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NBR Fuel and Oil Hose

In this study, the effects of replacing N650 with N990 on the properties of NBR low permeation fuel filler neck hose compounds were evaluated. The chemical resistance of the compound to the fluids it's exposed to in service is critical in such applications. Superior fuel and oil resistance are typically achieved with high ACN content (>40%) NBR and high filler loading. Here, both high ACN content and medium ACN content (30%-40%) polymers were tested.

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

- Total filler loading in the medium ACN compound was increased from 110 phr to 205 phr with no significant change in Mooney viscosity or hardness. Total filler loading in the high ACN compound was increased from 100 phr to 195 phr with only a small increase in Mooney viscosity and hardness. This allows for a **reduction in compound cost**.
- After oven aging 70 hours at 125°C, compounds highly loaded with N990 experienced **lower changes in hardness and elongation** as compared to control compounds loaded with N650.
- After oil aging 70 hours at 125°C, compounds highly loaded with N990 experienced **lower changes in hardness and volume swell**.
- After ASTM Fuel C (50% isooctane, 50% toluene) aging 48 hours at 23°C, compounds highly loaded with N990 experienced **lower changes in hardness, tensile strength, elongation, and volume swell**.
- After ASTM Fuel I (85% ASTM Fuel C, 15% Methanol) aging 48 hours at 23°C, compounds highly loaded with N990 experienced **lower changes in hardness, tensile strength, and volume swell**.

Overall, the high ACN compounds provided lower Mooney viscosities indicating improved processing, as expected. The medium ACN compounds had lower compression set values, as expected. Oil resistance was generally better for the medium ACN compounds with lower changes in hardness, tensile strength, and volume swell. The overall best ASTM Fuel C resistance and ASTM Fuel I resistance was provided by the high ACN compound with 150 phr N990.

The NBR compound test formulations are provided in Table 1 with additional information about the NBR grades shown in Table 2. Mooney, ODR, hardness, tensile, compression set, heat aging, and fluid aging properties were collected for each compound. Compounding and testing were performed at Canadian Rubber Testing and Development (CRTD). The N650 was replaced at a ratio of between 2.5-3.0 phr N990:1.0 phr N650 in order to maintain a Shore A hardness of approximately 75.

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

Table 1. Test Formulations

Ingredient	A1	A2	A3	B1	B2	B3
Krynac 4560*	100	100	100	-	-	-
Krynac 3370*	-	-	-	100	100	100
Hi-sil 233	20	20	20	20	20	20
Thermax® N990	**-**	**75**	**150**	**-**	**75**	**150**
N650	80	50	25	90	60	35
Merrol 4221	18	18	18	18	18	18
Plasticizer SC-B	12	12	12	12	12	12
Zinc Oxide	5	5	5	5	5	5
Coumin 100	5	5	5	5	5	5
Wingstay 29	2.5	2.5	2.5	2.5	2.5	2.5
TMQ	1.5	1.5	1.5	1.5	1.5	1.5
Sunproof Cdn Wax	2	2	2	2	2	2
Sulfur	0.5	0.5	0.5	0.5	0.5	0.5
TMTD	1	1	1	1	1	1
MBS	1.5	1.5	1.5	1.5	1.5	1.5
DTDM	1.5	1.5	1.5	1.5	1.5	1.5
Total	**250.5**	**295.5**	**345.5**	**260.5**	**305.5**	**355.5**

Table 2. Properties of NBR grades

NBR Grade	ACN Content (%)	ML(1+4), 100°C	Density (g/cm^3)
Krynac 4560	45	64	0.99
Krynac 3370	33	70	0.97

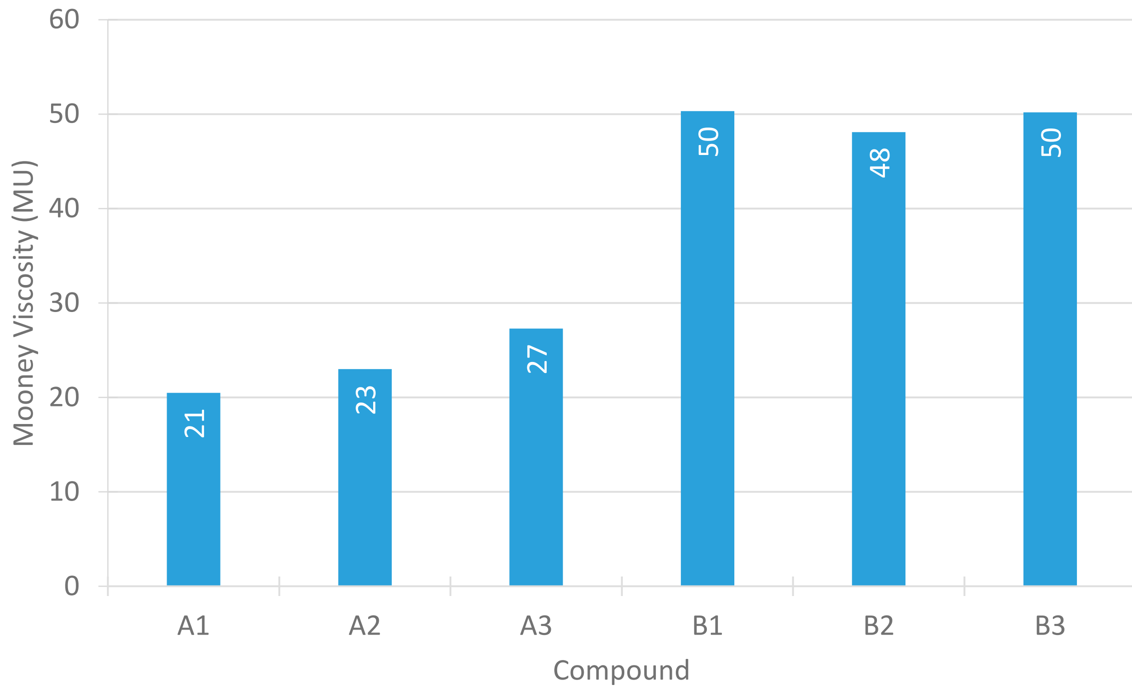

Figure 1. Mooney viscosity, ML1+4, at 100°C for the compounds. Viscosity was significantly lower for the high ACN compounds. Viscosity increased slightly for the high ACN content compound as N990 replaced N650. No change in viscosity was observed for the standard ACN compound despite almost doubling the total filler loading.

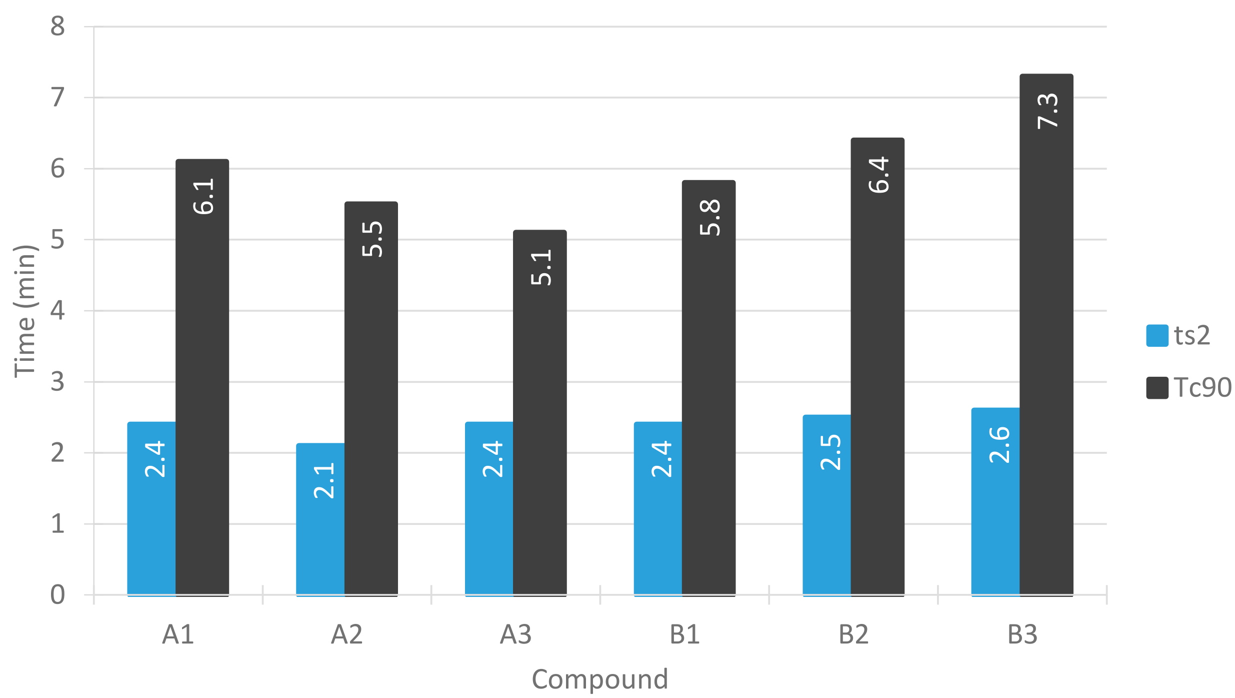

Figure 2. Scorch time, ts2, and cure time, Tc90, from an ODR run at 160°C. There were no significant changes in scorch time or cure time for the compounds.

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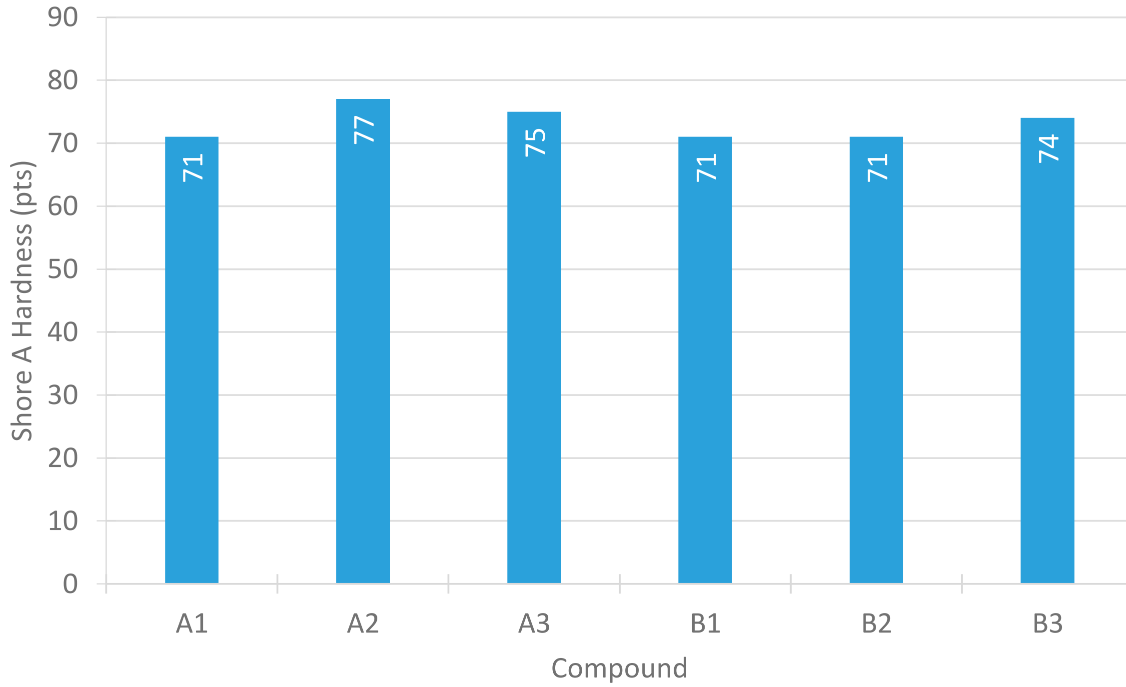

Figure 3. Shore A hardness for the compounds. All compounds fell within a 75±5 hardness specification.

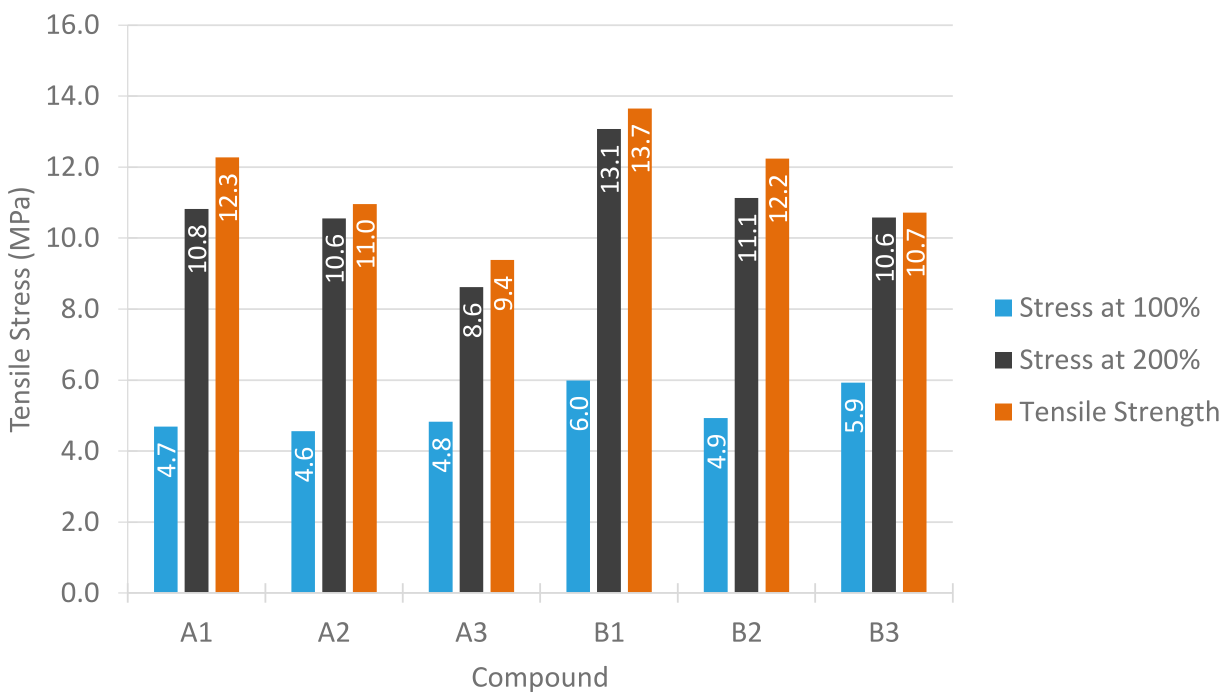

Figure 4. Tensile modulus and strength for the compounds. No significant change in stress at 100% strain was observed. Tensile strength decreased as N650 was replaced with N990 and total filler loading increased. Tensile strength was generally higher for the standard ACN content compounds.

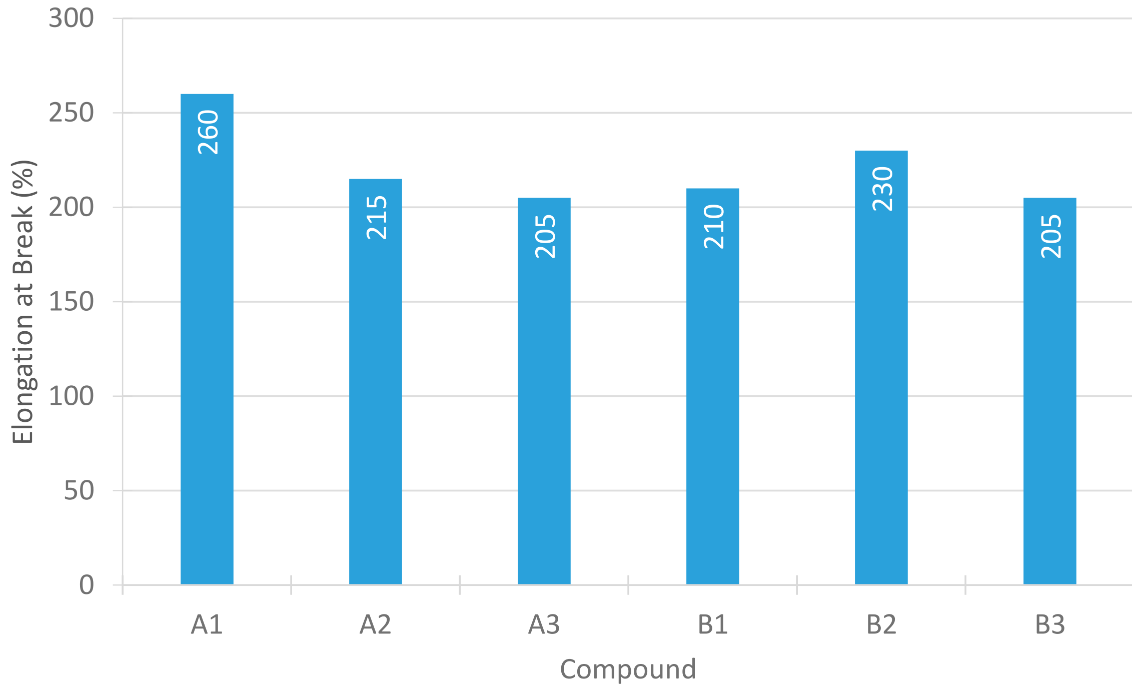

Figure 5. Elongation at break for the compounds. There was a small decrease in elongation as N650 was replaced with N990 in the high ACN content compound.

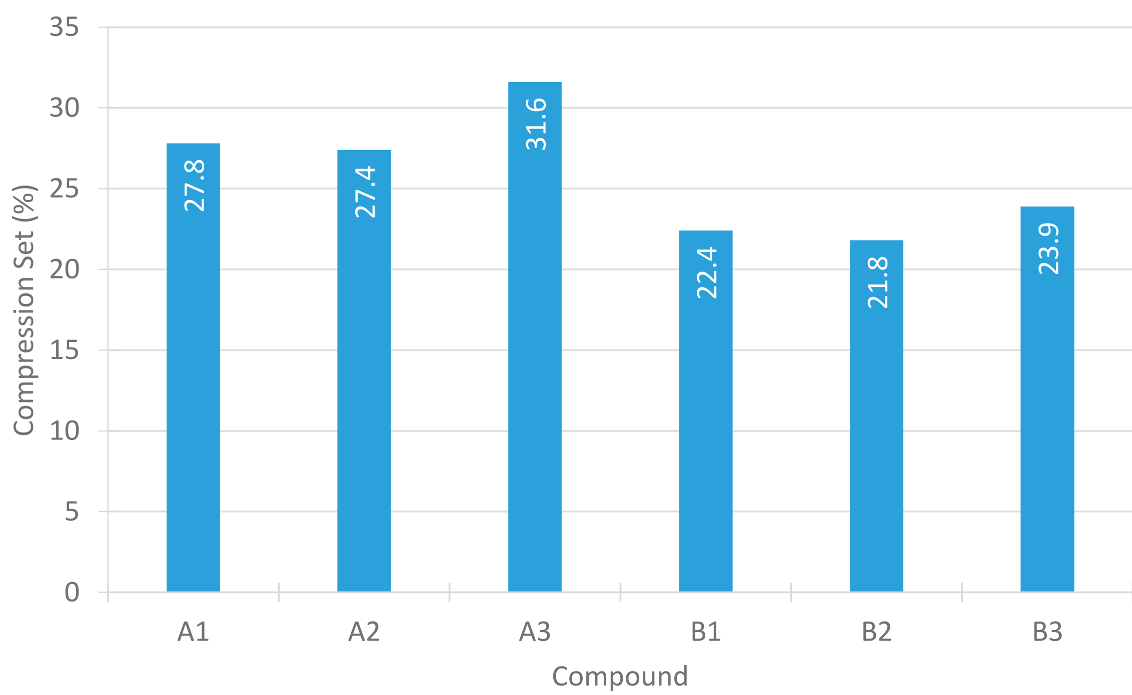

Figure 6. Compression set after 70 hours at 125°C for the compounds. There was no change in compression set at the N990 loading of 75 phr. At the N990 loading of 150 phr, a small increase in compression set was observed. Compression set was lower for the standard ACN content compounds.

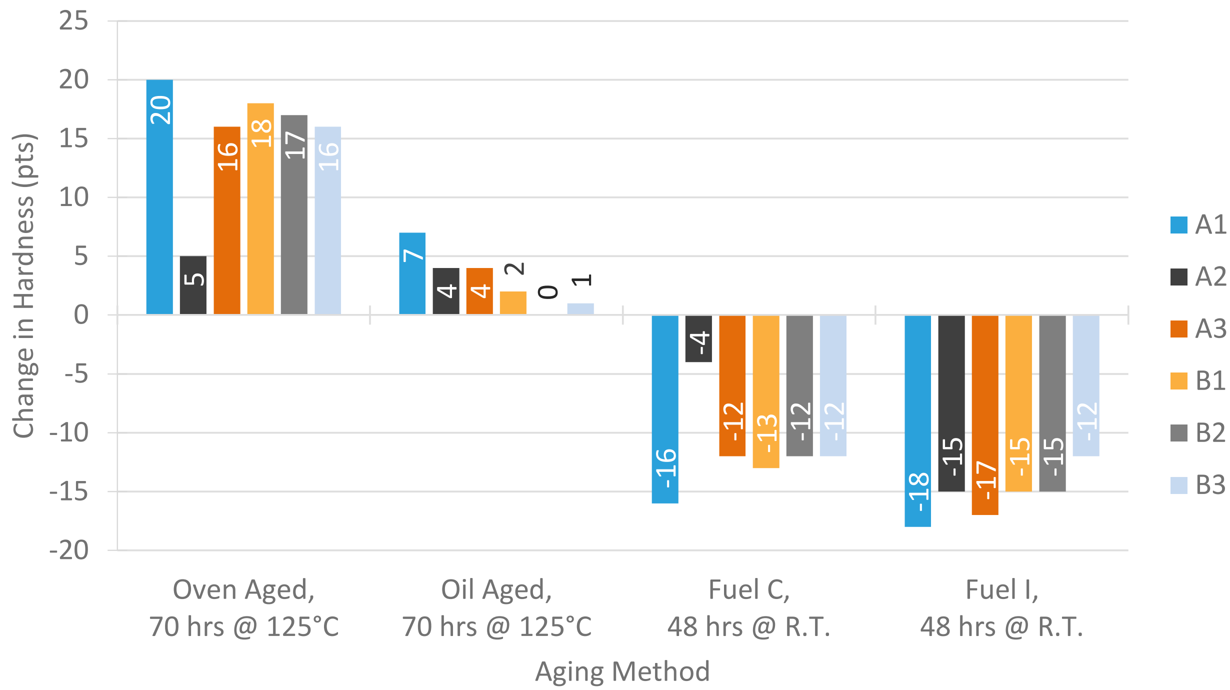

Figure 7. Change in hardness after aging tests performed under various conditions. For all methods, the change in hardness was lower for compounds loaded with 75 or 150 phr N990 in comparison to those with no N990. Generally, the change in hardness was lower for the standard ACN content compounds.

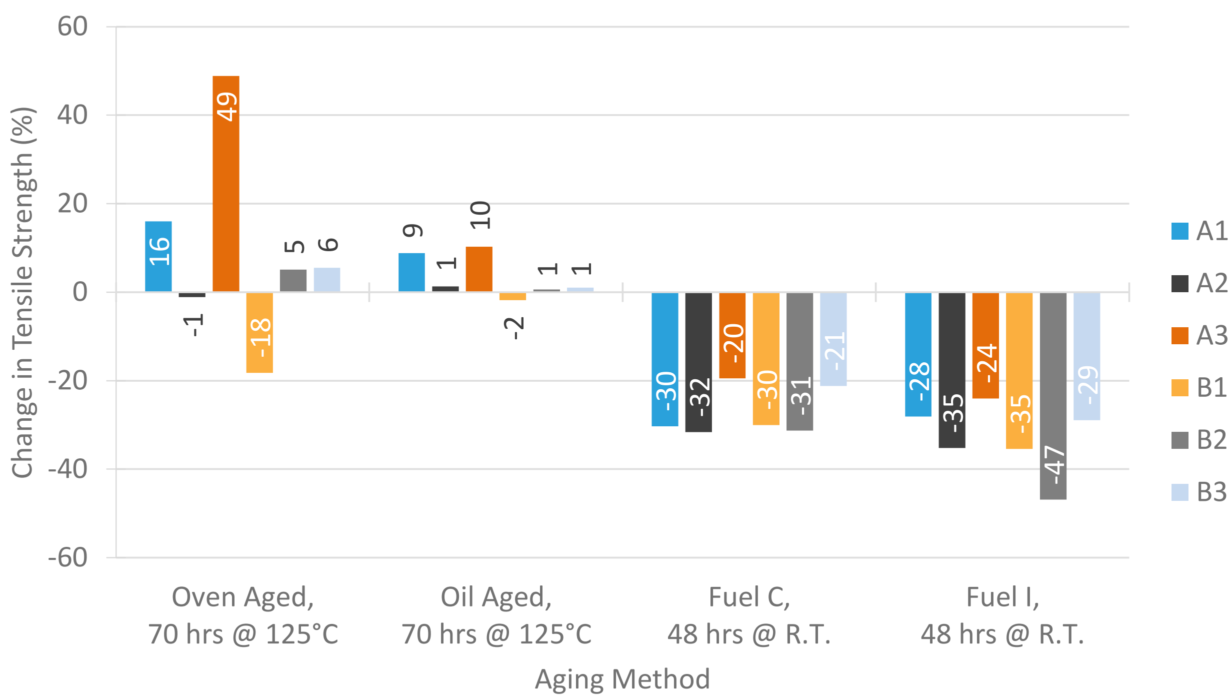

Figure 8. Change in tensile strength after aging tests performed under various conditions. For fuel aging, the change in tensile strength was lowest for compounds with 150 phr N990 for both high and standard ACN content compounds.

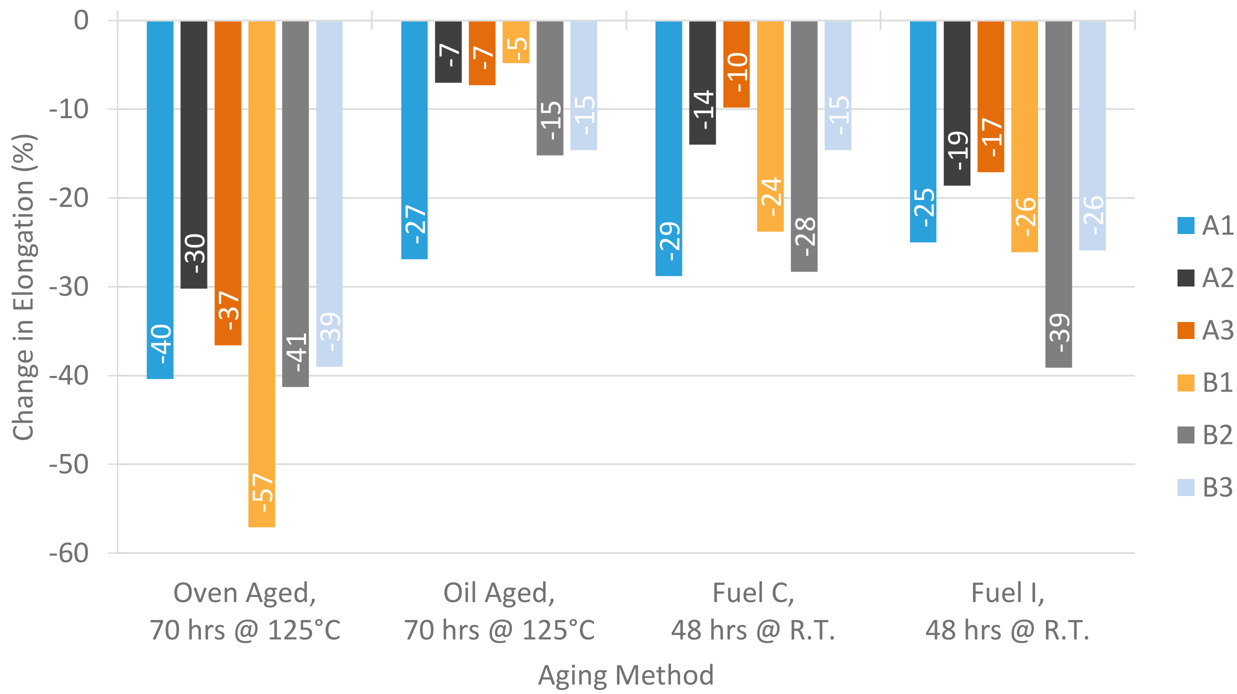

Figure 9. Change in elongation at break after aging tests performed under various conditions. For high ACN content compounds, the change in elongation was lower as N650 was replaced with N990.

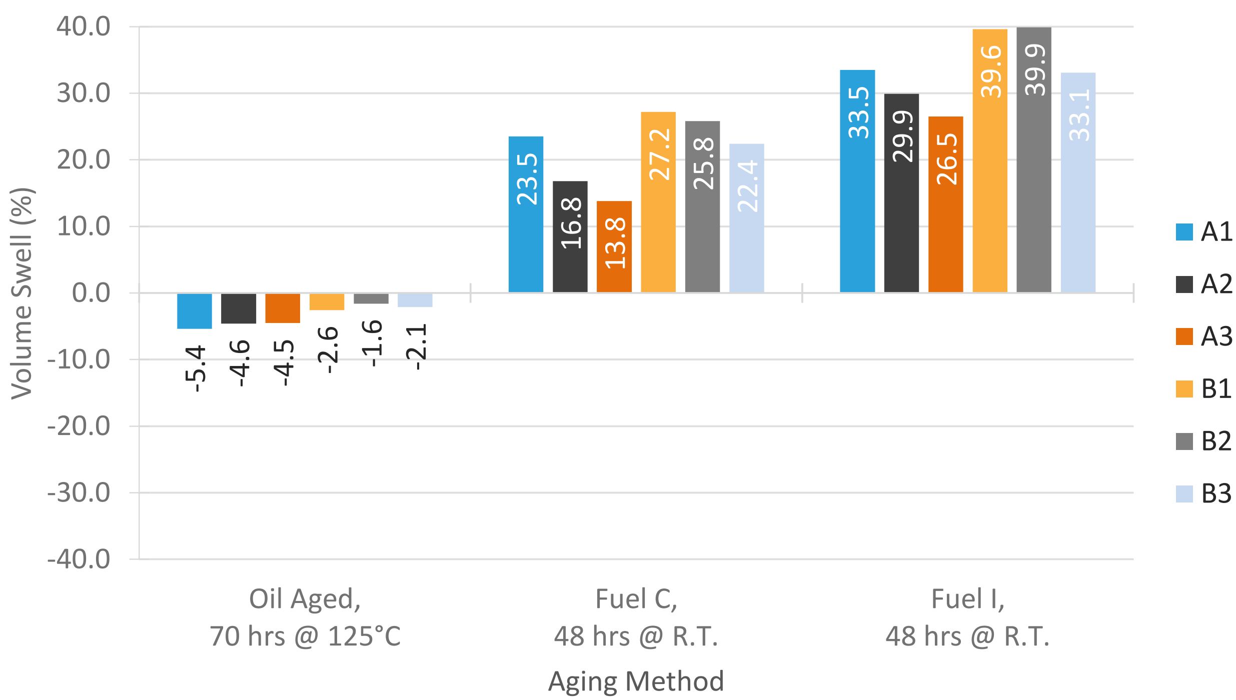

Figure 10. Volume swell after aging in different fluids. Volume swell decreased as N650 was replaced with N990 in all compounds. Volume swell in oil was lower for standard ACN content compounds. Volume swell in fuel was lower for high ACN content compounds.