

Vulcanized compounds based on SEPTON™ BIO-series for shoe sole

- Vulcanized and PO crosslinking -




Elastomer R&D department

Elastomer division

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Excellent grip performance

Sample is showing the wet grip function

	Golf grip	Grip tape (Tennis etc.)	Shoe sole
			
Molding	Injection	Calender Extrusion	Compression
V or Non-V	Non-V	Non-V	V

Formulation and properties for shoe sole (Target: Hs=60A±5)

Sample Name	Target	V-16	V-22	SBR	BIIR		
SEPTON™ BIO-series	SF904	100	100				
E-SBR	JSR1502			100			
BIIR	BROMO BUTYL 2244				100		
Sulfur ¹⁾	OT-20	2.25					
Sulfur ²⁾				1.8	1.8		
Peroxide	Perhexa25B-40		4				
ZnO		3		3	3		
Stearic acid		1		1	1		
Vulcanization accelerator	DM	1.1		1.1	1.1		
	TT	1.1		1.1	1.1		
Silica	7000GR	10	10	25	25	Molding conditions	
Silane coupling	Si-69			1.5	1.5	(1)Tensile test piece (0.5mmt) : Tc(90) x 1.2	
Polyethylene glycol	PEG4000			1.5	1.5	(2)DIN test piece (8mmt) : Tc(90) x 1.5	
EVA	EVA 560 (Tm= 90 deg.C)	15	15				
Tc(90)	160deg.C	min	-	-	5.4	17	V-16: (1)180deg.C, 3.8min. (2)180deg.C, 4.8min.
	180deg.C	min	3.2	7.5	-	-	
Coefficient of static friction	Dry	>5	6.4	7.1	3.1	4.7	V-22: (1)180deg.C, 9.0min. (2)180deg.C, 11.3min.
	Wet	>2.5	3.9	2.8	1.4	2.3	
Specific gravity		<1	0.96	0.94	1.09	1.02	
Hardness	Type A	60±5	58	57	59	49	SBR: (1)160deg.C, 6.5min. (2)160deg.C, 8.1min.
Tensile strength	MPa	>12	16	16	8.9	12	
Elongation	%	>700	830	710	220	560	
Tear strength	kN/m	>30	33	33	33	24	BIIR: (1)160deg.C, 20.4min. (2)160deg.C, 25.5min.
DIN abrasion	Mm ³	<200	202	279	146	846	

Formulation and properties for shoe sole (Target: Hs=65A±5)

Sample Name	Target	V-26	V-41	SBR	BIIR	
SEPTON™ BIO-series	SF904	100	100			
E-SBR	JSR1502			100		
BIIR	BROMO BUTYL 2244				100	
Sulfur ¹⁾	OT-20	2.25				
Sulfur ²⁾				1.8	1.8	
Peroxide	Perhexa25B-40		4			
ZnO		3		3	3	
Stearic acid		1		1	1	
Vulcanization accelerator	DM	1.1		1.1	1.1	
	TT	1.1		1.1	1.1	
Silica	7000GR	10	10	25	25	
Silane coupling	Si-69			1.5	1.5	
Polyethylene glycol	PEG4000			1.5	1.5	
EVA	VA=14wt% (Tm= 90 deg.C)	25	25			
Bio-LDPE			10			
Tc(90)	160deg.C	min	9.5	-	5.4	17
	180deg.C	min	-	6.8	-	-
Coefficient of static friction	Dry	>5	6.9	5.8	3.1	4.7
	Wet	>2.5	2.6	2.1	1.4	2.3
Specific gravity		<1	0.97	0.94	1.09	1.02
Hardness	Type A	65±5	61	61	59	49
Tensile strength	Mpa	>12	18	12	8.9	12
Elongation	%	>700	770	560	220	560
Tear strength	kN/m	>30	50	48	33	24
DIN abrasion	mm ³	<200	138	209	146	846

Molding conditions
(1)Tensile test piece (0.5mmt)
: Tc(90) x 1.2
(2)DIN test piece (8mmt)
: Tc(90) x 1.5

V-26: (1)160deg.C, 11min.
(2)160deg.C, 14min.

V-41: (1)180deg.C, 8.2min.
(2)180deg.C, 10min.

SBR: (1)160deg.C, 6.5min.
(2)160deg.C, 8.1min.

BIIR: (1)160deg.C, 20.4min.
(2)160deg.C, 25.5min.

Materials

SEPTON™ BIO-series SF904 (Kuraray Co., Ltd.)

E-SBR : JSR1502 / Mooney viscosity(100deg.C)=52, Bound styrene=23.4% (JSR Corporation)

BIIR : BROMO BUTYL2244 / Mooney viscosity(125deg.C)=46, Halogen content=2mol% (JSR Corporation)

Sulfur ¹⁾ : MUCRON OT-20 / oil con't=20wt% (Shikoku Chemicals Corporation)

Sulfur ²⁾ : GOLDEN FLOWER 200mash (Tsurumi Chemical Industry Co., Ltd.)

Peroxide : Perhexa® 25B-40 / Purity=40% (NOF Corporation)

ZnO (Sakai Chemical Industry Co., Ltd.)

Stearic acid : Lunac S-50 (Kao Corporation)

Vulcanization accelerator : DM (Ouchi Shinko Chemical Industrial Co., Ltd.)

Vulcanization accelerator : TT (Ouchi Shinko Chemical Industrial Co., Ltd.)

Silica : Ultrasil® 7000GR (Evonik Industries)

Silane coupling agent : Si69 (Evonik Industries)

Polyethylene glycol : PEG3400 (MP Biomedicals LLC)

EVA : VA con't=14%, MFR=3.4g/10min

Bio-LDPE: Bio-based cont.:95%, MFR=30g/10min

Friction coefficient measurement method that assumes the shoes

Condition

Load

2N



22.6N



50.4N



Load/ Area

0.05N/cm²
(General)

0.54N/cm²

1.26N/cm²

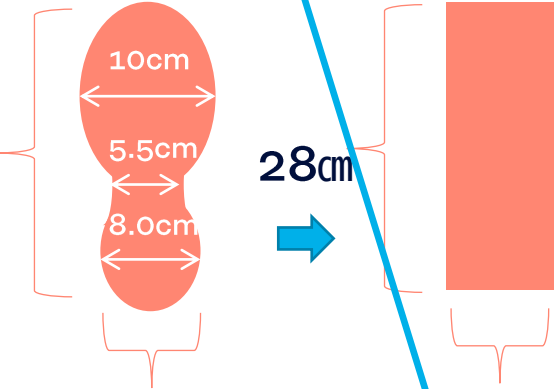
Grip



The area of the hand: 140cm² (Men average)
 Grip: 10 - 30kg (98 - 294N)
 Load/ Area: 98N/ 140cm²×2 = 0.35N/cm²
 294N/140cm²×2 = 1.05N/cm²

Shoes

28cm
(Sole)



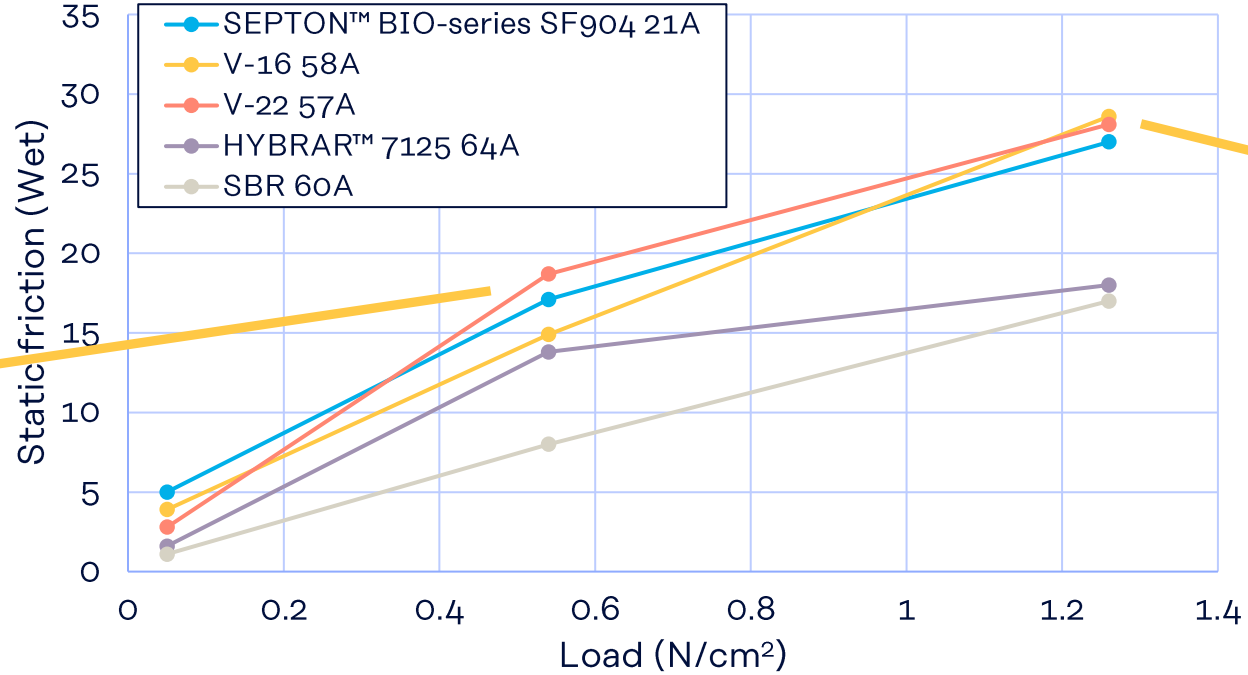
Average: 7.8cm

7.8cm

Ave. 0.70N/cm²

Body weight: 65kg (Man average)
 Load/ Area: 637N / 218×2cm² = 1.46N/cm²

Relationship between load and wet grip



SEPTON™ BIO-series SF904 based compound (Target: Hs=60A±5)

		SEPTON™ BIO-series SF904	V-16	V-22	SBR
Hardness	Type A	21	58	57	60
Static friction force (Wet)	Load	0.05N/cm²	3.9	2.8	1.1
		0.54N/cm²	15	19	8.0
		1.26N/cm²	27	28	17

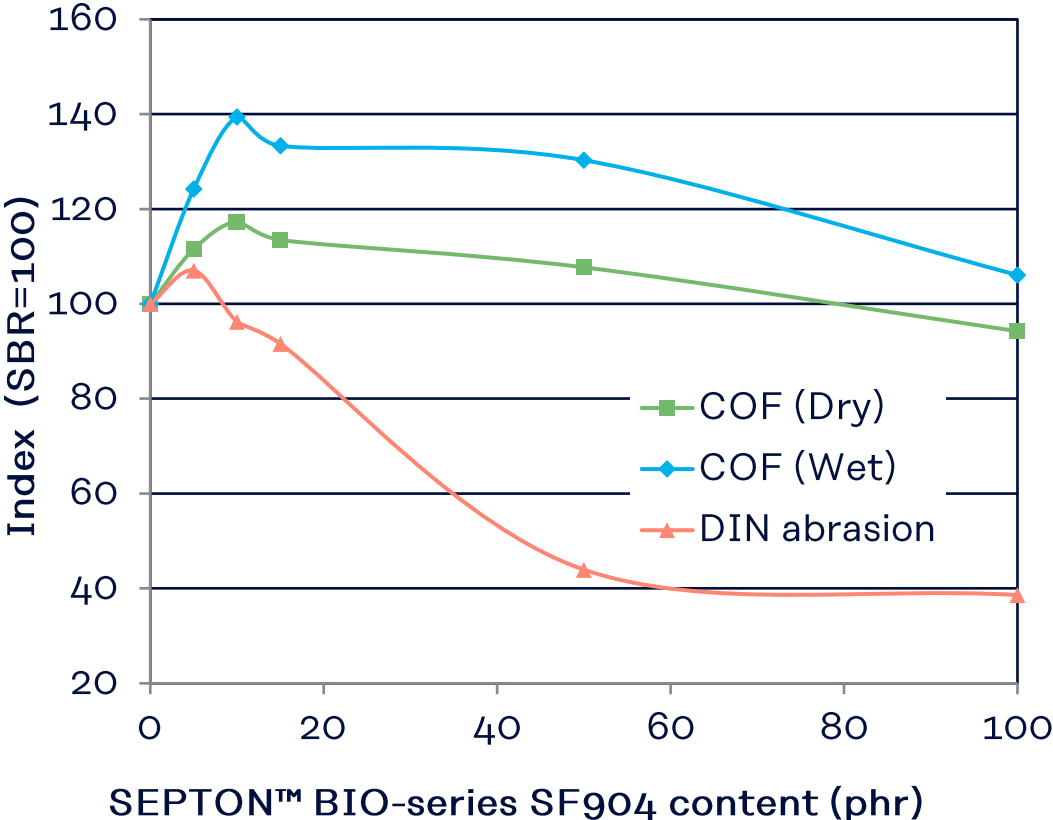
Evaluation of SBR / SEPTON™ BIO-series combined system

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Coefficient of static friction (Dry, Wet), DIN abrasion

Amount of SEPTON™ BIO-series SF904 : 5wt%, 10wt%
 Improved in grip performance, less decreased DIN abrasion



Content of SEPTON™ BIO-series SF904 in polymer (wt%)	COF		DIN abrasion (Index)
	Dry	Wet	
0	100	100	100
5	112	124	107
10	117	139	96.2
15	113	133	91.6
50	108	130	43.9
100	94.2	106	38.6

*COF=Coefficient of static friction

Formulation and mechanical properties

		SB-7	SB-8	SB-9	SB-10	SB-11	SB-12
E-SBR	SBR1502	100	95	90	85	50	
SEPTON™ BIO-series	SF904		5	10	15	50	100
ZnO		3	3	3	3	3	3
Stearic acid		1	1	1	1	1	1
Silica	7000GR	35	35	35	35	35	35
Si-75		3	3	3	3	3	3
Sulfur	OT-20	2.25	2.25	2.25	2.25	2.25	2.25
Vulcanization accelerator	DM	1.1	1.1	1.1	1.1	1.1	1.1
	TT	1.1	1.1	1.1	1.1	1.1	1.1
Coefficient of static friction	Dry	5.2	5.8	6.1	5.9	5.6	4.9
	Wet	3.3	4.1	4.6	4.4	4.3	3.5
Specific gravity		1.12	1.12	1.12	1.11	1.10	1.08
Hardness	Type A	64	66	65	65	67	66
Tensile strength	MPa	14	13	12	12	7.2	21
Elongation	%	260	240	230	230	130	700
Tear strength	kN/m	62	50	51	51	37	62
DIN abrasion	mm ³	73	71	79	83	173	197

Material

E-SBR : JSR1502 Mooney viscosity (100deg.C): 52, Bound styrene: 23.4% (JSR Corporation)

SEPTON™ BIO-series: SF904

ZnO (Sakai Chemical Industry Co., Ltd.)

Steric acid: Lunac S-50 (Kao Corporation)

Silica: Ultrasil® 7000GR (Evonik Industries)

Silane coupling agent: Si75 (Evonik Industries)

Sulfur: OT-20 Total sulfur 78-82% (Shikoku Chemicals Corporation)

Vulcanization accelerator: DM (Ouchi Shinko Chemical Industrial Co., Ltd.)

Vulcanization accelerator: TT (Ouchi Shinko Chemical Industrial Co., Ltd.)

Kneading conditions

Equipment

Plastograph EC 50cc (Brabender GmbH & Co. KG)

Process

1) Kneading step 1 x 2

Rubber temp. = 150 deg.C, 5 min. x 2

⇒ Polymer, ZnO, Stearic acid, Silica, Silane coupling agent etc.

a) Si75 is reactive to both silica and rubber

b) If you use Si69, you need to keep the rubber temp. below 140 deg.C.



2) Kneading step 2

Rubber temp. = < 100 deg.C (for w/o curing)

⇒ Sulfur, Vulcanization accelerator



3) Sheeting (Compression molding, 160deg.C)

Measurement condition

Friction test

ASTM D1894

Sled size: 63.5mm×63.5mm

Sled weight: 200g

Friction table material: Aluminum

Test pull rate of 150mm/min

*Wet: To measure 1.0 cc of distilled water on the table

Hardness, Tensile strength, Elongation, Tear strength

Hardness: JIS K6253, Type A durometer

Tensile strength, Tensile Elongation: JIS K6251, Cross-head speed: 500mm/min.

Dumbbell :JIS No.3

Tear strength: JIS K6252 angle type

DIN abrasion

DIN abrasion tester (Toyo Seiki Seisaku-sho, Ltd.)

Abrasive cloth: Alumina grinding material grain size No. 60, 450×475mm

JISK6264, Load:10N, Distance :40m



Friction test

Recommended formulation for shoe soles

~ Rubber modification ~

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Recommended formulation

We recommend 7000GR as a silica and A189 as a silane coupling agent.

Step-1	E-SBR	JSR1502	90
	SEPTON™ BIO-series	SF904	10
	ZnO		3
	Stearic acid	Lunac S-50	1
	Silica	7000GR	35
	Silane coupling agent	A189	3
Step-2	Sulfur	#200	1.8
	Vulcanization accelerator	CZ	1.1
		TT	0.4
Tc90 160 deg. C	min	4.7	
Coefficient of static friction	Dry	6.4	
	Wet	3.4	
DIN abrasion	mm ³	111	

Materials

Key Points	{	E-SBR	: JSR1502 (JSR Corporation) bound styrene 23.4%, Mooney viscosity (100 deg. C): 52
		SEPTON™ BIO-series	: SF904 (Kuraray Co., Ltd.)
		Silica	: Ultrasil® 7000GR (Evonik Industries)
		Silane coupling agent	: Silquest® A-189 (Momentive Performance Materials Inc.)
		Zinc oxide (ZnO)	: Grade No. 1 (Sakai Chemical Industry Co., Ltd.)
		Stearic acid	: #200
		Sulfur	
		Vulcanization accelerator-1	: Nocceler CZ (Ouchi Shinko Chemical Industrial Co., Ltd.)
		Vulcanization accelerator-2	: Nocceler TT (Ouchi Shinko Chemical Industrial Co., Ltd.)

Recommended formulation for shoe soles

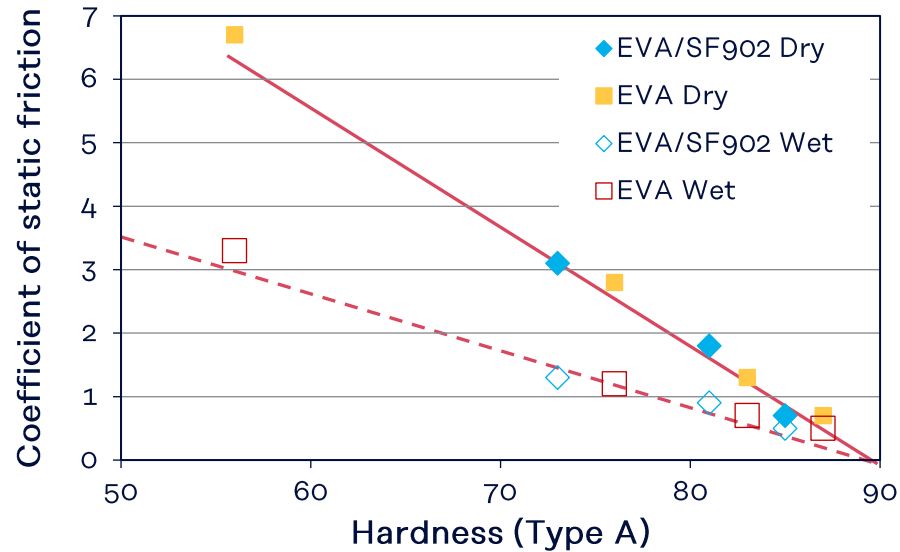
~ Cross-linked EVA foam modification ~

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Recommended formulations

- Strong correlation between grip performance and hardness



		Reference	SF904	SF902	
EVA (VA=19%)	EV460	100	70	90	
SEPTON™ BIO-series	SF904		30		
	SF902			10	
ZnO		2	2	2	
Stearic acid		1	1	1	
TiO ₂		4	4	4	
Dicumyl peroxide	PERCUMYL D-40	0.5	0.5	0.5	
Coefficient of static friction	Dry	Measured value	1.4	2.8	2.5
		Index	100	200	179
	Wet	Measured value	0.7	1.1	1.0
		Index	100	157	143
Hardness	Type A	65	54	57	

Materials

EVA	: EVAFLEX® EV460 (Dow-Mitsui Polychemicals Co., Ltd.) VA cont. 19 wt%, MFR 2.5 g/10min. (190 deg. C, 21N)
SEPTON™ BIO-series	: SF904 and SF902 (Kuraray Co., Ltd.)
Zinc oxide (ZnO)	: Grade No. 1 (Sakai Chemical Industry Co., Ltd.)
Stearic acid	: Lunac S-50 (Kao Corporation)
Titanium(IV) oxide (TiO ₂)	: A-100 (Ishihara Sangyo Kaisha, Ltd.)
Dicumyl peroxide	: PERCUMYL® D-40, purity: 40% (NOF Corporation)

Kuraray Co., Ltd.
Elastomer Division
Tokiwabashi Tower
2-6-4, Otemachi
Chiyoda-ku, Tokyo, 100-0004, Japan

✉ elastomer@kuraray.com

→ www.kuraray.com

→ www.elastomer.kuraray.com

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