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John Noël, PhD

[If applicable, insert document # here]

Efficient and Effective Test Parameters to Identify Best Performing Binders

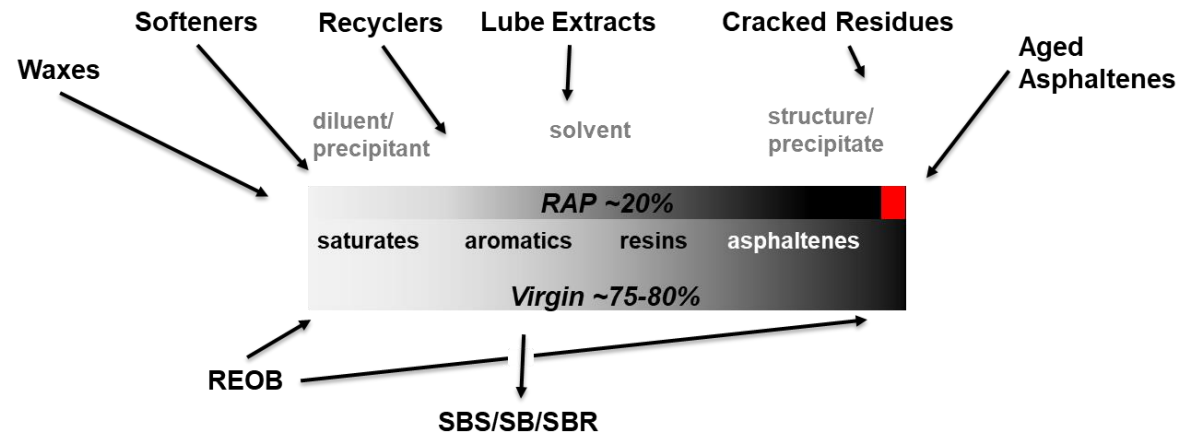
Special thanks to Marcel Hildebrand, Rezwan Quddus, and the Imperial Oil asphalt lab technologists for their efforts on this initiative

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Where Are We and How'd We Get Here?

- Superpave™ system developed based on straight-run binders from 1980/90s
- Chemistry of today's binders has changed, not all additive effects captured well
- Proliferation of new specifications to combat perceived shortfalls
 - exBBR & DENT
 - DeltaTc (20 & 40 h)
 - LAS
 - NCHRP 9-59/60
- What do we want to capture?

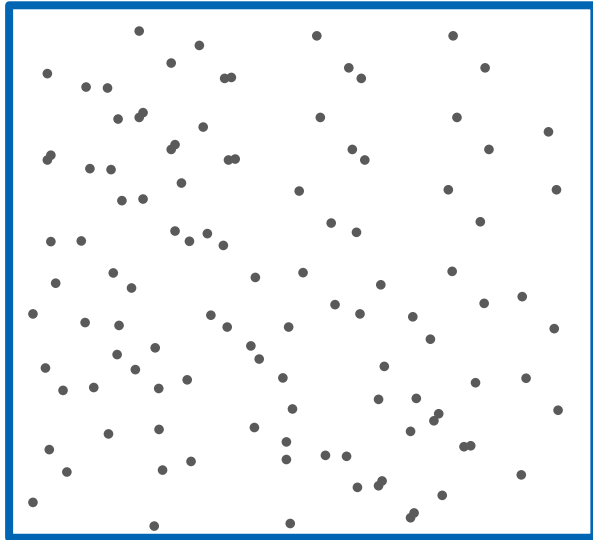


And many other additives: Bio, Plastics, Acids, WMA, Antistrips, Scavengers...

Colloidal Stability Key to Cracking Resistance

Stable

Asphaltenes Well-Dispersed



High Surface Area

Lower Maltene Viscosity at Given PG

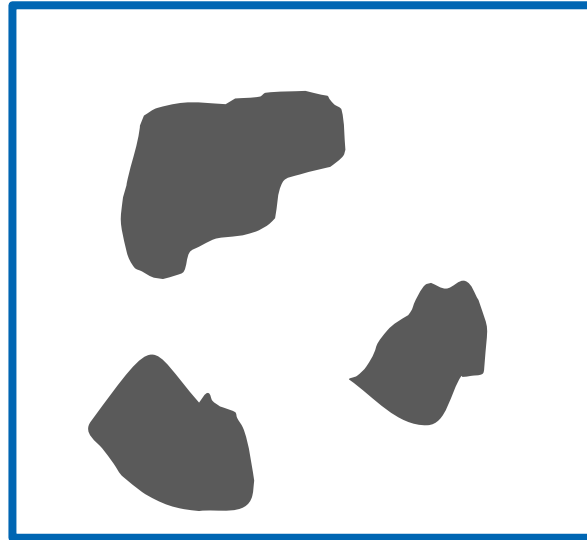
Smaller Failure Interface

Lower Aging Rate

Faster Relaxation

Unstable

Asphaltenes Poorly Dispersed



Low Surface Area

Higher Maltene Viscosity at Given PG

Larger Failure Interface

Higher Aging Rate

Slower Relaxation

Colloidal Instability Index described by Gaestel (Esso France) in 1960s:

$$CII = \frac{[Saturates] + [Asphaltenes]}{[Resins] + [Aromatics]}$$

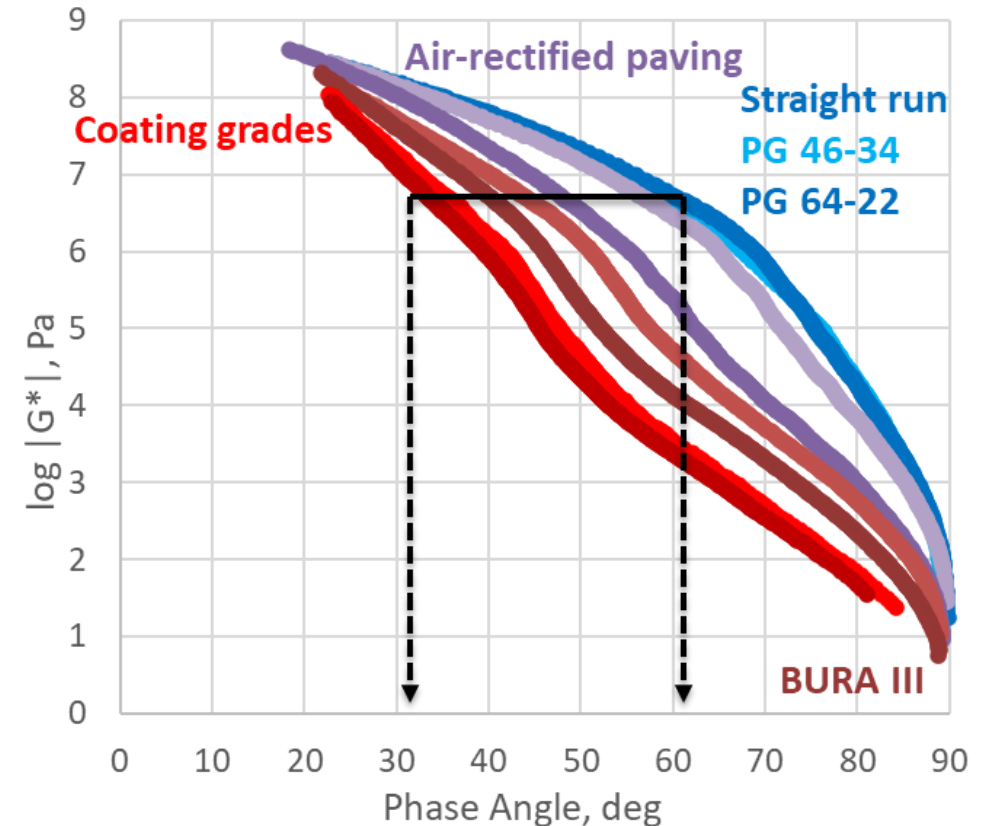
What is an Ideal Cracking Specification?

Differentiates good binders from poor-performing binders

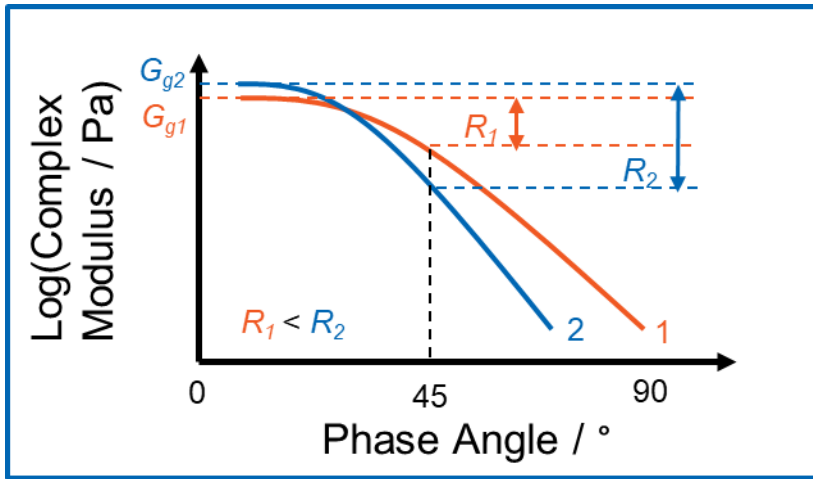
1. Established on Scientific Fundamentals
2. Cost Effective (Time & Resources)
3. Reproducible
4. Simple & Accessible
5. Field Validated

Shape Parameters

- Tell us about the shape of the mastercurve
- Shape of the mastercurve is tied to chemistry
 - Composition
 - Modification
 - Oxidation / Aging
- Can tell us about a binder's capacity to relax stress in the stiffness regions where cracking occur



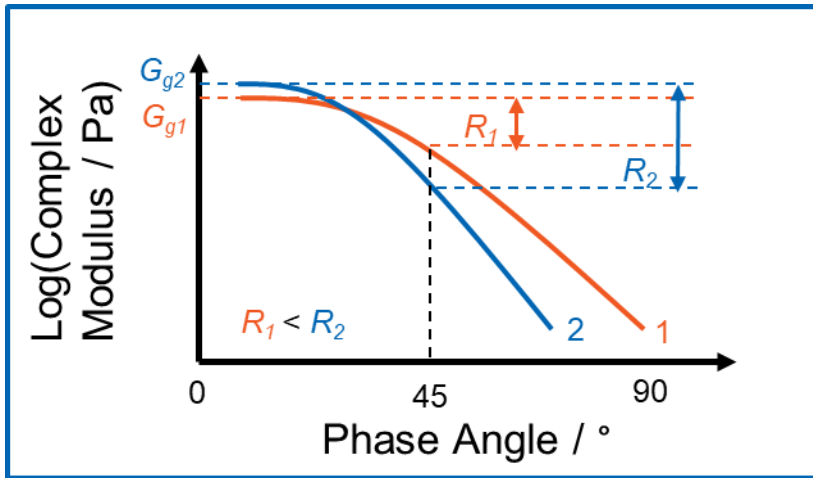
Example Shape Parameters



R-Value

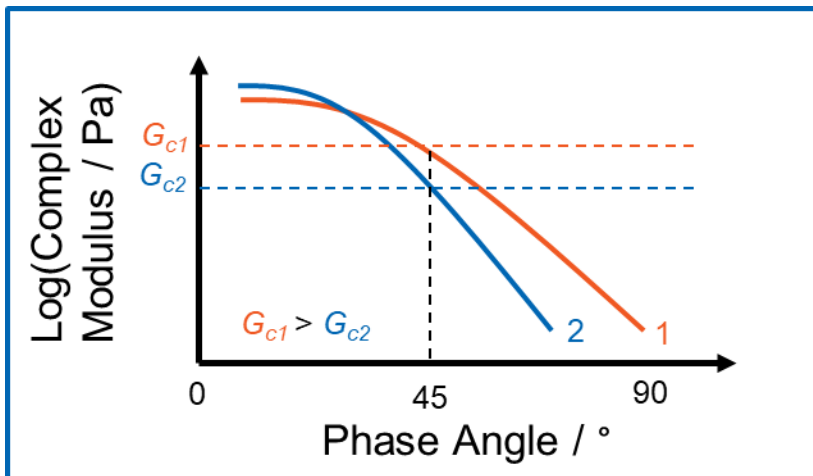
- Mastercurve
- BBR (NCHRP 9-59)

Example Shape Parameters



R-Value

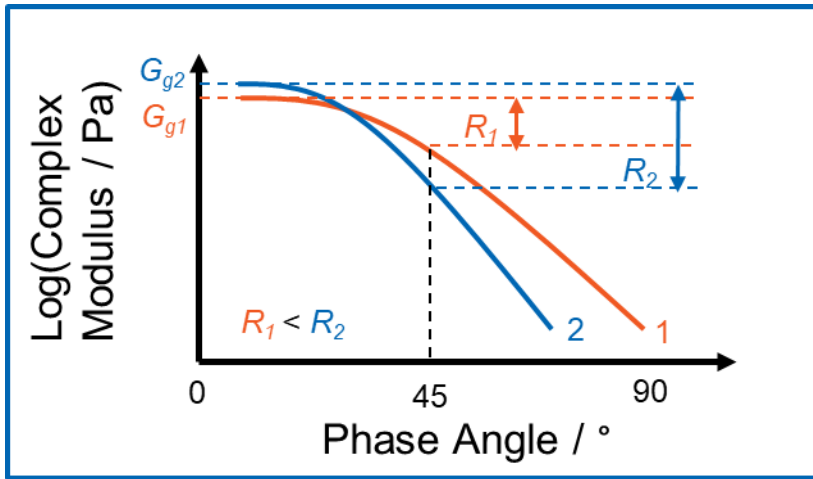
- Mastercurve
- BBR (NCHRP 9-59)



Crossover Modulus

- Mastercurve
- DSRp

Example Shape Parameters

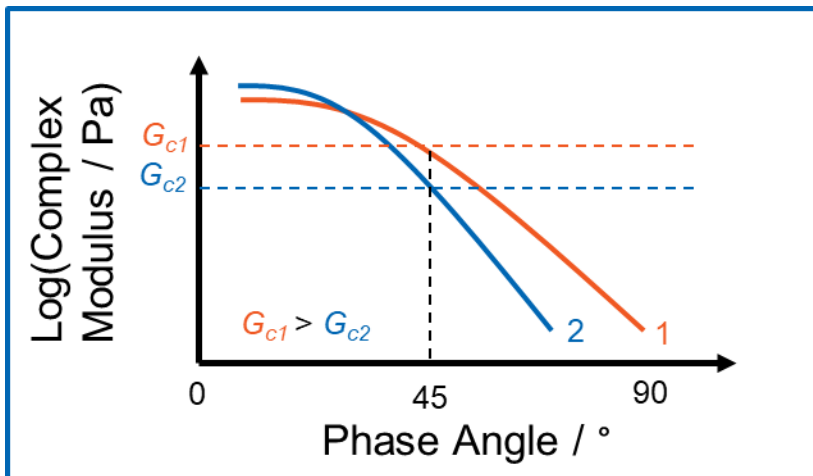
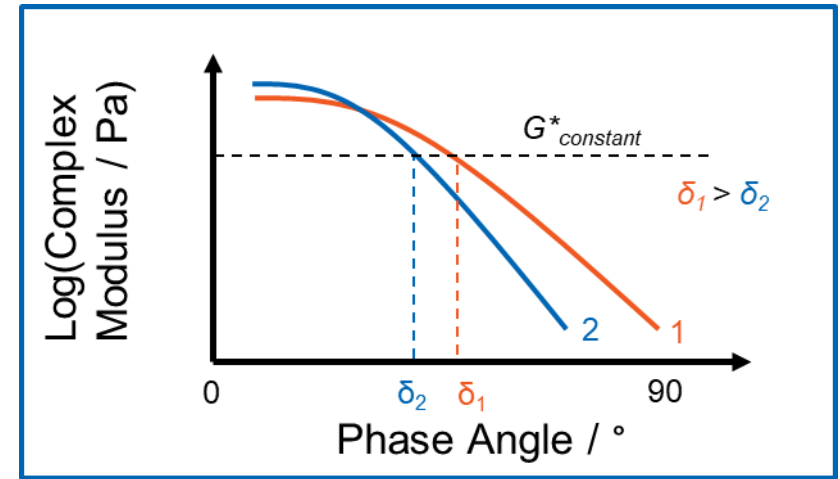


R-Value

- Mastercurve
- BBR (NCHRP 9-59)

Phase Angle at Constant Modulus

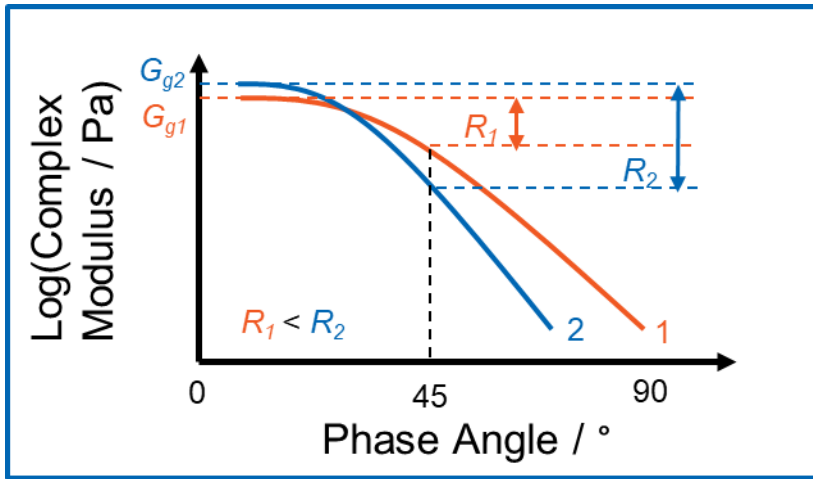
- Mastercurve
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Crossover Modulus

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Example Shape Parameters

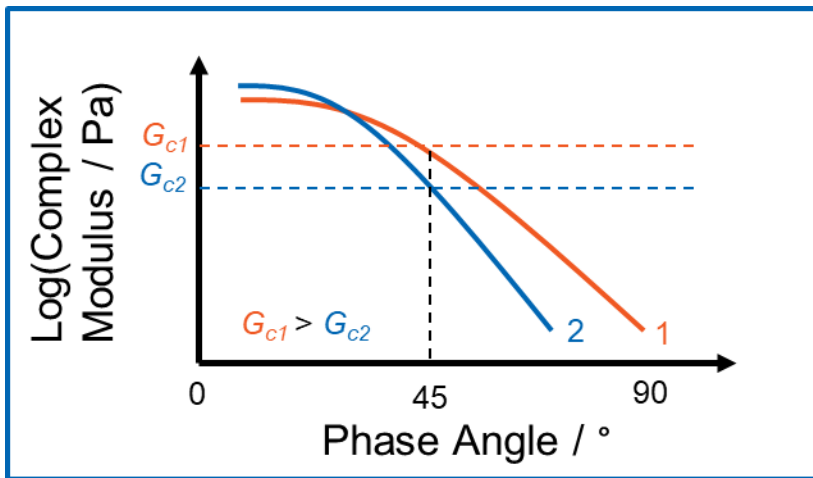
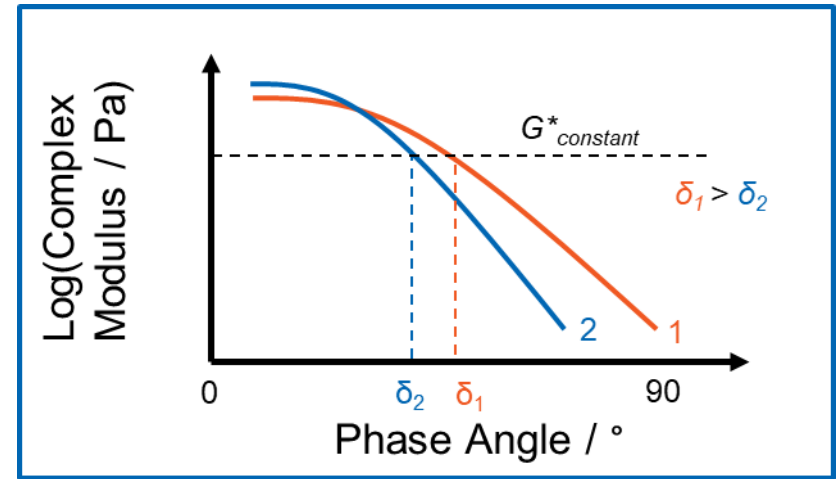


R-Value

- Mastercurve
- BBR (NCHRP 9-59)

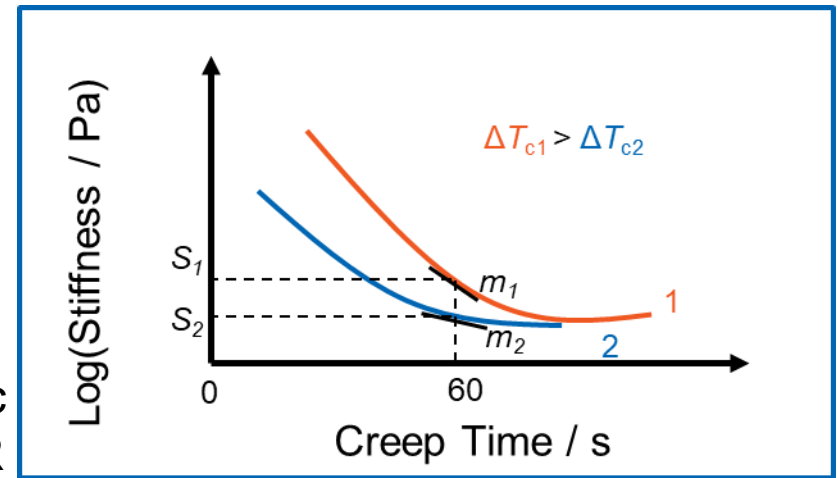
Phase Angle at Constant Modulus

- Mastercurve
- DSRp



Crossover Modulus

- Mastercurve
- DSRp



Delta Tc
• BBR

Sample Set

Base Binders:

PG 46-34

PG 52-28

PG 58-28

PG 64-22

PG 70-16

Blended Binders:

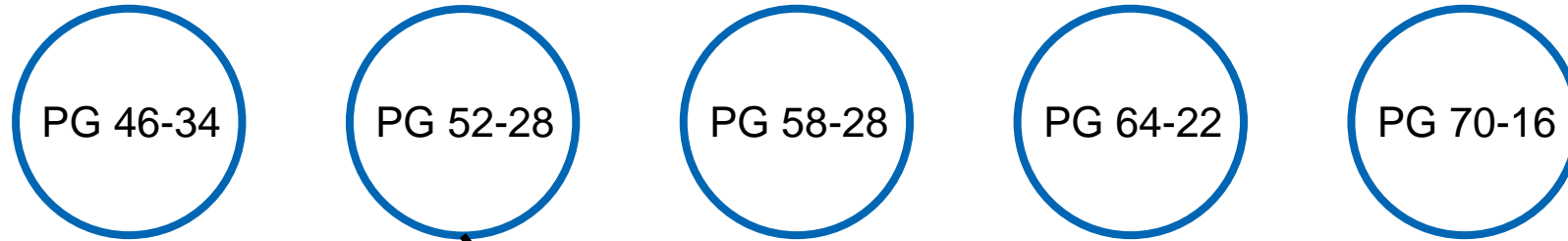
PG 52-28

PG 52-34

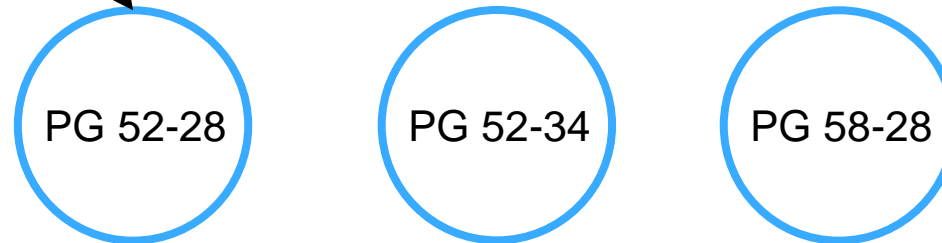
PG 58-28

Sample Set

Base Binders:

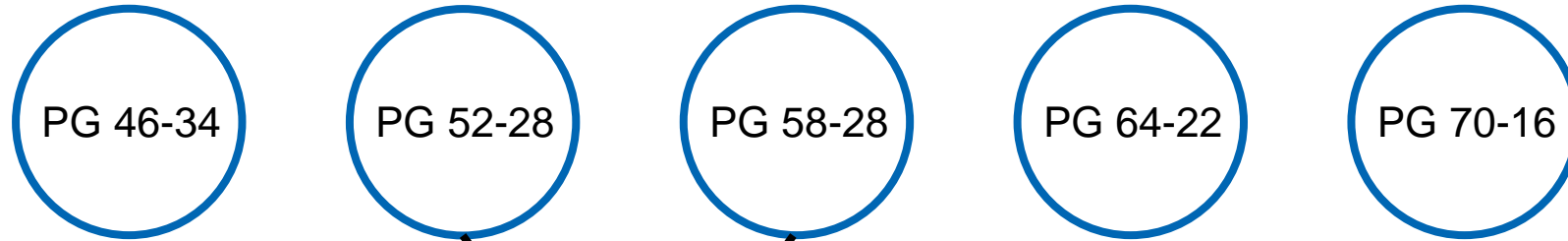


Blended Binders:

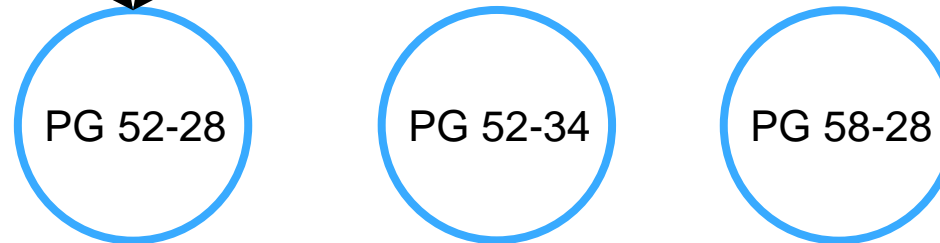


Sample Set

Base Binders:

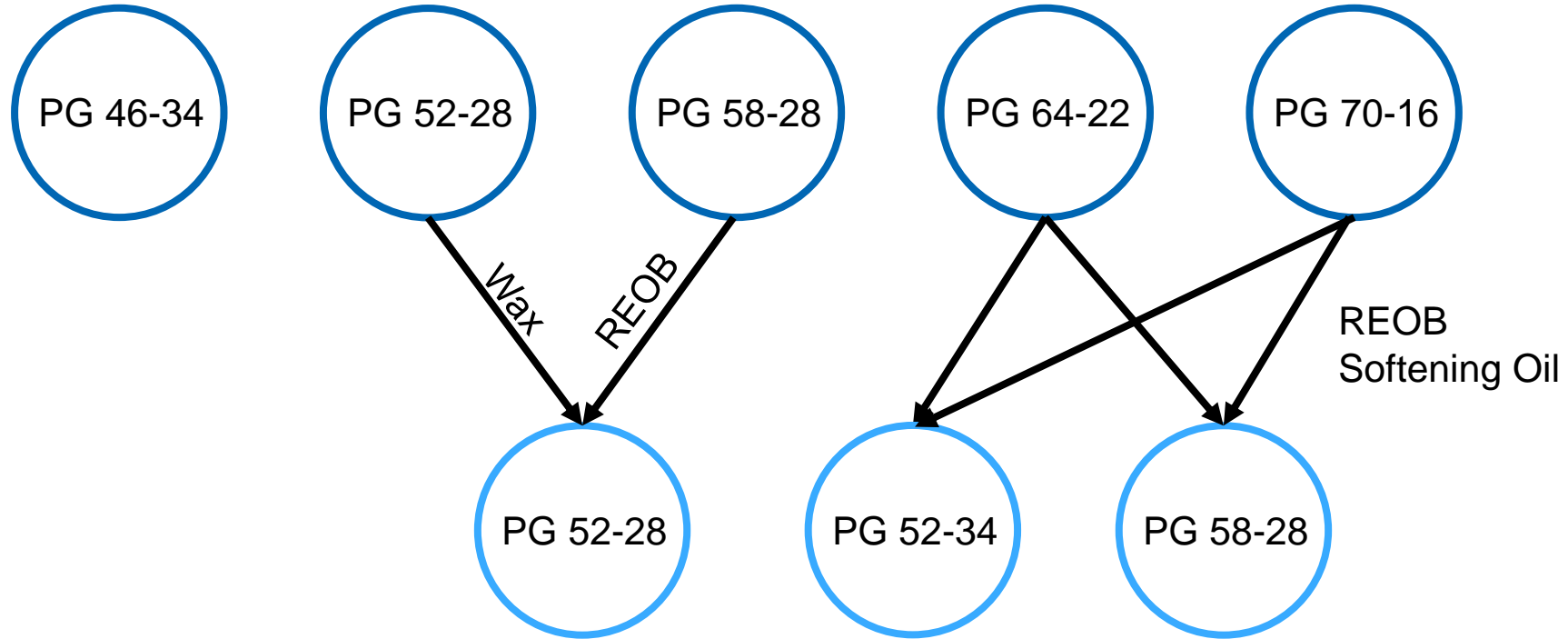


Blended Binders:



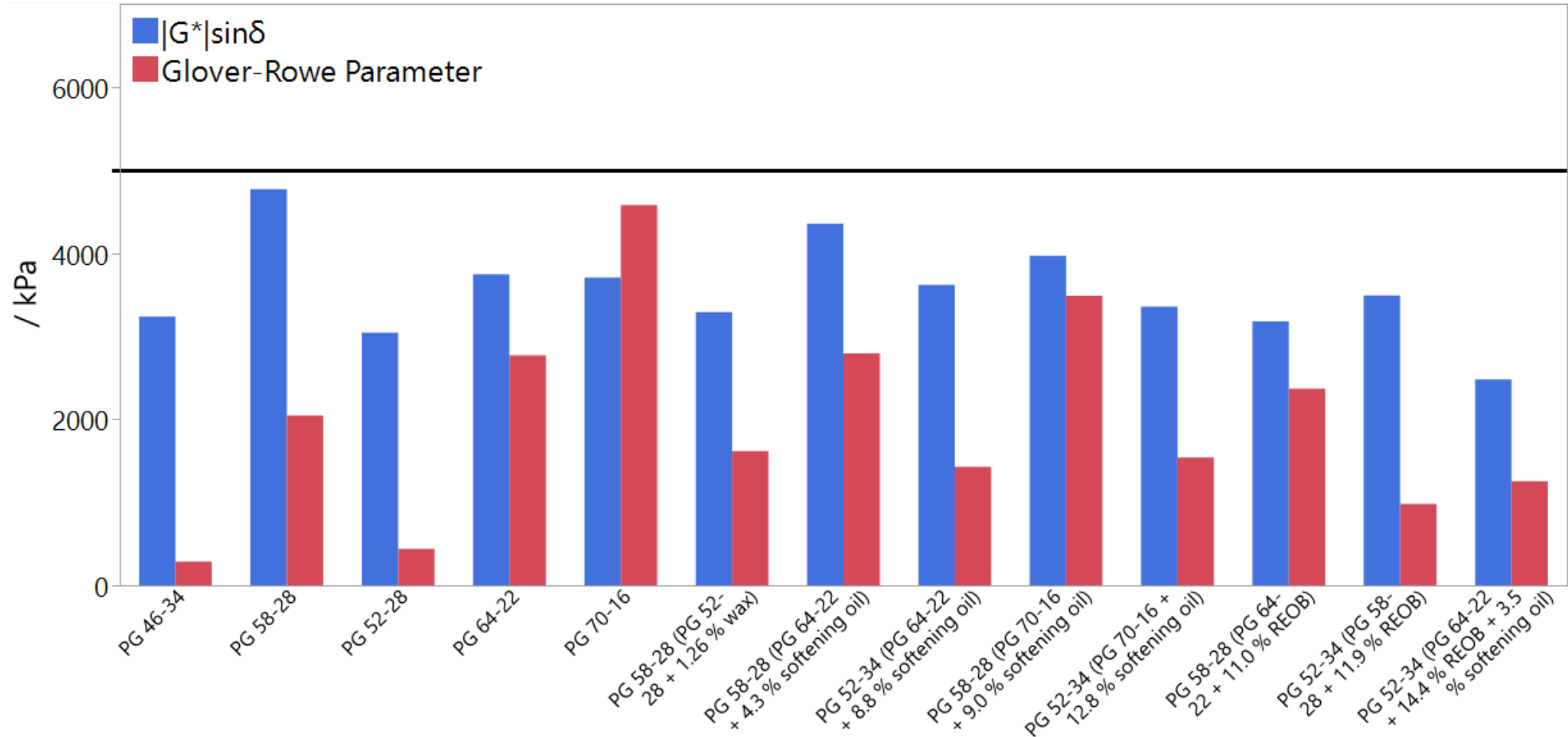
Sample Set

Base Binders:

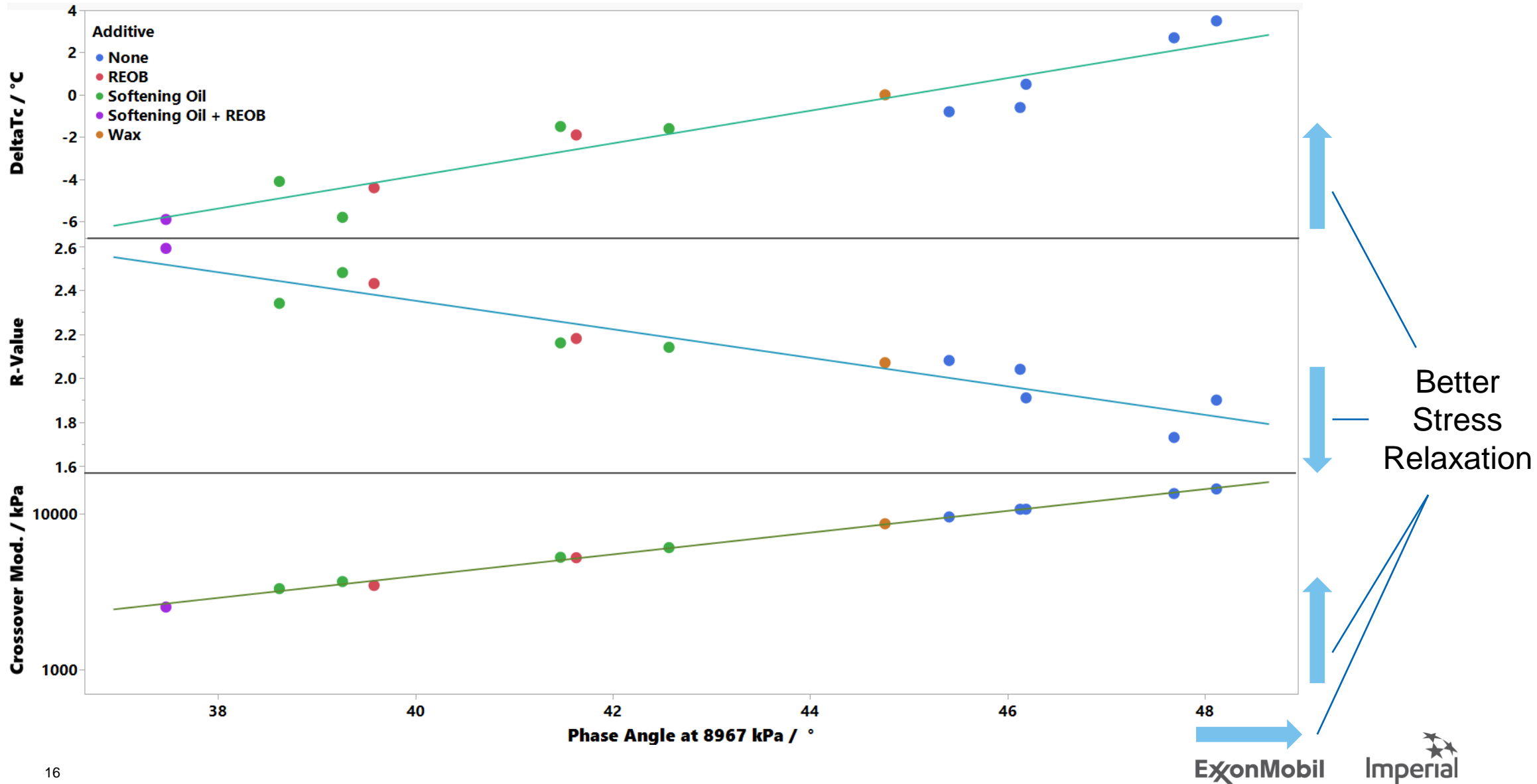


Blended Binders:

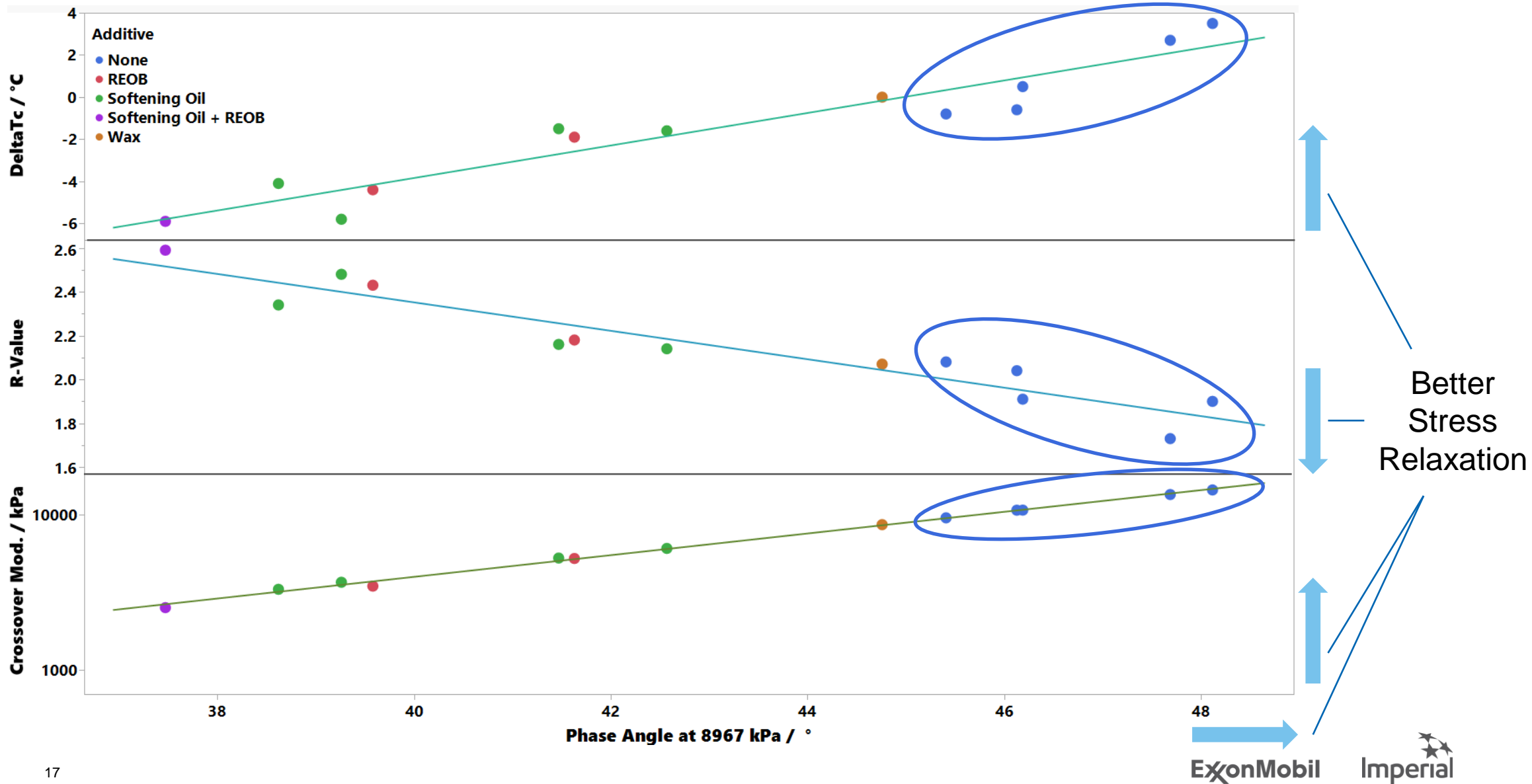
DSRp Doesn't Identify Poor Performers...



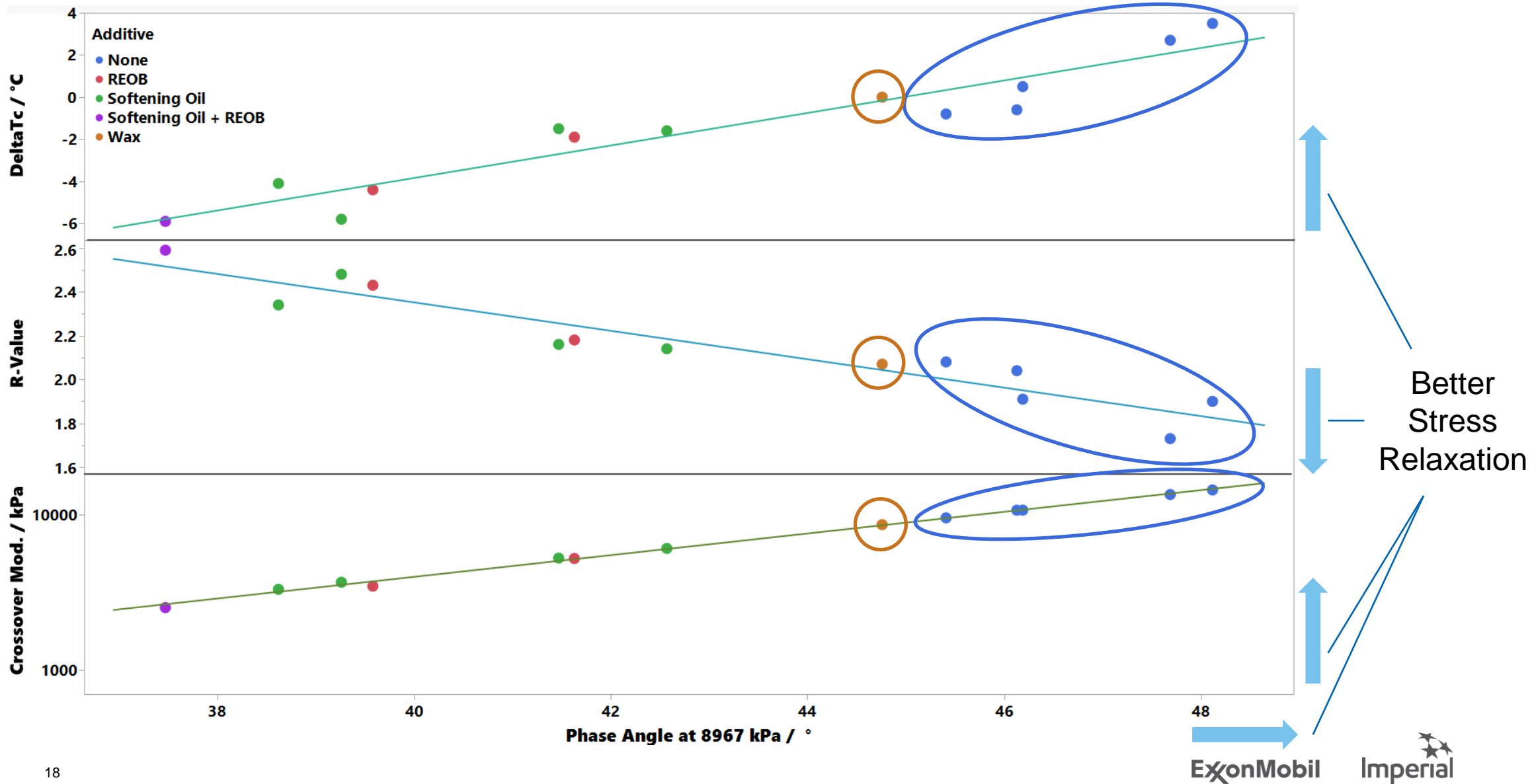
...But There are Effective Tests that Do



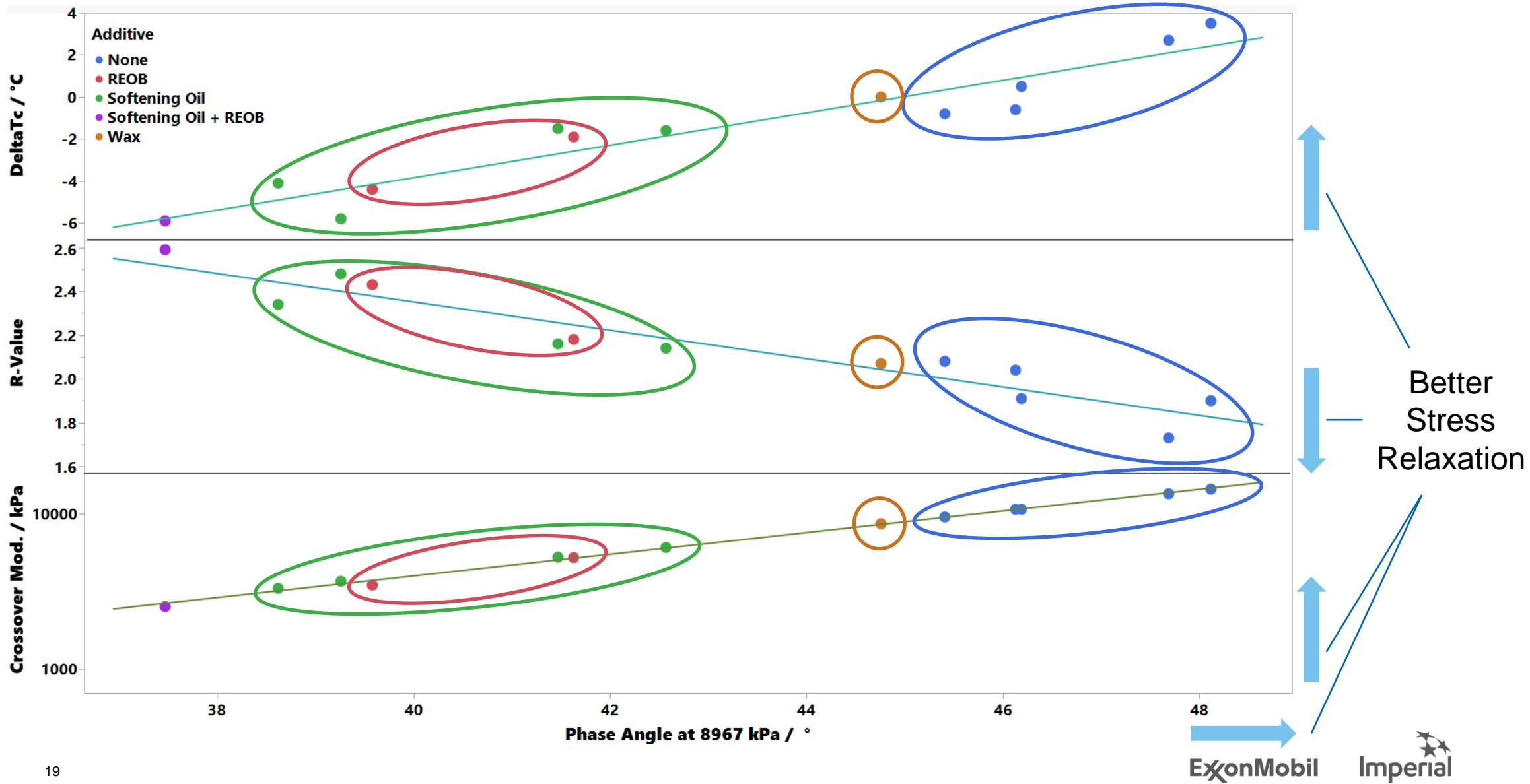
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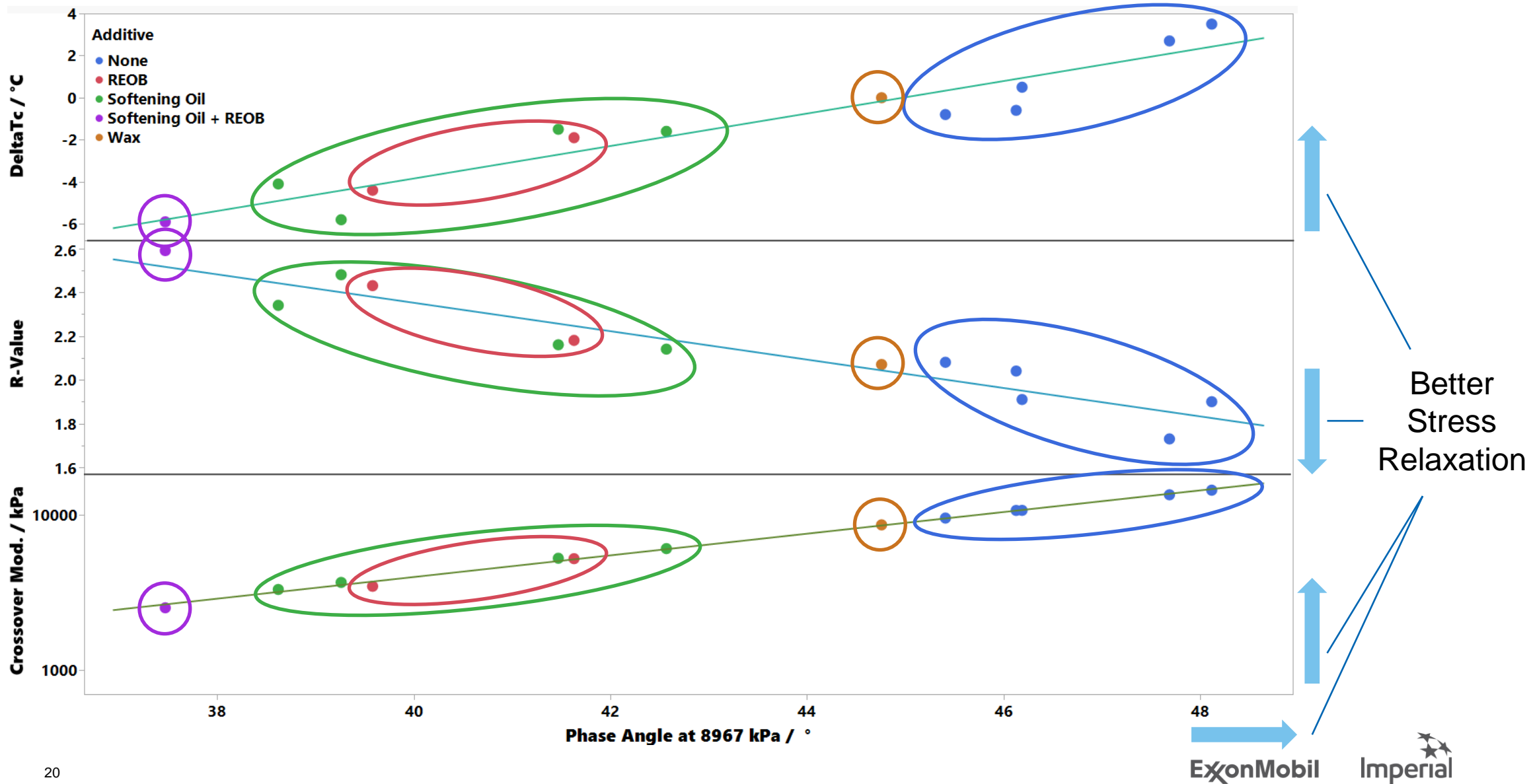
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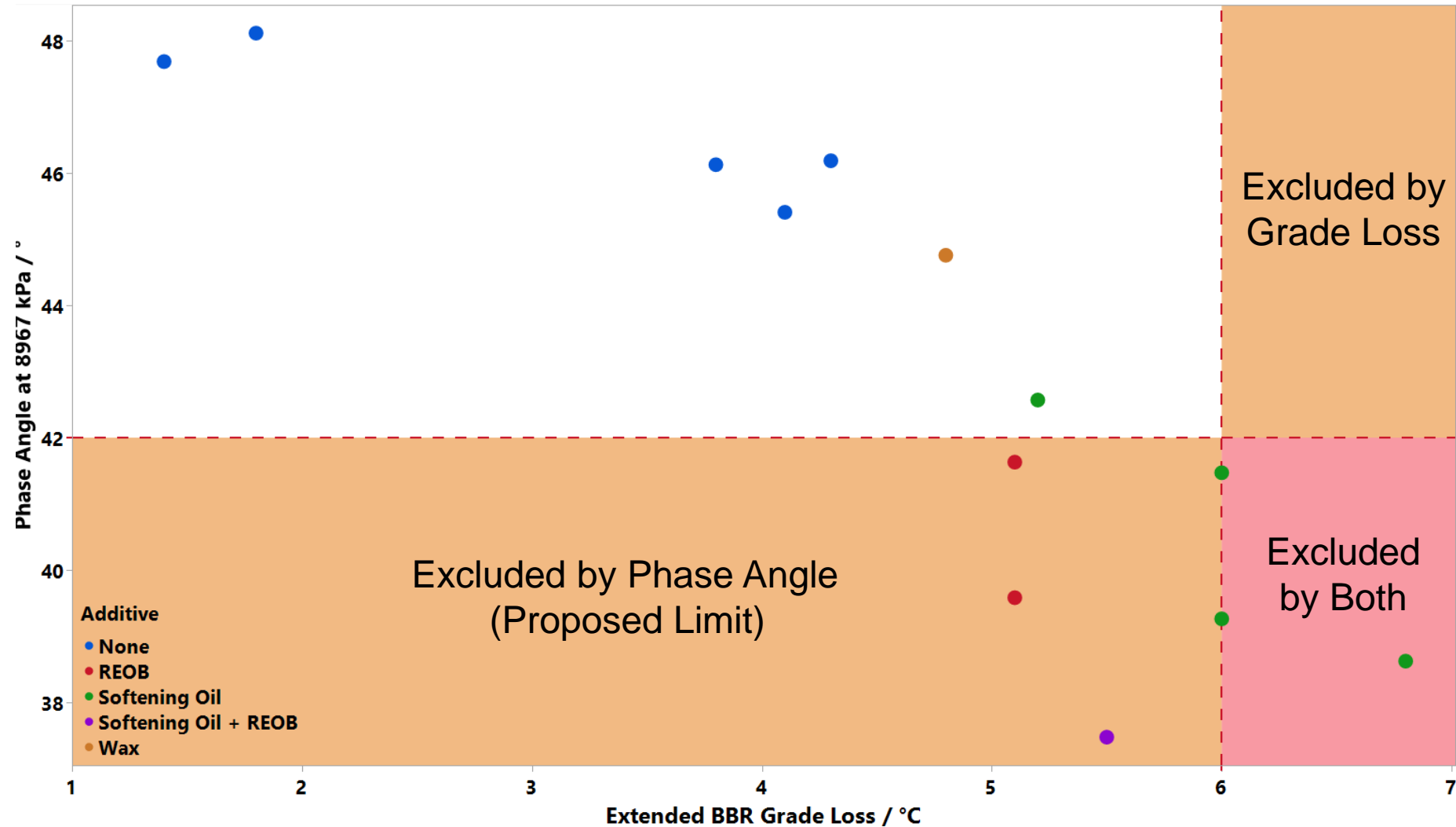
...But There are Effective Tests that Do



...But There are Effective Tests that Do



Same (Better?) Differentiation, Much Less Time than eBBR



Summary

- Current fatigue cracking specification does not identify poor-performers
- exBBR can identify poorer-performers, but is logistically challenging as a spec
- A shape parameter such as phase angle at constant modulus, crossover modulus, R-value, or DeltaTc can provide equivalent or superior differentiation in much less time and with high repeatability