

Blends of Vamac[®] HyPR 5015 and Ultra LT

Vamac[®] Ethylene Acrylic Elastomer - Technical Data

Best Combination of Heat Resistance and Low Temperature Flexibility

Description

Downsizing of cars and engines; and integration of new technologies for improved fuel efficiency have led to increasing temperatures under the hood. This trend is ongoing, and new specifications continue to show more and more severe heat ageing conditions. This can lead to changes from one polymer family to a more heat resistant one, very often associated to significant additional cost.

Oil for transmissions and engines nowadays often require oil cooler modules that are submitted to vibrations that need flexible sealing materials at low temperatures. In addition, new oils are used like 0W-16 or even 0-W8, which are lower in viscosity and exhibit higher fluidity at very low temperatures. First generation oils that are introduced for use in battery electric vehicles, very often based on Gas-To-Liquid-Technology, are even lower in viscosity, for which reason sealing materials with good sealing properties down to -40°C or lower are required.

Coincidentally the higher temperatures under the hood do not allow to just add more plasticizer to improve initial low temperature flexibility. New compounding solutions must be developed to achieve better low temperature flexibility combined with best heat resistance over a long part lifetime.

Among Vamac[®] elastomers, Ultra LT is the AEM polymer with best low temperature flexibility. The HyPR 5000 series is a range of Vamac[®] pre-compounds with a novel filler system that enhances the heat resistance of AEM compounds by 10 to 15°C. A combination of both product types can provide interesting solutions for parts where best heat resistance and long lifetime combined with best low temperature flexibility is required. As Ultra LT is low in viscosity, HyPR 5015 with the highest Mooney Viscosity of the current HyPR 5000 product range seems to be the best choice for blends to boost compound viscosity.

Table 1 – Product Description

Grade	Mooney Viscosity ML (1+4) at 100 °C	Tg °C (by DSC)	Key Feature
Vamac[®] HyPR 5015 (Formerly VMX5015)	57	-30	Best Heat Resistance, High Viscosity
Vamac[®] Ultra LT (Formerly VMX4017)	11	-41	Best Temperature Flexibility

Formulations

Table 2 shows compound formulations that were prepared in a 1.7 litre Intermix lab mixer. Compounds were mixed for about 3 minutes and dumped below 95°C to avoid Scorch. A 50/50 blend of Vamac[®] Ultra IP and Ultra LT, filled with 'normal' Carbon Black levels, was used for reference compound 1. This kind of compound has been used as a starting point formulation for applications, when best low temperature flexibility for AEM was required. Due to its low viscosity, Ultra LT has been combined with high viscosity Vamac[®] Ultra grades like Ultra IP.

Compounds 2, 3 and 4 compare different blend ratios of HyPR 5015 and Ultra LT. As the Vamac[®] HyPR 5000 series include fillers, the Hardness of the vulcanizates will decrease with decreasing HyPR 5015 level. Comparative examples of different carbon black and substitution Vamac[®] Ultra IP for Ultra LT are shown with 5 and 6. HMDC curative was held constant at

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medium levels. Somewhat higher levels of HMDC (1.3 to 1.5 phr) to optimize Compression Set may at the same time reduce Elongation at Break or Tear Strength. Plasticizer level was slightly reduced for the HyPR 5015 compounds, as they typically must withstand higher temperatures.

Table 2 – Formulations

Ingredient (phr)	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
Vamac [®] HyPR 5015		150	118	100	118	118
Vamac [®] Ultra LT	50	17.5	35	45	35	
Vamac [®] Ultra IP	50					35
Naugard [®] 445	2					
Safic-Chem 4ADA FL		1.5	1.5	1.5	1.5	1.5
Ofalub [®] SEO	1	1	1	1	1	1
Armeen [®] 18D	0.5					
Stearic Acid	1.5	0.5	0.5	0.5	0.5	0.5
FEF N550	60				25	25
MT N990		25	25	25		
Alcanplast [®] PO80	10	7	7	7	7	7
HDMC Curative	1.3	1.1	1.1	1.1	1.1	1.1
Vulcofac [®] ACT 55	2	2	2	2	2	2

Table 3 – Rheology

Rheology	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
<u>Mooney, ML1+4, 100°C, ISO 289-1</u>	44.2	49.0	38.8	34.6	51.9	64.8
<u>MDR, 15 min., 180°C, arc 0.5°, ISO 6502</u>						
ML, dNm	0.55	0.49	0.36	0.29	0.56	0.74
MH, dNm	13.11	14.31	12.28	11.09	14.23	15.86
Ts1, min	0.65	0.87	0.90	0.90	0.80	0.78
Ts2, min	0.91	1.22	1.26	1.28	1.12	1.04
T10, min	0.72	1.01	0.97	0.94	0.91	0.9
T50, min	2.24	3.34	3.01	2.84	2.97	2.92
T90, min	7.48	9.86	9.02	8.55	9.08	9.06
Tan delta at ML	1.145	1.245	1.306	1.276	1.161	1.108
Tan delta at MH	0.040	0.068	0.058	0.052	0.067	0.067
Peak rate, dNm/min	5	5	5	4	5	5

All compounds show properties comparable to normal compounds used for molding processes. Scorch and cure times are slightly longer for blends including HyPR 5015 when compared to the reference compound. If needed, stronger basic accelerators can be used to achieve shorter cure times. The blend with Ultra IP and FEF black is somewhat high in viscosity and may be better suitable for compression molding than for injection molding.

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Physical Properties at Room Temperature and at 150°C

Table 4 gives physical properties, measured at room temperature and at typical operating temperatures of 150°C. Cure conditions were 10 minutes press-cure, followed by post-cure of 4 hours at 175°C.

Table 4 – Physical Properties

Physicals	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
Specific Density (g/cm ³)	1.21	1.14	1.13	1.13	1.13	1.14
Tg by DSC (°C), ISO 22768	-44.1	-38.4	-40.5	-42.9	-40.5	-35.1
<u>Hardness</u>						
Shore A (1 s), ISO 7619-1	69	70	62	59	72	73
Shore A (3 s), ISO 7619-1	68	68	61	58	70	71
IRHD - Method N, ISO 48-2	69	68	60	56	70	72
<u>Tensile properties (type 2) at 23°C, ISO 37</u>						
Tensile Strength, MPa	16.9	19.2	18.1	16.1	18.0	20.5
Elongation at Break, %	258	220	254	255	220	253
25% Modulus, MPa	1.24	1.36	0.96	0.8	1.43	1.62
100% Modulus, MPa	6.2	7.2	4.3	3.7	6.9	7.1
<u>Tensile properties (type 2) at 150°C, ISO 37</u>						
Tensile Strength, MPa	4.4	5.3	5.3	3.7	6.1	6.8
Elongation at Break, %	83	103	130	108	114	121
25% Modulus, MPa	1.18	1.14	0.88	0.77	1.13	1.22
100% Modulus, MPa	2.35	2.31	1.69	1.45	2.26	2.42

Compounds with Vamac® HyPR 5015 are generally having lower density due to the different filler system compared to highly filled Carbon Black standard compounds. In this test series, the reference compound was about 7% higher in density.

Compounds 5 and 6 show that an exchange of 35 phr Ultra IP by 35 phr of Ultra LT will lower Tg by more than 5°C. Even at somewhat lower plasticizer levels, the use of Ultra LT allows to reach Tgs of below -40°C, whilst still maintaining good physical properties at Room Temperature. Properties at 150°C were better for all Vamac® HyPR 5015 based compounds, compared to reference compound 1.

Compression Set Resistance

Compression Set levels of all HyPR 5015 based compounds were significantly better compared to the reference compound. This may indicate that higher plasticizer levels would be allowable, if even lower Tg levels would be required. As expected, higher active FEF black has some negative effect on Compression Set.

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Table 5 – Compression Set

Compression Set, ISO 815-1, Type B	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
C. Set 70 h at 150°C, %	25	15	15	15	18	18
C. Set 168 h at 150°C, %	35	21	20	20	25	25

Heat Ageing

Two heat ageing conditions representing the most demanding of recent OEM specifications were tested to compare a highly Carbon Black filled reference compound with the HyPR 5015 compounds with its special filler system. Both heat ageing conditions can be seen as the upper limit in terms of heat resistance for the reference compound, indicated by 50% loss of the original Elongation at Break. All compounds with Vamac[®] HyPR 5015 exhibit significant better retention of Elongation at Break, Tensile Strength or Hardness. Weight change of the HyPR 5015 based compounds is somewhat higher than for carbon black filled compounds.

Table 6 – Heat Ageing

	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
504 h at 175°C						
Shore A (3 s), ISO 7619-1	76	69	62	58	74	76
Delta Hardness, pts	8	1	1	0	4	5
Tensile Strength, MPa	10.0	13.9	12.7	12.0	14.2	16.4
Delta Tensile Strength, %	-41	-28	-30	-26	-21	-20
Elongation at Break, %	130	180	179	192	149	171
Delta Elongation at Break, %	-50	-18	-30	-25	-32	-32
100% Modulus, MPa	7.7	7.4	5.0	4.1	8.7	9.4
Delta 100% Modulus, %	24	3	16	10	26	33
168 h at 190°C						
Shore A (3 s), ISO 7619-1	79	70	63	58	75	77
Delta Hardness, pts	11	2	2	0	5	6
Tensile Strength, MPa	9.6	14.0	12.9	11.6	14.5	15.3
Delta Tensile Strength, %	-43	-27	-29	-28	-19	-25
Elongation at Break, %	126	176	184	186	156	169
Delta Elongation at Break, %	-51	-20	-28	-27	-29	-33
100% Modulus, MPa	7.4	7.6	4.8	4.3	8.6	8.8
Delta 100% Modulus, %	20	5	11	16	25	24
Weight Change, %	-5.6	-8.5	-8.0	-8.4	-8.1	-7.5
Volume Change, %	-7.9	-11.2	-10.5	-11.0	-10.7	-10.1

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Fluid Ageing

Lubrizol® OS206304 has been used by several European OEMs as reference fluid for engine oils. More recently used engine and transmission fluids, based on low viscosity synthetic base oils do exhibit much lower swell to oils than this reference fluid. The data below therefore should only be seen as a first indication.

Table 7 – Fluid Ageing in Lubrizol® OS206304, 504 h at 150°C

Ageing in Lubrizol® OS2016403	Reference Ultra IP/ Ultra LT	HyPR 5015/ Ultra LT 68 Shore A	HyPR 5015/ Ultra LT 61 Shore A	HyPR 5015/ Ultra LT 58 Shore A	HyPR 5015/ Ultra LT FEF Black	HyPR 5015/ Ultra IP FEF Black
Shore A (3 s), ISO 7619-1	59	62	56	51	61	66
Delta Hardness	-9	-6	-5	-7	-9	-5
Tensile Strength, MPa	14.5	19.1	14.9	12.2	14.2	17.8
Delta Tensile Strength, %	-14	-1	-18	-24	-21	-13
Elongation at Break, %	168	177	191	183	148	171
Delta Elongation at Break, %	-35	-20	-25	-28	-33	-32
100% Modulus, MPa	7.8	8.8	5.5	4.8	8.2	9.2
Delta 100% Modulus, %	26	22	27	29	20	30
Weight Change, %	15.7	11.0	13.6	16.0	12.8	10.3
Volume Change, %	21.9	13.9	17.3	19.8	16.7	13.0

Volume swell in Lubrizol® oil depends on the level of Ultra LT that is used. All HyPR 5015 based compounds show good retention of properties after ageing in Lubrizol® reference fluid.