MSCR vs AASHTO M320 – High Temperature Grade for HPTO

Thomas Bennert, Ph.D.
Rutgers University, NJ
Center for Advanced Infrastructure and Transportation (CAIT)

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Problem Background

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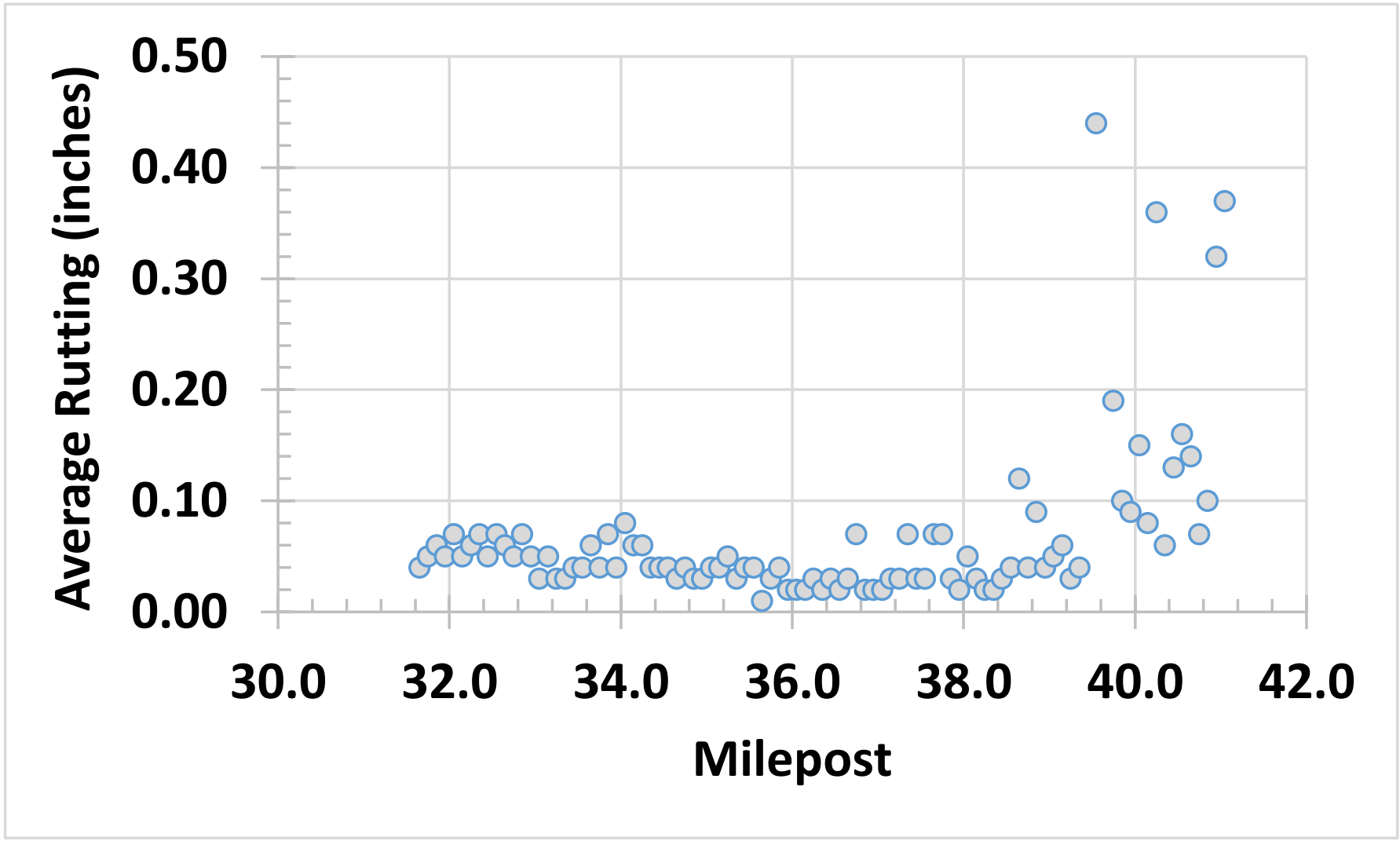
- In 2006, NJDOT began using HPTO using a polymer-modified PG76-22 asphalt binder
  - HPTO = High Performance Thin Overlay
  - NJDOT utilizes for thin-lift applications
  - Performance-Based design requiring APA (AASHTO T340) rutting requirement
  - General design
    - 4.75mm NMAS (fine 9.5mm NMAS)
    - Asphalt content > 7%
    - Design AV% = 3.5%
    - Design Gyrations = 50 gyrations

Problem Background

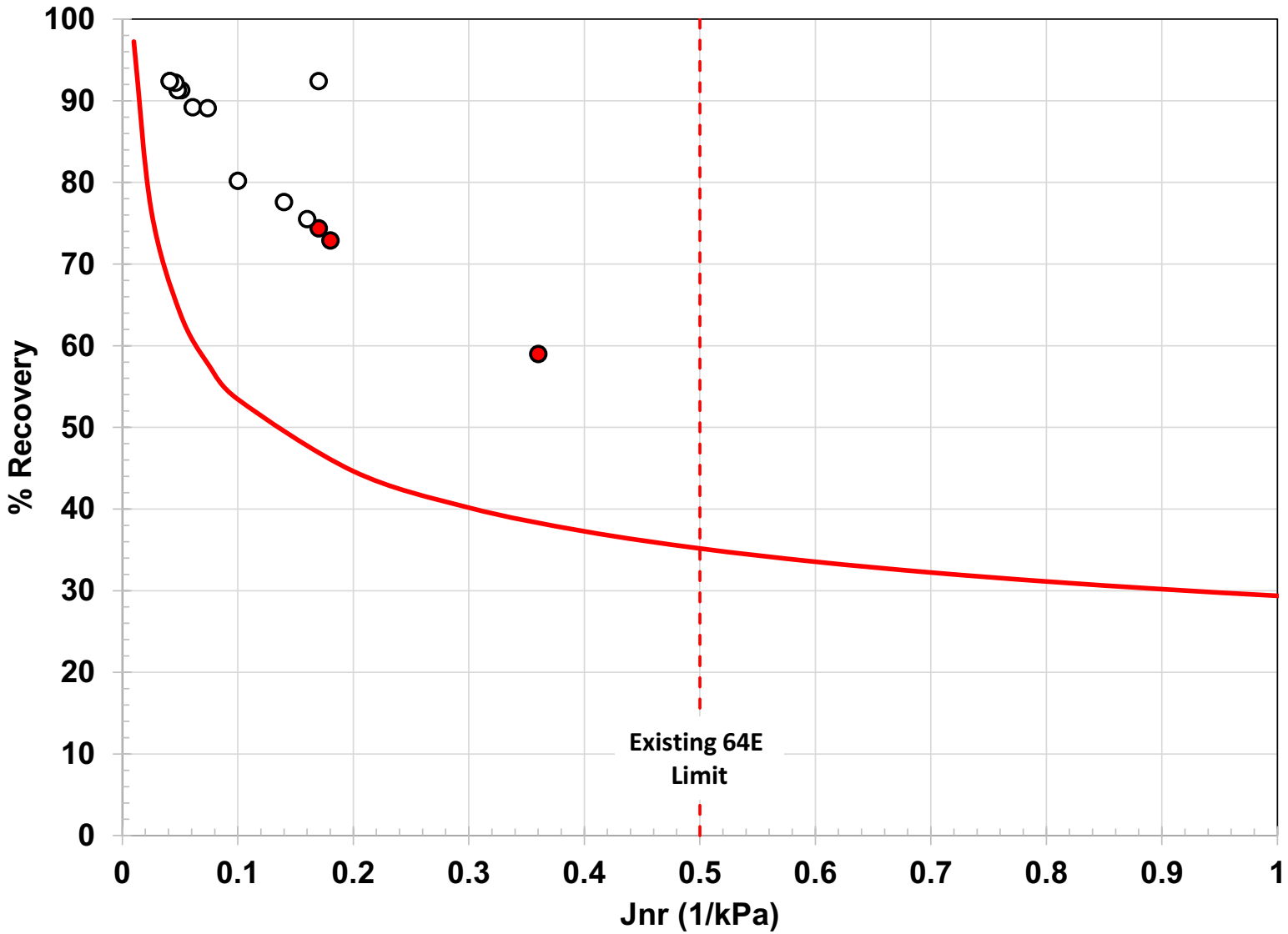
- Some issues in 2015 regarding failing HPTO mixtures specified using PG64E-22 asphalt binder
  - Minimal previous issues prior to PG64E use (i.e. – AASHTO M320)

Date	Original	RTFO	PG Grade	Jnr (1/kPa)	% Rec	MSCR Grade	δ @ 76C (Orig)	δ @ 76C (RTFO)	APA (mm)
5/27/2015	77	76.6	PG76	0.36	59	PG64E	73.6	68.3	6.56
5/28/2015	78.8	78.8	PG76	0.18	72.9	PG64E	69.5	64.5	6.23
5/29/2015	79.6	79.6	PG76	0.17	74.4	PG64E	69.9	64.5	6.5
6/3/2015	78.3	78.7	PG76	0.16	75.5	PG64E	69.6	63.5	6.84
6/4/2015	86.5	79	PG76	0.17	92.4	PG64E	58.9	58.4	3.66
6/5/2015	84.2	78.6	PG76	0.14	77.6	PG64E	65.4	64.8	3.87
6/9/2015	87	81.1	PG76	0.061	89.2	PG64E	60.7	60.1	3.92
6/10/2015	83.7	81.7	PG76	0.1	80.2	PG64E	66	61.8	4.32
6/11/2015	86.3	80.9	PG76	0.051	91.3	PG64E	60.8	58.4	3.98
6/12/2015	82.4	81.2	PG76	0.048	91.3	PG64E	66.8	60.4	3.73
6/17/2015	87.5	81.8	PG76	0.046	92.2	PG64E	60.6	57.9	3.83
6/18/2015	87.6	82.6	PG82	0.041	92.4	PG64E	61.2	59.2 @ 82C	2.94
6/19/2015	86.5	82.3	PG82	0.041	92.4	PG64E	59.2	59.2 @ 82C	2.73
6/24/2015	83.8	79.5	PG76	0.074	89.1	PG64E	62	59.7	3.99

2016 PMS Data (August, 2016)

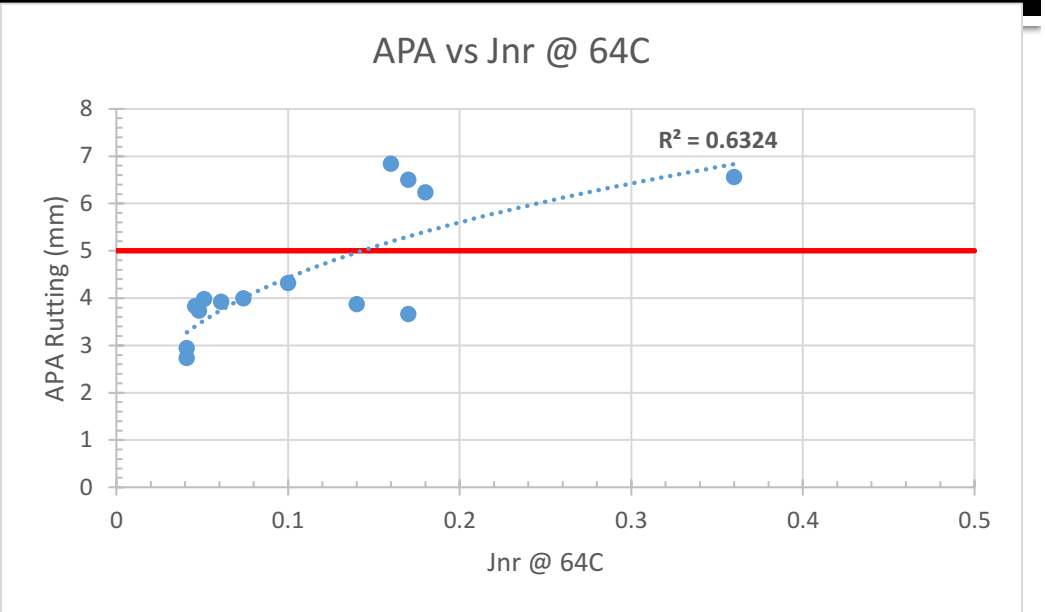


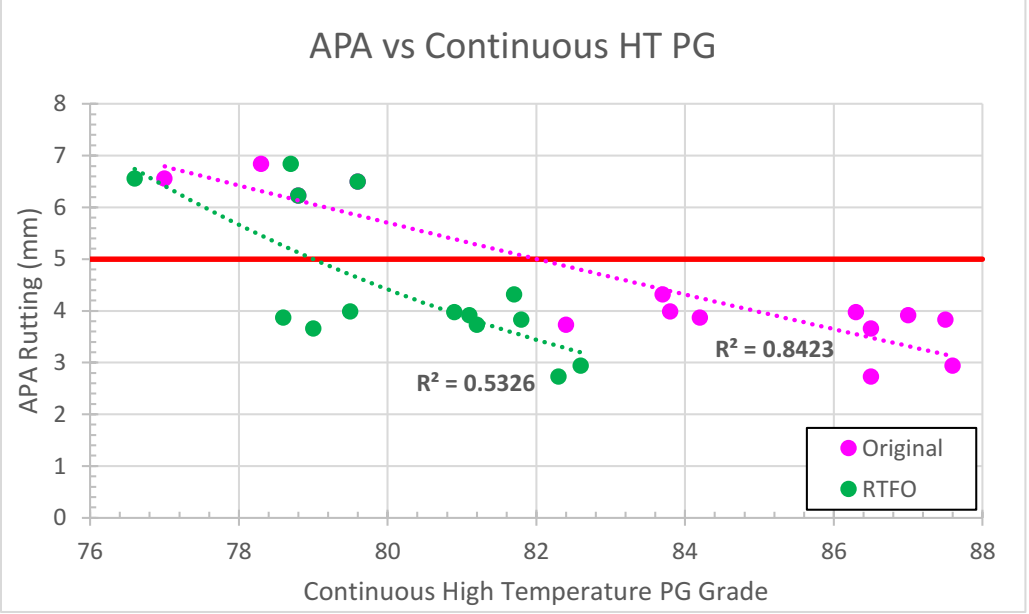
2015 Failing HPTO Binders



Results of 2015 Testing (1 of 2)

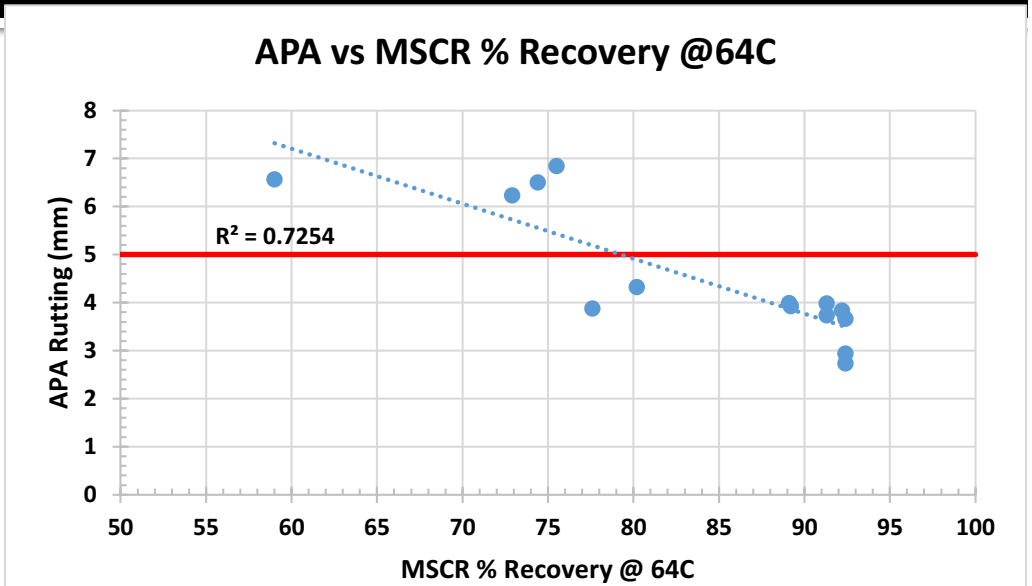
- Jnr > 0.16 resulted in failing APA rutting
- RTFO PG grade < 79° resulted in <u>failing</u> APA rutting
- Orig PG Grade < 82° resulted in <u>failing</u> APA rutting
- Binders from retains taken at plant during production

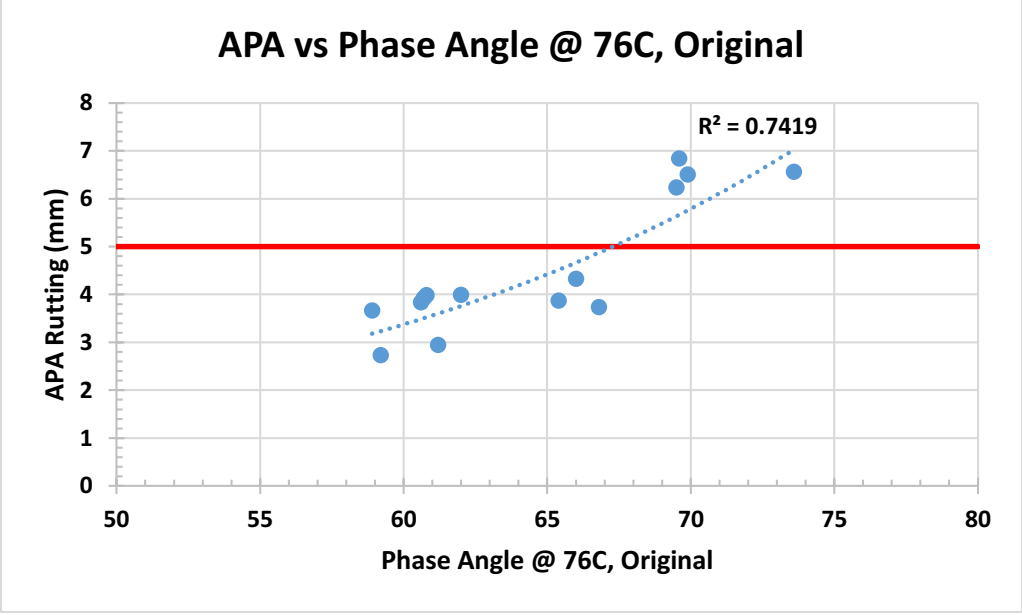




Results of 2015 Testing (2 of 2)

- MSCR % Recovery < 77% resulted in <u>failing</u> APA rutting
- Orig δ @ 76°C > 67 degrees resulted in <u>failing</u> APA rutting

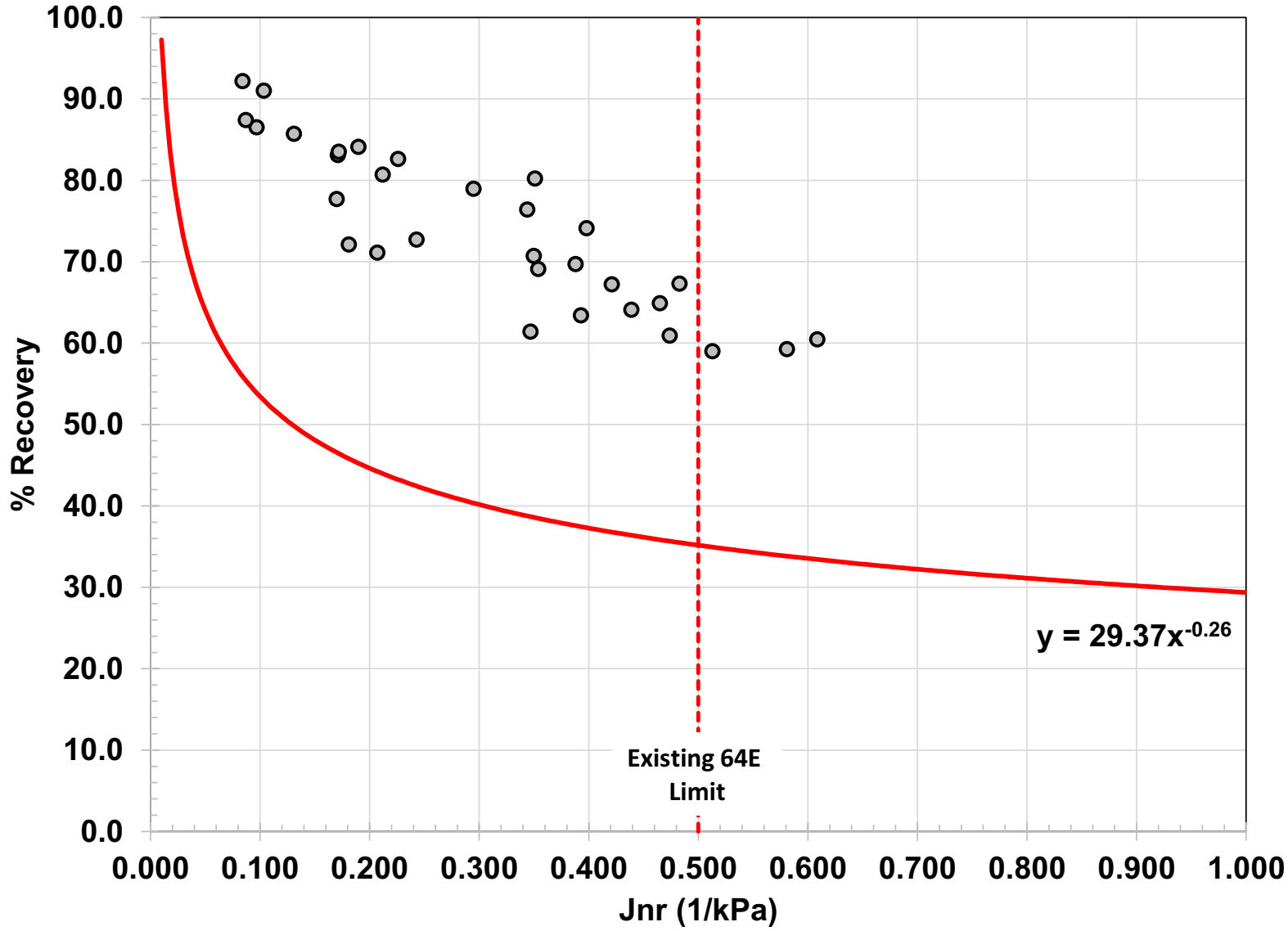




2015 PANYNJ Issues

- At the same time, Rutgers working with PANYNJ on high temperature binder issues
  - 31 Cores taken from areas where failed binder retains occurred – sent to Rutgers for recovery, PG grading – MSCR also conducted
    - PANYNJ specified job for PG76-22; not using MSCR yet
  - All 31 cores failed for high temp of 76°C; 28 were at 70°C, 3 were 64°C
  - 28 of 31 cores PASSED for a PG64E-22

PANYNJ Cores
(All Samples Failed PG76 High Temp)



Question?

- During MSCR implementation, northeast states tested binders, that at the time, met the current PG grade
  - Compared MSCR results to PG grades to help establish equivalent M332 traffic levels
    - NJDOT agreed that PG76-22 (at that time) would meet a PG64E
- Now that MSCR has been implemented, are states that are used to getting previous binder performance, still receiving those binders?
  - Or has binder modification now changed to meet M332, creating binders that no longer compare to what states were previously receiving under M320?

MSCR Jnr Divisions

- Where did the Jnr grading divisions come from?
  - Spoke with John D'Angelo
  - Neat binders for regional climate usually around and under 4.0 to 4.5 1/kPa
  - When conducting mixture testing, every ≈50% reduction in permanent deformation was approximately a ≈50% reduction in Jnr
  - So, original divisions went from: 4.0 to 2.0 to 1.0 to 0.5
  - Should Jnr divisions be revisited now that suppliers are formulating binders based on M332?

Laboratory Testing Program

M332 vs M320 HPTO Binder Spec

- Testing program
  - Procure 8 binders from different suppliers consisting of different sources and modifications
  - PG grade according to M320 and M332
  - Use binders in a NJDOT approved HPTO mix and conduct testing after; 1) Volumetric Conditioning and 2) STOA Conditioning
    - APA @ 64C (Standard for HPTO Spec)
    - Flow Number @ 54C (Using NCHRP 9-33 protocols)
  - Compare binder to mixture performance and determine if current MSCR requirements are appropriate for NJDOT HPTO

New Jersey Department of Transportation

HMA Mix Design

04/09/2015

Region: North

Mix ID#	N01DN0201VIR	Effective Date	6/3/2013
Mix Type	HMA, HIGH PERFORMANCE THIN OVERLAY	Expiration Date	5/1/2016
Producer	TILCON - MOUNT HOPE, NJ (HMA PLANT)	Verification Type	Lab Verification
Mix Temp. (F)	330	Designer	REBECCA GUARDINO
Compaction Temp. (F)	312.5		

SIEVE SIZE Inch	SIEVE SIZE mm	Job Mix Formula	Broadband min.	Broadband max.	Production Tolerances min.	Production Tolerances max.
2	50		100	100		
1 1/2	37.5		100	100		
1	25		100	100		
3/4	19		100	100		
1/2	12.5		100	100		
3/8	9.5	100	100	100		
No.4	4.75	77	65	85		
No.8	2.36	43	33	55		
No.16	1.18	29	20	35		
No.30	0.6	21	15	30		
No.50	0.3	14	10	20		
No.100	0.15	7	5	15		
No.200	0.075	5.2	5.0	8.0		

Tests Performed	Test Results	Test Criteria min.	Test Criteria max.
%Air Voids (Va)	3.52		
%VMA	20.5	18	
%VFA	83		
Dust/Asphalt Ratio	0.7	0.6	1.3
Drain Down			
VCA - Mix			<VCA dry
VCA - dry			
Max. Sp.Grav. (Gmm)	2.387		
Bulk Sp.Grav. (Gmb)	2.303		
% Gmm @ N Max			
Sp. Grav. of Binder (GB)	1.028		
Sp. Grav. of Agg. Blend (Gsb)	2.688		
Moist.Sensitivity TSR	85.1		
lbs./Square Yard/Inch	107.82		
% Gmm @ N Design		95.5	97.5
Ignition Oven Agg. Correction Factor.CFI		0.14 @ 538 Degrees C	
% Absorbed AC	0.37		

COMPONENT MATERIALS	TOTAL MIX %	COMPONENTS - PRODUCER &
AGGREGATES, STONE SAND, WASHED	16.7	TILCON NEW JERSEY - MOUNT HOPE, NJ (AGGREGATE)
AGGREGATES, STONE SAND, UNWASHED	30.6	TILCON NEW JERSEY - MOUNT HOPE, NJ (AGGREGATE)
AGGREGATES, COARSE, *9, BROKEN STONE	44.6	TILCON NEW JERSEY - MOUNT HOPE, NJ (AGGREGATE)
AGG. FOR HMA, MINERAL FILLER	0.9	TILCON NEW JERSEY - MOUNT HOPE, NJ (AGGREGATE)
ASPHALT, BINDER, GRADE PG64-E -22	7.2	NJDOT APPROVED BINDER

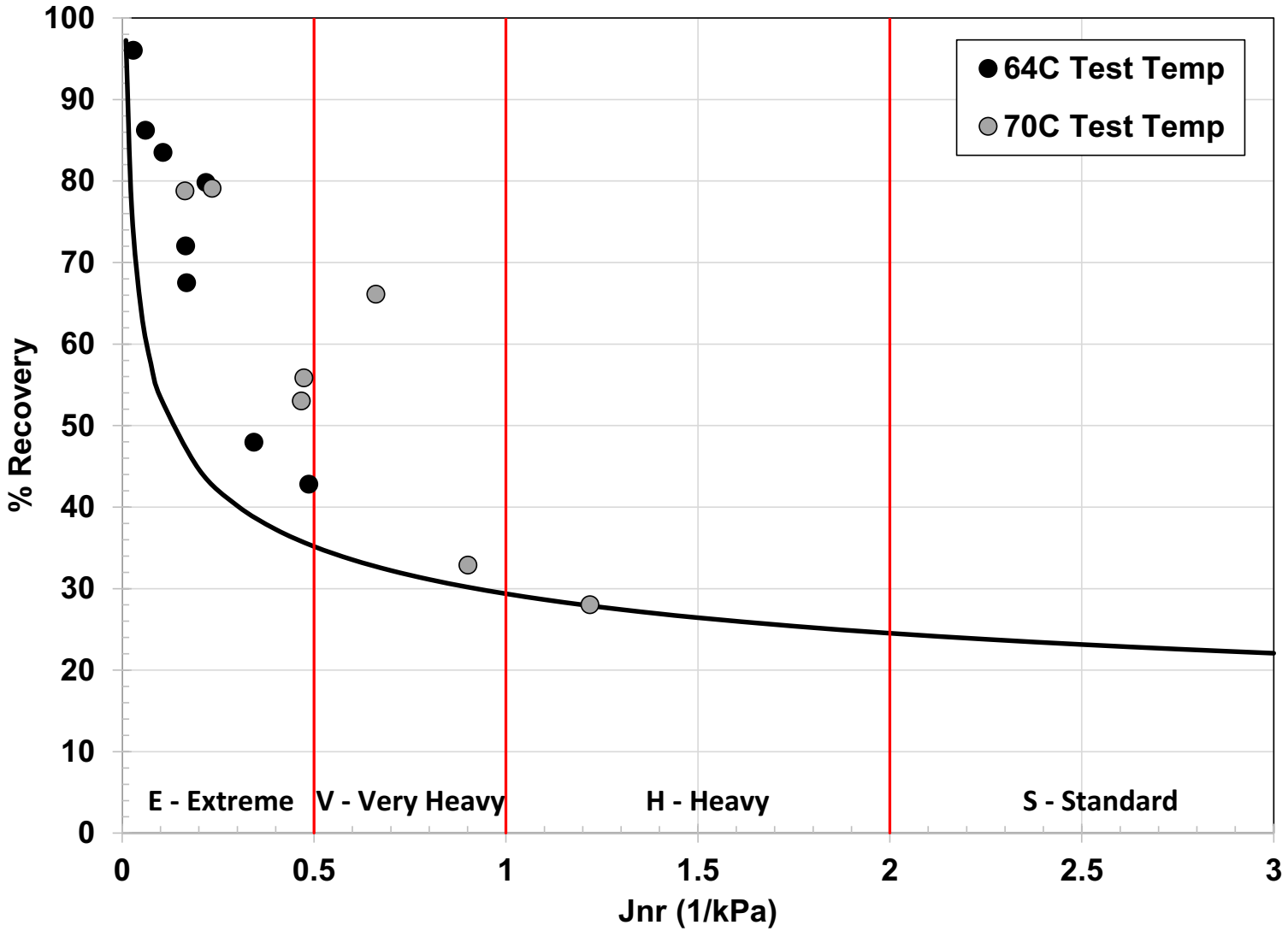
Remarks: APA AASHTO TP63 <4.0mm = 3.83mm
DRAINDOWN 0%< MAXIMUM 0.1%

Asphalt Binders in Study

Supplier	Description
Road Science	Southeast Phase Angle
Road Science	NJDOT - PPA + SBS
Road Science	NYSDOT - SBS Only
All States	NYSDOT - SBS Only
Axeon	76-22 (Pre-MSCR)
Axeon	PG64E-22 2016
Lion Oil	4.25% SBS
Suit Kote	PG64E-22 2016

Asphalt Binder Test Results

AASHTO M332 Results

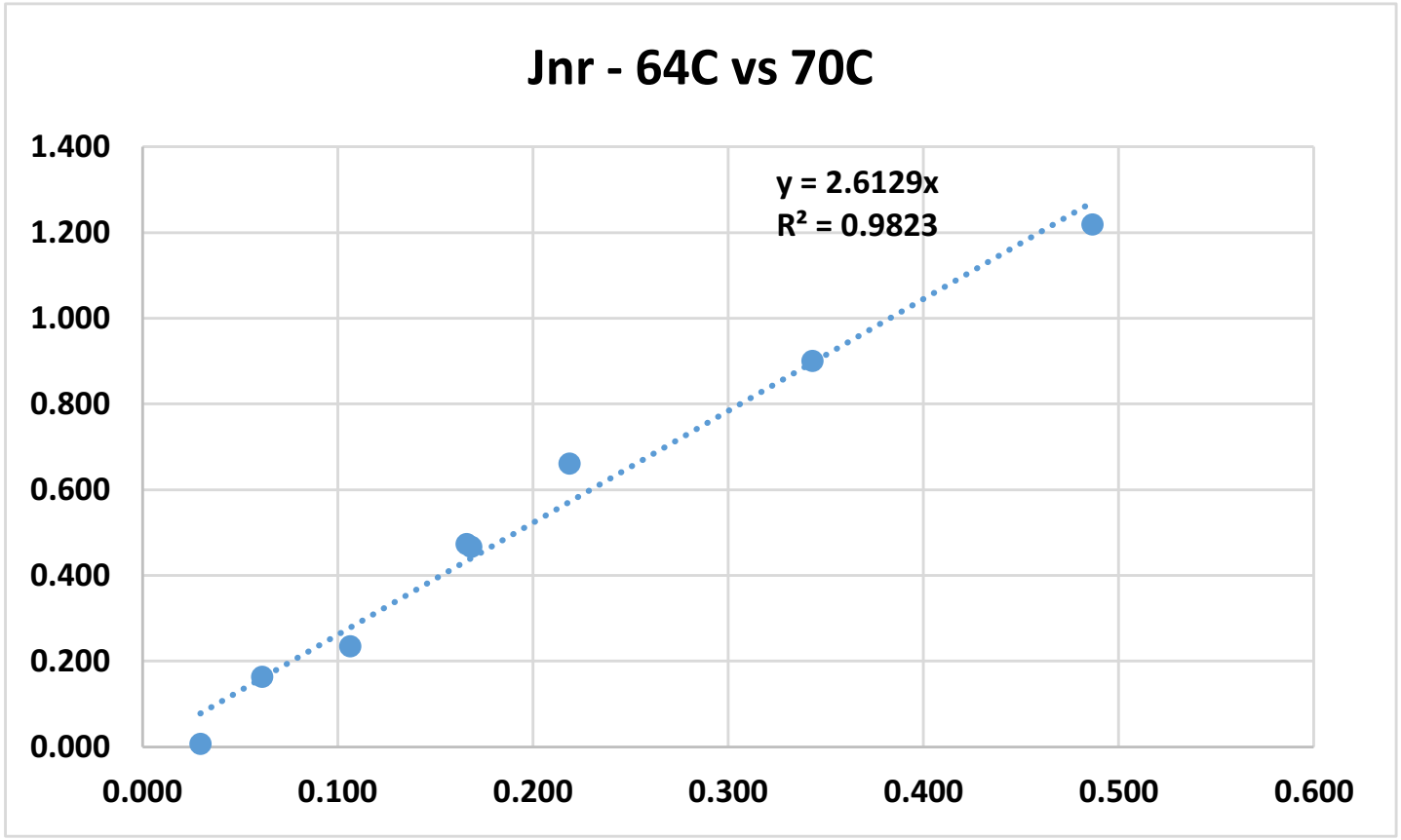


AASHTO M320 Results

Supplier	Description	Orig Continuous High Temp	RTFO Continuous High Temp	Orig Phase Angle @ 76C	RTFO/Orig	RTFO - Orig
Road Science	Southeast Phase Angle	81.5	80.9	69.6	0.99	-0.6
Road Science	NJDOT - PPA + SBS	80	81.2	71.5	1.02	1.2
Road Science	NYSDOT - SBS Only	83.6	82.9	66.4	0.99	-0.7
All States	NYSDOT - SBS Only	76.4	74.8	68.5	0.98	-1.6
Axeon	76-22 (Pre-MSCR)	79.3	78.3	75.9	0.99	-1.0
Axeon	PG64E-22 2016	80.4	78.4	74.7	0.98	-2.0
Lion Oil	4.25% SBS	85.7	78.7	60.5	0.92	-7.0
Suit Kote	PG64E-22 2016	82.5	79.1	64.5	0.96	-3.4

Change in Jnr Due to Change PG Grade Test Temp

- Changing 6°C (1 PG grade test temp) in Jnr test from 64C to 70C reduced Jnr by 62%



Change in Jnr Due to Change PG Grade Test Temp

- Looked at additional change in temps and included another 14 binders (n = 22) to check on consistency of Jnr change

- On average, when increasing test temp by 6°C, Jnr reduces by 60%, or becomes 40% of the previous test temperature's value

All	**2.52**
	40%
58C to 64C	**2.39**
	42%
64C to 70C	**2.53**
	39%
70C to 76C	**3.11**
	32%
76C to 82C	**2.48**
	40%

Jnr Requirement Determined within PG Grade "Bump"

- Hypothesis: since we are still using 6°C intervals for testing, should the Jnr divisions be modified to represent how the binder is performing within these test temperatures?

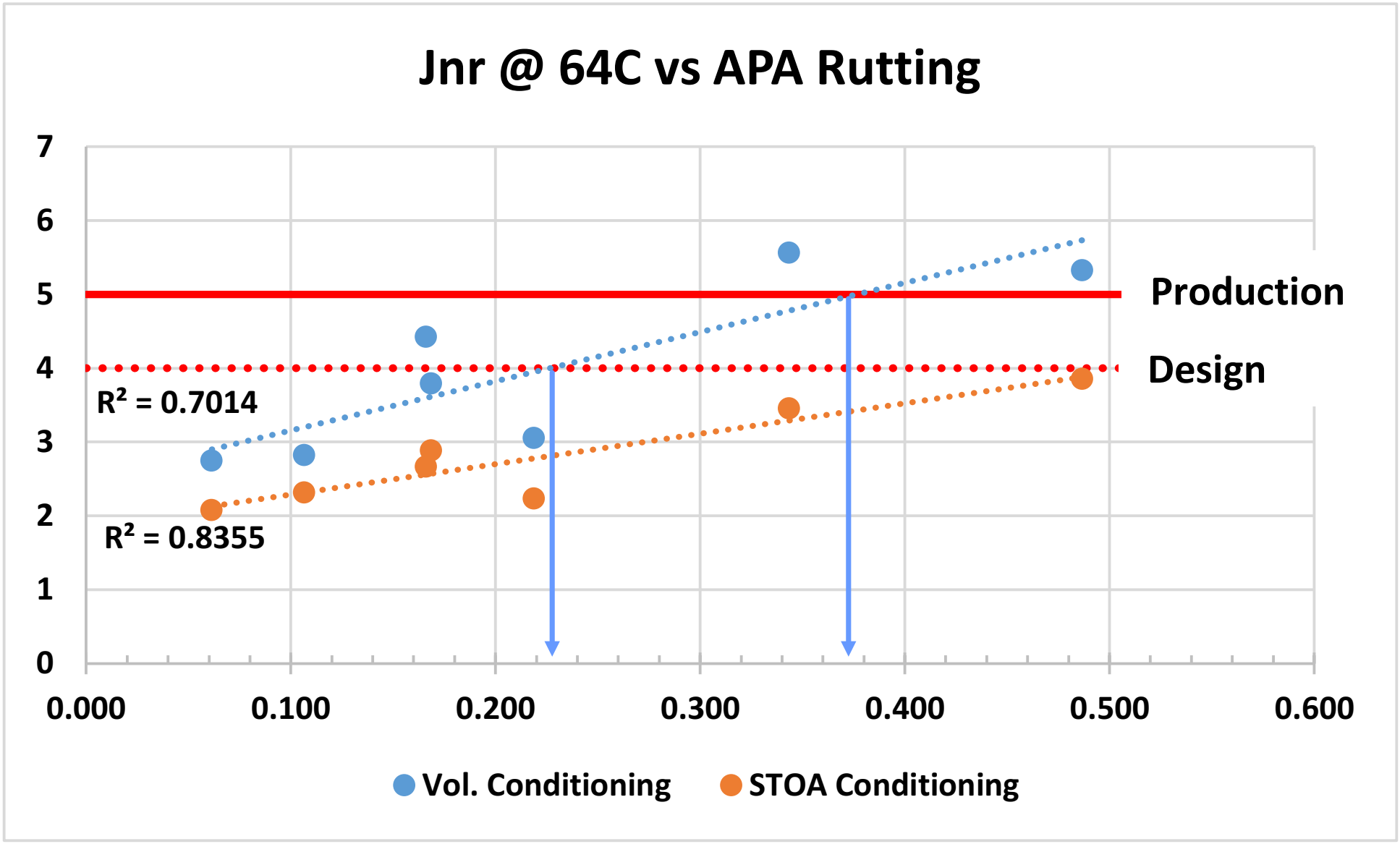
Traffic Designation	AASHTO M332	Based on PG Temp "Bump"
S	4.5	4.5
H	2.0	1.8
V	1.0	0.7
E	0.5	0.3

Mixture Test Results

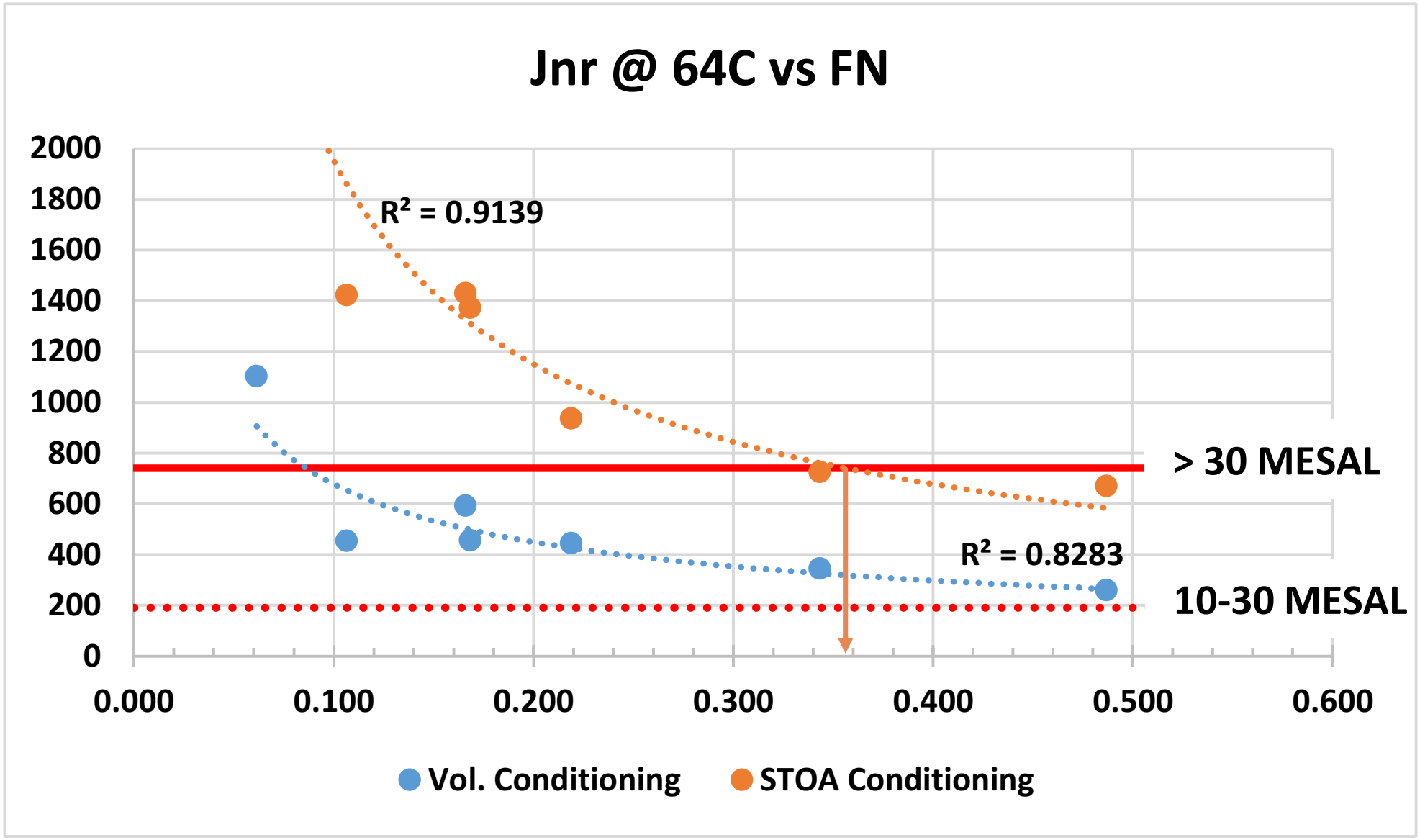
Mixture Test Results

Supplier	Description	APA Testing		Flow Number	
		Volumetric Conditioning	STOA Conditioning	Volumetric Conditioning	STOA Conditioning
Road Science	Southeast Phase Angle	4.43	2.67	593	1430
Road Science	NJDOT - PPA + SBS	3.8	2.89	455	1373
Road Science	NYSDOT - SBS Only	2.75	2.08	1104	3449
All States	NYSDOT - SBS Only	3.06	2.24	445	936
Axeon	76-22 (Pre-MSCR)	5.33	3.86	260	669
Axeon	PG64E-22 2016	5.57	3.46	346	726
Lion Oil	4.25% SBS	2.67	2.87	710	679
Suit Kote	PG64E-22 2016	2.83	2.32	455	1422

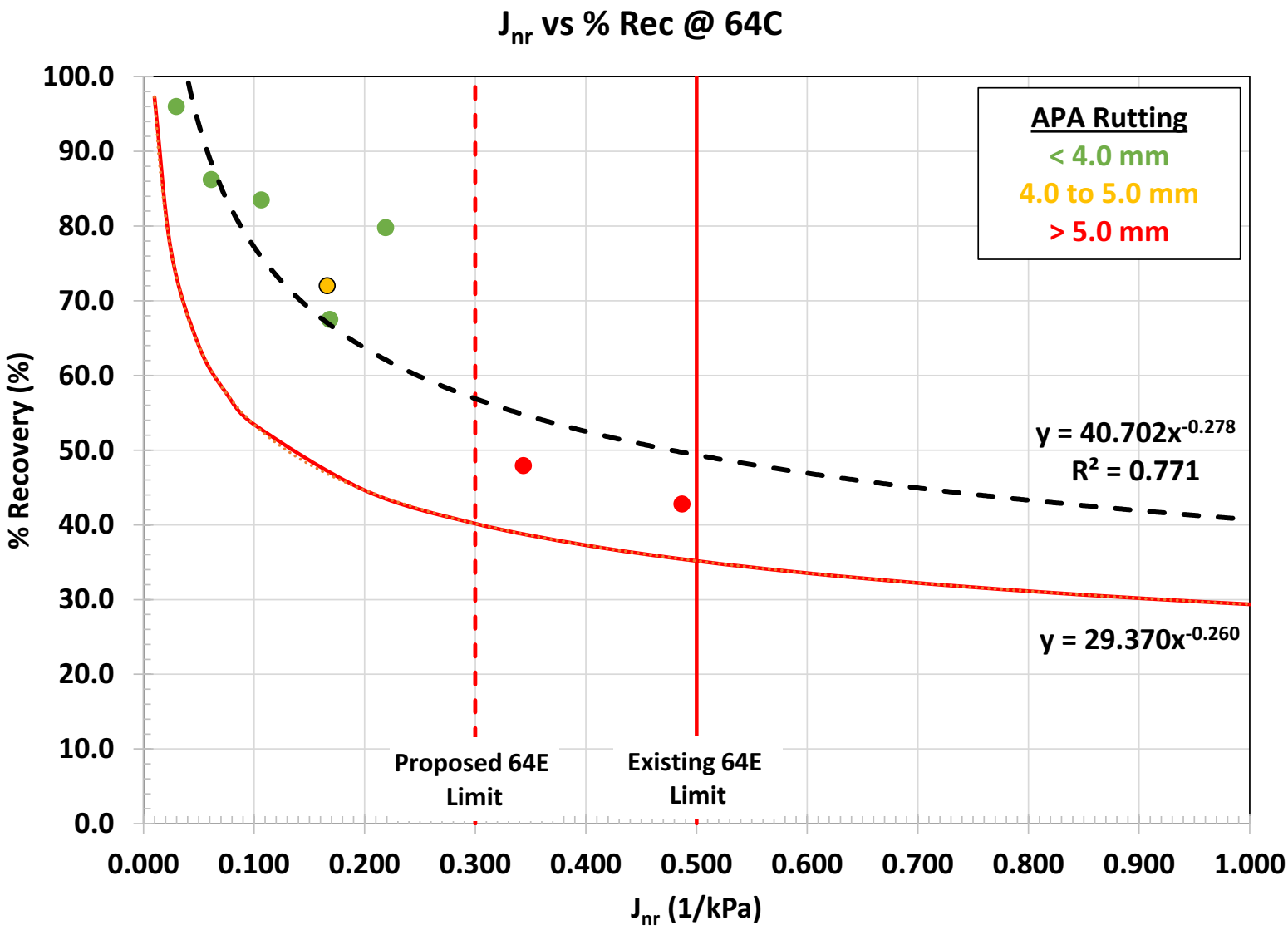
APA vs MSCR Jnr @ 64C



AMPT FN vs MSCR Jnr @ 64C



APA Results within MSCR



Study Conclusions

- Question: Will using current PG64E provide the same rutting resistance as previous PG76 for NJDOT's HPTO mixtures?

- Answer: It appears that the current M332 divisions may need to be modified for NJDOT HPTO mixtures
  1. APA rutting for Volumetric Conditioning shows
     1. < 0.37 for Production APA rutting
     2. < 0.23 for Design APA rutting
  2. Flow Number for STOA Conditioning shows
     1. < 0.35 for traffic levels > 30 MESAL's
  3. MSCR Jnr limit of 0.3 kPa^{-1} was able to differentiate PASSING/FAILING HPTO mixtures using Production tolerance.

NJDOT Moving Forward

- To elevate issues with binder grade with HPTO, NJDOT is utilizing Performance-Related specifications
  - APA rutting requirement
  - Overlay Tester fatigue requirement

"Use polymer modified asphalt binder that is specially formulated for meeting the mix performance criteria in this specification. Consult with the asphalt binder supplier to obtain the appropriate material for the specific mix design. Submit a certificate of analysis (COA) showing the PG continuous grading (AASHTO R 29) for the asphalt binder used in the mix design."

Final Thoughts

- In adopting MSCR for high temperature, many states looked at how their PG binders were fitting into the MSCR system.
  - Example: NJDOT acknowledged that previous PG76-22 would have fell into 64E designation (Jnr < 0.5 kPa^{-1})
- However, have we looked back now to see how the binders we are currently getting (modified to meet MSCR) would have fit into our previous PG system?
  - Are they what we were used to receiving?
  - If not, will performance change?


Thank you for your time!
Questions?
Thomas Bennert, Ph.D.
Rutgers University
609-213-3312
bennert@rci.rutgers.edu