

Natural Rubber

Engineering Data Sheet

1980

EDS 19

The Malaysian Rubber Producers' Research Association, Tun Abdul Razak Laboratory, Brickendonbury, Hertford SG138NL, England. A Malaysian Rubber Research and Development Board Organization.

The information in these sheets is believed to be reliable but the Association does not accept any responsibility for it. Users are reminded that these sheets may contain matter the subject of patent protection and they should therefore satisfy themselves as to the position and obtain any necessary licences before employing processes described therein.

Natural Rubber engineering vulcanizate: 0.47MPa shear modulus (43 IRHD)

Ref. no. MRPRA EDS 19

A conventional accelerated-sulphur vulcanizate containing no filler. This is the gum base of most of the vulcanizates in the series EDS 14 to 30. Suitable for most engineering applications at moderate and low temperatures with the addition of 1 part of black for u-v protection.

Formulation

	parts by weight
Natural rubber, SMR CV60	100
Zinc oxide	5
Stearic acid	2
Antioxidant/antiozonant, HPPD ¹	3
Antiozonant wax ²	2
CBS ³	0.6
Sulphur	2.5

- 1 N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine; Santoflex 13 (Monsanto) was used.
- 2 Sunproof Improved (Uniroyal) was used.
- 3 N-cyclohexylbenzothiazole-2-sulphenamide.

Where ingredients in MRPRA formulations are designated by trade names this indicates only that these were the materials used to develop the formulation and does not imply recommendation of specific trade materials. Chemically equivalent materials would normally be expected to give similar results.

Mix preparation and properties

Francis Shaw K1 Intermix, 3kg batch, 60°C, 45rev/min, 0.55MPa (80 lbf/in ²) ram pressure. 0min: add rubber. 1min: add ZnO, StA, HPPD, wax. 5½min: sweep down. 6min: discharge. Mix finalized on cold mill.	
Mooney viscosity (ISO/R289), ML1+4, 100°C	38
Mooney scorch (ISO 667), ts, 120°C, min	55.6
Monsanto Rheometer (ISO 3417), 140°C scorch, ts ₁ , min	15.8
time to 95% crosslinking, min	31.7

Vulcanizate properties

for press cure 45min at 140°C	
Density (ISO 2781), Mg/m ³	0.966
Hardness (ISO 48), IRHD	43
Tensile strength (TS) (ISO 37), MPa	26
Elongation at break (EB) (ISO 37), %	770
Modulus at 300% elongation (M300) (ISO 37), MPa	1.7
Relaxed modulus (MR100), MPa	0.77
Compression set (ISO 815)	
22h at 23°C, %	4
22h at 70°C, %	27
22h at 100°C, %	46
22h at 125°C, %	62
22h at 150°C, %	89
7 days at 23°C, %	7
7 days at 70°C, %	43
3 days at 100°C, %	54
Resilience, Lüpke (ISO 4662), %	89
Stress relaxation, bonded disk 13mm dia × 6.3mm	
20% compression, % per decade	2.1

Tear strength (ISO 34)

trouser, kN/m	8.0
angle, without nick, kN/m	31
angle, with 1mm nick, kN/m	10
creasent (with 1mm nick), kN/m	32

Tension fatigue, ring test pieces, kc to failure

strain	range	0%	12½%	25%	37½%
minimum strain					
50%	>2000	1502	>2000	>2000	>2000
75%	1568	792	1158	>2000	>2000
100%	301	392	452	>2000	>2000
125%	141	127	151	1075	1075
150%	45	50	80	182	182

Goodrich Flexometer (ISO 4666)

static stress IMPa, stroke 5.71mm, 30Hz, 100°C	
temperature increase after 120min, degC	5
Abrasion loss, Akron (BS 903:A9) dusted, mg/1000rev	1400

Ozone resistance (ISO 1431), 40°C, 20% strain

No cracks after 7 days at 100pphm ozone	
Resistance to liquids (ISO 1817), 70h at 100°C	
Oil No. 3, volume change, %	360
Water, volume change, %	7.4

Low temperature hardness (ISO 3387) IRHD

days	1	3	7	14	21	28
0°C	43	43	43	43	43	43
-10°C	44	44	47	46	47	45
-25°C	47	46	48	47	47	47
-40°C	43	44	46	47	47	48

Low temperature compression set (ISO 1653)

days	1	3	7	14	21	28
lubricated small disks, set after 30min recovery, %						
0°C	10	9	11	10	12	12
-10°C	6	8	9	10	13	13
-25°C	17	22	22	26	52	73
-40°C	19	19	22	19	22	19

Impact brittleness (ISO 812), -40°C

no failures

Air-oven ageing resistance (ISO 188)

increase in IRH, deg	decrease in TS and EB, %	increase in M300 and MR100, %	IRH	TS	EB	M300	MR100
			3	6	9	6	-1
3 days at 70°C			3	4	11	31	8
7 " " "			1	5	12	30	-3
14 " " "			4	8	12	24	-9
3 days at 100°C			-1	34	20	26	0
4 " " "			-2	51	31	47	4
7 " " "			-3	89	69	—	20
14 " " "			0	93	84	—	—
1 day(s) at 125°C			-8	94	67	—	-18
3 " " "			-8	95	87	—	—
1 day at 150°C			-3	93	95	—	—

EDS 19

Stress-strain characteristics

Shear modulus (0-2%)	0.49MPa
" (0-50%)	0.47MPa
Bulk modulus (calculated)	2000MPa

Static shear moduli

Chord modulus G_{ch} = stress/strain; tangent modulus G_{tan} = slope of stress-strain curve. Strain rate ~ 30%/min.

Strain, %	2	5	10	25	50	75	100	150	200	250	300	350
1st cycle G_{ch} , MPa	0.51	0.50	0.49	0.48	0.47	0.45	0.44	—	—	—	—	—
G_{tan} , MPa	0.50	0.49	0.48	0.47	0.44	0.42	0.42	—	—	—	—	—
10th cycle G_{ch} , MPa	0.49	0.49	0.48	0.48	0.47	0.46	0.44	0.42	0.42	0.42	0.42	0.45
G_{tan} , MPa	0.49	0.48	0.48	0.46	0.44	0.42	0.41	0.38	0.40	0.44	0.50	0.60

First nine cycles to 100% strain. Set at end of 9th cycle 1.6%.

Static compression moduli

Chord modulus E_{ch} = stress/strain; tangent modulus E_{tan} = slope of stress-strain curve. Strain rate 1-2%/min.

Diameter/thickness	2 (S = 0.5)				4 (S = 1)				8 (S = 2)			
	5	10	15	20	5	10	15	20	5	10	15	20
1st cycle E_{ch} , MPa	2.8	3.0	3.1	3.3	5.4	5.7	6.0	6.5	16.2	17.2	18.2	20
E_{tan} , MPa	3.0	3.3	3.5	3.8	5.7	6.3	7.2	8.2	17.2	19.4	22.2	27
10th cycle E_{ch} , MPa	2.8	3.0	3.1	3.3	5.4	5.7	6.0	6.3	15.9	16.9	17.8	19
E_{tan} , MPa	3.0	3.3	3.5	3.8	5.5	6.1	6.9	8.0	16.4	18.4	20.8	25
Max strain on 1st cycle	28%				29%				30%			
Set at end of 9th cycle	0.5%				1.2%				0.8%			
Diameter/thickness	12 (S = 3)				20 (S = 5)				32 (S = 8)			
	5	10	15	20	5	10	15	20	5	10	15	20
1st cycle E_{ch} , MPa	35	37	39	43	96	103	116	—	235	257	—	—
E_{tan} , MPa	37	41	48	61	100	114	179	—	244	375	—	—
10th cycle E_{ch} , MPa	34	36	38	40	91	97	105	—	219	237	—	—
E_{tan} , MPa	35	39	45	55	92	102	135	—	219	340	—	—
Max strain on 1st cycle	33%				25%				13%			
Set at end of 9th cycle	1.5%				1.7%				0.5%			

Dynamic shear moduli and phase angles

Shear modulus is the ratio of stress amplitude to strain amplitude. Mean strain is zero.

Frequency	0.1Hz			1Hz						15Hz			
	2	10	50	1	2	5	10	20	50	100	2	5	10
Shear modulus, MPa													
150°C	0.47	0.47	0.43	0.49	0.48	0.48	0.48	0.47	0.45	0.41	0.50	0.48	0.49
125°C	0.55	0.56	0.54	0.55	0.56	0.55	0.57	0.56	0.55	0.52	0.57	0.56	0.58
100°C	0.52	0.54	0.53	0.53	0.53	0.54	0.55	0.55	0.54	0.51	0.54	0.53	0.56
70°C	0.50	0.52	0.50	0.51	0.51	0.51	0.53	0.52	0.51	0.48	0.53	0.52	0.54
50°C	0.51	0.52	0.50	0.52	0.52	0.52	0.53	0.52	0.50	0.47	0.54	0.53	0.54
23°C	0.52	0.52	0.49	0.53	0.53	0.53	0.52	0.51	0.50	0.47	0.55	0.53	0.55
0°C	0.51	0.51	0.47	0.52	0.52	0.52	0.52	0.50	0.48	0.45	0.55	0.53	0.54
-10°C	0.50	0.51	0.47	0.52	0.52	0.52	0.52	0.50	0.49	0.45	0.57	0.55	0.57
-25°C	0.51	0.52	0.48	0.55	0.55	0.55	0.54	0.53	0.52	0.49	0.88	0.87	0.85
-40°C	0.59	0.58	0.53	1.08	1.07	0.99	0.93	0.86	0.78	0.62	4.40	3.77	2.70
Phase angle, degrees													
150°C	0.7	1.0	1.2	1.0	0.8	0.8	1.0	1.0	1.2	1.0	0.7	0.7	0.7
125°C	0.8	0.7	1.2	0.3	0.5	0.3	0.5	0.7	0.5	0.7	1.0	0.2	0.5
100°C	0.5	0.7	0.7	0.3	0.5	0.5	0.5	0.7	0.7	0.7	0.8	0.3	0.7
70°C	0.8	0.7	0.8	0.7	0.8	0.7	0.7	0.7	0.8	0.7	1.0	0.8	0.2
50°C	1.0	0.7	0.8	0.7	0.8	0.7	0.7	0.7	0.8	0.7	1.7	0.2	0.5
23°C	0.7	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.8	0.7	1.8	1.0	0.8
0°C	0.8	1.0	1.0	1.0	1.3	1.2	1.3	1.3	1.5	1.3	3.5	3.3	3.7
-10°C	1.3	1.3	1.3	2.3	2.2	2.0	2.3	2.0	2.3	2.0	8.7	8.7	7.7
-25°C	2.5	2.5	2.3	7.5	7.3	7.7	7.3	7.5	7.5	6.7	27	29	27
-40°C	14	13	9.2	36	35	34	33	31	29	22	56	54	50

Further information

- EDS 1 Test methods used for the natural rubber engineering vulcanizates in the EDS series
- EDS 2 Properties given for the natural rubber engineering vulcanizates in the EDS series
- EDS 3 Effect of compounding on the properties of natural rubber engineering vulcanizates