

Natural Rubber

Engineering Data Sheet

1980

EDS 16

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A Malaysian Rubber Research and Development Board Organization.

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Natural Rubber engineering vulcanizate: 1.12MPa shear modulus (71 IRHD) Ref. no. MRPRA EDS 16

A conventional accelerated-sulphur vulcanizate containing 45 parts phr of HAF (N-330) carbon black.
Suitable for most engineering applications at moderate and low temperatures.
EDS 17 and 18 have the same formulation but different mix preparations.

Formulation

parts by weight	Resilience, Lüpke (ISO 4662), %	63
Natural rubber, SMR CV60	100	
Zinc oxide	5	
Stearic acid	2	
Carbon black, HAF (ASTM N-330)	45	
Process oil ¹	4.5	
Antioxidant/antiozonant, HPPD ²	3	
Antiozonant wax ³	2	
CBS ⁴	0.6	
Sulphur	2.5	
1. Low viscosity naphthenic oil; Fina Process Oil 2059 (Petrofina) was used.		
2. N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine; Santoflex 13 (Monsanto) was used.		
3. Sunproof Improved (Uniroyal) was used.		
4. N-cyclohexylbenzothiazole-2-sulphenamide.		
Stress relaxation, bonded disk 13mm dia × 6.3mm 20% compression, % per decade		3-6
Tear strength (ISO 34) trouser, kN/m		24
angle, without nick, kN/m		112
angle, with 1mm nick, kN/m		52
crecscnt (with 1mm nick), kN/m		112
Tension fatigue, ring test pieces, kc to failure		
strain	minimum strain	
range	0%	12½%
50%	>2000	1234
75%	700	359
100%	218	187
125%	139	100
150%	57	60
25%	1789	594
37½%	>2000	238
489		104
198		49
89		
Goodrich Flexometer (ISO 4666) static stress 1MPa, stroke 5.71mm, 30Hz, 100°C time to failure, min		121
Abrasion loss, Akron (BS 903:A9) dusted, mg/1000rev		48
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, %		315
Water, volume change, %		5.3
Low temperature hardness (ISO 3387) IRHD		
days	1	3
0°C	67	67
-10°C	71	73
-25°C	74	77
-40°C	74	75
7	14	14
14	21	21
21	28	28
28	35	35
35	42	42
42	49	49
49	56	56
56	63	63
63	70	70
70	77	77
77	84	84
84	91	91
91	98	98
98	105	105
105	112	112
112	119	119
119	126	126
126	133	133
133	140	140
140	147	147
147	154	154
154	161	161
161	168	168
168	175	175
175	182	182
182	189	189
189	196	196
196	203	203
203	210	210
210	217	217
217	224	224
224	231	231
231	238	238
238	245	245
245	252	252
252	259	259
259	266	266
266	273	273
273	280	280
280	287	287
287	294	294
294	301	301
301	308	308
308	315	315
315	322	322
322	329	329
329	336	336
336	343	343
343	350	350
350	357	357
357	364	364
364	371	371
371	378	378
378	385	385
385	392	392
392	399	399
399	406	406
406	413	413
413	420	420
420	427	427
427	434	434
434	441	441
441	448	448
448	455	455
455	462	462
462	469	469
469	476	476
476	483	483
483	490	490
490	497	497
497	504	504
504	511	511
511	518	518
518	525	525
525	532	532
532	539	539
539	546	546
546	553	553
553	560	560
560	567	567
567	574	574
574	581	581
581	588	588
588	595	595
595	602	602
602	609	609
609	616	616
616	623	623
623	630	630
630	637	637
637	644	644
644	651	651
651	658	658
658	665	665
665	672	672
672	679	679
679	686	686
686	693	693
693	700	700
700	707	707
707	714	714
714	721	721
721	728	728
728	735	735
735	742	742
742	749	749
749	756	756
756	763	763
763	770	770
770	777	777
777	784	784
784	791	791
791	798	798
798	805	805
805	812	812
812	819	819
819	826	826
826	833	833
833	840	840
840	847	847
847	854	854
854	861	861
861	868	868
868	875	875
875	882	882
882	889	889
889	896	896
896	903	903
903	910	910
910	917	917
917	924	924
924	931	931
931	938	938
938	945	945
945	952	952
952	959	959
959	966	966
966	973	973
973	980	980
980	987	987
987	994	994
994	1001	1001
1001	1008	1008
1008	1015	1015
1015	1022	1022
1022	1029	1029
1029	1036	1036
1036	1043	1043
1043	1050	1050
1050	1057	1057
1057	1064	1064
1064	1071	1071
1071	1078	1078
1078	1085	1085
1085	1092	1092
1092	1099	1099
1099	1106	1106
1106	1113	1113
1113	1120	1120
1120	1127	1127
1127	1134	1134
1134	1141	1141
1141	1148	1148
1148	1155	1155
1155	1162	1162
1162	1169	1169
1169	1176	1176
1176	1183	1183
1183	1190	1190
1190	1197	1197
1197	1204	1204
1204	1211	1211
1211	1218	1218
1218	1225	1225
1225	1232	1232
1232	1239	1239
1239	1246	1246
1246	1253	1253
1253	1260	1260
1260	1267	1267
1267	1274	1274
1274	1281	1281
1281	1288	1288
1288	1295	1295
1295	1302	1302
1302	1309	1309
1309	1316	1316
1316	1323	1323
1323	1330	1330
1330	1337	1337
1337	1344	1344
1344	1351	1351
1351	1358	1358
1358	1365	1365
1365	1372	1372
1372	1379	1379
1379	1386	1386
1386	1393	1393
1393	1400	1400
1400	1407	1407
1407	1414	1414
1414	1421	1421
1421	1428	1428
1428	1435	1435
1435	1442	1442
1442	1449	1449
1449	1456	1456
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1463	1470	1470
1470	1477	1477
1477	1484	1484
1484	1491	1491
1491	1498	1498
1498	1505	1505
1505	1512	1512
1512	1519	1519
1519	1526	1526
1526	1533	1533
1533	1540	1540
1540	1547	1547
1547	1554	1554
1554	1561	1561
1561	1568	1568
1568	1575	1575
1575	1582	1582
1582	1589	1589
1589	1596	1596
1596	1603	1603
1603	1610	1610
1610	1617	1617
1617	1624	1624
1624	1631	1631
1631	1638	1638
1638	1645	1645
1645	1652	1652
1652	1659	1659
1659	1666	1666
1666	1673	1673
1673	1680	1680
1680	1687	1687
1687	1694	1694
1694	1701	1701
1701	1708	1708
1708	1715	1715
1715	1722	1722
1722	1729	1729
1729	1736	1736
1736	1743	1743
1743	1750	1750
1750	1757	1757
1757	1764	1764
1764	1771	1771
1771	1778	1778
1778	1785	1785
1785	1792	1792
1792	1799	1799
1799	1806	1806
1806	1813	1813
1813	1820	1820
1820	1827	1827
1827	1834	1834
1834	1841	1841
1841	1848	1848
1848	1855	1855
1855	1862	1862
1862	1869	1869
1869	1876	1876
1876	1883	1883
1883	1890	1890
1890	1897	1897
1897	1904	1904
1904	1911	1911
1911	1918	1918
1918	1925	1925
1925	1932	1932
1932	1939	1939
1939	1946	1946
1946	1953	1953
1953	1960	1960
1960	1967	1967
1967	1974	1974
1974	1981	1981
1981	1988	1988
1988	1995	1995
1995	2002	2002
2002	2009	2009
2009	2016	2016

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Stress-strain characteristics

Shear modulus (0-2%)	2.39MPa
„ (0-50%)	1.12MPa
Bulk modulus (calculated)	2140MPa

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	1.85	1.96	1.78	1.45	1.23	1.14	1.11	—	—	—	—	—
G_{tan} , MPa	2.02	1.77	1.46	1.11	0.97	1.00	1.41	—	—	—	—	—
10th cycle G_{ch} , MPa	2.39	1.92	1.65	1.32	1.12	1.05	1.14	1.31	1.59	1.96	2.39	2.85
G_{tan} , MPa	1.98	1.60	1.28	1.00	0.87	1.02	1.72	1.98	2.93	3.99	5.09	5.78

First nine cycles to 100% strain. Set at end of 9th cycle 7.2%.

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	9.2	8.0	7.6	7.4	16.5	14.4	14.1	14.6	42	40	45	54
E_{tan} , MPa	7.1	6.7	6.7	7.1	13.3	12.7	14.6	18.4	36	45	65	105
10th cycle E_{ch} , MPa	8.1	7.4	7.1	7.1	13.9	12.7	12.5	13.1	35	32	34	38
E_{tan} , MPa	7.1	6.6	6.8	7.6	11.9	11.8	13.2	17.7	31	32	42	69
Max strain on 1st cycle	26%				27%				27%			
Set at end of 9th cycle	1.8%				1.5%				3.0%			
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	80	83	103	150	185	225	360	—	440	—	—	—
E_{tan} , MPa	69	111	185	330	194	415	720	—	570	—	—	—
10th cycle E_{ch} , MPa	64	64	70	89	146	153	210	—	335	—	—	—
E_{tan} , MPa	59	74	120	220	144	270	450	—	400	—	—	—
Max strain on 1st cycle	23%				16%				9%			
Set at end of 9th cycle	3.0%				2.1%				1.3%			

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	—	—	—	—	—	—	—	—	—	—	—	—	—
125°C	1.54	1.32	1.07	1.77	1.63	1.47	1.38	1.26	1.11	1.07	1.75	1.55	1.46
100°C	1.56	1.33	1.10	1.85	1.68	1.50	1.40	1.29	1.15	1.09	1.81	1.58	1.48
70°C	1.91	1.49	1.11	2.34	2.03	1.73	1.48	1.33	1.15	1.09	2.17	1.79	1.63
50°C	2.09	1.59	1.15	2.59	2.23	1.86	1.57	1.37	1.18	1.14	2.38	1.95	1.75
23°C	2.43	1.77	1.17	3.13	2.68	2.19	1.77	1.49	1.23	1.17	2.89	2.30	2.00
0°C	2.96	2.06	1.27	3.84	3.24	2.60	2.06	1.65	1.33	1.26	3.76	2.92	2.45
-10°C	3.14	2.16	1.29	4.27	3.56	2.78	2.17	1.67	1.38	1.30	4.33	3.07	2.74
-25°C	3.72	2.49	1.37	5.23	4.57	3.60	2.66	1.92	1.55	1.46	7.52	4.72	4.42
-40°C	6.30	3.41	1.54	13.5	11.5	8.90	5.67	2.95	2.12	1.98	29.7	16.0	9.16
Phase angle, degrees													
150°C	—	—	—	—	—	—	—	—	—	—	—	—	—
125°C	5.3	4.2	3.0	4.7	5.0	5.2	4.3	3.5	3.3	3.2	4.5	5.0	4.5
100°C	6.3	4.8	3.2	5.7	6.2	6.0	5.0	4.0	3.3	2.8	5.3	5.5	4.8
70°C	7.5	6.0	3.8	6.5	7.5	6.8	6.0	4.7	3.8	3.0	7.0	7.0	5.7
50°C	8.2	6.5	4.0	6.8	7.5	7.3	6.5	5.3	4.0	3.5	7.7	8.2	7.0
23°C	8.8	7.7	4.8	8.0	8.8	9.2	7.8	6.7	5.3	4.8	9.2	9.8	9.0
0°C	10	9.3	6.3	9.5	11	12	11	9.0	7.2	6.3	13	14	14
-10°C	11	11	7.0	10	13	14	13	11	8.8	7.3	18	20	18
-25°C	14	14	9.2	15	18	20	18	15	14	13	30	33	32
-40°C	25	27	16	31	35	39	37	32	28	25	41	43	42

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