Thermax® N990 in Evolmer® Compounds

Evolmer is a new elastomer produced by Denka Company Ltd. It is a copolymer of acrylonitrile and chloroprene which is said to demonstrate an excellent balance of oil resistance, low temperature compression set, dynamic properties with low heat build-up, and flex-fatigue resistance. It is intended to be used in high performance industrial applications such as seals, hoses, and belts. In this study, Thermax® N990 replaced furnace black N330 in an Evolmer formulation.

The benefits of Thermax® N990 confirmed in the study were:

- **Significant improvement in dispersion**
- Increase in crosslink density and tensile modulus
- **Improvement in oil resistance.** Tensile properties were better maintained and volume swell was reduced.
- **Improvement in fuel resistance.** Tensile properties were better maintained and volume swell was reduced.

The Evolmer formulations can be found in Table 1. To maintain constant hardness the N330 was replaced at a 2.5:1.0 N990:N330 ratio. Testing was completed at 20%, 50% and 100% replacement of N330. Dispersion, MDR, crosslink density, Shore A hardness, tensile, heat aging, and fluid aging tests were run on all compounds. The compounding and testing were completed at ARDL in Akron, Ohio. Testing results can be found in the figures on the following pages.

Table 1. Test formulations

Ingredient	Control	A	B	C
Evolmer EV 2502	100	100	100	100
N330	50	40	25	0
Thermax® N990	**0**	**25.2**	**63**	**126**
Maglite D	4	4	4	4
DOS	10	10	10	10
Stearic acid	0.5	0.5	0.5	0.5
Naugard 445	3	3	3	3
Kadox 920C	5	5	5	5
Rhenogran MTT-80	1.25	1.25	1.25	1.25
Total	**173.75**	**188.95**	**211.75**	**249.75**

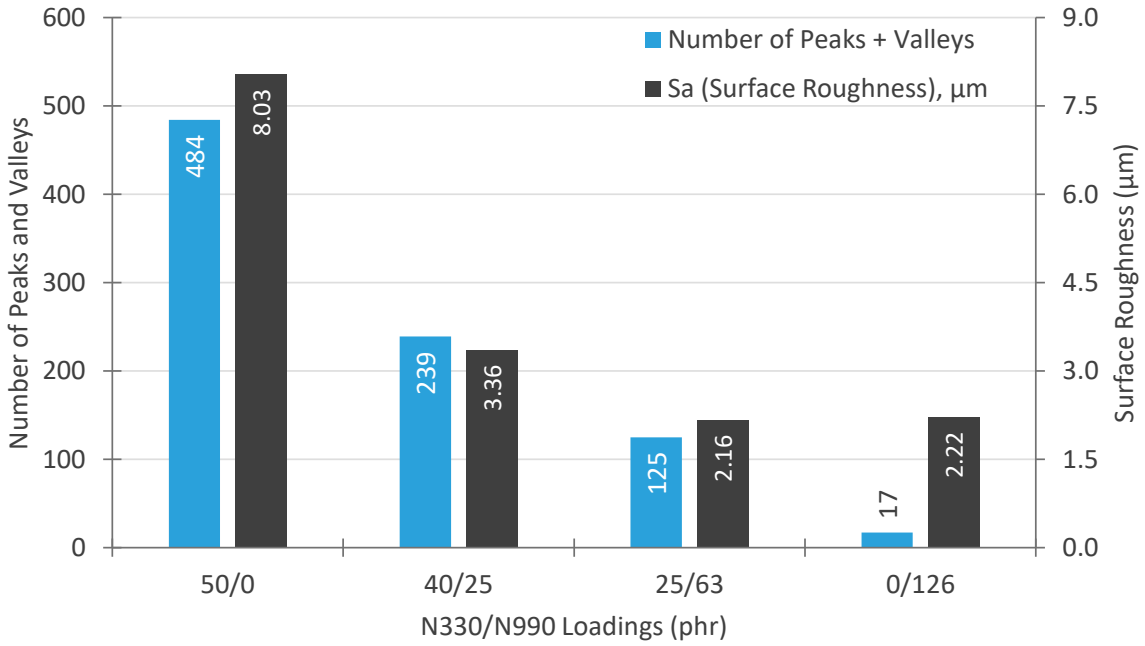

Figure 1. Number of peaks and valleys and average surface roughness of the compounds as measured by optical microscopy using the Nanotronics nSpec 3D. Dispersion improved as N990 replaced N330.

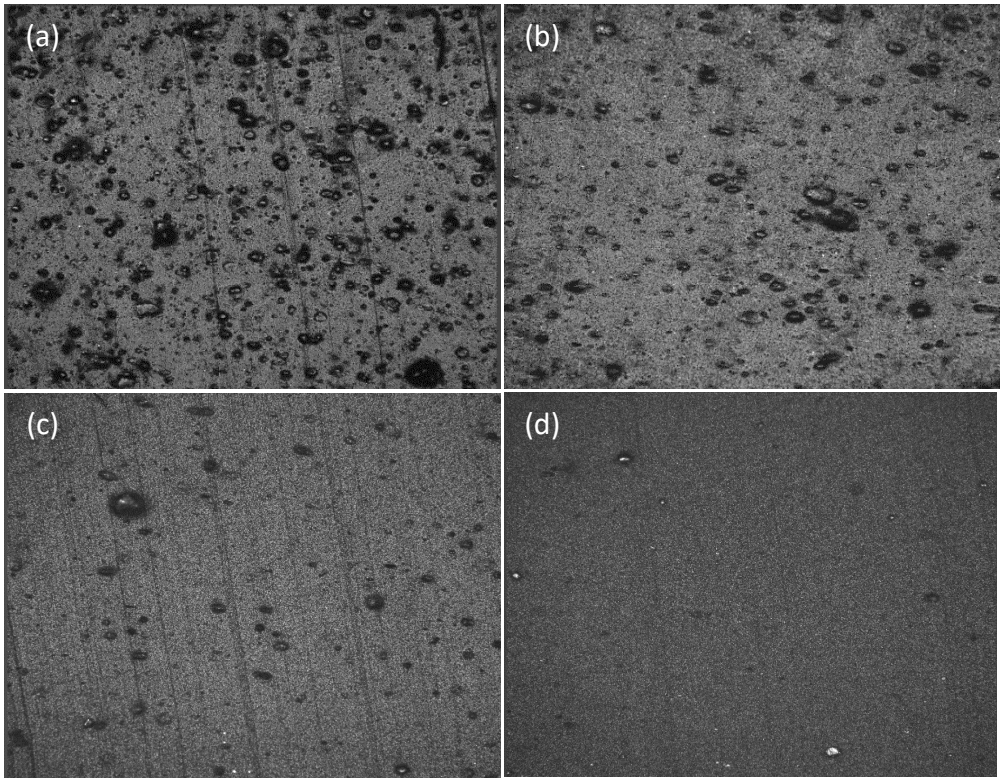

Figure 2. Pictures of compounds with N330/N990 loadings of (a) 50/0, (b) 40/25, (c) 25/63, and (d) 0/126. Dispersion improved as N990 replaced N330.

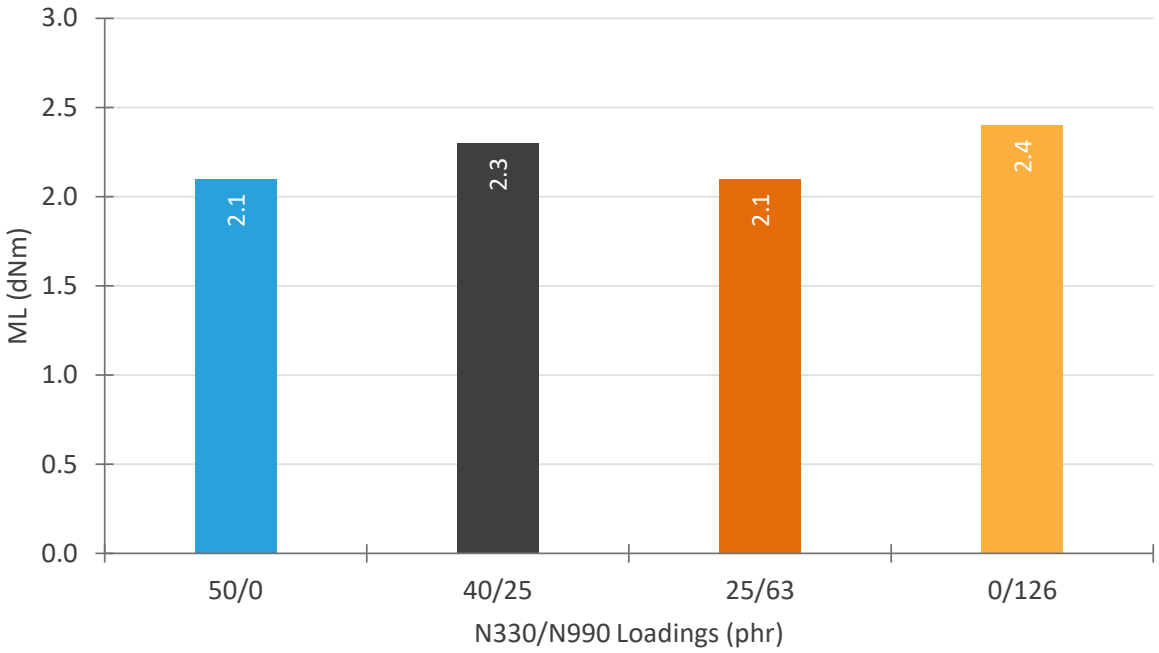

Figure 3. MDR minimum torque, ML, measured at 170°C for the compounds. There were no significant differences observed.

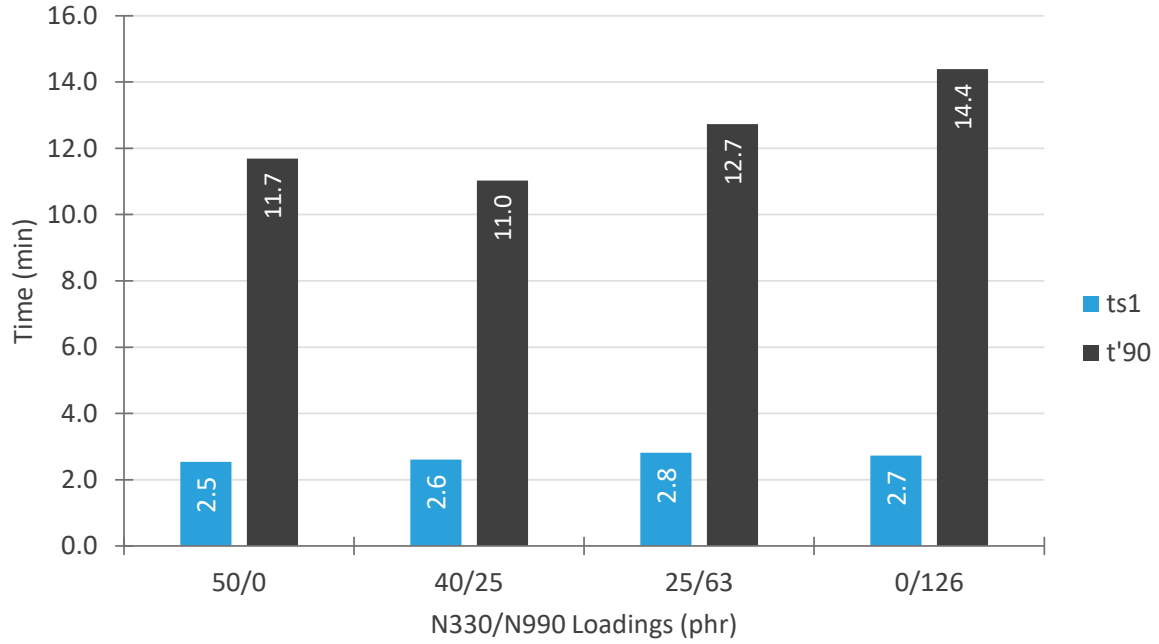

Figure 4. MDR scorch and cure times for the compounds at 170°C. Cure time tended to increase at higher N990 loadings.

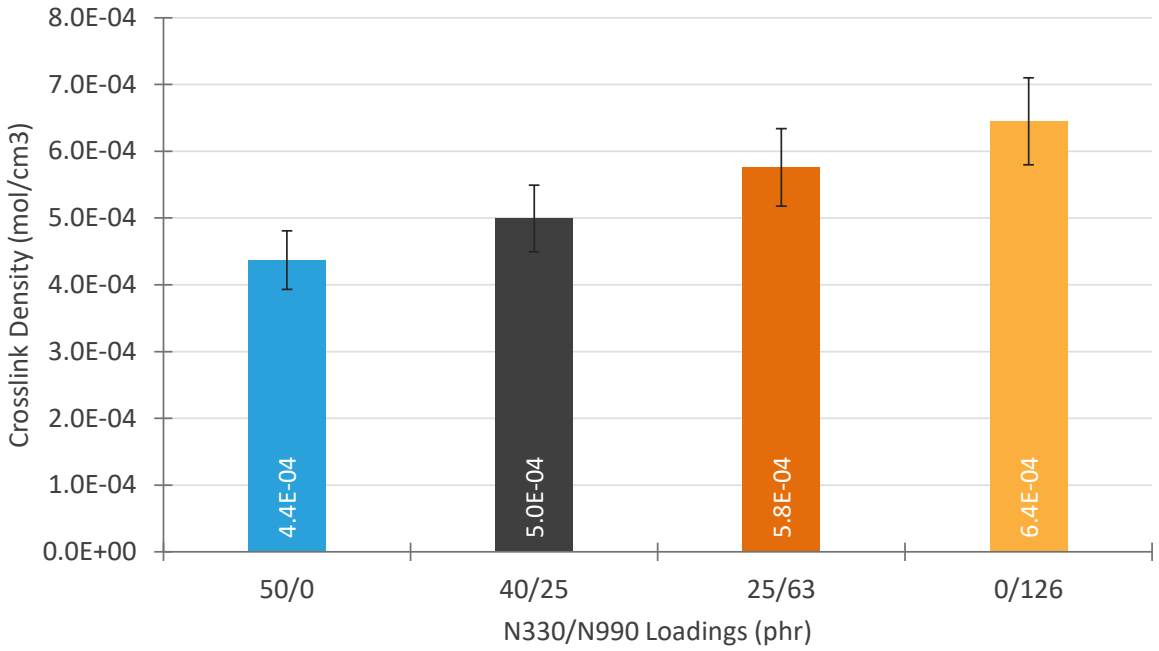

Figure 5. Crosslink density of the compounds measured by swelling in chloroform. Polymer-solvent interaction constant was 0.35. Crosslink density tests were run after it was observed that MDR MH increased as N990 loading increased. Crosslink density also increased as N990 loading increased.

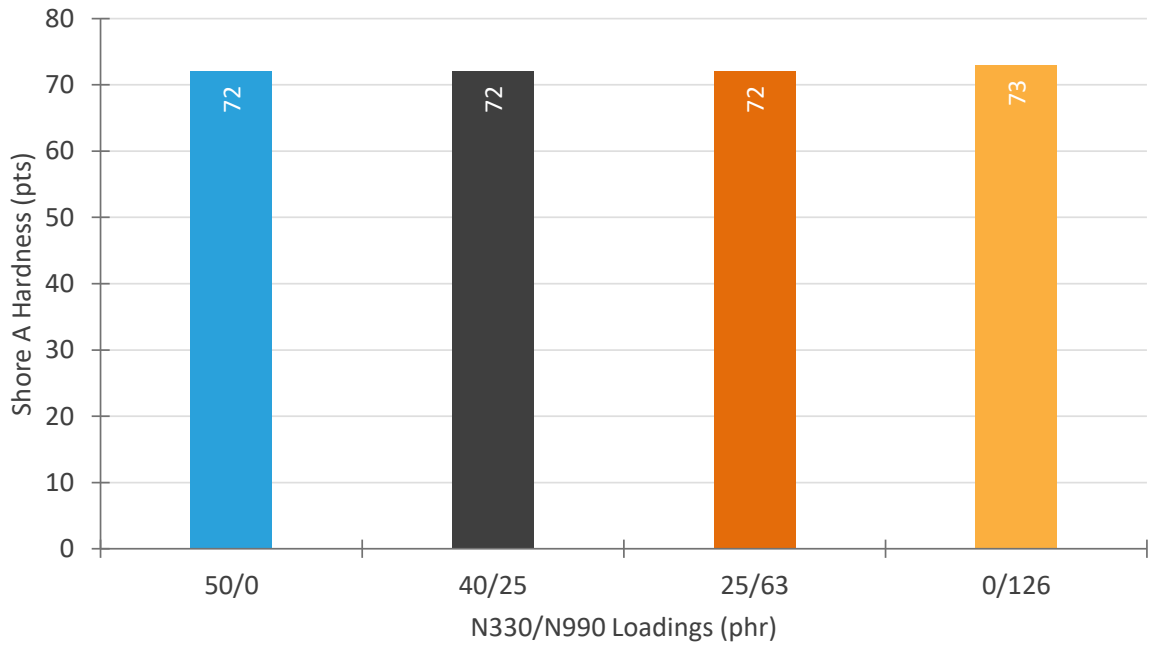

Figure 6. Shore A hardness of the compound. All compounds had similar hardness.

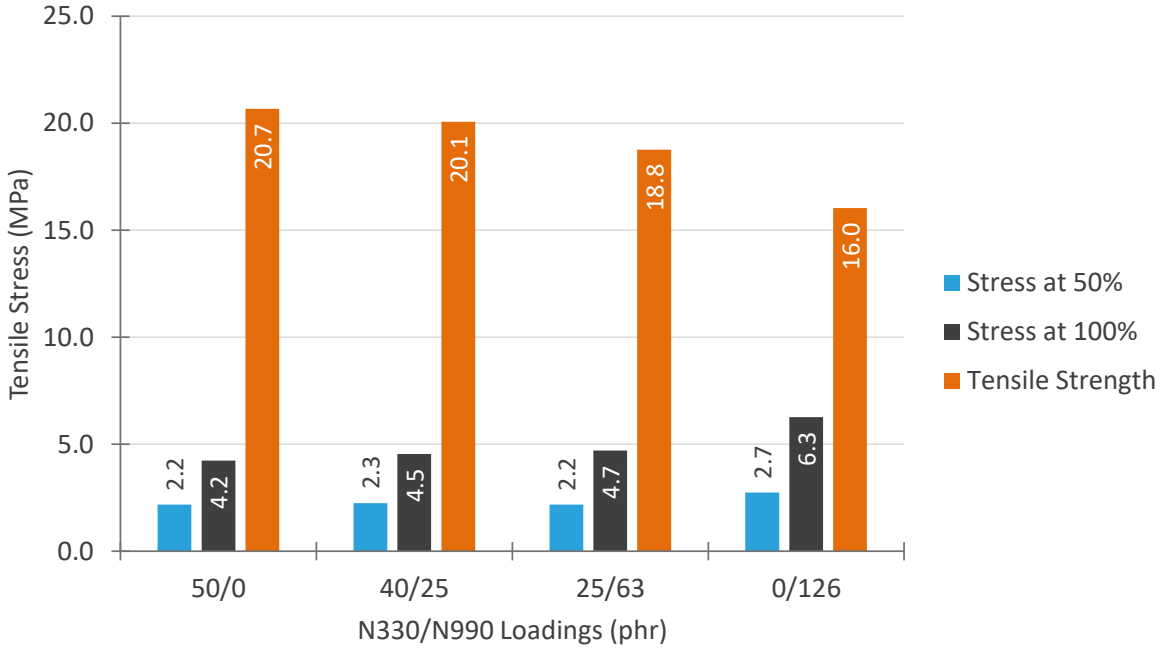

Figure 7. Tensile stress of the compounds as measured by ASTM D412. Modulus tended to increase with increasing N990 loading. This was due to the increased crosslink density of the compounds. The tensile strength tended to decrease as N990 replaced N330.

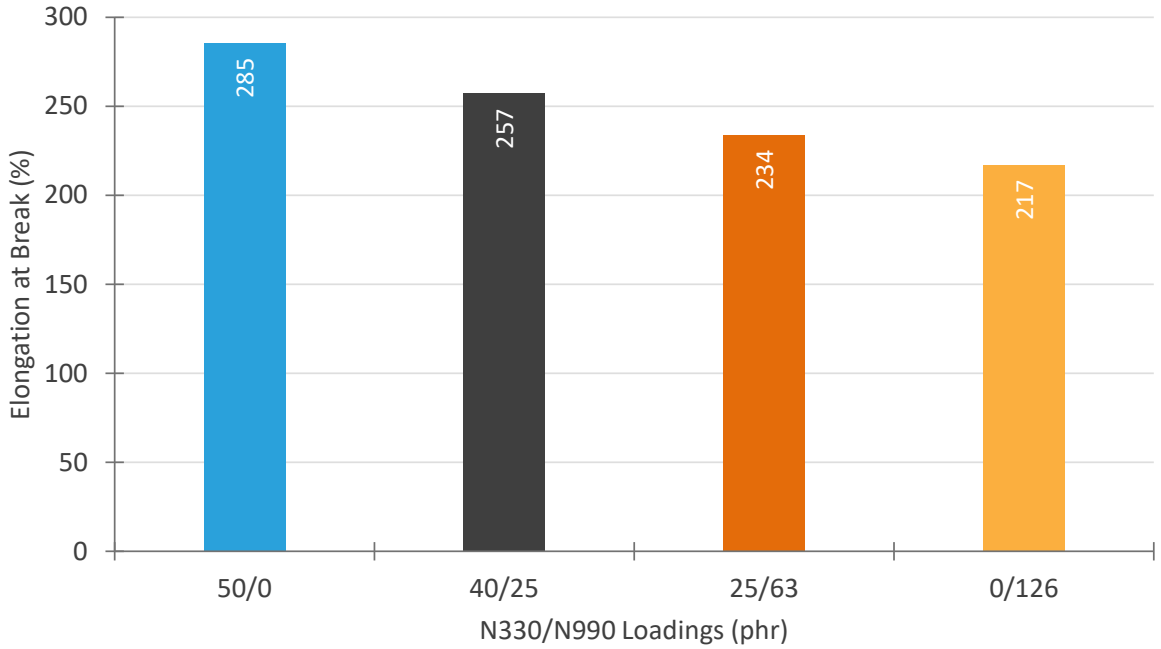

Figure 8. Elongation at break of the compounds as measured by ASTM D412. Elongation tended to decrease as N990 loading increased. This was due to the increase in crosslink density.

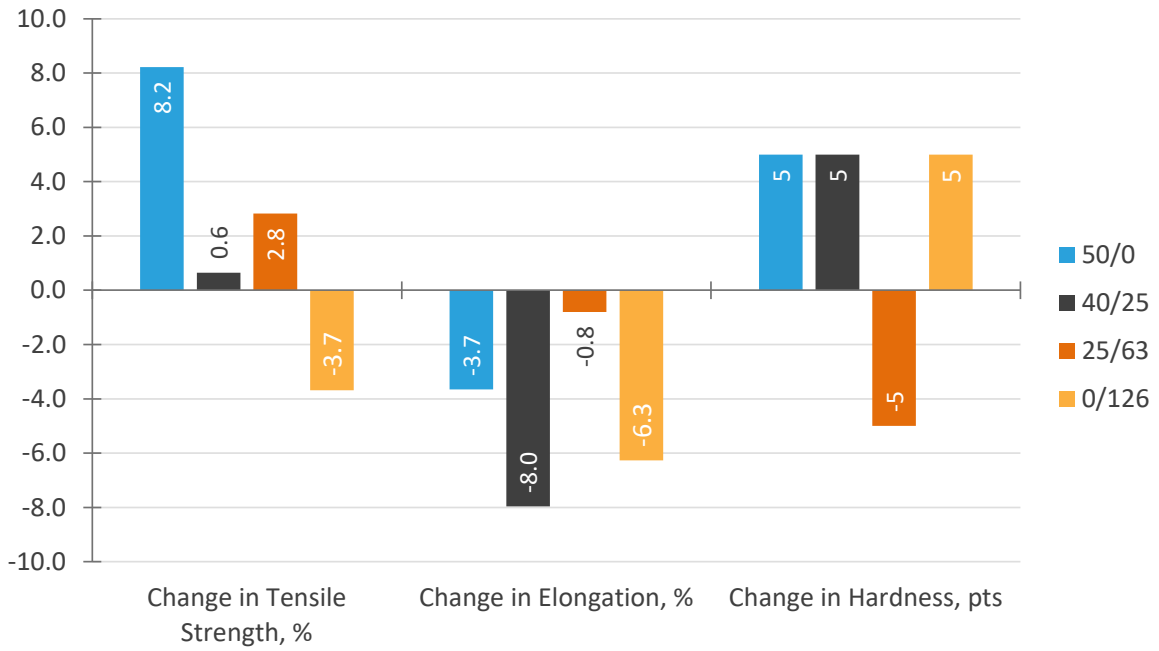

Figure 9. Change in physical properties after heat aging 70 hours at 120°C. Compounds exhibited similar heat resistance.

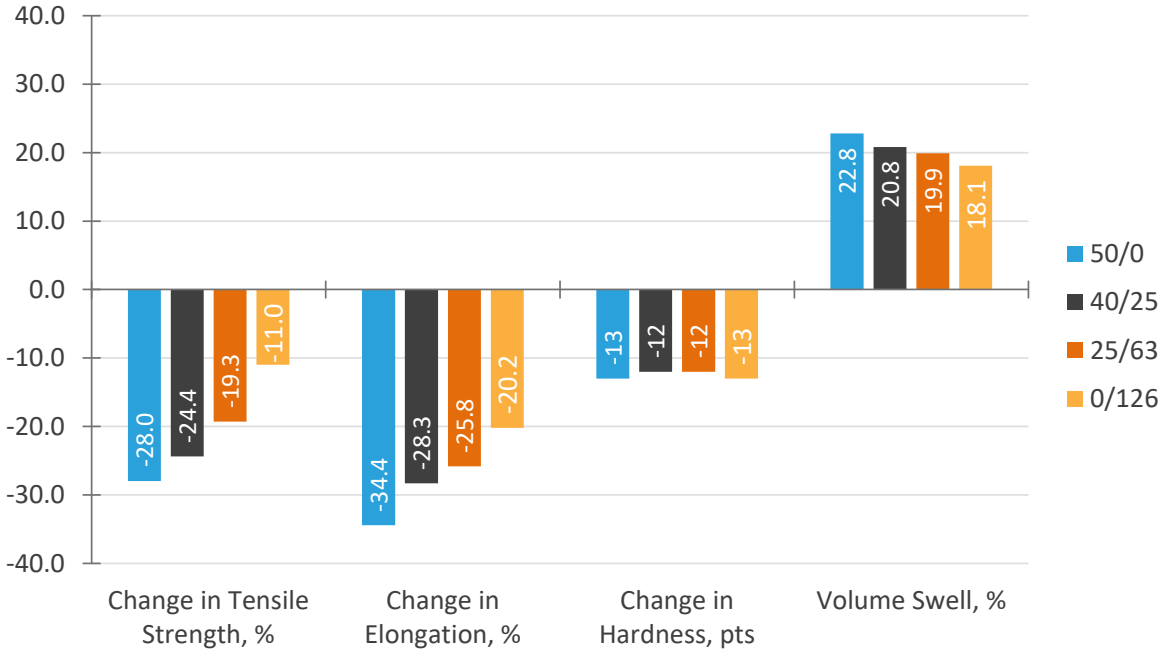

Figure 10. Change in properties after aging in IRM 903 for 72 hours at 120°C. Improvement in aged tensile properties as N990 replaced N330. Volume swell decreased as N990 replaced N330.

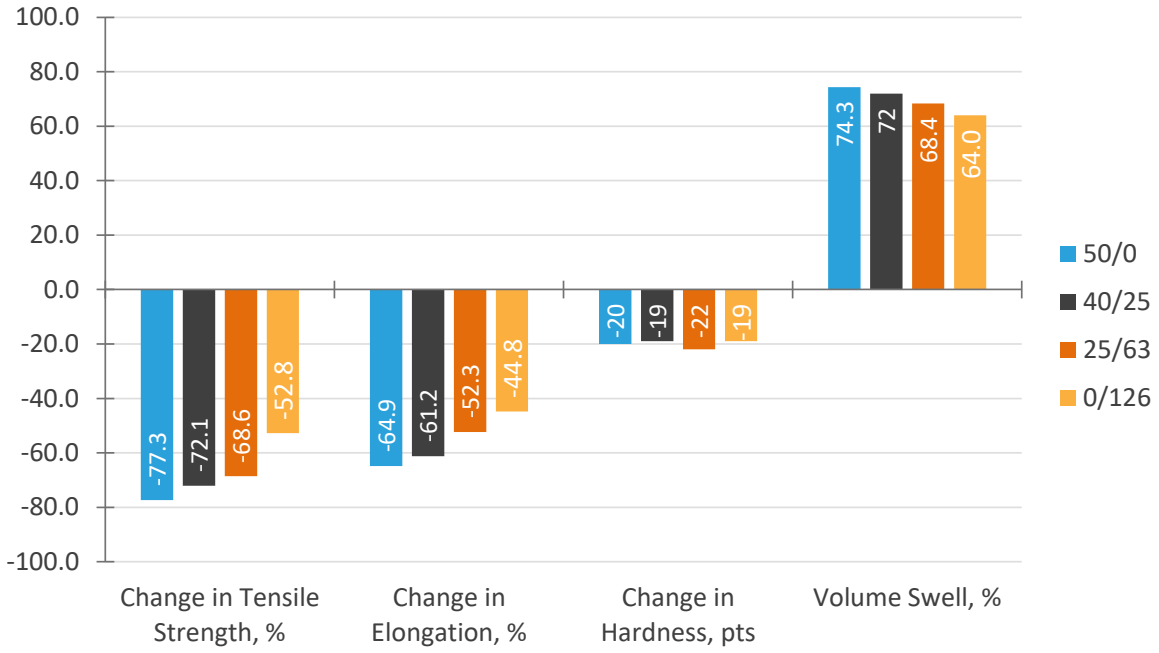

Figure 11. Change in properties after aging in Fuel B for 72 hours at room temperature. Improvement in aged tensile properties as N990 replaced N330. Volume swell decreased as N990 replaced N330.