Recent Advances in Fluorosilicone Rubber for Turbocharger Hose

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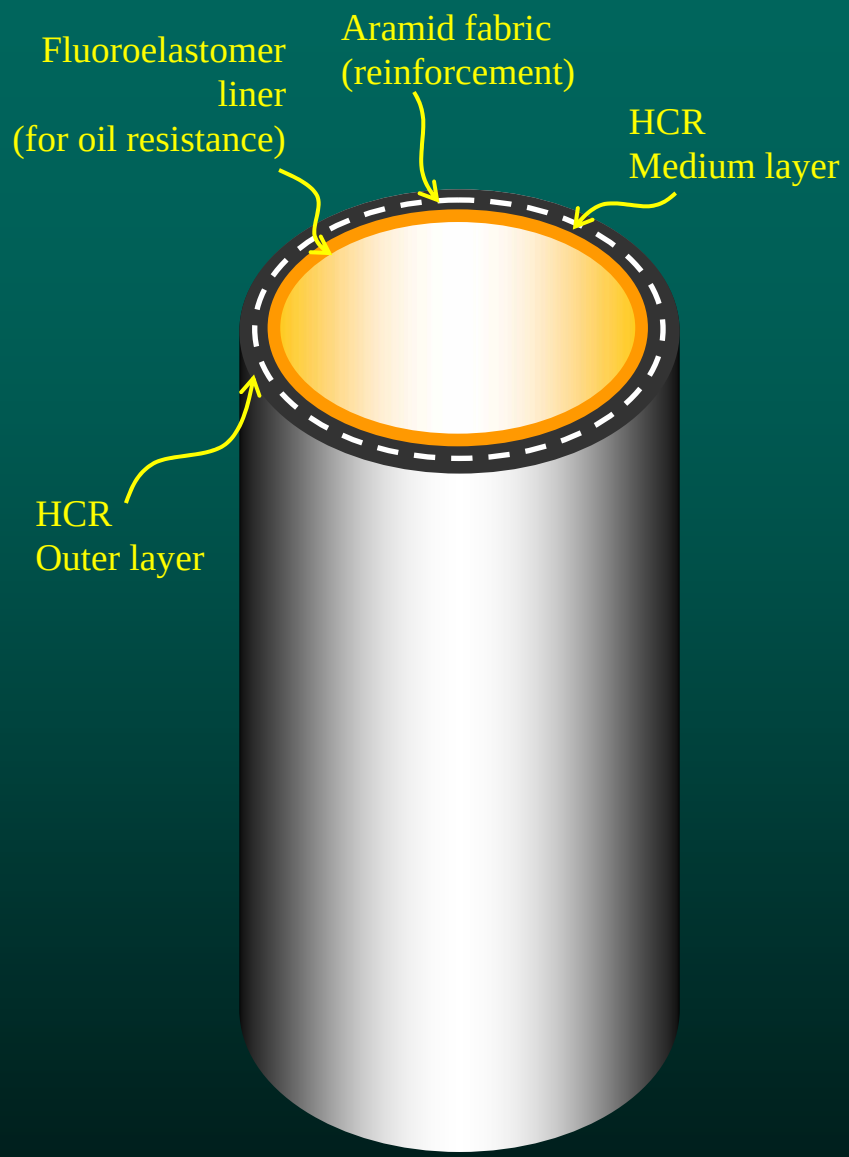
Introduction

- Turbodiesel passenger cars are experiencing huge growth in Western Europe
- Modern diesel technology improves performance but puts greater demands on system components
- Flexible hose sections must survive at higher continuous use temperatures AND must resist increasingly aggressive, synthetic engine oils
- Typical hose structure consists of aramid fabric reinforcement encapsulated with silicone rubber (VMQ) and lined internally with an oil resistant fluoroelastomer (FVMQ or FKM)



Silicone rubber (VMQ, more often termed HCR) is now well established to satisfy the requirements for high temperature stability

Hose liner can be either Fluorosilicone (FVMQ or FSR) or Fluorocarbon (FKM)

Liner needs to provide oil barrier properties combined with long lasting functional performance and hose integrity

Key Performance Requirements

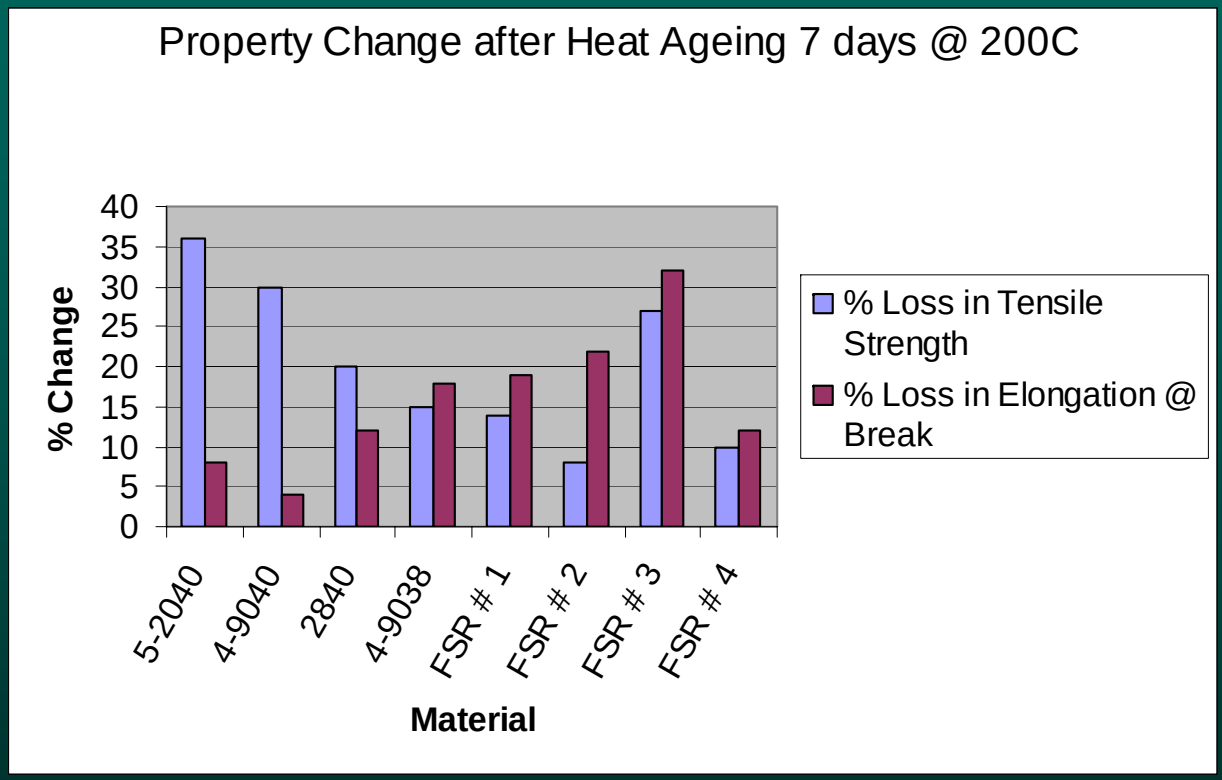
- Temperature Resistance
- Oil Resistance
- Fuel Resistance
- Interlayer Adhesion
- Processing Characteristics
  - Calendering
  - Co-extrusion

Temperature Resistance

- Under the bonnet temperatures are increasing
- Continuous use temperatures of ~ 200C are commonly specified
- Materials are expected to survive excursions to 225C, 250C or higher
- Formulation expertise is extremely important
- Our preferred FSR formulations show excellent property retention after relevant heat ageing
- FSR shows superior property retention vs FKM when measured at typical service temperatures

Temperature Resistance

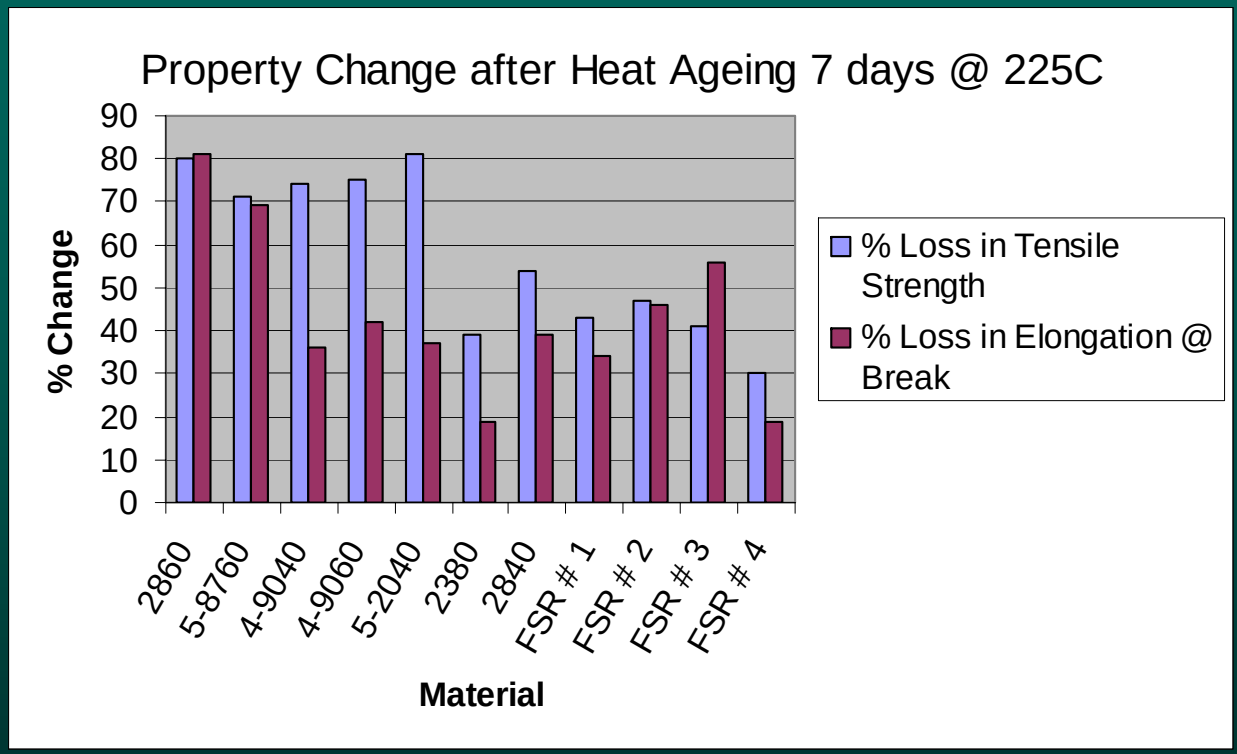
Traditional View: Hold @ Temperature → Cool → Test



- Poor FSR recommendations exhibit 30-40% loss in Tensile Strength
- Many FSRs show minimal property change (10% loss in both Tensile Strength and Elongation at Break after 7 days @ 200C)

Temperature Resistance

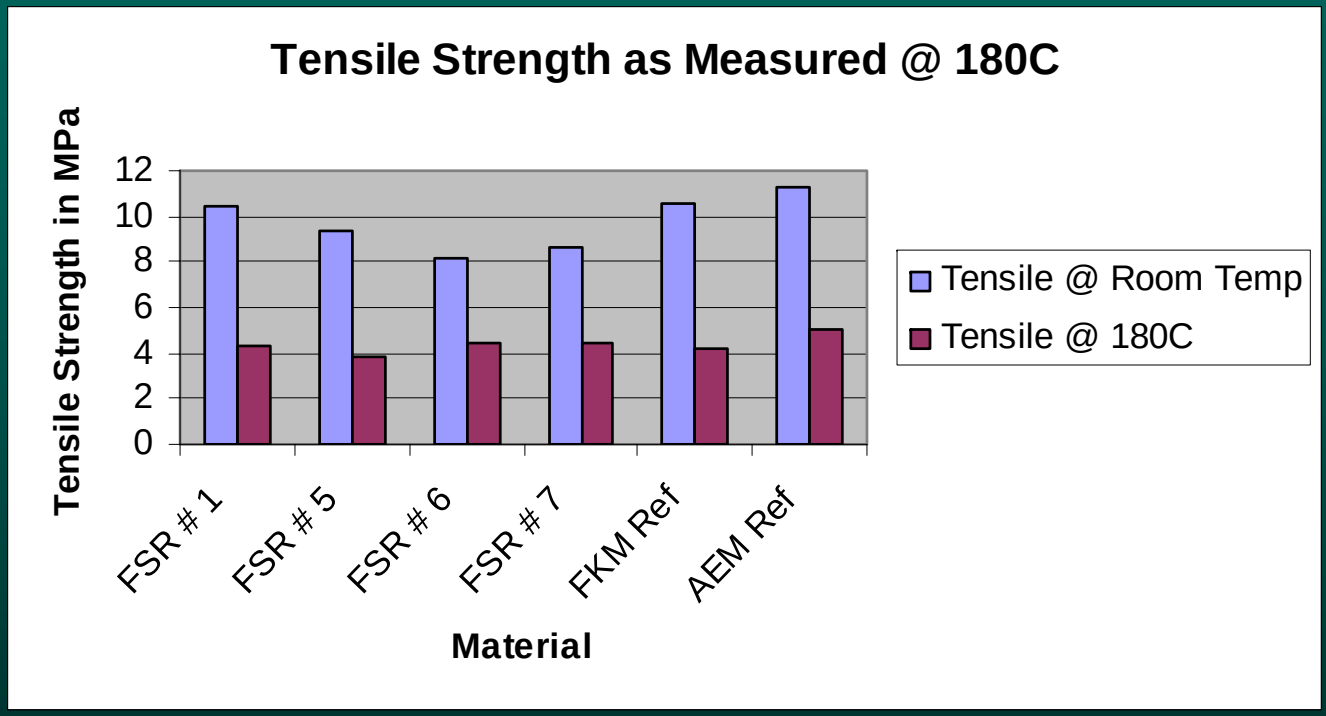
Traditional View: Hold @ Temperature → Cool → Test



- Again, unsuitable recommendations will yield quite extreme property changes (up to 80% loss)
- Optimised formulations can reduce Tensile Strength change to 30% and Elongation at Break change to 20%

Temperature Resistance

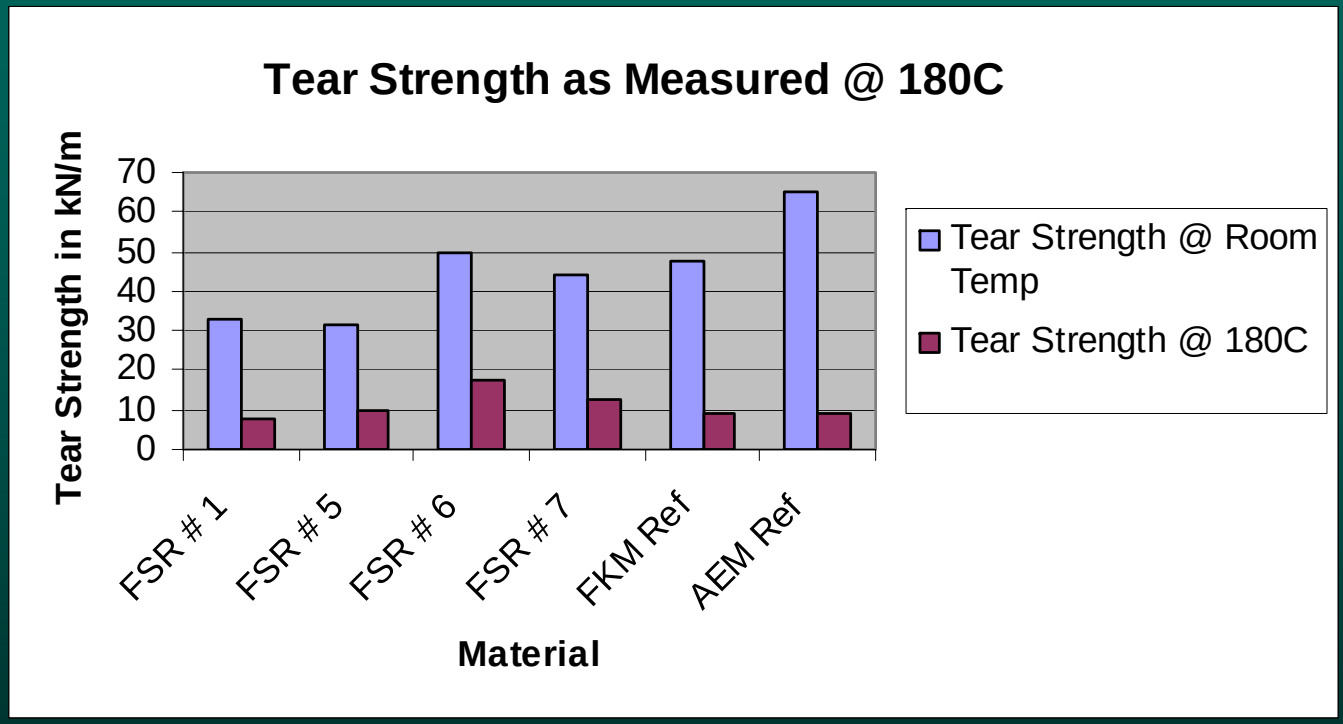
Alternative View: Measure @ Service Temperature



- Room temperature results range from 6-12 MPa
- Results @ 180C are ~ 4 MPa for all materials, with best FSRs showing the smallest property change

Temperature Resistance

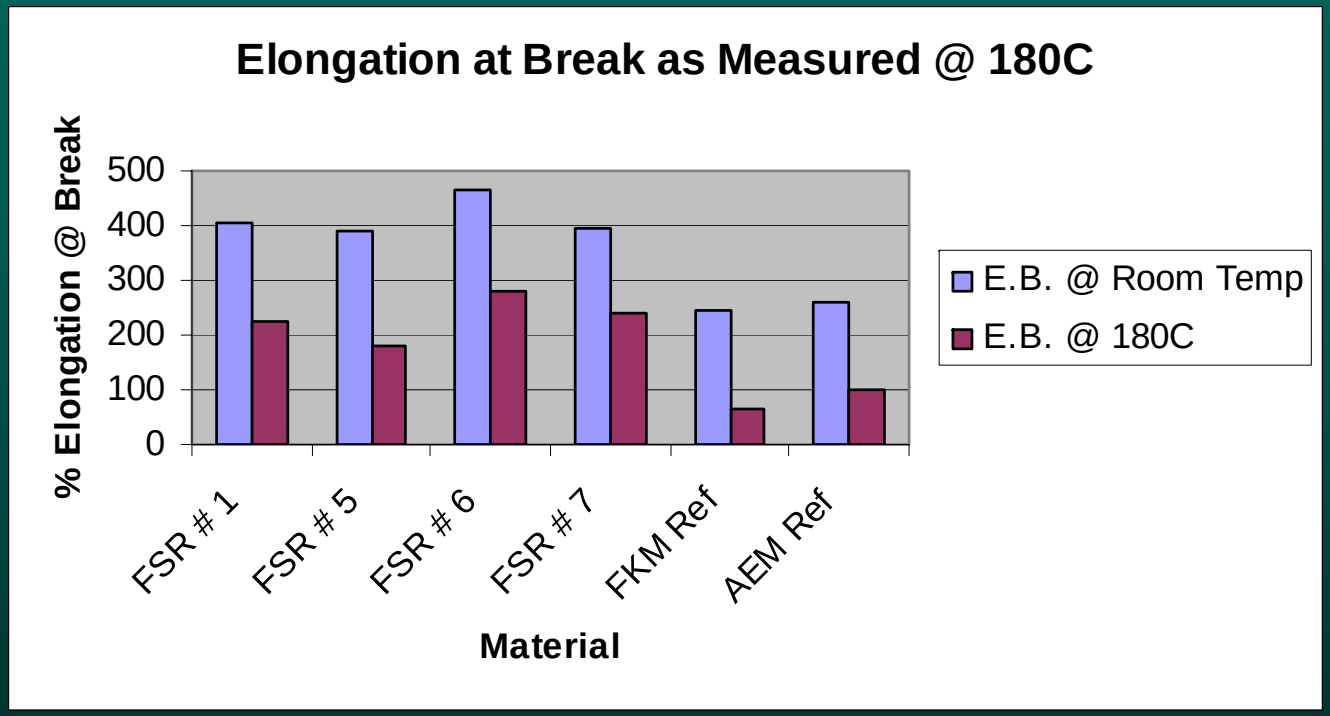
Alternative View: Measure @ Service Temperature



- Room temperature results range from 30-60 kN/m
- Best FSRs yield maximum Tear Strength @ 180C (~ 20 kN/m)
- FKM shows approx 80% loss of its room temperature Tear Strength

Temperature Resistance

Alternative View: Measure @ Service Temperature

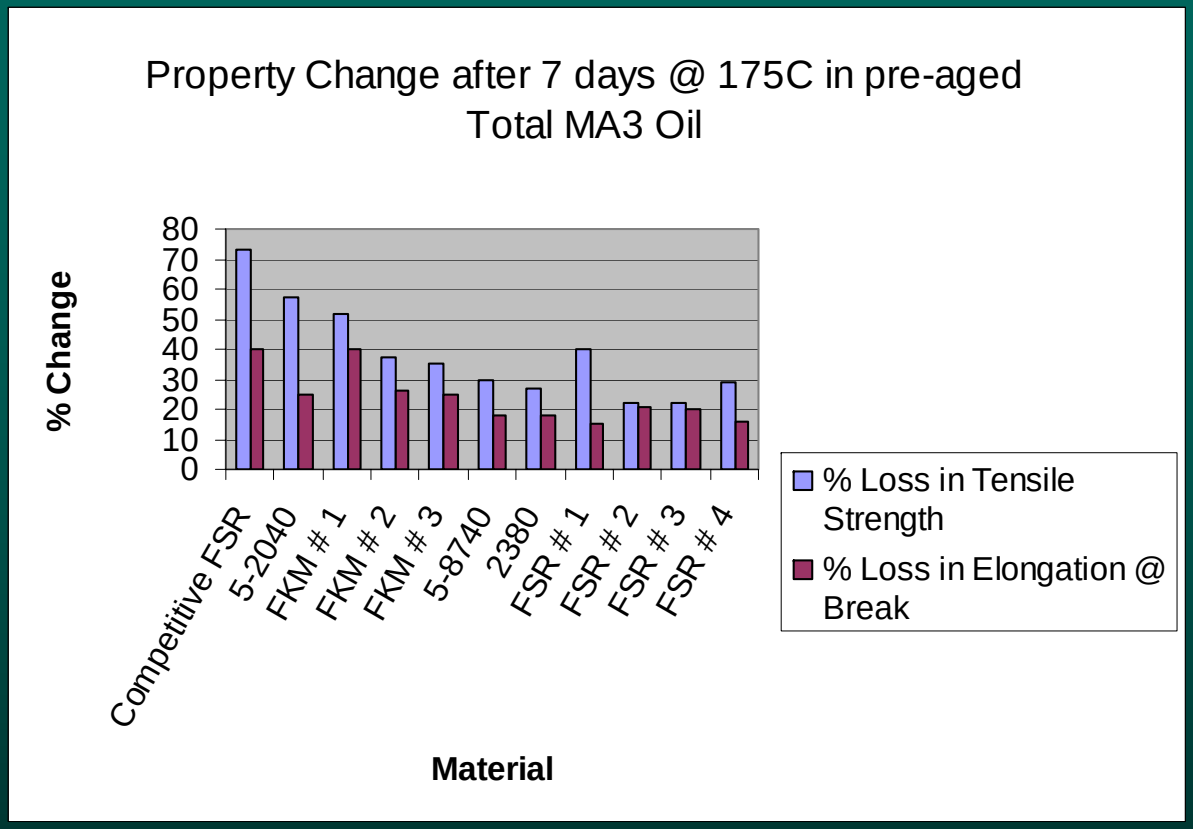


- Room temperature values of > 400% EB are achievable with FSR
- FSR @ 180C can still maintain 200-300% EB
- FKM @ 180C shows < 100% EB

Oil Resistance

- Hose liner must act as a barrier layer to prevent oil weep into subsequent layers and degradation of the hose
- Typical testing involves immersion in hot oil and measurement of change in mechanical properties
- Test temperatures are trending upwards (150C → 175C → 200C)
- Oils are becoming more aggressive due to their fully synthetic nature and additive packages for extended service intervals, anti-corrosion properties etc
- One widely specified oil is TOTAL MA3 5w30

Oil Resistance

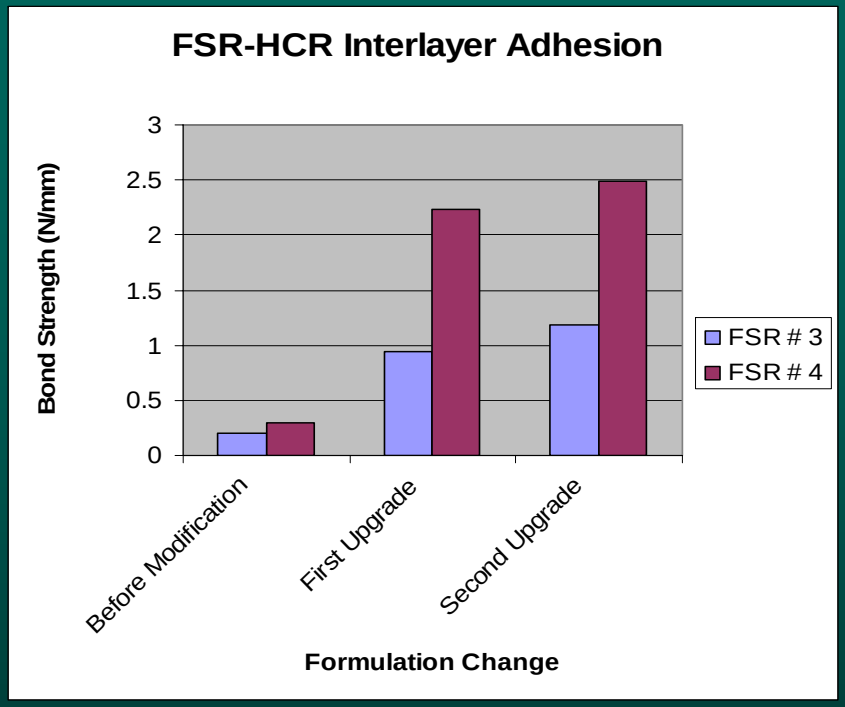


- Combination of oil type and test temperature is VERY aggressive
- Unoptimised FSR can show up to 80% loss in Tensile Strength
- Best FSRs show ~ 20% loss in both Tensile Strength and EB

Fuel Resistance

- A basic level of fuel resistance is required in this application, but it's not the most critical performance requirement
- Primary need is to survive hot oil contact
- Typical fuel testing would consist of Fuel C immersion e.g. for 70 hours @ 23C
- Volume swell target < 25% can be met comfortably with a range of FSR formulations

Interlayer Adhesion



- Significant effort has been devoted to both adhesion promoter chemistry and test method development
- Initial peel strengths of < 0.5 N/mm are unacceptable
- Modified formulations can achieve 2.0-2.5 N/mm

Processing Characteristics

- FSR has many attributes that are well matched with the needs in this application
- Wide range of hardness → both calendering and co-extrusion are possible to yield thin and therefore extremely cost effective layers
- Similarity between FSR and HCR (chemical nature of siloxane backbone, cure chemistry, absolute cure speed)
- Low specific gravity of FSR (1.4) compared to FKM (1.8) → cost per litre is very similar

Conclusions

- We can now recommend specific FSR formulations to expand this material's use as a turbocharger hose liner
- Formulation expertise can minimise changes in mechanical properties after exposure to dry heat and/or hot oil immersion
- Property retention of FSR as measured at elevated temperatures is superior to that of FKM
- Novel adhesion promoter technology has been developed to greatly improve FSR:HCR bond strength
- We'd like to explore these possibilities further through customer collaborations …