Vamac® Ultra EV

Ethylene Acrylic Elastomer - Technical Data

Description

Vamac® Ultra EV (formerly VMX3020) is an intermediate Mooney viscosity grade at 23 MU (ML1+4, 100°C), between Vamac® G (16.5 MU) and Vamac® Ultra IP (29 MU). This offering provides customers with a broader choice of ethylene-acrylic elastomers for applications such as Static and Dynamic Seals or Hoses and Tubes. The 23 Mooney Vamac® products have shown physical properties that are much closer to their respective 29-30 Mooney grades than to the grades with lower molecular weight. The different viscosities of these polymers allow for optimized processing behavior in a range of process technologies, such as injection, compression or transfer molding, and extrusion.

Product Properties

Property	Target Values	Method
Mooney Viscosity ML1+4 at 100 °C	19.0 – 27.0	ASTM D1646
Volatiles, % max	0.6 wt. %	Internal Celanese Test
Form (25kg nominal bale size)	51.6 x 34.4 x 13.6 cm	Visual Inspection
Color	Clear to light yellow translucent	Visual Inspection

Vamac® Ultra EV- Tailor-made for Applications in E-Mobility

Compounds based on Vamac® Ultra EV offer performances that come close to properties based on Ultra IP with identical recipes. Properties needed for high performance applications in internal combustion engines, such as good low temperature flexibility, excellent heat resistance, good physical properties and very good compression set are comparable to Ultra IP.

For E-Mobility, often new requirements are mentioned.

Some new applications, especially in fuel cell applications, need materials that are clean and do not contain leachable ingredients. The same low levels of leachable ingredients are needed when fluids shall not be changed in properties, for example dielectric fluids used as coolant for directly, immersion cooled batteries. For such applications, rubber compounds should be formulated without any plasticizers and low levels of processing aids, as these can be washed out when liquids get in contact to such rubber parts. Plasticizer-free rubber compounds are usually very high in viscosity and may be difficult in processes such as Injection Molding or Extrusion. Ultra EV with its lower viscosity than Ultra IP can be better compounded without plasticizers and low levels of process aids and can still provide good processing behavior.

Other topics that are very often discussed for E-Mobility applications are 'Electrical Resistivity' and 'Flame Retardance'. To meet these requirements, compounds have to use inorganic fillers, for FR compounds very high levels of halogen-free flame retardants like $Al(OH)3$. Such inorganic fillers, especially when added at high levels, also bring high compound viscosity, and therefore do not allow the use of base polymers with high polymer Mooney Viscosity. On the other side, most inorganic fillers do not provide the same reinforcing effect to polymers as Carbon Black fillers, and therefore also need a polymer with a certain molecular weight for good physical like Tensile Strength, Tear Strength or Elongation at Break. Vamac® Ultra EV has been designed as an optimized compromise for both sides.

Physical Properties

Ultra EV fits when Vamac® G compounds provide too low physical properties or insufficient sealing performance. The higher viscosity of Ultra EV vs. Vamac® G results in improvements in Compression Set, Tensile, and Elongation at Break. Compression Set according to VW PV3307 is especially improved. Heat ageing and fluid ageing performance is comparable to Vamac® Ultra IP.

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Processing

Ultra EV is useful if Vamac® G based compounds, for a required Hardness level, would be too low in viscosity or in compound green strength to avoid collapse of the uncured hose, or to avoid that reinforcement yarns cut into the veneer layer. It is also more suitable than Vamac® G when Compressive forces need to be high for crimping processes. Contrary, Vamac® Ultra EV may be used when Ultra IP would result in problems like too high compound viscosity or high pressure in injection molding or during extrusion at the extruder head for the same Hardness range. At Hardness levels of 70 Shore A and above, Ultra EV will provide significantly better compound flow than Ultra IP and shorter injection times.

Handling Precautions

Because Vamac® ethylene-acrylic elastomers contain small amounts of residual methyl acrylate monomer, adequate ventilation should be provided during storage and processing to prevent worker exposure to methyl acrylate vapor. Additional information may be found in the Vamac® product Safety Data Sheet (SDS), and bulletin, *Safe Handling and Processing of Vamac®*.

Test Compounds

Vamac® Ultra EV was compared in identical compounds to Vamac® G, and Vamac® Ultra IP as fast curing grades, and Vamac® Ultra XF which shows longer Scorch and Cure times. One Ultra EV based compound used a catalyst with higher basic activity (DBU70) compared to the other compounds. This compound was intended to examine possible improvements in Cure Speed and Compression Set. The Vamac® Ultra XF based compound was added to compare Cure Speed to the faster curing grades. Compounds were mixed on a 1.6-liter internal lab mixer.

Compound Formulation, phr	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Vamac® Ultra IP	100				
Vamac® G		100			
Vamac® Ultra EV			100	100	
Vamac® Ultra XF					100
Spheron® SOA (FEF N 550)	60	60	60	60	60
Alcanplast® PO 80	10	10	10	10	10
Naugard® 445	2	2	2	2	2
Ofalub® SEO	1	1	1	1	1
Stearic Acid Reagent (95%)	1	1	1	1	1
Armeen® 18 D	0.5	0.5	0.5	0.5	
Vulcofac® ACT 55	2	2	2		2
Alcanpoudre® DBU70				2	
Vulcofac® HDC	1.3	1.3	1.3	1.3	1.3

Polymer and Compound Mooney Viscosity

Mooney viscosity for polymer and the ACT55 based compounds of this study are shown in Chart 1. Mooney Viscosity of the Ultra EV polymer was exactly in the middle between the Mooney of Vamac® G and Ultra IP. Compound viscosity for the Ultra EV based compound however is much closer to the Viscosity of the Ultra IP based compound. This should provide clearly superior green strength and collapse resistance for Ultra EV vs Vamac® G.

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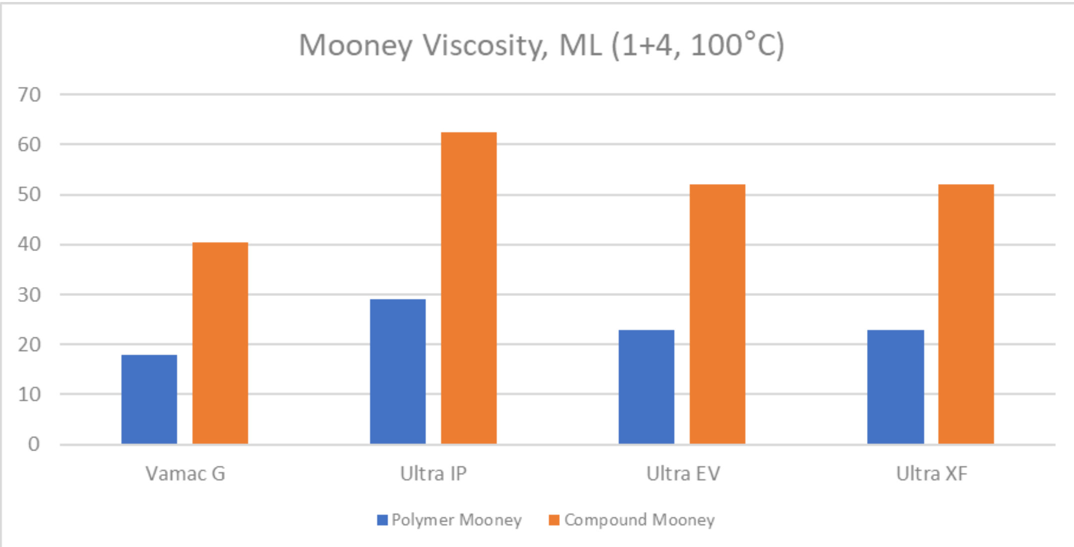
Chart 1 – Mooney Viscosity



Rheology

Vamac® Ultra IP and Ultra EV provide both slightly longer scorch and cure times than Vamac® G. Vamac® Ultra XF, as expected, shows both longest Scorch and Cure times. Maximum crosslinking density (MH) is provided by Ultra IP due to its highest molecular weight. MH and cure speed of Ultra EV compounds can be further increased by using DBU70 as coagent with higher activity.

	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Mooney Scorch 45 min at 121°C, ISO 289-2					
Ts1 [min]	5.4	4.6	5.0	5.0	5.7
Ts2 [min]	6.5	5.4	6.1	6.0	7.1
T5 [min]	9.1	7.5	8.7	8.5	10.5
T10 [min]	12.2	10.0	11.6	11.3	14.6
T35 [min]	24.0	26.8	27.2	25.5	43.9
MDR cure rate 15 min / 180°C, arc 0.5°, ISO 6502					
ML [dNm]	0.66	0.41	0.56	0.51	0.58
MH [dNm]	16.23	11.76	13.33	14.59	11.94
Ts1 [min]	0.64	0.65	0.71	0.64	0.84
Ts2 [min]	0.84	0.88	0.98	0.84	1.23
T10 [min]	0.75	0.68	0.79	0.72	0.89
T50 [min]	2.12	1.82	2.35	1.92	3.03
T90 [min]	6.67	6.18	7.33	5.56	9.27
Tan delta at ML	1.030	1.098	1.071	1.137	1.069
Tan delta at MH	0.051	0.051	0.053	0.047	0.068
Peak rate [dNm/min]	6	5	4	6	3

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Physical Properties

Vamac® Ultra IP and Ultra EV show similar levels for all physical properties, both measured at room temperature and at typical operating temperatures for Vamac® at 150°C. Both show better properties than Vamac® G. Vamac® Ultra XF, as expected, shows both longest Scorch and Cure times. Maximum crosslinking density (MH) is provided.

	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Initial Specific Gravity [g/cm³]	1.22	1.22	1.22	1.22	1.22
Tg by DSC (°C)	-37.6	-36.2	-37.7	-37.4	-38.2
Original Physical Properties					
Hardness Shore A (1 s), ISO 7619-1	74.1	71.2	73.3	73.9	72
Hardness Shore A, 3s, ISO 7619-1	72	68	71.6	71.7	70.2
Tensile properties (type 2) at 23°C ISO 37					
Tensile Strength [MPa]	18.7	17.4	18.6	17.5	17.2
Elongation at break [%]	278	252	290	292	316
Modulus at 25 % [MPa]	1.42	1.21	1.43	1.4	1.3
Modulus at 100 % [MPa]	6.5	6.0	6.2	6.2	5.6
Tear strength type C – Crescent, ISO 34-1 [kN/m]	29.1	24.1	28.9	30.1	30.5
Tensile properties (type 2) at 150°C, ISO 37					
Tensile Strength [MPa]	6.5	4.6	6.1	6.4	6.4
Elongation at break [%]	105	90	108	108	122
Modulus at 25 % [MPa]	1.21	1.01	1.17	1.2	1.07
Modulus at 100 % [MPa]	6.0		5.6	5.9	5.0
Tear str. type C - Crescent at 150°C, ISO 34-1 [kN/m]	5.3	4.7	5.3	5.5	5.8

Compression Set and Heat Ageing

Vamac® Ultra EV and Ultra IP are again very close in Compression Set and Heat Ageing for six weeks at 160°C. Ultra EV with DBU70 can provide further improvements for sealing performance if needed. Vamac® Ultra EV and Ultra IP both indicate better Compression Set than the Vamac® G and Ultra XF compounds.

For heat ageing, Vamac® G shows slightly more hardening effect, which can also be seen in Moduli increase. All other compounds behave very similar in Hardness Change, Tensile Strength, and Elongation-at-Break change, as well as in Moduli change.

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	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Compression set 70 h at 150°C - type B, ISO 815-1 [%]	23	28	24	21	26
Compression set 168 h / 150°C - type B, ISO 815-1 [%]	31	37	34	31	36
Compression set 1008 h at 150°C - type B, ISO 815-1 %]	54	62	57	53	58
Heat ageing 1008 hours at 160°C, ISO 188					
Hardness Shore A (1 s), ISO 48-4	77.2	76.0	76.8	76.2	73.0
Delta hardness [pts Sh. A]	3.1	4.8	3.5	2.3	1.0
Tensile properties (type 2) at 23°C, ISO 37					
Tensile Strength [MPa]	14.2	13.1	13.9	15.3	14.0
Delta TS [%]	-24	-25	-25	-13	-19
Elongation at break [%]	202	168	210	216	243
Delta EaB [%]	-27	-33	-28	-26	-23
Modulus at 25 % [MPa]	2.00	1.94	1.96	1.94	1.84
Delta 25% [%]	41	60	37	39	42
Modulus at 100 % [MPa]	7.1	7.8	7.0	7.3	6.2
Delta 100% [%]	10	30	12	17	12

Similar trends are shown for compounds tested after accelerated heat ageing after one week at 190°C

	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Heat ageing 168 hours at 190°C, ISO 188					
Hardness Shore A (1 s), ISO 48-4	80.8	82.1	80.5	81.5	79.3
Delta hardness [pts Sh. A]	6.7	10.9	7.2	7.6	7.3
Tensile properties (type 2) at 23°C, ISO 37					
Tensile Strength [MPa]	9.4	8.5	9.7	10.8	10.2
Delta TS [%]	-50	-51	-48	-38	-41
Elongation at break [%]	110	79	122	127	146
Delta Elong. [%]	-60	-69	-58	-57	-54
Modulus at 25 % [MPa]	2.62	3.07	2.63	2.61	2.4
Delta 25% [%]	85	154	84	86	85
Modulus at 100 % [MPa]	8.6		8.3	8.7	7.3
Delta 100% [%]	33		33	39	30

Fluid Ageing

Vamac® polymers are used in many applications in contact to oils or aggressive blends between oils and oxidized fuel such as a Worst Case Used Oil designed by a European OEM. Especially AEM polymers with lower content in Methyl Acrylate such as Vamac® G or Ultra IP have demonstrated excellent resistance to this WCUO.

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The next table contains data in WCUO, as well as ageing test data in an oil used in modern Battery Electric Vehicles, Shell ef6. Performance of Vamac® Ultra IP and Ultra EV are again comparable to each other, both are better retaining properties than Vamac® G.

	Ultra IP	G	Ultra EV ACT55	Ultra EV DBU70	Ultra XF
Fluid Ageing 1008 h at 150°C in Shell ef6, ISO1817					
Hardness Shore A (1 s), ISO 48-4	76.6	73.0	75.6	77.1	75.8
Delta hardness [pts Sh. A]	2.5	1.8	2.3	3.2	3.8
Tensile properties (type 2) at 23°C ISO 37					
Tensile Strength [MPa]	17.7	16.4	17.6	17.7	17.4
Delta TS [%]	-6	-6	-5	1	1
Elongation at break [%]	198	171	215	178	197
Delta Elong. [%]	-29	-32	-26	-39	-38
Modulus at 25 % [MPa]	1.86	1.78	1.88	2.16	2.00
Delta 25% [%]	31	47	31	54	54
Modulus at 100 % [MPa]	8.6	8.7	8.0	10.0	8.4
Delta 100% [%]	32	45	29	61	51
Weight Change [%]	5.0	4.0	4.8	2.7	3.0
Volume change [%]	7.4	6.0	7.0	4.8	5.5
Fluid ageing 168 h at 150°C in WCUO, ISO 1817 (in Autoclave)					
Hardness Shore A (1 s), ISO 48-4	81.5	81.9	79.4	81.9	76.7
Delta hardness [pts Sh. A]	7.4	10.7	6.1	8.0	4.7
Tensile Strength [MPa]	16.1	15.2	16.1	15.3	14.6
Delta TS [%]	-14	-13	-14	-12	-15
Elongation at break [%]	110	97	119	117	150
Delta Elong. [%]	-60	-62	-59	-60	-53
Modulus at 25 % [MPa]	2.89	2.85	2.72	2.54	2.06
Delta 25% [%]	104	136	90	81	58
Modulus at 100 % [MPa]	14.6		14.3	13.1	9.5
Delta 100% [%]	124		130	111	71
Weight Change [%], ISO 1817	2.4	1.8	2.3	1.7	3.3
Volume change [%], ISO 1817	2.4	1.6	2.2	1.5	4.1

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