Viton™ B Fluoroelastomers

Heat- and Fluid-Resistant Fluoroelastomer

Technical Information

Introduction

Viton™ B is a fluoroelastomer terpolymer of the "B family" from Chemours. It has better fluid resistance and retains flexibility better after dry heat aging than polymers of the Viton™ A family. It is recommended for applications requiring maximum retention of elastic properties combined with good mechanical properties.

Features

Viton™ B has an excellent overall combination of heat resistance, fluid resistance, physical properties, and processing characteristics.

Uses

- Molded goods—O-rings, seals, packings, diaphragms
- Roll covers
- Tubing and hose lining
- Solution coatings and coated fabrics
- Wire insulation and jacketing
- High-temperature expansion joints

Product Description

Physical Form	Slabs
Appearance (Color)	Off-white
Odor	None
Mooney Viscosity at 121 °C (250 °F), ML 1 + 10	Approximately 74
Specific Gravity	1.86
Solubility	Soluble in low molecular weight ketones and esters
Storage Stability	Excellent

Note: These data are presented to describe Viton™ B and not intended to serve as specifications.

Handling Precautions

Before handling or processing Viton™ B, be sure to read and be guided by the suggestions in Chemours' technical bulletin, "Handling Precautions for Viton™ and Related Chemicals."

Chemours™

General Vulcanizate Properties

Physical Properties

The physical properties of vulcanizates of Viton™ B fluoroelastomer are compared with those of vulcanizates of Viton™ A and Viton™ E-60C in Tables 1, 2, and 3. Specific properties are discussed in the sections following.

Heat Resistance

Both Viton™ A and Viton™ B are resistant to long-term aging at temperatures above 204 °C (400 °F), but each reacts in a different manner to such exposure. Heat-aging tests at 232–316 °C (450–600 °F) show that vulcanizates of Viton™ B change less in hardness and retain more elongation, but lose more tensile strength than similar vulcanizates of the Viton™ "A family" fluoroelastomers—both A and E series (see Tables 1, 2, and 3).

Compression Set Resistance

The minimum compression set values obtainable with Viton™ B are inherently higher than those obtainable with members of the Viton™ "A family" fluoroelastomers at equivalent curative levels (see Tables 1 and 3).When compression set resistance is an important vulcanizate property, Viton™ Curatives No. 20 and No. 30 should be used, rather than Diak™ No. 3 or other diamine curatives. See Chemours' technical bulletin, "Compounding with Viton™ Curative Masterbatches," for comparative data.

In all cases, for maximum compression set resistance, it is necessary to post-cure for at least 24 hr at a minimum temperature of 200 °C (392 °F). Post-curing at temperatures as high as 260 °C (500 °F) generally increases resistance to compression set, relative to post-curing at 200 °C (392 °F).

Stress/Strain Properties

When cured with the appropriate amounts of Viton™ Curatives No. 20 and No. 30, vulcanizates of Viton™ B have similar stress/strain properties to those of vulcanizates of Viton™ A or Viton™ E-60C (see Tables 1 and 2).

When cured with 3 phr Diak™ No. 3, vulcanizates of Viton™ B have similar stress/strain properties to those of Viton™ A cured with 2 phr Diak™ No. 3; but, they have lower modulus and hardness and higher tensile strength and elongation at break than Viton™ A cured with 3 phr Diak™ No. 3 (see Tables 1 and 3).

Other Mechanical Properties

Table 3 summarizes other properties of Viton™ B compared with Viton™ A when both polymers are cured with Diak™ No. 3. Similar differences would be expected between the two types when compounded with Viton™ Curatives No. 20 and No. 30.

Tear Resistance—Viton™ B has better tear resistance than Viton™ A at room and elevated temperatures. The tear resistance of both polymers can be improved by using a silica filler in place of carbon black.

Resilience—As measured by the Yerzley Oscillograph, the resilience of Viton™ B is approximately the same as that of Viton™ A. Static modulus and effective dynamic modulus are higher for Viton™ B.

Abrasion Resistance—Taber abrasion tests show that Viton™ B has slightly better abrasion resistance than Viton™ A.

Low-Temperature Properties—Vulcanizates of Viton™ B have lower brittleness temperatures than vulcanizates of Viton™ A, but are less flexible at low temperatures.

Table 1. Heat and Compression Set Resistance of Viton™ B Compared with Viton™ A

Compound	1A	1B	1C	1D	1E
Viton™ B	100	—	100	—	—
Viton™ A	—	100	—	100	100
High-Activity MgO	3	3	—	—	—
Low-Activity MgO	—	—	15	15	15
MT Carbon Black (N908)	30	30	25	25	30
Calcium Hydroxide	6	6	—	—	—
Viton™ Curative No. 20	3.3	2.4	—	—	—
Viton™ Curative No. 30	4.1	3.2	—	—	—
Diak™ No. 3	—	—	3.0	2.0*	3.0*
Stock Properties					
Mooney Scorch, MS at 121 °C (250 °F)					
Minimum Viscosity, units	77	42	57	36	32
Time to 5-unit rise, min	26	24	33	27	—
Time to 10-unit rise, min	30	26	39	38	28
ODR, 30 min at 177 °C (350 °F); Microdie, 0.017 rad (1°) Arc, 1.67 Hz (100 cpm)					
$t_s0.2$ (t_s2), min	1.7	1.8	3.4	4.0	3.3
M_c90, N·m (lbf·in)	5.4 (48)	5.0 (44)	4.6 (41)	2.6 (23)	4.3 (39)
t_c90, min	4.0	5.0	18.0	20.0	17.3
Vulcanizate Properties					
Press Cured: 10 min at 177 °C (350 °F); Oven Cured: 24 hr at 232 °C (450 °F)					
Stress/Strain Hardness					
Original—Tested at 24 °C (75 °F)					
100% Modulus, MPa (psi)	5.6 (800)	5.0 (725)	4.2 (600)	3.0 (425)	6.6 (950)
Tensile Strength, MPa (psi)	13.2 (1,925)	11.6 (1,675)	16.2 (2,350)	16.2 (2,350)	12.4 (1,800)
Elongation at Break, %	230	220	350	460	210
Hardness, durometer A	77	77	74	72	78
Original—Tested at 177 °C (350 °F)					
100% Modulus, MPa (psi)	—	—	2.6 (375)	1.8 (250)	—
Tensile Strength, MPa (psi)	4.0 (600)	4.0 (600)	3.4 (500)	3.4 (500)	—
Elongation at Break, %	100	100	150	190	—
After Oven-Aging 70 hr at 275 °C (528 °F)—Tested at 24 °C (75 °F)					
100% Modulus, MPa (psi)	4.8 (700)	5.6 (800)	3.4 (500)	3.2 (475)	8.0 (1,150)
Tensile Strength, MPa (psi)	12.0 (1,750)	12.0 (1,750)	10.8 (1,575)	10.2 (1,475)	10.4 (1,500)
Elongation at Break, %	250	210	380	390	180
Hardness, durometer A	77	79	78	78	86
Oven-Aged—Tested at 177 °C (350 °F)					
100% Modulus, MPa (psi)	—	—	1.4 (200)	1.4 (200)	—
Tensile Strength, MPa (psi)	4.2 (600)	3.0 (425)	2.0 (300)	2.2 (325)	—
Elongation at Break, %	160	100	150	160	—
Compression Set, Method B, %, O-Rings, 25.4 mm × 3.5 mm (1.0 in × 0.139 in)					
After 70 hr at 200 °C (392 °F)	31	30	71	76	56

*The normal recommendation for the amount of Diak™ No. 3 to use with Viton™ A is 3 phr. The 2 phr level was included because it produces a compound with compression set and other properties similar to those obtained with 3 phr Diak™ No. 3 in Viton™ B.

Table 2. Heat Resistance of Viton™ B Compared with Viton™ E-60

Compound	2A Viton™ B	2B Viton™ E-60C
Viton™ B Precompounded with Curatives*	100	—
Viton™ E-60C*	—	100
High-Activity MgO	3	3
MT Carbon Black (N908)	30	30
Calcium Hydroxide	6	6
Vulcanizate Properties		
Press Cured: 10 min at 177 °C (350 °F); Oven Cured: 24 hr at 260 °C (500 °F)		
Stress/Strain and Hardness		
Original		
100% Modulus, MPa (psi)	6.8 (975)	5.6 (800)
Tensile Strength, MPa (psi)	15.6 (2,275)	14.8 (2,150)
Elongation at Break, %	190	220
Hardness, durometer A	79	77
After Oven-Aging 2 months at 232 °C (450 °F)		
100% Modulus, MPa (psi)	3.6 (525)	5.6 (800)
Tensile Strength, MPa (psi)	8.0 (1,150)	10.0 (1,450)
Elongation at Break, %	260	180
Hardness, durometer A	81	81
After Oven-Aging 2 weeks at 260 °C (500 °F)		
100% Modulus, MPa (psi)	2.8 (400)	4.2 (600)
Tensile Strength, MPa (psi)	6.6 (950)	7.6 (1,100)
Elongation at Break, %	290	200
Hardness, durometer A	77	82
After Oven-Aging 4 weeks at 260 °C (500 °F)		
100% Modulus, MPa (psi)	3.2 (475)	—
Tensile Strength, MPa (psi)	4.8 (700)	7.2 (1,050)
Elongation at Break, %	190	70
Hardness, durometer A	87	96
After Oven-Aging 6 weeks at 260 °C (500 °F)		
100% Modulus, MPa (psi)	3.8 (550)	↑ Brittle ↓
Tensile Strength, MPa (psi)	4.2 (600)	
Elongation at Break, %	120	
Hardness, durometer A	86	
After Oven-Aging 7 days at 288 °C (550 °F)		
100% Modulus, MPa (psi)	3.0 (425)	—
Tensile Strength, MPa (psi)	3.8 (550)	5.8 (850)
Elongation at Break, %	180	60
Hardness, durometer A	87	96
After Oven-Aging 14 days at 288 °C (550 °F)		
100% Modulus, MPa (psi)	—	↑ Brittle ↓
Tensile Strength, MPa (psi)	4.2 (600)	
Elongation at Break, %	70	
Hardness, durometer A	93	
After Oven-Aging 24 hr at 316 °C (600 °F)		
100% Modulus, MPa (psi)	2.2 (325)	3.0 (425)
Tensile Strength, MPa (psi)	3.8 (550)	4.4 (650)
Elongation at Break, %	220	160
Hardness, durometer A	71	75
After Oven-Aging 48 hr at 316 °C (600 °F)		
100% Modulus, MPa (psi)	—	↑ Brittle ↓
Tensile Strength, MPa (psi)	2.6 (375)	
Elongation at Break, %	100	
Hardness, durometer A	74	

*The Viton™ B used in this comparison was precompounded with Viton™ Curative No. 20 and No. 30 in the following proportions: Viton™ B, 93.2; Viton™ Curative No. 20, 3.0; Viton™ Curative No. 30, 3.8. Viton™ E-60C is precompounded from Viton™ E-60, a member of the A family. Its composition is: Viton™ E-60, 94.35; Viton™ Curative No. 20, 1.65; Viton™ Curative No. 30, 4.0.

Table 3. General Physical Properties of Viton™ B Compared with Viton™ A

Compound	3A Viton™ B	3B Viton™ A
Viton™ B	100	—
Viton™ A	—	100
Low-Activity MgO	15	15
MT Carbon Black (N908)	20	20
Diak™ No. 3	3*	2*
Stock Properties		
Mooney Scorch, MS at 121 °C (250 °F)		
Minimum Viscosity, units	71	41
Time to 10-unit rise, min	20	30
Vulcanizate Properties		
Press Cured: 30 min at 149 °C (300 °F), followed by Oven Step-Cure consisting of 1 hr at 100 °C (212 °F), 1 hr at 121 °C (250 °F), 1 hr at 149 °C (300 °F), and 1 hr at 177 °C (350 °F), followed by 24 hr at 204 °C (400 °F)**		
Stress/Strain and Hardness		
Original		
100% Modulus, MPa (psi)	3.8 (550)	2.4 (350)
Tensile Strength, MPa (psi)	15.4 (2,225)	15.2 (2,200)
Elongation at Break, %	390	460
Hardness, durometer A	74	68
After Oven-Aging 20 days at 260 °C (500 °F)		
100% Modulus, MPa (psi)	2.4 (350)	8.6 (1,250)
Tensile Strength, MPa (psi)	3.8 (550)	8.6 (1,250)
Elongation at Break, %	400	100
Hardness, durometer A	83	94
Compression Set, Method B, % Pellets, 12.7 mm × 28.7 mm (0.5 in × 1.13 in)		
After 70 hr at 121 °C (250 °F)	27	29
After 46 hr at 177 °C (350 °F)	37	36
After 22 hr at 232 °C (450 °F)	93	88
Tear Resistance, Die B, kN/m (lbf·in)		
At 24 °C (75 °F)	32.4 (185)	28.4 (162)
At 149 °C (300 °F)	6.7 (38)	5.1 (29)
Resilience, Yerzley Oscillograph Compression at 24 °C (75 °F)		
Resilience, %	47	45
Load at 20% Deflection, MPa (psi)	1.4 (2,00)	1.0 (150)
Static Modulus, 5% Deflection, MPa (psi)	7.6 (1,100)	5.0 (725)
Effective Dynamic Modulus, MPa (psi)	17.0 (2,475)	14.0 (2,025)
Abrasion Resistance, Taber H-22 Wheel, 1,000 g Load		
Weight Loss per 1,000 Revolutions, g	0.143	0.198
Low-Temperature Properties, Specimen Thickness—1.9 mm (0.075 in)		
Brittleness Temperature, °C (°F)	−45 (−49)	−40 (−40)
Retraction Temperature, °C (°F)		
TR_{10}	−17 (−1.5)	−21 (−6)
TR_{50}	−8 (18)	−20.5 (−5)
Clash-Berg Stiffness, MPa (psi)		
At 24 °C (75 °F)	3.0 (425)	1.9 (275)
At −7 °C (20 °F)	6.6 (950)	4.4 (650)
At −12 °C (10 °F)	32.8 (4,750)	9.2 (1,325)
At −18 °C (0 °F)	366.8 (53,200)	59.4 (8,625)
Ozone Resistance, Bent Loop Test, 100 ppm Ozone, 40 °C (104 °F)		
After 1,000 hr	No Cracking	No Cracking

*The normal recommendation for amount of Diak™ No. 3 to use with Viton™ A is 3 phr. The 2 phr level was used in this comparison because it produces a compound with compression set and other properties similar to those obtained with 3 phr Diak™ No. 3 in Viton™ B.
** An oven step-cure such as this is typical procedure to prevent fissuring in thick-sectioned parts.

Fluid Resistance

Resistance to Fuels, Oils, and Solvents

The resistance of Viton™ B fluoroelastomer to organic fluids is generally superior to that of Viton™ A and E types, as shown in Tables 4 and 5. However, both Viton™ B and Viton™ A swell considerably in highly polar materials, such as methyl ethyl ketone.

Table 4. Resistance of Viton™ B to Fuels, Oils, and Solvents

Compound	4A Viton™ B				4B Viton™ A			
Vulcanizate Properties								
Original—See Table 3	Volume Change, %	Tensile Strength, % Retained	Elongation, % Retained	Hardness Change, Points	Volume Change, %	Tensile Strength, % Retained	Elongation, % Retained	Hardness Change, Points
After Immersion in:								
Reference Fuel B								
7 days at 24 °C (75 °F)	+1	90	100	+1	+1	96	99	+1
Silicate Ester Hydraulic Fluid (OS-45)								
7 days at 204 °C (400 °F)	+3	75	98	−2	+ 3	82	85	−1
14 days at 204 °C (400 °F)	+4	74	68	+1	+ 4	61	63	+ 2
21 days at 204 °C (400 °F)	+4	67	54	0	+ 4	56	48	+ 4
Silicate Ester Hydraulic Fluid (Oronite 8515)								
7 days at 204 °C (400 °F)	+4	80	68	−1	+ 5	70	61	+ 1
14 days at 204 °C (400 °F)	+7	53	39	−2	+ 7	55	43	+ 2
21 days at 204 °C (400 °F)	+7	43	29	0	+ 8	40	30	+ 3
Diester Lubricant (Turbo Oil No. 15, MIL-L-7808)								
7 days at 204 °C (400 °F)	+9	71	98	−3	+16	68	99	−5
14 days at 204 °C (400 °F)	+12	62	73	−4	+17	59	78	−6
21 days at 204 °C (400 °F)	+13	59	68	−4	+18	47	61	−5
Phosphate Ester Hydraulic Fluid (Skydrol 500)								
7 days at 149 °C (300 °F)	+96	29	68	−46	+342	2	11	−55
Tricresyl Phosphate								
7 days at 149 °C (300 °F)	+7	93	110	−3	+21	84	104	−7
14 days at 149 °C (300 °F)	+7	81	88	−4	+20	68	78	−9
21 days at 149 °C (300 °F)	+7	71	83	−3	+18	62	70	−13
Benzene								
7 days at 149 °C (300 °F)	+12	79	93	−8	+22	52	69	−14
14 days at 149 °C (300 °F)	+15	62	83	−8	+23	48	69	−15
21 days at 149 °C (300 °F)	+15	61	73	−8	+23	45	69	−16
Methyl Ethyl Ketone								
7 days at 24 °C (75 °F)	+313	—	—	−43	+458	—	—	−51

Table 5. Resistance of Viton™ B to Oils and Solvents

Compound	5A Viton™ B	5B Viton™ E-60C
Viton™ B Precompounded with Curatives*	100	—
Viton™ E-60C*	—	100
High-Activity MgO	3	3
MT Carbon Black (N908)	30	30
Calcium Hydroxide	3	6
Vulcanizate Properties		
Press Cured: 10 min at 177 °C (350 °F); Oven Cured: 24 hr at 260 °C (500 °F)		
Stress/Strain and Hardness at 24 °C (75 °F)		
Original		
100% Modulus, MPa (psi)	4.4 (650)	5.6 (800)
Tensile Strength, MPa (psi)	16.2 (2,350)	14.8 (2,150)
Elongation at Break, %	220	220
Hardness, durometer A	78	77
Fluid Resistance		
Stress/Strain and Hardness After Immersion in Fluid		
After 336 hr at 200 °C (392 °F) in Mobil Jet Oil II		
100% Modulus, MPa (psi)	4.2 (600)	—
Tensile Strength, MPa (psi)	9.8 (1,425)	4.4 (650)
Elongation at Break, %	180	100
Hardness, durometer A	68	62
After 70 hr at 24 °C (75 °F) in Benzene		
100% Modulus, MPa (psi)	5.0 (725)	4.6 (675)
Tensile Strength, MPa (psi)	11.2 (1,625)	8.4 (1,225)
Elongation at Break, %	200	150
Hardness, durometer A	71	67
Volume Change, %		
After 70 hr in Stauffer Blend 7700 at 200 °C (392 °F)	+14	+20
After 7 days in Tricresyl Phosphate at 149 °C (300 °F)	+11	+19
After 336 hr in Mobil Jet Oil II at 200 °C (392 °F)	+16	+26
After 70 hr in Benzene at 24 °C (75 °F)	+11	+15

* The Viton™ B used in this comparison was precompounded with Viton™ Curatives No. 20 and No. 30 in the following proportions: Viton™ B, 93.2; Viton™ Curative No. 20, 3.0; Viton™ Curative No. 30, 3.8. Viton™ E-60C is precompounded from Viton™ E-60, a member of the A-family. Its composition is: Viton™ E-60, 94.35; Viton™ Curative No. 20, 1.65; Viton™ Curative No. 30, 4.0.

Solution Properties

Uncured Viton™ B fluoroelastomer is soluble in a number of highly polar solvents (such as methyl ethyl ketone, methyl isobutyl ketone, acetone, ethyl acetate, and dimethylformamide) and, so, can be used in a variety of solution applications. The solution viscosity of Viton™ B compounds is higher than that of Viton™ A compounds. Smooth, workable solutions with solids contents in the range of 20–35% may be obtained. These solutions may be cast to form unsupported films or used as coatings on a variety of substrates, including fabrics and metals.

Solutions can be prepared by ball milling the metal oxide and filler in solvent and combining this with a solvent solution of Viton™ B. The curing agents can then be stirred into each batch as necessary. A preferred procedure is to mix the compounding ingredients into Viton™ B on a rubber mill and then dissolve the compounded stock in the solvent. Coatings or unsupported films of Viton™ B made from methyl ethyl ketone solutions will dry to the touch in approximately 20 min. Sufficient time, depending on film thickness, should be allowed for complete evaporation of the solvent prior to curing at high temperatures. To avoid blistering at temperatures of 204 °C (400 °F) and above, it is advisable to use the stepwise system of approaching the curing temperature.

The Diak™ curing agents are the preferred curatives for solution applications. The effect of Diak™ No. 1 and Diak™ No. 3 on the pot life and cure rate of a solution of Viton™ B is shown in Table 6. The solution containing Diak™ No. 1 is less stable, but has a faster cure rate than the one containing Diak™ No. 3. Higher temperature cures are needed with the more stable solutions to develop optimum film strength.

Table 6. Properties of Cast Films of Viton™ B

Compound	7A	7B
Viton™ B	100	100
Low-Activity MgO	15	15
MT Carbon Black (N908)	20	20
Diak™ No. 1	1	—
Diak™ No. 3	—	2
Methyl Ethyl Ketone	540	540
Solution Properties		
Solution Viscosity, Brookfield, MPa·s (cP)		
After 1 day at 24 °C (75 °F)	360 (360)	340 (340)
After 3 days at 24 °C (75 °F)	680 (680)	360 (3,601)
After 6 days at 24 °C (75 °F)	Gel	440 (440)
After 14 days at 24 °C (75 °F)	—	Gel
Film Properties		
Stress/Strain Properties (Films 0.635 mm [0.025 in] Thick)		
100% Modulus, MPa (psi)		
Cured 7 days at 24 °C (75 °F)	2.6 (375)	1.4 (200)
Cured 30 min at 149 °C (300 °F)	3.8 (550)	3.2 (475)
Cured 8 hr at 149 °C (300 °F)	4.0 (575)	4.2 (600)
Step-Cure, Then 24 hr at 204 °C (400 °F)	4.4 (650)	4.6 (675)
Tensile Strength, MPa (psi)		
Cured 7 days at 24 °C (75 °F)	7.2 (1,050)	4.0 (575)
Cured 30 min at 149 °C (300 °F)	12.6 (1,825)	9.6 (1,400)
Cured 8 hr at 149 °C (300 °F)	12.8 (1,850)	12.4 (1,800)
Step-Cure, Then 24 hr at 204 °C (400 °F)	17.2 (2,500)	14.4 (2,100)
Elongation at Break, %		
Cured 7 days at 24 °C (75 °F)	300	1160
Cured 30 min at 149 °C (300 °F)	260	460
Cured 8 hr at 149 °C (300 °F)	260	310
Step-Cure, Then 24 hr at 204 °C (400 °F)	260	310

Basic Compounding

Compounding of Viton™ B follows the same general principles and uses the same basic compounding ingredients as compounding of other types of Viton™ fluoroelastomers.

Curing Agents

Viton™ B can be vulcanized with either diamine or dihydroxy curatives. The type and level of metal oxide selected will vary with the basic cure system used. Otherwise, selection of compounding ingredients for either cure system is based on the properties desired.

Diamine Curatives

The diamine curing agents (Diak™ Nos. 1, 3, and 4) cure Viton™ B effectively at 149–163 °C (300–325 °F) and, as a class, give compounds that bond well to metals during vulcanization. However, diamine-cured Viton™ B exhibits a greater tendency to stick to and cause fouling of molds than does Viton™ B cured with Viton™ Curative masterbatches.

Diak™ No. 1 gives the best physical properties and compression set resistance of the diamines. However, it gives compounds with the poorest processing safety (i.e., the least resistance to scorching). The normal amount used is about 1.5 phr.

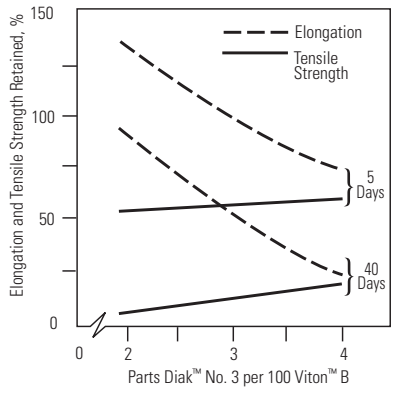
Diak™ No. 3 is a blocked curative that provides improved processing safety (i.e., longer scorch times) in stocks of Viton™. The normal amount used is 3 phr. It has a plasticizing effect, which improves processing characteristics. Compression set resistance of compounds cured with Diak™ No. 3 can be improved significantly by post-curing 24 hr at 260 °C (500 °F).

As the amount of diamine curative used increases, scorch time decreases, compression set resistance is improved, and resilience is lowered. In addition, the amount of curing agent has a marked effect on the heat-aging characteristics of Viton™ B, as shown in Figure 1 with Diak™ No. 3. As the concentration of curing agent is increased, the tensile strength retained increases slightly, but the elongation retained decreases considerably. Thus, in choosing the optimum amount of curing agent for a certain application, it is necessary to consider the properties required before and after aging.

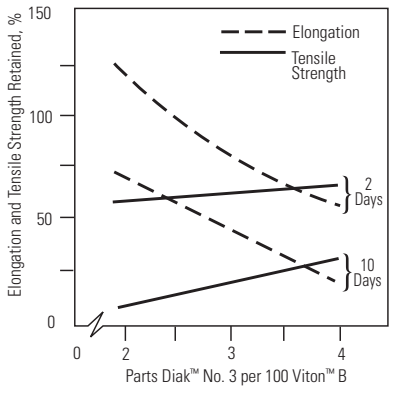
For more detailed information on Diak™ curing agents, see Chemours' technical bulletin, "Diak™ Curing Agents."

Figure 1. Effect of Diak™ No. 3 on Dry Heat Aging of Viton™ B

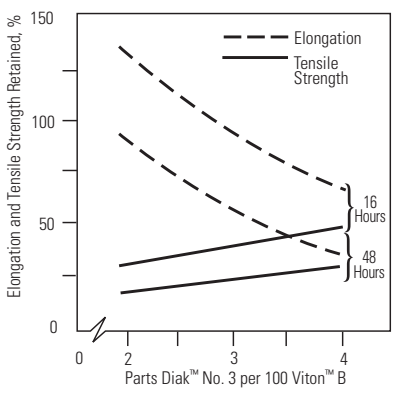
1a. Oven-Aging at 260 °C (500 °F)



1b. Oven-Aging at 288 °C (550 °F)



1c. Oven-Aging at 316 °C (600 °F)

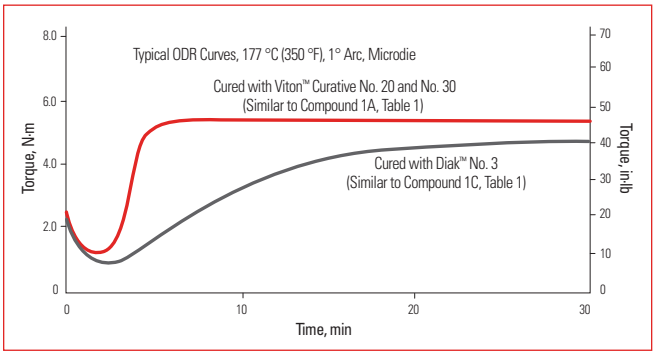


Compound	
Viton™ B	100
Low-Activity MgO	15
MT Carbon Black (N908)	20
Diak™ No. 3	As Shown
Cure: Press—30 min at 149 °C (300 °F) Oven—Step-Cure to 204 °C (400 °F) plus 24 hr at 204 °C (400 °F)	

Dihydroxy Curatives (Viton™ Curative Masterbatches)
Viton™ Curatives Nos. 20, 30, and 40 can be used with Viton™ B to give more processing safety, faster cure rates, and improved compression set resistance compared with the diamine curing agents. Vulcanizate properties can be varied selectively by adjusting the amounts of the curative masterbatches.

The oscillating disk rheometer (ODR) curves in Figure 2 show typical cure characteristics of a compound of Viton™ B cured with Viton™ Curatives Nos. 20 and 30 compared to one cured with Diak™ No. 3. The compounds have equivalent scorch characteristics at 121 °C (250 °F). Note the much faster rate of cure of the compound containing curative masterbatches. The use of curative masterbatches gives the formulator much more latitude in controlling cure rate and cure state than was previously available.

Figure 2. Comparison of Cure Characteristics of Compounds of Viton™ B Cured with Viton™ Curative Nos. 20 and 30 and Diak™ No. 3



Compression set and other physical properties provided by the two cure systems can be compared with Compounds 1A, 1D, and 1E in Table 1.

Viton™ B can be cured at lower temperatures (130–155 °C [266–311 °F]) by using Viton™ Curative No. 40 instead of Curative No. 30. Tensile strength and elongation are higher with Curative No. 40, while modulus and hardness are lower. Compression set resistance is not as good as that achievable with Viton™ Curative No. 30, but better than that obtained with Diak™ No. 3.

Detailed information on adjusting stock and vulcanizate properties with Viton™ curative masterbatches can be found in Chemours' technical bulletin, "Viton™ Curatives Nos. 20, 30, and 50."

Combinations of Diak™ No. 3 and Viton™ Curative No. 20
Diak™ No. 3 provides good processing safety and adhesion to metal. However, it is slow-curing compared to the dihydroxy curing system (Viton™ Curatives Nos. 20 and 30). Viton™ Curative No. 20 can be added to compounds of Viton™ B fluoroelastomer cured with Diak™ No. 3 curing agent to increase cure rate and cure state with minimal effect on processing safety. As little as 0.75 phr Viton™ Curative No. 20, used in combination with 2.5 phr Diak™ No. 3, provides a marked acceleration of cure rate at 177 °C (350 °F). At 3 phr of Viton™ Curative No. 20, cure rate is very similar to that obtained with Viton™ E-60C (with some sacrifice in processing safety and some improvement in compression set resistance).

Metal Oxides

Metal oxides are used as acid acceptors. They help to absorb small amounts of acidic materials that may be given off at high temperatures, and they also promote the curing reaction in most formulations of Viton™. The most common metal oxide used in compounds of Viton™ B cured with Diak™ curing agents is a low-activity grade of magnesium oxide (magnesia). When the Viton™ Curative masterbatches are used, the usual metal oxides are calcium hydroxide in combination with high-activity magnesium oxide.

When curing thick cross-sections, calcium oxide (15 phr) is useful in place of magnesium oxide. It helps to prevent fissuring by reacting with the moisture given off during curing. It also reduces shrinkage during curing and improves compression set resistance. On the negative side, calcium oxide reduces the bin storage stability of mixed compounds. Also, vulcanizates containing it have a tendency to absorb atmospheric moisture (a problem not encountered with magnesia).

Fillers

Tables 7 and 8 show the effects of various fillers on the stock and vulcanizate properties of compounds of Viton™ B. Because mineral fillers tend to retard cure, stocks containing them were cured with 4 parts of Diak™ No. 3; whereas, gum and black stocks were cured with 3 parts of Diak™ No. 3.

Table 7. Fillers in Viton™ B

Viton™ B	100							
Low-Activity MgO	15							
Fillers	As Indicated							
Diak™ No. 3	As Indicated							
Compound	**8A**	**8B**	**8C**	**8D**	**8E**	**8F**	**8G**	**8H**
Filler Type	No Filler	MT Black (N908)	MT Black (N908)	MT Black (N908)	FEF Black (N550)	Precip. Whiting*	Blanc Fixe	Silica with Silicone Oil**
Filler Amount, phr	—	20	40	60	20	30	45	25
Diak™ No. 3, phr	3	3	3	3	3	4	4	4
Stock Properties								
Mooney Scorch, MS at 121 °C (250 °F)								
Minimum Viscosity, units	58	71	79	88	85	60	64	77
Time to 10-unit rise, min	21	20	18	16	17	8	18	17
Vulcanizate Properties								
Press Cured: 30 min at 149 °C (300 °F), followed by Oven; Step-Cure to 204 °C (400 °F), followed by 24 hr at 204 °C (400 °F)								
Stress/Strain and Hardness								
Original								
100% Modulus, MPa (psi)	1.4 (200)	3.8 (550)	5.8 (850)	8.0 (1,150)	7.0 (1,025)	7.2 (1,050)	4.4 (650)	5.6 (800)
Tensile Strength, MPa (psi)	15.4 (2,225)	15.5 (2,250)	14.8 (2,150)	14.4 (2,100)	14.6 (2,125)	16.6 (2,400)	14.8 (2,150)	15.6 (2,250)
Elongation at Break, %	460	390	340	220	180	200	320	400
Hardness, durometer A	62	74	84	91	82	79	74	82
After Oven-Aging 10 days at 260 °C (500 °F)								
Tensile Strength, % Retained	36	35	38	41	43	50	38	33
Elongation, % Retained	156	121	118	118	133	140	106	70
Hardness, Points Change	+4	+3	+4	+ 3	+7	+6	+7	+3
Compression Set, Method B, % Pellets, 28.7 mm × 12.7 mm Diameter (1.13 in × 0.5 in) Thick								
After 70 hr at 121 °C (250 °F)	32	27	29	30	35	20	25	40

*Super Multiflex was used.
**Mixture of 100 parts silica (Hi-Sil 233) and 20 parts silicone oil (LM-3)

Table 8. Effect of Austin Black on Properties of Viton™ B

Compound	9A	9B
Viton™ B	100	100
Calcium Oxide	15	15
MT Carbon Black (N908)	25	20
Austin Black	—	20
Diak™ No. 3	3	3
Stock Properties		
Mooney Scorch, MS at 121 °C (250 °F)		
Time to 10-unit rise, min	16	15
ODR, 30 min at 177 °C (350 °F)		
Time to Torque of 5.6 N·m (50 in·lb)	16	12
Vulcanizate Properties		
Press Cured: 20 min at 177 °C (350 °F); Oven Cured: 24 hr at 260 °C (500 °F)		
Stress/Strain and Hardness		
Original		
100% Modulus, MPa (psi)	4.8 (700)	7.4 (1,075)
Tensile Strength, MPa (psi)	10.4 (1,500)	10.2 (1,475)
Elongation at Break, %	220	240
Hardness, durometer A	80	85
After Oven-Aging 70 hr at 275 °C (528 °F)		
100% Modulus, MPa (psi)	4.2 (600)	5.8 (850)
Tensile Strength, MPa (psi)	6.6 (950)	5.8 (850)
Elongation at Break, %	220	100
Hardness, durometer A	84	88
Compression Set, Method B, %		
O-Rings, 25.4 mm × 3.5 mm (1.0 in × 0.139 in)		
After 70 hr at 200 °C (392 °F)	59	41
After 336 hr at 200 °C (392 °F)	93	79
After 70 hr at 232 °C (450 °F)	85	56
Pellets, 28.7 mm × 12.7 mm Diameter (1.13 in × 0.5 in) Thick		
After 70 hr at 200 °C (392 °F)	26	27
After 336 hr at 200 °C (392 °F)	47	47
After 70 hr at 232 °C (450 °F)	43	44

Black Fillers

MT carbon black is the most common filler used with all types of Viton™ fluoroelastomers, including Viton™ B. It gives a good balance of physical properties, as well as good heat-aging characteristics. At equal loading, the more highly reinforcing carbon blacks, such as FEF black, give higher stock viscosities, increased modulus, higher tensile strength at elevated temperatures, increased hardness and compression set, and reduced elongation.

Austin Black is a low specific gravity (1.22) filler for Viton™, which gives compounds with improved high-temperature compression set resistance. Austin Black is seldom used as the only filler because it produces compounds that do not process well and have low tensile strength. However, combinations of MT carbon black and Austin Black yield a fast cure rate and good tensile strength, along with improved compression set resistance, compared with MT carbon black alone (see Table 8). Such combinations also improve processing characteristics relative to Austin Black alone. A concentration of 20 parts of Austin Black has been found optimum with respect to compression set resistance, with greater amounts showing no further improvement. Post-curing at 260 °C (500 °F) is necessary to obtain optimum compression set resistance.

Non-Black (Mineral) Fillers

A wide variety of mineral fillers can be used with Viton™ B. Some examples are cited below.

Precipitated whiting gives the best electrical properties, particularly DC resistivity. It also provides good aging properties. Processing safety (scorch time) is somewhat poorer than with other fillers.

Blanc fixe is a good general-purpose mineral filler for compounds of Viton™. It yields vulcanizate physical properties similar to those obtained with MT carbon black.

Fine particle size silica generally produces stiff, difficult-to-process stocks, unless it is used in conjunction with a compatible plasticizer. A treated silica usually produces an easier-processing stock.

Nyad® 400 is a good non-black filler that produces a fast cure rate and excellent compression set resistance, but somewhat low elongation.

Fibrene® C-400 yields vulcanizates with low tensile strength and poor compression set resistance, relative to other fillers.

Celite® 350 is a good non-black filler that produces a fast cure rate and excellent compression set resistance. Original elongation tends to be on the low side.

Titanium dioxide (rutile grades) permits the preparation of white compounds of Viton™ with good physical properties. Properties of such compounds after heat aging are not quite as good as those obtained with compounds made with MT black or other mineral fillers.

Pigments

Pigments can be added to all mineral-filled compounds to produce a colored stock. Non-pigmenting fillers will produce a mass tone, while titanium dioxide will produce a pastel. Less than 1 phr of suitable organic pigments should be sufficient. Pigments used must be stable at normal processing, curing, and service temperatures for compounds of Viton™ fluoroelastomer.

Processing Aids

VPA Nos. 1 and 2 are useful as processing aids for Viton™ B fluoroelastomer. VPA No. 1 is a general-purpose processing aid that provides excellent mill and mold release. It has little or no effect on vulcanizate properties and is useful in all types of molded goods.

VPA No. 2 is an extrusion aid. It has some adverse effect on high-temperature compression set, but is an excellent processing aid for all types of extruded goods where the ultimate in compression set resistance is not required.

At a concentration of 2 phr, both VPA Nos. 1 and 2 produce an additional 0.3–0.4% shrinkage after post-cure. More information on the use of these processing aids can be found in Chemours' technical bulletin, "Processing Aids for Viton™: VPA No.1 and VPA No. 2."

Mixing

Compounds of Viton™ B can be mixed on a conventional two-roll rubber mill or in an internal mixer (e.g., Banbury) using the same procedures that are used with other fluoroelastomers.

Mill Mixing

Mill mixing of Viton™ B should be carried out on as cold a mill as possible. Mixing should start with a tight nip; once Viton™ B has bonded, the nip can be opened for compounding. When Diak™ curing agents are used, the fillers, metal oxides, and curing agents should be blended together before they are added to the polymer. If the stock is particularly scorchy, the curing agent should be held until the end of the mix or added after the stock has cooled. For best dispersion, the stock should be allowed to "rest" for 16–24 hr and then refined on a cold, tight mill.

When Viton™ Curative masterbatches are used in mill mixing, they may be added to the base polymer band on the mill. The polymer and masterbatches should be well blended before adding any other ingredients.

Internal Mixing

Mixing of stocks of Viton™ B in an internal mixer is best accomplished with a load factor of about 70%. Higher load factors might result in scorch problems, while lower load factors may fail to "grab." Experience has shown that a "sandwich" of polymer surrounding the powders is usually effective. At higher fill or loading, the powders may be added first as an alternative.

With internal mixing, Diak™ curing agents should be added on a cool mill after the batch has been dumped. Viton™ Curative masterbatches are usually added along with the base polymer, unless the stock is scorchy. In such cases, the curatives can be added during a short second pass in the mixer or on a cool mill.

Cooling Mixed Stock

Stock can be cooled by a water dip or spray, but residual moisture must be removed before stacking. After cooling to approximately 35 °C (95 °F), the slabbed compound can be stacked. No partitioning agent should be required; however, talc can be used if desired. Stearates should be avoided.

Storage of Mixed Stock

Excessive humidity can seriously affect the scorch safety of Viton™ B compounds. Storage at 18 °C (65 °F) and low humidity is recommended. Warming to room temperature for 4 hr before milling will minimize problems from water that may condense on the surface of the stock.

Table 9 is a guideline for the approximate bin storage stability of typical compounded stocks of Viton™ containing the different Diak™ curing agents. A stock compounded for comparable cure rate with Viton™ Curatives Nos. 20 and 30 would have storage stability similar to that of the compound with Diak™ No. 3.

Table 9. Bin Storage Stability of Stocks of Viton™ Compounded with Diak™ Curing Agents

Time to 20-unit rise in Minimum Viscosity (Measured by MS at 121 °C [250 °F])		
	Storage Conditions	
Compound	38 °C (100 °F)/ 50% RH	38 °C (100 °F)/ 100% RH
Viton™ B/Diak™ No. 1	2 weeks	4 days
Viton™ B/Diak™ No. 3	>6 months	2 weeks

Extrusion

Stocks of Viton™ B for extrusion should be dry and free of surface moisture to avoid blistering in the extrudate. Cold-feeding of the stock is recommended.

Best results are obtained with a relatively cool barrel and screw (50–80 °C [122–176 °F]). When using a processing aid, it is best to keep the feed zone cool relative to the head and die (to avoid stock slippage).

If the compound contains Diak™ curing agents, a cool die (50–70 °C [122–158 °F]) with a long land should be used. With the Viton™ Curative masterbatches, a warm to hot die (100–120 °C [212–248 °F]) can be used.

Calendering

Compounds of Viton™ B can be calendered into smooth sheets with the middle roll of the calender at 40–50 °C (104–122 °F) and the top roll as hot as possible without causing sticking (95–100 °C [203–212 °F]). The stock should not be permitted to band on the calender rolls.

A good processing aid such as carnauba wax or VPA No. 1 should be included in compounds that are to be calendered. The feedstock to the calender should be uniform in temperature and viscosity.

Compounds containing Diak™ No. 3 will typically calender more smoothly than compounds containing Viton™ Curatives Nos. 20 or 30. Therefore, smaller quantities of processing aids such as VPA No. 1 may be required.

Molding and Curing

Stocks of Viton™ B compounded with Diak™ curing agents may be cured at temperatures as low as 160 °C (320 °F); but when using curative masterbatches, 170 °C (338 °F) is a minimum temperature if practical cure times are desired. These are guidelines for a simple, compression-molded part; in transfer molding or compression molding, where the stock flows significantly, enough shear heat may result to shorten "expected" cure times significantly.

To attain maximum physical properties, cured parts of Viton™ B must also be oven post-cured for 24 hr at a temperature between 200–260 °C (392–500 °F). For more information, see Chemours' technical bulletin, "Effect of Oven Post-Cure Cycles on Vulcanizate Properties." Parts thicker than 6 mm (0.25 in) should be step-post-cured to avoid internal fissuring.

Test Procedures

Property Measured	Test Procedure
Abrasion Resistance, Taber	ASTM D3389
Brittleness Temperature	ASTM D746
Clash-Berg Stiffness	ASTM D1043
Compression Set, Pellets	ASTM D395, Method B, 25% deflection
O-Rings	ASTM D1414
Fluid Resistance (Property change after immersion in fluids)	ASTM D471
Hardness	ASTM D2240, durometer A
Heat-Aging Resistance (Property change after aging in air oven)	ASTM D573
Mooney Scorch	ASTM D1646, using the small rotor. Minimum viscosity and time to 5- or 10-unit rise are reported.
Mooney Viscosity	ASTM D1646, using the large rotor. Polymer viscosity reported after 10 min.
ODR (Vulcanization characteristics measured with an oscillating disk cure meter)	ASTM D2084
Ozone Resistance	ASTM D1149, Procedure B (bent loop specimen)
Resilience, Yerzeley	ASTM D945
Retraction Temperature	ASTM D1329
Solution Viscosity	Brookfield viscometer ASTM D1084
Specific Gravity (polymer)	ASTM D792
Stress/Strain Properties 100% Modulus Tensile Strength Elongation at Break	ASTM D412, Die C
Tear Strength, Die B	ASTM D624, Die B

Note: Test temperature is 24 °C (75 °F), except where specified otherwise.

For more information, visit Viton.com

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