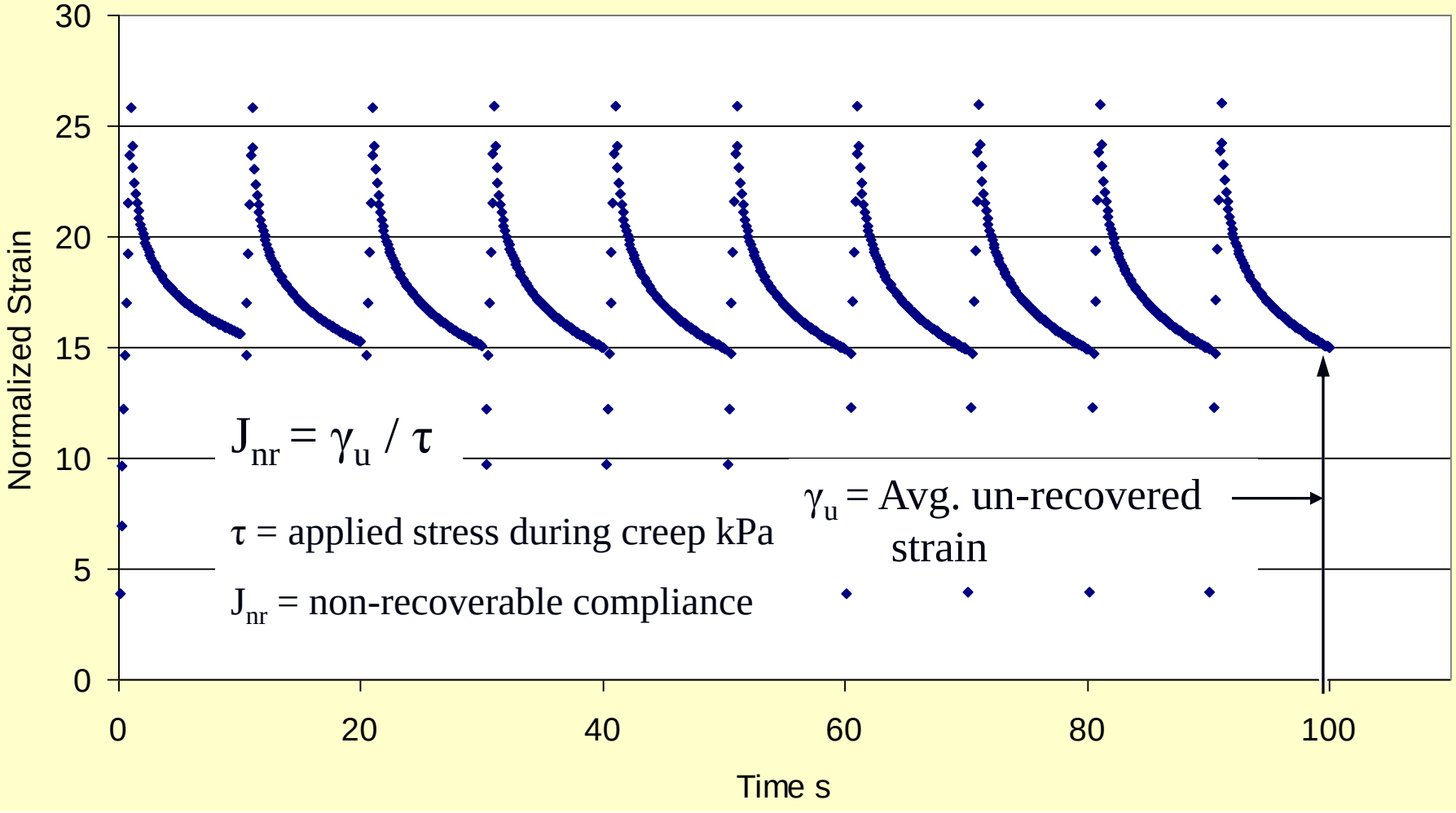
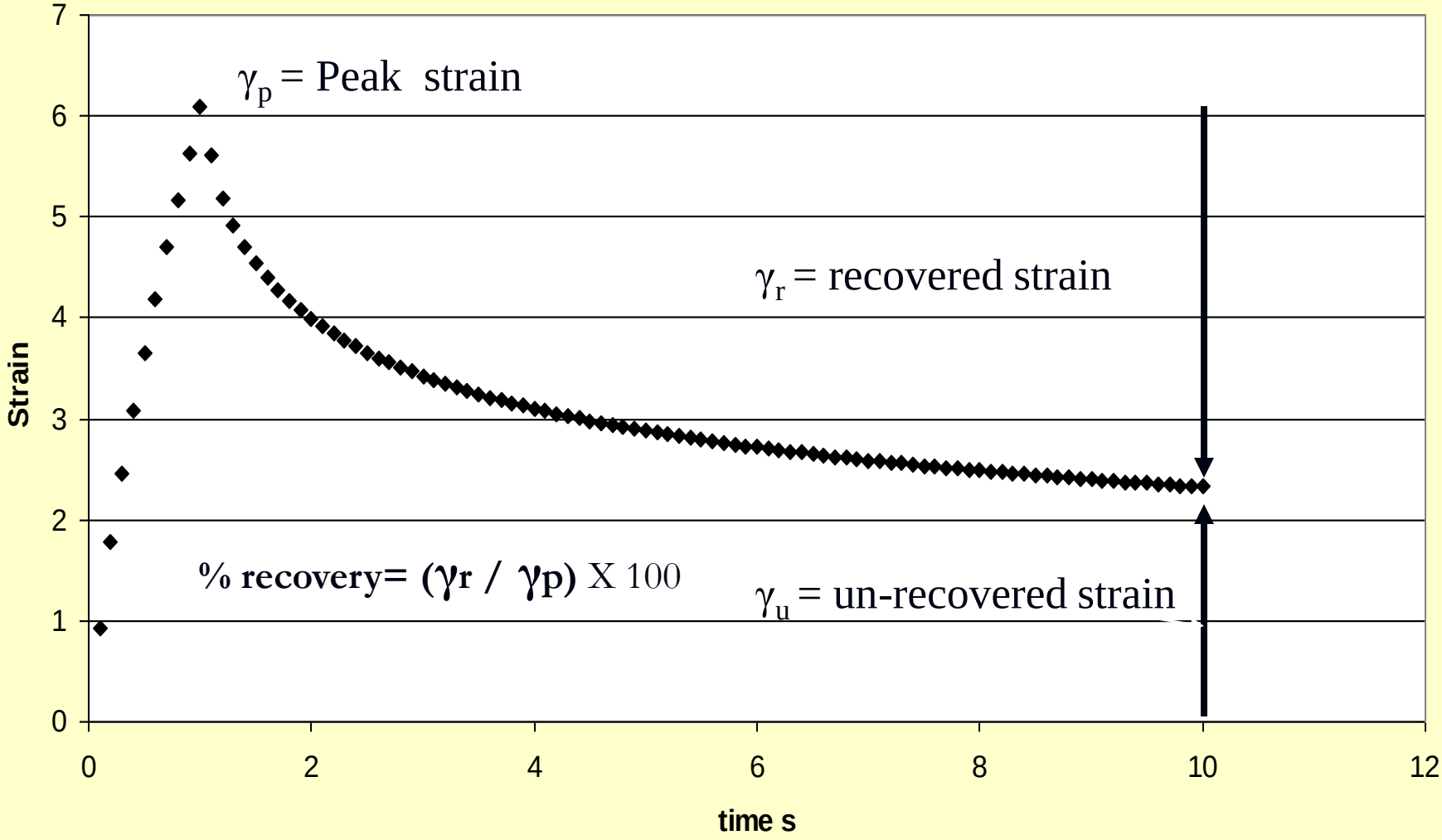
Multi-Stress Creep and Recovery Test Method
A New Specification

John D'Angelo
Federal Highway Administration
Phone 202-366-0121 fax 202-493-2070
John.D'angelo@dot.gov

Determination of Jnr



What is % Recovered Strain



Standard Test Procedure developed for AASHTO

Standard Method of Test for

Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

AASHTO Designation: TP 70-08

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001

MSCR and Rutting

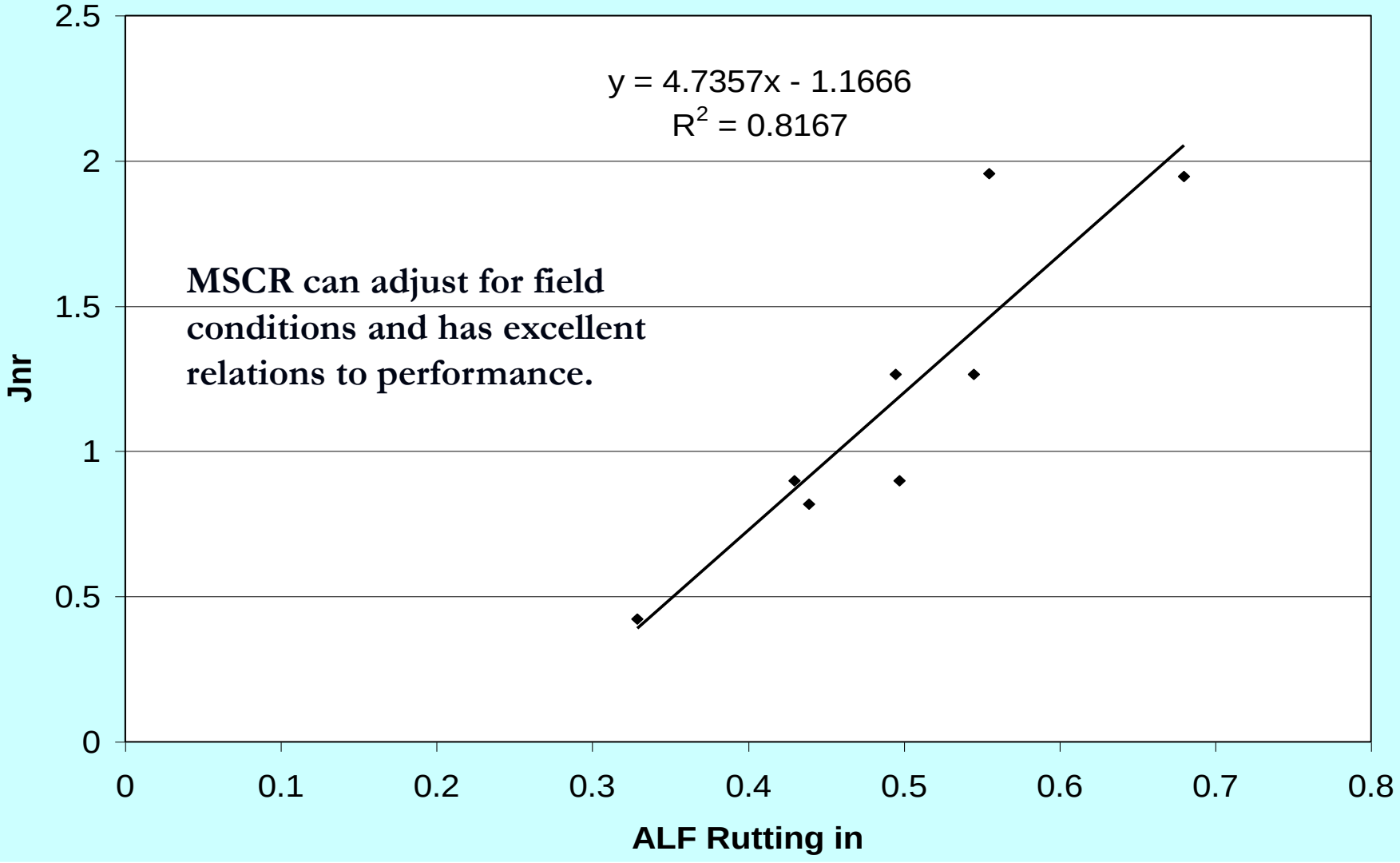
- Any new specification must be blind to modification.
- A new specification must identify the rutting potential of all binder types under multiple conditions.

7 Asphalt Binders

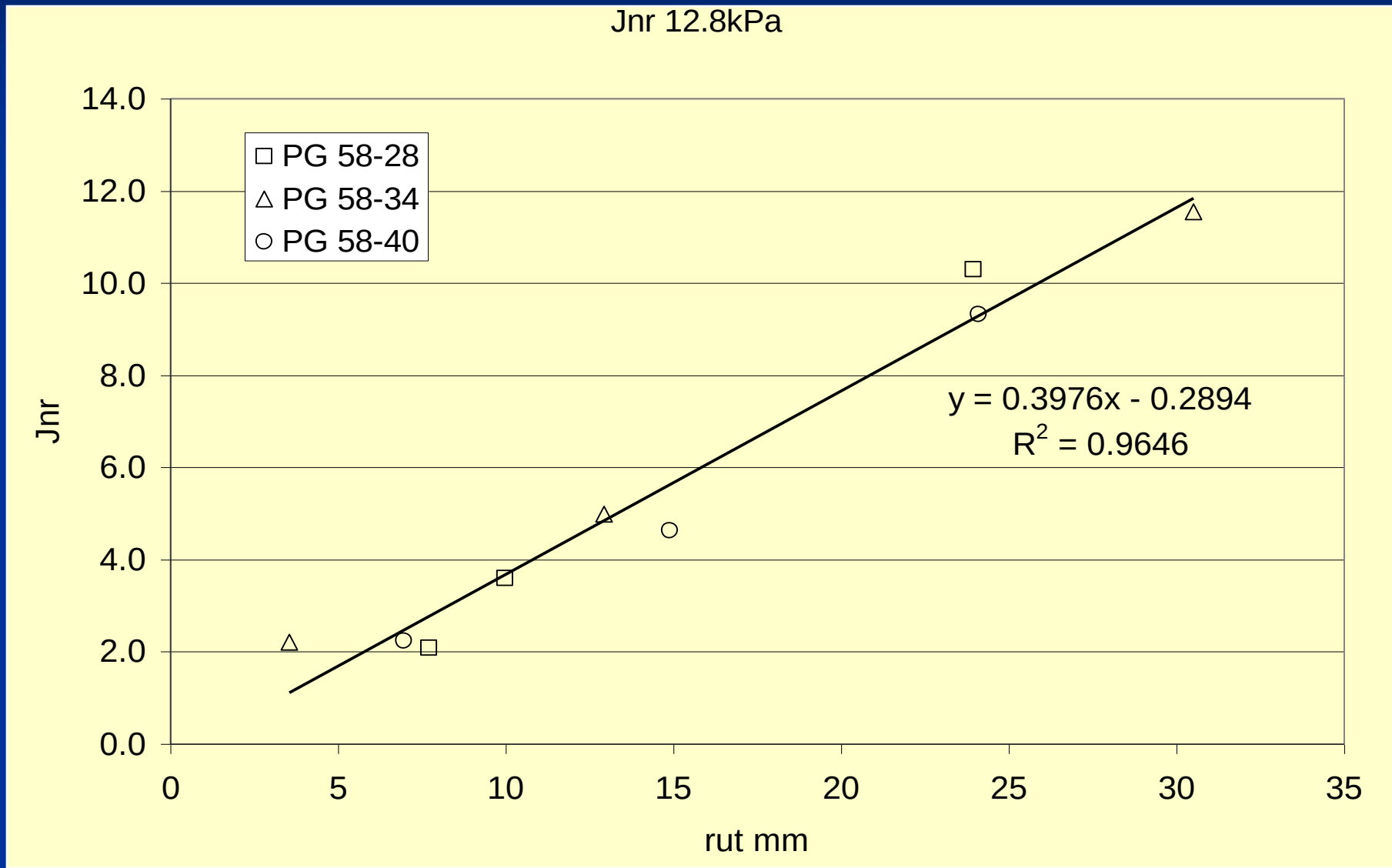
AZ CRM ---- 70-22	PG 70-22 Control	Air Blown	SBS	TX TBCR	TP	PG 70-22 + Fibers	PG 70-22	SBS 64-40	Air Blown	SBS	TP
1	2	3	4	5	6	7	8	9	10	11	12

Relationship between Jnr and ALF rutting

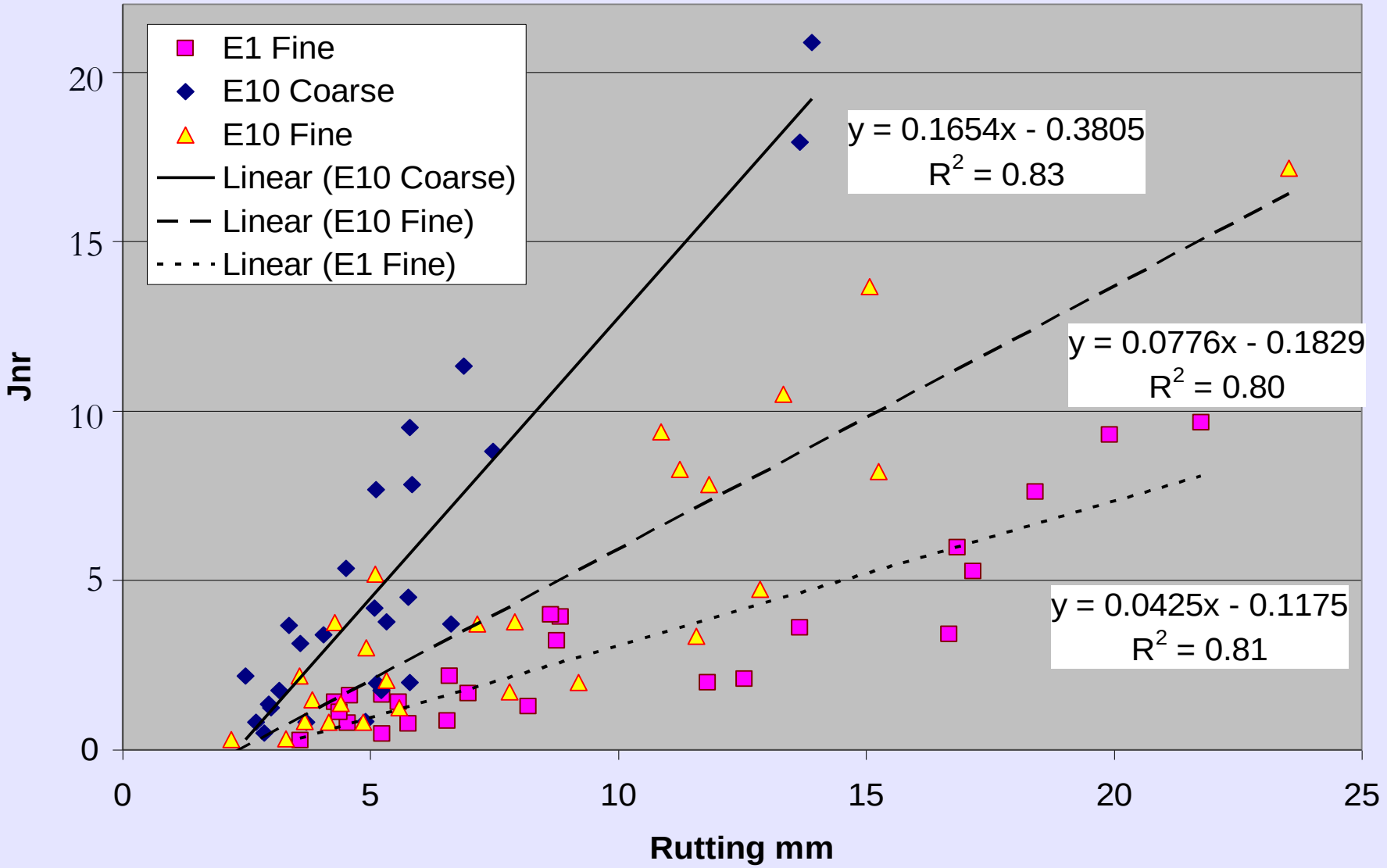
25.6kPa



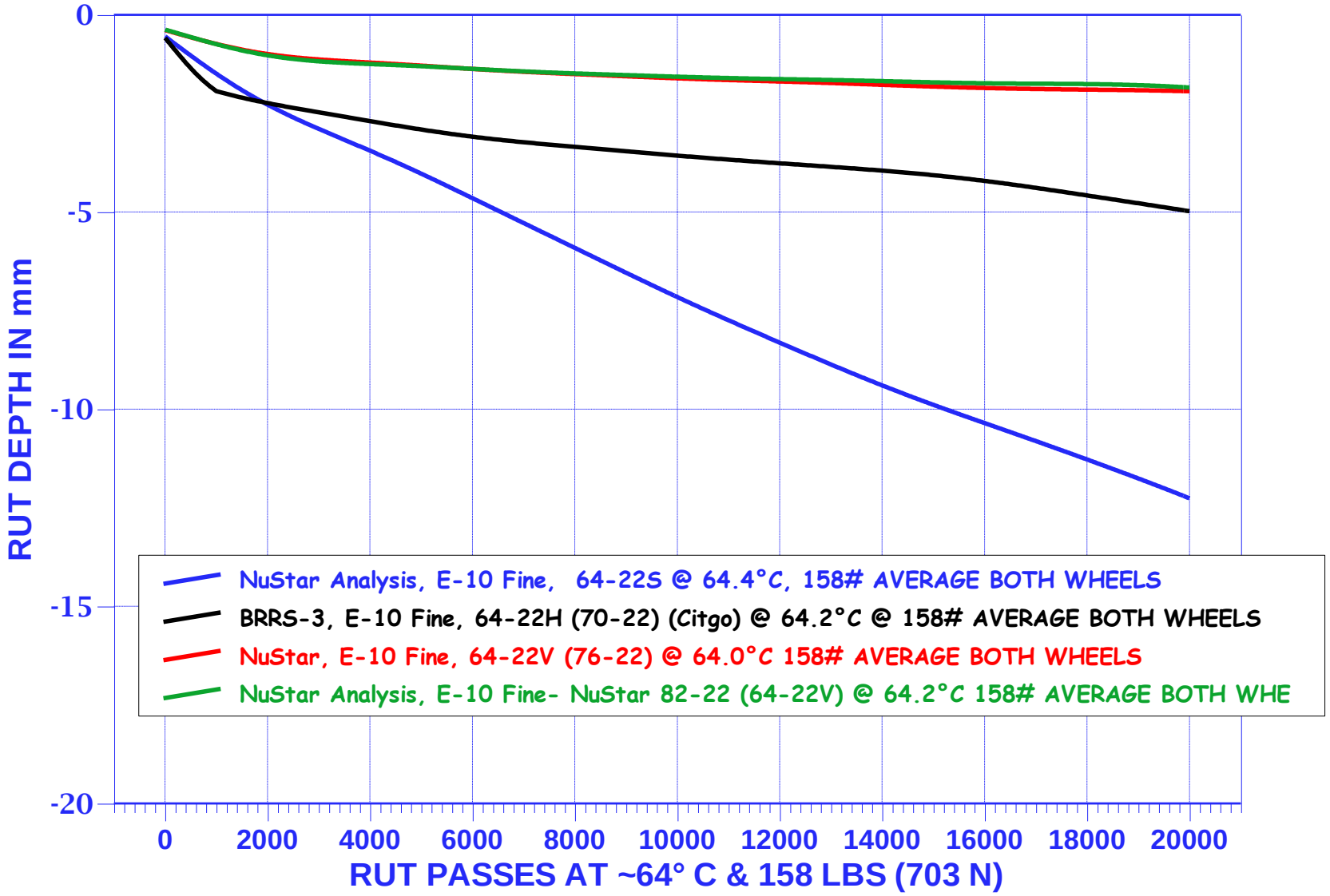
Hamburg Rut testing MINN Road mixes



Effect of Gradation on Rutting



NUSTAR STUDY PG 64-22S, 64-22H, 64-22V BINDERS TESTED IN HAMBURG DRY AT ~ 64° C, 158# LOAD, E-10 FINE LIMESTONE BLEND



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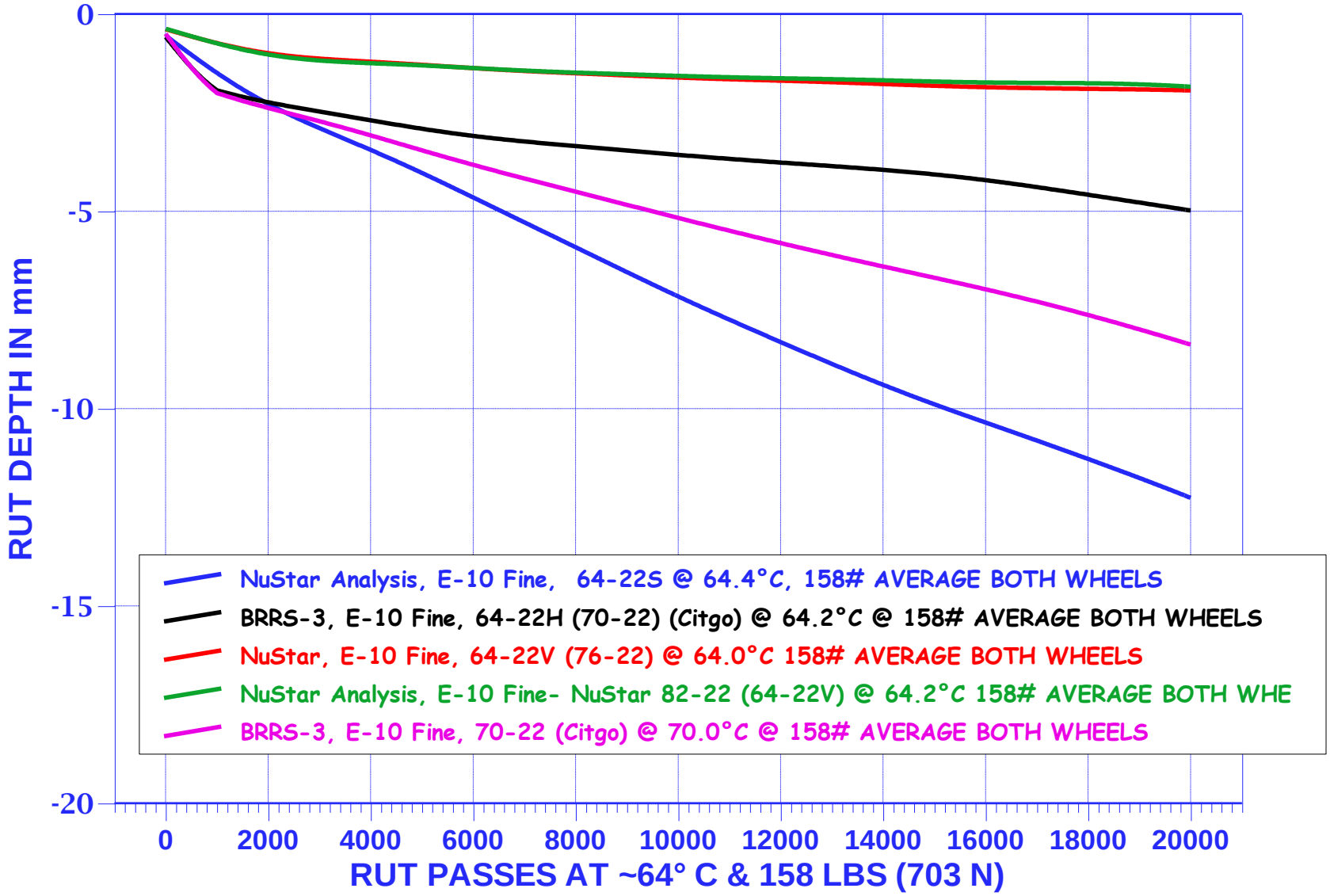

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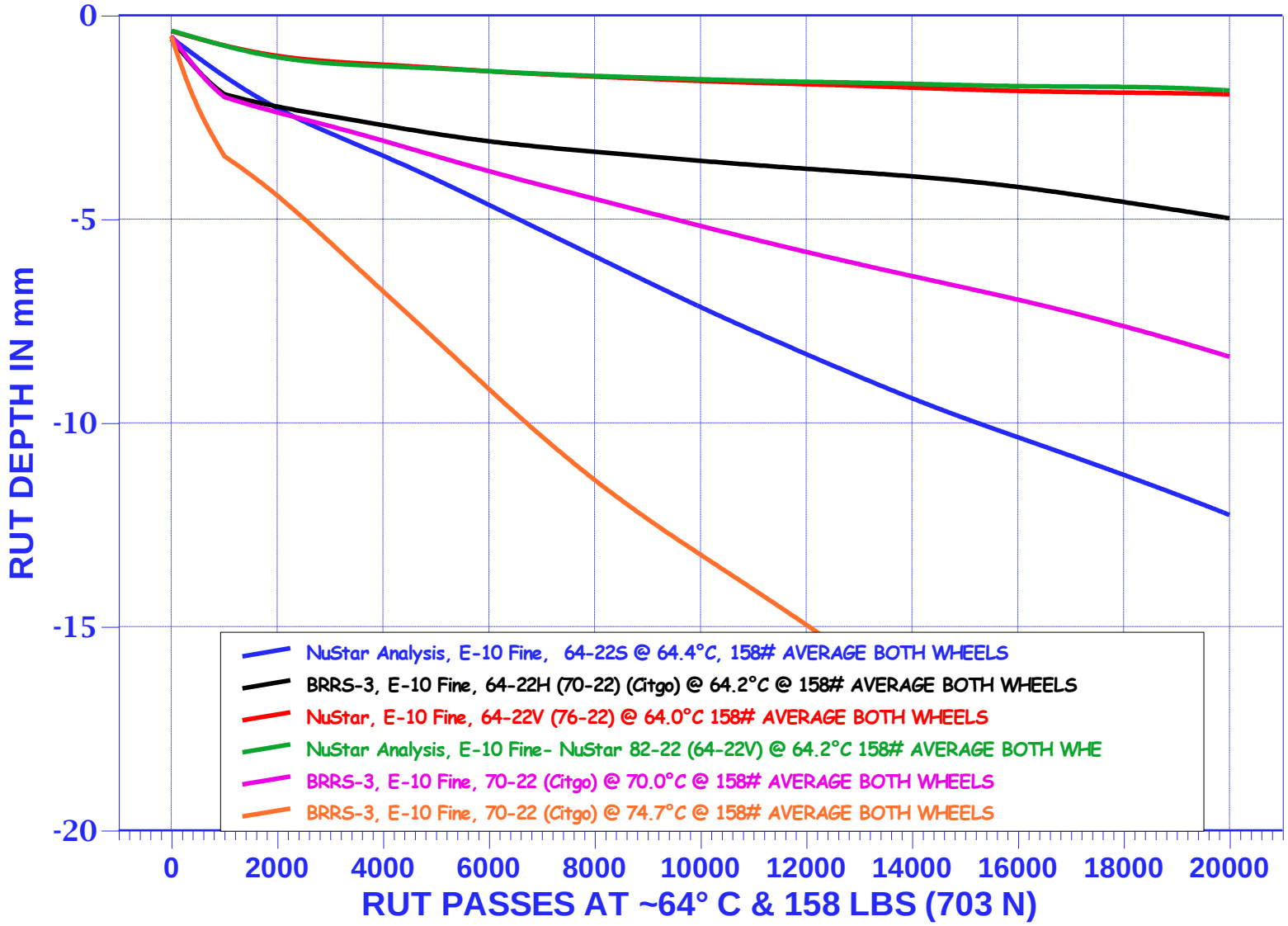
NUSTAR STUDY PG 64-22S, 64-22H, 64-22V BINDERS TESTED IN HAMBURG DRY AT ~ 64° C, 158# LOAD, E-10 FINE LIMESTONE BLEND



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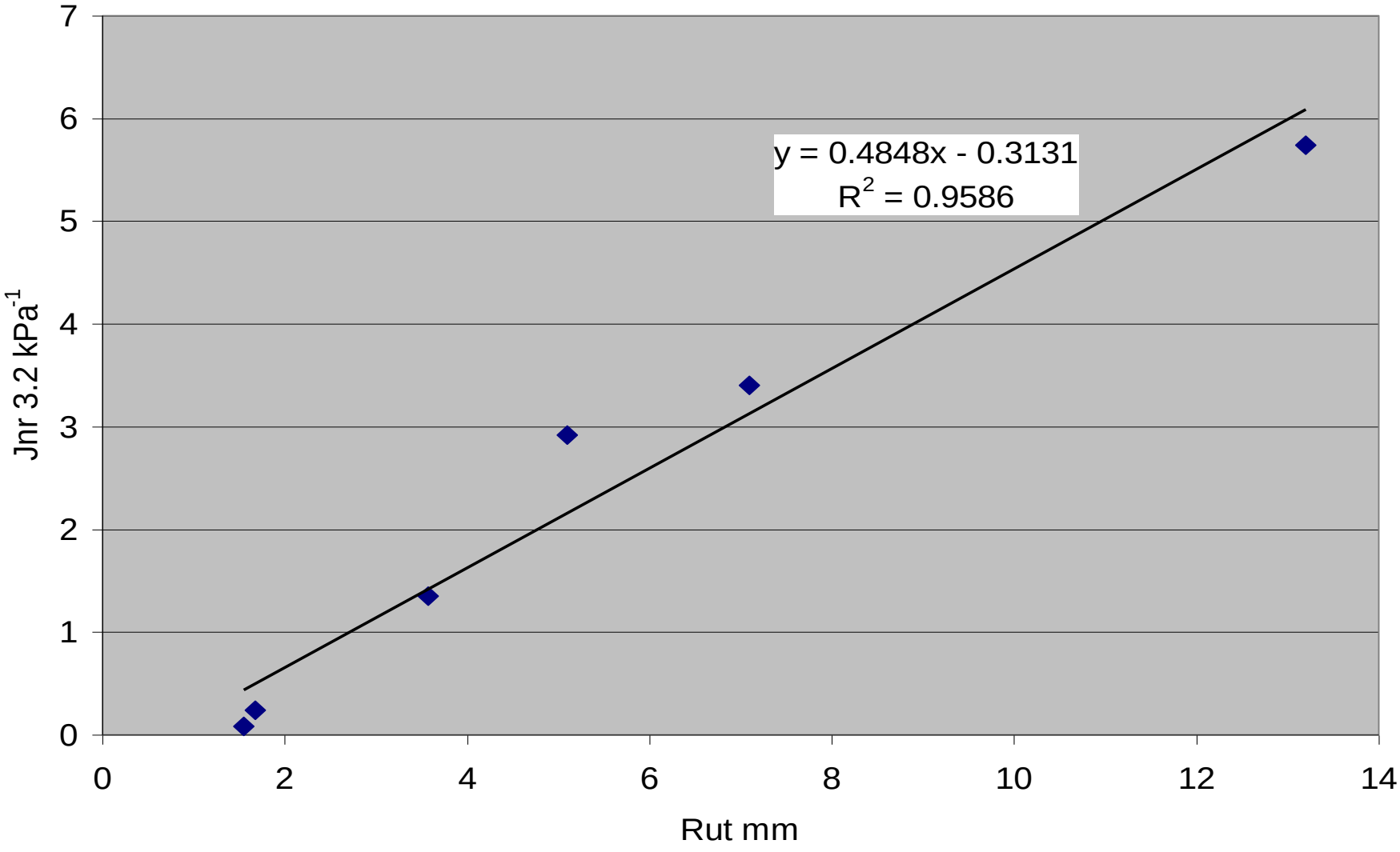
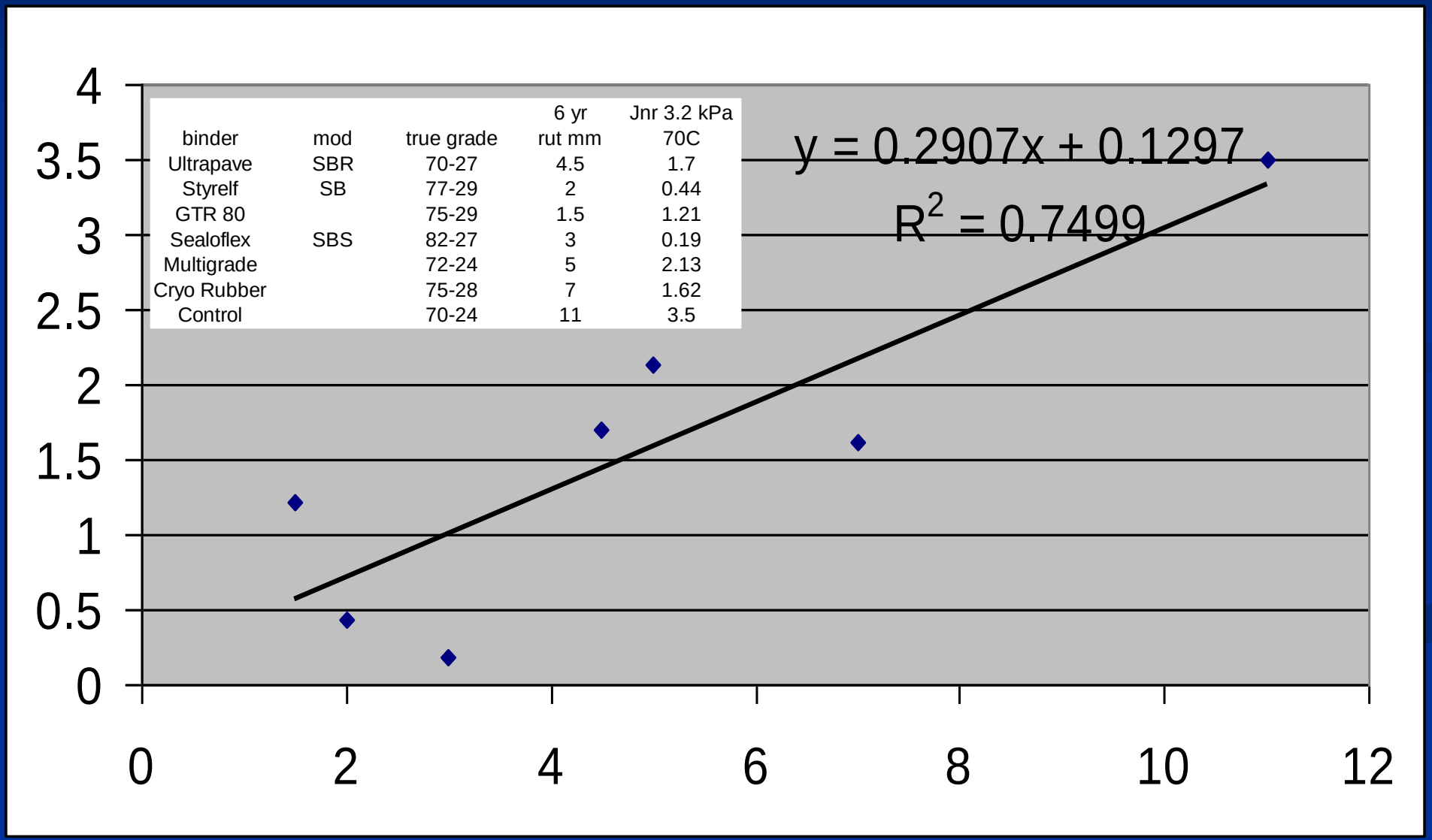
NuStar Rutting Study Dry Hamburg WI E10 fine mix

Rut test temp	PG GRADE	PG GRADE (Jnr)	Jnr at Rut Test Temp	%RECOVERY	MIN %RECOVERY	RUT DEPTH 10000 PASSES
64	76-22	64-22V	0.24	55.8	50.6	1.68
64	64-22	64-22S	3.4	3.4	---------	7.1
64.4	70-22	64-22H	1.35	4.4	33.7	3.57
64	82-22	64-22E	0.082	78.5	66.1	1.55
70	70-22	70-22S	2.92	1.5	---------	5.1
74.7	70-22	70-22<S	5.74	0.5	---------	13.2

NuStar Rutting Study Dry Hamburg WI E10 fine mix



Miss I55 6yr rut Jnr 3.2 kPa



binder	mod	true grade	6 yr rut mm	Jnr 3.2 kPa 70C
Ultrapave	SBR	70-27	4.5	1.7
Styrelf	SB	77-29	2	0.44
GTR 80		75-29	1.5	1.21
Sealoflex	SBS	82-27	3	0.19
Multigrade		72-24	5	2.13
Cryo Rubber		75-28	7	1.62
Control		70-24	11	3.5

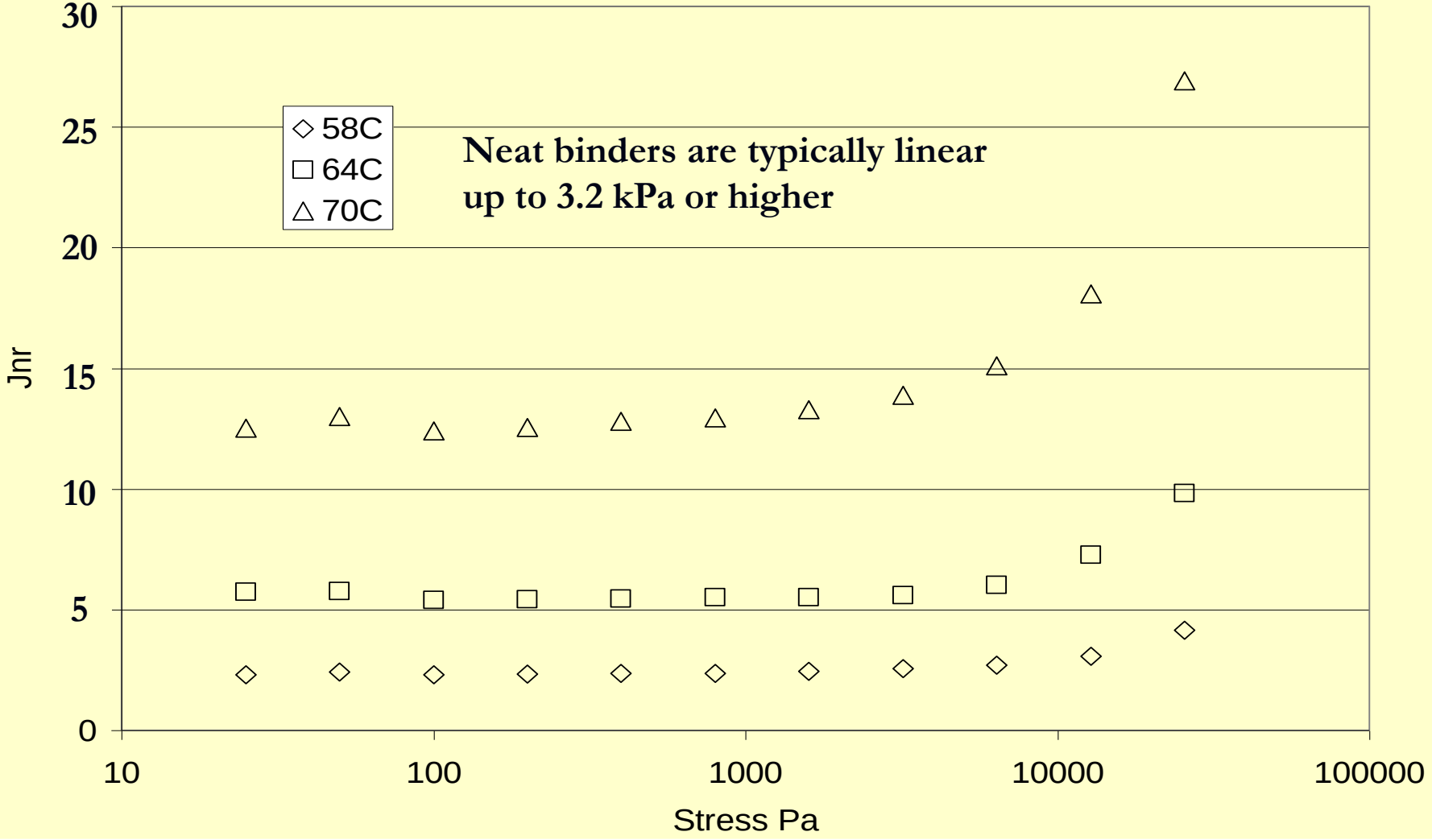
Affect of Jnr on Rutting

- Reducing J_{nr} by half typically reduced rutting by half.
- This affect is seen on ALF sections and Hamburg Rut Testing
- But most importantly this is seen on the Mississippi I 55 sections.
- For all mix types and loadings Jnr less than 1 had minimal rutting.

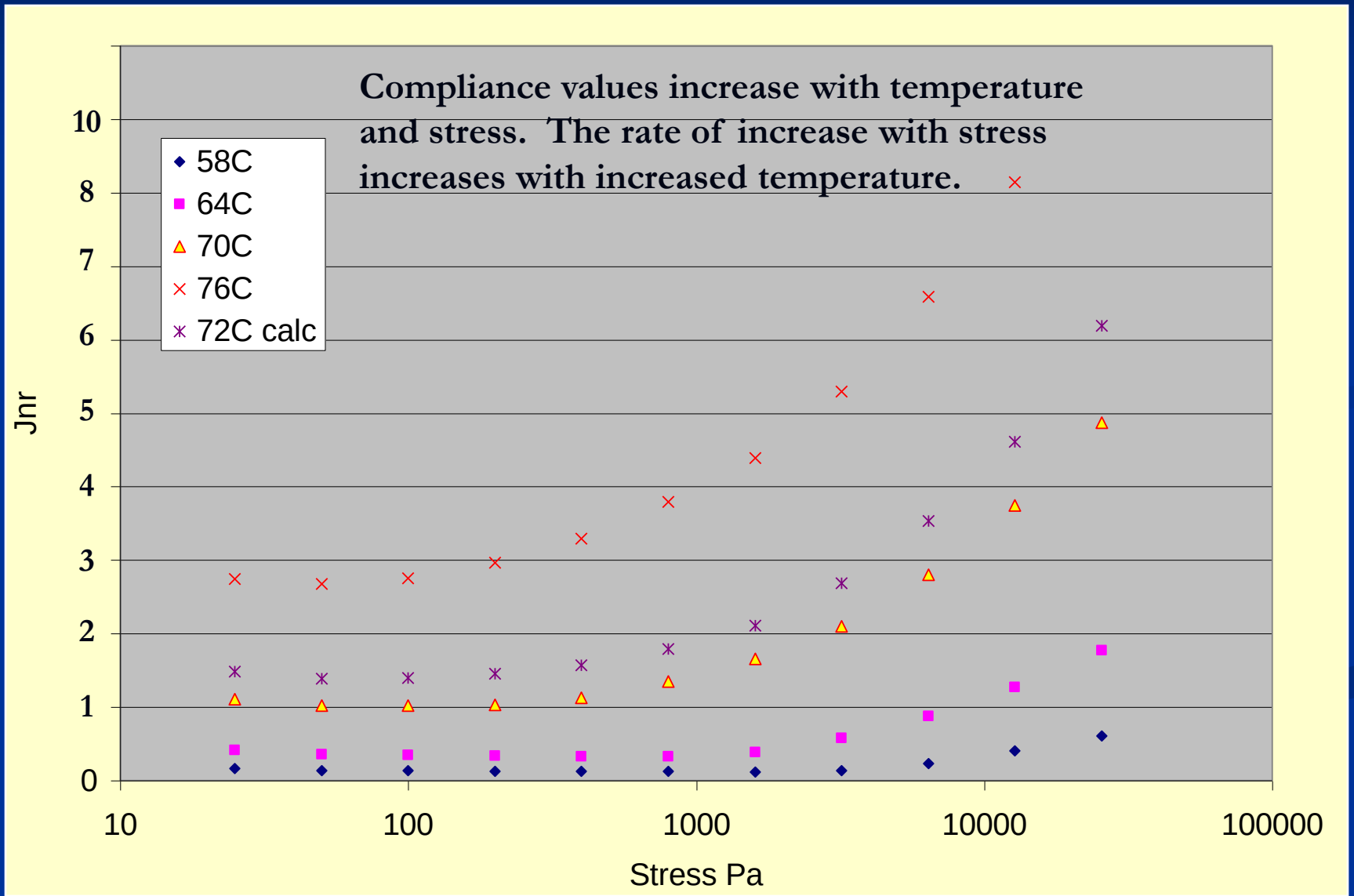
New high Temp Spec

- PG 64 (Standard, Heavy, Very heavy) based on traffic.
  - PG 64S-XX J_{nr} =< 4.0
  - PG 64H-XX J_{nr} =< 2.0
  - PG 64V-XX J_{nr} =< 1.0
    - Special Cases Port Facilities, Quarry Entrances, Etc. a PG 64E-XX J_{nr} =< 0.5 can be considered.

Neat PG58-28 at multiple temperatures



SBS PG 70-28 SBS



New MSCR Binder Spec AASHTO M320 Table 3

Original					
DSR G*/sinδ Min 1.0	64				
RTFOT					
64 Standard MSCR3.2 <4.0	[(MSCR3.2 – MSCR 0.1)/ MSCR 0.1] < .75	64			
64 Heavy MSCR 3.2<2.0		64			
64 Very heavy MSCR3.2 <1.0		64			
PAV					
S grade DSR G*sinδ Max 5000	28	25	22	19	16
H & V grade DSR G*sinδ Max 6000	28	25	22	19	16

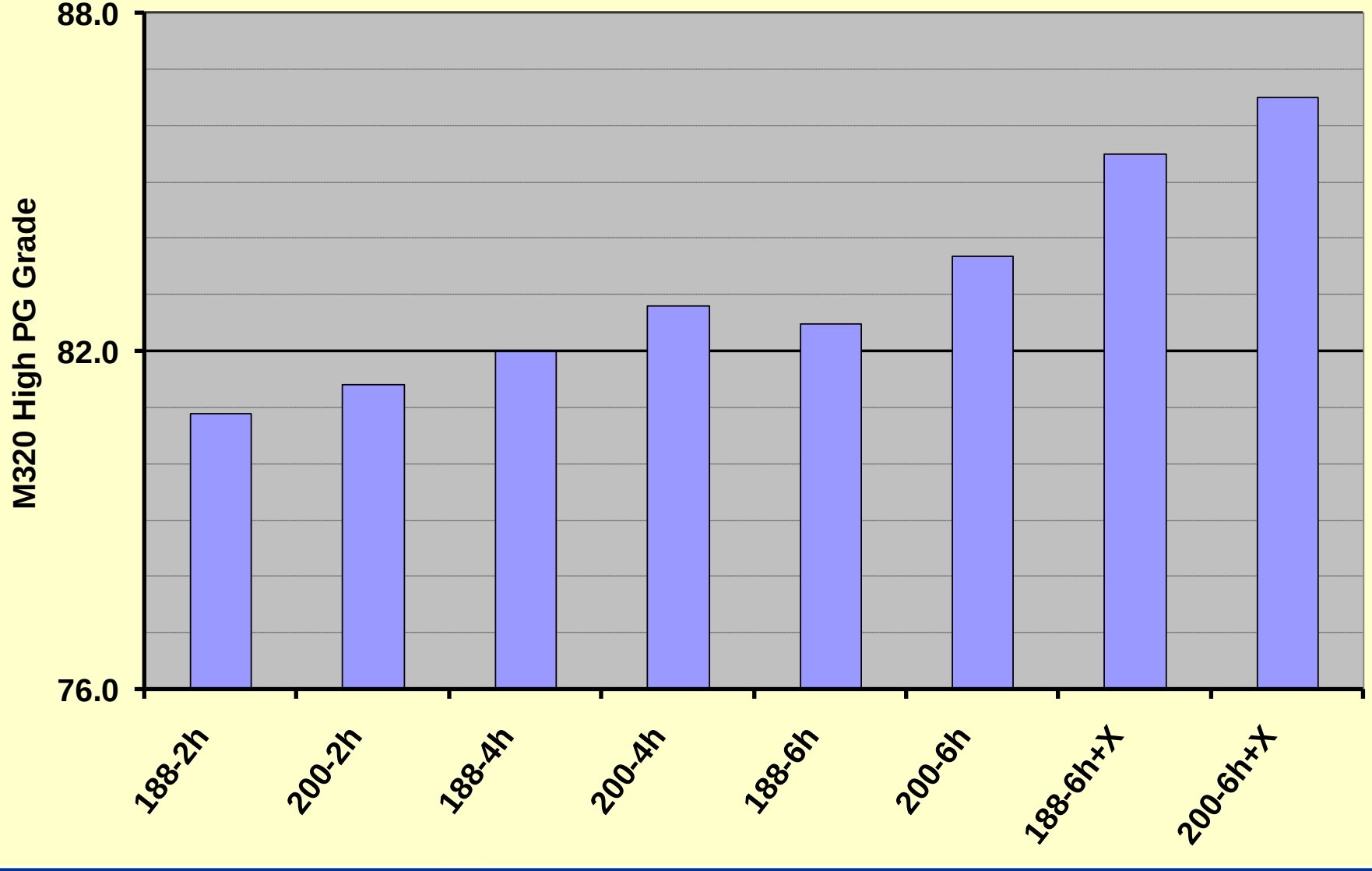
Low temp BBR and DTT remain unchanged

Experiment Design
Time Temperature study

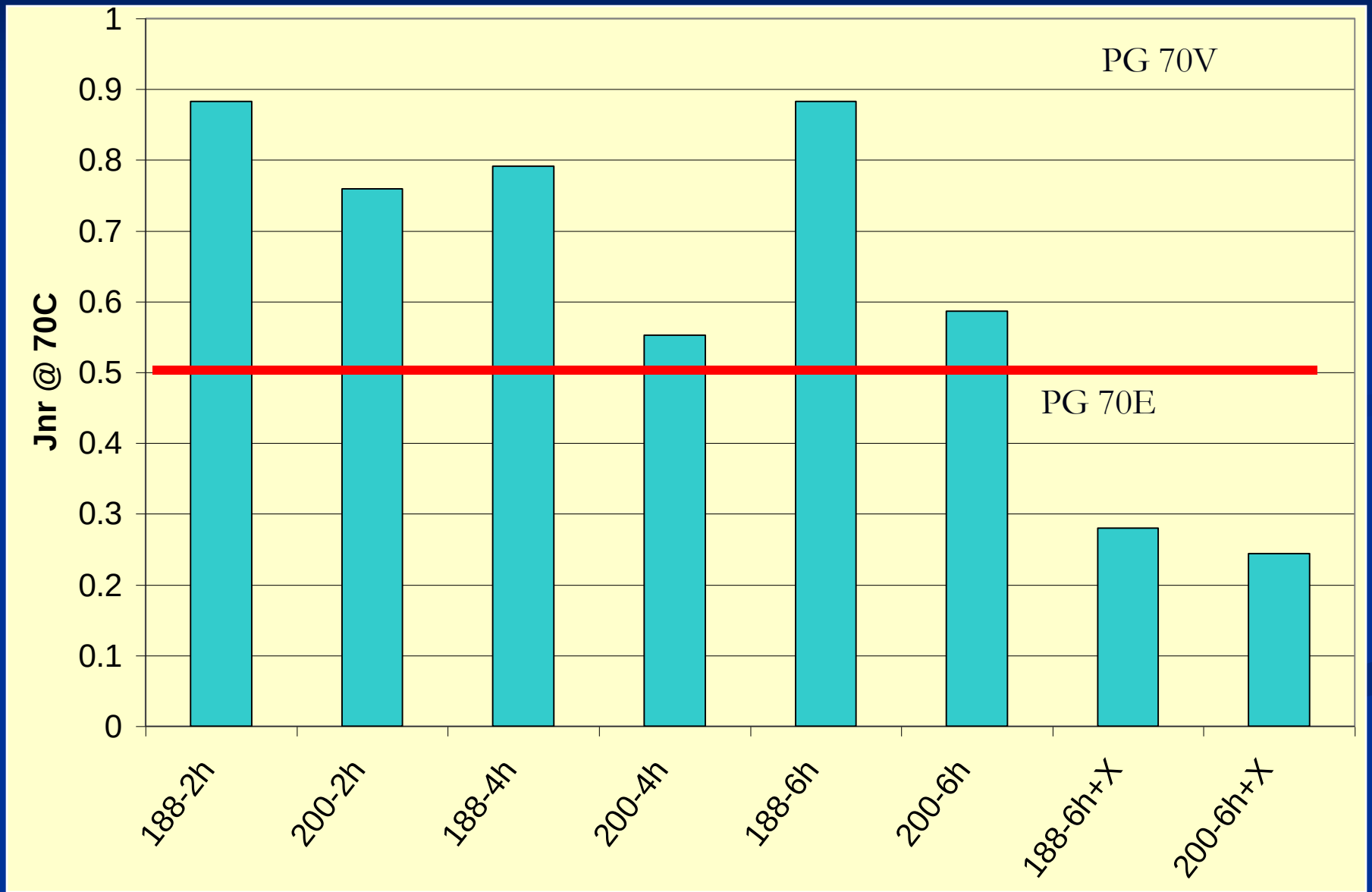
Incompatible 67-22 base binder mixed with 4% linear SBS elemental sulfur as a cross linker.

Blending Time, hours	2 h		4 h		6 h		6 h + x-linking	
Blending Temperature, °C	188	200	188	200	188	200	188	200
M320 High Temp DSR	X	X	X	X	X	X	X	X
UDOT Elastic Recovery	X	X	X	X	X	X	X	X
MSCR Test	X	X	X	X	X	X	X	X
UV Microscopy	X	X	X	X	X	X	X	X

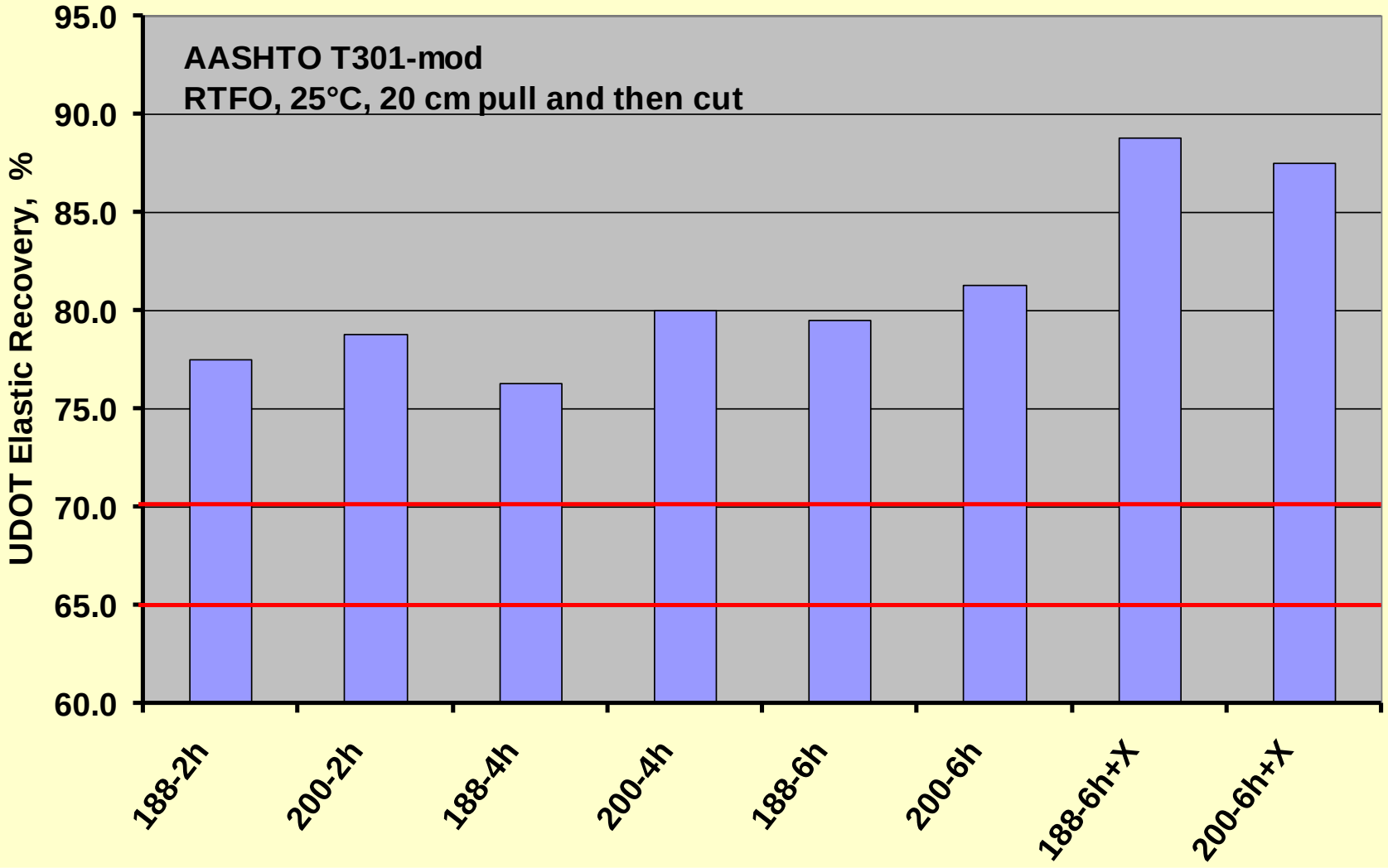
Changes in M320 High Temp PG with Processing



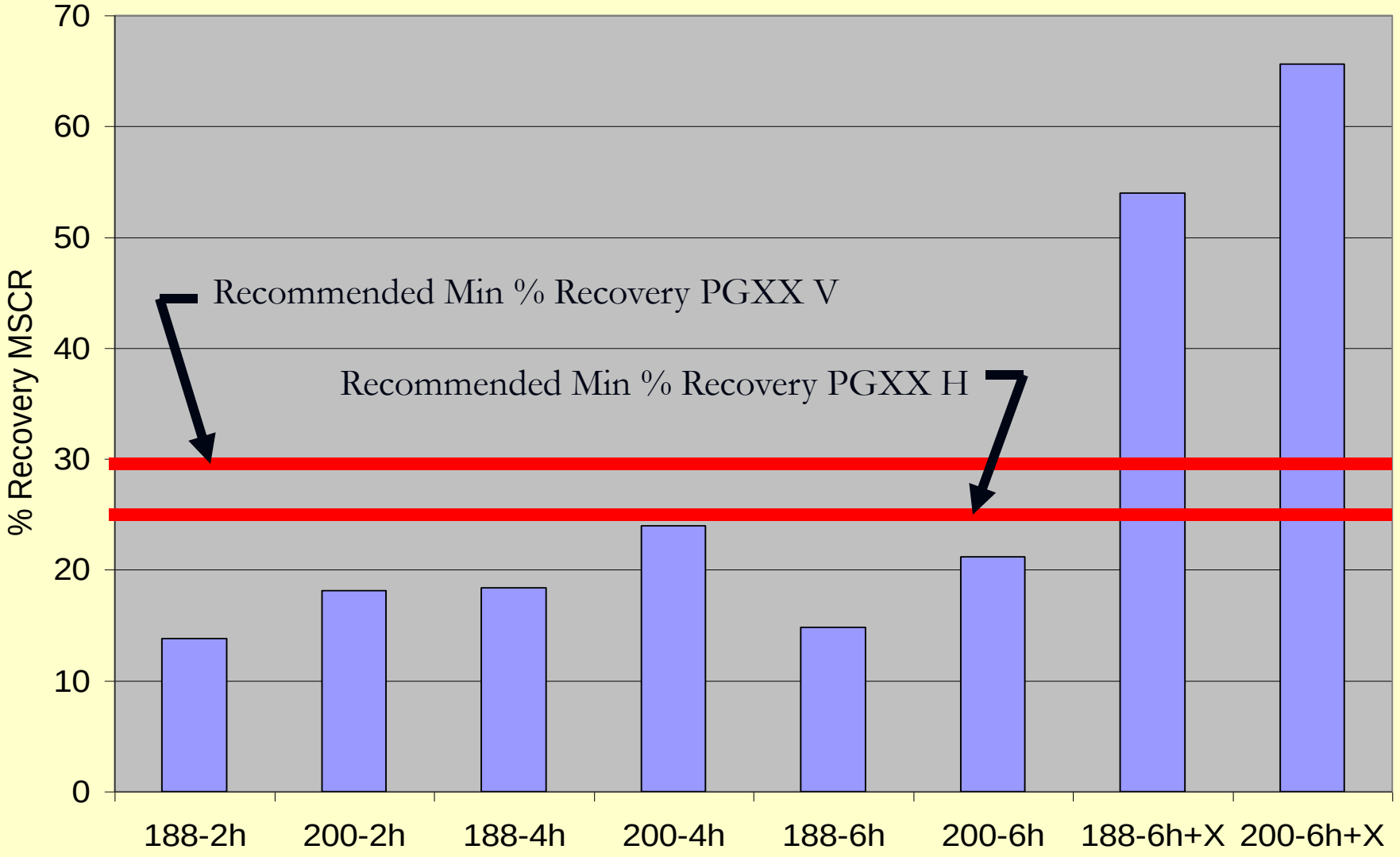
Changes in J_{nr} with Processing



Changes in UDOT Elastic Recovery with Processing

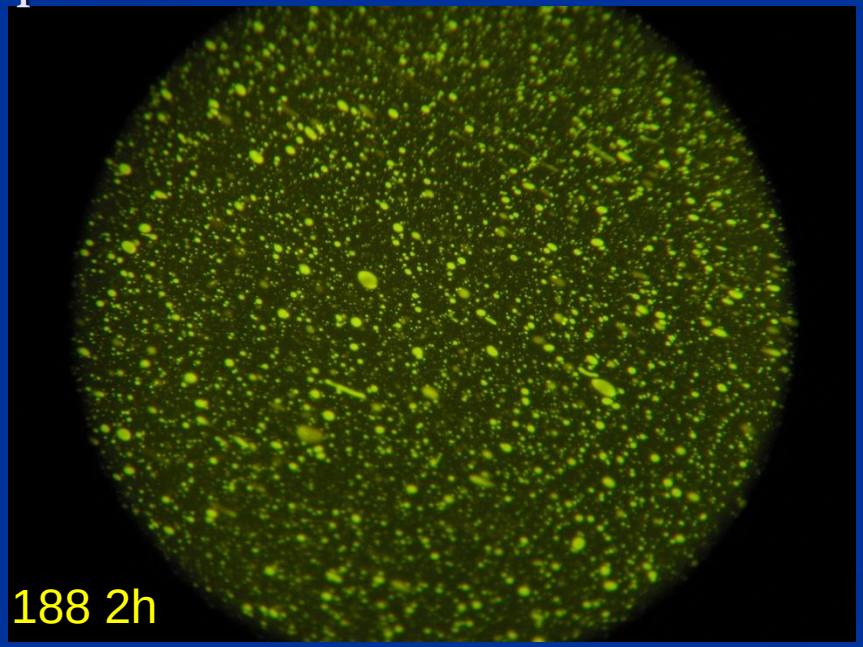


Changes in % Recovery MSCR test with Processing

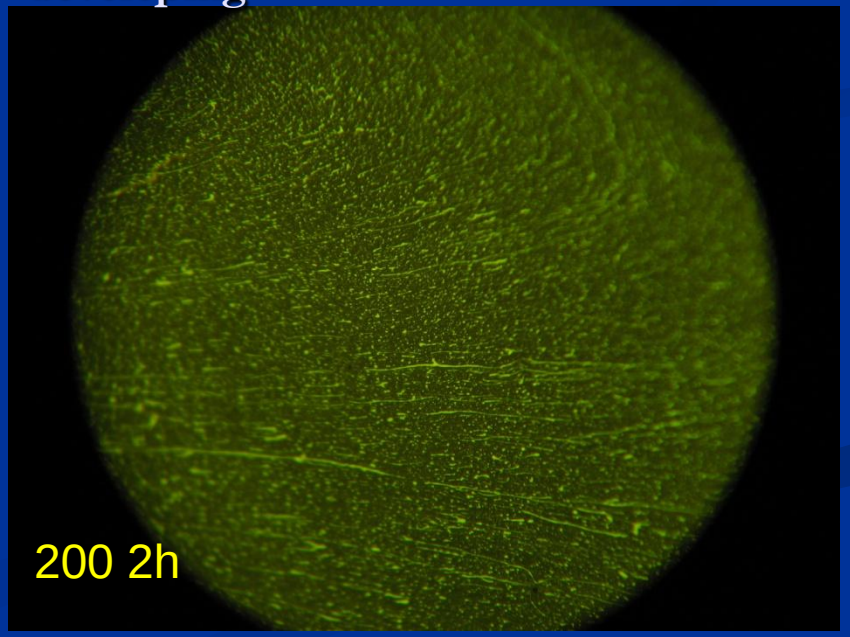


Fluorescence Micro-graphs at 250 magnification

Discreet polymer particles



polymer strands developing



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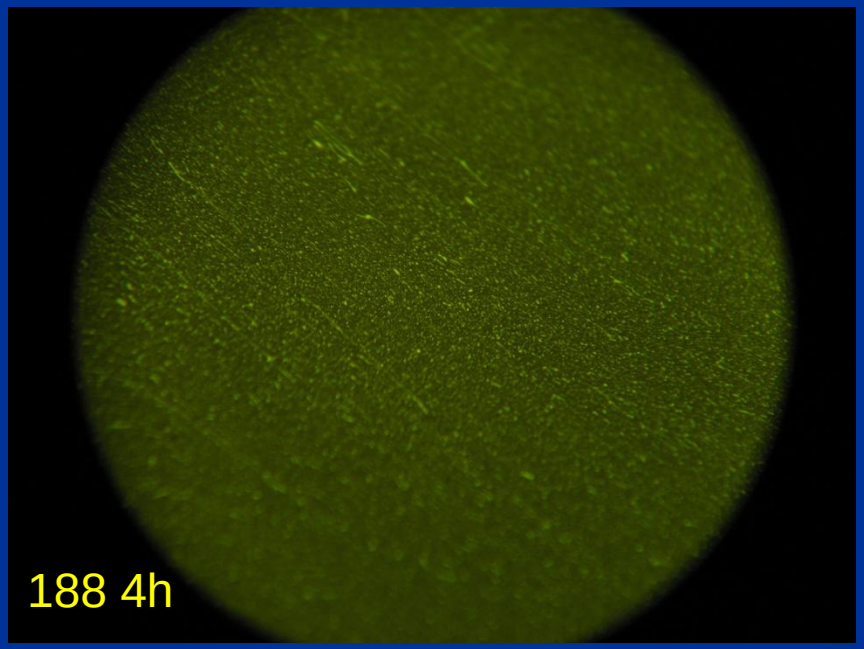
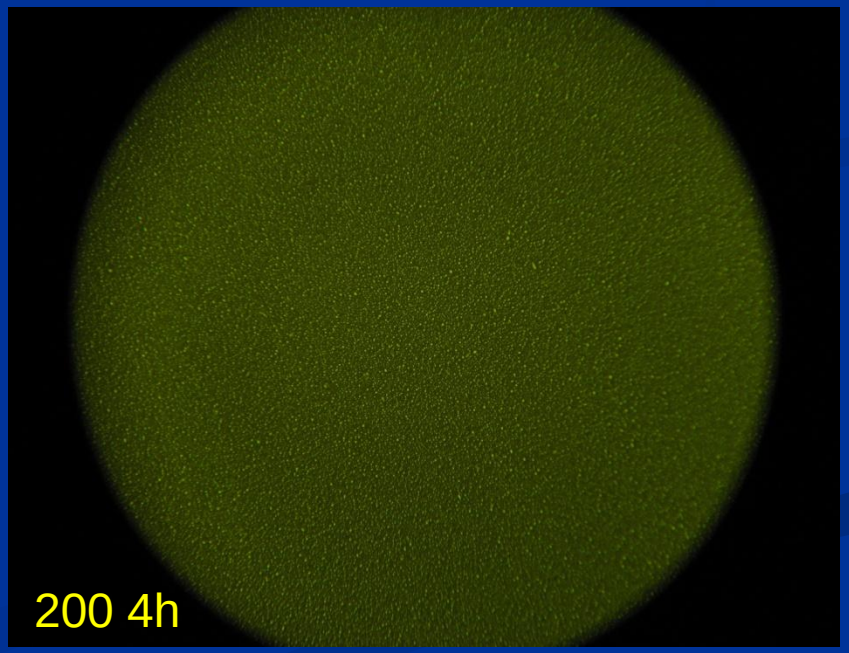


More uniform dispersion almost cross-linked



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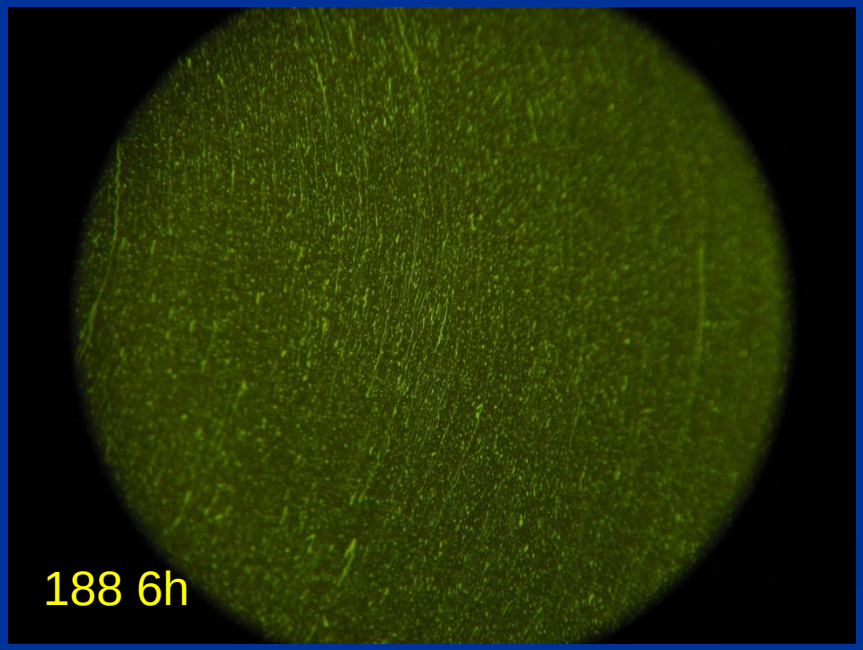
polymer strands developing



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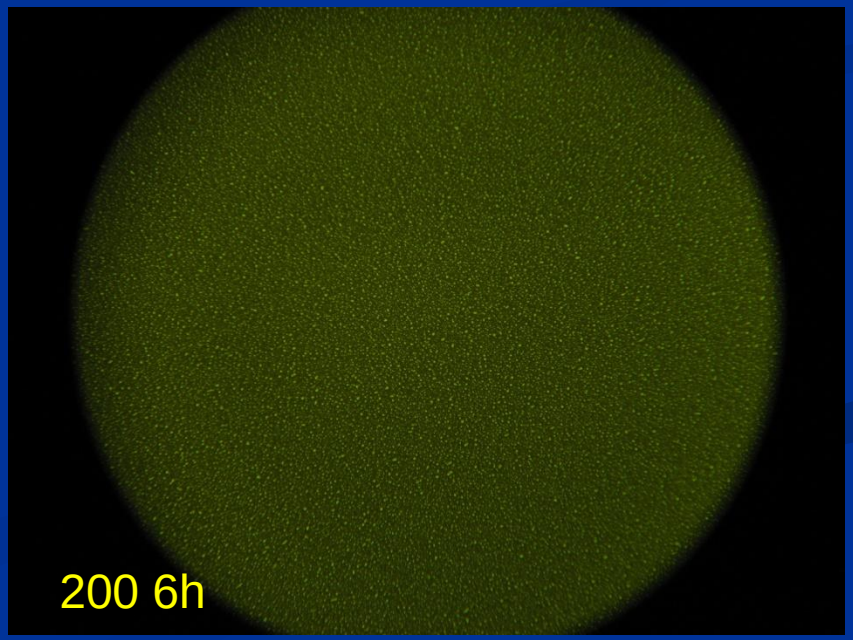

Fluorescence Micro-graphs at 250 magnification

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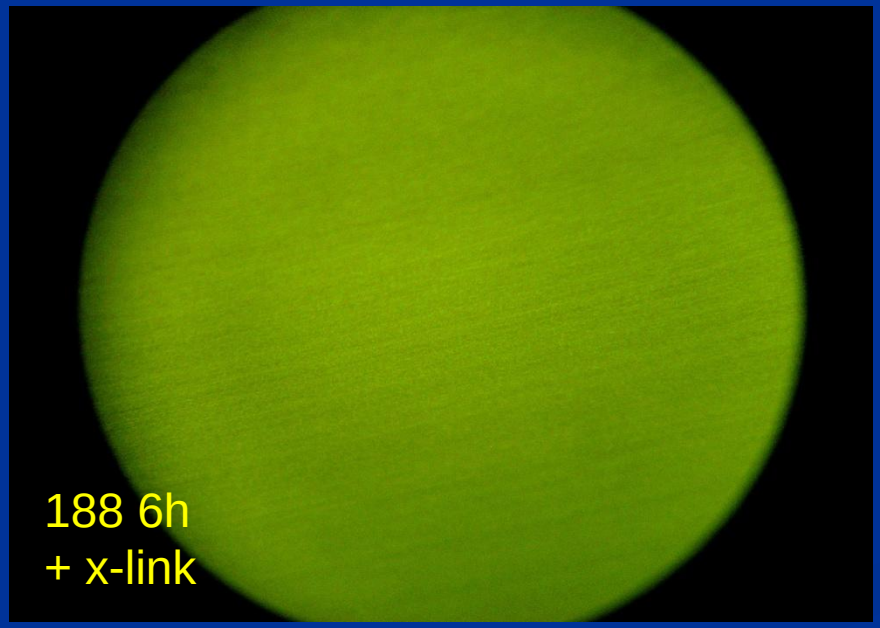
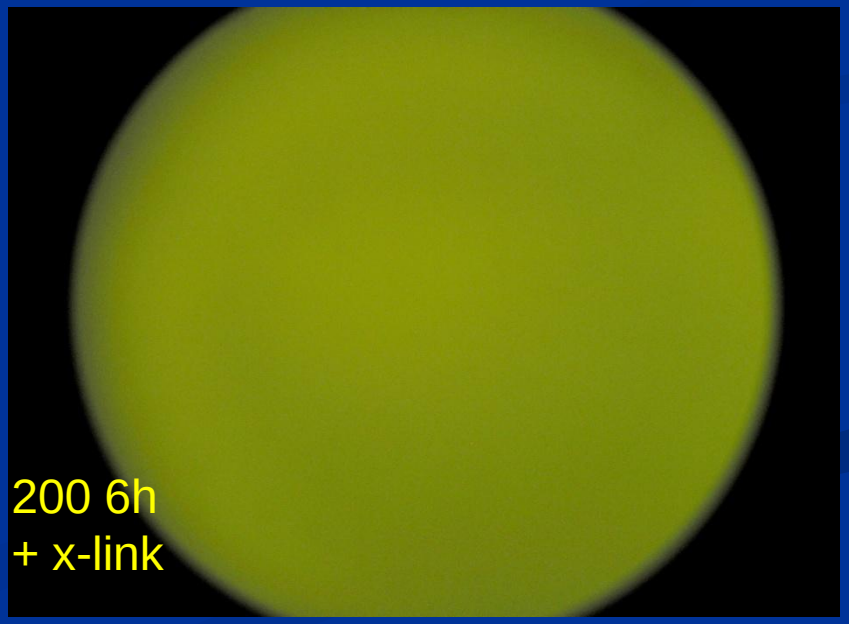


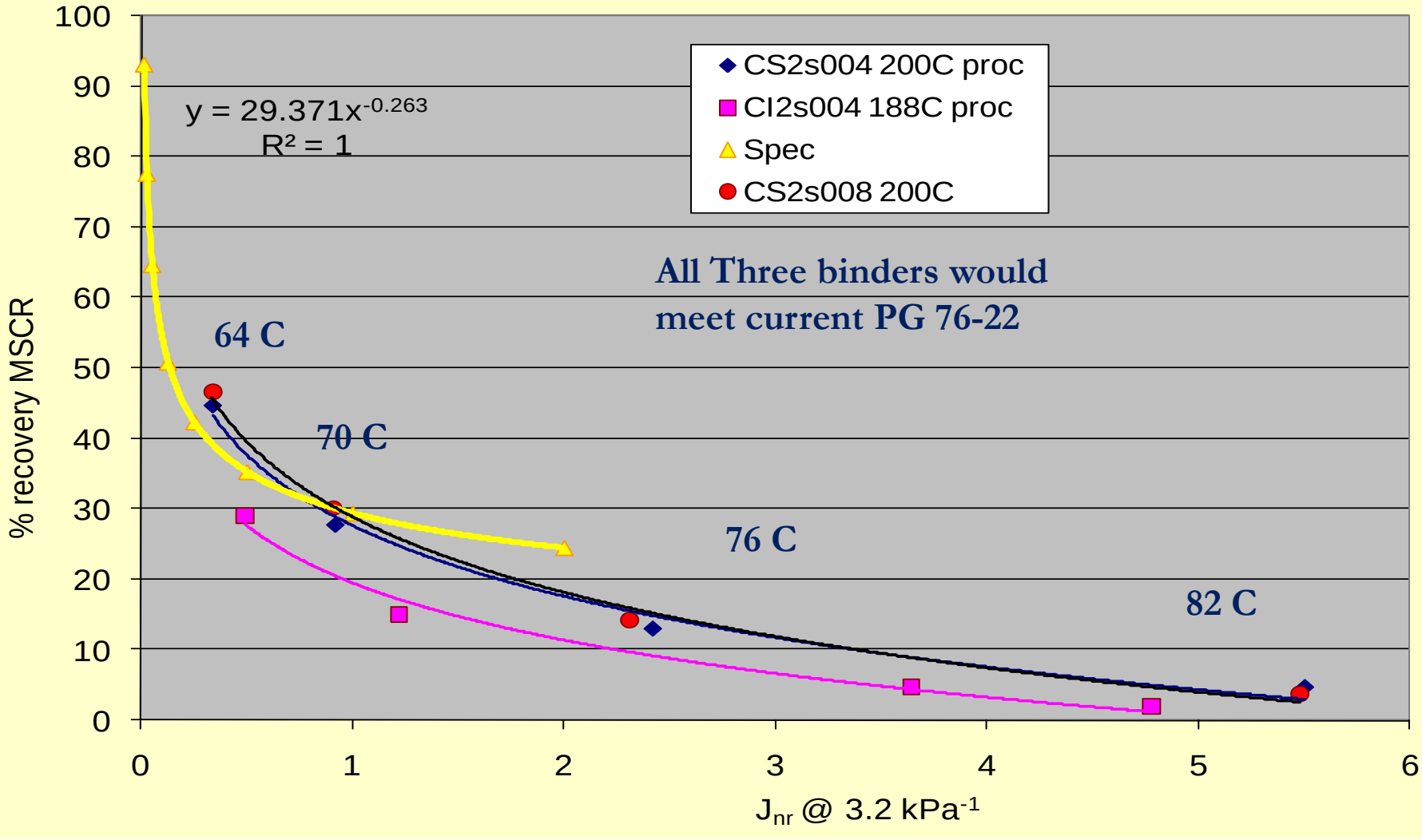
Uniform dispersion cross-linked



Continuation of Blending Study

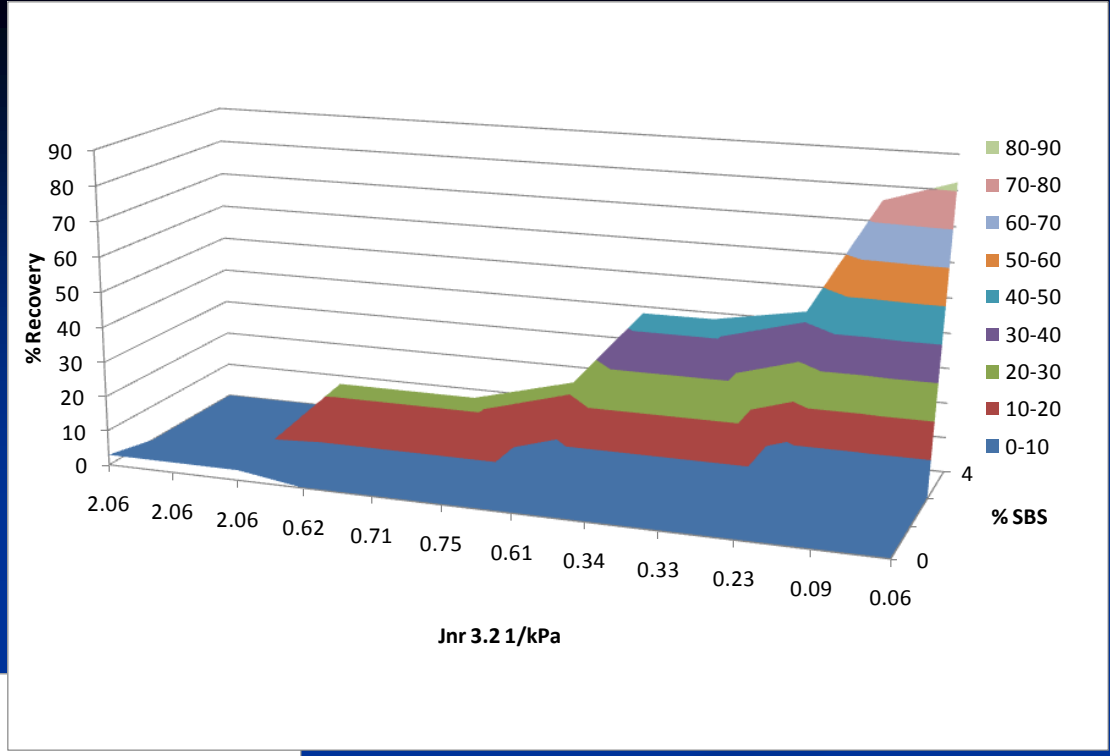
PG67-22 - Incompatible				
% Sulfur/% polymer	Percent polymer (linear SBS)			
	0	1	2	4
None	CS	CS1 nxl	CS2 nxl	CS4 nxl
0.02		CS1s002	CS2s004	CS4s008
0.04		CS1s004	CS2s008	CS4s016

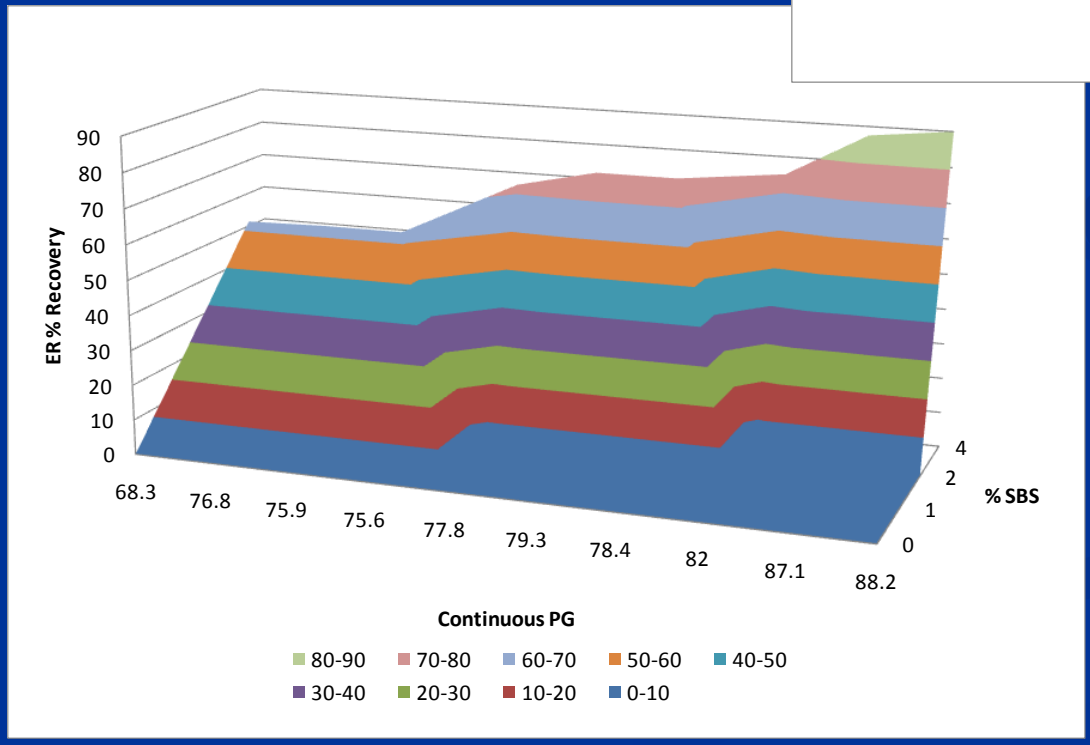
2% SBS .2% sulfur/%SBS different processing temps, multiple test temp



1% SBS in a 67-22 will produce a PG76-22 and an ER of 60%

2% SBS in a 67-22 will produce a PG 76-22 and an ER of 75%





1% SBS in a 67-22 will produce a PG64 -22 V and an MSCR % Recovery of 22%

2% SBS in a 67-22 will produce a PG 64-22 E and an MSCR% Recovery of 45%

Conclusions and Recommendations

- Mixing Temperature and X-linking effect the properties of polymer modified binders.
- The Elastic Recovery showed little difference between the different processing methods.
- Both SHRP $G^*/\sin\delta$ and MSCR indicated the differences between the different processing methods, but results are different for each.
- The MSCR both J_{nr} and MSCR % Recovery indicated larger differences than the SHRP and ER tests.
- The Larger differences were verified by the Florescence Microscopy.

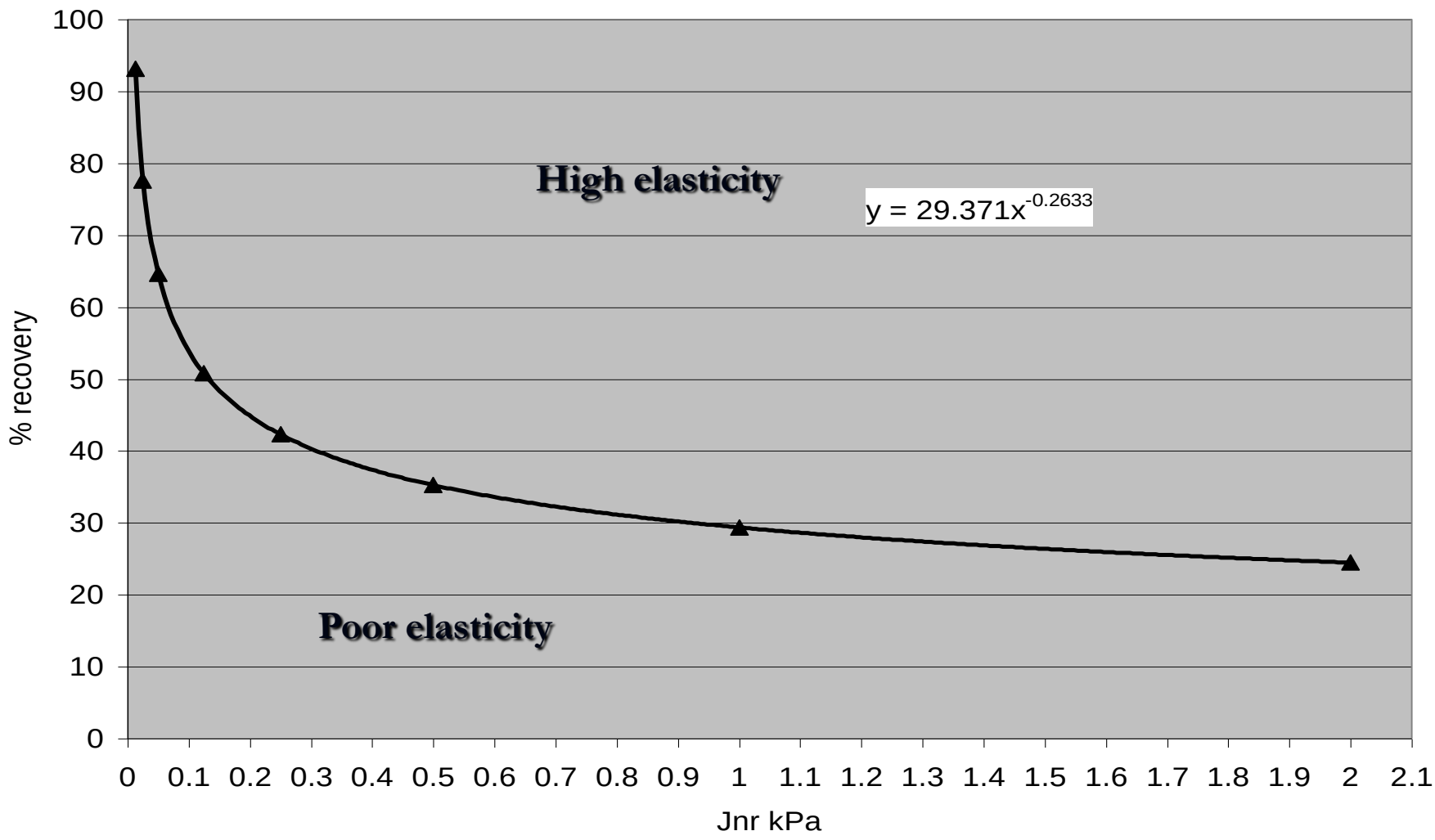
Implications

- MSCR test is more discriminating and a fundamental property test
- New practice for SBS blend optimization?
  - For research
  - For spec.

Implementation

- MSCR can replace the ER
  - Single protocol
  - Quick and easy
  - Fundamental property

MSCR % recovery can be added to validate polymer modification



New MSCR Specification

- MSCR test procedure TP-70 published Spring 2008.
- New Table 3 accepted by AASHTO . To be published Spring 2009.

Thank You

Blend study interrelations
% SBS, % xl/%SBS, % Recovery