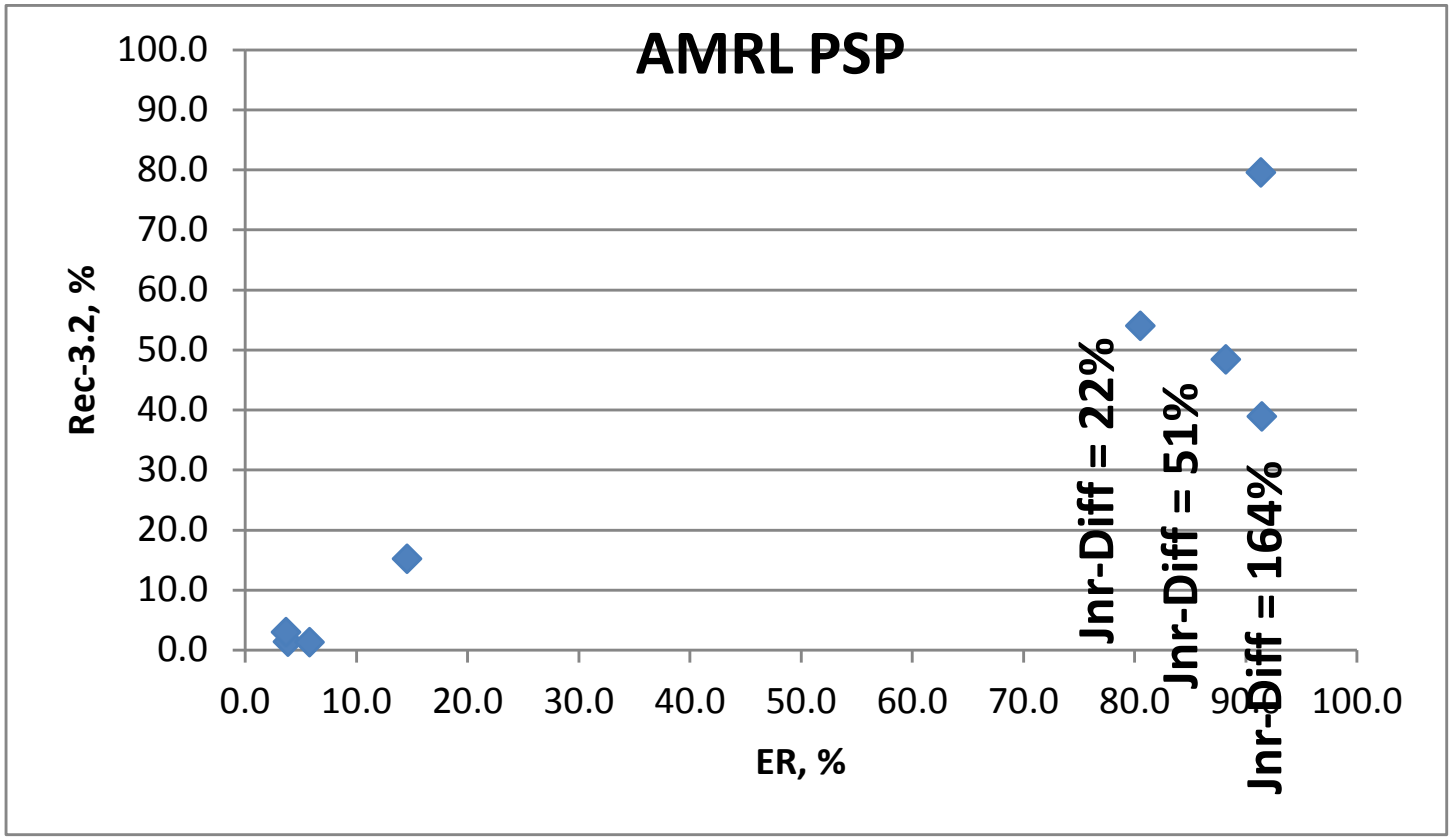

Implementation of the MSCR Test and Specification

- Variability of MSCR test
  - Continued expressed concerns about variability in Jnr and Rec
  - WCTG Data Set
    - Higher test temperature
    - Higher applied shear stress

Implementation of the MSCR Test and Specification

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- Variability of MSCR test
  - WCTG Data Set

COV Comparison of Superpave PG Plus Tests, 2010-2011 samples				
Test	Maximum	Minimum	Average	Median
Ductility, Unaged	21.8%	6.3%	11.8%	10.8%
Ductility, RTFO	17.4%	8.2%	13.9%	13.9%
Toughness, Unaged	23.6%	4.6%	14.9%	14.9%
Tenacity, Unaged	49.0%	8.9%	21.9%	17.9%
Jnr, 3.2 kPa @ PG Temp.	57.0%	5.2%	27.5%	29.1%
Jnr, 3.2 kPa @ PG - 6 °C Temp.	51.1%	6.9%	24.3%	23.9%
Jnr, 10 kPa @ PG Temp.	878.4%	52.0%	137.1%	78.7%
Jnr, 10 kPa @ PG - 6 °C Temp.	237.3%	54.0%	92.8%	77.6%
% Rec, 3.2 kPa @ PG Temp.	58.4%	2.7%	13.8%	6.7%
% Rec, 3.2 kPa @ PG - 6 °C Temp.	18.8%	0.8%	7.2%	3.9%
% Rec, 10 kPa @ PG Temp.	86.5%	12.1%	39.1%	35.1%
% Rec, 10 kPa @ PG - 6 °C Temp.	55.4%	5.6%	22.1%	20.6%
% Elastic Recovery, 25 °C	5.9%	1.0%	2.5%	2.0%
Maximum	878.4%	54.0%	137.1%	78.7%
Minimum	5.9%	0.8%	2.5%	2.0%

Implementation of the MSCR Test and Specification

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Minimum	5.9%	0.8%	2.5%	2.0%

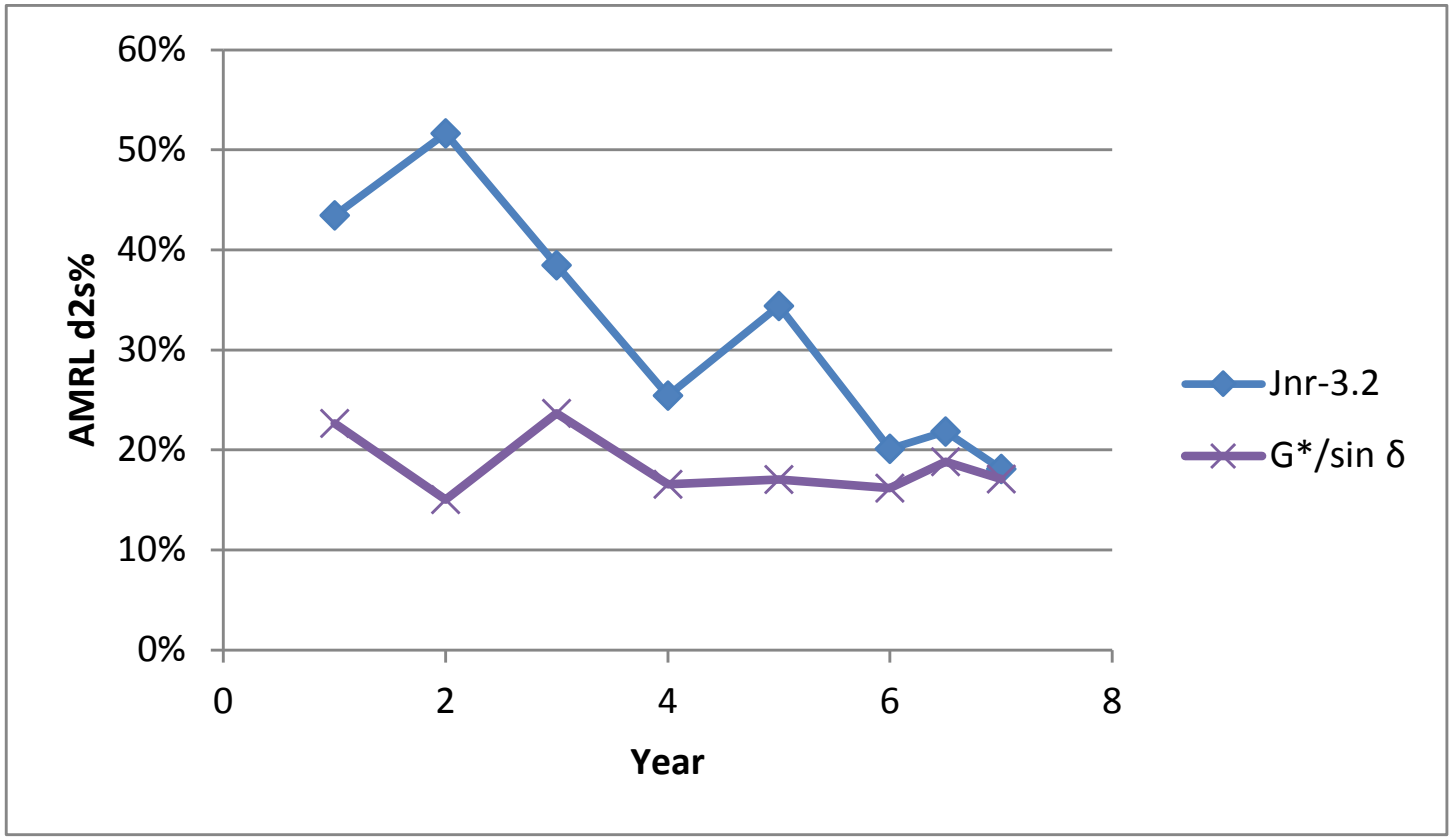
Implementation of the MSCR Test and Specification

- Variability of MSCR test
  - AI-Coordinated ILS
    - d2s% shown for between lab (reproducibility)

ILS	Multi-Lab Rec-3.2	Multi-Lab Jnr-3.2
ETG 2009	18.1%	22.0-42.6%
NEAUPG 2010	18.7%	33.7%
SEAUPG 2011	9.8%	28.0%
NEAUPG 2012	7.6%	33.0%
PCCAS 2013	13.8%	36.8%

Implementation of the MSCR Test and Specification

- Variability of MSCR test
  - AMRL PSP



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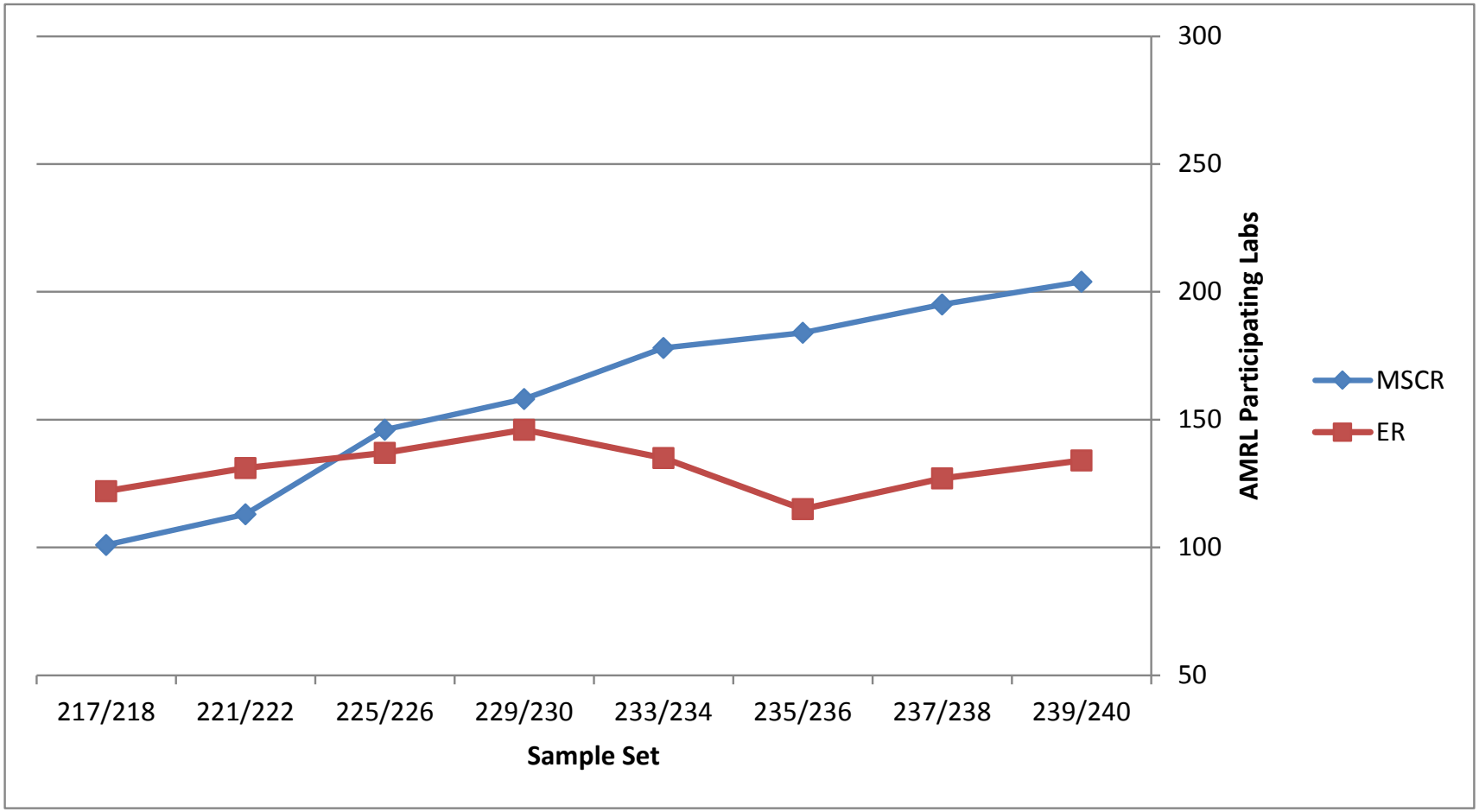

Implementation of the MSCR Test and Specification

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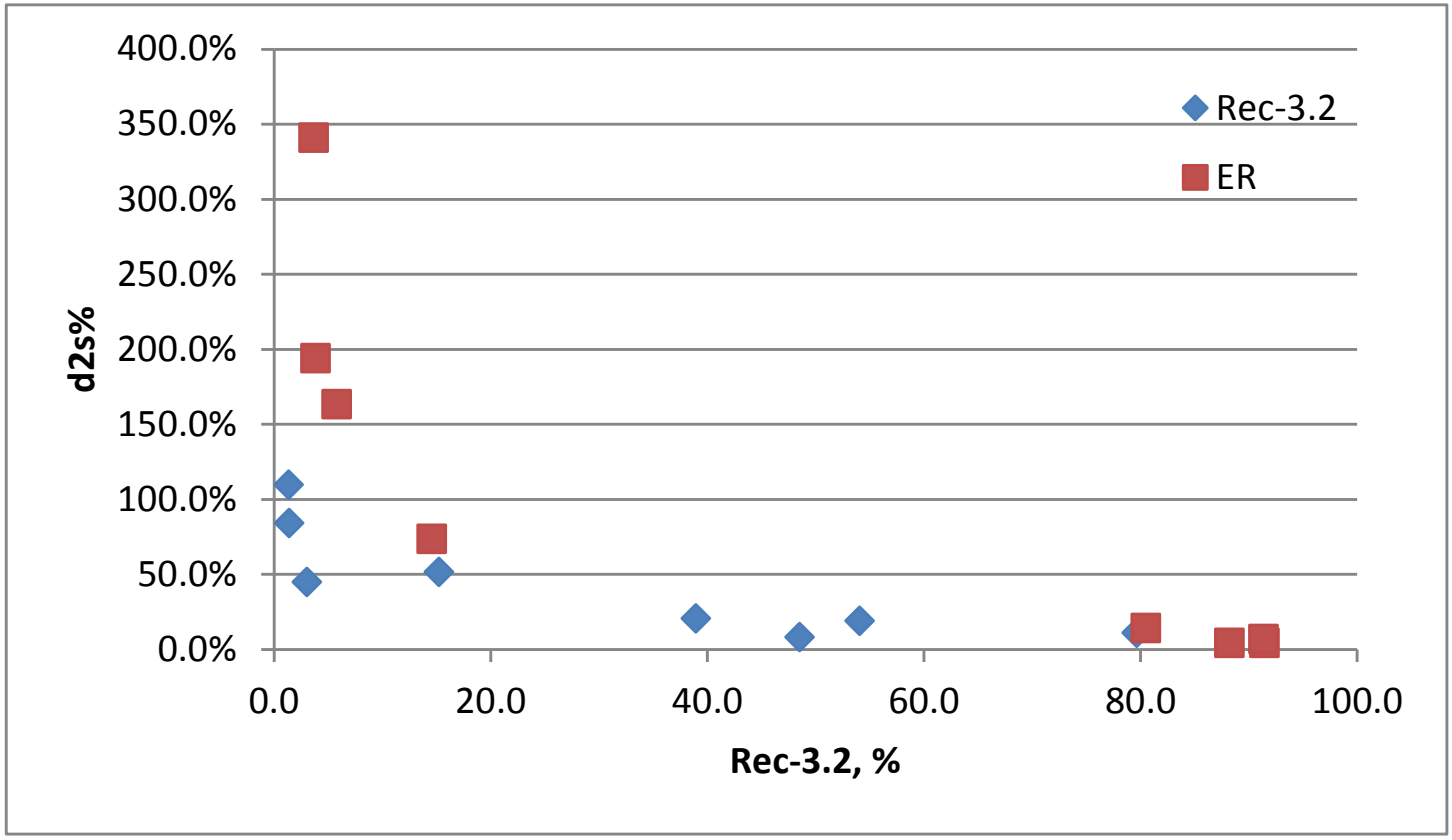


Implementation of the MSCR Test and Specification

- Variability of MSCR test
  - PCCAS ILS (2013)

Table 20: Estimated Repeatability and Reproducibility from ILS

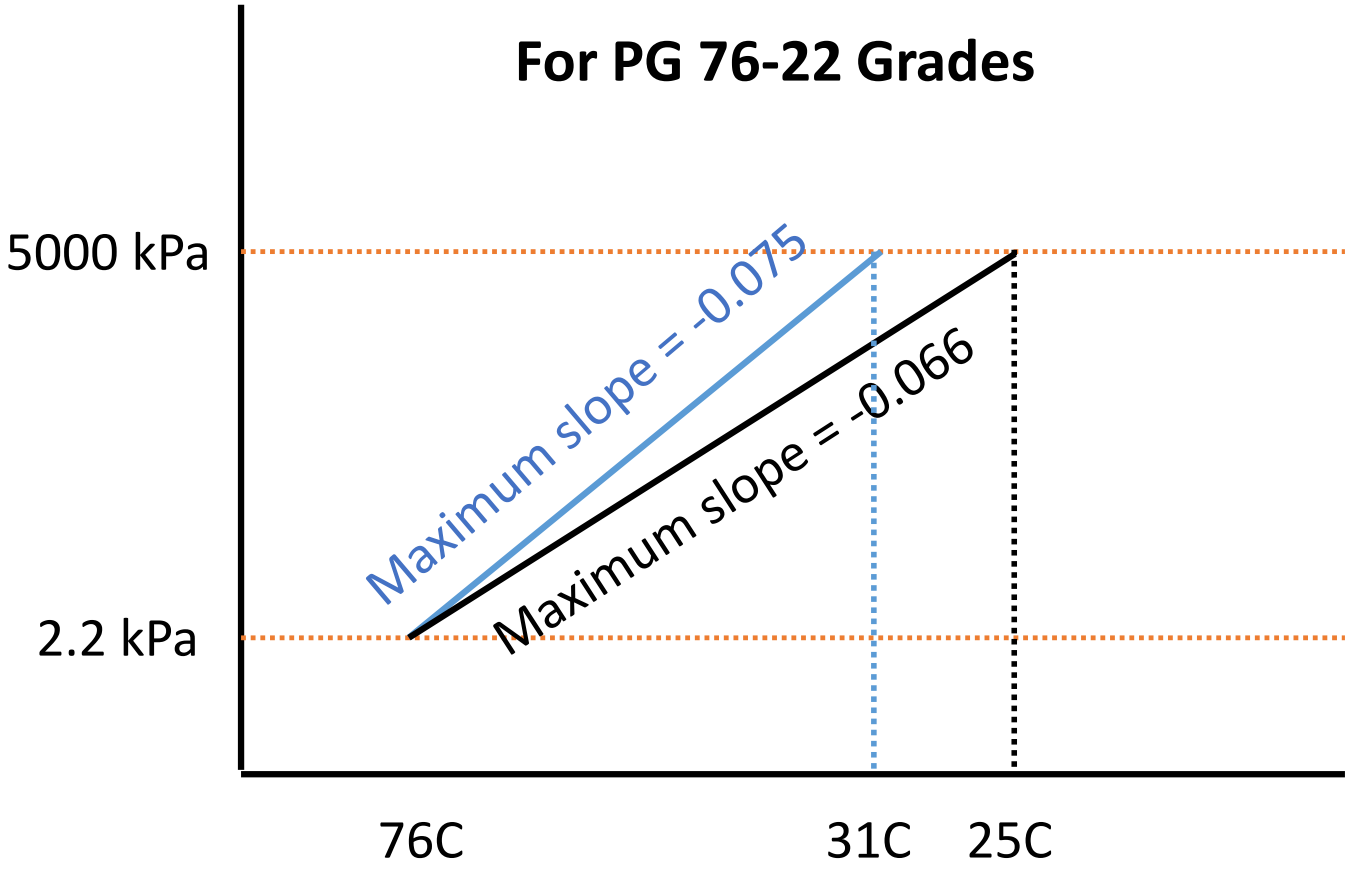
Test	*Acceptable Range of Two Test Results (d2s%) 2013 PCCAS ILS*	
	Single Operator Precision	*Multilaboratory Precision*
Elastic Recovery (RTFO) at 25°C	5.6%	9.2%
R&B Softening Point	2.8%	7.7%
Ductility (Original) at 4°C	17.9%	75.0%
Ductility (RTFO) at 4°C	19.5%	95.1%
Toughness at 25°C	15.3%	29.1%
Tenacity at 25°C	17.9%	30.0%
MSCR Rec-3.2	8.0%	17.3%

Implementation of the MSCR Test and Specification

- Use and criterion for intermediate temperature binder parameter (G*sin δ)
  - Not specifically concern with MSCR
    - Use of G*sin δ as intermediate parameter
    - Change to environmental temperature makes matters worse
      - PG 76-22 would be tested at 31°C and G*sin δ would have to be ≤ 5000 kPa
      - PG 64V-22 would be tested at 25°C and G*sin δ would have to be ≤ 6000 kPa
    - Shouldn't criterion change for each grade (H,V, and E)?

Implementation of the MSCR Test and Specification

- Use and criterion for intermediate temperature binder parameter (G*sin δ)



Implementation of the MSCR Test and Specification

- Quick QC Testing on Original Binder
  - Terminal labs may not have RTFO oven
  - Need to validate presence of modifier and verify grade before shipping
  - MSCR testing on original binder?
  - Use of phase angle as surrogate?

Implementation of the MSCR Test and Specification

- Grade names in AASHTO M332
  - Acceptance of letter designation for traffic
  - Need high temperature (environmental) as part of the grade name to know appropriate test temperature
  - PG designation is still appropriate
    - Still a Performance Graded asphalt binder
      - Even more so since Jnr is better correlated to rutting distress than $G^*/\sin\delta$ for both modified and unmodified binders
  - Education for Designers, truck drivers
  - Confusion of E and V (similar sounds) when ordering
    - Consider “X” instead of “E”?

Implementation of the MSCR Test and Specification

- Inconsistent implementation by specifying agencies
  - We don't have a rutting problem so why do we need a better high temperature parameter?
  - Every M320 grade may not equate to a distinct M332 grade
    - the current polymer loading in a PG 70-22 and PG 76-22 may be high enough that both grade to a PG 64V-22

Implementation of the MSCR Test and Specification

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- MTE Rutting Study: Hamburg WI E10 Fine Mix

PG GRADE (M320)	PG GRADE (MP19)	Test Temp, C	Jnr-3.2 at Test Temp, kPa^{-1}	Rec-3.2, %	HWT Rut Depth at 10,000 Passes, mm
70-22	n/a	75	5.74	0.5	13.2
64-22	64-22S	64	3.40	3.4	7.1
70-22	70-22S	70	2.92	1.5	5.1
70-22	64-22H	64	1.35	4.4	3.6
76-22	64-22E	64	0.24	55.8	1.7
82-22	64-22E	64	0.08	78.5	1.6

Implementation of the MSCR Test and Specification

- Leadership/champion
  - Implementation belongs to everyone
    - PG system had leaders in all areas
      - Researchers
        - Dr. Tom Kennedy, A-001 Research Program Leader
      - Users
        - FHWA (implementation funding and technology transfer)
        - Lead States
      - Industry
        - Expert Task Group
        - Suppliers
    - Need leaders in user agencies, industry

Implementation of the MSCR Test and Specification

- Suggestions for Path Forward
  - Need to repackage message
    - What should have been done as PG system was implemented was to change high temperature criterion as grade was bumped (due to traffic)
    - Need to change criterion rather than test temperature
    - Recognize that this is a major specification change instead of just focusing on MSCR as a new test
      - Truer to concept of a performance-based specification
      - Next step in evolution of specification

Thanks!