Free can soda with orders over $100.00

# THE BELCHING DRAGON

50 lbs. white rice with every order

CHINESE FOOD TO EAT IN OR TAKE OUT

## SOUPS

- Dropped Egg Soup ..... 1.75
- ★ One Ton Soup ..... 1.75
- Hot & Scalding Soup ..... 2.25
- Ten Ingredients Water ..... 3.25
- Sweet and Salmonella Soup ..... 2.95
- ★ Chinese Fire Drill Soup
- ★ Happy Bacteria Cup

## APPETIZERS

- Steam-Cleaned [illegible] ..... 3
- ★ Burn Your [illegible] Platter ..... 8.2
- Barbecued [illegible] ..... 6.30
- ★ Scallion Cow Pancakes (for two) ..... 2.95
- MSG with Orange Flavor ..... 4.95

## NOODLES

- ★ Cellophane Noodles
- Cold Noodles in Sesame Waste ..... 3.50
- Some Glum Noodles ..... 8.25
- No Fun Noodles ..... 4.75

## PORK

- New Shoe Pork ..... 6.75
- Roasted Pork in Shriner Hat ..... 6.95
- Recently Shampooed Pork ..... 6.95
- Andrew Diced Pork ..... 9.75
- ★ Roast Pork Puppy Chow ..... 7.25
- ★ Porky Pig Cartoonese Style ..... 7.50
- Pork and Mindy ..... 6.75

## VE[illegible]

- ★ [illegible]man Sauce ..... 5.95
- Shredded Documents with Peking Sauce ..... 5.25
- ★ Bean Crud
- [illegible] Yo[illegible]
- [illegible]n Beans with Black Bean Sauce ..... 4.95
- Black Beans
- [illegible]th Green Bean Sauce ..... 5.
- [illegible] Bean Powder
- [illegible] Substance ..... 4.95
- ★ [illegible] with [illegible]ption Paper ..... 4.95
- Vegetables with Tingling Horse Flavor ..... 5.50

## BEE[illegible]

- Air-Dropped Beef ..... 6.85
- Double Chin Beef ..... 6.85
- ★ Beef with More Beef ..... 7.75
- ★ Carnage of Beef ..... 6.85
- [illegible]ton Beef
- [illegible]d Pepp[illegible]
- [illegible]plit on Lap
- Beef with Bad News ..... 8.85
- ★ Great Barrier Beef ..... 6.85
- ★ What's Your Beef ..... 7.25

## SEAFOOD

- Squished Eel Delight ..... 8.50
- ★ Shrimp with Alibi ..... 8.25
- [illegible] Dead Fish
- [illegible] Noodle
- Prawns in [illegible] Bean Sauce ..... 50
- Aromatic Octopus On Wheels ..... 10.50
- Force Fed Shrimp ..... 7.75
- [illegible] Tar

## POULTRY

- [illegible] Chicken with Tar ..... 6.25
- [illegible] ..... 6.25
- Peeking Duck ..... 7.25
- ★ Lemon Pledge Chicken ..... 6.25
- Amazing [illegible]ken
- ★ [illegible] Duck
- Chicken & Grief ..... 6.25
- Duck [illegible]
- [illegible]
- ★ Chicken Escaping With Wings ..... 7.75
- Mocked Duck ..... 7.25
- ★ General Schwarzkopf Chicken ..... 6.75
- Goofy Grinning Chicken ..... 6.75
- Innocent Bystander Chicken ..... 6.25

## CHEF'S SPECIALS

- ★ Sesame Street Duck ..... 11.75
  *Choice chunks of undernourished fowl pelted with waterchestnuts and stir-fried in a sizzling wok by popular Muppets.*
- Overpriced Happy Family ..... 84.95
  *Scallops, crabmeat and psychotropic mushrooms sauteed with fresh chef's [illegible] on a Sealy*
- ★ Tienanmen Square Beef ..... 17.75
  *Oppressed young beef, severely [illegible] with bamboo shoots [illegible] as you watch [illegible] your table on a big screen.*
- [illegible] Inspector's Seafood Delight ..... FREE!
  *Fresh lobster, shrimp and prawns expertly prepared in the clean Mexican restaurant down the block, brought in [illegible] and served with a crisp fifty dollar bill rolled in a napkin. (Must be ordered in advance.)*

## DESSERTS

- [illegible]unate C[illegible] ..... 2.50
- Sweet Fried Rolaids ..... 3.95
- Ice Cream with Garlic Sauce ..... 2.75
- ★ Boneless Pudding ..... 3.50
- Chicken Almond Ring Ding ..... 3.95

★ May Not be Edible

Waiter will change shirt at your request.



A MAD POSTER

# A Chinese Menu Approach to Cost Effective Modification

## Marty Burrow – Vance Brothers

## Association of Modified Asphalt Producers Meeting

## Santa Ana Pueblo, New Mexico

## AMAP 13th Annual Meeting – February 7-9, 2012

Free can soda with orders over $100.00

# THE BELCHING DRAGON

50 lbs. white rice with every order

CHINESE FOOD TO EAT IN OR TAKE OUT

## SOUPS

- Dropped Egg Soup ..... 1.75
- ★ One Ton Soup ..... 1.75
- Hot & Scalding Soup ..... 2.25
- Ten Ingredients Water ..... 3.25
- Sweet and Salmonella Soup ..... 2.95
- ★ Chinese Fire Drill Soup ..... 2.50
- ★ Happy Bacteria Cup ..... 2.50

## APPETIZERS

- Steam-Cleaned Dumplings ..... 3.95
- ★ Burn Your Tongue Platter ..... 8.95
- Barbecued Bear Ribs ..... 6.30
- ★ Scallion Cow Pancakes (for two) ..... 2.95
- MSG with Orange Flavor ..... 4.95

## NOODLES

- ★ Cellophane Noodles with Styrofoam Peanuts ..... 5.50
- Cold Noodles in Sesame Waste ..... 3.50
- Some Glum Noodles ..... 8.25
- No Fun Noodles ..... 4.75

## PORK

- New Shoe Pork ..... 6.75
- Roasted Pork in Shriner Hat ..... 6.95
- Recently Shampooed Pork ..... 6.95
- Andrew Diced Pork ..... 9.75
- ★ Roast Pork Puppy Chow ..... 7.25
- ★ Porky Pig Cartoonese Style ..... 7.50
- Pork and Mindy ..... 6.75

## VEGETABLES

- ★ Broccoli in Human Sauce ..... 5.95
- Shredded Documents with Peking Sauce ..... 5.25
- ★ Bean Crud with Special Rotting Fungus ..... 6.25
- ★ Snow Shovel with Peas ..... 7.75
- Egg Neil Young ..... 4.95
- Green Beans with Black Bean Sauce ..... 4.95
- Black Beans with Green Bean Sauce ..... 5.95
- Eggplant Prepared Under Mysterious Circumstances ..... 5.95
- ★ Baby Corn with Adoption Papers ..... 4.95
- Vegetables with Tingling Horse Flavor ..... 5.50

## POULTRY

- San Diego Chicken with Pine Tar ..... 6.25
- Battering Ram Chicken ..... 6.25
- Peeking Daffy Duck ..... 7.50
- ★ Lemon Pledge Chicken ..... 6.25
- Amazing Talking Chicken ..... 8.75
- ★ Tongue Licked Duck ..... 7.50
- Chicken & Grief ..... 6.25
- Duck Edwing Prepared in Questionable Taste ..... 6.25
- ★ Chicken Escaping With Wings ..... 7.75
- Mocked Duck ..... 7.25
- ★ General Schwarzkopf Chicken ..... 6.75
- Goofy Grinning Chicken ..... 6.75
- Innocent Bystander Chicken ..... 6.25

## BEEF

- Air-Dropped Beef ..... 6.85
- Double Chin Beef ..... 6.85
- ★ Beef with More Beef ..... 7.75
- ★ Carnage of Beef ..... 6.85
- Sizzling Wanton Beef ..... 6.85
- Beef and Dried Pepper Spilled on Lap ..... 9.25
- Beef with Bad News ..... 8.85
- ★ Great Barrier Beef ..... 6.85
- ★ What's Your Beef ..... 7.25

## SEAFOOD

- Squished Eel Delight ..... 8.50
- ★ Shrimp with Alibi ..... 8.25
- Young Dead Fish ..... 9.25
- Crispy Fish with Discarded Needle ..... 9.95
- ★ Prawns in L.L. Bean Sauce ..... 7.50
- Aromatic Octopus On Wheels ..... 10.50
- Force Fed Shrimp ..... 7.75
- ★ Flounder with Water Pistol ..... 8.95

## DESSERTS

- Unfortunate Cookies ..... 2.50
- Sweet Fried Rolaids ..... 3.95
- Ice Cream with Garlic Sauce ..... 2.75
- ★ Boneless Pudding ..... 3.50
- Chicken Almond Ring Ding ..... 3.95

## CHEF'S SPECIALS

- ★ Sesame Street Duck ..... 11.75
  *Choice chunks of undernourished fowl pelted with waterchestnuts and stir-fried in a sizzling wok by popular Muppets.*
- Overpriced Happy Family ..... 84.95
  *Scallops, crabmeat and psychotropic mushrooms sauteed with fresh chef's thumbs and served on a Sealy Posturpedic.*
- ★ Tienanmen Square Beef ..... 17.75
  *Oppressed young beef, severely battered, crushed with bamboo shoots and brutally smothered as you watch from your table on a big screen.*
- Health Inspector's Seafood Delight ..... FREE!
  *Fresh lobster, shrimp and prawns expertly prepared in the clean Mexican restaurant down the block, brought in through our back door and served with a crisp fifty dollar bill rolled in a napkin. (Must be ordered in advance.)*

★ May Not be Edible

Waiter will change shirt at your request.



A MAD POSTER

# SBS Replacements & Hybrids

- Column A
  (Stand alone modifiers)
  ENTREES
  - SBS/SB
  - SBR
  - Elvaloy
  - GTR
- Column B
  (hybrid components)
  SIDE DISHES
  - Entira™ Bond
  - EVA
  - PPA
  - Titan Polymers

# DuPont Innovative Asphalt Modifiers

How to save money with Elvaloy® RET and Entira™ Bond asphalt modifiers

Hal Panabaker
Sales Development Manager
DuPont Packaging & Industrial Polymers

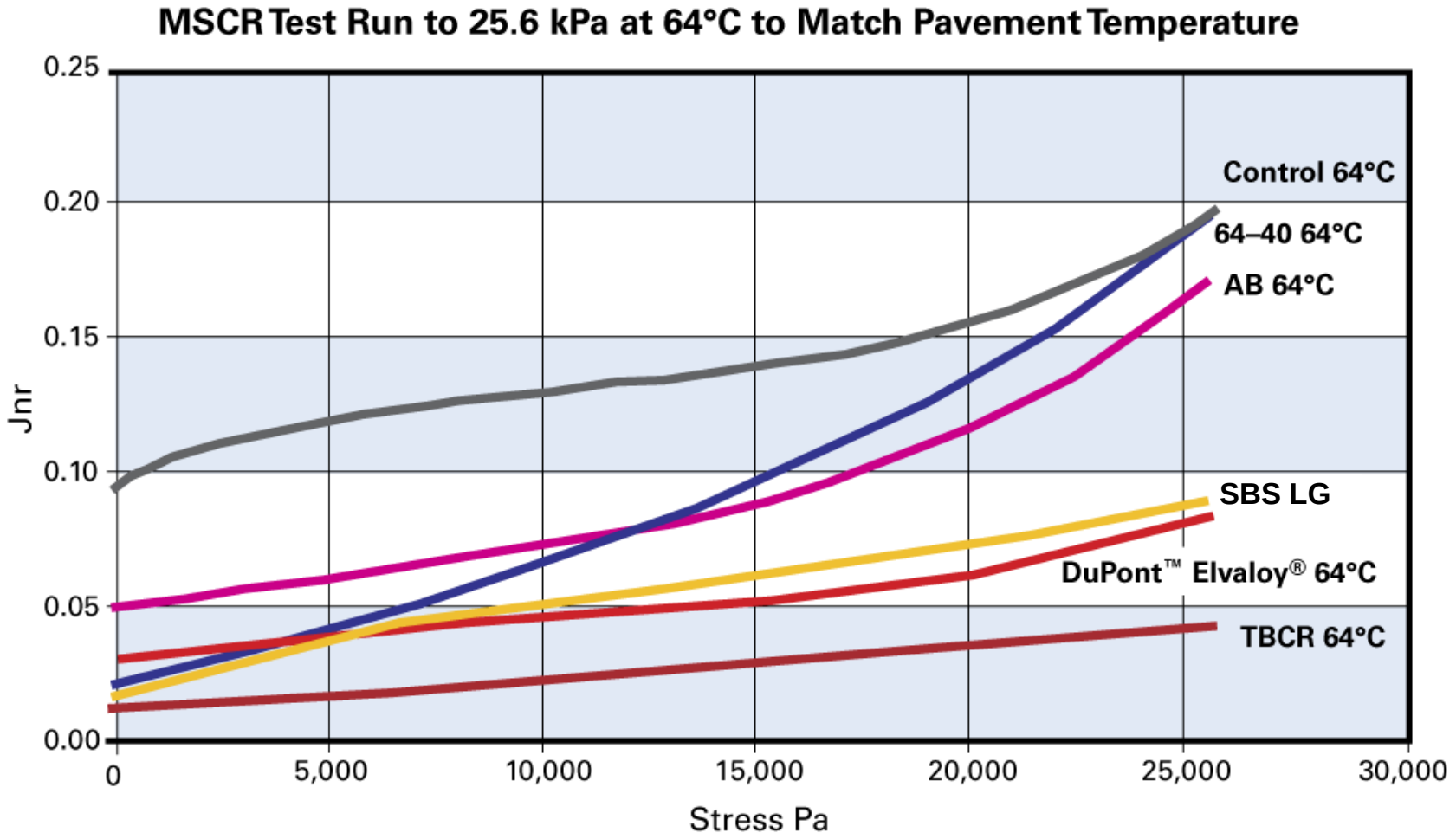
DUPONT
The miracles of science™

# Elvaloy® RET (Reactive Elastomeric Terpolymers)

## Benefits

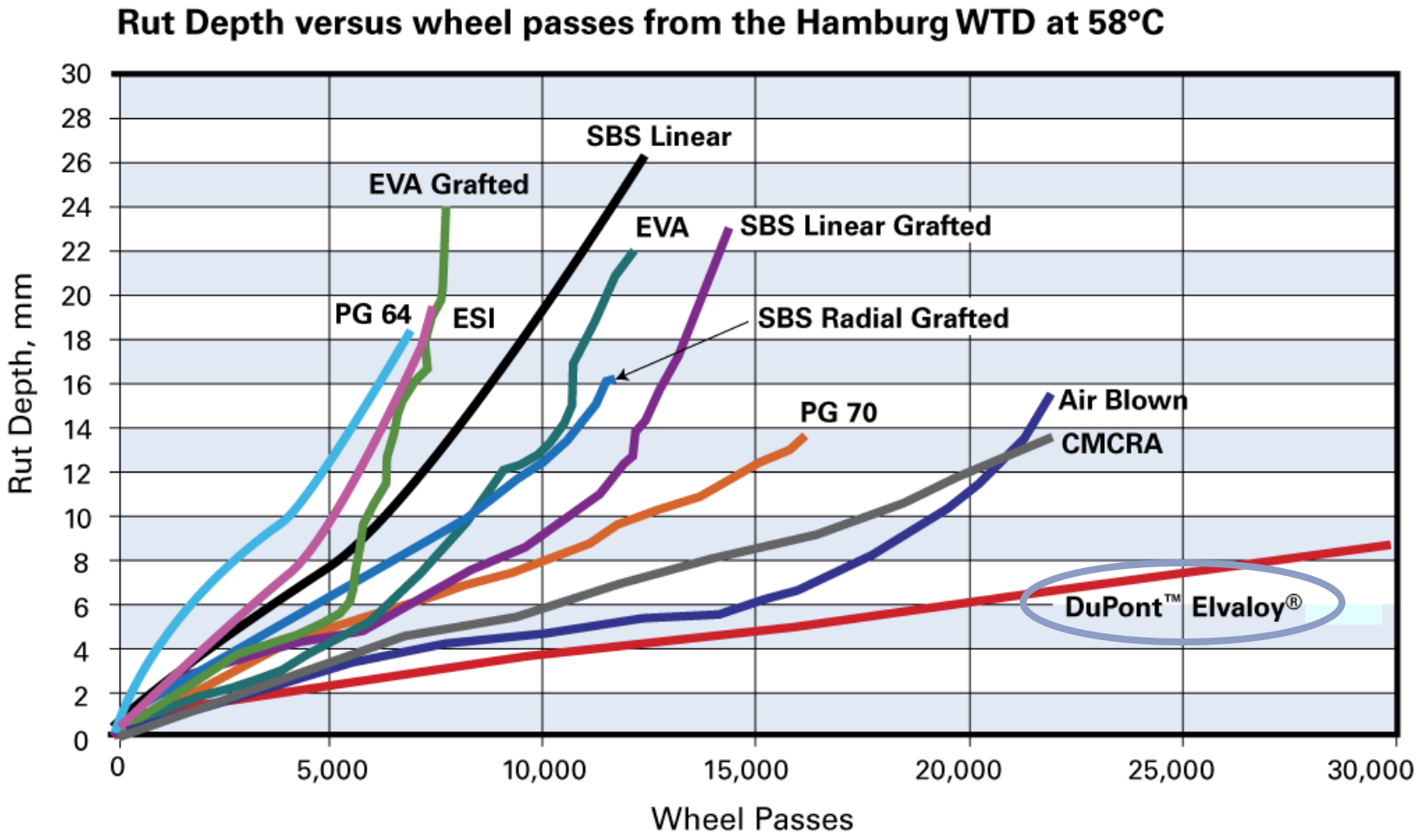
- Easy to use – no high-shear mill required. Melt into asphalt along with low level of PPA to bump several SHRP grades higher
- Phase angle equal to or less than SBS-modified, normally less than 70°
- Elastic recoveries similar to SBS, commonly over 70%
- Also improves other properties that aren't directly measured by the PG system such as fatigue cracking and low-temperature cracking – may lead to lower life-cycle costs
- Competitive cost per ton of asphalt versus other polymer modifiers
- Mix is less sticky than SBS-modified mixes

# RET Performance Data: Fatigue




D'Angelo, John. "**Development of a High Temperature Performance Based Binder Specification**", FHWA presentation at AMAP Feb 13, 2007, Slide #33

# RET Performance Data: Rutting




K.D. Stuart, J. S. Youtcheff, Ph.D., W. S. Mogawer Ph.D. "Understanding the Performance of Modified Asphalt Binders in Mixtures: Evaluation of Moisture Sensitivity", FHWA-RD-02-029, Figure #2

# MSCR Data

**The three polymer modified binders, even though they have the same base asphalt, have very different temperature sensitivity. This sensitivity is dependent on the polymer network and how strong it remains as the base binder softens with an increase in temperature. This verifies that a standard temperature shift function can not be assumed for all binders and that grade bumping with temperature will provide questionable performance results."**
**Ref: D'Angelo, J. Development of a Performance Based Binder Specification for Rutting Using Creep and Recovery Testing University of Calgary, 2009.**

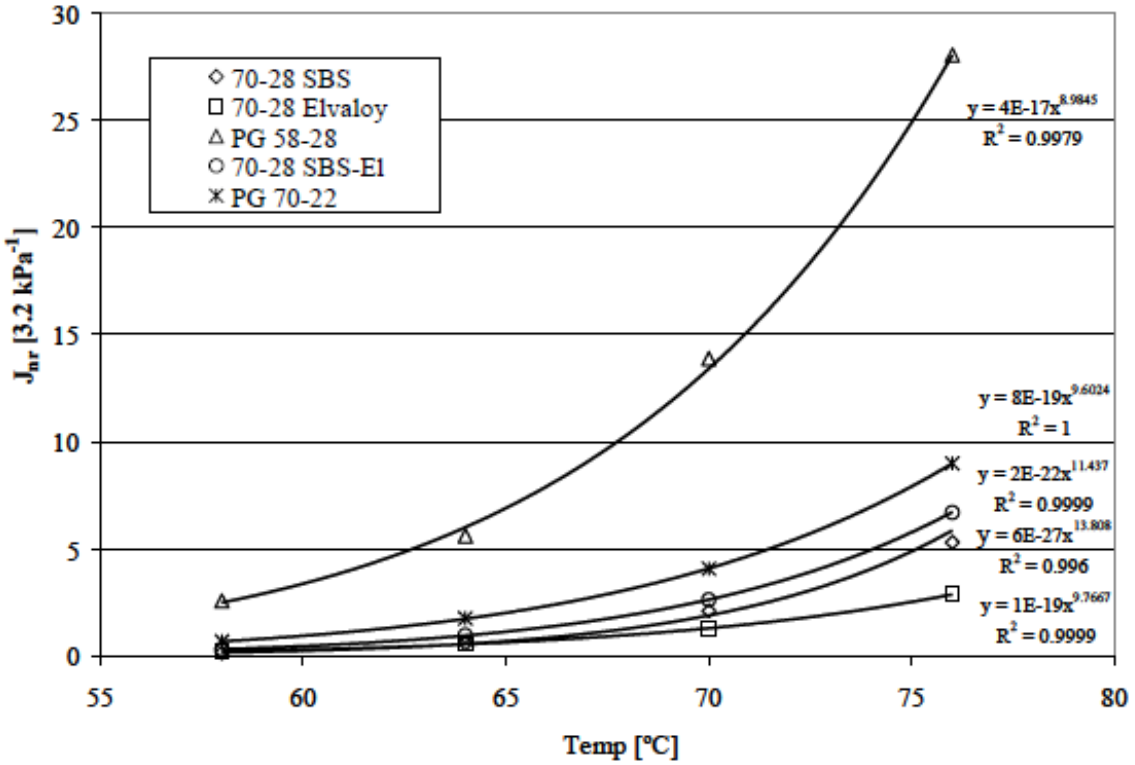



**Figure 4.13: Plot of the Change in $J_{nr}$ at 3.2 $kPa^{-1}$ With Change in Temperature for Several Neat and Polymer Modified Binders.**

# Elvaloy® RET (Reactive Elastomeric Terpolymers)

## Pitfalls

- Can’t add more than 2.5% Elvaloy® or asphalt may gel
- Can’t add more Elvaloy® after PPA added – better to overshoot and add neat asphalt if necessary

## Easy to use

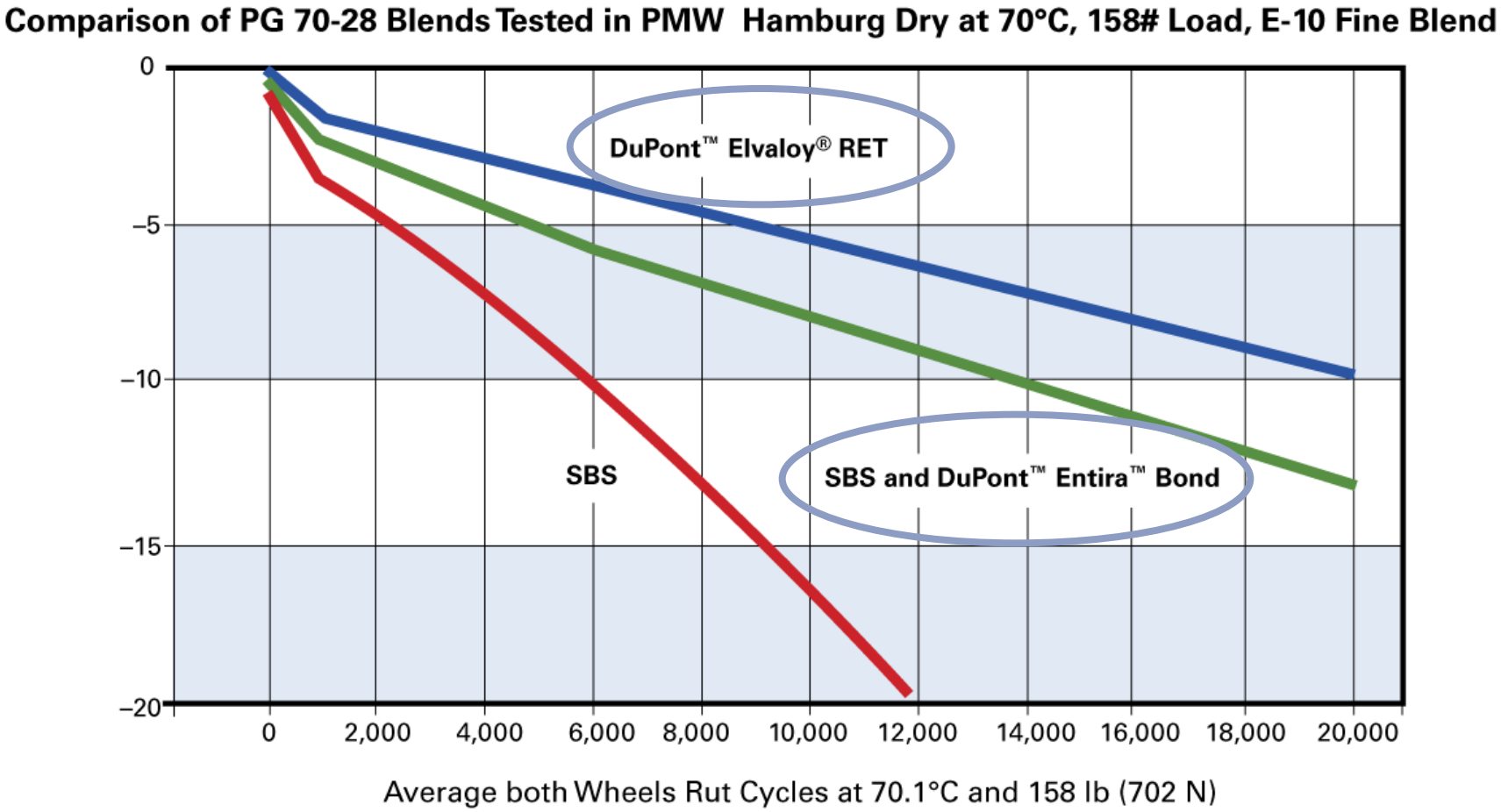
- Use between 0.7% and 2% Elvaloy® depending on asphalt and final grade
- Add to hot asphalt binder and stir – Elvaloy® melts into liquid (no high-shear mill)
- Add small amount of PPA to tank and stir (0.2% - 0.3%)
- Typically four-hours from Elvaloy® addition to ready for aggregate

# Additional Dupont Polymer: Entira™ Bond 12

**Benefits:**

- Entira™ Bond asphalt modifier works with SB/SBS modifiers and sulfur – no PPA
- Typically replace half of the SB/SBR/SBS polymer with half as much Entira™ Bond
  - **For example, 4% SBS would be with 2% SBS and 0.8% Entira™ Bond**
- Entira™ Bond has similar performance in binder tests versus SBS alone
- Mix testing indicates improved performance of Entira™ Bond versus SBS alone, although still not as good as Elvaloy® RET
- Designed to help reduce material cost per ton of asphalt

# Performance Data: Rutting (includes Entira™ Bond)




DuPont evaluation by independent lab

# Additional Dupont Polymer: Entira™ Bond 12

## Pitfalls

- Lower total polymer concentration is cost savings, but will have lower elastic recovery

## Easy to use

- Add to hot SBS-modified or unmodified asphalt – no high-shear mill necessary. Entira™ Bond melts into liquid
- Add cross-linker to tank and stir (no PPA required)
- Ready for aggregate in 4 hours

Product safety information is available upon request. This information corresponds to our current knowledge on the subject. It is offered solely to provide possible suggestions for your own determinations. It is not intended, however, to substitute for any testing you may need to conduct to determine for yourself the suitability of our products for your particular purposes. It is the user's responsibility to determine the level of risk and the proper protective equipment needed for the user's particular purposes. This information may be subject to revision as new knowledge and experience becomes available. Since we cannot anticipate all variations in actual end-use conditions, DUPONT MAKES NO WARRANTIES AND ASSUMES NO LIABILITY IN CONNECTION WITH ANY USE OF THIS INFORMATION. Nothing in this publication is to be considered as a license to operate under or a recommendation to infringe any trademark or patent right.



DUPONT®

*The miracles of science™*

# Honeywell Titan™ Asphalt Polymers for High-Performance, Cost Effective Asphalt

Honeywell

# What Are Honeywell Titan™ Polymers?

- **Low molecular weight polyolefin homopolymers, copolymers and modified polymers**
- **Unique molecular weight (and properties) between a paraffin wax and polyethylene resin**
- **Ethylene based chemistry derived from low cost natural gas**

## What do Honeywell Polymers Do in Paving and Roofing?

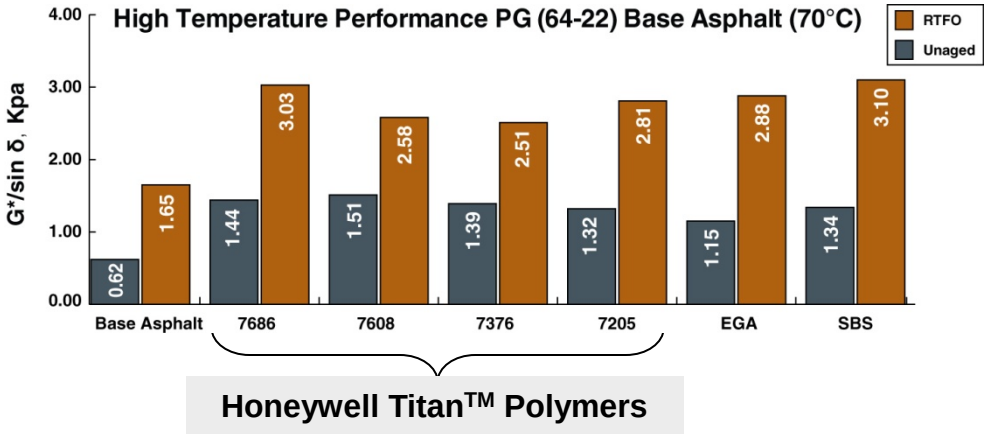
- **Lower material costs – More efficient grade bumping**
  - Typically + 6-9° TG @ 1.5-2%
  - Equal to or better performance than traditional PMA additives
- **Reduced PMA viscosity**
  - Retains low viscosity of the base asphalt
  - Mixing rather than milling
  - Reduced temperature and energy (1 hour, 300 °F)
- **Synergistic when used with SBS**
  - Reduced hybrid (SBS/Honeywell Titan) system viscosity
  - Higher concentrate levels
- **Improved asphalt adhesion**
  - Can eliminate the need for added Anti-strips
  - Stronger roofing membranes
- **Increases softening point and reduces penetration (harder)**

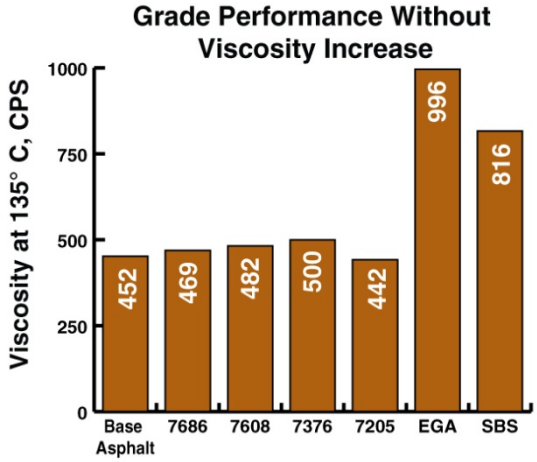


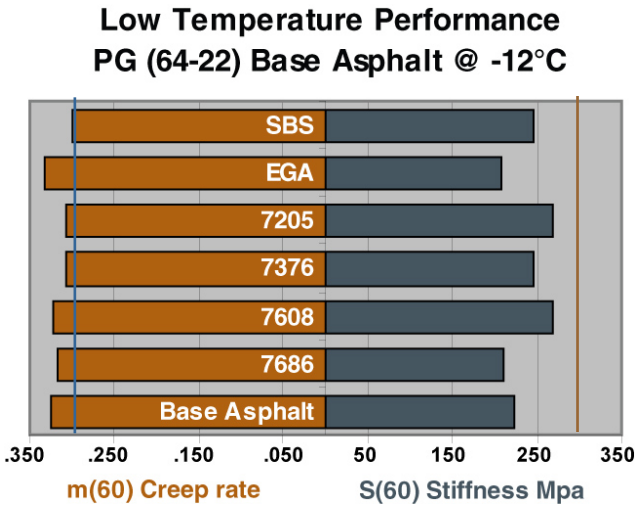
*Key functionality Required for Each Application*

# Honeywell Titan™ Performance in Paving*

- **Efficient grade bumping while:**
  - Maintaining the low viscosity of base asphalt
  - Allowing blending at lower temperatures (Δ70°F vs. milling)
  - While being readily dispersed in 1 hour
  - Having little to no effect on the intermediate or low-temperature properties

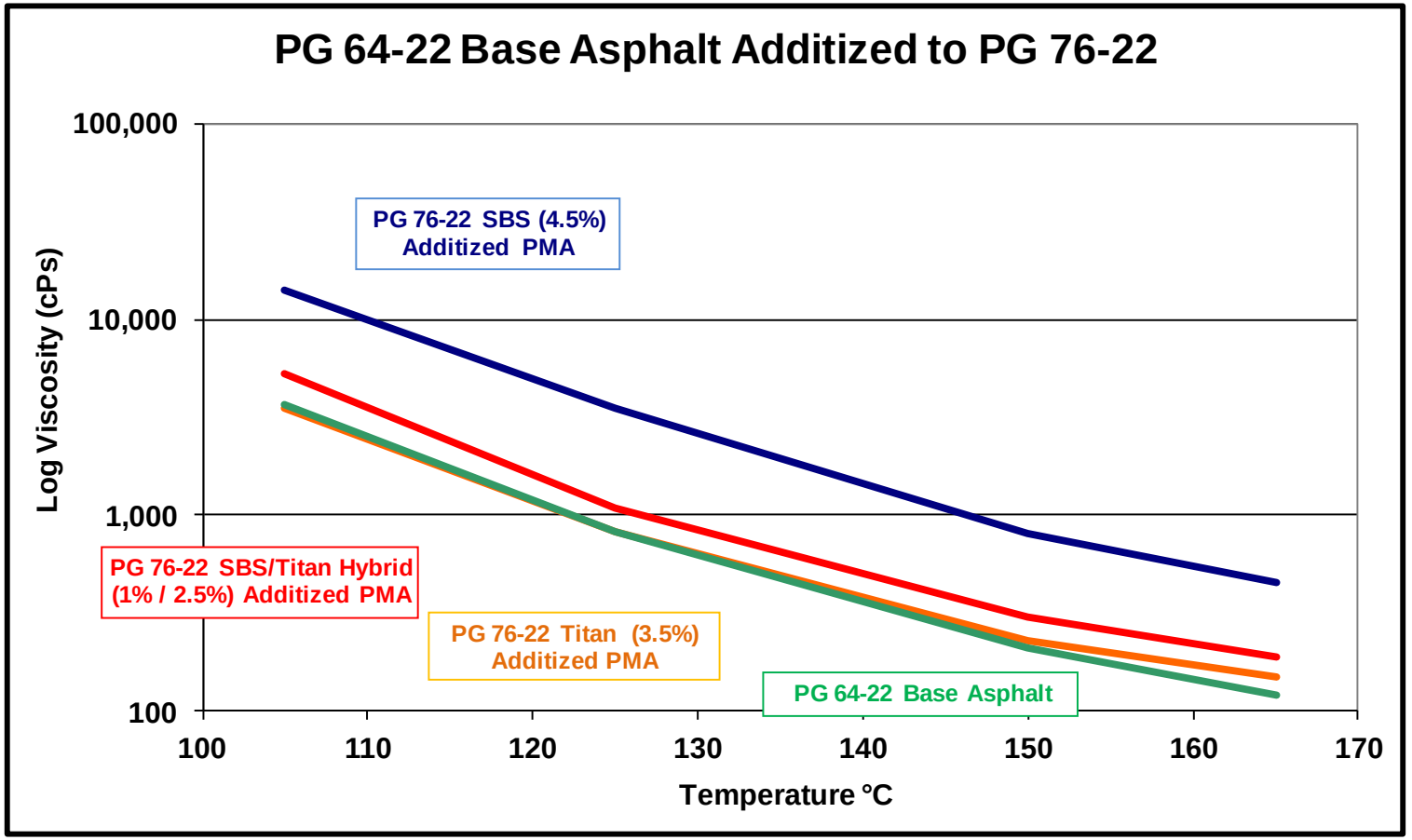



*Note: All additives at 2% by weight in PG 64-22 except Elvaloy at 0.8% with acid. SBS not crosslinked. Evaluation completed in collaboration with Modified Asphalt Research Center – MARC at Univ. of Wisconsin Madison

# Reduced PMA Viscosity—Retains Base Asphalt Viscosity




*Lower viscosity systems even when used with SBS*

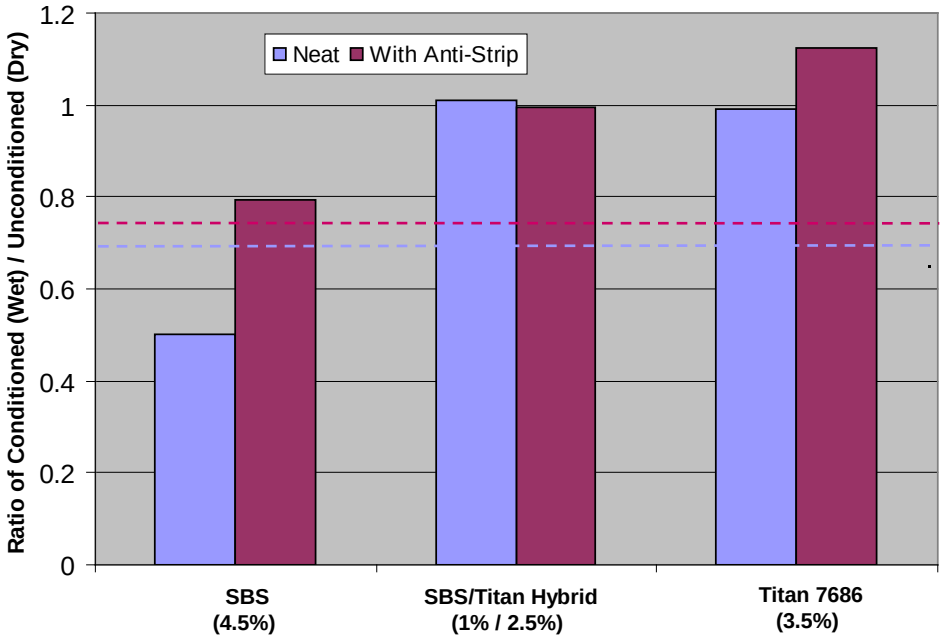


*Evaluation completed in collaboration with Modified Asphalt Research Center – MARC at Univ. of Wisconsin Madison*

# Potential to Eliminate Anti-Strip Additives

## Tensile Strength Ratio*

All Compositions Additized to PG 76-22




## Boiling Water Test**

***3% SBS***

***3% Titan 7686***

Dorservis Russian lab test shows increased adhesion to granite

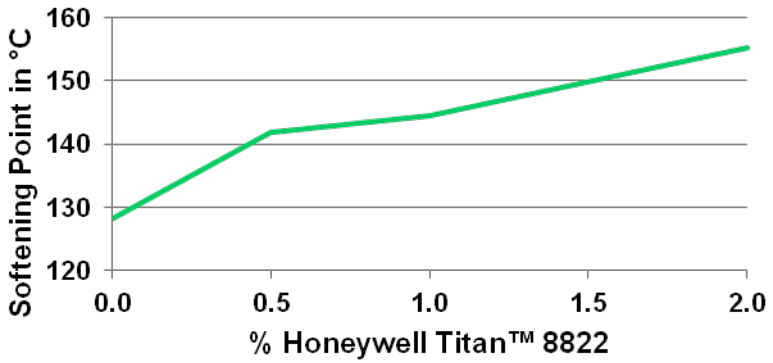
*Reduces or eliminates need for anti-strip additives*

*Evaluation completed in collaboration with Modified Asphalt Research Center – MARC at Univ. of Wisconsin Madison

**North West Russian Granite Aggregate

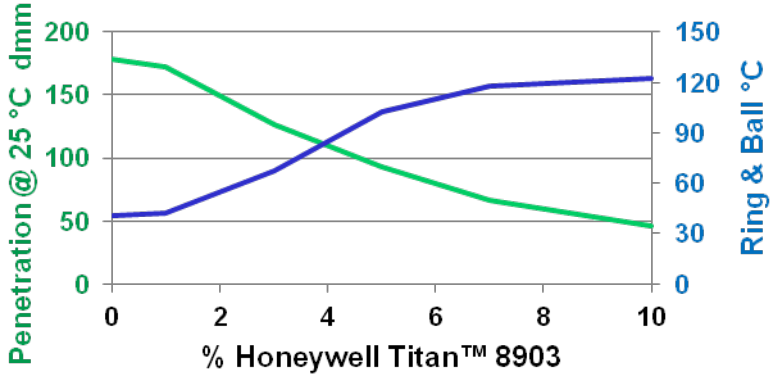
# Honeywell Titan™ in Roofing and Other Applications

**Filled SBS (3%) Modified Asphalt with Honeywell Titan™ 8822**




*Evaluation by Honeywell*

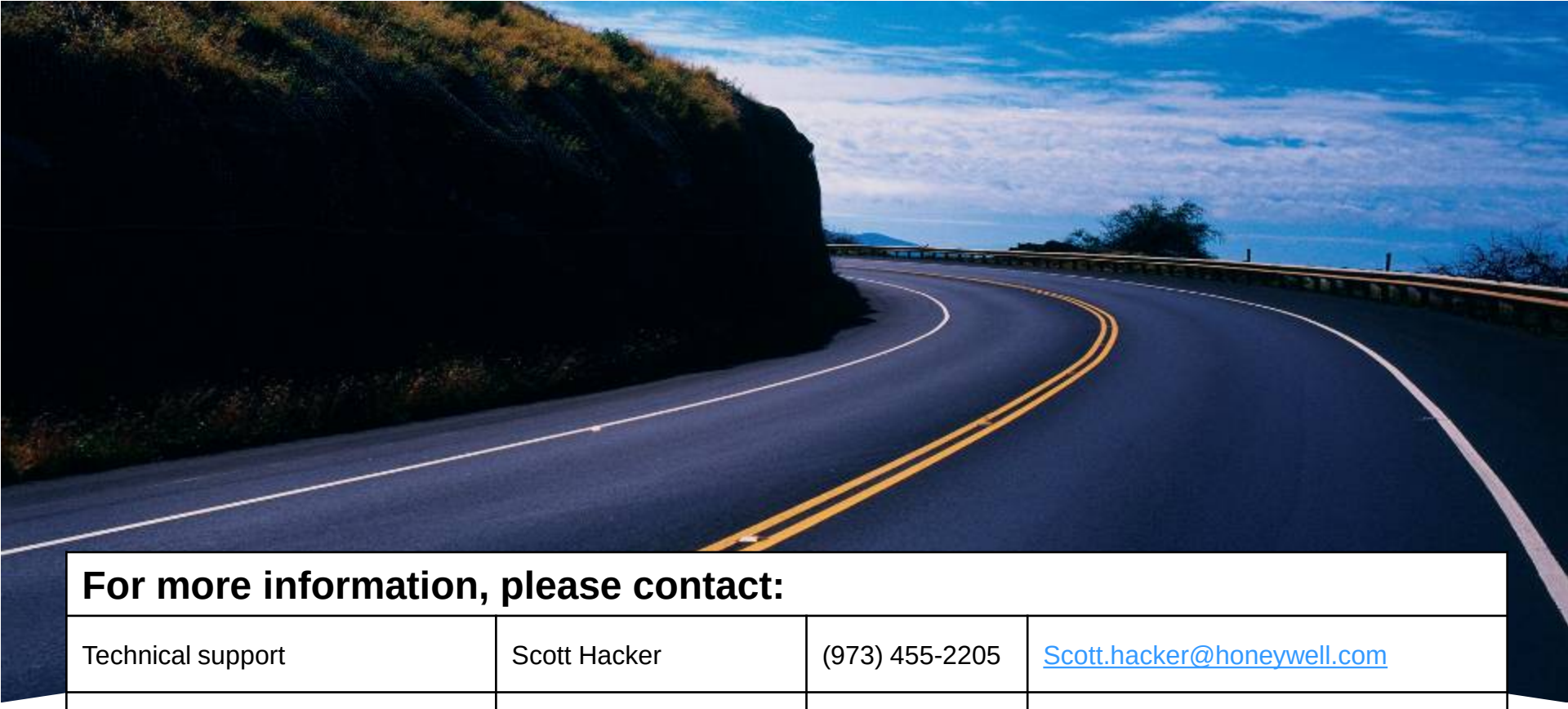
**160/220 Roofing Bitumen with Titan™ 8903**




*Evaluation completed in collaboration with Baustofflabor Hamburg*

| | |
|---|---|
| **Softening Point** | ↑ |
| **Penetration** (Lower=harder, less penetration) | ↓ |
| **Viscosity** | – ↓ |
| **Adhesion / Coupling** | ↑ |
| **Oil Bleeding** (Lower=less bleeding) | ↓ |

*Range of Effects are Polymer and Asphalt Specific*



## For more information, please contact:

| | | | |
|---|---|---|---|
| Technical support | Scott Hacker | (973) 455-2205 | Scott.hacker@honeywell.com |
| Sales: Eastern U.S. & Canada | Blake Wiseman | (804) 353-0406 | Blake.wiseman@honeywell.com |
| Sales: Western U.S. & Latin America | Steve Rotz | (973) 455-5059 | Steven.rotz@honeywell.com |
| Sales: Europe, Middle East, India, China, Asia | Cynthia Kostelansky | (973) 455-2475 | Cynthia.kostelansky@honeywell.com |





Honeywell

# SBR Latex Modified Asphalt Cement Current Markets

BASF
The Chemical Company

## Current Markets – Plant-Site Injection

- Ohio – PG 70-22
  - Dense-graded wearing course
- Mass. + Vermont – PG 64-22 + 3% SBR latex solids
  - Recipe specification - OGFC wearing course

## Mexico, Central America, South America, Europe

- Plant-site injection + pre-blend (small percentage)

# SBR Latex Modified Asphalt Cement Suggestions – State of the Practice

BASF
The Chemical Company

- **Plant-site injection preferred method**
  - Accurate with proper metering controls and technique
  - Mixing occurs in pug mill or at nozzle/in continuous drum
  - Low cost + efficient method for polymer addition
  - No need for storage of multiple PG grades
    - Eliminates storage and thermal stability problems
    - Produce PG grade binder *in-situ* from standard base AC
    - Pre-blend SBR and grade to determine loading to meet required PG grade (usually PG 70-22 or PG 76-22)
    - Submit base AC certification + recorded proof of latex addition rate for state materials QC requirement

# Plant-Site Injection – Drum Plant

BASF
The Chemical Company

# SHRP Plus Props – SBR, SBS, Elvaloy®AM
# Mexican AC-20 Base AC

BASF
The Chemical Company

| Binder Tests | Test Method ASTM/AASHTO | Mexican AC-20 Base Asphalt | | | |
|---|---|---|---|---|---|
| | | AC-20 | NX 1129 | SBS | Elvaloy |
| | | 0.0 | 3.0 | 3.0 | 2.0 |
| | | SHRP PG Testing | | | |
| Brookfield Viscosity (135°C,cps) | ASTM D4402 | 458 | 2141 | 1412 | 1850 |
| Temp. @ DSR G*/sinδ =1.0 kPa (°C) | AASTHO T 315 | 66.7 | 77.7 | 80.5 | 77.0 |
| Phase Angle (76°C, °) | | ----- | 77.1 | 76.0 | 70.1 |
| Temp. @ RTFO G*/sinδ =2.2 kPa (°C) | | 69.7 | 79.9 | 85.6 | 80.7 |
| Phase Angle (82°C, °) | | ----- | 71.1 | 72.7 | 64.5 |
| Temp. @ PAV G* x sinδ = 5000 kPa (°C) | | 19.5 | 13.2 | 19.5 | 19.1 |
| Temp. @ S=300 MPa (60s,°C) | AASHTO T 313 | -20.8 | -23.6 | -20.4 | -20.8 |
| Temp. @ m=0.30 (60s,°C) | | -15.5 | -13.1 | -9.1 | -14.6 |
| Continuous SHRP PG Grading | AASHTO R 29 | 67-26 | 78-23 | 81-19 | 77-25 |
| **SHRP PG Grading** | **AASHTO M 320** | **64-22** | **76-22** | **76-16** | **76-22** |
| | | SHRP PG "Plus" Testing | | | |
| Compatibility - $\Delta_{sp}$(°F) | ASTM D5892 | 0.2 | 5.3 | 12.8 | 0.1 |
| Elastic Recovery (10°C,%) | AASHTO T 301 | 10 | 50 | 61 | 38 |
| Elastic Recovery (25°C,%) | | 6 | 61 | 74 | 58 |
| RTFO-ER (25°C,10 cm,no wait,%) | | 31 | 64 | 71 | 70 |
| Ductility (4°C,cm) | ASTM D113 | 4 | 13 | 8 | 5 |
| Penetration (4°C,dmm) | ASTM D5 | 25 | 26 | 19 | 25 |
| Penetration (25°C,dmm) | | 58 | 48 | 38 | 49 |
| Softening Point (°F) | ASTM D36 | 124 | 137 | 143 | 143 |

# SHRP Plus Props – SBR vs SBS
# Chevron PG 64-28 Base AC

BASF
The Chemical Company

| Tests on Binder | Test Method ASTM/AASHTO | Control 0.0 | NX 1129 2.0 | NX 1129 3.0 | Rad. SBS 3.0 |
|---|---|---|---|---|---|
| **SHRP PG Testing** | | | | | |
| Brookfield Viscosity (135°C,cps) | ASTM D 4402 | 533 | 1208 | 1858 | 1612 |
| Temp. @ G*/sinδ = 1.0 kPa (°C) | AASTHO T 315 | 65.9 | 73.4 | 77.9 | 77.6 |
| Phase Angle (76°C, °) | AASHTO T 315 | ----- | 80.9 | 76.9 | 79.6 |
| Temp. @ S = 300 MPa (60s,°C) | AASHTO T 313 | -24.0 | -24.4 | -26.6 | -24.0 |
| Temp. @ m = 0.30 (60s,°C) | AASHTO T 313 | -19.1 | -20.2 | -17.2 | -17.0 |
| Continuous SHRP PG Grading | AASHTO R 29 | 65.9-29.1 | 73.4-30.2 | 77.9-27.2 | 77.6-27.0 |
| **SHRP PG Grading** | **AASHTO M 320** | **64-28** | **70-28** | **76-22** | **76-22** |
| **SHRP PG "Plus" Testing** | | | | | |
| Compatibility - $\Delta_{sp}$(°F) | ASTM D 5892 | 0.25 | 0.42 | 1.20 | 0.35 |
| Elastic Recovery (10°C, 5 cm/min to 20 cm, straight-sided molds, 5 min wait, %) | AASHTO T 301 | 10.5 | 48.2 | 56.9 | 55.0 |
| Elastic Recovery (10°C, 5 cm/min to 20 cm, straight-sided molds, no wait, %) | AASHTO T 301 | 19.4 | 56.2 | 64.4 | 65.0 |
| RTFO-Elastic Recovery (25°C, 5 cm/min to 10 cm, straight-sided molds, no wait, %) | AASHTO T 301 | 27.5 | 62.5 | 70.0 | 56.2 |

# SHRP Plus Props – SBR vs SBS
# Marathon PG 58-28 + United PG 58-28

BASF
The Chemical Company

| Binder Tests | Test Method ASTM/AASHTO | Marathon-Ashland PG 58-28 | | | United Refining PG 58-28 | | |
|---|---|---|---|---|---|---|---|
| | | Mar-Ash | 1129 | SBS | United | 1129 | SBS |
| | | 0.0 | 3.0 | 3.0 | 0.0 | 3.0 | 3.0 |
| | | SHRP PG Testing | | | | | |
| Brookfield Viscosity (135°C,cps) | ASTM D 4402 | 292 | 1812 | 792 | 300 | 1541 | 825 |
| Temp. @ G*/sinδ = 1.0 kPa (°C) | AASTHO T 315 | 59.4 | 66.6 | 69.6 | 60.5 | 67.8 | 69.1 |
| Phase Angle (64°C, °) | | 88.7 | 79.4 | 79.6 | 88.2 | 78.2 | 80.4 |
| Temp. @ G*/sinδ = 2.2 kPa (°C) | | 59.6 | 65.0 | 67.8 | 59.8 | 67.8 | 68.5 |
| Phase Angle (64°C, °) | | 86.7 | 74.6 | 75.9 | 85.7 | 72.9 | 77.0 |
| Temp. @ S = 300 MPa (60s,°C) | AASHTO T 313 | -20.8 | -22.4 | -21.2 | -21.6 | -23.3 | -22.5 |
| Temp. @ m = 0.30 (60s,°C) | | -20.6 | -19.9 | -19.9 | -20.8 | -19.2 | -20.0 |
| Continuous SHRP PG Grading | AASHTO R 29 | 59.4-30.6 | 65.0-29.9 | 67.8-29.9 | 59.8-30.8 | 67.8-29.2 | 68.5-30.0 |
| **SHRP PG Grading** | **AASHTO M 320** | **58-28** | **64-28** | **64-28** | **58-28** | **64-28** | **64-28** |
| | | SHRP PG "Plus" Testing | | | | | |
| Compatibility - $\Delta_{sp}$(°F) | ASTM D 5892 | ----- | 1.90 | **>36.6** | ----- | 0.20 | **>38.9** |
| Elastic Recovery (10°C,%) | AASHTO T 301 | 5.8 | 65.9 | 76.3 | 6.3 | 65.0 | 74.4 |
| Elastic Recovery (25°C,%) | | 0.0 | 63.8 | 85.6 | 1.2 | 62.6 | 85.6 |
| RTFO-ER (25°C,10 cm,no wait,%) | | 17.5 | 70.0 | 68.8 | 18.8 | 62.5 | 82.5 |
| Ductility (25°C,cm) | ASTM D 113 | 137 | 150 | 132 | 115 | 150 | 117 |

# Overview

- Polyphosphoric Acid (PPA)
- Modification of neat asphalt
  - Broaden PG grade
  - Recommended: One PG grade bump, <1.5% PPA
- Co-modifier with SB/SBS polymers
  - Discussion of classical and MSCR specs
  - Reduced polymer levels
  - Better performance than either modifier used alone
- Catalyst/Stabilizer with Ethylene Terpolymers
- Storage Stability
- Moisture Sensitivity
- Best Practices

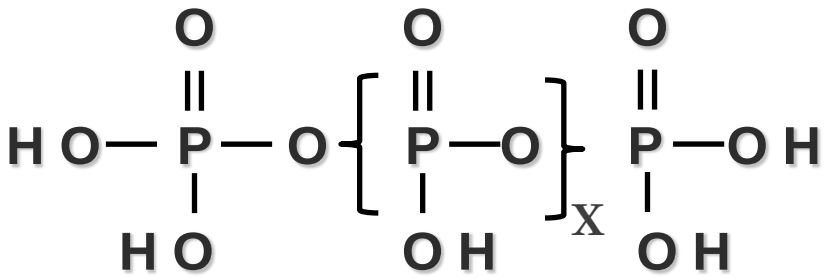
# History of PPA in Asphalt Pavement

- 35 years: Tosco-Lion, US Patent 3,751,278 (1973)
- 40+ Patents. Since 2000: 100+ Publications
  - Concerns: Amine, Lime Anti-Strip
- NCAT Test Track 2000/3 18 Test Sections, 10 M ESAL
  - SBS/PPA; Various aggregates; Amine or lime anti-strip
  - Improved rut depth, 1 fatigue crack, no moisture damage
- MnROAD test track 2007
  - Excellent performance to date
  - Successful PPA Symposium April 2009

PPA usage: 3.5 to 14% of the asphalt pavement in USA.

Estimated 150 to 550 million ton of hot mix over last 5 years.

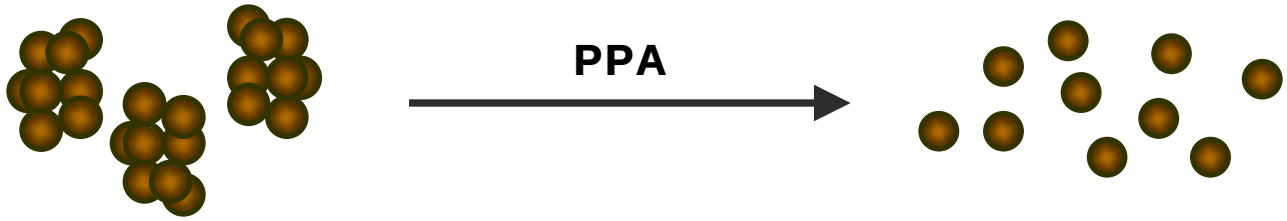
# Polyphosphoric Acid (PPA)




- PPA Chemical Attributes
  - Different from Orthophosphoric acid
  - No Free Water
- 105% and 115% most common
- Increases asphalt stiffness, improves rutting resistance, expands PG range to meet Superpave specs
- Does not affect low-temperature grading
- Modification does NOT involve oxidation and actually slows it down
- Retards binder aging

# Working Model

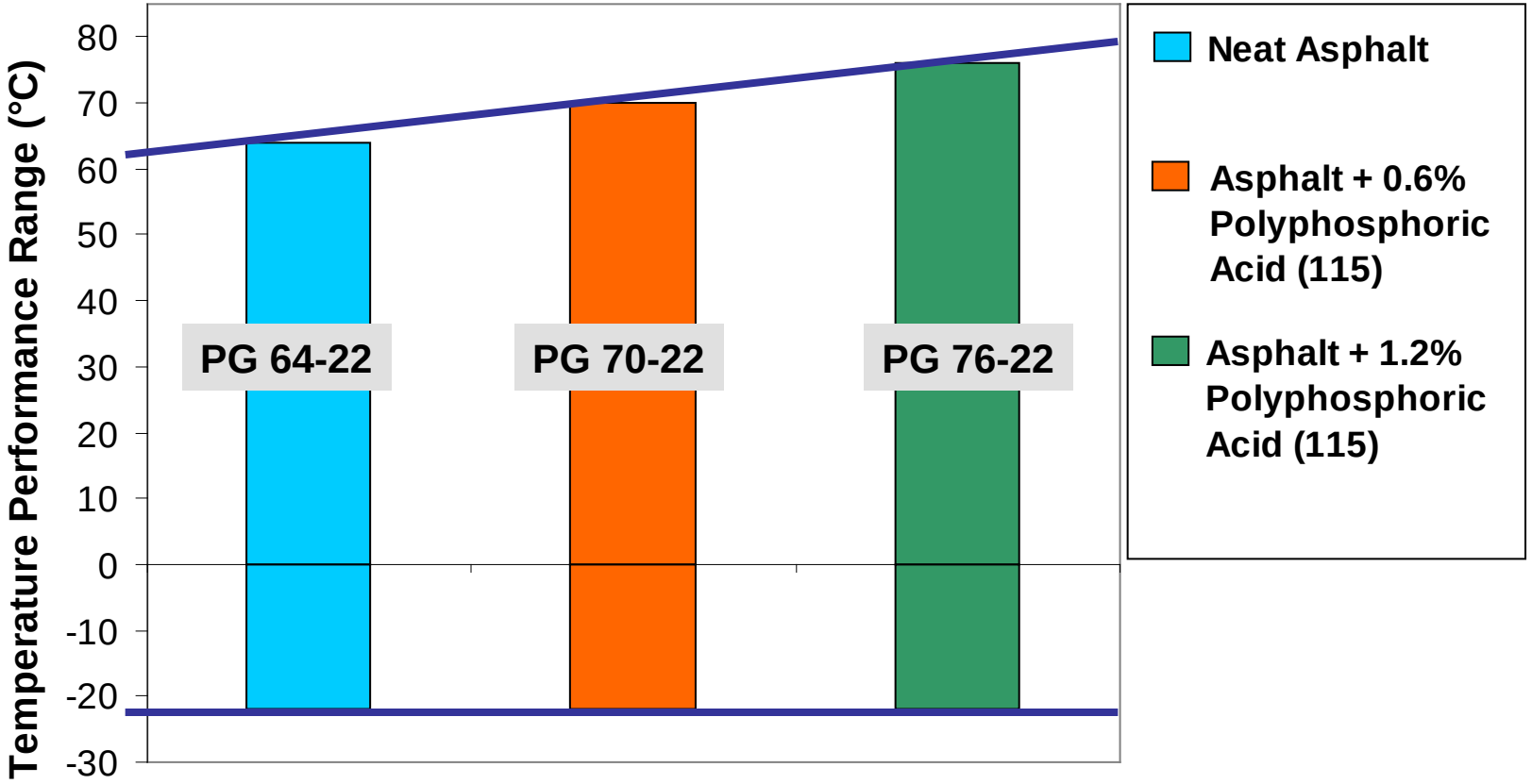
- Various mechanisms could account for the enhancement of asphalt properties with PPA
- One possible mechanism and current working model:
  - Polyphosphoric Acid reacts with active sites in asphaltene agglomerates (hydroxyl, amine, sulfur, other groups) breaking up the agglomerates




  - The dispersed asphaltene particles are better able to form long-range networks and contribute to elastic behavior
  - In addition, polyphosphoric acid leads to an apparent increase in the level of asphaltenes

Complex modulus is increased, phase angle is reduced. One of the benefits in asphalt pavement is increased high-temperature rating with no detrimental effect on low-temperature performance.

# Performance Grade Rating

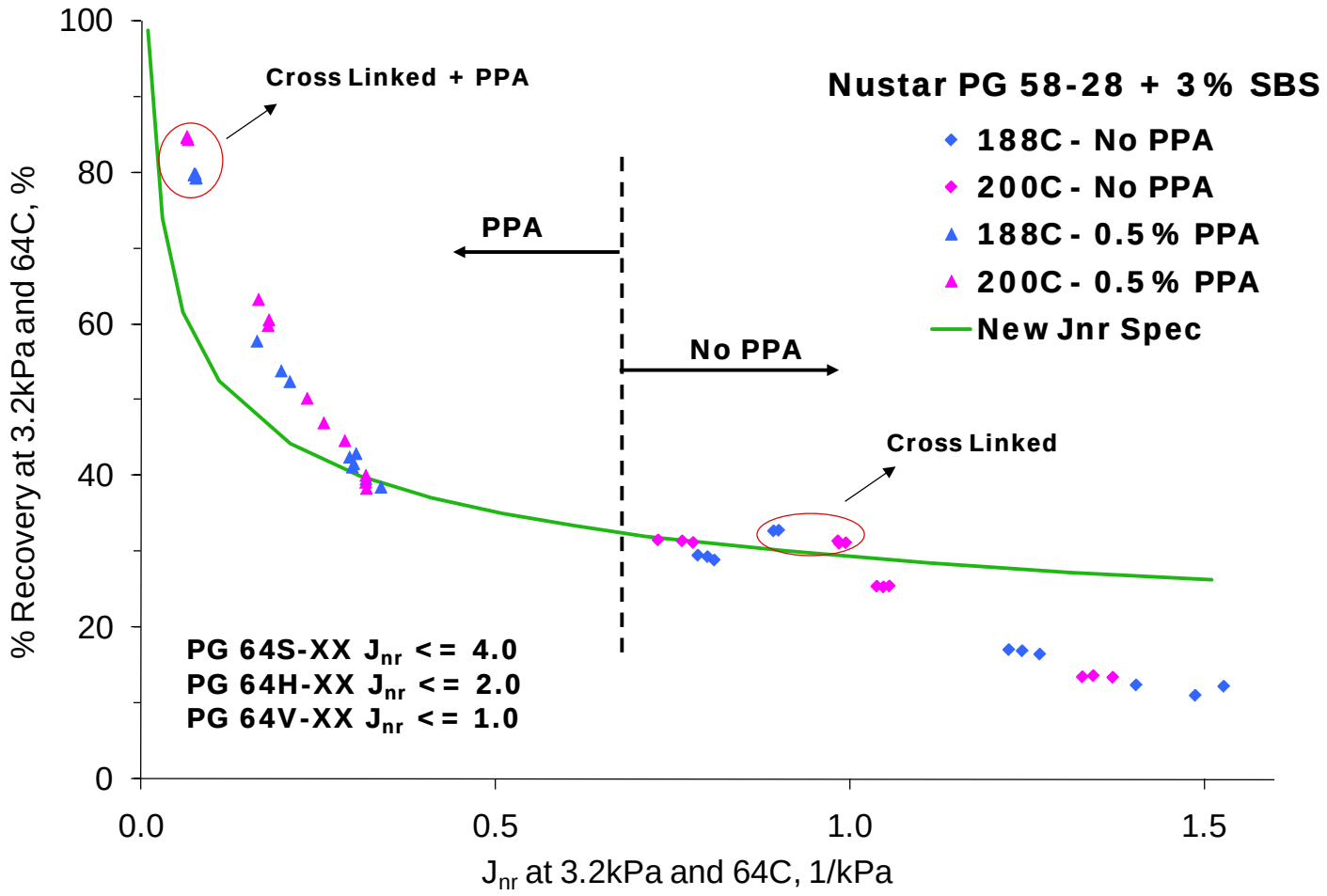



Polyphosphoric Acid increases the high-temperature grading with no loss of the low-temperature properties

# MSCR Experimental Design

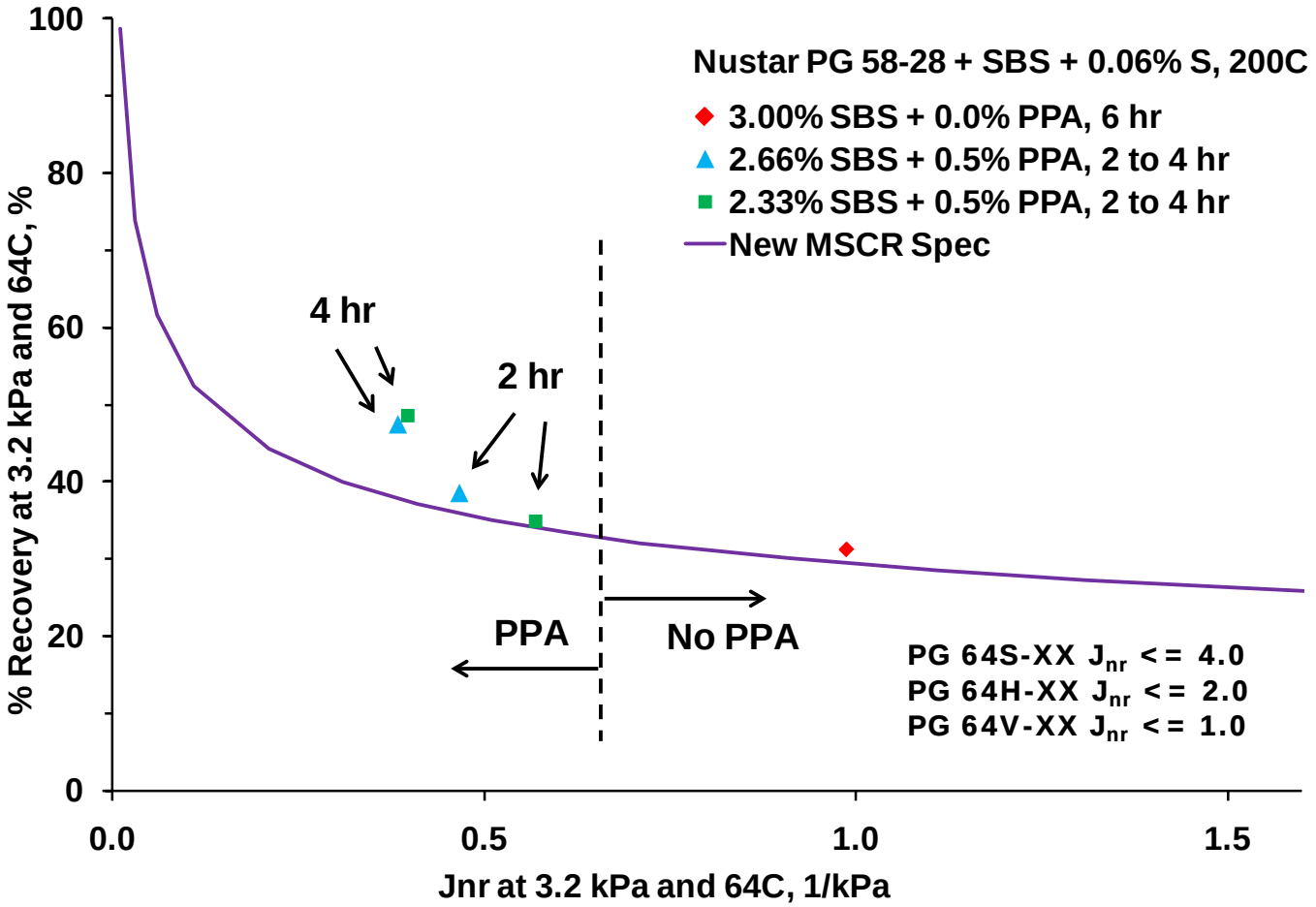
| MSCR Evaluation Experimental Design | | |
|---|---|---|
| **Composition** | | |
| Binder | Nustar PG 58-28 | |
| Polymer | SBS Kraton D1101 | @ 0 and 3% |
| PPA | ICL PPA 105 | @ 0 and 0.5 % |
| Crosslinker | Sulfur | @ 0 and 0.06 % |
| **Mix Parameters** | | |
| Blend Temperature | | 188 and 200 $^{o}$C |
| Blend Time | | 2, 4, and 6 Hours |
| **Measurements** | | |
| Elastic Recovery, UDOT | | |
| PG Grade | | |
| MSCR on RTFO Material | | |
| Percent Recovery, 100 Pa | | Three Replicates, Average |
| Percent Recovery, 3200 Pa | | Three Replicates, Average |

# SBS/PPA Asphalt Modification: Polymer Constant




MSCR shows PPA + Polymer is better than either alone.

# SBS/PPA Asphalt Modification: Polymer Reduction




MSCR shows PPA + Polymer is better than either alone.

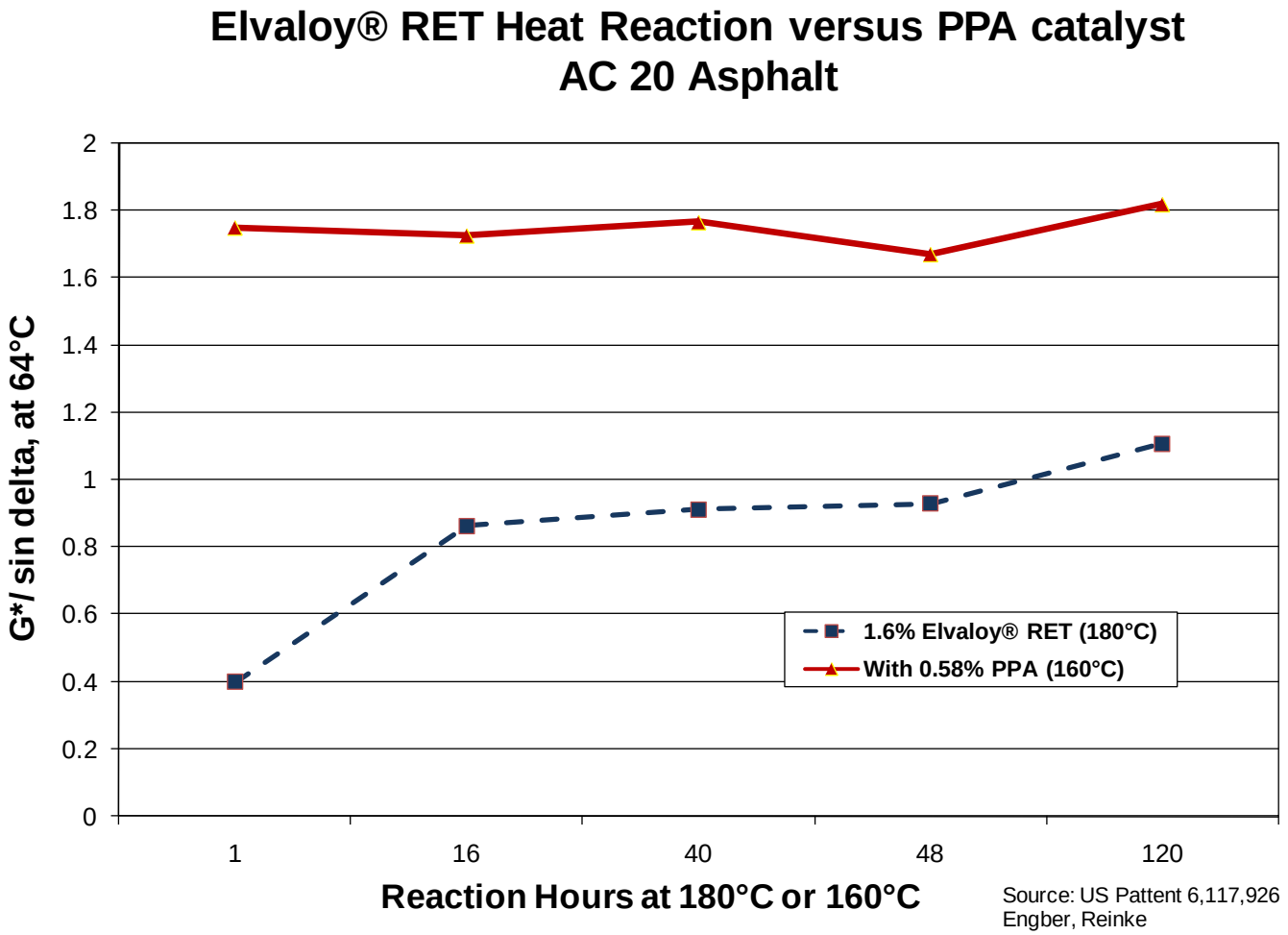
# MSCR Findings for PPA in SBS/Asphalt

- Improved Jnr
- Improved Percent Recovery
- Use of PPA may allow…
  - Modest reduction in polymer level
  - Reduction in processing time, and/or
  - Reduction in processing temperature

# Reactive Ethylene Terpolymer Combined with PPA

- Low levels of PPA used, typically 0.2 to 0.5 wt% of binder
  - This low usage level would have minimal impact on final properties if reactive terpolymer were not present.
- Reduction in reaction time from 18 hours to 1 hour
- Reduction in processing temperature

# PPA with Elvaloy™




Source: US Pattent 6,117,926
Engber, Reinke

# Best Practices

- Proper Dosage
- Anti-strip Selection
- Co-modification with Polymers
- Mixture Performance

# Proper Dosage

- Typical Range – 0.25 to 1.5%
- Most Common – 0.25 to 1.2%
- Affected by:
  - Specification Requirements
  - Reactivity of Base Asphalt
  - Interaction with Local Aggregates

# Best Practices

- Formal recommendations on proper use of product
- Recommended level selection and maximum % use of PPA:
  - Neat asphalt:  Typical 0.5 – 1.2 weight %
  - SBS/asphalt:  Typical 0.2 – 1.0 weight %
- Procedures for proper use with SBS polymers
- Procedures for proper use with ethylene terpolymers

# Conclusions

- Long history of successful use. Estimated 150 to 550 Million Tons of pavement currently in place where PPA has been used in the last 7 years
- As stand-alone modifier, high temp. stiffness, no low temp. effect, no impact on aging
- Unique properties and improved processes obtainable when used as a co-modifier with polymers
- Successfully used with hydrated lime and selected amines. Best practice is to test finished products
- PPA modified binders are storage stable

# Acknowledgements


- Association of Modified Asphalt Producers (AMAP)
- John D'Angelo, D'Angelo Consulting
- Terry Arnold, TFHRC
- Beth Griffin, DuPont
- Tom Bennert, Rutgers University
- Hussain Bahia, University of Wisconsin

# Terminal Blended Ground Tire Rubber **(GTR) MODOT**

by

**Hugh Chapman**

Manager Promotions & Specialty Products

Seneca Petroleum Co,. Inc.

13301 South Cicero Ave.

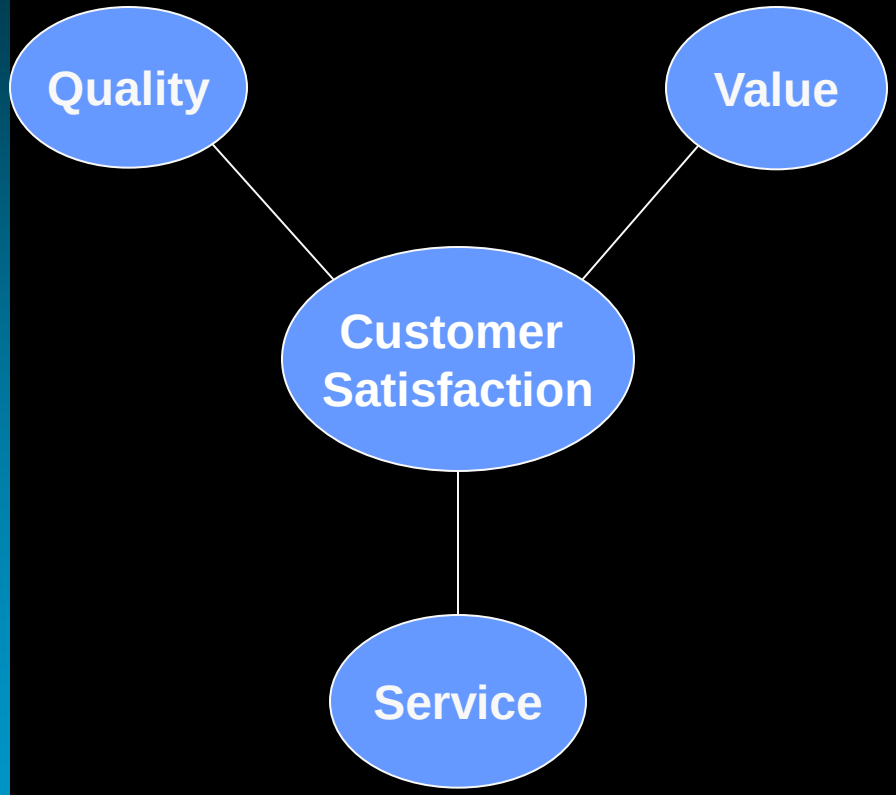
Crestwood, IL 60445

Phone: 708-878-9074

# Objective

- To keep used car and truck tires out of landfills.
- To reduce the disposal cost of used tires
- To recycle these used tires in a environmentally friendly manner
- To provide an engineered high quality product that will extend the useful life of our road ways.

# Customer Requirements




- Environmentally Friendly
- Enhanced Physical Properties
- Safety
- Workability

# Enhanced Physical Properties

- Increased Rut Resistance
- Reduced Reflective Cracking
- Reduced Thermal Cracking
- MDOT 13A Regular mix using PG64-22 has a Marshall Stability of 2400 and Flow of 12
- MDOT 13A mix using GTRPG76-22 has a Marshall Stability 3600 and Flow of 16

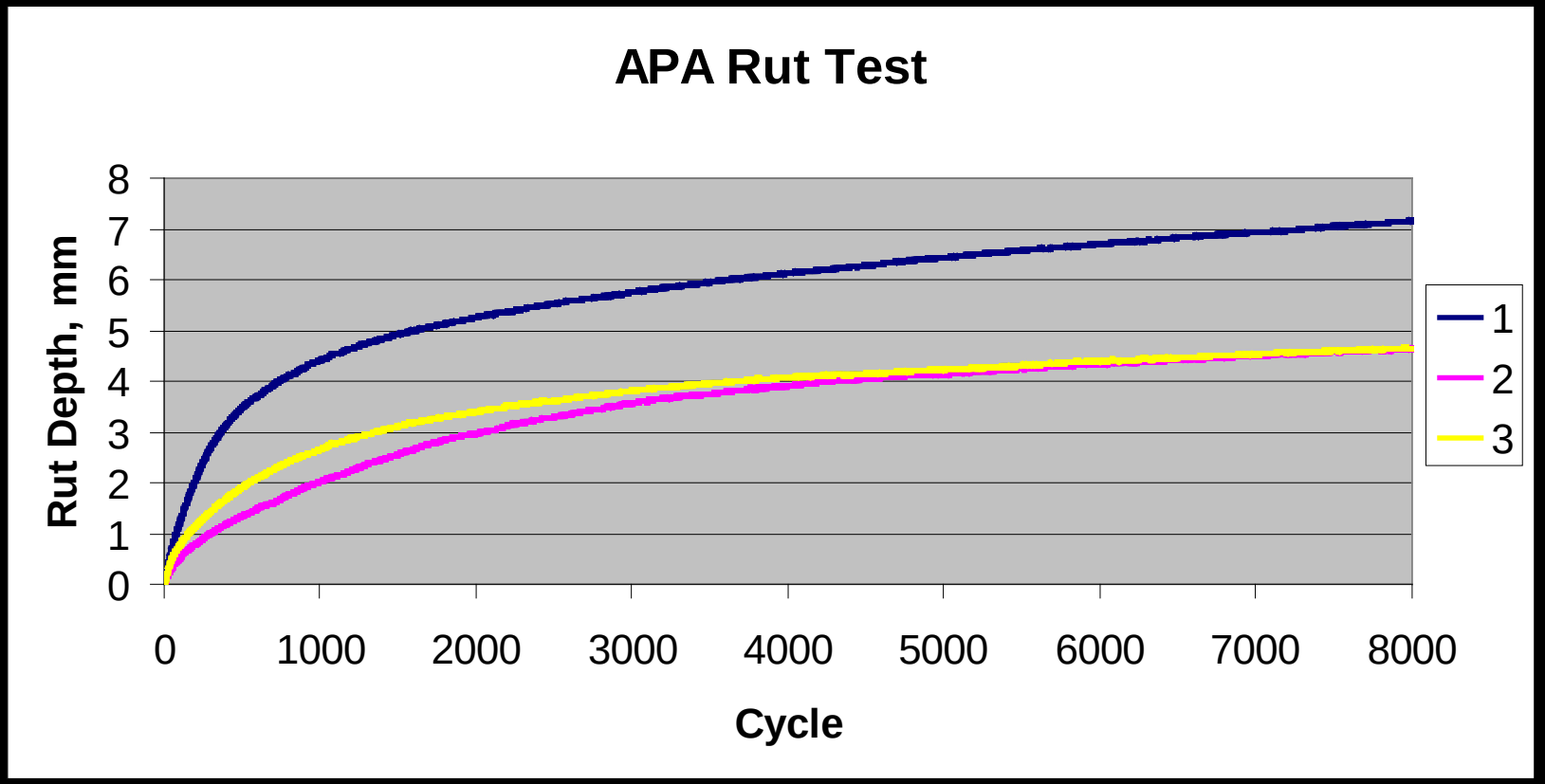
# APA Rut Test Results

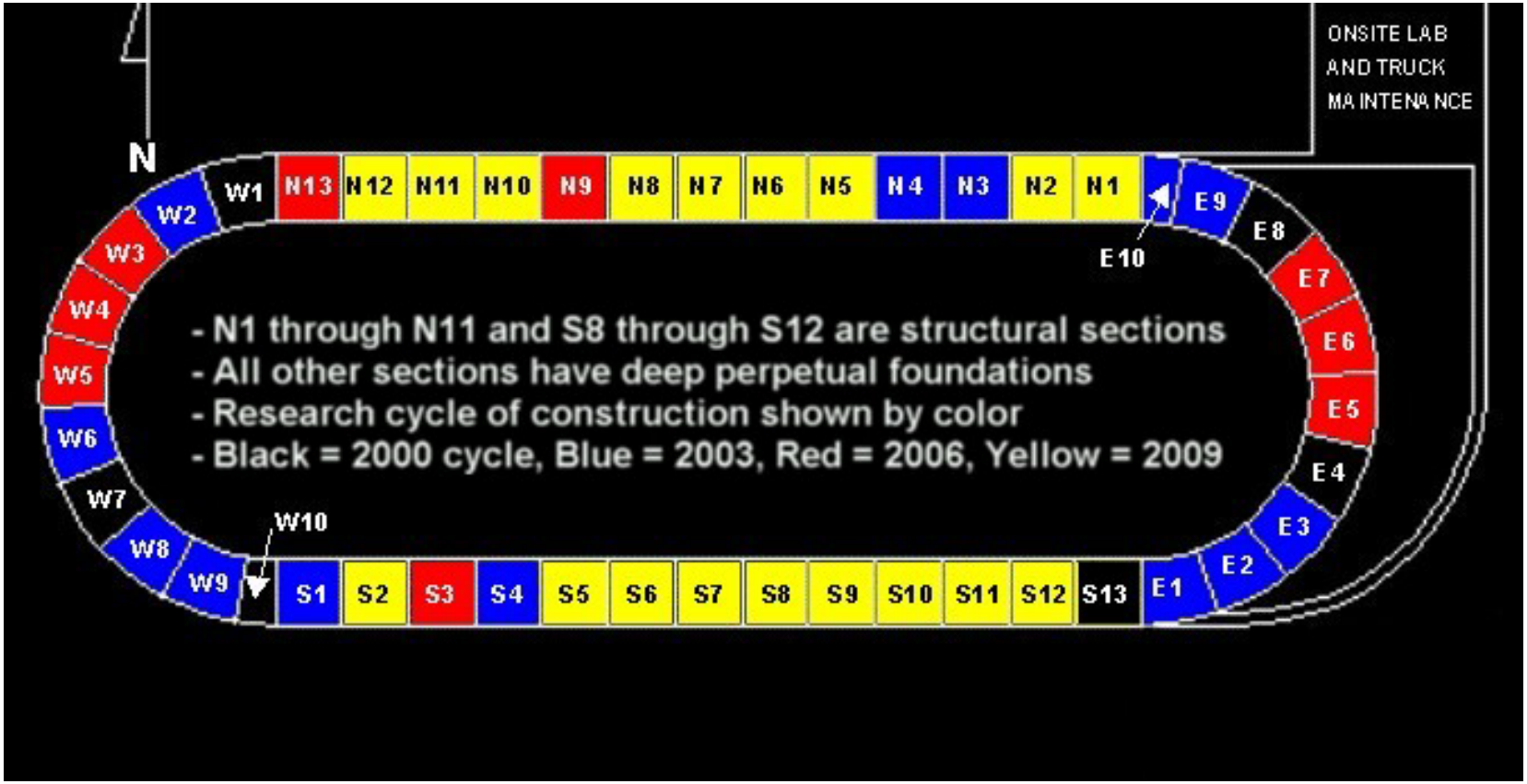
**All three mixes are the same mix design; the only difference is the liquid in each.**

**Mix # 1 has PG64-22 with a rut depth of 7.1715 mm.**

**Mix # 2 has SBSPG76-22 ILDOT Spec. or PG76-22P MDOT Spec. with a rut depth of 4.6645 mm.**

**Mix # 3 has GTRPG76-22 with a rut depth of 4.6915 mm.**




ONSITE LAB
AND TRUCK
MA INTENA NCE
N
W1
W2
W3
W4
W5
W6
W7
W8
W9
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N13
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E1
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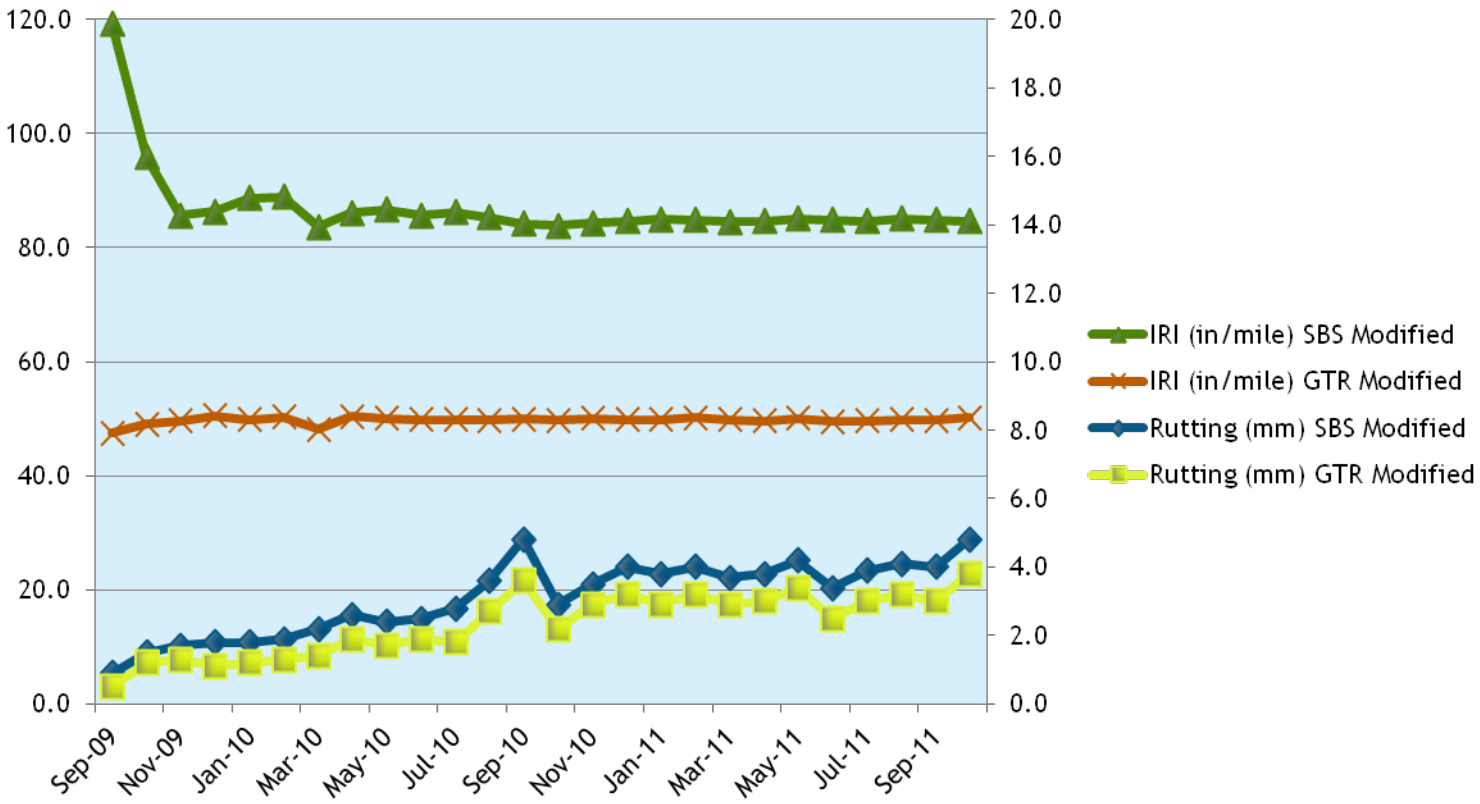
S2
S3
S4
S5
S6
S7
S8
S9
S10
S11
S12
S13
- N1 through N11 and S8 through S12 are structural sections
- All other sections have deep perpetual foundations
- Research cycle of construction shown by color
- Black = 2000 cycle, Blue = 2003, Red = 2006, Yellow = 2009

# S6 vs S7 Rut and IRI



# GTR liquid handling at HMA Plant

- A dedicated storage tank for “terminal blended GTR asphalt binder” shall be provided at the HMA plant. This tank must be capable of providing continuous mixing and/or recirculation of the GTR asphalt binder. This tank shall be heated and capable of maintaining the temperature of the homogeneous blend of asphalt binder and GTR at 300°F to 350°F (149°C to 177°C). The maximum storage time of the GTR asphalt binder at the HMA plant shall be 3 days, unless approved by the Engineer.
- Hot Mix Plant. The type of plant used for the manufacture of GTR asphalt binder mixtures may be either a batch or dryer drum plant.
- The GTR asphalt binder portable storage tank shall be positioned on-site, at the HMA plant, at a point just before the GTR asphalt binder is mixed with the aggregates. The delivery system must be capable of delivering the GTR asphalt binder with an accuracy of ±0.40% of the quantity required. The plant asphalt cement metering system shall be calibrated with the proposed GTR asphalt binder.
- The mixing temperature of the GTR asphalt binder HMA mixture shall be 300°F to 350°F (149°C to 177°C).
- Storage and Conveyance. Silo storage of GTR asphalt binder HMA mixtures shall not exceed 4 hours.
- Plant Calibration. The HMA plant shall be calibrated and approved by the Engineer before production of the GTR asphalt binder HMA mixture.

# SBS Replacements & Hybrids

- Column A
  (Stand alone modifiers)
  ENTREES
  - SBS/SB
  - SBR
  - Elvaloy
  - GTR
- Column B
  (hybrid components)
  SIDE DISHES
  - Entira™ Bond
  - EVA
  - PPA
  - Titan Polymers


That wasn't chicken

or you think you can’t...

# QUESTIONS