DuPont™ Vamac® Fluid Resistance

Technical Information — Rev. 2, August 2010

Vulcanizates of DuPont™ Vamac® ethylene/acrylic elastomer remain serviceable in contact with many common fluids at elevated temperatures. Resistance to swelling is very good in such fluids as water, hot oils, hydrocarbon- or glycol-based lubricants, hydraulic fluids, and engine coolants. Vamac® is not recommended for applications involving immersion in esters, ketones, or highly aromatic fluids such as gasoline.

Table 1 lists the stress/strain and fluid resistance properties of a black loaded, lightly plasticized compound of Vamac® to a variety of fluids.

Table 2 lists the effects post curing has on the fluid resistance of Vamac®.

Table 3 lists the effects compound extension has on the fluid resistance of Vamac®.

Physical Properties of Vamac® After Aging in Selected Fluids

Table 1 lists the effects various common and commercial fluids have on a typical formulation of Vamac®. This table is intended to be used as a guide in helping the compounder.

It should be noted that Vamac® is not recommended for service in contact with aromatic hydrocarbons, esters, gasoline, and ketones. Where possible, compounds should be tested under actual service conditions.

COMPOUND #1

Vamac® G	100
Naugard® 445	2
Vanfre® VAM	1
Stearic Acid	1.5
Armeen® 18D	0.5
SRF BLACK (N-774)	100
TP 759	10
DOTG	4
Diak™ #1	1.25

VULCANIZATE PROPERTIES

CURE: Press – 10 min at 177 °C [350 °F]

POST-CURE: — 2 hours at 177 °C [350 °F]

STRESS-STRAIN AND HARDNESS (Original Properties)

100% Modulus MPa [psi]	Tensile Strength MPa [psi]	Elongation at Break	Hardness Durometer A
7.4 [1075]	12.8 [1850]	227%	78

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Table 1 — Fluid resistance of DuPont™ Vamac® ethylene acrylic elastomer (% of Original Properties Retained)

FLUID	TIME (hrs)	TEMP. °C [°F]	100% MODULUS	TENSILE STRENGTH	ELONGATION AT BREAK	DURO-METER A, (points change)	% VOLUME CHANGE
WATER AND COOLANTS							
Ethylene Glycol	70	100 [212]	105	108	103	6	–1
Ethylene Glycol	168	100 [212]	110	108	100	8	1
Ethylene Glycol	336	100 [212]	111	108	93	5	4
Ethylene Glycol	504	100 [212]	115	111	99	4	4
Ethylene Glycol	804	100 [212]	114	104	73	2	12
Steam	24	80 psi [320]	101	105	99	-3	–3
Steam	168	80 psi [320]	—	178	15	17	–1
Steam	168	125 psi [353]	—	236	11	20	–5
Water	70	100 [212]	97	104	91	5	2
Water	168	100 [212]	99	106	98	3	8
Water	336	100 [212]	105	108	96	3	7
Water	504	100 [212]	115	111	96	4	6
Water/Prestone Antifreeze (50/50)	70	100 [212]	110	106	101	6	–1
Water/Prestone Antifreeze (50/50)	168	100 [212]	112	112	97	5	7
Water/Prestone Antifreeze (50/50)	336	100 [212]	114	112	96	5	6
Water/Prestone Antifreeze (50/50)	504	100 [212]	125	117	93	6	7
Water/Ethylene Glycol (50/50)	168	100 [212]	104	104	100	2	0
ACIDS AND BASES							
Acetic Acid, 20%	168	24 [75]	87	96	101	–1	3
Acetic Acid, glacial	70	24 [75]	—	28	26	–30	113
Acetic Acid, glacial	168	24 [75]	—	29	24	–28	115
Hydrochloric Acid, 20%	70	24 [75]	102	104	96	–1	0
Hydrochloric Acid, 20%	168	24 [75]	92	99	100	4	–1
Hydrochloric Acid	70	24 [75]	93	95	109	–1	6
Nitric Acid, 30%	168	24 [75]	82	91	101	–4	3
Sodium Hydroxide, 20%	168	24 [75]	101	103	83	–1	1
Sulfuric Acid, 20%	168	24 [75]	101	102	96	0	–2
Sulfuric Acid, concentrated	70	24 [75]	*	*	*	*	206
*Could not test sample							
ASTM STANDARD OILS AND REFERENCE FUELS							
ASTM #1 Oil	70	150 [300]	101	108	102	0	5
ASTM #1 Oil	70	177 [350]	98	106	93	1	4
ASTM #2 Oil	70	150 [300]	83	100	115	–17	35
ASTM #2 Oil	70	177 [350]	78	97	115	–16	29
ASTM #3 Oil	70	100 [212]	88	92	84	–22	39
ASTM #3 Oil	70	150 [300]	82	82	83	–27	50
ASTM #3 Oil	168	150 [300]	80	85	87	–28	60
ASTM # 3 Oil	70	177 [350]	73	78	91	–31	56
ASTM Ref. Fuel A	168	24 [75]	87	85	74	–13	26
ASTM Ref. Fuel B	168	24 [75]	87	52	46	–25	82
ASTM Ref. Fuel C	168	24 [75]	—	36	29	–24	130
ASTM Service Fluid 101 (Anderol 774)	70	177 [350]	79	56	53	–34	87

(continued)

Table 1 — Fluid resistance of Vamac® ethylene acrylic elastomer *(continued)*
(% of Original Properties Retained)

FLUID	TIME (hrs)	TEMP. °C [°F]	100% MODULUS	TENSILE STRENGTH	ELONGATION AT BREAK	DURO-METER A, (points change)	% VOLUME CHANGE
SOLVENTS							
Acetone	168	24 [75]	85	52	45	–25	106
Amyl Alcohol	168	24 [75]	84	71	63	–24	38
n-Butyl Alcohol	168	24 [75]	83	71	62	–21	35
Cyclohexane	168	24 [75]	—	20	9	–23	186
Dibutyl Phthalate	70	24 [75]	92	60	47	–27	50
Diesel Fuel	168	24 [75]	98	90	78	–19	24
Ethyl Alcohol	168	24 [75]	80	79	74	–16	30
Formaldehyde, 37%	70	24 [75]	87	96	98	–2	2
Freon® 11	168	24 [75]	—	44	33	–28	26
Freon® 113	168	24 [75]	89	54	45	–22	39
Gasoline Unleaded, 87 Octane	70	24 [75]	—	46	34	–24	65
Gasoline Unleaded, 87 Octane	168	24 [75]	85	56	49	–24	68
Gasoline Unleaded, 87 Octane (dried 24 hours at 100° [212°F] before testing)	70	24[75]	120	105	97	9	-8
Kerosene	168	24 [75]	87	81	69	–21	31
Jet Fuel JP-4	70	24 [75]	80	75	70	–22	31
JP-4	168	24 [75]	89	73	61	–21	32
Jet Fuel JP-5	70	24 [75]	85	84	79	–18	25
JP-5	168	24 [75]	94	83	76	–19	30
Jet Fuel JP-7	70	24 [75]	84	94	89	–9	13
JP-7	168	24 [75]	84	86	78	–13	17
Methyl Alcohol	168	24 [75]	83	85	81	–9	16
Methyl Isobutyl Ketone	168	24 [75]	—	35	26	–23	148
Methyl tert-Butyl Ether	70	24 [75]	—	35	32	–26	118
Tetrahydrofuran	70	24 [75]	—	11	9	–26	197
Toluene	168	24 [75]	—	25	20	–22	212
HYDRAULIC FLUIDS AND LUBRICANTS							
Delco Supreme, #11 Brake Fluid	70	121 [250]	—	51	43	–35	91
Delco Supreme, #11 Brake Fluid	70	150 [300]	—	51	42	–36	102
Dexron® II ATF	70	150 [300]	100	100	81	–16	25
Dexron® II ATF	168	150 [300]	100	102	81	–16	25
Dexron® II ATF	504	150 [300]	114	104	66	–17	25
Mineral Oil	70	24 [75]	95	98	100	1	0
Mobile Jet Oil II	168	150 [300]	86	58	52	–34	94
Mobil 5W/30 Oil	70	150 [300]	91	96	98	–13	21
Mobil 5W/30 Oil	168	150 [300]	79	96	99	–14	21
Mobil 5W/30 oil	504	150 [300]	97	103	93	–11	23
Quaker State® 10W/30 Oil	70	150 [300]	90	97	93	–11	18

(continued)

Table 1 — Fluid resistance of Vamac® ethylene acrylic elastomer ***(continued)***
(% of Original Properties Retained)

FLUID	TIME (hrs)	TEMP. °C [°F]	100% MODULUS	TENSILE STRENGTH	ELONGATION AT BREAK	DURO-METER A, (points change)	% VOLUME CHANGE
Quaker State® 10W/30 Oil	168	150 [300]	87	99	93	–14	19
Quaker State® 10W/30 Oil	504	150 [300]	86	101	102	–12	19
Skydrol® 500A	168	121 [250]	—	39	36	–34	131
Stauffer Blend 7700	70	177 [350]	85	53	46	–32	94
TEL 4081	70	177 [350]	77	52	50	–35	98
Texaco® 4634 Power Steering Fluid	70	150 [300]	87	95	93	–18	22
Texaco® 4634 Power Steering Fluid	168	150 [300]	87	102	93	–14	29
MISCELLANEOUS FLUIDS							
Linseed Oil	70	24 [75]	88	98	96	–5	6
Tricresyl Phosphate	70	24 [75]	94	92	79	–4	13
Triethanol Amine	70	24 [75]	98	102	95	2	1

Effects of Post-Curing on the Fluid Resistance of DuPont™ Vamac®

Vulcanizates of DuPont™ Vamac® can be post-cured to optimize compression set resistance and tensile strength. However, post-curing has little or no effect on the volume increase. Post-curing can be used to increase the original tensile strength of a compound. This increase will be evident in the aged sample.

The following table evaluates the effects various post-cure times have on the physical properties of fluid aged samples.

COMPOUND #2	
Vamac® G	100
Naugard® 445	2
Vanfre® VAM	1
Stearic Acid	1.5
Armeen® 18D	0.5
SRF BLACK (N-774)	100
TP 759	10
DOTG	4
Diak™ #1	1.25

STOCK PROPERTIES	
Mooney Scorch, MS at 121 °C (250 °F)	
Minimum Viscosity, units	17.8
Time to 10-Unit rise, min	8.9
ODR at 177 ºF [350 ºF]	
Microdie, 0.052 rad [3’] arc	
ML, in-lbs	5.8
ts 0.2 [ts2], minutes	1.1
t’90, minutes	8.9
MH, in-lbs	61.0

Table 2 — Post-Cure Effects on Vulcanizate Stress-Strain and Hardness Properties

CURE: Press – 10 min at 177 °C [350 °F] POST-CURE: Time at 177 °C [350 °F]	**A** **No Post Cure**	**B** **2 hours**	**C** **4 hours**	**D** **8 hours**
Original				
100% Modulus, MPa (psi)	5.2 (760)	7.1 (1030)	7.7 (1120)	7.5 (1090)
Tensile Strength, MPa (psi)	10.6 (1530)	12.9 (1875)	13.2 (1920)	13.5 (1960)
Elongation at Break, %	295 ()	210 ()	203 ()	206 ()
Hardness, durometer A	77	82	80	82
Aged 70 hours in ASTM #1 Oil at 150 °C [300 °F]				
100% Modulus, MPa (psi)	7.3 (1065)	7.7 (1110)	8.0 (1160)	8.1 (1180)
Tensile Strength, MPa (psi)	12.7 (1840)	14.0 (2035)	14.5 (2105)	14.8 (2150)
Elongation at Break, %	219	216	205	195
Hardness, durometer A	81	82	80	81
Volume Change, %	1	3	3	3
Aged 70 hours in ASTM #3 Oil at 150 °C [300 °F]				
100% Modulus, MPa (psi)	5.0 (720)	5.5 (795)	6.3 (920)	6.3 (920)
Tensile Strength, MPa (psi)	10.1 (1460)	10.4 (1510)	10.8 (1565)	11.0 (1595)
Elongation at Break, %	259	177	182	179
Hardness, durometer A	45	51	52	52
Volume Change, %	53	50	50	51
Aged 70 hours in Water at 100 °C [212 °F]				
100% Modulus, MPa (psi)	6.8 (980)	7.3 1060()	7.2 (1050)	7.6 (1095)
Tensile Strength, MPa (psi)	12.3 (1780)	13.7 (1980)	14.3 (2080)	14.2 (2065)
Elongation at Break, %	241	225	225	208
Hardness, durometer A	79	79	78	82
Volume Change, %	2	2	2	2
Aged 168 hours in 50/50 Prestone Antifreeze/Water at 100 °C [212 °F]				
100% Modulus, MPa (psi)	9.1 (1315)	8.6 (1250)	8.2 (1195)	8.4 (1220)
Tensile Strength, MPa (psi)	14.3 (2070)	14.3 (2070)	14.8 (2145)	14.9 (2160)
Elongation at Break, %	203	219	218	210
Hardness, durometer A	82	83	82	82
Volume Change, %	8	4	6	6
Aged 70 hours in ASTM Reference Fuel B at 24 °C [75 °F]				
100% Modulus, MPa (psi)	4.8 (700)	6.6 (950)	5.0 (725)	0.0 (0)
Tensile Strength, MPa (psi)	6.9 (1000)	6.9 (1000)	6.3 (915)	5.9 (850)
Elongation at Break, %	144	107	131	81
Hardness, durometer A	48	55	55	55
Volume Change, %	70	69	71	71
Aged 70 hours Texaco 4634 Power Steering Fluid at 150 °C [300 °F]				
100% Modulus, MPa (psi)	5.5 (795)	6.8 (985)	6.7 (970)	7.3 (1060)
Tensile Strength, MPa (psi)	11.8 (1710)	13.1 (1895)	13.5 (1960)	13.9 (2010)
Elongation at Beak, %	243	207	206	197
Hardness, durometer A	63	65	63	66
Volume Change, %	18	21	21	21

Effects of Compound extension on the Fluid Resistance of DuPont™ Vamac®

The volume swell of DuPont™ Vamac® may be lowered by extending the compound with plasticizers and fillers. This extension will have the effect of decreasing volume swell and reducing compound costs. However, there may be some sacrifice to the processing and physical properties of the compounds. The following points may be helpful when modifying compounds.

Hardness decreases approximately six points with each ten phr of monoester plasticizer (such as DOS).

Hardness increases approximately six points with each ten phr of N-550 (FEF) carbon black, and approximately four points with each ten phr of N-774 (SRF) carbon black.

To maintain compound hardness during extension, use nine phr of FEF black or twelve phr of SRF black for every ten phr of ester plasticizer.

Table 3 evaluates the effects compound extension has on the physical properties of fluid aged samples.

Table 3 — Effects of Compound Extension on the Fluid Resistance of DuPont™ Vamac®

COMPOUND	3	4	5	6
DuPont™ Vamac® G	100	100	100	100
Naugard® 445	2	2	2	2
Vanfre® VAM	1	1	1	1
Stearic Acid	1.5	1.5	1.5	1.5
Armeen® 18D	0.5	0.5	0.5	0.5
SRF BLACK (N-774)	100	112	124	136
TP 759	10	20	30	40
DOTG	4	4	4	4
Diak™ #1	1.25	1.25	1.25	1.25
STOCK PROPERTIES				
Mooney Scorch, MS at 121 °C [250 °F]				
Minimum Viscosity, units	17.7	15.7	13.5	11.1
Time to 10-Unit rise, min	8.9	9.4	9.2	10.8
ODR at 177 ºC [350 ºF]				
Microdie, 0.052 rad [3'] arc				
ML, in-lbs	5.5	5.5	5.4	4.0
ts 0.2 [ts2], minutes	1.2	1.3	1.3	1.4
t'90, minutes	7.7	8.2	7.7	8.0
MH, in-lbs	61.5	53.6	44.8	39.8
VULCANIZATE PROPERTIES				
CURE: Press – 10 min at 177 °C [350 °F]				
POST-CURE: - 2 hours at 177 °C [350 °F]				
Stress-Strain and Hardness				
Original				
100% Modulus, MPa (psi)	6.9 (995)	6.8 (990)	5.9 (850)	5.8 (835)
Tensile Strength, MPa (psi)	12.9 (1865)	11.5 (1670)	10.6 (1540)	9.3 (1345)
Elongation at Break, %	222	205	204	188
Hardness, Durometer A	80	79	77	76

(continued)

Table 3 — Effects of Compound Extension on the Fluid Resistance of DuPont™ Vamac® *(continued)*

COMPOUND	3	4	5	6
Aged 70 hours in ASTM #1 Oil at 150 °C [300 °F]				
100% Modulus, MPa (psi)	7.2 (1050)	7.2 (1040)	7.3 (1060)	7.0 (1020)
Tensile Strength, MPa (psi)	13.5 (1955)	12.6 (1820)	11.4 (1655)	10.2 (1485)
Elongation at Break, %	222	218	219	187
Hardness, Durometer A	80	80	82	82
Volume Change, %	5	0	–4	–6
Aged 70 hours in ASTM #3 Oil at 150 °C [300 °F]				
100% Modulus, MPa (psi)	5.8 (835)	5.5 (795)	5.0 (720)	4.6 (670)
Tensile Strength, MPa (psi)	10.5 (1520)	9.9 (1430)	9.6 (1390)	8.6 (1240)
Elongation at Break, %	202	188	191	186
Hardness, Durometer A	52	51	51	53
Volume Change, %	52	47	42	38
Aged 70 hours in Water at 100 °C [212 °F]				
100% Modulus, MPa (psi)	6.5 (940)	6.8 (985)	5.8 (840)	6.3 (920)
Tensile Strength, MPa (psi)	13.3 (1930)	12.0 (1735)	10.8 (1570)	9.6 (1385)
Elongation at Break, %	224	203	217	198
Hardness, Durometer A	77	77	80	82
Volume Change, %	6	3	–1	–3
Aged 168 hours in 50/50 Prestone Antifreeze/Water at 100 °C [212 °F]				
100% Modulus, MPa (psi)	7.9 (1140)	8.1 (1170)	8.1 (1180)	7.7 (1120)
Tensile Strength, MPa (psi)	14.1 (2050)	12.8 (1855)	11.8 (1710)	11.0 (1595)
Elongation at Break, %	222	216	191	181
Hardness, Durometer A	83	87	86	80
Volume Change, %	+0	–3	–7	–7
Aged 70 hours in ASTM Reference Fuel B at 24 ºC [75 ºF]				
100% Modulus, MPa (psi)	—	5.8 (845)	5.2 (755)	4.3 (625)
Tensile Strength, MPa (psi)	6.7 (965)	6.1 (890)	5.4 (790)	5.0 (720)
Elongation at Break, %	100	104	105	111
Hardness, Durometer A	55	54	52	48
Volume Change, %	73	67	58	54
Aged 70 hours in Texaco 4634 Power Steering Fluid at 150 °C [300 °F]				
100% Modulus, MPa (psi)	6.2 (905)	6.2 (895)	5.8 (845)	5.7 (825)
Tensile Strength, MPa (psi)	12.6 (1830)	11.8 (1715)	10.7 (1555)	9.9 (1440)
Elongation at Break, %	214	221	195	193
Hardness, Durometer A	64	67	71	74
Volume Change, %	22	17	12	8

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