DUPONT™ VAMAC® ULTRA XF (VMX3041)

ETHYLENE ACRYLIC ELASTOMER

Description

Vamac® Ultra XF (formerly called VMX3041) was developed as an intermediate viscosity grade at 23 MU (ML1+4, 100°C), between Vamac® GXF (17.5 MU) and Vamac® Ultra HT (29 MU). This offering provides customers with a broader choice of ethylene-acrylic elastomers for applications such as Turbo Charger Hose, other hose applications, or applications where excellent resistance to dynamic flex fatigue is needed. Such applications typically suffer in flex fatigue resistance when polymer blends are used to achieve the optimum processing performance.

Processing

Vamac® Ultra XF fits in when Vamac® GXF compounds for a required Hardness levels 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. This may happen when hoses are designed to withstand higher internal pressures and thicker yarns are applied at higher stress levels. On the other side, Vamac® Ultra XF may be used when Vamac® Ultra HT would result in problems like too high compound viscosity or high pressure at the extruder head for the same Hardness range.

Physical Properties

The higher viscosity of Vamac® Ultra XF vs. Vamac® GXF results in slight 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® GXF.

Handling Precautions

Because Vamac® Ultra XF contains 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® Ultra XF (VMX3041) product Safety Data Sheet (SDS), and bulletin, Safe Handling and Processing of Vamac® (VME-A10628), available on the DuPont website.

Table 1. DuPont™ Vamac® Ultra XF — Typical Product Properties

Property	Target Values	Method
Mooney Viscosity ML1+4 at 100 °C	23	ASTM D1646
Volatiles, wt%	≤0.5	Internal DuPont Test
Form, mm (in)	Bale size is nominally:	Visual Inspection
	560 x 370 x 165 (22 x 15 x 7)	
Color	Clear to light yellow translucent	Visual Inspection

Test Compounds

Vamac® Ultra XF was compared to Vamac® GXF and Vamac® Ultra HT in identical compounds, and in compounds with varying curative levels and a carbon black type with lower structure and larger particle size.

Compound Formulation & Rheology	GXF	Ultra XF	Ultra HT	Ultra XF		
				High Diak™	Low Diak™	SRF black
Vamac® GXF	100					
Vamac® Ultra XF		100		100	100	100
Vamac® Ultra HT			100			
Spheron® SOA (FEF N 550)	60	60	60	60	60	
Corax® N 772 (SRF)						80
Alcanplast® PO 80	10	10	10	10	10	10
Naugard 445	2	2	2	2	2	2
Vanfre® VAM	1	1	1	1	1	1
Stearic Acid Reagent (95%)	1	1	1	1	1	1
Vulcofac® ACT 55	2	2	2	2	2	2
Rubber chem Diak™ no 1	1.1	1.1	1.1	1.3	0.9	1.1

Mooney Scorch 45 minutes at 121°C (ISO 289-2:1994)						
Initial Mooney [MU]	23	29	34	29	28	26
Minimum Mooney [MU]	15	19	22	19	19	17
Ts1 [min]	5.2	4.9	5.3	4.7	4.8	4.8
Ts2 [min]	6.4	5.9	6.5	5.6	5.8	5.8
T5 [min]	9.2	8.2	9.2	7.8	8.4	8.0
T10 [min]	12.7	11.0	12.4	10.5	11.9	10.6

MDR cure rate 15 min at 180°C, arc 0.5° (ISO 6502:1999)						
ML [dNm]	0.54	0.68	0.77	0.67	0.69	0.75
MH [dNm]	11.0	10.9	13.3	12.7	8.6	12.1
Ts1 [min]	0.70	0.70	0.68	0.69	0.70	0.60
Ts2 [min]	1.04	1.03	0.97	1.01	1.05	0.90
T10 [min]	0.72	0.70	0.76	0.76	0.62	0.65
T50 [min]	2.3	2.3	2.5	2.7	1.9	2.3
T90 [min]	7.5	8.3	7.7	8.9	7.5	8.4
Tan delta at MH	0.068	0.070	0.055	0.053	0.100	0.076
Peak rate [dNm/min]	4	5	5	5	4	5

Original Properties & De Mattia	GXF	Ultra XF	Ultra HT	Ultra XF		
				High Diak™	Low Diak™	SRF black
Compression molding 10 minutes at 180°C / Post-cure 4 hours at 175°C (ISO 2393:1994)						
Hardness (ISO 7619-1: 2004)						
Hardness Shore A, 1s	73	73	72	74	68	71
Hardness Shore A, 3s	71	71	70	72	65	68
Tensile Properties (type 2) at 23°C (ISO 37:2005 Cor 1 2008)						
Tensile Strength [MPa]	16.9	17.6	18.3	18.6	15.9	16.6
Elongation at Break [%]	308	317	326	290	343	246
Modulus at 50 % [MPa]	2.3	2.4	2.3	2.7	1.9	2.2
Modulus at 100 % [MPa]	5.1	5.5	5.4	6.5	4.3	5.3
Tear Strength, type C - Crescent (ISO 34-1:2004)						
Tear Strength, type C – Crescent [kN/m]	28	28	31	27	27	25

De Mattia Crack Growth at 23°C (ISO 132:2005)						
Cycles to 4.5mm	5	5	6	4	200	4
Cycles to 8.5mm	2390	2410	1650	255	25500	1780
Cycles to 12.5mm	10050	8750	5850	1150	131000	4650

Compression Set & Air Oven Aging	GXF	Ultra XF	Ultra HT	Ultra XF		
				High Diak™	Low Diak™	SRF black
Compression Set – Type B (ISO 815-1:2008)						
70 hours at 150°C [%]	27	26	23	26	39	32
70 hours at 175°C [%]	37	36	28	35	45	39
Compression Set, VW 22 hours at 175°C (VW PV 3307:2004-08)						
Measured after 5 seconds [%]	77	65	60	54	83	64

Heat aging 168 hours at 175°C (ISO 188:2007)						
Hardness Shore A, 1s (ISO 7619-1:2004)	75	75	75	77	70	74
Delta Hardness Shore A [pts]	2	2	3	3	2	3
Tensile Strength [MPa]	12.9	13.3	15.1	15.4	10.1	13.2
Delta TS [%]	-23	-25	-17	-17	-36	-20
Elongation at Break [%]	325	328	357	286	377	264
Delta Elong. [%]	6	3	10	-1	10	7

Modulus at 50 % [MPa]	2.3	2.5	2.5	3.1	2.0	2.4
Delta 50% [%]	-1	7	7	15	2	10
Modulus at 100 % [MPa]	4.4	4.8	5.0	6.2	3.6	4.8
Delta 100% [%]	-15	-12	-7	-5	-16	-10

Heat aging 504 hours at 175°C (ISO 188:2007)						
Hardness Shore A, 1s (ISO 7619-1:2004)	82	81	79	81	76	81
Delta Hardness	9	8	7	7	8	10
Tensile Strength [MPa]	9.7	9.2	10.6	11.1	7.3	9.1
Delta TS [%]	-42	-48	-42	-40	-54	-45
Elongation at Break [%]	195	192	203	181	205	170
Delta Elong. [%]	-37	-39	-38	-38	-40	-31
Modulus at 50 % [MPa]	3.4	3.2	3.1	3.3	2.5	3.3
Delta 50% [%]	44	35	33	23	32	52
Modulus at 100 % [MPa]	5.9	5.6	5.9	6.5	4.4	5.8
Delta 100% [%]	15	3	9	1	3	10

Fluid Aging	**GXF**	**Ultra XF**	**Ultra HT**	**Ultra XF**		
				High Diak™	**Low Diak™**	**SRF black**
Fluid Aging 168 hours at 150°C in Lubrizol OS 206304 (ISO 1817:2005)						
Hardness Shore A, 1s (ISO 7619-1:2004)	64	65	63	66	57	64
Delta Hardness	-9	-8	-9	-8	-11	-7
Tensile Strength [MPa]	15.9	16.3	17.2	17.2	14.7	14.2
Delta TS [%]	-6	-8	-6	-7	-7	-15
Elongation at Break [%]	266	243	282	246	279	204
Delta Elong. [%]	-14	-23	-14	-15	-19	-17
Modulus at 50 % [MPa]	2.3	2.4	2.1	2.7	1.8	2.1
Delta 50% [%]	-3.4	0.9	-9.5	-1.5	-6.3	-4.6
Modulus at 100 % [MPa]	5.6	6.0	5.5	7.0	4.5	5.7
Delta 100% [%]	9.8	10.3	2.4	8.2	5.4	8.1
Weight Change [g]	11	11	11	10	11	9
Volume Change [%]	17	16	17	15	17	15
Initial Specific Gravity [g/cm³]	1.22	1.22	1.22	1.22	1.22	1.27

Fluid Aging	GXF	Ultra XF	Ultra HT	Ultra XF		
				High Diak™	Low Diak™	SRF black
Fluid Aging 504 hours at 150°C in Lubrizol OS 206304 (ISO 1817:2005)						
Hardness Shore A, 1s (ISO 7619-1:2004)	65	65	64	67	58	64
Delta Hardness	-8	-8	-8	-7	-10	-7
Tensile Strength [MPa]	15.3	16.2	18.4	16.9	15.2	13.3
Delta TS [%]	-9	-8	1	-9	-4	-20
Elongation at Break [%]	221	226	251	206	251	176
Delta Elong. [%]	-28	-29	-23	-29	-27	-28
Modulus at 50 % [MPa]	2.5	2.3	2.3	3.0	1.9	2.3
Delta 50% [%]	8	-3	-3	10	-3	6
Modulus at 100 % [MPa]	6.4	6.0	6.3	7.8	4.8	6.6
Delta 100% [%]	24	9	16	20	13	25
Weight Change [g]	12	10	12	10	11	9
Volume Change [%]	18	16	18	16	17	15

Test Compounds – Different Carbon Black Levels

Vamac® Ultra XF was compounded at different FEF N-550 levels and compared to a compound with SRF N-772 Carbon Black to show physical properties at different Hardness levels.

Compound Formulation	50 phr FEF	60 phr FEF	70 phr FEF	85 phr SRF
Vamac Ultra XF (VMX 3041)	100	100	100	100
Spheron™ SOA N-550	50	60	70	
Corax SRF N-772				85
Alcanplast PO 80	10	10	10	10
Naugard 445	2	2	2	2
Ofalub SEO	1	1	1	1
Stearic Acid Reagent (95%)	1	1	1	1
Vulcofac HDC	1,1	1,1	1,1	1,1
Vulcofac ACT 55	2	2	2	2
Mooney Visc. ML 1+4, 100°C, ISO 289-1	40,8	51,2	65,2	46,2
Mooney Scorch 45 min., 121°C, ISO 289-2				
Ts2 [min]	6,8	6,3	5,7	6,4
Ts5 [min]	10	9,2	8,2	9,2

	50 phr FEF	60 phr FEF	70 phr FEF	85 phr SRF
MDR, 15 min., 180°C, arc 0.5° , ISO 6502				
ML [dNm]	0,43	0,62	0,89	0,71
MH [dNm]	9,65	11,19	13,09	12,99
Ts1 [min]	0,8	0,72	0,65	0,63
Ts2 [min]	1,17	1,05	0,93	0,92
T10 [min]	0,76	0,74	0,71	0,7
T50 [min]	2,37	2,34	2,33	2,36
T90 [min]	8	8,08	8,27	8,1

Original Physical Properties	50 phr FEF	60 phr FEF	70 phr FEF	85 phr SRF
Compression molding 10 minutes at 180°C / Post-cure 4 hours at 175°C (ISO 2393:1994)				
Hardness Shore A, 1s (ISO 7619-1:2004)	63	73	77	74
Hardness Shore A, 3s (ISO 7619-1:2004)	61	71	75	72
Tensile Strength [MPa]	17,6	17,8	16,2	17,0
Elongation at break [%]	404	331	268	248
Modulus at 50 % [MPa]	1,6	2,3	3,2	2,5
Modulus at 100 % [MPa]	3,4	5,1	6,9	5,7
Modulus at 200 % [MPa]	8,7	11,5	13,2	13,7
Tear Strength type C, Crescent, ISO 34-1:2004				
Tear Strength [kN/m]	29,4	28,4	30,2	26,8

De Mattia crack growth at 23°C ISO 132:2005				
Kcl to 4.5mm	225	5,5	2	2,5
Kcl to 8.5mm	6360	2920	130	580
Kcl to 12.5mm	19350	10570	2120	2900

Compression Set	50 phr FEF	60 phr FEF	70 phr FEF	85 phr SRF
Compression Set – Type B (ISO 815-1:2008)				
70 hours at 150°C [%]	28	28	29	29
70 hours at 175°C [%]	35	36	37	38
Compression Set, VW 22 hours at 175°C (VW PV 3307:2004-08)				
Measured after 5 seconds [%]	81	82	87	72

Air Oven Aging	50 phr FEF	60 phr FEF	70 phr FEF	85 phr SRF
Heat aging 94 hours at 190°C (ISO 188:2011)				
Hardness Shore A (1 s), ISO 7619-1:2010	67	74	83	80
Delta hardness	4	1	6	6
Tensile Strength [MPa]	13,1	12,7	12,9	13,4
Delta TS [%]	-26	-29	-21	-21
Elongation at break [%]	383	317	260	275
Delta Elong. [%]	-5	-4	-3	11
Modulus at 100 % [MPa]	3,1	4,4	6,2	4,9
Delta 100% [%]	-7	-13	-9	-13

Heat aging 504 hours at 175°C (ISO 188:2011)				
Hardness Shore A (1 second) ISO 7619-1:2004	71	77	86	85
Delta hardness	8	4	9	11
Tensile Strength [MPa]	9,7	9,7	10,2	9,3
Delta TS [%]	-45	-46	-37	-45
Elongation at break [%]	212	161	142	140
Delta Elong. [%]	-48	-51	-47	-44
Modulus at 100 % [MPa]	4,7	6,4	8,4	7,2
Delta 100% [%]	39	26	23	27

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