DuPont™ VMX-2122

High Viscosity, Peroxide Cured AEM Dipolymer

Developmental Product Information — October 2013

VMX-2122

Introduction

Vamac® ethylene acrylic elastomer, introduced in 1975, has been successfully used for many years in demanding automotive applications, where excellent resistance to heat, engine and transmission fluids or Blow-By is required. DuPont's latest manufacturing technology allows production of enhanced AEM grades that are significantly improved compared to the existing standard Vamac® elastomers. These grades, designated and sold as Vamac® Ultra, provide a true step-change improvement in processability, performance and customer value for targeted applications. The new manufacturing technology has now also been applied to a new EMA Dipolymer, called VMX-2122.

Major Performance Properties and Applications

Higher viscosity is the major difference between the standard AEM grades and the Vamac® Ultra family of polymers, of which four Terpolymers, cured by Diamine curatives, have been already commercialized. VMX-2122 is a high viscosity version of Vamac® DP. It provides good mold release, comparable to Vamac® Ultra Terpolymers. Increased green strength of compounds helps to avoid collapse during extrusion processes, and may help in applying reinforcement layers without cutting the inner tube by filaments. The optimized polymer structure ensures gains in physical properties, resulting in improved performance of rubber parts such as cables, seals, gaskets or extruded hoses.

Best physical properties of VMX-2122 are obtained in rubber parts having a hardness range between 50 and 90 Shore A.

Handling Precautions

Because VMX-2122 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 DuPont Material Safety Data Sheet (MSDS), and bulletin, *Safe Handling and Processing of Vamac®* (VME-A10628), available from DuPont Performance Polymers.

Like every other grade of Vamac®, VMX-2122 is halogen-free. Typical properties of this new experimental polymer are shown in Table 1.

Table 1 - Vamac® VMX-2122 - Typical Product Properties

Property	Limit	Method
Form	Bale size is nominally: 560 mm by 370 mm by 165 mm (22 in. by 15 in. by 7 in.)	Visual Inspection
Color	Clear	Visual Inspection
Total Volatile Matter	< 0.6%	DuPont MP 726-1
Polymer Viscosity ML (1+4), 100°C (MU)	26 ± 8	ASTM D 1646

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Mixing

VMX-2122 has higher viscosity than Vamac® DP which permits better and faster dispersion of fillers and other compounding ingredients. VMX-2122 also showed reduced sticking to mixing equipment in all lab tests compared to Vamac® DP. Due to the general good scorch safety of peroxide cured compounds, changes in mixing cycle due to higher viscosity are not considered necessary.

Compounding and Physical Properties- Wire & Cable

Table 2 shows a comparison of VMX-2122 to Vamac® DP in identical formulations, which can be used as a starting point for halogen-free, flame retardant Wire & Cable applications.

Table 2 - Compound Properties, HFFR W&C Compound

Vamac® DP	100	
VMX-2122		100
Naugard® 445	1	1
Armeen®18 D	0.5	0.5
Stearic Acid	1.5	1.5
Martinal ®OL-111 LE	160	160
Dynasilan® 6490	1	1
Perkadox® 14-40B-GR	4.5	4.5
Rubber chem HVA-2	1	1
Total PHR	269.0	269.0
Polymer Mooney ML (1+4) @ 100 °C	22	27.5
Compound Mooney ML (1+4) @ 100 °C	40.5	51
MDR 180 °C / 0.5deg / 15 min		
ML (dNm)	0.44	0.48
MH (dNm)	16.3	17.6
Ts 1 (min)	0.4	0.42
Ts 2 (min)	0.48	0.49
t10 (min)	0.45	0.47
t50 (min)	1.36	1.34
t90 (min)	4.41	4.26
Tan at MH	0.075	0.091
Peak rate (dNm/min)	14	16
Compression Moulding, 15 min @ 180°C		
Original Properties @ 23 °C		
Hardness (Sh. A, 1 sec.), 6 mm plied	75.9	78.5
Tensile Strength at Break ISO 37 T2 (MPa)	9.8	11.5
Elongation at Break (%)	261	267
M 100% (Mpa)	6.6	7.0
Crescent Tear Die C, ISO 34-1 Fmax (N/mm)	39	38
Trouser Tear Die A, ISO 34-1 Fmax (N/mm)	5.5	6.5
Tg by DSC 10 °C/min (°C)	-28.6	-27.8
Ageing 168 h at 100 °C in IRM 903		
Hardness (Sh. A, 1 sec.), 6 mm plied	61.6	65.4
Hardness Change (pts.)	-14.3	-13.1
Tensile Strength at Break (Mpa)	10.3	11.8
Tensile Strength at Break Change (%)	5	3
Elongation at Break %	163	181
Elongation at Break Change (%)	-38	-32
M 100% (Mpa)	7.1	7.2
Volume Change (%)	29.3	27.4
Weight Change (%)	16.8	15.8

Ageing in air 168 h at 160 °C		
Hardness (Sh. A, 1 sec.), 6 mm plied	82.4	82
Hardness Change (pts.)	7	4
Tensile Strength at Break (Mpa)	11.4	12.3
Tensile Strength at Break Change (%)	16	7
Elongation at Break %	209	241
Elongation at Break Change (%)	-20	-10
M 100% (Mpa)	8.3	8.6
M 100% Change (%)	27	22
Ageing in air 168 h at 175 °C		
Hardness (Sh. A, 1 sec.), 6 mm plied	82.2	83.3
Hardness Change (pts.)	6	5
Tensile Strength at Break (Mpa)	10.8	11.7
Tensile Strength at Break Change (%)	10	2
Elongation at Break %	170	184
Elongation at Break Change (%)	-35	-31
M 100% (Mpa)	9.2	9.4
M 100% Change (%)	40	33

Polymer and Compound Mooney are higher for VMX-2122. The tighter crosslink network and faster cure lead to slightly higher Hardness, with higher Tensile Strength and still slightly higher Elongation at Break. The polymer lots used for this study slightly differ in MA content, which can be seen from differences in Tg and Volume Swell in IRM-903. After Heat Ageing, VMX-2122 maintains its properties better than Vamac® DP.

Compounding and Physical Properties – Carbon Black Filled Compounds

The major difference between compounds based on diamine cured Vamac® Terpolymers and peroxide cured Dipolymers is that process aids and plasticizers have to be kept at a minimum needed for good low temperature performance and good mold release, as they significantly impact the cure speed and crosslink density of peroxide cure systems. However, addition of small amounts of Vanfre® VAM showed positive impact on heat ageing in our lab tests.

In simple Carbon Black filled compounds shown in Table 3, VMX-2122 showed slightly faster cure, higher MH, along with significant better combination of tensile and Elongation and Break compared to Vamac® DP, whilst Compression Set was slightly inferior for VMX-2122.

Table 3 - Compound Properties, 70 Shore A Carbon Black Filled Compounds

Vamac® DP	100			
VMX-2122		100	100	100
Vanfre® VAM	0.5	0.75	0.75	0.75
Naugard® 445	1	1	1	1
Stearic Acid Reagent (95%)	0.5	0.5	0.5	0.5
Spheron™ SOA (N 550)	50	50	50	50
Luperox® DC 40 P	8	8	8	8
Rubber chem HVA 2				3
Sartomer® SR 350 (TRIM)	3	3		
Diak™ No. 7 (TAIC)			3	
Mooney Viscosity ML 1+4, 100°C	30	38	43	46
MDR cure rate 15 min. / 180°C, arc 0.5°, ISO 6502:1999				
ML [dNm]	0.44	0.52	0.55	0.66
MH [dNm]	10.16	10.74	16.47	12.79
Ts2 [min]	0.94	0.93	0.91	0.36
T10 [min]	0.68	0.68	0.83	0.32
T50 [min]	1.54	1.55	1.91	0.61
T90 [min]	3.29	3.19	4.23	1.97
Tan delta at MH	0.061	0.071	0.031	0.068
Peak rate [dNm/min]	6	7	8	25
Compression moulding 10 minutes at 185°C				
Hardness Shore A (1 second)	67	66	71	68
Tensile properties (type 2) at 23°C				
Tensile Strength [MPa]	15.9	17.8	19.3	14.4
Elongation at break [%]	337	371	185	207
Modulus at 100 % [MPa]	4.0	3.7	8.5	5.3
Cset 70 h / 150°C, pliedISO 815-1:2008 (%)	24	29	17	22
Cset o-ring (ASTM D 1414) 70 h / 150°C - size: AS-214	ASTM D 1414-08			
3 min/185°C comp. molded o-ring (%)	31	31	26	35
Cset o-ring (ASTM D 1414) 70 h / 150°C - size: AS-214	ASTM D 1414-08			
10 min/185°C comp. molded o-ring (%)	24	31	11	29
Cset, VW 22 h/150°C VW PV 3307 [%]	84	86	48	80
Cset, 168 h/ 150°C – plied, ISO 815-1 [%]	32	36	28	32
Tensile properties (type 2) at 150°C ISO 37				
Tensile Strength [MPa]	5	5	4.2	3.5
Elongation at break [%]	142	148	75	90
Modulus at 100 % [MPa]	3.1	2.9		

Replacing TRIM as coagent by TAIC or HVA-2 results in much higher MH and better Compression Set, but properties measured at room temperature and 150°C are low, which may result in problems during moulding or in the final application.

Optimization of Properties and Compression Set

To obtain a good combination of Compression Set resistance and physical properties, Table 4 shows possibilities with combinations of coagents and an alternative peroxide with higher decomposition temperature.

Table 4 – Optimizing Compression Set and Physical Properties – Coagent Level and Type

VMX-2122	100	100	100	100
Naugard® 445	1	1	1	1
Stearic acid	0.5	0.5	0.5	0.5
Vanfre® VAM	0.5	0.5	0.5	0.5
Spheron® SOA N550	50	50	50	50
Rubber chem HVA 2	3	1.5		3
Sartomer® SR 350 (TRIM)			1.5	
Diak™ No. 7 (TAIC)		1.5	1.5	
Luperox® 101 XL 45				8
Luperox® DC 40 P	8	8	8	
MDR cure rate 15 min at 180°C, arc 0.5°				
ML [dNm]	0.45	0.53	0.48	0.57
MH [dNm]	12.32	14.35	13.31	13.25
Ts1 [min]	0.33	0.35	0.56	0.32
Ts2 [min]	0.38	0.42	0.74	0.37
T10 [min]	0.34	0.37	0.61	0.34
T50 [min]	0.68	1.18	1.57	0.79
T90 [min]	2.07	3.09	3.66	3.41
Tan delta at MH	0.071	0.047	0.044	0.046
Peak rate [dNm/min]	23	16	7	24
Compression moulding 5 min. / 185°C				
Hardness Shore A (1 second)	68	69	68	68
Tensile properties (type 2) at 23°C				
Tensile Strength [MPa]	16.2	17.9	19.1	16
Elongation at break [%]	266	228	252	232
Modulus at 100 % [MPa]	4.3	5.6	5.2	5.1
Comp set 70 h / 150°C - plied (%)	44	28	27	67
Compression moulding 10 min. / 185°C				
Hardness Shore A (1 second)	67	69	68	67
Tensile properties (type 2) at 23°C				
Tensile Strength [MPa]	15.5	17.6	18.4	15.4
Elongation at break [%]	245	217	248	204
Modulus at 100 % [MPa]	4.5	6.1	5.2	5.6
Compression set 70 h / 150°C – plied (%)	22	16	16	21

A combination of TAIC with either HVA-2 or TRIM offers good combinations of physical properties and Compression Set, as well as options for reduced cure times. Dicumylperoxide provided better Compression Set, but results have to be taken with care, as active oxygen index at same phr levels are different for both peroxides used.

Another study, shown in Table 5, looked at different peroxide levels to those typically used for Vamac® DP.

Table 5 – Optimizing Compression Set and Physical Properties – Peroxide Level

Vamac® DP	100				
Vamac® VCX 1122		100	100	100	100
Naugard® 445	1	1	1	1	1
Stearic Acid Reagent (95%)	0.5	0.5	0.5	0.5	0.5
Vanfre® VAM	1.25	0.75	0.75	0.75	0.75
Spheron™ SOA (N 550)	50	50	50	50	50
Sartomer® SR350 (TRIM)	1.5	1.5	1.5	1.5	1.5
Luperox® DC 40 P	8	8	6.5	5	4
Rubber chem Diak™ no 7	1.5	1.5	1.5	1.5	1.5
Luperox® 230 XL 40 SP					2.5
Mooney Viscosity ML 1+4, 100°C [MU]	34	45	42	44	39
MDR, 15 min at 180°C, arc 0.5°					
ML [dNm]	0.43	0.61	0.54	0.56	0.46
MH [dNm]	14.49	15.32	12.39	9.93	11.06
Ts1 [min]	0.56	0.52	0.6	0.68	0.6
T10 [min]	0.64	0.6	0.63	0.64	0.61
T50 [min]	1.67	1.58	1.72	1.84	1.62
T90 [min]	4.22	3.64	4.05	4.49	4.4
Tan delta at MH	0.036	0.043	0.06	0.09	0.077
Peak rate [dNm/min]	7	8	7.2	6	7
Compression moulding 5 min at 185°C					
Hardness Shore A (1 second)	68	70	68	67	67
Tensile Strength [MPa]	17	18.2	16.7	15.8	16.1
Elongation at break [%]	225	238	282	370	309
Modulus at 100 % [MPa]	6.1	6.3	4.7	3.6	3.8
Compression set 70 h / 150°C , plied disks, 3x2 mm ISO 815-1:2008	26	27	23	31	42

VMX-2122 provided best Compression Set resistance at levels of about 6.5 phr Dicumylperoxide. This level also provides significant better Elongation at Break.

Injection Moulding Performance

Vamac® Terpolymers are usually material of choice for parts that are produced in Injection, Transfer or Compression Moulding. Dipolymers historically have been chosen rarely due to stickiness of peroxide cured AEM compounds. VMX-2122 showed excellent properties in demoulding in lab trials, reaching performance levels of Ultra Terpolymers like Vamac® Ultra IP.

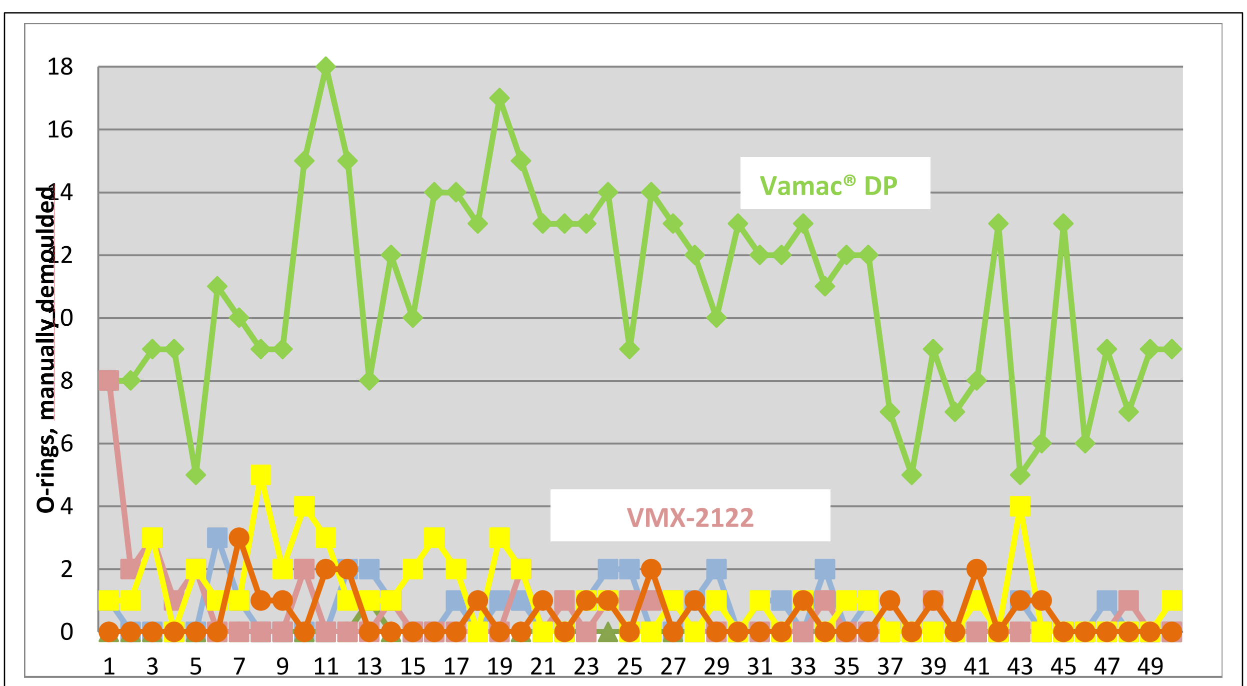
The procedure used in DuPont labs to determine mold release uses a horizontal injection moulding machine, and a mold with 40 cavities of O-rings, Size AS-214. Cold runners are used, and central single point injection. The mold is cleaned according to the same procedure before a new compound is tested. Mold temperature has been set at 185°C. Cure time has been set at 30 seconds, where blister-free O-rings have been obtained. After mold opening, a brush is removing most of the O-rings from the mold. The number of O-rings sticking to the mold after brushing is counted.

Table 6 – Compounds used for Injection Moulding Tests

	Vamac® DP	VMX-2122	VMX-2122, TRIM	VMX-2122, Process Aid in compound	VMX-2122, Process Aid in polymer	VMX-2122, Plasticizer
Vamac® DP	100					
VMX-2122		100	100	100		100
VMX-2122					100	
Naugard® 445	1	1	1	1	1	1
Stearic Acid Reagent (95%)	0.5	0.5	0.5	0.5	0.5	0.5
Vanfre® VAM	1.25	1.25	1.25	1.25	1.25	1.25
Spheron™ SOA (N 550)	50	50	50	50	50	60
Alcanplast® PO 80						10
Rubber chem HVA 2	2	2		2	2	2
Sartomer® SR 350 (TRIM)			3			
Luperox® DC 40 P	8	8	8	8	8	8

Chart 1 shows the protocol of the IM trials, reporting the number of O-rings that had to be removed from the mold manually throughout the 50 shots that have been made with each of the compounds shown in Table 5. Whilst the compound based on Vamac® DP (green line) could not be well demolded, nearly all the O-rings based on VMX-2122 were released either automatically or by brushing.

Chart 1 – Injection Moulding Test Report, O-rings, Manually Demolded



Fluid Resistance, Comparison to AEM Terpolymers

Vamac® Terpolymers are known for their excellent sealing capabilities and extensively used for seals such as cam cover gaskets, oil pan gaskets or transmission seals in harsh automotive environments. New oils contain significant levels of additives, which lead to additional crosslinking effects of AEM Terpolymers during ageing in such oils. VMX-2122 as a Dipolymer does show much less tendency to form such crosslinks during fluid ageing and maintains its original Elongation at Break levels much better, as shown in Table 7. Exxon MB Formula 5W30 is used as first fill oil for truck diesel engines, Fuchs Titan 5W30 as a first fill oil for passenger car gasoline engines by a well-known German OEM. Pentosin FFL-4 is a lubricant used in automatic transmissions.

Table 7 – Comparison to Vamac® Terpolymers, Engine Oil Ageing

Vamac® GLS	100			
Vamac® Ultra LS (VMX-3110)		100		
Vamac® Ultra IP (VMX-3040)			100	
VMX-2122				100
Naugard® 445	2	2	2	1
Vanfre® VAM	1	1	1	
Armeen® 18D PRILLS	0.5	0.5	0.5	
Stearic Acid Reagent (95%)	2	2	2	0.5
MT Thermax® Floform N 990	30	30	30	
Spheron™ SOA (N 550)				25
Regal® SRF N 772	45	45	45	40
Alcanplast® 810 TM	15	15	15	5
Rubber chem Diak™ no 1	1.3	1.3	1.3	
Alcanpoudre® DBU-70	3	3	3	
Luperox® DC 40 P				8
Rubber chem HVA 2				2
Press-Cure, 5 min / 190°C,				
Post-cure 4 h / 175°C				
Hardness Shore A (1 sec)	64.2	65.3	63.8	70.3
Tensile Strength [MPa]	14.7	17.1	17.4	14.2
Elongation at break [%]	262	314	310	276
Modulus at 100 % [MPa]	4.1	4.2	4.1	4.9
C.Set, 24 h / 150°C, plied, ISO815-1:2008 [%]	16.3	13.5	11.4	14.5
C.Set, 94 h / 150°C, VW PV3307:2004-08 [%]	67.9	56.8	52.2	89.3
C.Set, 22 h / 150°C, plied, ISO 815-B (cold release)	26.9	23	20.8	46.3
Fluid ageing 1008 h / 150°C in Exxon Mobil MB Formula 225.18, 5W-30,				
Hardness Shore A (1 sec)	74.5	72.4	65.4	67.7
Delta hardness	10.3	7.1	1.6	-2.6
Tensile Strength [MPa]	7.1	9.6	10.2	12.0

Delta TS [%]	-51.8	-43.7	-41.6	-15.4
Elongation at break [%]	101	118	136	185
Delta Elong. [%]	-61.5	-62.4	-56.1	-33
Modulus at 100 % [MPa]	7.1	8	6.3	5.5
Delta 100% [%]	73	89.7	55.2	12.7
Weight Change [%] ISO 1817:2005	-2.8	-1.7	3.9	6
Volume Change [%] ISO 1817:2005	-3.6	-1.8	6	8.7
Fluid ageing 1008 h / 150°C in Fuchs Titan EM 225.16 (HTHS 3,5), 5W-30				
Hardness Shore A (1 sec)	72.8	71.3	63.2	67.4
Delta hardness	8.6	6	-0.6	-2.9
Tensile Strength [MPa]	9.4	13.2	16	12.6
Delta TS [%]	-35.9	-22.6	-7.8	-11.6
Elongation at break [%]	120	169	235	208
Delta Elong. [%]	-54.2	-46.2	-24.2	-24.6
Modulus at 100 % [MPa]	8	6.3	5	5
Delta 100% [%]	95.4	51.1	22.7	3.5
Weight Change [%] ISO 1817:2005	-3.2	-2.6	2.3	5.1
Volume Change [%] ISO 1817:2005	-4	-2.8	4.3	7.9
Fluid ageing 1008 h / 150°C in Pentosin FFL-4				
Hardness Shore A (1 sec)	76.3	74.6	66.3	70.1
Delta hardness	12.1	9.3	2.5	-0.2
Tensile Strength [MPa]	13.6	15.4	16.7	13.4
Delta TS [%]	-8	-10	-4	-6
Elongation at break [%]	124	166	193	176
Delta Elong. [%]	-53	-47	-38	-36
Modulus at 100 % [MPa]	10.1	8.1	5.8	6.4
Delta 100% [%]	145	93	43	30
Weight Change [%] ISO 1817:2005	-1.2	-0.8	4	7.4
Volume Change [%] ISO 1817:2005	-1.5	-0.8	6.1	10

Continuous Vulcanization without external Pressure (UHF, Salt Bath)

Vamac® Terpolymers are used as standard material for hoses, due to good physical properties and excellent green strength of compounds for extrusion. Dipolymer compounds usually had lower green strength. VMX-2122 offers higher green strength and better properties compared to Vamac® DP and can meet existing AEM specifications.

Straight tubes can be cured in pressureless, continuous systems like UHF ovens or salt baths. Suitable compounds need Calcium Oxide (CaO) as absorbent for moisture which is always present in any rubber compounds. CaO would react with the acidic cure sites of Vamac® Terpolymers, for which reason these polymers cannot be used for such cost-effective continuous vulcanization processes. Vamac® Dipolymers can be used along with CaO, and some compounding possibilities have been developed in the past to produce compounds fit for use in pressureless cure processes. VMX-2122 showed improvements over Vamac® DP in lab trials, which did not use all tricks. For example, a combination of two peroxides with lower and higher decomposition temperatures was not used in this study. Table 8 gives some indications, more Info can be provided on request.

Table 8 – Compounds for Pressureless Cure Processes

Vamac® DP	100	85				
Vamac® Ultra LS (formerly VMX-3110)		15		15	25	25
VMX-2122			100	85	75	75
Naugard® 445	1	1	1	1	1	1
Armeen® 18D PRILLS	0.5	0.5	0.5	0.5	0.5	0.5
Stearic Acid Reagent (95%)	1	1	1	1	1	1
Struktol® WS 180	0.5	0.5	0.5	0.5	0.5	0.5
Kezadol® GR	10	10	10	10	10	10
Spheron™ SOA (N 550)	65	65	65	65	65	20
MT Thermax® Floform N 990						80
Luperox® DC 40 P	8	8	8	8	8	8
Sartomer® SR350 (TRIM)	2	2	2	2	2	2
Mooney Viscosity ML 1+4, 100°C, MU	54.2	64.6	69.2	83.9	91.6	61.8
MDR, 12 min / 190°C, arc 0.5°						
ML [dNm]	0.78	1.13	1.02	1.27	1.61	0.76
MH [dNm]	12.4	13.39	13.21	14.27	15.01	10.18
Ts1 [min]	0.45	0.45	0.43	0.41	0.39	0.45
T50 [min]	0.87	0.88	0.82	0.82	0.8	0.77
T90 [min]	1.81	1.9	1.6	1.72	1.74	1.78
Tan delta at MH	0.094	0.115	0.098	0.138	0.154	0.133
Peak rate [dNm/min]	14	15	16	16	17	14
Compression Moulding, 5 min / 190°C						
Hardness Shore A (1 second)	72.4	74.8	75.3	79.1	80.1	71.3
Tensile Strength [MPa]	12.4	14	13.9	14.3	15.8	12.3
Elongation at break [%]	283	258	312	275	278	306
Modulus at 100 % [MPa]	4.7	6.6	5.4	7	8.2	4.7
Trouser Tear, Type A , ISO 34-1, N/mm	7.4	6.1	8.6	6.9	9.9	7.8
C.set 70 h / 150°C - Type B, ISO 815-1 (%)	52.5	68.2	51.5	71.2	82.4	81.2
C.set 70 h/ 150°C – Plied, ISO 815-1 (%)	46.3	64.3	48.9	68.1	77.7	71.6
Ageing 168 h/150°C in Lubrizol OS 206304						
Hardness Shore A (1 second)	59.4	62.7	62.8	69.4	69.3	61.9
Delta hardness	-13	-12	-12.5	-9.7	-10.8	-9.5
Tensile Strength [MPa]	10.2	11.8	10.9	12.7	13.2	11.2
Delta TS [%]	-18	-16	-22	-11	-16	-9
Elongation at break [%]	261	242	302	274	243	271
Delta Elong. [%]	-8	-6	-3	0	-13	-11
Modulus at 100 % [MPa]	4	5.4	4.3	5.6	6.4	4.3
Delta 100% [%]	-15	-18	-20	-20	-22	-7
Weight Change (%)	10.5	9.6	10.1	9.2	8.9	7.6
Volume change [%]	11.2	16.3	12.3	14	8.9	13.6

These compounds were extruded through a Garvey Die and then cured in a standard heat ageing oven. Compound 1 and 3 showed significant blistering, VMX-2122 being significantly better. The blends with 15 phr of Ultra LS were significantly lower in blistering, 25 phr of Ultra LS along with VMX-2122 was principally free of blisters.

List of Compound Ingredients

Material	Chemical Composition	Supplier
Polymer		
Vamac® GLS	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Vamac® Ultra LS	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Vamac® Ultra IP	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Vamac® DP	Ethylene Acrylic Elastomer	DuPont Performance Polymers
VMX-2122	Ethylene Acrylic Elastomer	DuPont Performance Polymers
Release Aids		
Armeen® 18D	Octadecyl Amine	Akzo Nobel
Vanfre ® VAM	Complex Organic Phosphate Ester	R.T. Vanderbilt
Stearic Acid		
Anti-Oxidant		
Naugard® 445	Diphenyl Amine	Chemtura
Plasticizer		
Alcanplast® 810TM	Trimellitate Plasticizer	Safic-Alcan
Alcanplast® PO80	Mixed Ether/Ester Plasticizer	Safic-Alcan
Fillers		
Spheron™ SOA (N 550)	Carbon Black	Cabot
Regal® SRF N 772	Carbon Black	Cabot
MT Thermax® Floform N 990	Carbon Black	Cancarb
Martinal ®OL-111 LE	$Al(OH)_3$	Martinswerke
Dynasilan® 6490	Coupling Agent	Evonik
Curatives		
Diak™ No. 1	Hexamethylene Diamine Carbamate	DuPont Performance Polymers
Perkadox® 14-40B-GR	Di(tert-butylperoxyisopropyl)benzene	AkzoNobel
Luperox® DC 40 P	Dicumylperoxide	Arkema
Accelerators		
Alcanpoudre® DBU-70	DBU accelerator	Safic-Alcan
Rubber chem HVA-2	N,N'-phenylene bismaleimide	DuPont Performance Polymers
Sartomer® SR 350	Trimethylolpropane Trimethacrylate	Arkema
Diak™ No. 7	Triallylisocyanurate	DuPont Performance Polymers
Test Fluids		
IRM-903	Reference Fluid	
Pentosin® FFL-4	Transmission Fluid	Deutsche Pentosinwerke
Fuchs Titan EM225.1 5W30	Engine Oil	Fuchs
Mobil MB Formula 5W30	Engine Oil	Exxon Mobil

Test Methods

Test	Method
Rheology	
Mooney Viscosity	ISO 289-1:2005
Mooney Scorch	ISO 289-2:1994
MDR	ISO 6502:1999
Physical Properties	
Hardness	ISO 868:2003
Tensile Strength, Elongation, Modulus	ISO 37:1994
Compression Set	ISO 815:1991
Compression Set	Volkswagen PV3307
Compressive Stress Relaxation (CSR)	ISO 3384
Aging in Air Oven	ISO 188:2007
Fluid Aging	ISO 1817:2005
Tg by DSC	ISO 22768:2006
Tear Strength Die C	ISO 34-1:2004

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