HNBR Automotive Hoses and Seals

In this study, the effects of replacing N762 with Thermax® N990 on the properties of HNBR automotive hose and seal compounds were evaluated. The compound's chemical resistance to fluids is critical in these types of applications. Superior fuel and oil resistance are typically achieved with high ACN content (>40%) HNBR and high filler loading. Here, a medium ACN content (34%) polymer was selected and the impact of the filler system was evaluated.

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

- Reduction in compound cost due to higher filler loading
- Decrease in compression set
- After oven aging 70 hours at 150°C, compounds highly loaded with N990 **experienced lower changes in elongation** as compared to control compound loaded with N762.
- After oil aging 70 hours at 150°C, compounds highly loaded with N990 **experienced lower changes in tensile strength and elongation**.
- After fuel aging 70 hours at 23°C, compounds highly loaded with N990 **experienced lower changes in tensile strength and elongation**.

The HNBR compound test formulations are provided in Table 1. Mooney, MDR, RPA, hardness, tensile, compression set, heat aging, and fluid aging properties were collected for each compound. Compounding and testing were performed at ACE Products and Consulting in Ravenna, Ohio. The N762 was replaced at a ratio of 1.0 phr N762:1.3 phr Thermax® N990 to maintain a Shore A hardness of approximately 75.

Table 1. Test Formulations

Ingredient	Control	1	2	3	4	5
Therban® 3407	100	100	100	100	100	100
Thermax® N990	**-**	**5**	**10**	**34**	**70**	**106**
N762	80	80	75	54	26	-
Magnesium Oxide	5	5	5	5	5	5
Naugard® 445	1	1	1	1	1	1
ZMMBI	0.4	0.4	0.4	0.4	0.4	0.4
Zinc Oxide	5	5	5	5	5	5
Monoplex® DOS	6	6	6	6	6	6
Ricon® 153-D	8	8	8	8	8	8
DCP 40C	9.5	9.5	9.5	9.5	9.5	9.5
Total	**214.9**	**219.9**	**219.9**	**222.7**	**231.1**	**240.9**

Detailed compound test results are provided in the figures on the following pages.

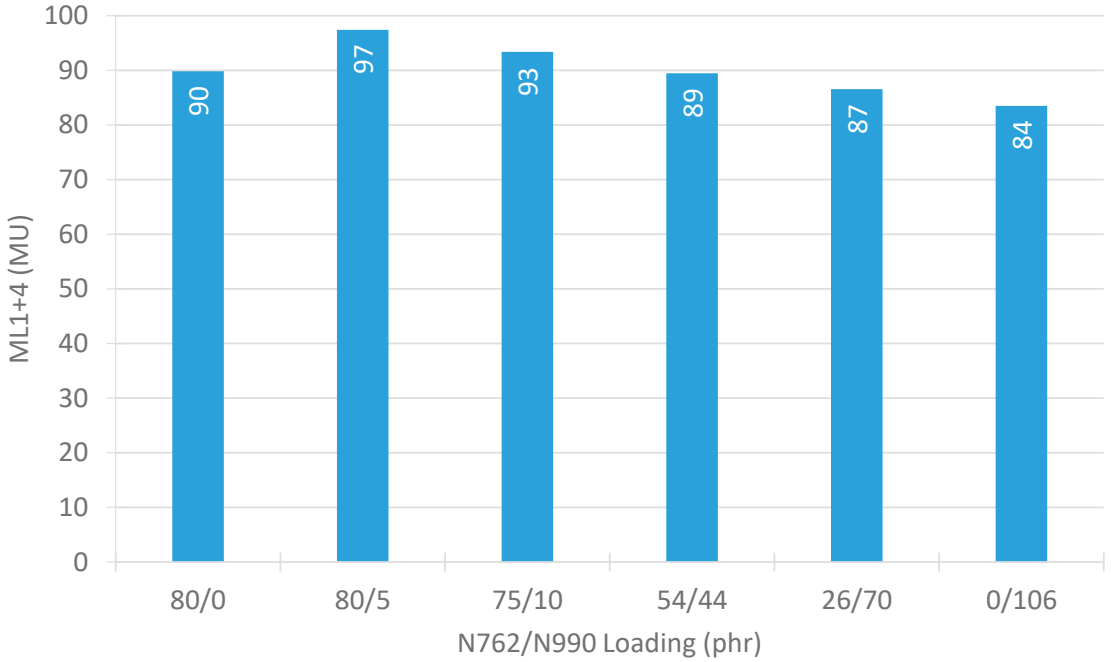

Figure 1. Mooney viscosity, ML1+4, at 100°C for the compounds. Viscosity increased slightly when 5 phr Thermax® N990 was added to formulation. Viscosity decreased slightly when N762 was completely replaced with N990.

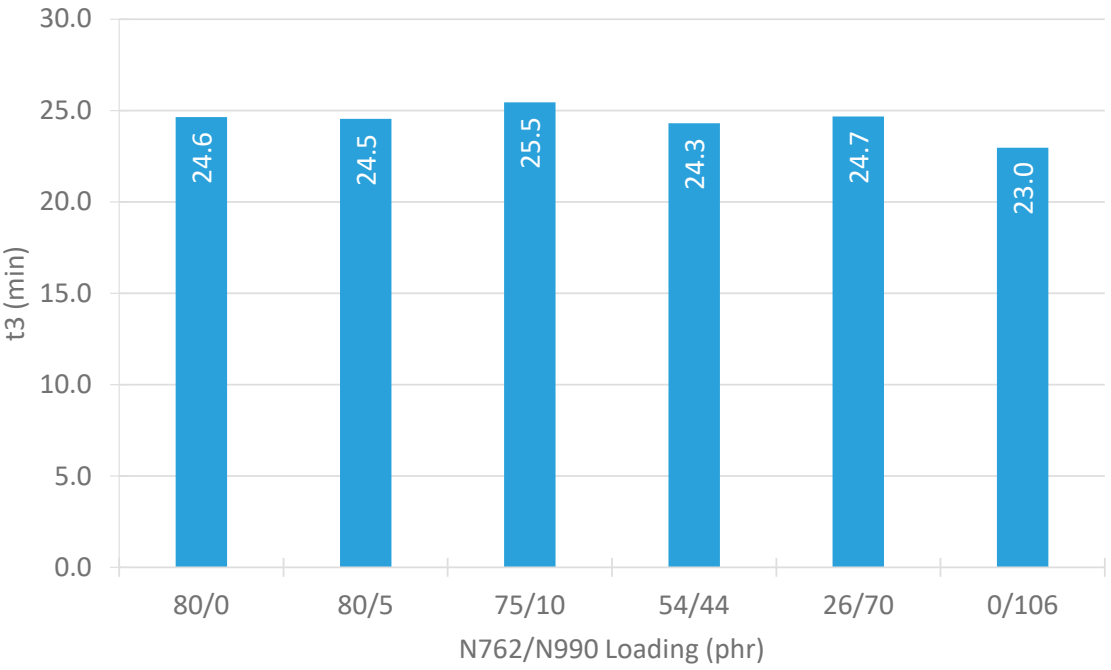

Figure 2. Mooney scorch time, t_3, at 125°C for the compounds. No significant change in scorch times was observed for the samples.

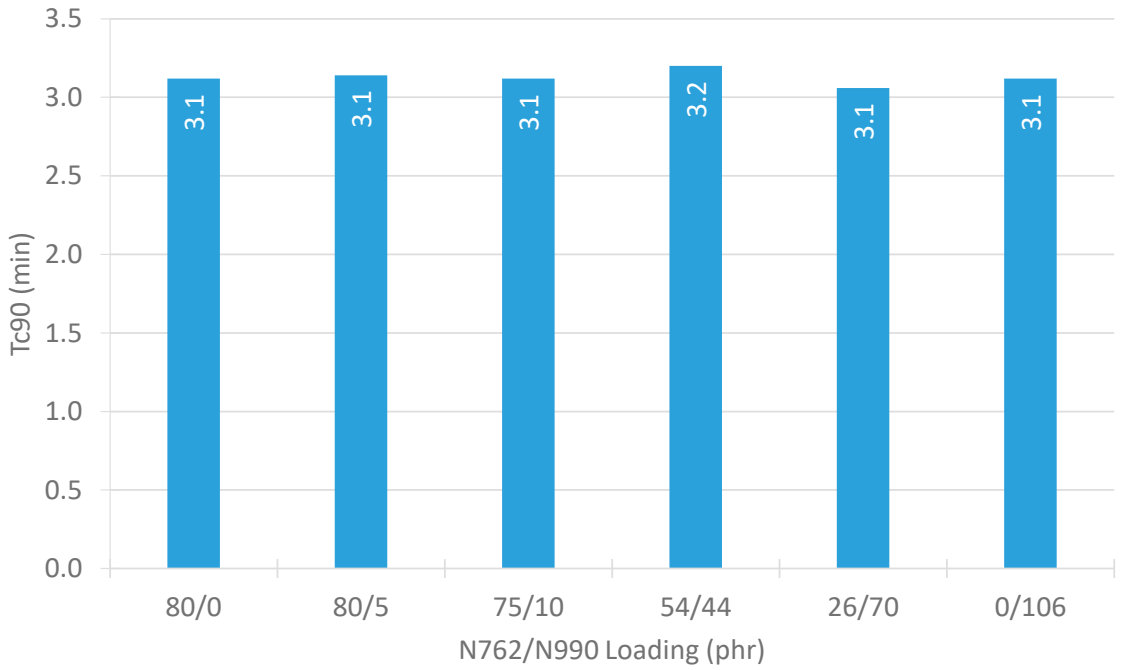

Figure 3. MDR cure time, Tc90, at 180°C for the compounds. No significant difference in cure times was observed.

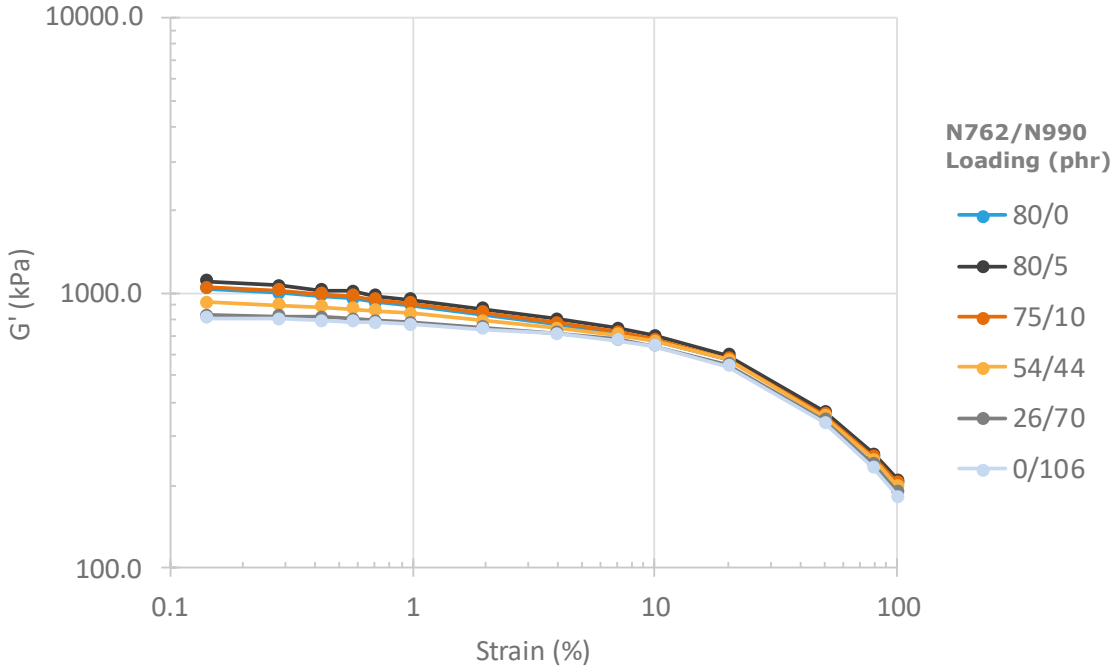

Figure 4. Payne Effect, G' versus strain amplitude, at 70°C and 1 Hz for the compounds. Small strain modulus is reduced ~20% and medium strain modulus is reduced ~10% when N762 is replaced with Thermax® N990. This reflects the reduction in filler-filler and filler-polymer interactions present in the compounds. Additionally, the reduction in Payne Effect indicates lower hysteresis meaning less energy loss and heat generation in the compound during processing.

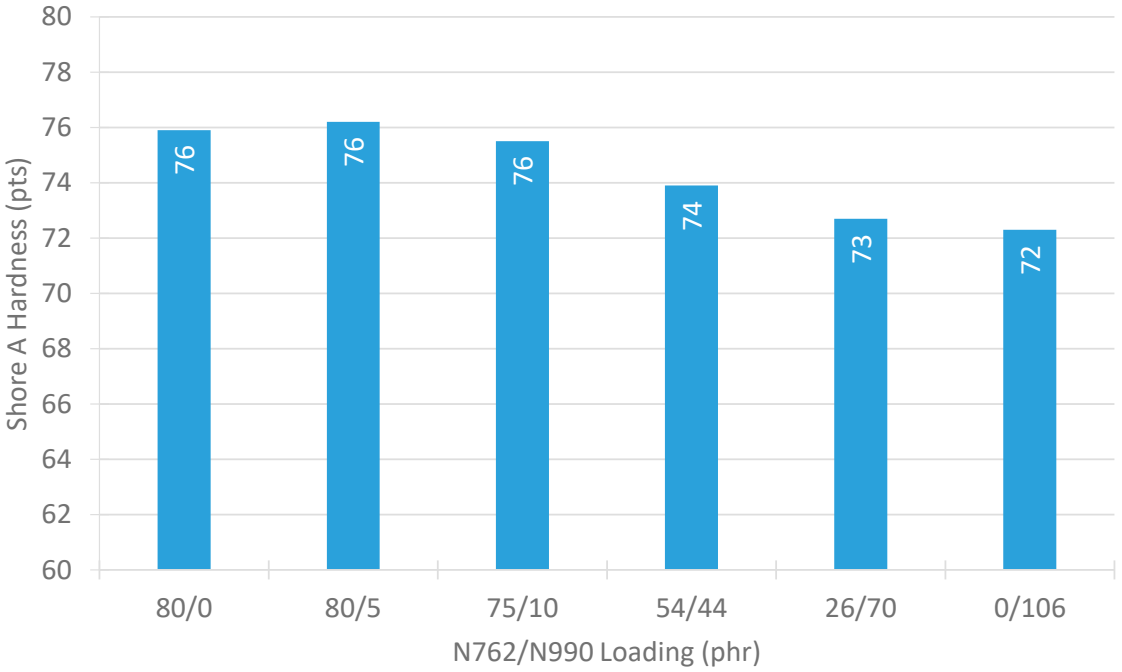

Figure 5. Shore A hardness for the compounds. All compounds fell within 75±5 specification. Slight decrease in hardness observed indicating replacement rate should be higher.

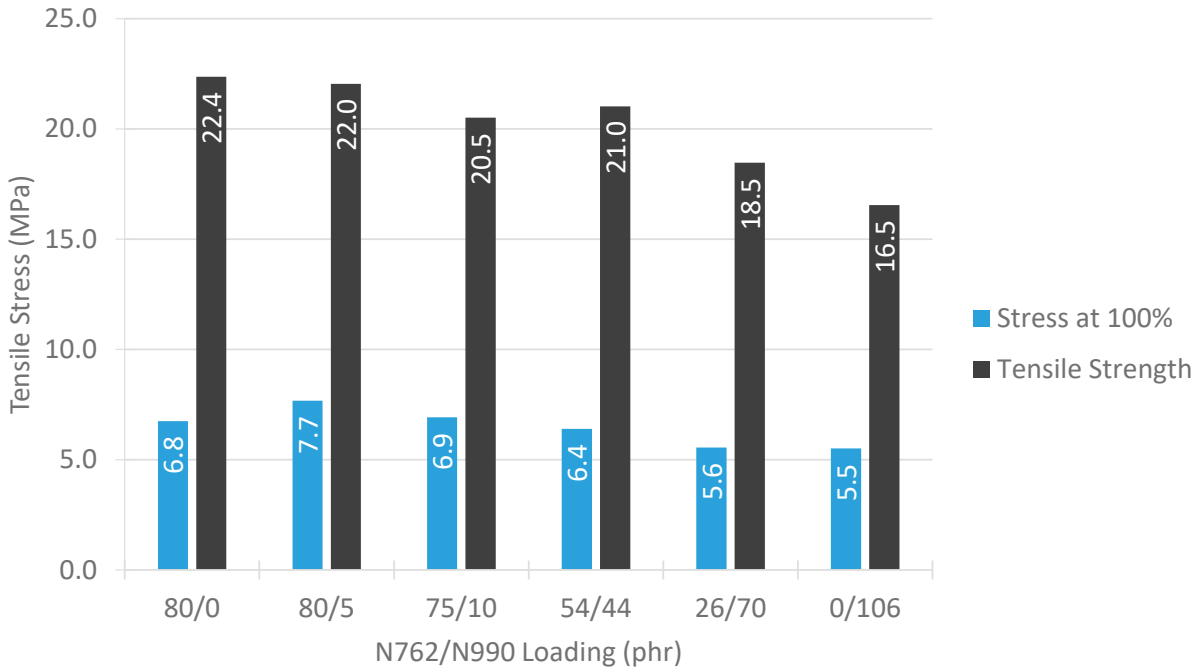

Figure 6. Tensile modulus and strength for the compounds. As N762 is replaced with Thermax® N990, the modulus and tensile strength tended to decrease.

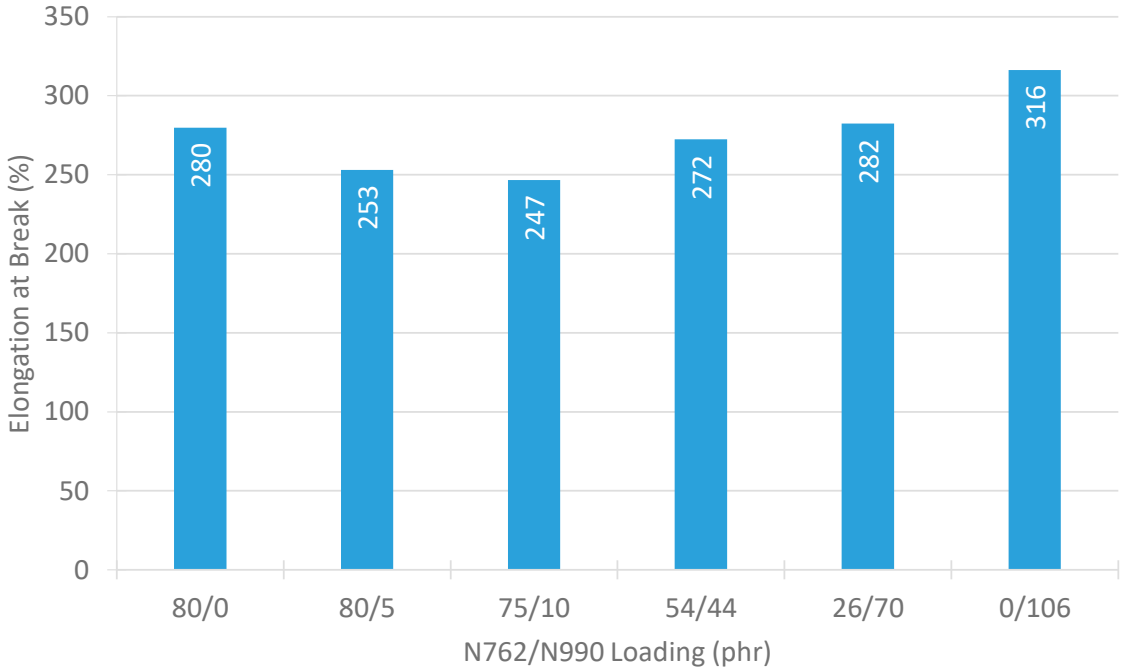

Figure 7. Elongation at break for the compounds. No significant differences in elongation were observed.

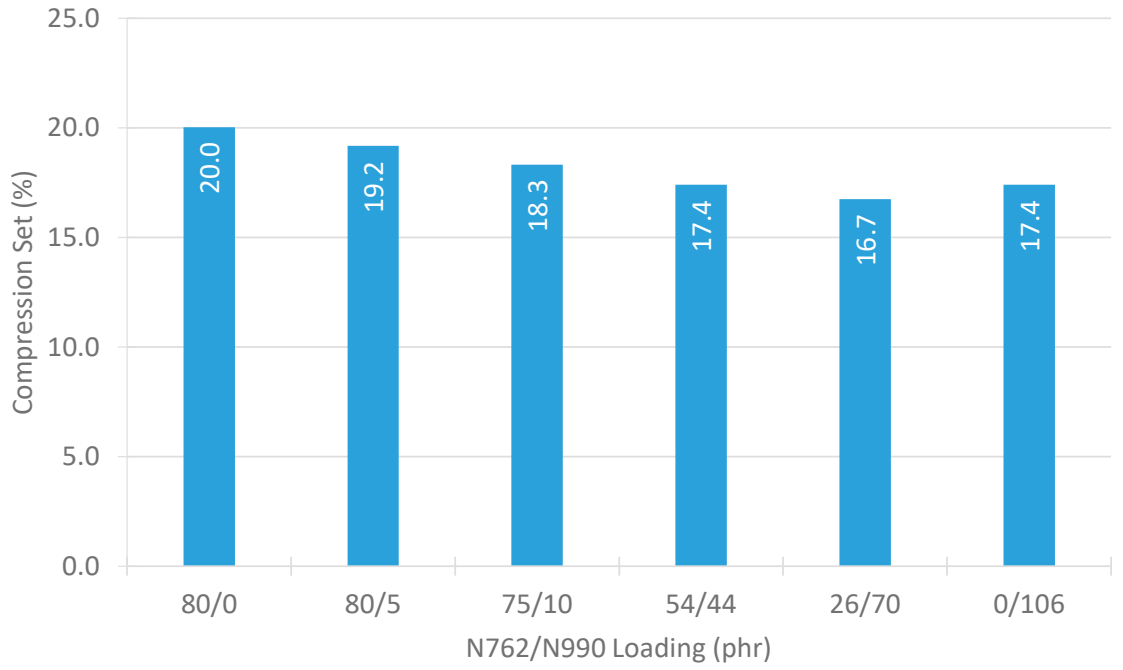

Figure 8. Compression set after 22h at 150°C for the compounds. Compression set tended to decrease as N762 was replaced with Thermax® N990.

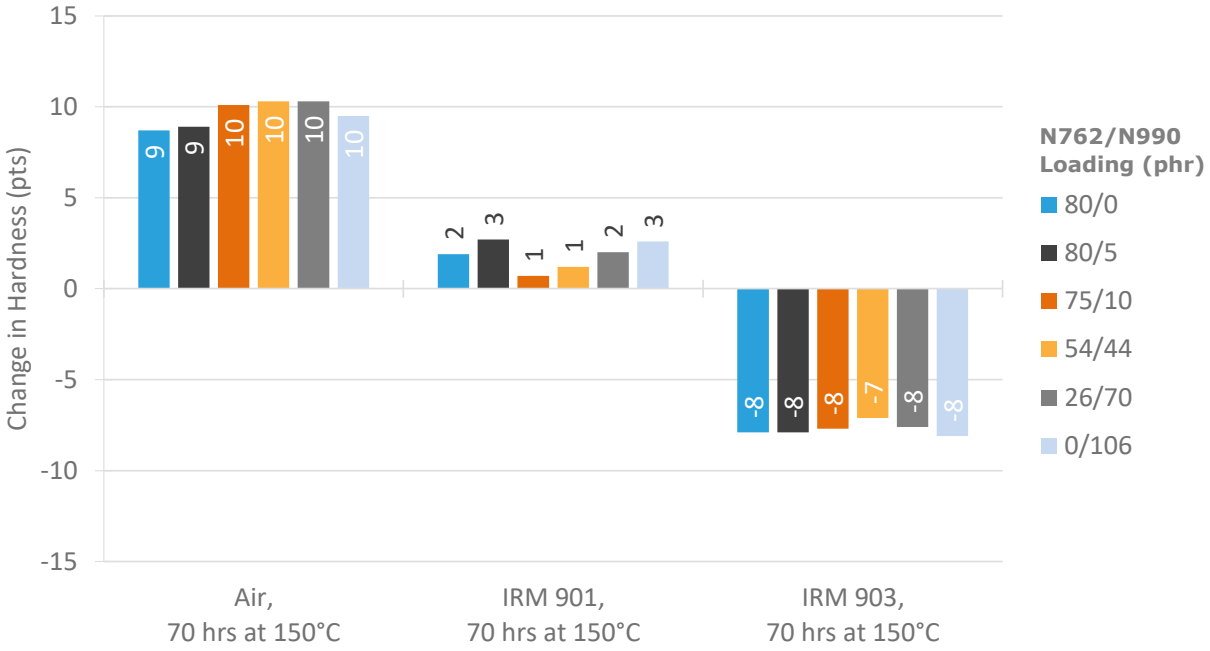

Figure 9. Change in hardness after aging performed in air and oil. There were no significant differences observed. IRM 901 is a paraffinic oil and IRM 903 is a naphthenic oil.

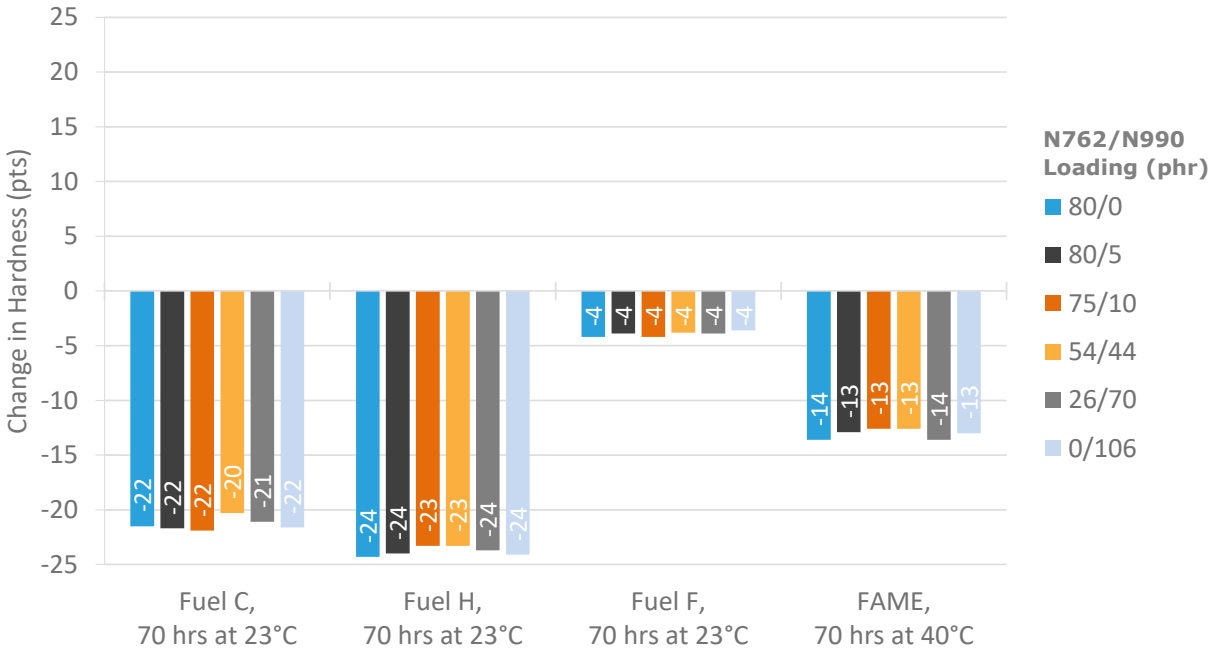

Figure 10. Change in hardness after aging performed in fuel. There were no significant differences observed between the compounds. Data follows polarity of fluids: Fuel H (85% Fuel C, 15% ethanol)>Fuel C (50% isooctane, 50% toluene)>FAME (biodiesel)>Fuel F (diesel) and suggests that this grade of HNBR is not suitable for gasoline vehicles. A higher ACN content grade would likely perform significantly better in Fuel C and Fuel H.

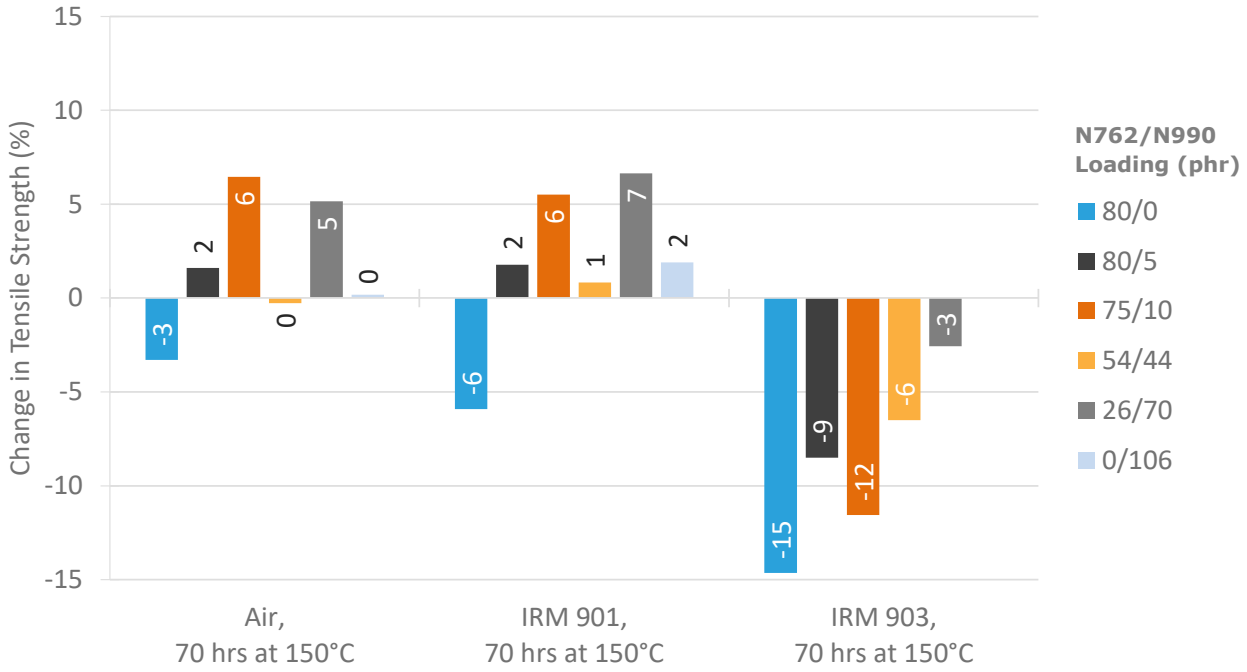

Figure 11. Change in tensile strength after aging performed in air and oil. Performance generally improved, particularly for IRM 903, as N762 was replaced with Thermax® N990.

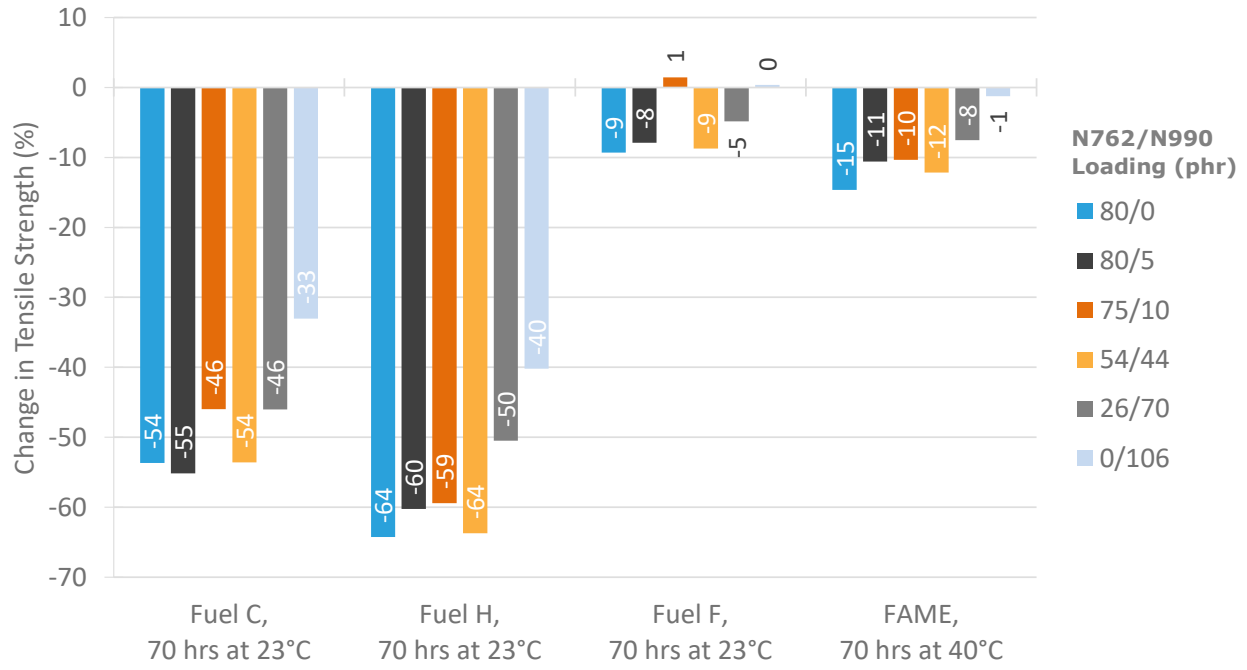

Figure 12. Change in tensile strength after aging performed in fuel. Performance tended to improve as N762 was replaced with Thermax® N990.

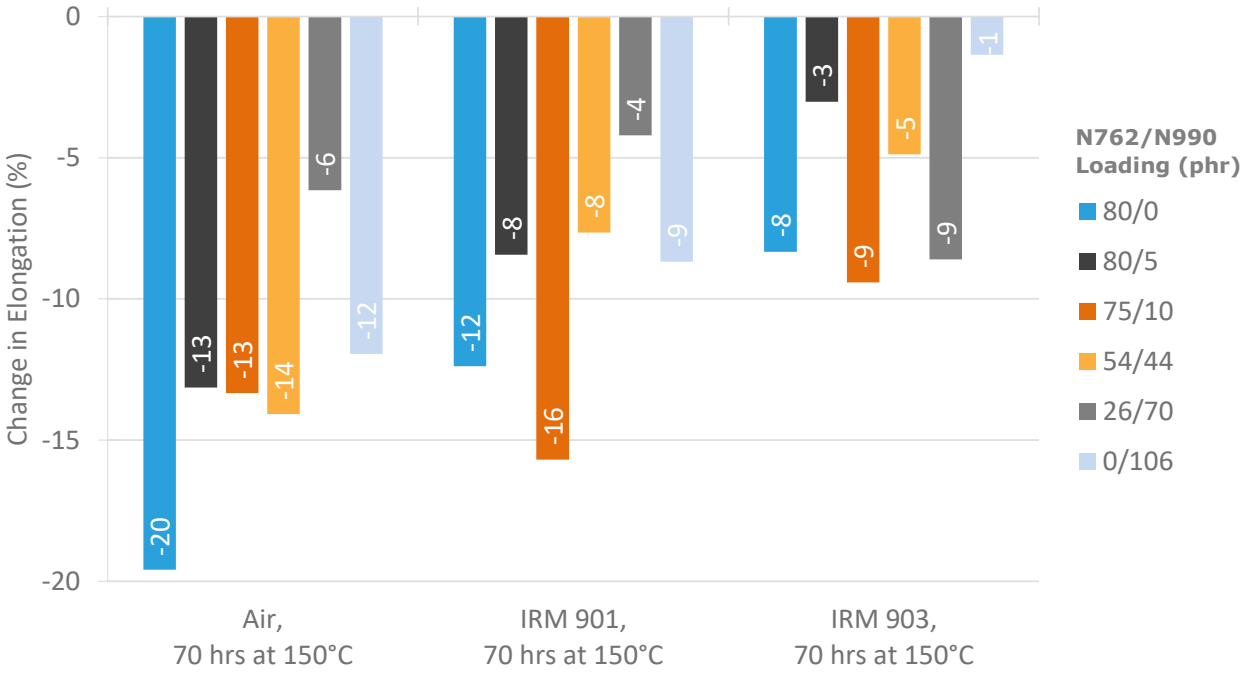

Figure 13. Change in elongation after aging performed in air and oil. All compounds performed well.

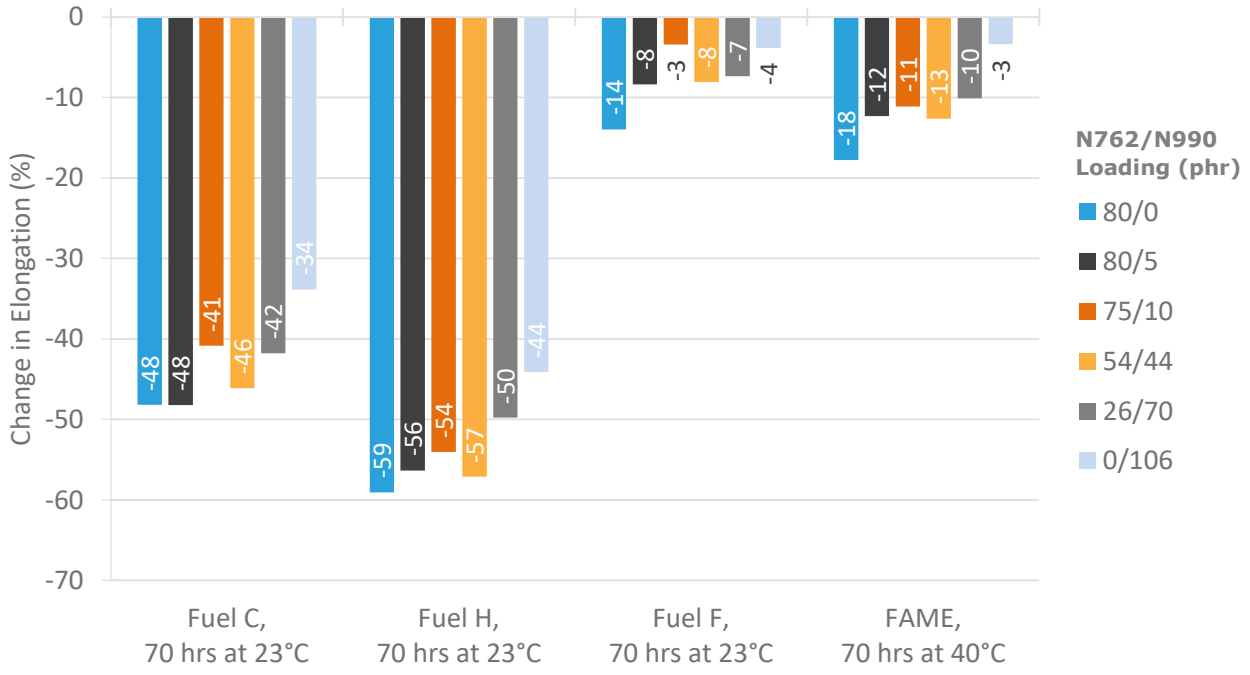

Figure 14. Change in elongation after aging performed in fuel. Performance generally improved as N762 was replaced with Thermax® N990.

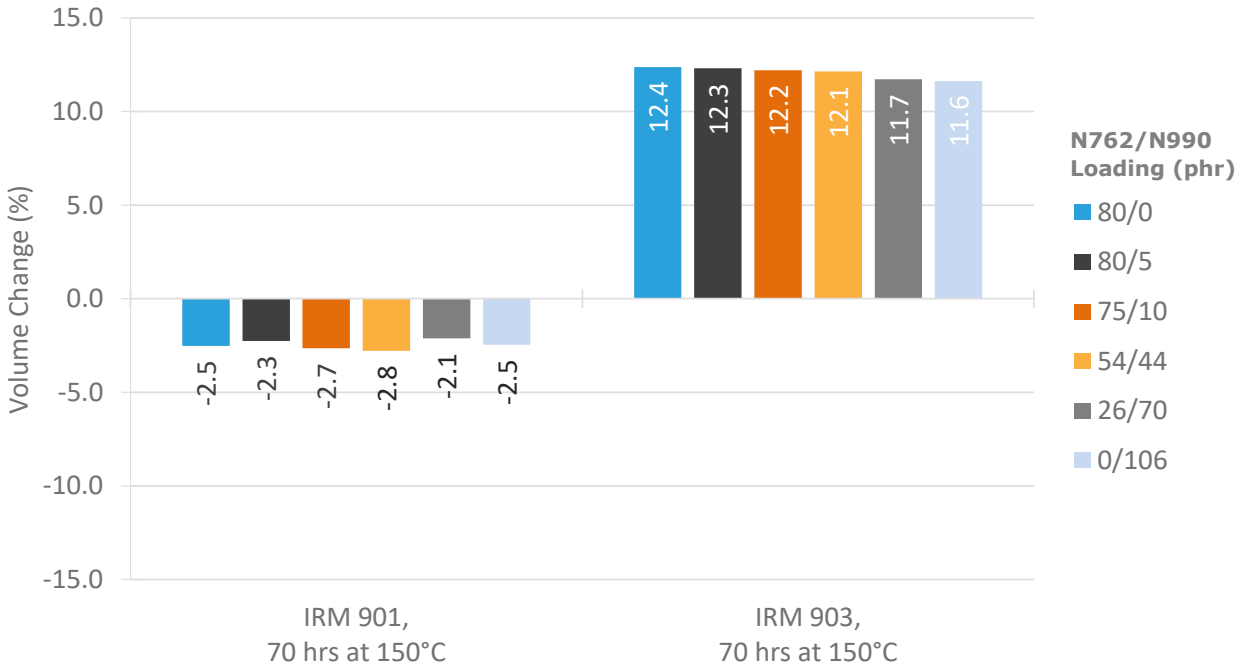

Figure 15. Change in volume after aging performed in oil. There was a slight trend of decreasing volume swell with increasing N990 loading for IRM 903.

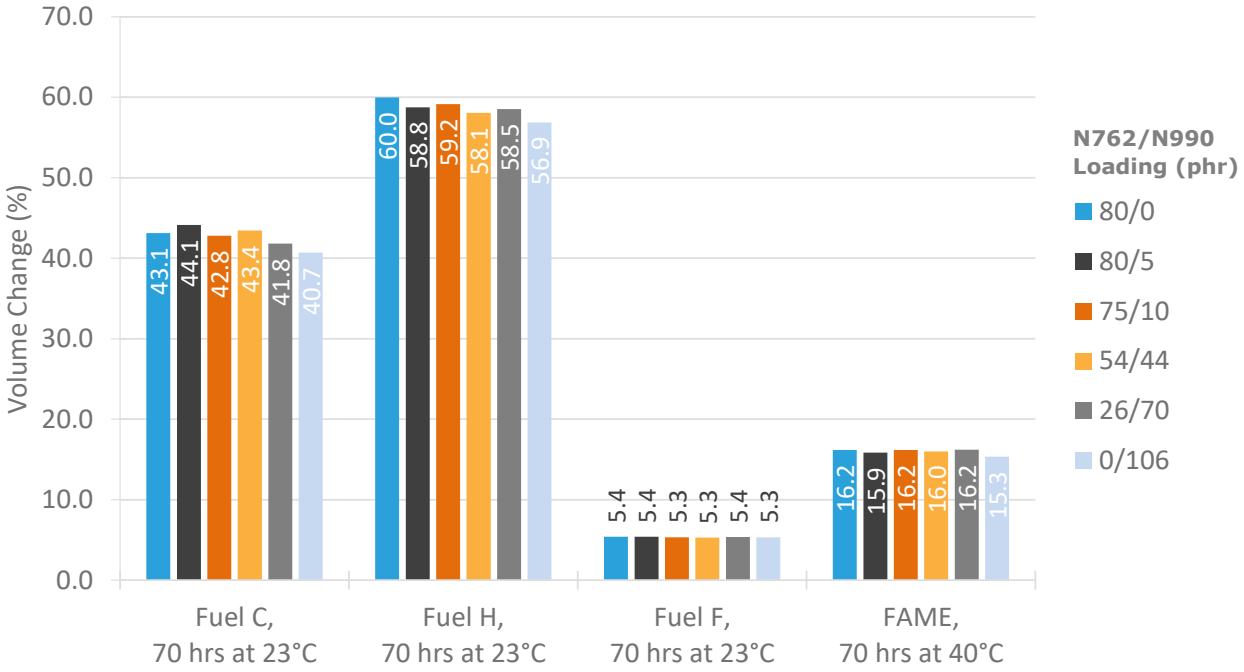

Figure 16. Change in volume after aging performed in fuel. Volume swell tended to decrease with increasing N990 loading for Fuel C and Fuel H.