KES

Method for Test of Rubber Materials

KES B-L006

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Contents

KIA MOTORS

(3) Phase of test piece

Rubber test piece shall be sample from the product or the sample manufactured in same oil-added condition of the product. The same oil-added condition is when there is 0.03 or less of difference in specific gravity and 5% or less of difference in volume change rate throuhg the elongation test.

(4) Conversion method of test result

Test results from each test shall be converted according to KES A-A003 (Termination method of number), and indicated in digits in Table 2.

Table 2

Test item	Unit (SI unit)	Required test result
Tensile strength	kgf/cm² (MPa)	integer
Tensile stress	kgf/cm² (MPa)	integer
Elongation	%	2 effective digits
Hardness change		integer
Heat-endurance strength	kgf/cm (N/m)	integer
Low expansion stress	kgf/cm² (MPa)	1 decimal point
Elasticity rate	kgf/cm² (MPa)	1 decimal point
Repulsion elasticity	%	integer
Yerzley resilience	%	integer
Tensile strength, elongation change rate	%	1 decimal point
Weight, volume change rate	%	1 decimal point
Brittle temperature	°C	integer
T_5, T_{50}	°C	integer
Compression permanent deformation	%	integer
Creep speed	—	2 effective digits
Relief time	minutes	3 effective digits
Number of crack formation	rounds	2 effective digits
Speed of crack growth	mm/10^4 rounds	2 effective digits
Coefficient of loss	—	2 effective digits
Peel-off strength	kgf/cm (N/m)	1 decimal point
Adhesion strength	kgf/cm² (MPa)	integer
Wear-resistance rate	%	integer

4. Tensile Test

4.1 Purpose

This test is performed to measure the maximum stress required in cutting (called tensile strength), the elongation at the moment of cutting (called simply, elongation) and the stress for the specific elongation (called tensile stress) of oil-added rubber.

4.2 Test Piece

4.2.1 Shape and figure of test piece

Shape and figure of the test piece shall conform to Table 3, Figure 1.

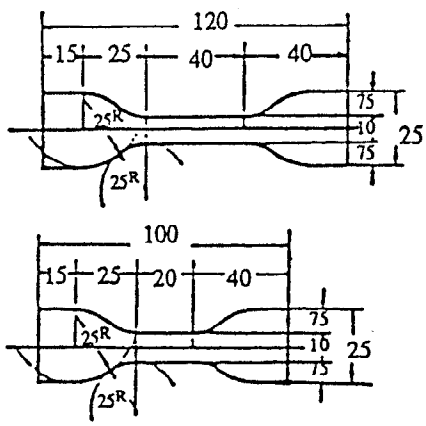
Table 3. Base figure of dumbbell, test piece

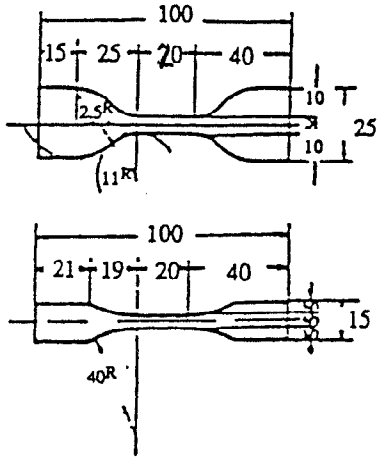
Unit: mm

(Shape)	Figure of major portion				
	Width of parallel portion	Length of parallel portion	Length	Thickness of parallel portion	Distance of marking line
Type 1	10	40		3 or less	40
Type 2	10	20		3 or less	20
Type 3	5	20		3 or less	20
Type 4	5	20		3 or less	20

Figure 1. Shape and figure of test piece

Unit: mm





4.4.2 Cutter

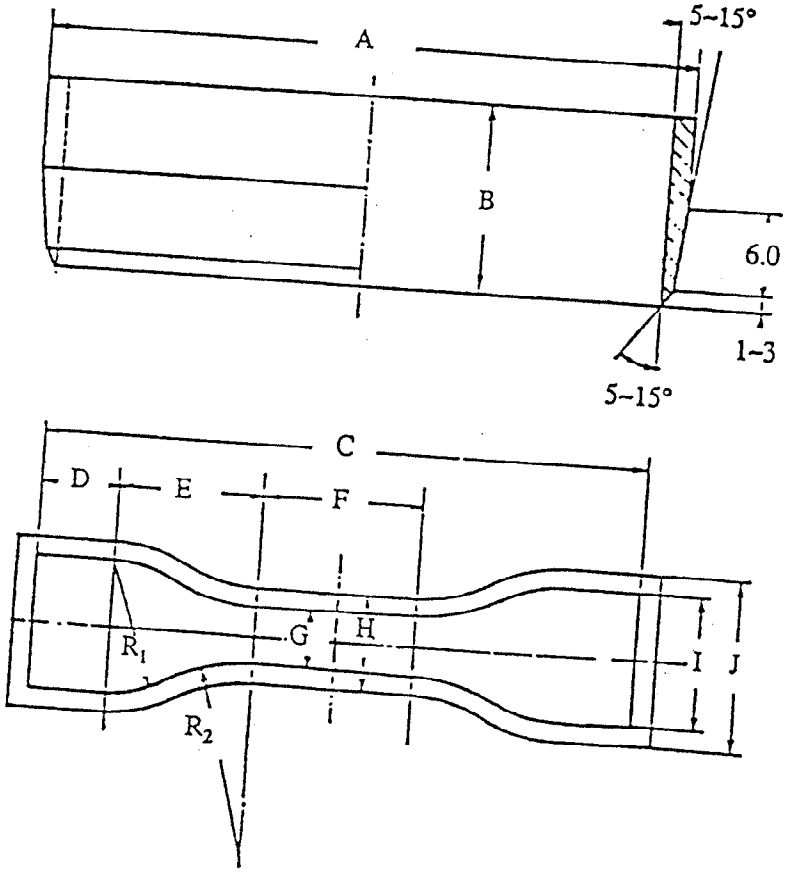
Test piece cutters appropriate for each test piece shall be used for the test pieces in Table 3. Shape and figure of the cutter shall conform to Table 4 and Figure 2. However, substitution can be done if the shape of the edge is the same.

Table 4. Figures of test piece cutter

Type	Figure portion											
	A	B	C	D	E	F	G	H	I	J	R_1	R_2
Type 1	127	34	120	15	25	40^{+2}_{-0}	10.0±0.1	17	25.0±0.5	32	25	21
Type 2	107	34	100	15	25	20^{+2}_{-0}	10.0±0.1	17	25.0±0.5	32	25	21
Type 3	107	34	100	15	25	20^{+2}_{-0}	5.0±0.1	12	25.0±0.5	32	25	11
Type 4	107	34	100	21	19	20^{+2}_{-0}	5.0±0.1	12	25.0±0.5	32	—	40

Figure 2

Unit: mm



4.2.3 Selection of test piece

Type 3 test piece is used, in principle.

4.2.4 Sampling and construction of test piece

The test piece is sampled and constructed by the following method.

(1) In principle, test piece shall be parallel with the grain of the rubber.

(2) In case of a sampling test piece directly from the product, flatten the rubber 30mm in width from the product and construct the sample from this.

If a cotton string is attached, cut off the sample in an appropriate size with cotton string attached to it, and cut or peel off the cotton string by applying minimal tension to the rubber with an appropriate device so that as many flat rubber surface as possible can be obtained. In case there are figures on the surface, apply the minimal possible tension to the rubber and obtain a flat rubber as possible in accordance with above method. The thickness of the severed rubber shall be as close to 3mm as possible if the original thickness of the sample rubber is over 3mm, and as close to original thickness as possible

if the original thickness of the sample rubber is 3mm or less. Use type 1 of KS M 2611 (Gasoline for industrial purpose) if the cotton string must be peeled off by using solvent, and dry well by leaving it, at least for an hour.

(3) If each end of the test piece is not flat, grind them as evenly as possible with a grinder. Grinding shall be performed in a manner where minimal heat is generated and excessive grinding is prevented. Thickness of the parallel portion of the test piece shall be 2-3mm, in principle after grinding. However, if the thickness of the test piece is 2mm or less before grinding, make in as close as possible to the original thickness.

(4) In case the test piece from the rubber plate is identically oil-added, as the product, it shall be 2-3mm.

(5) The test piece is constructed by the test piece cutter. When utilizing the test piece cutter, an elastic sheet such as leather, plywood, semi-hard rubber etc. shall be used as the support, and cutting shall be completed at once. Test piece shall be hooked on a grinder for cutting, in principle.

4.2.5 Measurement of thickness and width

Measurement of the thickness and width of the test piece shall conform to the following:

(1) Thickiness gauge shall be one with a 1/100mm scale, and a parallel pressure surface and circular pressure surface 5mm in diameter. Pressurization load of the gauge shall shall be 30g in principle, and shall not changed ±15% or less within gauging range.

(2) Measurement of the thickness shall be performed at several locations on the parallel portion of the test piece, and the minimum gauged value will be the thickness of the test piece.

(3) Use the width of the cutter (inner surface of the edge) as the width. However, when using a cutter other than that of Table 4 , measure the inner surface of the edge and use it, as the width.

(4) Cross-sectional area of the test piece is calculated by the following formula:
Cross-sectional area (cm^2) = thickness (cm) x width of parallel portion

4.2.6 Marking line for the elongation measurement

Marking line for the elongation measurement (hereinafter called "marking line") shall conform to the following method:

(1) Space between marking lines shall be 20mm. However, when using type 1 use 40mm.

(2) Marking shall be precise and clear with it's center on the center of the parallel portion of the test piece.

4.2.7 Inspection of test piece

Test pieces shall be inspected in advance, and those with more than 1mm difference in thickness of the parallel portion, different widths, foreign matter, bubbles and inappropriate scratches at the bottom area when severed shall be excluded.

4.3 Testing Device

Tensile tester satisfying the following condition shall be used.

4.3.1 Device of tester

Tester shall have a load supporting mechanism and automatic tightening mechanism.

4.3.2 Capacity of tester

Tester with a maximum load within a range of 15-85% of it's capacity when testing shall be used.

4.3.3 Tensioning speed

Moving speed of the test piece shall be 500±25mm/min (0.0083±0.0004), in principle.

4.3.4 Allowance of tester

Allowance of the load scale of the tester shall be ± 2%.

4.3.5 Inspection of tester

Tester shall be precise, and shall be inspected once or more a year.

4.4 Testing Method

4.4.1 Installation of test piece

Test sample shall be installed precisely and firmly so that it is not crooked or inappropriately located during the test.

4.4.2 Measurement of tensile strength and elongation

Tensile strength shall be measured by reading the maximum load at the moment of test piece cut-off by the device on 4.3. Also, the elongation is measured by scaling the distance between the marking lines up to mm, with an appropriate manner at the moment of cut-off.

4.4.3 Measurement of tensile stress

Tensile stress is the stress when the specific elongation is applied to the test piece, and is measured when the elongation is 100% or more appropriate manner when the distance between marking lines has reached the specific distance.

4.4.4 Calculation

Tensile strength: Elongation and tensile stress shall be calculated by the following formula.

(1) Tensile strength

$Tb = Fb/A$

where, Tb: tensile strength (kg/cm^2 {MPa})

Fb: maximum load (kgf {N})

A: cross-sectional area of test piece (cm^2)

(2) Elongation

$E = \{ (L_1-L_0)/L_0 \} \times 100$

where, Eb: elongation (%)

L_1: distance between marking lines at the moment of cut-off (mm)

L_0: distance between marking lines

(3) Tensile stress

$Mn = Fn/A$

where, Mn: tensile stress (kg/cm^2 {MPa})

Fn : load applied to specific elongation (kgf {N})

A : cross-sectional area of test piece (cm^2)

n : specific elongation M200 indicates 200% of tensile stress

4.5 Organizing Test Result

4.5.1 Number of test pieces

Number of test pieces shall be four. However, in case four is not available, use three or two. The number of test pices shall be recorded in this case.

4.5.2 Test score

(1) Tensile strength and elongation

If the measured values are $S_1 \geq S_2 \geq S_3 \geq S_4$, respectively, in descending order, the tensile strength and elongation shall be calculated and indicated by the following formula:

(a) If test pieces are four

$Tb \text{ (or } Eb) = 0.5\ S_1 + 0.3\ S_2 + 0.1\ (S_3 + S_4)$

(b) If test pieces are three

$Tb \text{ (or } Eb) = 0.7S_1 + 0.2S_2 + 0.1S_3$

(c) If test pieces are two

$Tb \text{ (or } Eb) = 0.9S_1 + 0.1S_2$

(2) Tensile stress

The tensile stress shall be the average value of the measurements.

4.5.3 Recording

The test result reports shall include the following:

(1) Tensile strength and elongation (tensile stress)

(2) Capacity of tester

(3) Testing temperature

(4) Other necessary items

5. Permanent Elongation Test

5.1 Purpose

This test is to measure the remaining elongation when a certain amount of time has lapsed after the shrinking oil-added rubber rapidly, which had been sustained a certain length, for a certain time, with tension.

5.2 Test Piece

Dumbbell type 1 test piece, sampled and constructed by the method of 4.2, is used in principle.

5.3 Test Device

5.3.1 Tester

Use a device which can apply a tension at the constant speed and sustain at a certain length for a certain time. Tensile tester (refer to 4.3) can also be used.

5.3.2 Tensioning speed

Tensioning speed shall be constant, at which time, the specified length can be obtained in 15 seconds, in principle.

5.4 Testing Method

5.4.1 Classification of measurement

Indicate the elongation measuring marking line (refer to 3.2.6) on the test piece and apply a tension to the specified length.

5.4.2 Measurement

Apply a tension to the test piece so that the length is 1/2 the elongation (%) and sustain for 10 minutes. Measurement shall be done 10 minutes after shrinking rapidly, without repulsion, in principle.

Remark: Length is comparable to 1/2 the elongation, and is obtained from the following formula:

$Lx = L_0 + 1/2 (L_1 - L_0)$

where Lx: length comparable to 1/2 the elongation (mm)

L_1: distance between marking lines at the moment of cut-off (mm)

L_0: distance between marking lines (mm)

5.4.3 Calculation

Permanent elongation will be calculated by the following formula:

$PS = \{(L_2 - L_0) / L_0\} \times 100$

where, PS: permanent elongation (%)

L_1: distance between marking lines 10 minutes after shrinkage (mm)

L_0: distance between marking lines (mm)

5.5 Organizing Method of Test Result

In principle, the test score shall be the average value of the elongation of the two test pieces.

5.6 Recording

The following shall be recorded in the test result:

(1) Permanent elongation

(2) Test temperature

(3) Other necessary items

6. Hardness Test

6.1 Purpose

This test is performed to measure the hardness of oil-added rubber. Hardness test is performed by the following method, in principle.

(1) Spring type hardness test

(2) International rubber hardness test

6.2 Spring Type Hardness Test (A type)

6.2.1 Test piece

A test piece 12mm or more in thickness shall be used, in principle. However, for a piece 12mm in thickness, stack up the pieces so that the thickness exceeds 12mm. If the measuring surface of test piece is not flat, grind it evenly. Also, the test piece shall large enough to accommodate a pressurizing surface.

6.2.2 Tester

Spring type hardness tester in the shape of figure 3 shall be used. When pressurizing the surface: (1) contact the test piece surface, returning the distance of the needle, (2) bouncing from the center of pressurizing surface by a spring pressure, and (3) indicate the hardness in scale.

Notes (1) Pressurizing surface shall be vertical to the pressure needle, and shall have a hole in it's center in which the pressure needle in Figure 4 can pass through, and shall have a diameter 10mm or more.

(2) Allowance of the basic line (refer to Figure 5) which indicates the relationship with the spring force when the scale and pressure needle is moving, shall be ±8g. Also, no space is allowed between the movement of the pressure needle and directional needle.

(3) Pressure needle material shall have a wear-resistancy and corrosion-resistancy in the shape and size of Figure 4. Pressure needle shall contact the pressurizing surface precisely.

Needle tip shall extrude from the pressurizing surface about $2.54\ ^{+0}_{-0.05}$ mm when the scale is 0, and shall be at the level when the scale is 100.

(4) Scale shall be divided from 0 to 100 in identical widths.

6.2.3 Testing method

Place the tester in vertical position, and place the pressure needle vertically to the test piece measuring surface and contact the pressurizing surface lightly, and read the scale immediately to measure the hardness of the test piece. In case the scale was read when a certain amount of time has elapsed after contacting the pressurizing surface, place the tester vertically, and place the pressure needle in a vertical position to the measuring surface and use an appropriate assisting device. Press the tester vertically with 1000gf (9.81N) of load and read the scale in this case.

Figure 3

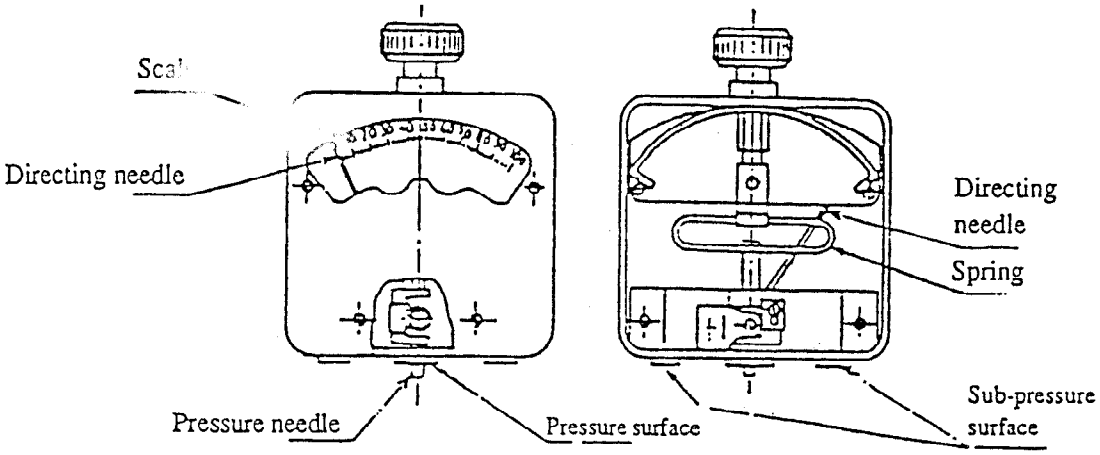


Figure 4

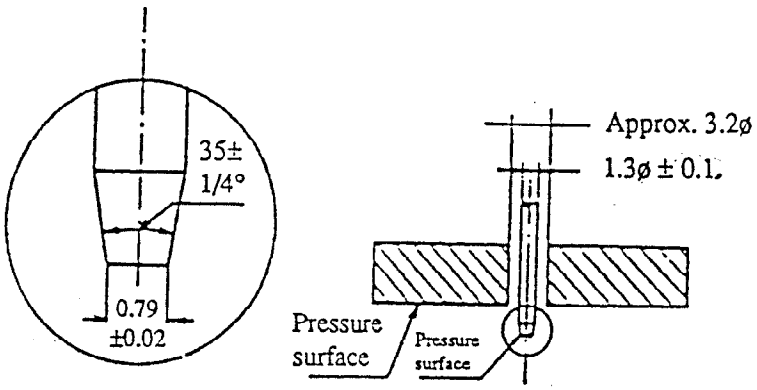
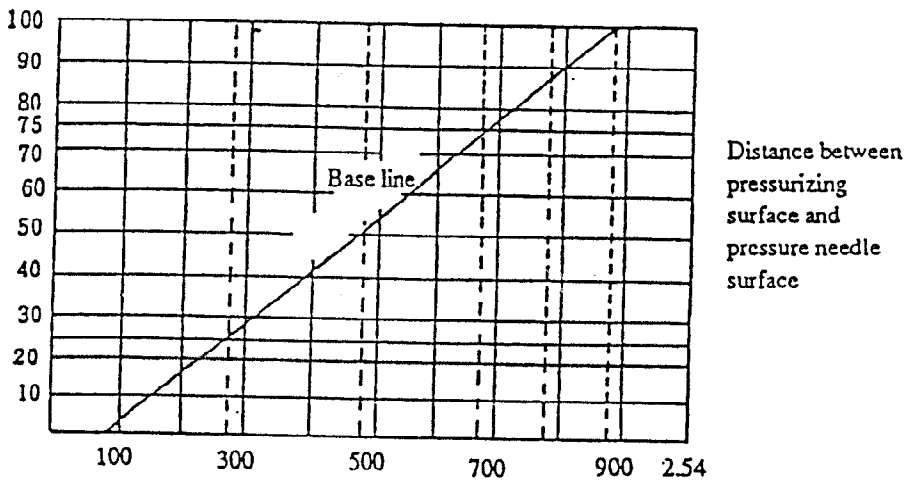


Figure 5. Load applied to needle line by spring



6.2.4 Recording

Test result report shall include the following.

(1) Hardness

(2) Test temperature

(3) Other necessary items

6.3 International Rubber Hardness Test

6.3.1 Tester

Tester is consisted of a test piece supporter, a pressure regulating device which regulates the pressure applied to the test piece, a pressurizing device which provides the adhesion of the test piece, a pressure needle which applies pressure to the test piece, a loading device which applies load to the test piece, and depth measuring device which measures the depressed depth of the test piece.

(1) Pressure regulating device

The pressure regulating device (5) shall be able to apply 24.0 ± 3.0 gf {235±30mN} of load when measuring the test piece between the test piece supporter and test piece pressurizing device.

Note (5) When regulating the pressure by the pressure regulating spring loacted in the bottom of the test piece supporter, the pressure regulating spring shall be adjusted to 38.7±3.0gf {380±30mN} [380 = 235 + 145mn], since 14.8gf {145 mN} of the main load is applied during measurement.

(2) Pressure needle

The pressure needle shall have a sphere-shaped tip 0.395±0.005mm in diameter, as shown in Figure 6.

Note (6) Pressure needle material shall have wear-resistancy and corrosion-resistancy.

(7) Holding stem shall not exceed the diameter of the tip.

(3) Compression device of the test piece

Compression device of the test piece shall have a hole in which a pressure needle can pass through. Outer diameter of the contacting surface to the test piece shall be 3.35 ± 0.05 mm, and the inner diameter shall be 1.00 ± 0.05 mm.

(4) Load device

The load device shall be able to apply a positive load on the tip of the pressure needle, precisely. Loads shall be as following.

Contacting load (8) 0.84±0.05gf {8.3±0.5mN}

Main load (9) 14.79±0.05gf {145.0±0.5mN}

Notes (8) Load which makes contact between the pressure needle and test piece.

(9) Load which push the pressure needle against the test piece after contacting with the main load.

Figure 6. Pressure needle

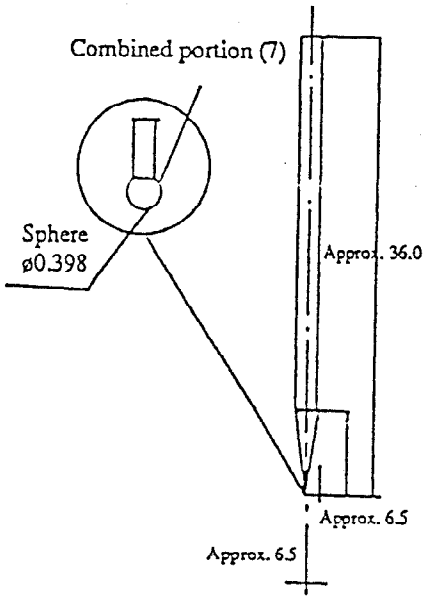
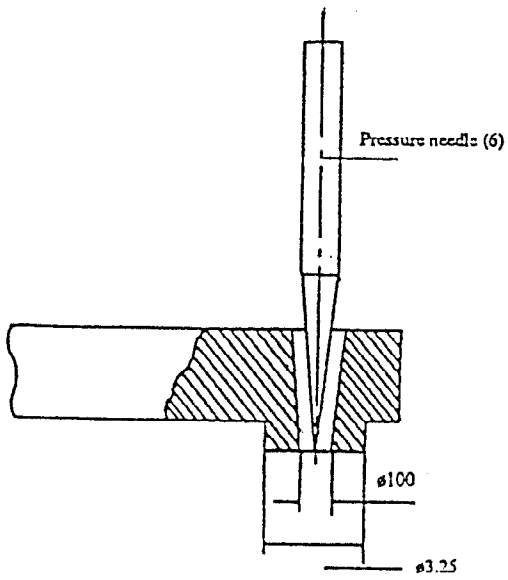


Figure 7. Test piece compressing device



(5) Penetrated depth measuring device

Measurement shall be vertically read the penetrated depth by the main load, in integers, with IRHD. The relationship between the penetrated depth and IRHD is shown in Table 4. However, a value which is the penetrated depth of Table 4 divided into 6, shall be used.

Remarks: ISO 48 (Vulcanized Rubber-Determination of Hardness) is the international hardness test, and regulates the normal test and micro-test. The major shape and figure of the micro test is a 1/6 scale model of the normal test. This specification regulates the micro test only. In the original specification, it is a table of the relationship between the penetrated depth of the normal test and IRHD. The penetrated depth of the micro test shall be the penetrated depth of Table 4 divided into 6. For this reason, JIS (Micro test) employs Table 4, which indicates the relationship between the penetrated depth of the normal test by the original specification and IRHD. Also, the penetrated depth in JIS shall be the depth of Table 4 divided into 6.

Table 4. Relationship between penetrated depth and IRHD

Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD
0	100	45	73.9	90	52.3	135	38.9
1	100	46	73.3	91	52.0	136	48.7
2	99.9	47	72.7	92	51.6	137	38.4
3	99.3	48	72.2	93	51.2	138	38.2
4	99.6	49	71.6	94	50.9	139	38.0
5	99.3	50	71.0	95	50.5	140	37.8
6	99.0	51	70.4	96	50.2	141	37.5
7	98.6	52	69.8	97	49.8	142	37.3
8	98.1	53	69.3	98	49.5	143	37.1
9	97.7	54	68.7	99	49.1	144	36.9
10	97.1	55	68.2	100	48.8	145	36.7
11	96.5	56	67.6	101	48.5	146	36.5
12	95.9	57	67.1	102	48.1	147	36.2
13	95.3	58	66.6	103	47.8	148	36.0
14	94.7	59	66.0	104	47.5	149	35.8
15	94.0	60	65.5	105	47.1	150	35.6
16	93.4	61	65.0	106	46.8	151	35.4
17	92.7	62	64.5	107	46.5	152	35.2
18	92.0	63	64.0	108	46.2	153	35.0
19	91.3	64	64.5	109	45.9	154	3458
20	90.6	65	63.0	110	45.6	155	34.6
21	89.8	66	62.5	111	45.3	156	34.4
22	89.2	67	62.0	112	45.0	157	34.2
23	88.5	68	61.5	113	44.7	158	34.0
24	87.8	69	61.1	114	44.4	159	33.8
25	87.1	70	60.6	115	44.1	160	33.6
26	86.4	71	60.1	116	43.8	161	33.4
27	85.7	72	59.7	117	43.5	162	33.2
28	85.0	73	59.2	118	43.3	163	33.0
29	84.3	74	58.8	119	43.0	164	32.8
30	83.6	75	58.3	120	42.7	165	32.6
31	82.9	76	57.9	121	42.5	166	32.4
32	82.2	77	57.5	122	42.2	167	32.3
33	81.5	78	57.0	123	41.9	168	32.1
34	80.9	79	56.6	124	41.7	169	31.9
35	80.2	80	56.2	125	41.4	170	31.7
36	79.5	81	55.8	126	41.1	171	31.6

Table 4. (Cotinued)

Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD	Penetrated depth 0.01mm	IRHD
37	78.9	82	55.4	127	40.9	172	31.4
38	78.2	83	55.0	128	40.6	173	31.2
39	77.6	84	54.6	129	40.4	174	31.1
40	77.0	85	54.2	130	40.1	175	30.9
41	76.4	86	53.8	131	39.9	176	30.7
42	75.8	87	53.4	132	39.6	177	30.0
43	75.2	88	53.0	133	39.4	178	30.4
44	74.5	89	52.7	134	39.1	179	30.2
						180	30.0

6.3.2 Test piece

(1) Shape and figure of test piece

(a) Both the top and bottom surface of the test piece shall be flat and parallel to each other (10)

(b) Test piece shall be 2.0 ± 0.5mm thickness (11) and 4mm or more width and length, and the standard one shall not separated from the supporter.

(c) Test piece 1.0 - 4.0mm is thickness (12) shall also be acceptable.

Notes (10) Test on a test piece with a circular or irregular shape (ie. O-ring) sampled from the product can be performed upon the agreement between related parties. However, it is impossible to compare this test result with that of flat and parallel surfaces. In this case, insert the measured value with an outlook hardness to ( ).

(11) Hardness test shall be performed at location, 2mm apart from the tip of the test piece.

(12) In case the thickness of the test piece is 1.0mm or less, two test pieces shall be overlapped, to achieve the desired thickness. However, bonding three or more pieces shall not be done. In case the thickness of the test piece is 4.0mm or more, cutting or grinding shall be done, to achieve specified thickness.

(2) Sampling and construction of test piece

(3) Shall conform to the sampling and construction of the test piece.

6.3.3 Testing method

(1) Adjustment of pressure needle position

Adjust the tip of the test piece so it is located at the center of test piece compressor and make sure the test needle extrudes as much as 1/2 the tip sphere surface from the bottom of the test piece compressor, and does not contact the inner surface of the test piece compressor.

(2) Operating method

(a) Insert the test piece in between the test piece supporter and test piece compressor and adjust the pressure regulating apparatus to ensure a certain pressure to the test piece.

(b) Immediately after applying a contact load with the pressure needle for 5 minutes, adjust the scale of the IRHD indicator to 100.

(c) Apply the main load to the pressure needle immediately.

(d) After 30 seconds, read the inserted depth of the test piece, in integer digits, by IRHD.

(e) Measure 3-5 locations with the new measuring location, for each measurement.

6.3.4 Organizing test result

Indicate the test results by inserting the kind of test (international rubber hardness) or it's symbol (IRHD) to the average value of the 3-5 location measurements.

6.3.5 Recording

The following shall be recorded in the test results:

(1) Test result

(2) Temperature of laboratory

(3) Other necessary items

Corresponding international specification: 150 48 Vulcanized Rubbers Determination of Hardness (Hardness between 30 and 85 IRHD) (Micro Test)

7. Aging Test

7.1 Purpose

This test is performed to measure the aging character of oil-added rubber by heating. The aging test, in principle, is performed to measure the tensile strength, elongation, tensile stress, and hardness after heating by any of the following methods, and to observe the change of their values, compared to that before-heating:

(1) Air-heating aging test

(2) Test tube-heating aging test

7.2 Test Piece

Test piece shall be constructed as in 4.2, in principle. Measure the thickness and width prior to aging, and indicate the marking line for the elongation before heat-treatment.

7.3 Air-heating Aging Test

7.3.1 Gear type aging tester or a comparable device shall be used. Tester shall have such a mechanism so that the inside air can be replaced, at least once an hour. The temperature inside, shall be within ±2°C of the center area. An automatic temperature regulating device which can adjust the inner temperature ±1°C shall also be used.

7.3.2 Testing condition

(1) Testing temperature

The testing temperature shall be any of 70±1°C, 100±1°C, 120±1°C, 130±1°C, 150±1°C.

175±2°C, 200±2°C, 225±2°C, 250±3°C or 275 ±3°C of the center area temperature.

(2) Testing time

The testing time shall be 70 hours, in principle.

(3) Weight of test piece

Weight of the test piece shall not exceed 1g for each 10mℓ of tester volume.

7.3.3 Testing method

(1) Testing operation

Put the test piece in the tester and let it heat-age. Test pieces at that time shall not contact each other or the inner wall of the tester. Also, do not put in different rubber test pieces together which can react with each other.

(2) Measuring method

Measure the tensile strength, elongation, tensile stress, and hardness after extracting the test pieces from the aging tester and leave them 16 to 96 hours at room temperature.

7.4 Test Tube-Heating Aging Test

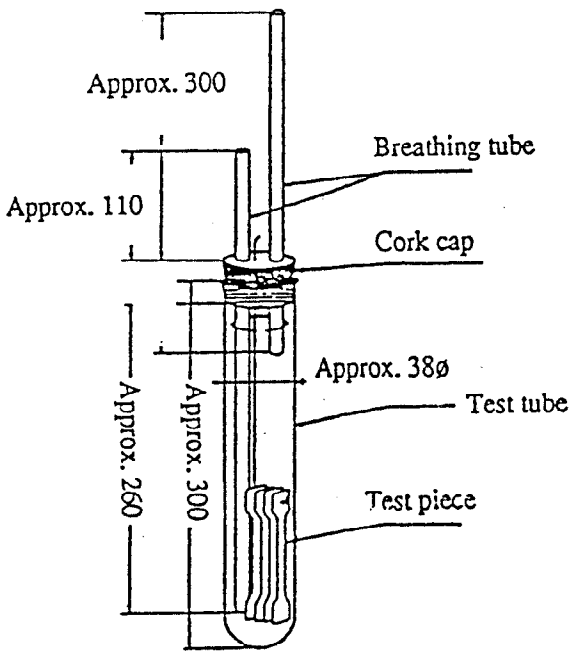
7.4.1 Testing device

The testing device consist of a glass test tube (13) and heating apparatus (14).

Notes (13) Glass test tube shall have a 38mm outer diameter and 300mm length, and shall be cork-capped so it can be breathing tubes.

(14) Heating apparatus shall be able to regulate the inner temperature of the test tube ± 1°C by using an oil bath or metal block as the heating media. When an oil bath apparatus is used, attention shall be paid since the mixture of oil vapors and air can flow into the test tube through the pipe, during heating.

Figure 8



7.4.2 Testing condition

(1) Testing temperature

The testing temperature shall be any of 70±1°C, 100 ±1°C, 120 ± 1°C, 130±1°C, 150±1°C, 175±2°C, 200±3°C, 225±2°C, 250±3°C or 275 ± 3°C.

(2) Testing time

The testing time shall be 70 hours, in principle.

7.4.3 Testing method

(1) Number of test pieces

Maximum number of test pieces in a test tube shall be four, made of identical materials.

(2) Testing operation

Put the test piece in and adjust the heating device to the specified temperature, and put the breathing tube installed test tube in the heating device, and heat for a specified time. Pay attention since the top of the test tube will be within 50mm apart from the heating device. Suspend the test pieces vertically and as close to the bottom of the tube as possible so that they do not contact with each other or to the inner wall of the test tube. Any contamination in the test tubes or breathing pipes shall be removed before the initiation of test.

7.5 Calculation

7.5.1 Tensile strength, elongation, and tensile stress shall be calculated by the following formulas:

(1) In case the number of test pieces is four

$A_R = (S_{21}/S_{11}+S_{12}+S_{23}+S_{24}/S_{14}) \times 25$

$A_C = A_R - 100$

(2) In case the number of test pieces is three

$A_R = (S_{21}/S_{11}+S_{22}/S_{12}+S_{23}/S_{13}) \times (1/3) \times 100$

$A_C = A_R - 100$

(3) In case the number of test pieces is two

$A_R = (S_{21}/S_{11}+S_{22}/S_{12}) \times 50$

$A_C = A_R - 100$

where, A_R: Remnants after heating (%) compared to the tensile strength, elongation and tensile stress of before-heating

A_C: Rate in change of above (%)

S_{11}: Arrangement of tensile strength, elongation, and tensile stress before heating according to measuring sequence (i = 1-4)

S_{21}: Each value of above after heating

7.5.2 Change of hardness

Change of hardness shall be calculated by the following formula:

$A_H = H_2 - H_1$

where, A_H: Change of hardness

H_2: Hardness before heating

H_1: Hardness after heating

7.6 Organizing Test Result

Test results shall be obtained by measurement the test pieces, in principle. However, if 4 pieces are not available, 2 or 3 pieces can be used, and in this case, the number of the test pieces shall be recorded.

7.7 Recording

Test results shall include the following:

(1) Change rate of tensile strength, elongation, tensile stress, and change of hardness
(2) Sort of aging tester
(3) Test condition
(4) Other necessary items

8. Peel Off Test

8.1 Purpose

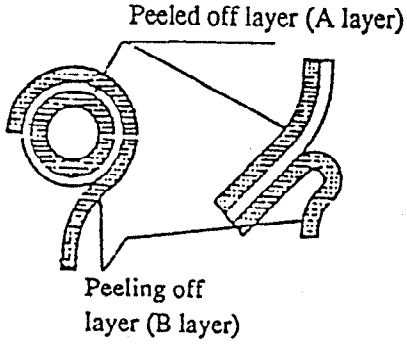
This test is performed to measure the magnitude of the adhesion force when the layers stuck to rubber are peeled off at a specified speed. This method is applied to the cylinder shaped test layer surface formed by the tire-case, belt, insertion, sheet, or hose. A special method shall be used for those with sharply angled bending or irregular shapes.

8.2 Test Piece

8.2.1 Shape and figure of test piece

Shape of the test piece shall be rectangle. Figures of rectangles shall be larger than 25.0 ± 0.5mm in width and 100mm in length, in principle. Its cross sections shall have a right angle to the axial direction. In any case, the thickness of the peeled off layer (hereinafter called "A layer", refer to Figure 9) shall be 6mm or less.

Figure 9



8.2.2 Sampling and construction of test piece

(1) Rectangular shaped test piece

Rectangular shaped test piece shall be cut 25.0 ± 0.5mm in width, and shall have a definite cut section. Cut section shall be parallel to the length of the cotton thread and parallel to the transverse direction of the cotton thread for the transverse direction. If the cut section is damaged due to an irregular cord layer, use the test piece in a somewhat wide width and make the peeling off layer (hereinafter called "B layer") 25mm.

(2) Ring shaped test piece

Insert the wooden column in the center and cut in the same shape to construct the ring shaped test piece. A ring shaped test piece with a inner diameter 100mm or more shall be incised and used in the construction of the rectangular test piece.

(3) Thickness of test piece

Those with over 6mm in thickness of peeling off layer shall be cut by a small knife or grinded by a grinder so that the thickness shall be within 6mm. Also, A layer shall not be thinner than B layer.

8.3 Testing Device

The testing device with the following performance shall be used.

8.3.1 Tester

Tester shall be equipped with an automatic fastening and suspending apparatus, and a automatic recording apparatus of the peel off distance. Scale shall move freely according to the change in load.

8.3.2 Capacity of Tester

Tester having a tensile load which is within 15~85 % of it's capacity during the test shall be used.

8.3.3 Tensioning Speed

Moving speed of the test piece shall be variable from 25.0 ± 1.5mm/min to 50.0 ± 2.5mm.

8.4 Testing Method

8.4.1 Sampling of Test Piece

Peel off one side of the test piece by hand. Carefully apply the peel-off force uniformly. If the test piece is rectangular, layer A and layer B shall be 180 degrees. If the test piece is circular, 90 degrees shall be maintained with the tangential line of layer A at the peel-off point of layer B, and an wooden column shall be used so that the peel-off resisting force has a right angle to the axis of revolution.

8.4.2 Test Piece

Moving speed of test piece shall be 50 ± 2.5mm/min (0.0008 ± 0.0004 m/sec) for rectangular shapes and 25.0 ± 1.5mm/min (0.0004 ± .0.00003m/sec) for ring shapes. Peel off as much length as required to ensure sufficient measurement of the adhesion force.

If the expansion heat of the rubber is generated during the test, cut the piece off with small knife and retry the test.

8.4.3 Calculation

Draw the tensile load curves on a graph, and calculate the average of their apexes (highest numbers), and calculate the adhesion strength according to following formula by using the average value as the peel-off load:

$T = F/b$

where, T_F : peel-off strength kgf/cm {N/m}

F : peel-off load kgf {N}

b : width of test piece (cm)

8.5 Organizing Test Result

Test results shall be the average value of the adhesion strengths of the two test pieces, in principle.

8.6 Recording

Test results shall contain the following:

(1) Peel-off strength

(2) Sort of tester

(3) Shape and figure of test piece

(4) Testing temperature

(5) Other necessary items

9. Adhesion Test of Metal and Oil-added Rubber

9.1 Purpose

This test is performed to measure the adhesion strength of metals and oil-added rubber.

9.2 Test Piece

9.2.1 Shape and dimension of test piece

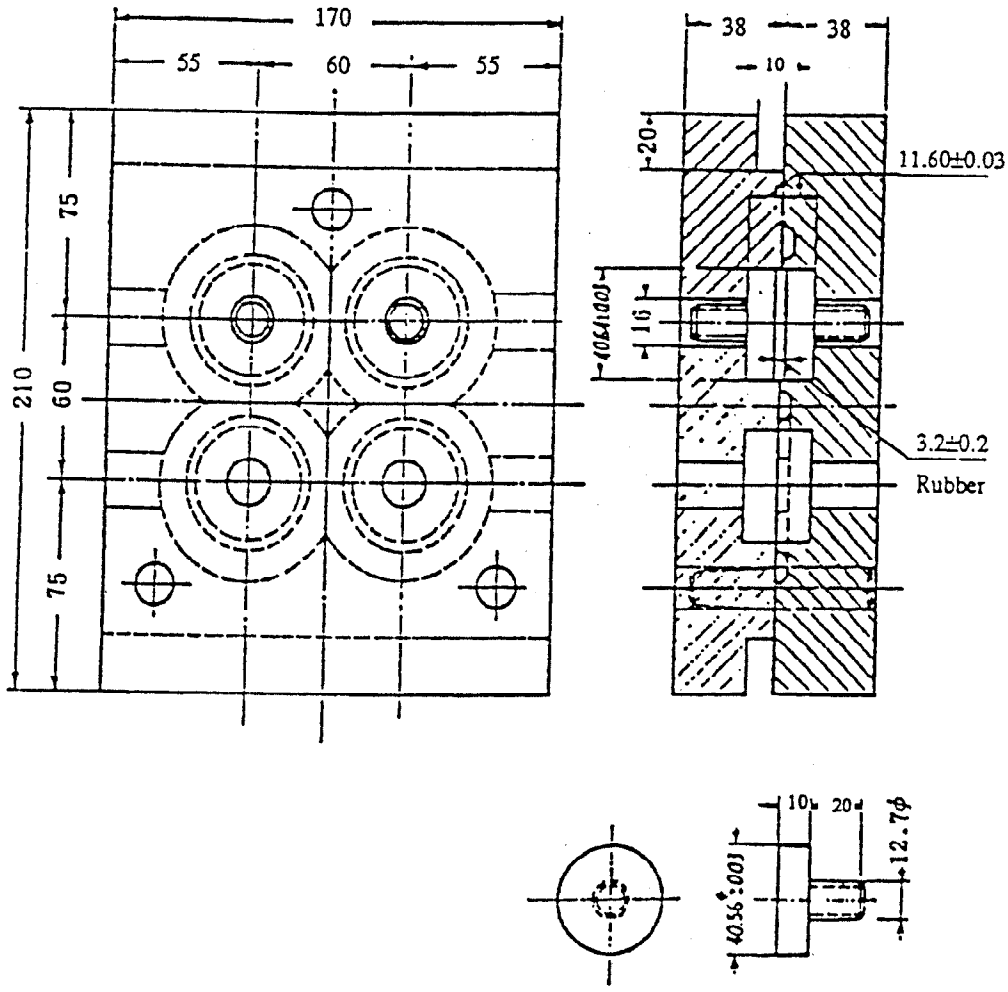
Test piece is constructed by bonding the upper and lower surfaces of cylindrical rubber 3.2 ± 0.2mm in thickness and 40.56mm (standard figure) in diameter to a metal plate 40.56 ± 0.03 mm in diameter and a thickness 9.53mm or more. The surface of the metal plate bonded to the rubber shall be flat, and after bonding the rubber, both surfaces shall be parallel.

9.2.2 Construction of test piece

Construction of the test piece shall conform to the following method. The metal plate with the circular column shall be annular steel of SS41 of KS D 3503 (Shapes and dimensions of corrugated steel sheets) or a post machine-treated one. However, if the figures of major portions are indicated, other metals can be used. For non oil-added rubber, cut-off a piece 35mm in diameter and 4.8mm in thickness or the pressure insertion method by a pot shall be used to ensure sufficient depression of the rubber against both surfaces of the metal sheet. Bonding surfaces shall be cleaned or surface-treated in the appropriate manner. Add oil to the metal sheet and oil-added rubber piece. The typical shape and test pieces are shown in

Figure 10. To prevent tearing of the rubber from the end of the metal sheet, the sides of the metal sheet shall be covered by rubber 0.04mm in thickness after adding the oil, and the bonding surface shall be kept clean and free of dust, water, etc. The test piece after oil-adding shall be handled with care so that no force is applied to the bonding surface, before cooling it down.

Figure 10



9.3 Testing Device

9.3.1 Tester

In measuring the adhesion strength, a tensile tester shall be used in such a manner that the maximum load of the tester is within 15-20 % of it's capacity.

9.3.2 Tensile strength

The tensioning speed shall be 25.0 ± 1.5 mm/min {0.0004 ± 0.0003m/s}, in principle.

9.4 Testing Method

9.4.1 Installation of test piece

In installing the test piece, a sphere seat shall be used so that the load is applied to the center of the test piece during testing. Test piece shall be held up by a screw. Example of the installation method is shown in Figure 10.

9.4.2 Testing operation

Carefully install the test piece in the center to distribute the tension force uniformly during the test, and apply a tension until the rubber is separated from the metal surface or severed.

9.4.3 Testing temperature

Testing temperature shall be 25 ± 5°C.

9.4.4 Calculation

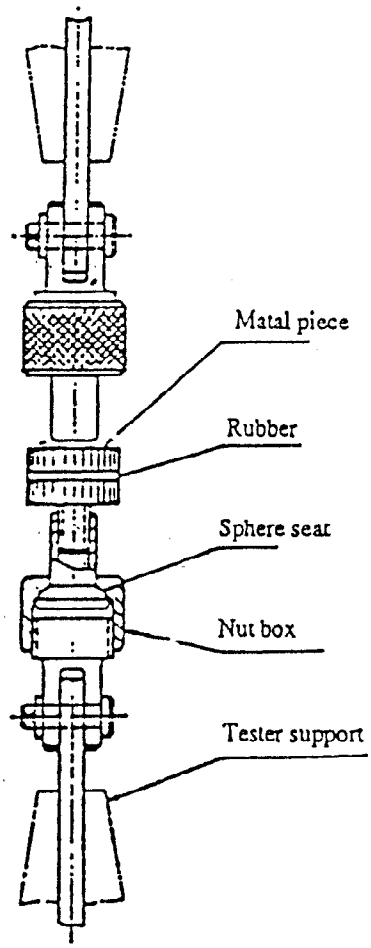
Adhesion strength shall be calculated by the following formula:

$T = F / A$

where, T : Adhesion strength (kgf/cm^2 {MPa})

F : Maximum load (kgf {N})

A : Area of bonding surface (cm^2)



9.5 Organizing Method of Test Result

9.5.1 Number of test pieces

The number of test pieces shall be four.

9.5.2 Test score

Adhesion strength shall be the average value.

For each test piece, the type of adhesion damage and ratio (%) shall be recorded according to the following:

9.5.3 Type of adhesion damage and indication method

(1) Damage of rubber areas (symbol R)

(2) Damage between rubber areas and adhesive (symbol Rc)

(3) Damage between adhesives (symbol CP)

(4) Damage between metal and adhesive (symbol M0>)

9.6 Recording

The following shall be recorded in the test results:

(1) Adhesion strength

(2) Capacity of tester

(3) Testing temperature

(4) Kind of adhesion damage and ratio

(5) Other necessary items

10. Expansion Heat Test

10.1 Purpose

This test is performed to the the expansion heat strength of oil-added rubber.

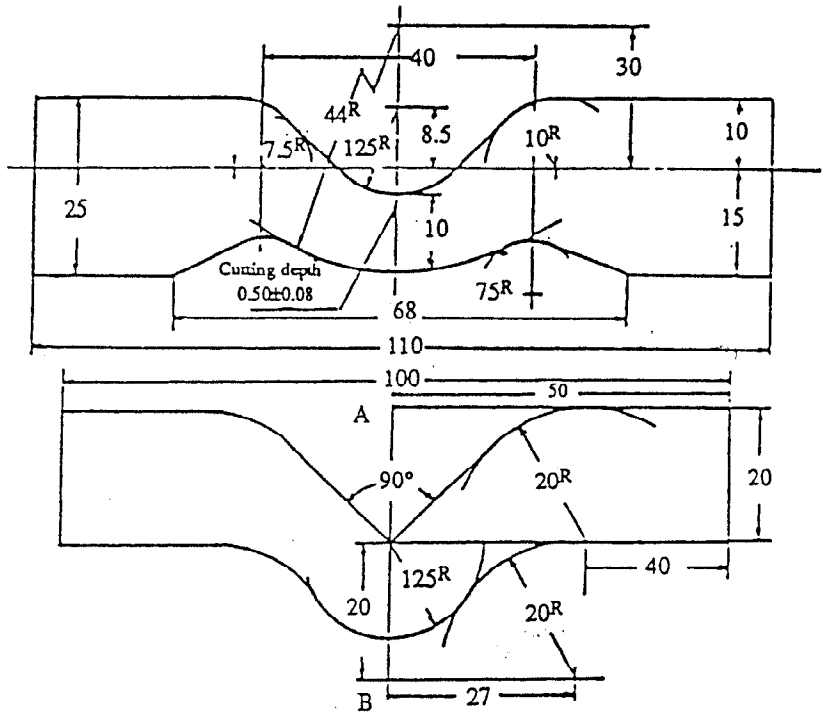
10.2 Test Piece

10.2.1 Shape and figure of test piece

Shape and figure of test pieces shall conform to type B of Figure 10, in principle.

Figure 11

Unit: mm



10.2.2 Sampling and construction of test piece

Test pieces shall be sampled and constructed in a right angle to the heat-treatment direction according to 4.2.4, in principle.

10.2.3 Thickness of Test Piece

Thickness of the test piece shall be measured according to 4.2.5. Thickness of the test piece shall be 2.0~3.0mm, in principle, and the thickness allowance of the test area (line AB in Figure 11) shall be 0.05mm or less. The thickness shall be used in the averaging of 4 locations.

10.3 Testing Device

Use a tensile tester (refer to 3.3) with a tensioning speed of 500 ± 25 mm/min.

10.4 Testing Method

10.4.1 Testing Operation

Apply a tension until the test piece is severed.

10.4.2 Calculation

Expansion heat strength shall be calculated by the following:

Tr = F /:

where, Tr : expansion heat strength (kgf/cm {N/m})

F : maximum load (kgf {N})

t : thickness of test piece (cm)

10.5 Organizing Method of Test Result

Test scores shall be, in principle, the average value of the expansion strengths of the three test pieces.

10.6 Recording

The following shall be included in the test scores:

(1) Expansion heat strength

(2) Capacity of tester

(3) Testing temperature

(4) Other necessary items

11. Compression Permanent Deformation

11.1 Purpose

This test is performed in order to measure the remnant deformation of oil-added rubber by heat-compression.

11.2 Test Piece

Construction of the test piece shall conform to any one of the following three methods. However, in any case, the test piece shall be a straight cylinder shaped 12.70 ± 0.13mm in thickness and 29 mm in diameter.

(1) In case of pulling the test piece from the product :

First, construct the rubber plate with a certain thickness. If grinding is required to adjust the thickness, it shall be done lightly to prevent over heating. Also, the upper and bottom surfaces shall be parallel to each other. Next, pull the test piece apart by using a cylindrical revolving knife 28.70 ±0.05mm in inner diameter. Pay attention to ensure that the upper and bottom surfaces are vertical to the axis of the cylinder.

(2) In case of pulling the test piece from the rubber block sample : Construct a rubber block with the same oil-added condition as of the product, and perform according to the same method as of (1).

(3) In case of building the test piece as an oil added type:

Construct in the same oil-added condition as of the product. However, it is better to use an oil-added type 29.20 ± 0.05mm in diameter in the oil-added test piece area with the expectation of shrinkage.

11.3 Testing Device

Compressing device, constant-temperature container, and thickness gauge is used in this test.

(1) Compression Device

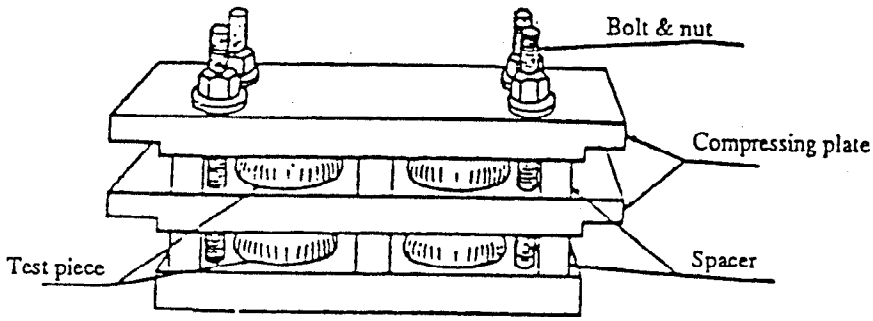
The compressing device consists of a flat compression plate, compression plate fixing bolt,

and nut spacer. The compression plate shall be constructed with a steel plate thick enough to resist bending from loading and to resist heat. The compression surface shall be flat, well ground, and Cr galvanized. Example of the compressing device is shown in Figure 12.

(2) Constant temperature container

Constant temperature container shall be able to ventilate heated dry air smoothly and regulate the specified temperature within ±1°C for a specified time.

Figure 12



(3) Thickness gauge

Thickness gauge shall be the one specified in 4.2.5 (1), which shall have under 50g of compressing load and a circular compressing surface 95.0 ± 0.05mm in diameter. The test piece shall be mounted on a circular plate having the same diameter as that of the pressing surface.

11.4 Testing Method

11.4.1 Measuring thickness

Thickness measurement shall be done by the thickness gauge of 11 (3) at a center location on the test piece.

11.4.2 Method of applying compression

Insert a spacer with a thickness of $9.52\ ^{+0.01}_{-0.02}$ mm at each end of the test piece as shown on Figure 12. Each end of the test piece shall not contact the spacer during compression. After inserting the test piece and spacer, apply pressure until the upper and bottom surfaces of the compression plate contact the spacer closely, and fix with a fastening bolt.

11.4.3 Compression ratio

Compression ratio of the test piece shall be 25% of the test piece thickness, in principle.

11.4.4 Heat treatment

Heat treatment temperature of the compression test shall be any one of 70 ± 1°C , 100 ± 1°C , 120 ± 1°C, 130 ± 1°C, 150 ± 1°C, 175 ± 2°C, 200 ± 2°C, 225 ± 3°C, 250 ± 3°C, or 275 ± 3°C. Heat treatment time shall be between 22 and 70 hours for any of the cases. Pre-heat the compression device sufficiently to reach the specified temperature before test piece insertion. Test piece insertion and compression shall be done within 10 minutes. Put the compression device in a constant temperature container for 22 hours at the specified temperature after completing the test piece insertion and compression. After 22 hours of heat treatment, pull the test piece out of the compression device promptly, and cool it down at room temperature. Cooling down time shall be 30 minutes until the final thickness measurement, and during that time, leave it on a wooden desk. Thickness measurement shall be done according to 11.4.1 Within one hour after pulling out the test piece, reinsert the test piece and compress in the constant temperature container for the specified time (48 hours) and measure the thickness in the above method.

11.4.5 Calculation

The permanent compression deformation ratio is calculated by the following method:

$CS = \{ (t_0-t_1) / (t_0-t_2) \} \times 100$

where, CS : compression permanent deformation ratio (%)

t_0 : original thickness of test piece (mm)

t_1 : thickness of test piece 30 minutes after pulling out from the compression device (mm)

t_2 : thickness of spacer (mm)

11.5 Organizing Method of Test Result

Test score shall indicate, in principle, the average value of the compression permanent ratio of three test pieces.

11.6 Recording

The following shall be recorded in the test scores:

(1) Compression permanent deformation after 22 hours and no less than 70 hours of heat treatment.

(2) Heat treatment temperature and time

(3) Testing temperature

(4) Other necessary items

12. Resilience Test

12.1 Purpose

This test is performed to measure the resilience of oil-added rubber indicating the magnitude of energy absorption, and by one of the following methods:

(1) Repulsion resilience test

(2) Yerzley resilience test

12.2 Repulsion Resilience Test

12.2.1 Test piece

The test piece specified in 11.2 shall be used. However, in case of a sampling from the product, overlapping of test pieces is acceptable when the thickness is less than the specified.

12.2.2 Testing device

A repulsion resilience tester having the same structure as in Figure 13 shall be used. An iron rod, one end of which is a half sphere and the other end having a directing needle, is suspended horizontally by 4 straps of string. The iron rod is annular shaped 356mm in length, 12.7mm in diameter, and 350g in weight. The suspending height of the iron rod shall be 2,000mm and the drop height shall be 100mm, vertically. The test piece support shall be fixed firmly as shown in Figure 14, so no vibrations will be generated by the impact of the iron rod. A scale shall have 625mm in horizontal height, 2,000mm in arc radius, and a graduation of vertical height 100mm divided by 100. The directing needle shall be adjusted so that the needle indicates 0 and the tip of iron rod contacts the surface of the test piece lightly when the iron rod is suspended freely.

12.2.3 Testing method

Adjust the directing needle to 100 of the scale, and when the iron rod is dropped freely from that height, measure the scale of the repulsion height. Repeat this operation, and measure the repulsion height from the impact of the 4th round, and use the value as the repulsion resilience.

12.2.4 Organizing method of test result

Test scores shall be, in principle, the average repulsion resilience of three test pieces.

12.2.5 Recording

Test score shall include the following:

(1) Repulsion resilience

(2) Testing temperature

(3) Other necessary items

12.3 Yerzley Resilience Test

12.3.1 Testing method

The testing method shall conform to 25, Mechanical oscillograph test.

12.3.2 Recording

The following shall be recorded in the test results:

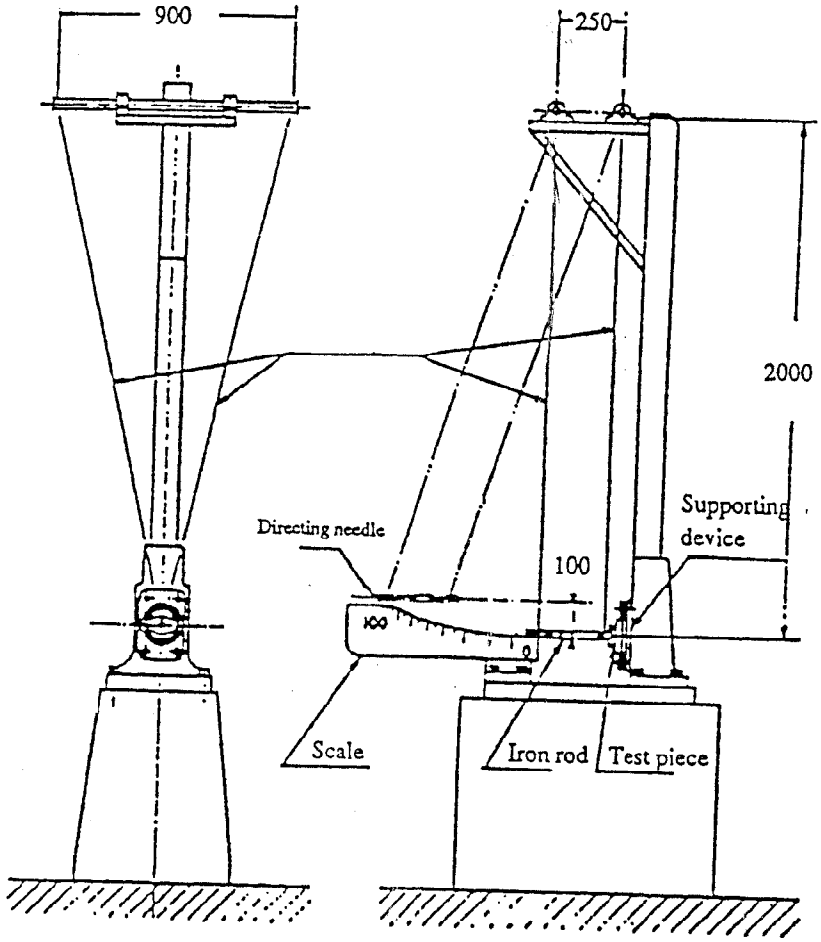
(1) Yerzley resilience

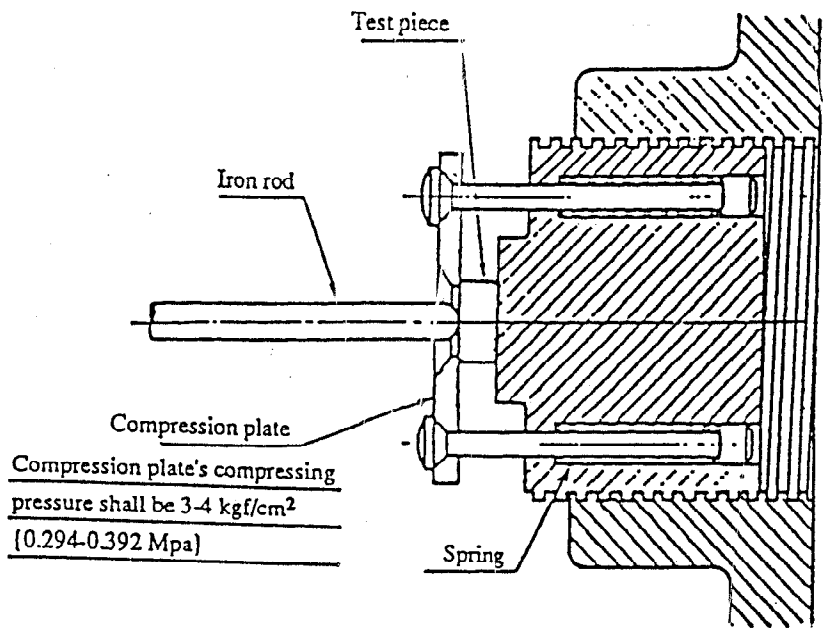
(2) Test method (shear, compression)

(3) Test temperature

(4) Other necessary items

Figure 14


900
250
2000
Directing needle
100
Supporting device
Scale
Iron rod
Test piece


Test piece
Iron rod
Compression plate
Compression plate's compressing pressure shall be 3-4 kgf/cm²
{0.294-0.392 Mpa}
Spring

13. Oil (fluid) Resistance Test

13.1 Purpose

This test is performed to measure the oil (fluid) resistance characteristic of oil-added rubber. Resistance against sour-gasoline is measured by 13.7, Sour-gasoline resistance test.

13.2 Test Piece

13.2.1 Sampling and construction of test piece

The test piece is sampled from the oil-added rubber plate, in principle. In case of a sampling from the product, it shall conform to 4.2.4.

13.2.2 Shape and figure of test piece

(1) Test piece 10mm in width, 20mm in length, and 2-3mm in thickness shall be used for the weight, volume change test, and physical appearance change test. In case of measuring equivalently expanded test piece, different shape and figures of test piece cmpare to above are acceptable.

(2) Type 3 dumbbell is used for tensile strength and elongation change test.

(3) Test piece with 12mm or more of thickness obtained by overlapping is used for hardness change test.

13.3 Testing Device

13.3.1 Testing Fluid

Any oil conforming to Table 5-9 can be used as testing oil (fluid), in principle.

Table 5. Testing oil

Sort of oil / Test item	No.1 Oil	No.2 Oil	No2. Oil	No.3 Oil
Dynamic viscosity	(98.9°C)	(98.9°C)		(37.8°C)
(cSt){mm /S}	18.71-21.05	19.19-21.52	1/1 mixture of	31.96~34.18
Annealine point (°C)	124 ± 1	93 ± 3	NO.1 oil and NO.3	69.5 ± 3
Ignition point (°C)	244 or more	246 ± 6	oil by volume	166 ± 3

Table 6. Testing brake fluid

Ingredient	Ratio
KIA pure brake fluid	100

Table 7. Testing coolant

Volume %

Ingredient	Ratio	
	A	B
KIA pure long-life coolant	—	55
Ethlyene Glycol	50	—
Pure water	50	45

Table 8. Testing fuel oil

Volume %

Kind of fuel oil / Ingredient	A	B	C	D
ISO-Octane (15)	100	70	50	60
Toluene (15)	—	30	50	40

Note (15) Shall be better than 1st class of KS M 8153 [toluene].

Table 9. Testing gasoline

Phase / Kind	Reaction	Ignition point (°C)	Distill 90% flow-out point°C	Flowing point °C	Remnant carbon weight for 10% remnant %	Cetane index (15)	Dynamic viscosity (30°C) cSt (16) {mm²/S}	Sulfur weight %
Special Kind	neutral	50 or more	360 or less	+5 or less	0.10 or less	50 or more	2.7 or more	0.50 or less
Kind 1			360 or less	-5 or less		50 or more	2.7 or more	
Kind 2			350 or less	-10 or lessr		45 or more	2.5 or more	
Kind 3			330 or less	-20 or less		45 or more	2.0 or more	
Special Kind			330 or less	-30 or less		45 or more	1.8 or more	

Note (15) Cetane value can be used as the cetane index.

(16) 1 cSt = 1mm²/sec

13.3.2 Tester

A glass test tube 38mm in outer diameter and 300mm in length is used as the container. In case of volatile testing oil (flui), attach a circulating cooling device.

13.4 Testing Condition

Rubbers of unidentical material shall not be submerged in the same container. Submerging shallbe done in a place where there is no direct exposure to sun light, and the testing oil (fluid) shall be replaced for each test. The test temperature shall be selected from the following conditions, according to the usage of the product:

(1) Testing Temperature

30 ± 1°C, 40 ± 1°C, 70 ± 1°C, 100 ± 1°C, 120 ± 1°C, 130 ± 1°C, 150 ± 1°C, 175 ± 2°C, 200 ± 2°C.

(2) Testing Time

(a) 22, 46, and 70 hours (166 hours) for the measurement of weight and volume change.

(b) 70 hours for the measurement of the tensile strength and elongation strength change.

13.5 Testing Method

13.5.1 Weight change test

Put the test piece in a test container which can hold up to 1mg, in atmosphere, and add 150mℓ of testing oil (fluid), then cap with a light cork and submerge in an air bath, liquid bath, or metal bath with a temperature regulated to the specified point. The test piece shall not contact the container wall at this time. After submerging, cool the test piece down by submerging it in the same kind of new testing oil (fluid), for 10 to 30 minutes. Subsequently, submerge the test piece in acetone for the testing oil (fluid) of Table 5 and in water or alcohol for the testing oil (fluid) of Table 6 and 7, and drop the testing oil (fluid) (this is not necessary for the testing oil of Table 8 and 9), and wipe lightly with filter paper, and seal tightly in a submergable bottle, and measure the weight of the test piece after submerging. If it is necessary to perform the submerging subsequently, return it to the original oil (fluid) immediately after measuring the weight. Operations other than submergence shall be done within 20 seconds.

13.5.2 Volume change test

Measure the weight of test piece before submerging in the testing oil (fluid) according to 13.5.1, and measure the weight in the distilled water at room temperature, then pull out immediately after submerging in alcohol, and wipe and remove the moisture with filter paper. Subsequently, after submerging the test piece in the testing oil (fluid) for the specified time, submerge and cool down in the same kind of testing oil (fluid), at room temperature in the same method of 13.5.1, and remove the testing oil (fluid) with acetone, water, or alcohol, and measure the weight after sealing it in a submergable bottle in air, and measure the weight in the distilled water, at room temperature. If subsequent submerging is required, submerge in retesting oil (fluid) after wiping with filter paper.

13.5.3 Tensile strength, elongation, and hardness change test

After submerging the thickness measured test piece for a specified time by the same method of 13.5.2, cool it down and remove the remnant testing oil (fluid), and measure the tensile strength and elongation according to 4, and hardness according to 5.

13.5.4 Calculation

(1) Weight change rate and volume change rate are calculated by the following formulas:

$\Delta W = \{ (W_3-W_1/W\} \times 100$

$\Delta V = [\rho_2 (W_3-W_4) - \rho_4 (W_1-W_2)] / \{ \rho_4 (W_1-W_2)\}] \times 100$

where, ΔW : weight change rate (%)

ΔV : volume change rate (%)

W_1 : in-atmosphere weight before submerging (g)

W_2 : in-water weight before submerging (g)

W_3 : in-atmosphere weight after submerging (g)

W_4 : in-water weight after submerging (g)

ρ_2 : density of in-water weight measured water before submerging (g/cm^3)

ρ_4 : density of in-water weight measured water after submerging (g/cm^3)

(2) Tensile strength and elongation change rate are calculated by the following formulas:

(a) In case of four test pieces

$B_R = (1/4) \times (S_{21}/S_{11}+S_{22}/S_{12}+S_{23}/S_{13}) \times 100$

$B_T = B_R - 100$

(b) In case of three test pieces

$B_R = (1/3) \times (S_{21}/S_{11}+S_{22}/S_{12}+S_{23}/S_{13}) \times 100$

$B_T = B_R - 100$

(c) In case of two test pieces

$B_R = (1/2) \times (S_{21}/S_{11}+S_{22}/S_{12}) \times 100$

$B_T = B_R - 100$

where, B_R : remnant rate of tensile strength and elongation after test (%)

B_T : change rate of tensile strength and elongation after test (%)

S_{11} : values of tensile strength and elongation before test arranged according to test sequence (i=r~4)

S_{21} : values of tensile strength and elongation after test arranged according to test sequence (i=1~4) and calculated by using a across sectional area after the test. S_{21} is calculated from the cross sectional area after the test or by following the formula. (tensile strength only)

S_{21} : $S_{31}/[1 + (\Delta V/100)^{23}]$

S_{31} : values of tensile strength calculated by using the cross sectional area before the test and arranged according to the test sequence (i=1~4)

(3) Hardness change is calculated by the following formula:

$O_H = H' - H$

where, O_H: hardness change

H' : hardness before test

H : hardness after test

13.6 Organizing Method of Test Result

13.6.1 Number of test pieces

Four test pieces are used in each measurement, in principle. However, test pieces 12mm or more in overlapped thickness is used in the hardness test.

13.6.2 Test score

Test scores are obtained according to 13.5.4. However, the average value of 4 locations is used for the hardness test measurement.

13.6.3 Recording

The following shall be recorded in the test scores:

(1) Volume (weight) change rate, tensile strength change rate, elongation change rate, and hardness change

(2) Kind of testing oil (fluid)

(3) Submerging condition

(4) Other necessary items

13.7 Sour-gasoline Resistance Test

13.7.1 LPO addition method (A method)

Prepare the testing fluid by dissolving 3Wt% peroxide lauroyl (LPO) in oil fuel C of Table 8, and perform the test in the same method used in the oil resistance test performed with fuel oil C. However, the container in which the test piece is contained shall not be exposed to the sun, and the testing fluid shall be replaced for each test cycle. Append finding of crack formation (17) to the test result record.

Note (17) Within one minutes after pulling the test piece out of the testing fluid, observe the surface condition. Bend 180 degrees by hand and observe any formation of cracks.

13.7.2 Pressurized oxygen method (B method)

13.7.2.1 Test Piece

Shall conform to 13.2.2 (1).

13.7.2.2 Testing Device

Those of (1) - (6) with the structure shown in Figure 15.

(1) Bomb : bomb, structured as shown in Figure 16, shall be able to bear 15kgf/cm^2 {1.47MPa} of water pressure for one hour. Fill bomb with 7kgf/cm^2 {0.69MPa} of oxygen in 15~25°C and submerge in a water bath with a temperature regulated to 100 ± 1°C. After 24 hours, the pressure drop shall be within 0.14kgf/cm^2 {0.0137MPa} of maximum pressure.

(a) Bomb body and cap: As shown in Figure 17 and 18, it shall be built from stinless steel (SUS 304) with an easy to clean inner surface. To prevent corrosion, clean frequently.

(b) Installing metal device: Copper alloy as shown in Figure 19.

(c) O-ring: As specified in KS B 2805 (O-ring).

(d) Pipe: Shape and figure are shown in Figure 18. It shall be build from the same material as that of the bomb cap with an easy to clean inner surface. To prevent corrosion, clean frequently. Pipe shall have a circular metal plate, connecting flange, and needle valve.

(e) Revolving axis: Built from the same material as that of the bomb cap with the shape and figure as shown in Figure 20.

(2) Sample container and cover

Of Figure 94 and 95 specified in KS M 2670 (Glass ware for testing apparatus of petroleum products).

(3) Pressure gauge

Breton pipe or recorder type pressure gauge capable of measuring up to 15kgf/cm² {1.47 MPa} (gauge pressure). A scale corresponding to 3.5kgf/cm² {0.343 MPa} shall be 25mm in the upper arc for the 7-15 kgf/cm² {0.69–1.47 MPa} range. The micro scale shall be under 0.25kgf/cm² {0.0245 MPa}. Errors shall be under 0.15kgf/cm² {0.0147 MPa}. The pressure gauge is connected to the bomb, upright or through the connecting pipe.

(4) Connecting pipe

Connect a conduit pipe and pressure gauge using copper pipe or other pipes of the appropriate material, in the shape and length shown in Figure 15. The inside capacity of the connecting pipe shall be less than 30m ℓ , including the area of the conduit pipe.

(5) Thermometer

Theremometer number 6 (Gos) specified in KS B 5314 (Liquid-in-glass thermometers for testing of petroleum products).

(6) Constant temperature container

With the shape and figure as shown in Figure 15, the capacity shall be over 18 ℓ for one bomb. Increase 8 ℓ for each additional bomb. The structure shall be that the bomb cap is located at least 50mm below the fluid level when the circular metal located at least 50mm below the fluid level when the circular metal of the conduit pipe inserted bomb is in the constant temperature container. Prepare an assist cap in case the bomb is not placed. In case of using a bathing fluid 99. 5~100.5°C, a heating device capable of the intensive boiling of the bathing fluid and a circulating cooling device shall used. In case of using a bathing fluid over 100.5°C , a temperature control device capable of regulating the temperature of the bathing fluid at a constant 80 ± 1°C shall be used. Insulation resistance of the heater shall be 5MΩ or more when charging the compartment and the support is measured by a 500V insulation resistance meter. However, one 0.5 MΩ or more

when a heating circuit is included.

13.7.2.3 Testing oil

Type 1 or 2 gasoline specified in KS M 2612 (Automobile gasoline) with over 10 vol % of olefin (6).

Note (6) Olefin analyzing method. ASTM D 1319 (Standard test method for hydrocarbon type in liquid petroleum products by fluorescent indicator adsorption)

13.7.2.4 Testing condition

(1) Testing temperature and time

80°C x 22h shall be one cycle. Repeat until cracks form.

(2) Oxygen pressure

Shall be 5kgf/cm^2 {490 KPa}. Replace a new one for every test cycle.

(3) Copper catalyst

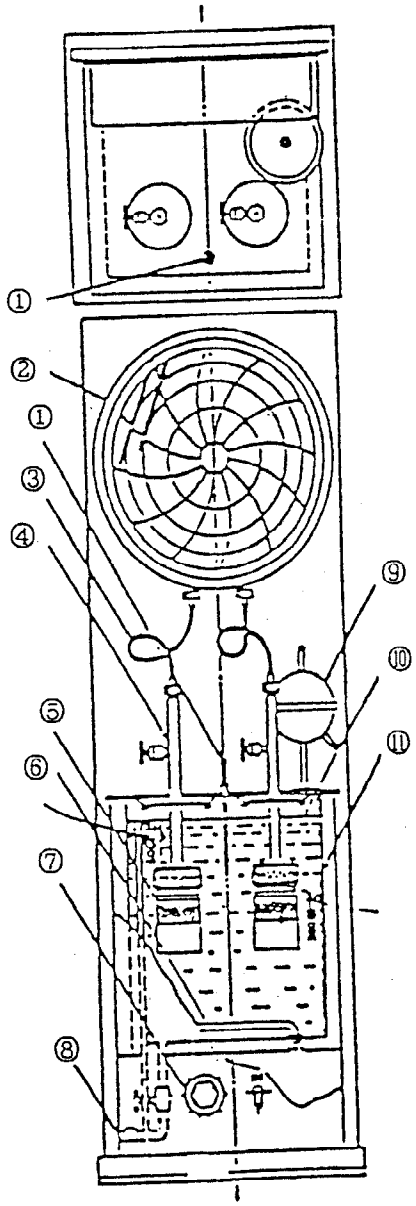
Shall be the material specified in KS D 5201 (Copper and copper alby sheets, plates strip and coiled sheets). Take a sample 20 x 100mm from a 0.02~0.05mm thick brand new copper sheet and fold. Put it into the sample container.

(4) Test piece and amount of catalyst

Put one test piece and one copper catalyst into one sample container.

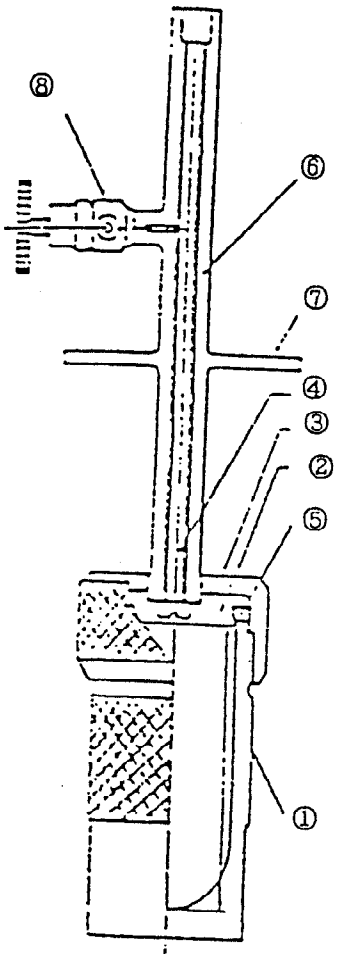
Figure 15. Oxidation stability tester (example)

unit : mm



① Thermometer
② Recorder type pressure gauge
③ Connecting pipe
④ Conduit pipe
⑤ Bomb
⑥ Electric heater
⑦ Temperature controller
⑧ Drain
⑨ Circulating cooling device
⑩ Bathing fluid
⑪ Constant temperature container

Figure 16. Bomb



① Bomb body
② Bomb cap
③ Installing device
④ Axial rod
⑤ O-ring
⑥ Conduit pipe
⑦ Circular metal plate
⑧ Needle valve

Figure 17. Bomb Body

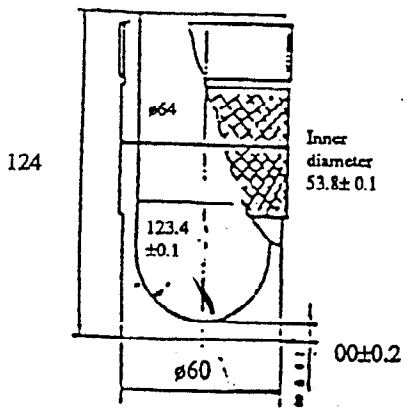


Figure 18. Bomb cap and conduit pipe

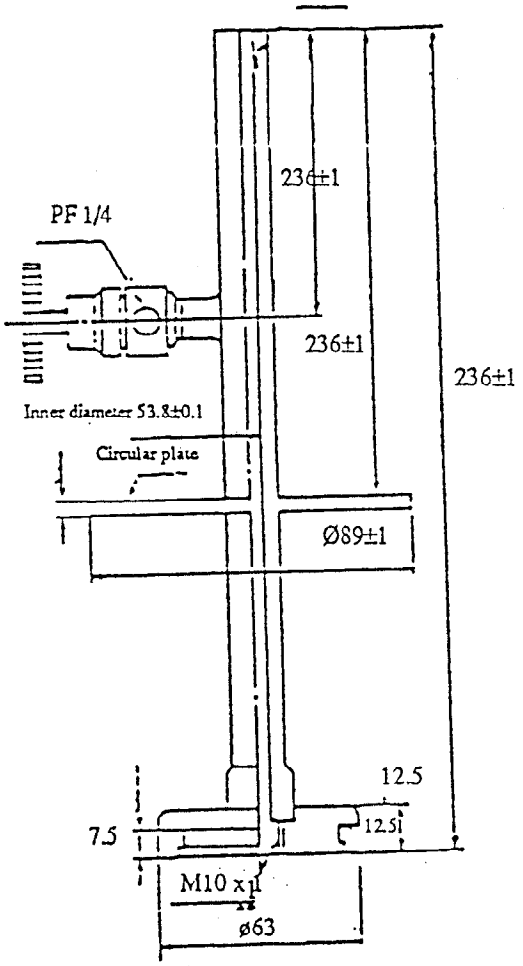


Figure 19. Fixture

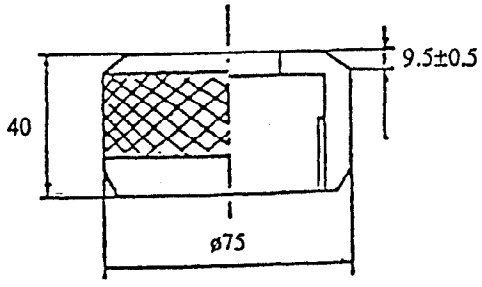
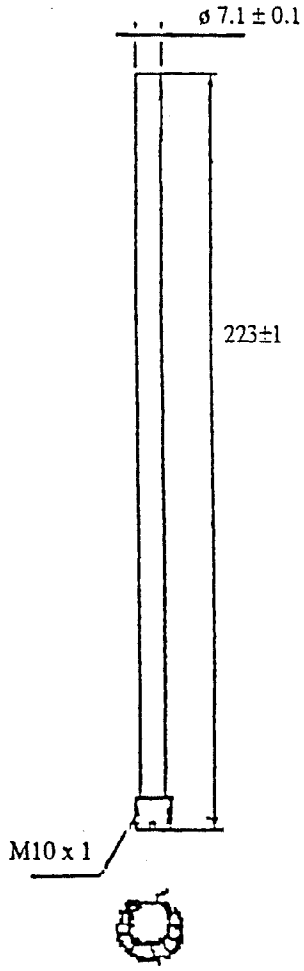


Figure 20: Axial rod

Screw portion is cut off to the outer diameter of the revolving axis



13.7.2.5 Testing method

(1) Testing chemicals

(a) Gum solvent: Equivalent mixture of toluene specified in KS M 8153 and acetone specified in KS M 8010 [Acetone)

(b) Chemical device detergent

Sulfur specified in KS M 8103 [sulfuric) saturated with dichromic acid natrium specified in JIS K 8517 (potassium dichromate) (hereinafter called "dichromic acid mixture fluid" (18)), or it's equivalent detergent.

Note (18) Dichromic acid misture fluid shall be innocuously treated.

(2) Test preparation

The test preparation shall be done as follows:

(a) After detaching the attached devices on the sample container, submerge them with it's cover in a glass device detergent at least 6 hours. Pull them out of the detergent using sample container tongs. When handling the sample container hereinafter, use sample container tongs. Clean with tap water sufficiently and dry at least one hour in a 100-150°C. After cooling down in a desiccator 2 hours or more without the addition of silica gel, measure precisely up to 0.1mg.

(b) Clean the inside of the bomb and cap with a clean cloth soaked with gum solvent and with a clean dry cloth subsequently. When removing gum and the remaining sample from the annular space between the inner wall of conduit pipe and axial rod using the gum solvent, separate the axial rod from the conduit pipe and carefully clean both of them. Both the inside and outside of the pipe connected to bomb shall be cleaned. Bomb and connecting pipes shall be dried completely before each initiation of the test.

(c) In case of using a constant temperature container of which the bathing temperature is regulated by a temperature controller, adjust the bathing temperature to 80 ± 0.1°C, and keep this temperature until the end of the test.

(3) Testing sequence

The testing sequence is as follows:

(a) Place the sample container containing the test piece and catalyst at the center of the bomb at 15-25°C, and inject 100 ± 1mℓ of testing oil. Cover the sample container and cap bomb (19), and insert oxygen up to 5.0-5.2kgf/cm^2. Slightly open the needle valve to discharge 3.5kgf/cm^2 (0.345 MPa) or less of gas per minute. Repeat this operation to force out the air injected first. Reinject oxygen up to 5.0-5.2kgf/cm^2 and check whether the air is leaking by observing the pressure gauge. Ignore the initial pressure drop [generally 0.5kgf/cm^2 (0.049 MPa)] due to the dissolving of oxygen in the sample. If

the ratio of the initial pressure drop does not exceed 0.15kgf/cm^2 (0.0147 MPa), it is assumed that there is no leaking, and test should be continued.
Note (19) Refer to Figure 21.

(b) Put the bomb containing the sample and oxygen in a constant temperature container, with care to prevent vibrations, and record the time of initiation. Leave the bomb in the constant temperature container for 16 hours.

(c) After oxidizing for 22 hours at 80°C, close the needle valve and cool down immediately with water. Remove pressure gradually at a rate of under 3. 5kgf/cm^2 {0.345MPa}, and uncap the bomb and pull out the sample container.

13.7.2.6 Result

Clean the tested test piece with JIS K 8594 (Petroleum benzine). Bend the test piece within a minute and observe any crack formating in the same method as in 13.7.1. Evaluation of cracks formating shall conform to the indicating method of Article 16, ozone aging test of JIS K 6301 (Physical testing method of vulcanized rubber).

13.7.2.7 Number of Test

Perform the test three times or more, for oil-added rubber. Also, test once or more for standard rubber (20).

Note (20) To compensate the effect of the testing oil variation to the test result, use the inner surface rubber of R-BG 710-Y118 specified in KES B-L 006 as the standard rubber, and add the comparison test.

13.7.2.8 Recording

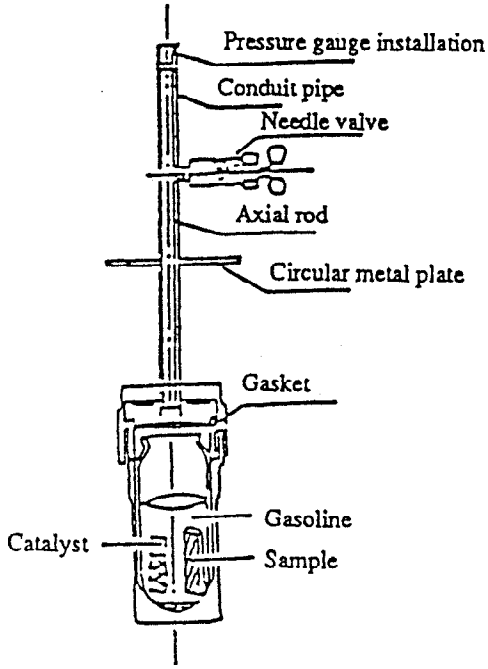
Test score shall indicate the following:

(1) Aging condition, crack formation condition, rubber hardness change, surface condition of sample, and standard rubber material

(2) Classification, testing temperature, oxygen pressure record, and number of test cycles of testing oil

(3) Other necessary items

Figure 21. Testing device



14. Low Expansion Stress Test

14.1 Purpose

This test is performed to measure the low expansion stress of oil-added rubber.

14.2 Test Piece

14.2.1 Shape and figures of test pieces

Shape of test piece shall be rectangular, and conform to Table 10.

Table 10

unit: mm

Type	Dimension			
	Width	Length	Thickness	Marking line distance
Type 1	5	100	2~3	40
Type 2	10	60	2~3	40

Type 1 test piece is used in principle, and type 2 is used for samples with low stress and when is hard to get type 1.

14.2.2 Sampling and construction of test piece

The sampling and construction of the test piece shall be done according to 4.2.4.

However, instead of 4.2.4, direct addition of oil to the test piece using tooling can be utilized.

14.2.3 Measurement of thickness and width

Measurement of the thickness and width of the test piece shall be done the following method:

(1) Use the thickness gauge specified in 4.2.5.

(2) Thickness of the test piece shall be the average of the measurements between the marking lines, including itself. Measuring locations shall conform to type 1, in principle, and shall be five for type 1 and three for type 3. It shall not be measured in such a condition that the pressure surface of the gauge is extruded outward from the boundary of the test piece.

(3) Width of the test piece shall be the average of the measurements between the upper and lower surfaces of the marking lines. Measurement of width shall be done by using a microscope with a 1/00mm scale.

(4) Cross sectional area of the test piece is calculated by the following formula:

Cross sectional area (cm^2) = width (cm) x thickness (cm)

14.2.4 Marking line for elongation measurement

(1) Distance of marking lines shall conform to Table 10.

(2) Marking line shall be drawn precisely and clearly by using the center of the test piece as it's center. Width of the marking line shall be less than 0.2mm.

14.2.5 Inspection of test piece

Test pieces shall be inspected prior to the test. Those over 0.1mm of deference in the maximum and minimum thickness, over 0.1mm of difference in the cross sectional width, ones with traces of foreign matter and with scratches shall be excluded.

14.3 Testing Device

Tensile tester satisfying the following conditions shall be used:

14.3.1 Capacity of tester

When the specified elongation ε % is applied, the load shall be within 15-85% of capacity.

14.3.2 Tensioning speed

Moving speed of the test piece support shall be 45 ± 15mm, in principle.

14.4 Testing Method

14.4.1 Installation of test piece

Installing location of the test piece in support shall be twice or more the distance of the marking lines at a point of equal distance to the marking lines. To prevent torsion or other inappropriate situations, installation shall be done precisely and firmly.

14.4.2 Preliminary test

In case of measuring ε % of the tensile stress, apply a load 4 times from 0% to 1.5 ε % of the elongation prior to the main test. For 0% and 1.5 ε %, let stand still for 30 seconds each round. Speed of tensioning and shrinkage shall be 30-60mm/min {0.0005-0.0010

m/s}, in principle.

14.4.3 Main test

Main test (5th round) shall be performed in a tensioned condition, in principle, with the same tensioning speed as that of the preliminary test. Let stand still for 30 seconds after the tensioning and measure the load.

14.4.4 ε % tensile stress

ε % tensile stress is calculated by the following formula:

$$\delta = F\varepsilon / A$$

where, $\delta\ \varepsilon$ = ε % tensile stress [kgf/cm^2 (M/Pa)]

$F\varepsilon$ = ε % load at tension [kgf (N)]

A = cross sectional area of test piece

ε = elongation, 25% in principle

14.5 Organizing Method of Test Result

Test scores shall be indicated by the average of 4 test pieces, in principle.

14.6 Recording

The following shall be recorded in the test scores:

(1) Low tensile stress

(2) Elongation

(3) Type of test piece

(4) Capacity of tester

(5) Testing temperature

(6) Other necessary items

15. Cold Resistance Test

15.1 Purpose

This test is performed to measure the cold resistance characteristics of oil-added rubber. Cold resistance test is performed by the following methods, in principle:

(1) Impact brittle test

(2) Low temperature torsion test

15.2 Impact Brittle Test

15.2.1 Test piece

Test piece shall be a rectangle 6.3 ± 0.3mm in width, over 32mm in length and 2.0 ± 0.4mm in thickness, and is sampled from the oil-added rubber plate, in principle.

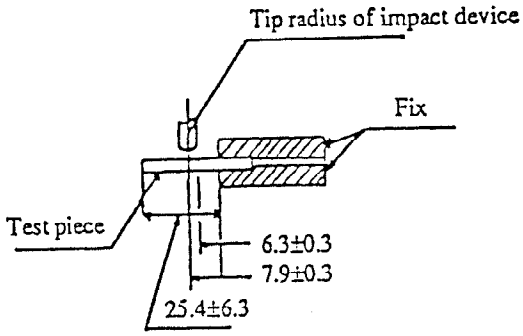
15.2.2 Testing device

Test device consists of an impact device capable of applying impact to the test piece and support at the specified speed and a constant temperature container capable of maintaining the test piece temperature at the specified degree.

(1) Test piece support and impact device

Test piece support shall be able to maintain the test piece firmly, and shall be 6.3mm or more in length. Impact device shall have a 15.7 ± 0.12mm tip radius, and when impacted, shall be able to maintain 1.97 ± 0.15m of uniform linear speed for at least 6mm of traveling distance. To maintain this uniform speed, it may be necessary to limit the number of test pieces simultaneously tested. Relative position of the impact device and support shall follow Figure 22, and the distance between the center line of the impact device and support shall be 7.9 ± 0.3mm at the moment of impact. Space between the impact device and support shall be 6.3 ± 0.3mm at and after the moment of impact.

Figure 22



(2) Constant temperature container

Constant temperature container filled with refrigerated liquid heat transfer media shall be able to maintain the test temperature within ± 0.5°C.

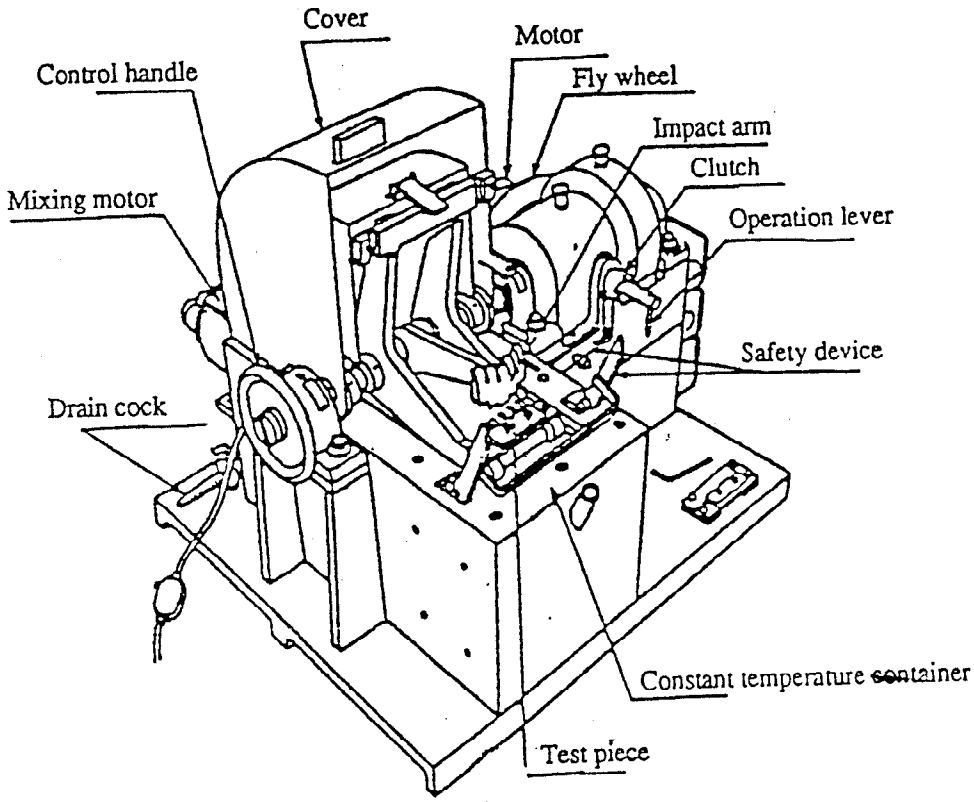
Remarks 1. Impact device can be operated by either a motor or solenoid. Figure 23 is an example of the testing device operated by a motor.

2. Heat transfer media shall be one which does not affect the test piece with the testing temperature.

15.2.3 Testing method

Maintain the heat transfer media at the specified temperature in the constant temperature container, beforehand. Impact the test piece submerged for 5 minutes in cold bath, and indicate whether the test piece is destroyed. Destruction means complete separation or cracks forming in the test piece. When observing cracks forming, bend the test piece in a right angle to the impact direction.

Figure 23



15.2.4 Organizing method of test result

Measure the destruction using five test pieces at the specified temperature, and take the lowest temperature at which no destruction occurs. Pay attention to this since it is different from JIS K 6301.

15.2.5 Recording

The following shall be recorded in the test scores:

(1) Test temperature and brittle temperature

(2) Presence of destruction

(3) Type of heat transfer media

(4) Other necessary items

15.3 Low Temperature Torsion Test

15.3.1 Shape and figures of test piece

Test piece shall be a rectangle 3 ± 0.15mm in width, 38 ± 2.5mm in length, and 2 ± 0.5mm in thickness with ±0.1mm of less of thickness variation in the same test piece. Sampling of the test piece shall conform to 4.2.4.

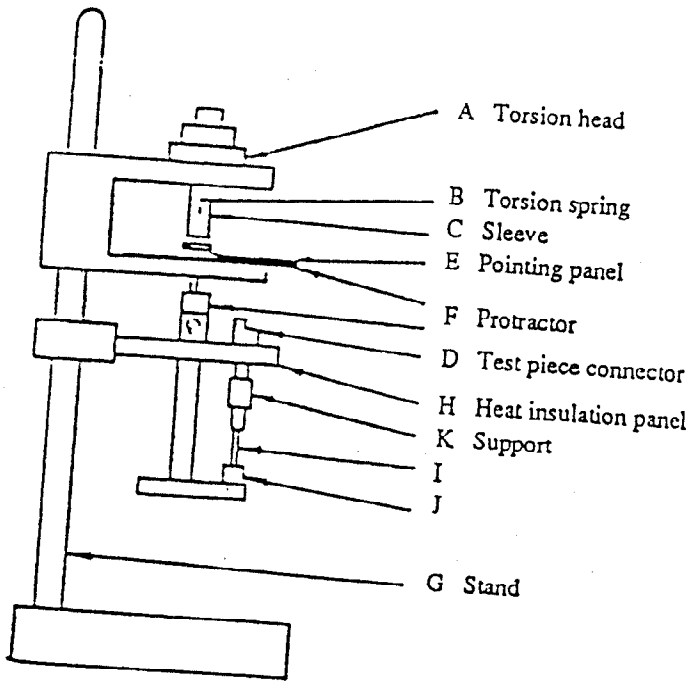
15.3.2 Testing device

Testing device consists of a torsioning device, torsion spring, sample fixing device, and constant temperature container, and shall satisfy the following conditions:

(1) Torsioning device

Outline of the device is shown in Figure 24. Sleeve C protects the torsion spring from contacting torsion head A, which is capable of a 180° rotation, horizontally by installing torsion spring B. The bottom of the torsion spring is fixed to test piece connector D by a screw. Displacement of the gauge can be obtained by installing the test piece connector and moving the pointing needle at the bottom of protecting sleeve. Install a protractor F capable of 0 calibration.

Figure 24



(2) Torsion spring

Although a torsion spring 64 ± 5mm in length, and 0.125, 0.550, 2,000g·cm/deg of spring constant can be used, 0.500g·cm/deg of torsion spring constant is the desirable standard.

3) Sample fixing device

Sample fixing device J shall not move when revolving the torsion spring.

) Constant temperature container

Constant temperature container shall be able to maintain ±0.5°C of a certain temperature within the range of -70 - +30°C. Alcohol is used as the heat transfer media, in principle.

3 Testing method

(1) Spring constant of torsion spring

Install and fix one end of the torsion spring vertically, and install it's bottom to the center of the column 6~8mmø in diameter and 200~250mm in length. Rotate this circular column 90 or less degrees and vibrate freely. Obtain a cycle by measuring the time required for 20 rounds of vibration.

Inertia moment

$$I = m \ell^2/12$$

where, I : Inertia moment ($g \cdot cm^2$)

m : Mass (g)

ℓ : Length (cm)

Torsion constant

$K = \pi \lambda$ (981 x 180)

$\lambda = 4\pi^2 I/T^2$

where, λ : Torsion constant of wire (Dyne•cm/Radian)

K : Torsion constant of wire (g•cm/deg)

T : Cycle (sec)

(2) Installation of test piece

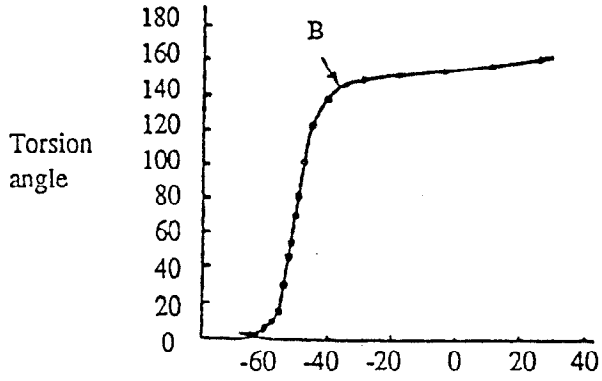
Install so that the distance between the supports are 25 ± 2.5mm. Loosening or the expansion of the test piece shall not occur during the torsion test.

(3) Measurement

Place the test piece in a constant temperature container so that the heat transfer media level is more than 30mm above the top of the test piece. Connect the test piece to the torsion spring and set the temperature to 25 ± 2°C. Place the pointing needle on 0 in the protractor and spin the torsion head rapidly. Rotate 180 degrees and measure the pointing needle location after keeping that location for 10 seconds. If the value is within 120-170, continue the test. Retry the test with a torsion spring with a lower spring constant if the value is over 170, and with a higher spring constant if the value is under 120. Place the torsion head at the starting position, and separate the test piece and torsion spring, and insert a spacer at the bottom of connector (D) to prevent deformation of the test piece.

Next, lower the temperature of the constant temperature constainer to the lowest testing temperature and maintain it for 5 minutes or more at ±5°C of the measuring temperature, and connect the test piece and torsion spring and remove the spacer. Continuously spin the torsion head as described above and measure the torsion angle. Henceforth, raise the temperature at a constant interval (interval is to be 2-4°C for low temperatures and 10-15°C for high temperatures from point B of Figure 25) and measure the torsion angle. Each temperature shall be held for over 5 minutes, and measurements shall terminate when the temperature is 0°C or more.

Figure 25



15.3.4 Calculation of result

(1) Obtain the relationship of the torsion angle and temperature in the form of Figure 25 from the results of measurements. The torsion elasticity rate of the test piece is proportional to (180 - x)/x [x:torsion angle]. Indicate this value obtained for the torsion angle in Table 11.

(2) Proportional modulus

This is a ratio of the modulus at a certain temperature against the modulus at 25°C, and is computed from Table 11. For instance, if the torsion angle is 144° at 25°C and 30° at t°C, the proportional modulus at t°C is obtained from Table 11 by the following formula:

$Mc = \{ (180-X_1)/X_1\}/\{ (180-X_2)/X_2\}$

where, Mc : Proportional modulus at t °C

X_1 : Torsion angle at t°C (30°)

X_2 : Torsion angle at 25°C (144°)

In this case, the proportional modulus is calculated from value Table 11 by the following formula:

$Mc = 5.0/0.25 = 20$

∴ Proportional modulus at t°C is 20.

Table 11

Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X
1	179	51	2.53	101	0.782	151	0.192
2	89	52	2.46	102	0.765	152	0.184
3	59	53	2.40	103	0.748	153	0.176
4	44	54	2.33	104	0.731	154	0.169
5	35	55	2.27	105	0.714	155	0.161
6	29	56	2.21	106	0.698	156	0.154
7	24.7	57	2.16	107	0.682	157	0.146
8	21.5	58	2.10	108	0.667	158	0.141
9	19.0	59	2.05	109	0.651	159	0.132
10	17.0	60	2.00	110	0.636	160	0.125
11	15.4	61	1.95	111	0.662	161	0.1180
12	14.0	62	1.90	112	0.607	162	0.1111
13	12.8	63	1.86	113	0.593	163	0.1043
14	11.86	64	1.81	114	0.579	164	0.0975
15	11.00	65	1.77	115	0.565	165	0.0909
16	10.25	66	1.73	116	0.552	166	0.0843
17	9.59	67	1.69	117	0.538	167	0.0778
18	9.00	68	1.65	118	0.525	168	0.0714
19	8.47	69	1.61	119	0.513	169	0.0651
20	8.00	70	1.571	120	0.500	170	0.0588
21	7.57	71	1.535	121	0.488	171	0.0527
22	7.18	72	1.500	122	0.475	172	0.0465
23	6.83	73	1.466	123	0.463	173	0.0405
24	6.50	74	1.431	124	0.452	174	0.0345
25	6.20	75	1.400	125	0.440	175	0.0286
26	5.92	76	1.368	126	0.429	176	0.0227
27	5.67	77	1.337	127	0.417	177	0.0169
28	5.43	78	1.308	128	0.406	178	0.0112
29	5.21	79	1.278	129	0.395	179	0.0056
30	5.00	80	1.150	130	0.385	180	0.0
31	4.81	81	1.222	131	0.374		
32	4.62	82	1.195	132	0.364		
33	4.45	83	1.169	133	0.353		
34	4.29	84	1.143	134	0.343		

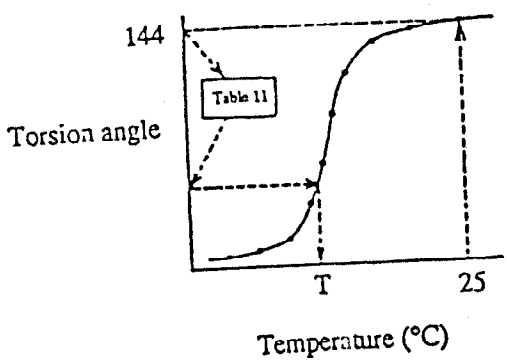
Table 11. (Continued)

Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X	Torsion angle X degree	(180-X)/X
35	4.14	85	1.118	135	0.333		
36	4.00	86	1.093	136	0.324		
37	3.86	87	1.069	137	0.314		
38	3.74	88	1.045	138	0.304		
39	3.62	89	1.022	139	0.295		
40	3.50	90	1.000	140	0.286		
41	3.98	91	1.978	141	0.277		
42	3.29	92	1.956	142	0.267		
43	3.19	93	1.935	143	0.258		
44	3.09	94	1.915	144	0.250		
45	3.00	95	1.895	145	0.241		
46	2.91	96	1.875	146	0.233		
47	2.88	97	1.856	147	0.224		
48	2.75	98	1.837	148	0.216		
49	2.67	99	1.818	149	0.208		
50	2.60	100	1.800	150	0.200		

(3) Temperature at which the proportional modulus become constant

This is the obtained temperature at which the proportional modulus become constant (2, 5, 10, 50). In principle, obtain the temperature at which the proportional modulus become 5 and 50, and indicate as T5 and T50.

Figure 26



(4) Traverse modulus of elasticity

Traverse modulus of elasticity is calculated by the following formula:

$$G = \frac{180}{\pi} \times \frac{K\,(180\text{-}X)\,L}{ab^3\,\mu X}$$

where, G : Traverse modulus of elasticity (gf/cm^2 {KPa})

K : Torsion constant of wire (gf•cm/deg {mN•m/rad})

L : Distance of test piece supports (cm)

X : Torsion angle (deg {red})

a : Width of test piece (cm)

b : Thickness of test piece (cm)

μ: Constant decided from a/b follows Table 12

Table 12

a/b	μ	a/b	μ
1.00	0.141	2.25	0.240
1.05	0.148	2.50	0.250
1.10	0.154	2.75	0.257
1.15	0.160	3.00	0.264
1.20	0.166	3.50	0.274
1.25	0.172	4.00	0.281
1.30	0.177	4.50	0.287
1.35	0.182	5.00	0.281
1.40	0.187	6.00	0.299
1.40	0.192	7.00	0.304
1.50	0.196	8.00	0.307
1.60	0.204	9.00	0.310
1.70	0.211	10.00	0.313
1.75	0.214	20.00	0.323
1.80	0.218	50.00	0.327
1.90	0.224	100.00	0.332
2.00	0.229		0.333

15.3.5 Recording

The followings shall be recorded in the test scores:

(1) Shape and dimensions of the test piece

(2) Spring constant of the torsion spring

(3) T5, T50 temperature. Transverse modulus of elasticity at certain temperatures, if necessary.

(4) Other Necessary Items

16. Fatigue Test

16.1 Purpose

This test is performed to measure the resistance of oil-added rubber against dynamic fatigue. Fatigue test is performed by any one of following methods, in principle:

(1) Bending crack formation test

(2) Expansion crack formation test

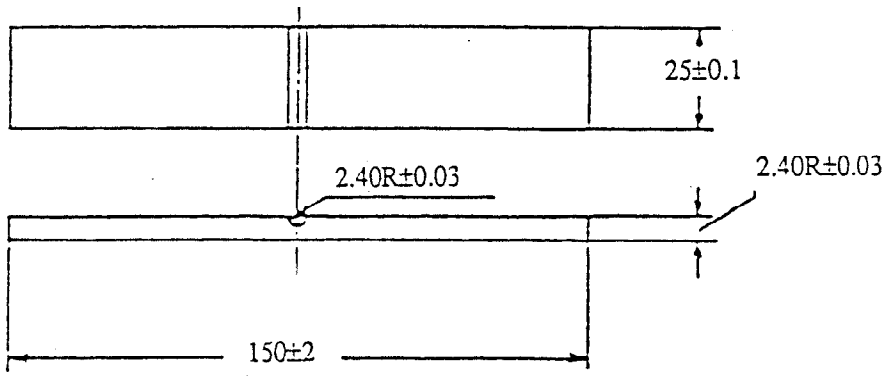
(3) Shear crack formation test

16.2 Bending Crack Formation Test

(1) Shape and dimensions of test piece

Shape and dimensions of test piece conform to Figure 27.

Figure 27



(2) Sampling and construction of test piece

Test piece shall be constructed the same as the oil-added condition of the product by using oil-added type material, and the length of the rubber is parallel to the grain. Thickness shall be at least 12.5mm for the test piece and at least 6.5mm for the cover, with sufficient space.

(3) Thickness measurement

Use the thickness gauge specified in 4.2.5 (1) and perform at several locations on the flat test piece.

(4) Selection of test piece

Test piece shall have a flat surface with no grooves or defects. Test pieces with a thickness more than 6.35 ± 0.1mm at the vicinity of the grooves, shall be excluded.

(5) Number of test pieces

Number of test pieces shall be three.

(6) Treatment for end of groove

Prevent cracks forming on the tip by appropriatly bending and burning with a solder iron,

since the tip of the groove is vulnerable to cracks due to concentrated stress.

16.2.2 Testing device

De. Meltia type tester specified in Figure 28 is used. This tester consists of a fixed part supporting one end of the test piece and a reciprocating part supporting the other end of the test piece. Maximum distance of the supports is $75.0 \, ^{+1.2}_{-0}$ mm and the minimum is 19.0 ± 0.1mm. Reciprocating occurs with it's axis on the center line of the supports. Supports shall be parallel to each other at all times, and the test piece shall be bent and maintained to the [<] shape at maximum distance. Reciprocating occurs by the motor axis wheel, thus the supported test piece is bent. Supports shall be fixed firmly to prevent unnecessary pressure on the test piece. Rounds of bending of the test piece shall be 300 ± 20 per minute. However, 1 reciprocation is considered one bending. Rounds of bending is measured by a counter.

Remark: Since the eccentrically centered wheel is driven by a belt, it is difficult to maintain a constant bending speed. Thus, it is not desirable to calculate the bending rounds from the test time.

16.2.3 Testing Method

(1) Installation of test piece

As shown in Figure 28, the test piece shall be placed in such a manner that the distance between the outer end of the test piece groove and support is maximized. The center of the groove before the test shall be placed at the center of the supports. (Using the gauge shown in Figure 29 is desirable for this). Also, the space between the test pieces shall be at least 3mm.

(2) Measurement of cracks

Minimize the space between supports, and observe the presence of cracks using a magnifier with a power of 10.

(3) Measured rounds of bending

Measure cracks for every 10 rounds, in principle, and perform at least 10^4 rounds of bending, after cracks form.

(4) Testing temperature

The testing is performed at room temperature, in principle.

16.2.4 Organizing method of test result

Test score shall be the average of three measurements, in principle. By using the following formula, calculate the crack forming speed from the size of the cracks grown by bending after it's formation.

$Vc = L - Lo$

where, Vc : Crack growing speed ($mm/10^4$)

Lo : Length of crack at the moment of it's formation (mm)

L : Length of crack with 104 rounds of bending after the measurement of Lo (mm)

Figure 28

Unit: mm

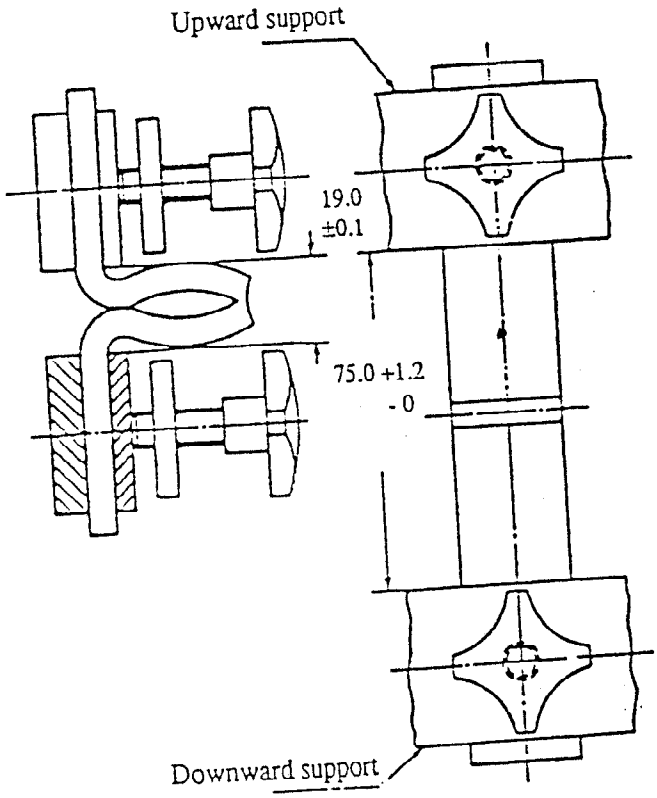
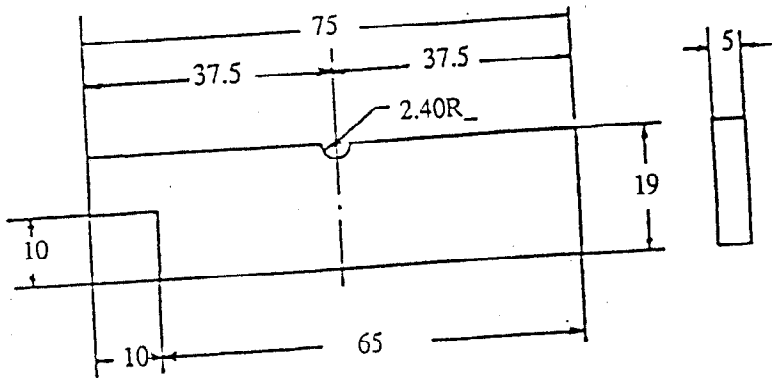


Figure 29

Unit: mm



16.2.5 Recording

The following shall be recorded in the test scores:

(1) Number of cracks forming and speed of growth.

(2) Speed of bending

(3) Testing temperature

(4) Other necessary items

16.3 Expansion Crack Formation Test

16.3.1 Test piece

Type 3 dumbbell with 20mm of the marking line distance used as the test piece.

16.3.2 Testing Device

Testing device shall conform to 16.2.2.

16.3.3 Testing Method

(1) Adjustment of device

Adjust eccentricity so that the reciprocating part can provide the specified elongation against the original length of the test piece (marking line distance).

(2) Installation of test piece

Maintain 15mm of one end of the test piece with the fixed part support, and maintain 15mm of the other end so that the distance between the reciprocating part and the fixed part is minimized. Test pieces shall be bended in the [<] shape at this time.

(3) Testing condition

Testing condition is as follows, in principle:

Testing elongation : 50% (or 100%)

Testing temperature : room temperature

(4) Measurement of cracks

Maximize the distance of the supports and observe the presence of cracks using a magnifier with a power of 10.

(5) Number of measurements

Shall conform to 16.2.3 (3).

16.3.4 Organizing method of test result

Shall conform to 16.2.4.

16.3.5 Recording

The following shall be recorded in the test scores:

(1) Number of cracks forming and speed of growth

(2) Testing elongation

(3) Test temperature

(4) Other necessary items

16.4 Shear Fatigue Test (pending)

17. Ozone (O3) Resistance Test

17.1 Purpose

This test is performed to measure the aging of oil-added rubber due to ozone in the atmospher. Expose the test piece to air containing artificially generated low-density ozone to expedite aging, and measure the ozone resistance characteristics. The ozone resistance test shall be performed by any one of the following, in principle:

(1) Static ozone aging test (A method, B method)

(2) Dynamic ozone aging test, A method (tensile method)

(3) Dynamic ozone aging test, B method (belt spin method)

17.2 Test Piece

Test piece is one sampled from the product, and it's surface shall not be grounded or treated. The shape of the test piece shall be rectangular 60mm in length, 10mm in width, and 2-3mm in thickness. However, the product itself, which can provide uniform expansion, can be used. When sampled from the oil-added rubber plate in the identical condition of the product use type 1 dumbbell according to 4.2.4.

17.3 Testing Device

17.3.1 Testing reservoir

Testing reservoir shall have 100 ℓ or more in volume with an insulation preventing the penetration of light from outside. Inner surfaces should be built with appropriate materials to prevent the decomposition of ozone. The inner temperature should be controlled to ±2°C, and air corresponding to 3/4 of the capacity, drainable every minute.

17.3.2 Ozone generator

In principle, a quartz mercury lamp is used as the ozone generator, which should be able to control the amount of ozone generated, by varying the primary voltage.

17.4 Testing Method

17.4.1 Concentration of ozone

Concentration of ozone shall be 50 ± 5pphm [21] or 100 ± 5pphm, in principle.

Note [21] pphm : Parts Per Hundred Million Parts of Air Per Volume

17.4.2 Testing temperature

In principle, the testing temperature shall be 40 ± 2°C.

17.4.3 Expansion

Mark at least 20mm (40mm for type 1 dumbbell) of marking lines on the test piece, and expand 20% with an appropriate device. If the expansion is more than 20%, at operation condition, use 1.5 times the operation condition expansion, as the test expansion.

Remarks 1. Use a ballpen in marking lines. Do not use pens or pencils with sharp tips.

2. By coating with chlorosulfonated polyethylene and ethylene propylene, form a protecting film on the circumference of the test piece and the area caught by the expansion device.

17.4.4 Preliminary treatment of test piece

Ozone resistance test is divided into A method and B method according to the preliminary treatment of the test piece.

A method : Heat-age test piece for 70 hours at 100°C according to 7.3 with the test piece expanded. After heat-aging, leave one or more hour at room temperature, while maintaining the specified expansion according to 17.4.3, and subsequently leave 20 to 24 hours in a sealed dark box at room temperature, and finally, place it in a test reservoir and perform the test.

B method : Perform the same method as of A while maintaining the specified expansion and without heat-aging.

17.4.5 Control of ozone concentration

When the test piece is in the test reservoir, the concentration of ozone shall be maintained as that of 17.4.1. Put the test piece in the test reservoir and suspend it vertically, and immediately after the initiation of the test, measure whether the concentration correspond to the specified value. Henceforth, measure at least once a day, and maintain the specified ozone concentration.

17.4.6 Testing time

The testing time shall be 72 hours, in principle.

17.4.7 Observation of aging condition

After continuously exposing the test piece for the specified time, extract from the test reservoir and observe the presence of cracks using a microscope with a power of 10.

17.5 Organizing Method of Test Result

Test scores shall indicate the result of 2 test pieces simultaneously, in principle.

17.6 Recording

The following shall be recorded in the test scores:

(1) Presence of cracks forming and testing method (A or B method)

(2) Measuring method of the concentration of ozone used. Concentration of ozone during exposure.

(3) Expansion

(4) Other necessary items

17.7 Dynamic Ozone Aging Test (C method (expansion method))

17.7.1 Testing device

(1) Test reservoir: Shall conform to 17.3.1.

(2) Ozone generator: Shall conform to 17.3.2.

(3) Expansion device

The expansion device consists of the end of a chuck supporting one end of the test piece and the dynamic testing device supporting the other end of the test piece with the same

reciprocating structure. It's movement, distance between chucks, O deformation for shortest, and maximum deformation specified for longest. Reciprocating shall be done at 0.5 ± 0.025Hz of the constant speed.

17.7.2 Test piece

(1) Shape and dimensions

(a) 60mm long, 10mm wide and 2mm thick rectangle with a flat surface

(b) 100mm long, 25mm wide and 2mm thick rectangle with a flat surface

(c) Type 1 dumbbell test piece

Remarks: Although the test piece of (a) is used in principle, appropriate figures can be selected.

(1) Sampling and construction of test piece

Sampling and construction of the test piece shall conform to 3.3, in principle.

(2) Number of test pieces

Three test pieces are used, in principle.

(3) Measurement of thickness and width of test piece

Measurement of the thickness and width of the test piece shall conform to 4.2.5.

(4) Marking line for elongation measurement

Draw the marking line on the test piece by the following method:

(a) Marking line distance shall be 20 or 40 mm.

(b) Marking line shall be drawn precisely with it's center on the center area of the test piece.

17.7.3 Testing method

(1) Testing condition

(a) Concentration of ozone

Shall conform to 17.4.1.

(b) Expansion

Draw marking lines having 20 or 40 mm of space on the test piece, and perform the test in such a manner that the maximum dynamic elongation become any of the following. However, 10% is standard.

Approximately 5, 10. 15, 20, 25; 30% of the elongation.

(c) Testing temperature

Shall conform to 17.4.2.

(d) Testing speed

0.5 ± 0.025 Hz

(e) Testing time

Testing time is selected from 2, 4, 8, 24, 72, or 96 hours, in principle.

(2) Operation method

(a) Adjust the test reservoir to the specified ozone concentration and test temperature.

(b) Let each test piece be exposed to the ozonized air at both surfaces, and maintain the length in the direction of the air flow.

(c) Install the test piece in the dynamic test device with O deformation, perform the reciprocation, and adjust to apply the specified expansion.

(d) After continuously exposing the test piece for the specified hours, extract from the test reservoir, and observe cracks forming according to 17.4.7. Extracting from the test reservoir at certain intervals and observing cracks forming is acceptable.

17.7.4 Organizing method of test result

In principle, indicate the cracks of the three test pieces together with the test time.

17.7.5 Recording

The following shall be recorded in the test scores:

(1) Result of test

(2) Kind of test

(3) Sampling and construction method of test pieces

(4) Concentration of ozone used and it's measuring method

(5) Test temperature (°C)

(6) Testing speed (Hz)

(7) Elongation (%)

(8) Other necessary items

17.8 Dynamic Ozone Aging Test

D method (belt spin method)

17.8.1 Testing device

(1) Test reservoir

Shall conform to 17.3.1.

(2) Ozone generator

(3) Belt spin device

Perform with the belt and pulley as specified below and test the reservoir which can accommodate them. The pulley is one pair of upper and lower 63.5mm in diameter, where the upper pulley spins the test belt at a speed of 0.67 Hz. The lower pulley, capable of moving up and down, pulls the test belt sufficiently. To ensure the accommodation of upper and lower pulley and belt, attach 18kg of weight. Test belt is 1.1kg/cm^2 of cotton fabrics 100mm in width and 2300 ± 25 mm in circumference length.

17.8.2 Test piece

(1) Test piece is a 100mm long, 25mm wide, and 3mm thick rectangle, with flat and smooth surfaces.

(2) Sampling and construction of test piece

In principle, sampling and the construction of the test piece shall conform to 3.3 sampling and construction of the test piece.

(3) Number of test pieces

The number of test pieces are three, in principle.

17.8.3 Testing method

(1) Testing condition

(a) Concentration of ozone

Shall conform to 17.4.1.

(b) Testing temperature shall conform to 17.4.2 (1), (c).

(c) Testing speed

0.67 Hz ± 0.03 Hz

(d) Testing time

Crack formation shall be investigated for 1, 2, 3, 4, 5, 6, 24, and 30 hours, in principle.

(2) Operation method

(a) Adjust the test reservoir to the specified ozone concentration and test the temperature.

(b) To fold-install the test piece in the test belt, and grind the test piece surface and apply an adhesion which does not affect the test piece, and adhered it to the test belt.

(c) Install the test piece in the dynamic test device in the O deformation condition, and spin.

(d) Spin the test belt at speed of 0.67 ± 0.03 Hz, and investigate cracks forming at certain time intervals.

17.8.4 Organizing method of test result

Shall conform to 17.7.4.

17.8.5 Recording

Shall conform to 17.7.5.

18. Modulus of Elasticity Test

18.1 Purpose

This test is performed to measure the modulus of elasticity of oil-added rubber, and by the following methods:

(1) Static shear modulus of elasticity test

(2) Modulus of elasticity test by bending

(3) Dynamic shear modulus of elasticity test

18.2 Static Shear Modulus of Elasticity Test

Although performed according to 18.3, in principle, it can be calculated from the low expansion strees by the following formula when inevitable:

$Gs = 1.639\ \sigma_{25}$

where, Gs : static shear modulus of elasticity [kgf/cm² (MPa)]

σ_{25} : 25% expansion stress (kgf/cm² (MPa)]

18.3 Bending Modulus of Elasticity Test

18.3.1 Shape and figures of test piece

In principle, the test piece shall be box shaped (25 ± 0.5) x (63 ± 0.5) x 6 mm and 0.05 mm or less in thickness variance throughout all surfaces.

18.3.2 Testing device

To maintain constant temperature, the testing device shall consist of a heater, temperature controller, loading device, test piece fixing holder, and deformation indicator, and shall satisfy the following conditions:

(a) Heater and temperature controller

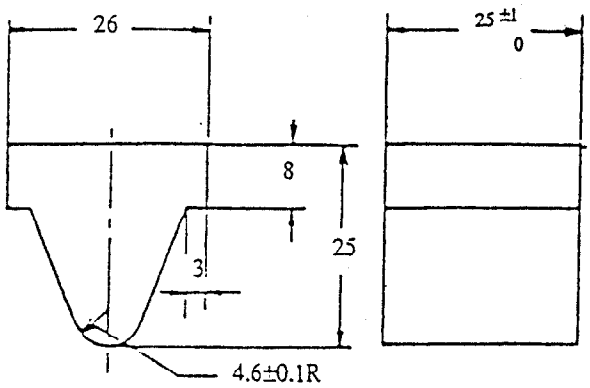
This device is to maintain the constant temperature within ±1°C of the

specified value. Installing the whole device in constant temperature container is acceptable.

(2) Loading device

This device is able to apply a load to the test piece, vertically. The shape of it's tip shall conform to that of Figure 30.

Figure 30

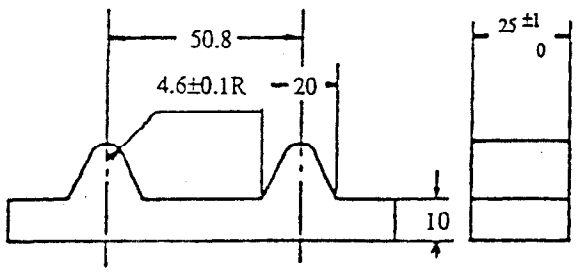


(3) Holder

Holder shall be able to fix the test piece without stress, and is shown in Figure 31.

Figure 31

Unit: mm



(4) Deformation indicator

This device shall be able to indicate the deformation of the loading device with aprecision 0.01 mm or more.

18.3.4 Testing method

After leaving the test piece at the test temperature, apply a load so that the deformation become 0.2 - 0.8 mm, and measure the deformation accurately after loadi

18.3.5 Testing temperature

Testing temperature shall be 25 ±1°C, in principle. However, in case of measuring the temperature dependability of rubber materials, perform at any temperature.

18.3.6 Calculation

Calculate the Young modulus due to bending by following formula:

$E = WL^3/(4\,dbh^3)$

where, E : Young modulus (kgf/cm^2 {MPa})

W : load generating d cm of deformation (kgf {IV})

L : distance between test piece supports (cm)

b : width of test piece (cm)

h : thickness of test piece

18.3.7 Organizing method of test result

Test scores shall be expressed by the average of the measurements of two test pieces, in principle.

18.4 Dynamic Shear Modulus of Elasticity Test

This test shall conform to 22, Dynamic characteristics test.

18.5 Recording

The following shALL be recorded in the test scores:

(1) Testing method

(2) Modulus of elasticity

(3) Test temeprature

(4) Other necessary items

19. Weather Resistance Test

Pending.

20. Creep Test

20.1 Purpose

This test is performed to measure the creep characteristics of oil-added rubber. The creep test is performed by the following methods, in principle:

(1) Shear creep test

(2) Torsion creep test

20.2 Testing Temperature

Testing temperature shall be 40 ± 1°C, in principle.

20.3 Testing Time

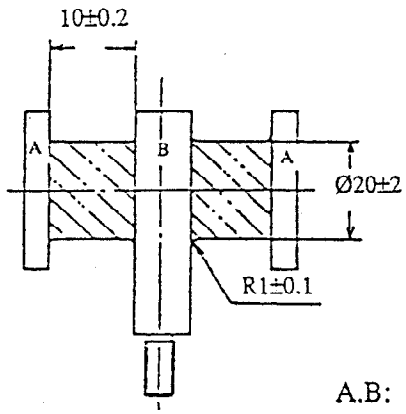
Deformation measurement time shall be 24 hours or more for it's final measurement.

20.4 Shear Creep Test

20.4.1 Test piece

Test piece with the same curing condition as that of the product and in the shape shown in Figure 22 shall be used. In principle, bond the metal piece at the time of the curing.

Figure 32



A.B: Metal piece

20.4.2 Testing device

Testing device is a constant temperature container which can control the specified temperature within ±1°C, including a device able to apply 40 kg or more of load to the test piece and measure the deformation of the test piece up to a precision of 0.01 mm or morre.

20.4.3 Testing method

Leave the test piece 30 minutes or more at the specified temperature prior to the test. When deformation becomes 40 ± 3%, apply a load for 60 seconds and remove the load. Repeat this operation five times for the preliminary deformation, and press a stopwatch applying the 6th deformation at the appropriate time intervals.

20.4.4 Organizing method of result

Obtain coefficient A and n using the minium second multiplication method by the following formula, and from the relationship between the testing time and deformation.

$\varepsilon\ (t) = At^n$

where, $\varepsilon\ (t)$: Deformation at time t

A, n : Coefficient

t : Time (t)

Value of A and n are expressed as the average of three test pieces, in principle.

20.5 Torsion Creep Test (pending)

20.6 Recording

The following shall be recorded in the test scores:

(1) Testing method

(2) Load and initial deformation (value of A)

(3) Value of n

(4) Standard deviation of obtained formula and actual measured data

(5) Final measurement time

(6) Other necessary items

21. Stress Relief Test

21.1 Purpose

This test is performed to investigate the stress relief of oil-added rubber by measuring the stress relief condition with time flow after applying the specified tension at room temperature or with heated air.

21.2 Test Piece

Sampled from the oil-added rubber sheet or product according to 4.2.4.

21.2.1 Figures of test piece(22)

Test piece is, in principle, a rectangle 40mm between the test device supports and 2 mm in thickness. Thickness variance of the parallel portion of the test piece shall be less than ±5%. Width of the parallel area shall be 5mm, in principle.

Note (22) Perform the comparison test with the test pieces having the same shape and figures.

21.2.2 Number of test pieces

The number of test piece shall be one, in principle.

21.3 Testing Device

Testing device shall be able to maintain the test piece in the specified tensioning condition, and immediately after tensioning, shall be able to indicate or measure the stress change at certain time intervals. Also, it shall be equipped with a constant temperature container accommodating the tensioned test piece.

21.3.1 Stress measuring device

(1) Scale type

With the test piece on one arm and the moving load on the other end, the scale shall be level while the moving load moves continuously, according to the stress decrease of the test piece.

(2) Load cell type

Stress indicated device or recorder with the load cell connected to the upper or bottom of the test piece.

(3) Other

Obtain the stress decrease of the tensioned test piece by measuring with something other than the methods of (1) or (2).

(4) Interpretation precision of stress measurement

Shall be able to interpret up to 1% of the initial stress specified in 19.4.3.

21.3.2 Constant temperature container

Shall be large enough to accommodate the test piece, elongation device, and supports with the capability of controlling the temperature to ±1°C (±1K) of specified value. Also, new air shall be able to flow in and air around the test piece shall move continuously.

21.4.1 Thickness and width measurement of test piece

In principle, by using a dial gauge with a 0.01 scale as specified in 4.2.5, read up to 0.01mm from the thickness gauge and take the average of five measurements of the horizontal area. For strict tests, use a projector or cassette-meter to read up to 0.01mm. Knife width is used as the test piece width in general. However, for strict tests, perform the same method as that of the thickness measurement by using a projector or cassette-meter.

21.4.2 Condition adjustment of test piece

After adjusting the temperature of the test piece to the specified value, install the test piece in the supports, and pre-heat for 20 minutes in a constant temperature container to obtain temperature equilibrium.

21.4.3 Measurement

After elongating the test piece rapidly to the specified value, and while maintaining it, operate a stopwatch at the same time with the test piece elongation, and measure the load after 3 minutes if the temperature is over room temperature and under 70°C, and after 36 seconds if the temperature is over 70°C, and use this as Fo (initial load). Although the elongation rate is 50%, in principle, other rates can be used, if required. Test temperature shall be the specified value.

21.5 Calculation

Calculate the stress remnant ratio R% from the measured values using the following formula:

$$R = \frac{Ft}{Fo} \times 100 = \frac{ft}{fo} \times 100$$

where, R : stress remnant ratio (%)

Fo : initial measured load of test piece after 3 minutes or 36 seconds (kgf/{IV})

Ft : initial measured load of test piece after t hours (kgf/ {N})

fo : stress of test piece after 3 minutes or 36 seconds (per original cross sectional area) (kg/cm^2 {MPa})

ft : stress of test piece after t hours (per original cross sectional area) (kgf/cm^2 {MPa})

21.6 Organizing Method of Test Result

Draw the stress relief curve with time t as the horizontal axis and the stress remnant ratio R as the vertical axis.

21.7 Recording

The following shall be recorded in the test scores:

(1) Stress remnant ratio after t time
(2) Fo, measurement time of Fo and Ft
(3) Testing temperature
(4) Elongation
(5) Shape of test piece
(6) Testing device
(7) Other necessary items

22. Dynamic Characteristic Test

22.1 Purpose

This test is performed to measure the dynamic characteristic of rubber material against mechanical vibrations. This test is performed by one of the following methods, in principle:

(1) Non-resonance method (normal vibration)
(2) Resonance method (possible vibration direction : B1 vertical or B2 horizontal)

22.2 Test Piece

Test piece is the same sulfur-added condition as that of product, shown in Figure 33 for the non-resonance method and Figure 34 for the resonance method, respectively.

Figure 33

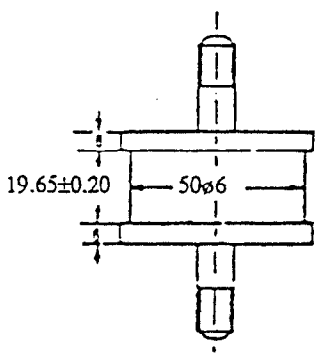
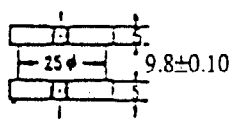


Figure 34



22.3 Testing Condition

The testing condition shall conform to Table 13, in principle.

Table 13

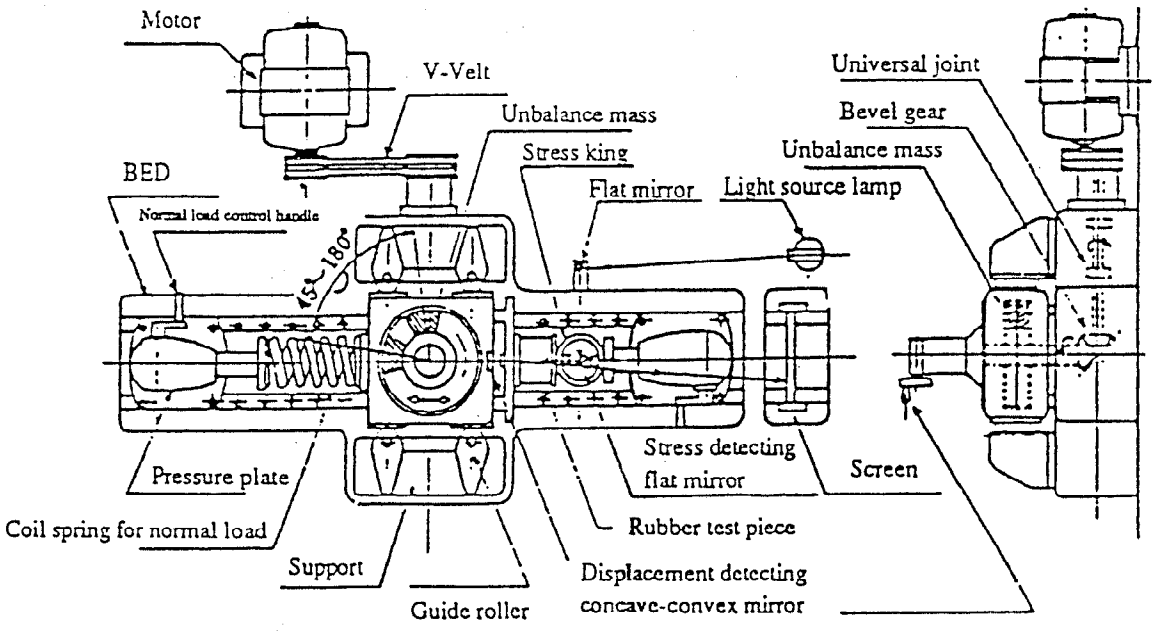
Items	Non-resonance method	Resonance method
Temperature (vicinity temp.) °C	25 ± 1°C	
Average displacement (compression, tensile) %	10	5 or less
Average displacement (shear) %	20	5 or less
Deformation amplitude (compression, tensile) %	±5	±2.5
Deformation amplitude (shear) %	±10	±2.5
Frequency Hz	10 – 25	10 – 50

22.4 Test by Non-Resonance Method

22.4.1 Testing device

Testing device, which provides normal vibrations, shall be able to record the load-deformation relationship curve or load-time and deformation-time relationship simultaneously, and shall satisfy the conditions in Table 13. In this case, the load-time relationship shall not deviate 5% or more from the standard wave. An example of the mechanism is shown in Figure 35.

Figure 35



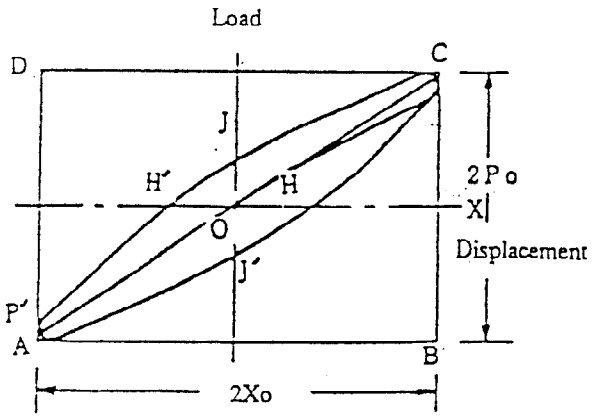
22.4.2 Testing method

In any case, to prevent the temperature rise of the test piece, it is desirable to perform measurement at each frequency as soon as possible when they are reached (1 to 3 minutes).

(1) In case of depending on load-displacement curve

Record the load-displacement curve and draw a rectangle circumscribing the curve with it's sides parallel to the load axis and displacement axis (refer to Figure 36). Each side of this rectangle indicates a forward gap 2Po and 2Xo of the load and displacement, and origin O indicates the condition of deformation amplitude O. In Figure 36, calculate the area of W, circumscribed by area 2W of the rectangle and load-deformation curve. (This areas can be in relative values). Measuring the length of HH' and JJ' is acceptable instead of the calculating area. From the above measurements, obtain the following:

Figure 36



$Po / Xo = BC / AB$ (1)

$\sin \delta = \ell / \sqrt{1 + \ell^2} = (2/X) \times \Delta W/W$ (2a)

$HH^1 / 2Xo = JJ' / 2Po$ (2b)

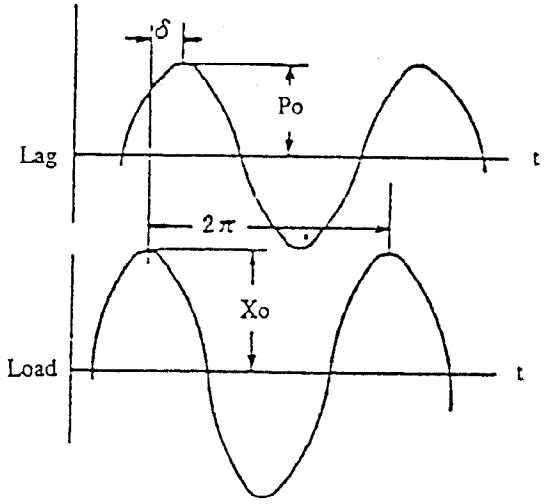
(2) In case of depending on the load-time and displacement-time relationship

Record the load-time relationship and displacement-time relationship on an oscillograph (Figure 37). Measure phase angle δ of the load and displacement at forward gap 2Po and 2Xo of the load and displacement. However, the phase angle is obtained from phase difference (time) Δt in case of considering one cycle as 2X. From the above measurements, Po / Xo and d are obtained by the following formulas:

$\delta = 2X (\Delta t/T)$ rad (3a)

$\delta = 360 (\Delta t/T)$ rad (3b)

Figure 37



22.4.3 Calculating method

(1) In case of depending on the load-displacement curve

Obtain Sin δ by formula (1), (2a) or (2b) and calculated $\ell = \tan\delta$ from this. Or by using formulas (1) and (4a) calculate the dynamic spring constant K1. If required, calculate loss spring constant K_1 by formula (4c)

(2) In case of depending on load-time and displacement-time curve

By the following formulas, calculate dynamic spring constant K1; loss coefficient 1 and loss spring constant K_2 if required from Po/Xo

$K_1 = (Po/Xo)\cos\delta$ (4a)

$\ell = \tan\delta$ (4b)

$K_2 = (Po/Xo)\,Sin\delta$ (4c)

22.5 Test by Resonance Method

22.5.1 Test device

This test device shall be able to apply the sine wave type compulsory displacement to one end of the test piece with a constant amplitude, and able to measure the resonance curve by varying the frequency and by measuring the amplitude of the additional weight installed to the other end of the test piece. The test device shall also satisfy the conditions of Table 13. Compulsory displacement-time relationship shall not deviate 5% or more from the sine wave at this time. An example of the device is shown in Figure 38 (vibration direction : vertical), (vibration direction : horizontal).

Figure 38

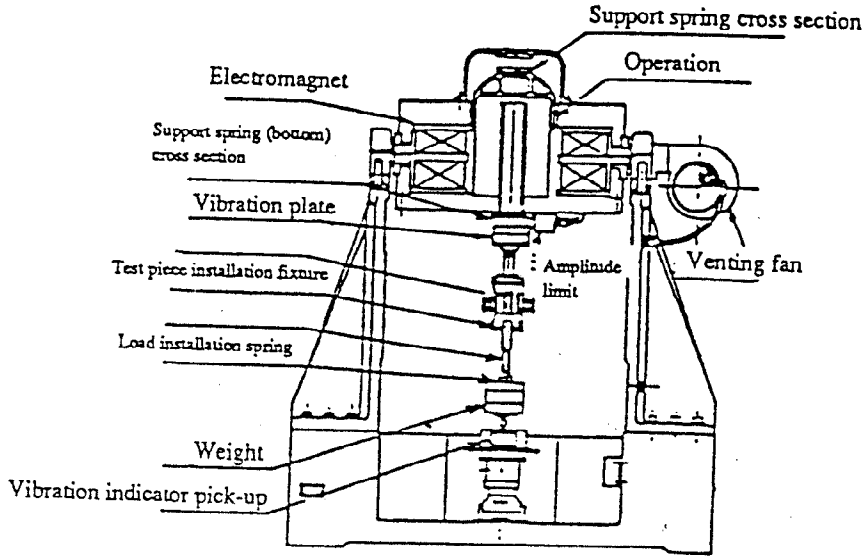
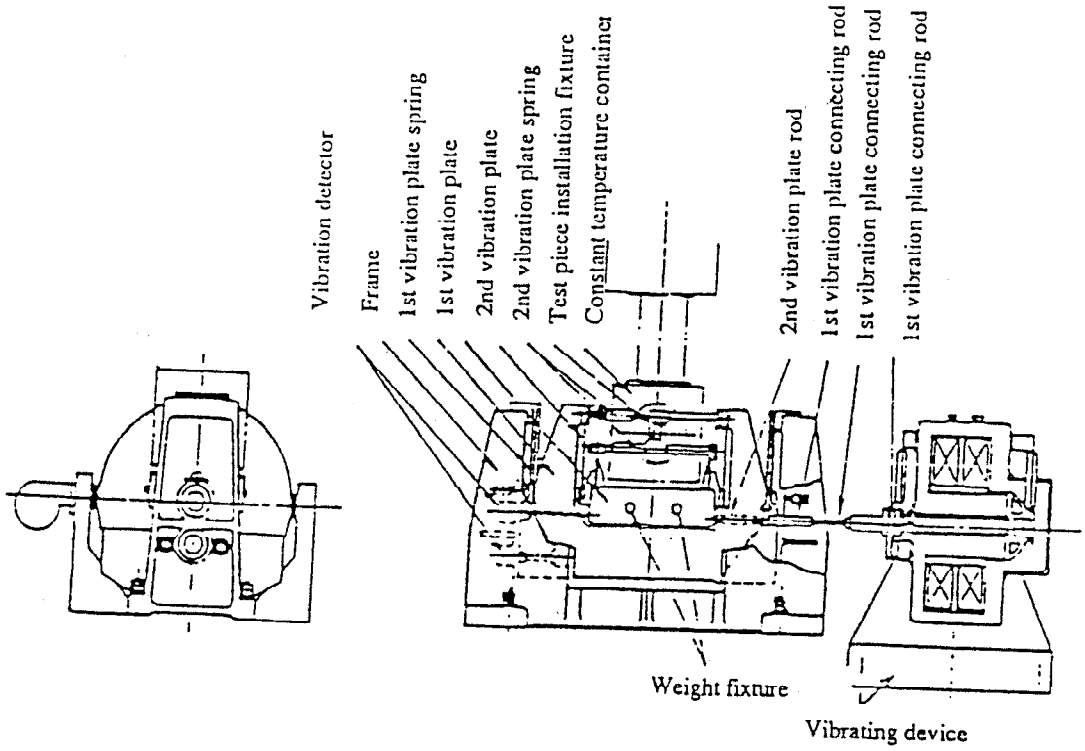


Figure 39



22.5.2 Testing method

In any case, to prevent the temperature rise of the test piece, it is desirable to perform measurements at each frequency, as soon as possible, when they are reached (1 to 3 minutes).

(1) In case of vertical direction to vibrating

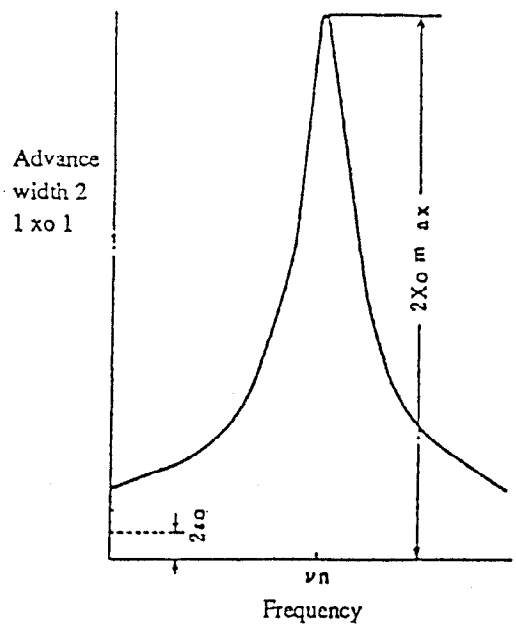
No elastic materials exists, other than the test piece between the vibrating axis (axis which provides compulsory displacement) and additional weight m. While maintaining amplitude εo of the compulsory displacement, vary the frequency and measure the amplitude of the additional weight. It is called resonance where maximum frequency occurs. Measure frequency Vn and amplitude Xo, max of the additional weight of that time, (refer to Figure 40). From the above measurements, resonance frequency Vn and resonance magnification μ =X, max/ε are obtained. Also, the displacement of rubber (relative displacement between each point) is obtained by the following formula:

$$\sqrt{(Xo/max.)^2 - \varepsilon 0^2} = 2\varepsilon o / \sqrt{\mu^2 - 1} = \varepsilon 0 / \ell \quad (5)$$

(2) In case of horizontal vibrating direction

Additional weight m is supported by the vibration axis with a vertical plate spring inserted in this case. Although the additional weight is changed to support the plate spring, it does not affect the average displacement of the test piece. This plate spring shall not diminish. It is the same as in 3.1.5.2 (1) for those other that than of above.

Figure 40



(1) In case of vertical vibrating direction

Calculate dynamic spring constant K_1, coefficient of loss l and loss spring constant K_2 if required from υn, μ and m obtained in 22.5.2 (1) by using the following formula:

$$K_1 = 4\pi^2 m \quad \upsilon n^2 \quad (6a)$$

$$\ell = 1/\sqrt{\mu^2 - 1} \quad (6b)$$

$$K_2 = K_1 \ell \quad (6c)$$

(2) In case of horizontal vibrating direction

Calculate K_1, ℓ and K_2 if required from υn, μ and m obtained in 22.5.2 (1) by using the following formula:

$K1 = 4\pi^2 m\ \upsilon n^2 - KL$ (7a)

$\ell = 1/\sqrt{\mu^2 - 1}$ (7b)

$K^2 = K_1\ \ell$ (6c)

where, K : Horizontal direction spring constant of whole plate spring

22.6 Dynamic Characteristics

Calculate the dynamic modulus of elasticity from the spring constant obtained by the following formulas. Special calculations are not required for the coefficient of loss.

(1) In case of compression and tensioning of the test piece

$Eap1 = (h/A)\ K1$ (8a)

$G1 = \{1/(3+4.935S^2)\}\ Eap1$ (8b)

$E1 = \{1(1=1.645S^2)\}\ Eap1$ (8c)

where, G1 : dynamic modulus of shear elasticity

E1 : dynamic modulus of Young

A : cross sectional area of test piece rubber portion

S : modulus of shape of test piece

d : diameter of test piece rubber portion

h : thickness of test piece rubber portion

If required, calculate G_2 or E_2 from the following formulas:

$Eap_2 = (h/A)K_2$ (9a)

$G_2 = \{1/(3+4.935S^2)\}Eap_2$ (9b)

$E_2 = \{1/(1+1.645S^2)\}Eap_2$ (9c)

(2) In case of shearing test piece

$Gap1 = (h/A)K1$ (10a)

$G1 = \{1+(2h/3d)^2\}Gap1$ (10b)

$E1 = 3G1$ (10c)

If required, calculate G_2 or E_2 from the following formulas:

$Gap2 = (h/A)K_2$ (11a)

$G_2 = \{1+(2h/3d)^2\}Gap2$ (11b)

$E_2 = 3G_2$ (11c)

22.7 Recording

The following shall be recorded in the test scores:

(1) Dynamic modulus of shear elasticity, dynamic modulus of Young, and the coefficient of loss

(2) If required, the loss modulus of shear elasticity and loss modulus of Young.

(3) Testing temperature

(4) Application direction of deformation and the average deformation

(5) Deformation amplitude
(6) Frequency (resonance frequency for the resonance method)
(7) Testing method or name of device
(8) Other necessary items

23. Contamination Characteristic Test

23.1 Purpose

This test is performed to measure the discoloration of oil film of paint coating and leather due to contact with oil-add rubber.

23.2 Test Piece

Test piece specified in 11.2 and agreed between the parties if required, is used in principle. Circular or angular columns having $4cm^2$ or more of contacting area with the film is used. Also, the thickness of the test piece shall be 5mm or more with 0.2mm or less of variance in the same surface.

22.3 Testing Device

Testing device shall include the device compressing rubber and oil film, constant temperature container maintaining ±1°C of the specified temperature, and an ultraviolet irradiation device radiating certain amounts of ultraviolet rays, and shall satisfy the following conditions.

23.3.1 Constant temperature device

Use the constant temperature device specified in 11.3.2.

23.3.2 Ultraviolet irradiation device

In principle, the weather meter is used as the ultraviolet irradiation device.

23.4 Testing Condition

Testing condition shall conform to 23.1, in principle.

Table 14

Heat treatment temperature (°C)	80 ±3
Heat treatment time (hours)	70
Ultraviolet irradiation temperature (°C)	63 ± 3
Ultraviolet irradiation time (hours)	6

23.5 Testing Method

This test performs the heat treatment transferring ingredients of rubber to organic film and the ultraviolet irradiation expediting discoloration of film. However, ultraviolet irradiation can be omitted by the agreement made between the parties.

23.5.1 Heat treatment

Contact the rubber test piece and center of the organic film 40mm or more long and over 40 mm wide sufficiently, and compress. Observe and compare the organic film compressed with rubber and organic film not contacted with rubber, after heat treating at 80 ± 1°C in a constant temperature container.

Remark: Use room temperature hardened white acryl lacquer for the paint coating.

23.5.2 Ultraviolet irradiation

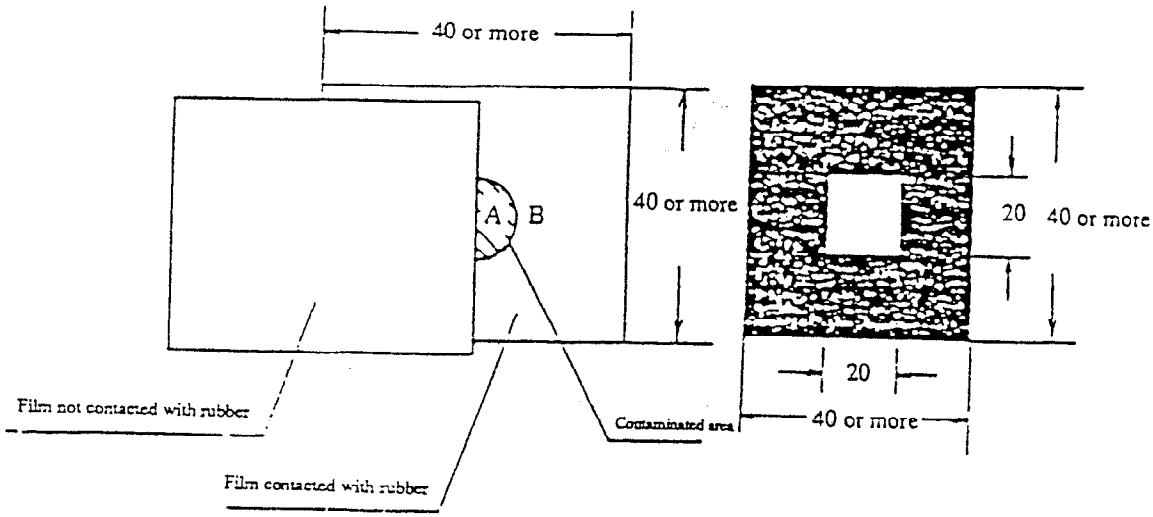
Observe and compare the above two organic films after ultraviolet irradiating for 6 hours.

23.5.3 Comparison method

Observe the color difference after overlapping the above two organic films as shown in Figure 41 and place a black paper having a 20 x 20 mm hole in it. If possible, observe and compare with KS K 0910 (Gray scale for assessing staining).

Figure 41

Figure 42



23.6 Indicating Method of Result

Evaluation of the result is performed by Table 15 after the heat treatment and ultraviolet irradiation. Take the bad results and contamination characteristics.

Table 15

Evaluation	Area contacted with rubber		Area not contacted with rubber	
	Degree of discoloration	Comparable grayscale No.	Degree of discoloration	Comparable grayscale No.
1	No contamination	5	No contamination	5
2	Little discoloration is confirmed	3 or more		
3	—	—		

23.7 Recording

The following shall be recorded in the test results:

(1) Name of organic film

(2) Evaluation of contamination characteristic

(3) Other necessary items

24. Wear Test

24.1 Purpose

This test is performed to measure the wear resistance characteristics of oil-added rubber. Wear test is performed by one of the following methods, in principle:

(1) William wear test

(2) Acron wear test

24.2 Standard Sample

Wear resistance characteristics of rubber test piece is evaluated by comparing to the wear of standard sample which is indicated below.

24.2.1 Mixture

Mixture of the standard sample is shown in Table 16.

Table 16

SBR 1502	100
ZnO #1	5
Sulfur	2
Stearin acid	1
Oil addition accelerator CZ (23)	1.5
Aging stopper D (24)	1.5
Carbon (25)	50

Note (23) N-Cyclohexyl benzothiadil sulfonamid

(24) Phenyl- β -naphthyamine

(25) Shisuto 116

24.2.2 Processing Method

Roll 500 g of the rubber material in 6 - 10" of open roll and burn for 5 minutes at 40 ± 5°C of the roll temperature and 0.5 mm of the roll interval. Subsequently, mix carbor black for 10 minutes and mix with the other additives for 5 minutes. If the roll temperature rises, cool down by cutting and separating the rubber, and continue mixing. After of roll up. If the weight of the rubber mixture is within the range of 800 - 810g after the completion of roll up, continue working. Otherwise, roll up 1.5 - 2mm of the roll interval. Pull out after one minute. Cure the rubber mixture for 20 hours or more and perform three rounds of roll up, and roll 1.5 - 2.0mm of the roll interval and extract after one minutes. Oil add the extracted rubber with the following conditions:

Oil-add condition ..... oil-add temperature 155 ± 2°C

oil-add time 15 minutes

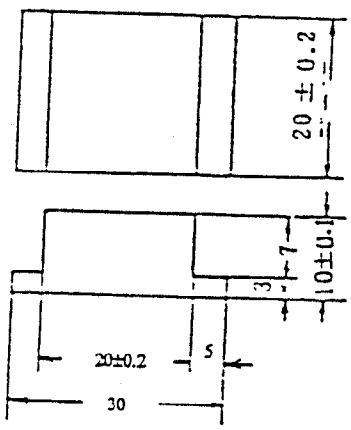
24.3 William Wear Test

24.3.1 Test piece

Cut off a test piece in the shape and figures as shown in Figure 43 from the product, or use the product press oil added at the same condition as that of the product.

Figure 43

Unit: mm



24.3.2 Testing device

An outline of the testing device is shown in Figure 44 and 45.

Figure 44

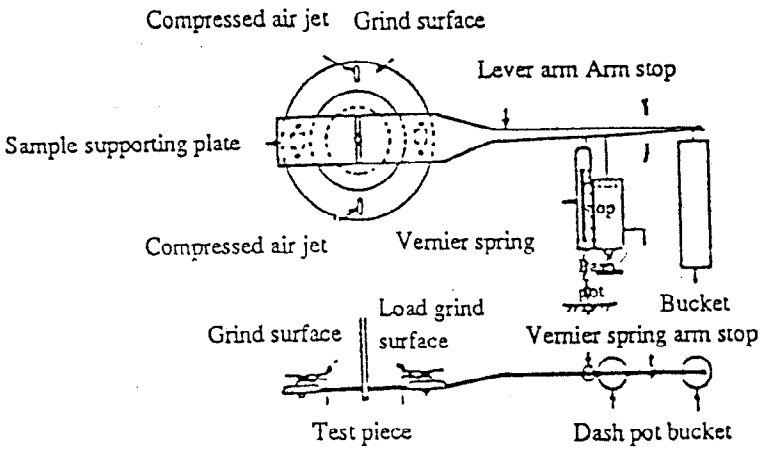
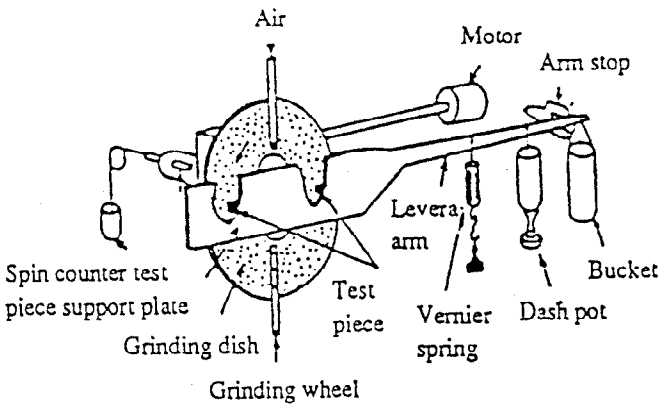


Figure 45



Testing device shall be in the following shape. Grinding surface attached wheel is installed to the axis within the vertical surface, and spun at 34 - 40Hz of constant speed in a counter clockwise direction. A spin counter is attached to this spinning axis. Fix two test pieces in the test piece support (Figure 45), and let the distance between the test piece and center of axis be 63.5mm. Test piece shall be compress-contacted to the grinding surface by a weight and caught in the tip of a net suspended downward from the circumference of a grooved pulley. Slipping of the rod from the test piece supporting plate is prevented by inserting a vertical pin to the tip of the rod in the groove of the test piece surface. Connect the test piece support and lever arm, and attach a bucket at the tip of the lever arm, and adjust the weight by inserting metal balls in it. Neutralize the spinning force applied to the lever arm during operation. Adjust the, delicate load by attaching a vernier spring to the lever arm. Attach a dash pot in between the bucket and vernier spring to prevent the over vibration of the lever arm. Grinding surface is annular in shape 165 mm in outer diameter and 70mm in inner diameter, and it's surface stays clean during the

operation through an air cleaner. Air, preliminary filtered for oil, and water and dust wit 1.8 kgf/cm^2 (0.177MPa) of pressure, is used. Install air injection holes, 3 in one group, mm apart from the grinding surface in the upper and lower parts of the annular grindin the grinding surface in the upper and lower parts of the annular grinding surface. Th injection holes shall be 1mm in diameter.

24.3.3 Testing method

(1) Testing temperature

Testing temperature shall be 25 ± 2°C, in principle.

(2) Adjustment of test piece

Use the test piece after leaving it for 24 hours or more at the test temperature.

(3) Installation of test piece

Fix two identical test pieces on the test piece support firmly. Friction surface of t piece shall not deform at this time.

(4) Operation

Perform the preliminary operation until the friction surface of the test piece contact an wear, and estimate the volume wear from the weight decrease due to wear by th following formula:

$Av = (Wo - W1) / P$

where, Av : wear volume (cm^3)

Wo : weight of test piece before preliminary operation (g)

W1 : weight of test piece after preliminary oper (g)

P : specific gravity of test piece

From the wear volume and preliminary operation time, c culate the wear speed by the following formula, and decide the testing time by Table 17 from the wear speed:

$V_A = Av / t$

where, V : wear speed (cm^3 / min)

t_A : preliminary operation time (min)

Table 17

wear speed due to preliminary operation (cm^3/min)	Testing time (min)
0.01 or less	30
0.01 - 0.05	24
0.05 - 0.10	16
0.10 - 0.20	8
0.20 - 0.40	4
0.40 or more	2

Perform the preliminary operation. After the preliminary operation, measure the weight of the test piece in mg, and operate for the specified time. Obtain the wear by measuring the weight before and after the test, and calculate the wear volume for every 1000 rounds of grinding surface from following formula.

$Aa = (W_2 - W_3) / P$

$Ab = (1000 / X) Aa$

where, Aa : wear volume during test (cm^3)

W_2 : weight of test piece before test operation (g)

W_3 : weight of test piece after test operation (g)

P : specific gravity of test piece

Ab : wear volume for 1000 rounds (cm^3 1000 rounds)

X : revolutions during test operation (rounds)

24.4 Acron Wear Test

24.4.1 Test piece

Test piece is dish shaped $63.5^{+0.5}_{-0}$ mm in diameter, $13.7 \pm^{+0.5}_{-0}$ mm in thickness with a hole in it's center, and is sampled from the product or constructed in the same oil-added condition as thet of the product.

24.4.2 Testing device

The testing device consist of the test piece support, test piece driving device, and grinding dish, and shall satisfy the following conditions. An outline of the test piece is shown in Figures 46 and 47.

(1) Test piece support

Two dishes are inserted at both tips and fixed by nuts. The outer dish is 56mm in diameter, and shall not be scratched on it's circumference. The inner dish is 44mm in diameter, and the inside of it's outer circumference protrudes 4mm in width and 0.5mm in thickness. The protruded area shall be on the center of the test piece when it is tightened by a nut.

(2) Test piece driving device

One which is able to drive the test piece on the circumference of the grinding dish at a speed of 250 ± 5Hz is used.

(3) Grinding dish

Grinding dish is a dish having 25 mm or more in thickness and 150 mm in diameter. The type of grindingstone is A 36-P5V (Bs-1814). Grinding dish shall be equipped with a spin counter and brush removing grinding particles, and shall be able to alter the angle of the test piece and grinding dish arbitrarily.

Figure 46

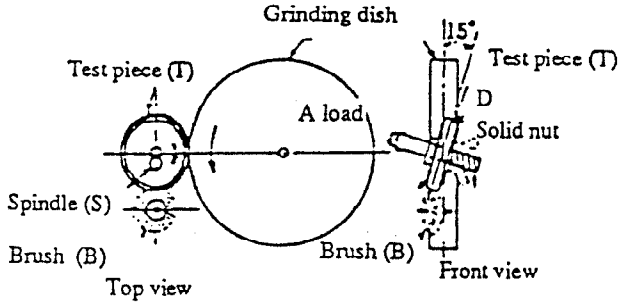
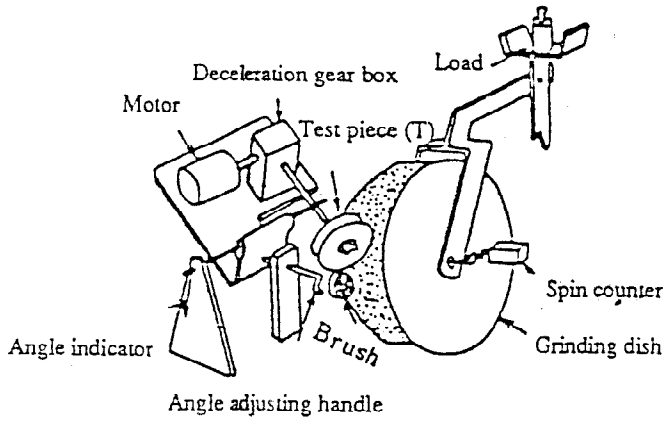


Figure 47



24.4.3 Testing method

(1) Testing temperature

Testing temperature shall be 25 ± 2°C in principle.

(2) Adjustment of test piece

Use the test piece after leaving it 24 hours at the testing temperature.

(3) Operation

Make the angle between the test piece and grinding dish be 20°C, and perform the preliminary operation until it worn from the grinding surface of the test piece extruding in the front by applying 4.5 kg of load to the grinding dish. Obtain the wear volume for 500 preliminary operations from the weight decrease due to wear by the following formula, and obtain the number of test operations by 24.2:

$Bv = 500 (Wo - W_1) / \rho X$

where, Bv : wear volume for 500 preliminary operations (cc/500 spins)

Wo : weight of test piece before test (g)

W1 : weight of test piece after preliminary operation (g)

ρ : specific gravity of test piece

X : number of preliminary operation

Table 18

Wear volume in preliminary operation (cm^3 /500 rounds)	Number of preliminary operation (revolutions)
0.05 or less	1,500
0.05 - 0.10	1,000
0.10 - 0.20	500
0.20 - 0.40	250
0.40 or more	125

After the preliminary operation, measure the weight of the test piece in mg, and operate up to the specified number. Obtain the wear volume by measuring the weight before and after the preliminary operation, and calculate the wear volume for 1000 revolutions of the grinding dish.

$Ba = (W_2 - W_3)\ \rho$

$Bb = (1000/X)Ba$

where, Ba : wear volume during test operation (cm^3)

Bb : wear volume for 1000 rounds (cm^3)

W_2 : weight of test piece before test operation (g)

W_3 : weight of test piece after test operation (g)

ρ : specific gravity of test piece

X : number of test operation (rounds)

24.5 Organizing Method of Test Result

Result of the wear test is calculated by obtaining the average of 3 measurements of the wear volumes.

$Ra = (As / At) \times 100$

where, Ra : wear resistance rate

As : wear volume of standard sample ($cm^3/10^3$ rounds : average value)

At : wear volume of test material ($cm^3/10^3$ rounds : average value)

24.6 Recording

The following shall be recorded in the test scores :

(1) Testing method

(2) Wear volume ($cm^3/10^3$ rounds) and wear resistance rate

(3) Testing temperature

(4) Other necessary items

25. Mechanical Oscillograph Test

25.1 Purpose

This test is performed to measure the following characteristics by the compression and shear of oil-added rubber:

(1) Resilience

(2) Static modulus of elasticity

(3) Dynamic modulus of elasticity

(4) Kinetic energy

25.2 Test Piece

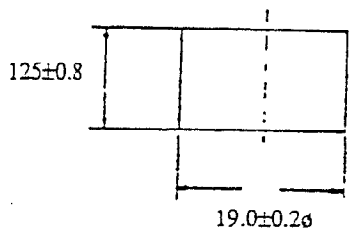
Test piece is sampled from the product or constructed in the same oil-added condition as that of the product. Test piece with traces of foreign material, scratches, or bubbles on the surface shall be excluded.

25.2.1 By compression

Shape and figures of the test piece are shown in figure 48.

Figure 48

Unit: mm

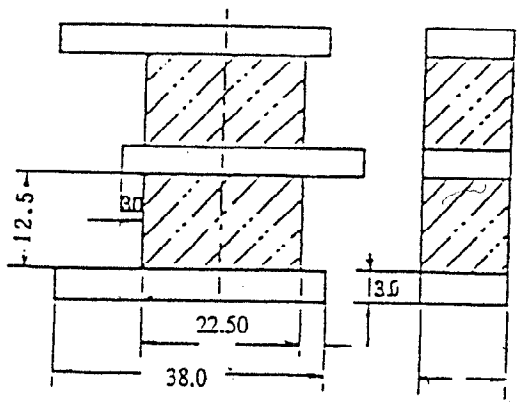


25.2.2 By shear

Shape and figures of the test piece are shown in Figure 49.

Figure 49

Unit: mm



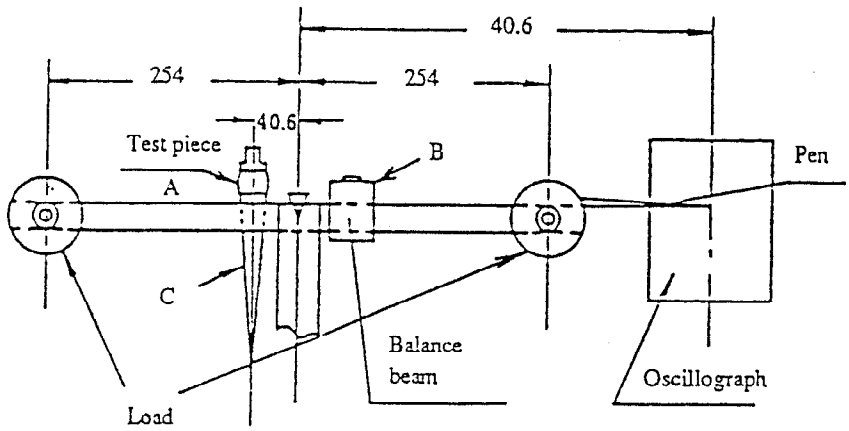
25.3 Testing Device

25.3.1 An outline of testing device

An outline of the testing device is shown in Figure 50.

Figure 50

Unit: mm



25.3.2 Balance beam

Support the center point of the balance beam by a knife edge, and fix the test piece at point A of Figure 50, and install a micro meter at the top of the test piece. To apply a parallel load to the test piece at all times. Support the stabilizer (C) with the knife edge too.

25.3.3 Recording pen

Install a recording pen in the balance beam to automatically record the movement of the balance beam, and to record the displacement of the test piece with 10 times of magnification.

25.3.4 Load

Use a dish shaped load, and use 14 of 640g and one of 320g. These loads shall be applied to the points, 254mm apart from the right and left from the center of the balance beam.

25.3.5 Recording plate

With the dish shape 121.34mm in diameter the recording plate shall be able to support the recording paper on the surface and spin vertically at a speed of 4 Hz.

25.4 Testing Method

25.4.1 Installation of test piece

(1) By compression

Fix the balance beam and remove all the loads. Subsequently, place the test piece, overlapped with sand paper of 400-A, on the center of the lower plate, and fix it so that the upper plate contacts the top of the test piece with a micro meter. Test piece shall not

deform at this time.

(2) By shear

Fix the balance beam and remove all the loads. Pull out the lower plate (dish), and fix the steel plate of the test piece, and make sure it does not unfolded when the load is applied. Set and fix by adjusting the micro meter so that the upper plate is located on the top of the test piece. The test piece shall not deform at this time.

25.4.2 Recording paper

Use a section paper as the recording paper which can cover the whole drum, and place it with it's cross lines in a horizontal position.

25.4.3 Preliminary deformation

Remove hook and apply 30% of the deformation by hand.

25.4.4 Measurement

With the hook removed, indicate the horizontal line (0 point) on the section paper a rotating drum. Apply the load once to the pen side of the balance beam, and rotate the drum a certain degree (approximately 5 mm), and add the load. Continue by repeating the same operation until all 14 loads are applied or deformation gets 50%. After applying the last load, rotate the drum the same degree in the reverse direction and remove the load one by one. Complete the S-S curve by repeating the same operation until all the loads are removed (refer to Figure 51). Remove all the loads, and close the hook on the balance beam, and raise the drum up to where the pen and S-S curve do not overlap. Obtain the load required for 20 ± 2% of deformation from the S-S curve, and apply this load to the pen side of the balance beam. With the drum fixed, remove the hook, and vibrate until the maximum amplitude indicates the same value 3 times or more. Subsequently, close the hook, and remove the hook by rapidly spinning the drum and draw the oscillograph on the section paper (refer to Figure 51).

25.5.1 Static modulus of elasticity

The static modulus of elasticity is calculated by the following formula, and from obtai the load (X1) when the displacement is 20% from the S-S curve in Figure 51:

$G = \sigma / \varepsilon$

where, G : modulus of elasticity (kgf/cm^2 {MPa})

σ : stress (kgf/cm^2 {MPa})

ε : deformation

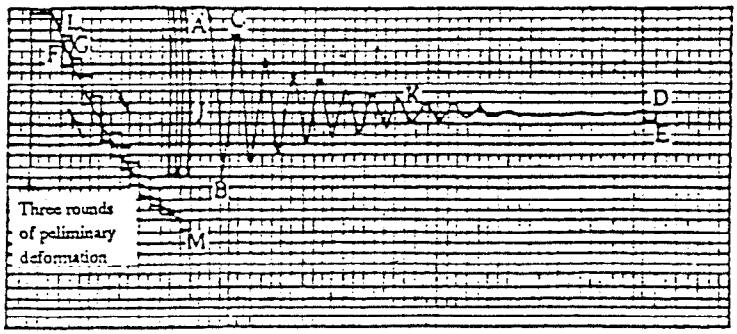
Stress can be calculated from 0.2 of 6.26 X_1 / A_1 by the following formula:

$G = (6.26\ X_1 / A) / 0.2$

$= 31.3\ X_1 / A$

where, X_1 : load when 20% of deformation (kgf)

A : pressurized area of test piece (cm^2)



25.5.2 Resilience

Resilience is calculated from the vertical displacement of BCDE of Figure 51, which is the first part of the oscillograph, by the following formula:

$Y_R = (1/2) \times (CD/BC + DE/CD) \times 100$

where, Y_R : Yerzley resilience

BC, CE, DE : vertical distance of each two points (mm)

25.5.3 Frequency

By arranging a few cycles of the oscillograph, obtain the distance in between (Y mm). Frequency f can be calculated by the following formula, since the circumferential speed becomes 25.4 mm/sec:

$f = 25.4 X/Y$

where, f : frequency

X : number of cycle between Y mm

25.5.4 Effective dynamic modulus of elasticity

Effective dynamic modulus of elasticity is calculated by the following formula:

Kc : $1.066\ 1\ f^2$

Ks : $0.5331\ f^2$

where, Kc : effective dynamic compression modulus of elasticity (kgf/cm^2 {MPa})

Ks : effective dynamic shear modulus of elasticity (kgf/cm^2 {MPa})

I : inertia efficiency ($kg \cdot cm \cdot sec^2$)

f : frequency (Hz)

Inertial efficiency is calculated by the following formula:

(1) For 25.4 x 25.4 mm of the cross section of the balance beam

$I = 1.124 + 0.424n$

(2) For 25.4 x 38.1 mm of the cross section of the balance beam

$I = 1.603 + 0.424n$

where n : number of 640g of the weight used

25.6 Recording

The following shall be recorded in the test scores:

(1) Yerzley resilience

(2) Static, dynamic modulus of elasticity

(3) Testing method and temperature

(4) Number of weight and frequency used

(5) Other necessary items

26. Expansion Test

26.1 Purpose

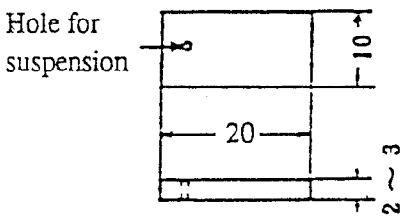
This test is performed to evaluate the oil-added condition of oil-added rubber by measuring the expansion.

26.2 Shape and Figures of Test Piece

Shape and figures shown in Figure 52 shall be used, in principle.

Figure 52

Unit: mm



26.3 Testing Device

26.3.1 Testing oil

Toluene specified in 13.3.1 is used as the testing oil, in principle.

26.3.2 Testing container

Use a glass test tube over 20mm in outer diameter and 200mm or more in length, and cap with a cork.

26.3.3 Constant temperature container

Constant temperature container shall be able to maintain the specified temperature within ± 0.2°C range.

26.4 Testing Temperature

Testing temperature shall be 30 ± 0.2°C or 40 ± 0.2°C, in principle.

26.5 Testing Method

Perform the test according to 13.5.1 and 13.5.2, and obtain the volume change rate according to 13.5.4. Testing time is up to the points where the equilibrium expansion is obtained.

26.6 Organizing Method of Test Result

Test score shall be expressed by the average of the volume change rates of two test pieces.

26.7 Recording

The followings shall be recorded in the test scores:

(1) Volume change rate - time curve and volume change rate at equilibrium expansion.

(2) Testing temperature

(3) Other necessary items

7. Fire Resistance Test

27.1 Purpose

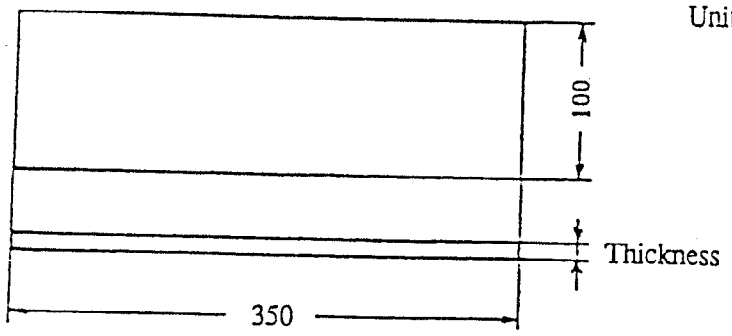
This test is performed to measure the burning speed of oil-added rubber. However, the evaluation of fire resistance of the vehicle interior components shall conform to KES C-H001 (Fire resistance of vehicle interior components).

27.2 Test Piece

27.2.1 Shape and figures

Shape and figures of the test pieces shall conform to Figure 53. Thickness shall be the same as that of the product. However, use 12.5 mm for those with over 12.5 mm in thickness.

Figure 53



27.2.2 Sampling of test piece

Test piece is sampled by the following method:

(1) Take 5 test pieces for one test from the product or separately oil-added sheet of the same thickness (Minimum of 10 pieces are required for initial aging).

(2) If there is directional characteristics, it shall be sampled to made able to test in all directions.

(3) For those with fuzzes in the surface, remove the fuzz by passing the test piece through a comb in a lengthwise direction.

27.3 Testing Device

Testing device consist of a metal cabinet, U-shaped fixture, and ignition apparatus.

27.3.1 Metal cabinet

Shape and figures of the metal cabinet shall conform to Figure 54.

27.3.2 U-shaped fixture

Use two U-shaped metal fixtures in the shape and figures shown in Figure 55.

27.3.3 Ignition apparatus

Ignition apparatus shall be able to adjust the flame height to 40mm by a bunsen burner 9 - 10mm in inner diameter with air induction holes completely closed. Liquified petroleum gas or city gas having a flame temperature comparable to natural gas is used as the fuel.

Figure 54

Unit: mm

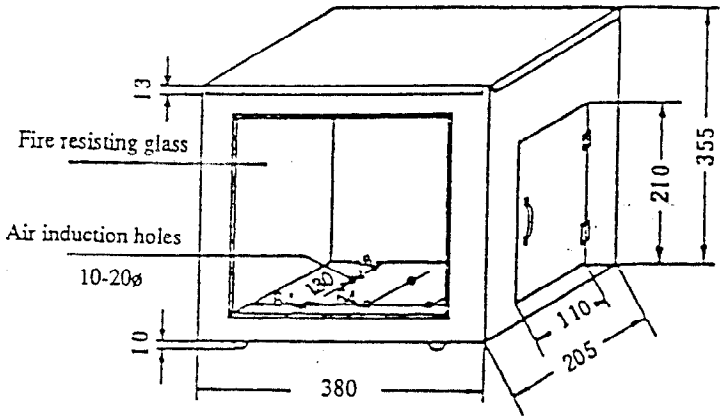
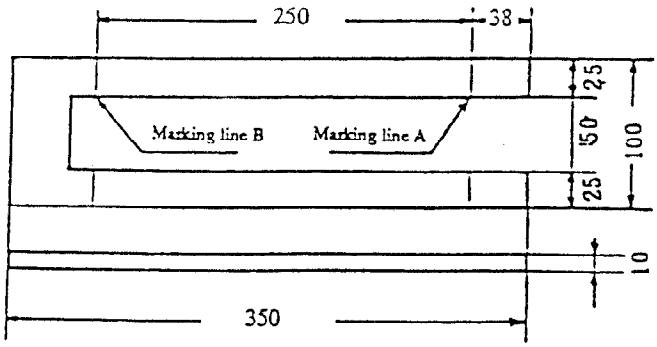


Figure 55

Unit: mm



27.4 Testing Method

27.4.1 Condition adjustment and testing condition

After maintaining the condition of the test piece for 24 hours at 20 ± 2°C and a relative humidity of 50±5% prior to the test, perform the test in a windless room under the same temperature and humidity conditons.

27.4.2 Initial fire resistance characteristic

Perform the test according to 27.4.1.

27.4.3 Combustion characteristic after aging

After aging the test piece by maintaining it for 240 hours in an air-circulating constant temperature container at 80 ± 2°C, perform the test according to 27.4.1.

27.4.4 Operation

(1) Insert the test piece in U-shaped fixture with the side space of the test piece facing the bottom, and place them horizontally on the stand. Install the stand so that the test piece is placed in the center of the cabinet.

(2) Adjust the center of the burner sphere so it is located 20mm below the bottom the center of the test piece.

(3) Ignite the burner and adjust it's flame height to 40mm.

(4) Expose the test piece to the flame for 15 seconds.

(5) Measure the time from when the flame passes marking line A to when the flame extinguishes or reaches marking line B.

(6) After the completion of the test, vent and cool down the combustion chamber.

27.5 Organizing Method of Test Result

Test result shall be organized by the following calculation:

27.5.1 Calculation method

Obtain (1) from the test scores of the five test pieces.

(1) Combustion speed, average combustion speed, and variation between the test pieces are calculated by the following formulas:

$$Bk = 60 \times \frac{D}{T}$$

$$\overline{B} = \frac{\sum_{k=1}^{n} Bk}{n}$$

$$S = \sqrt{\frac{\sum_{k=1}^{n} (B-Bk)^2}{n}}$$

where, B : combustion speed (m/min)

D : combustion length (m)

T : combustion time (sec)

B : average combustion speed (m/min)

Bk : combustion speed of each test piece (m/min)

n : number of test pieces

S : variation between test pieces

(2) Obtain the maximum combustion speed Bmax and B+3S from (1). If B+3S > 0.10 at Bmax ≤ 0.09, obtain the combustion speed of the additional five test pieces, and calculate Bmax, B+3S from the ten test pieces. However, if all five are extinguished within 50cm from marking line A and within 60 seconds, it is desirable to terminate the test without respect to the values of Bmax and B+3S.

27.6 Recording

Items (1) - (5) for the initial and after-aging combustion resistance characteristics shall be recorded in the test scores.

(1) Bmax and B+3S

(2) Number of test pieces

(3) Direction (separation in width and length)

(4) Testing temperature and humidity

(5) Other necessary items

28. Self-extinguishing Characteristic Test

28.1 Purpose

This test is performed to evaluate the self-extinguishing characteristics of oil-added rubber.

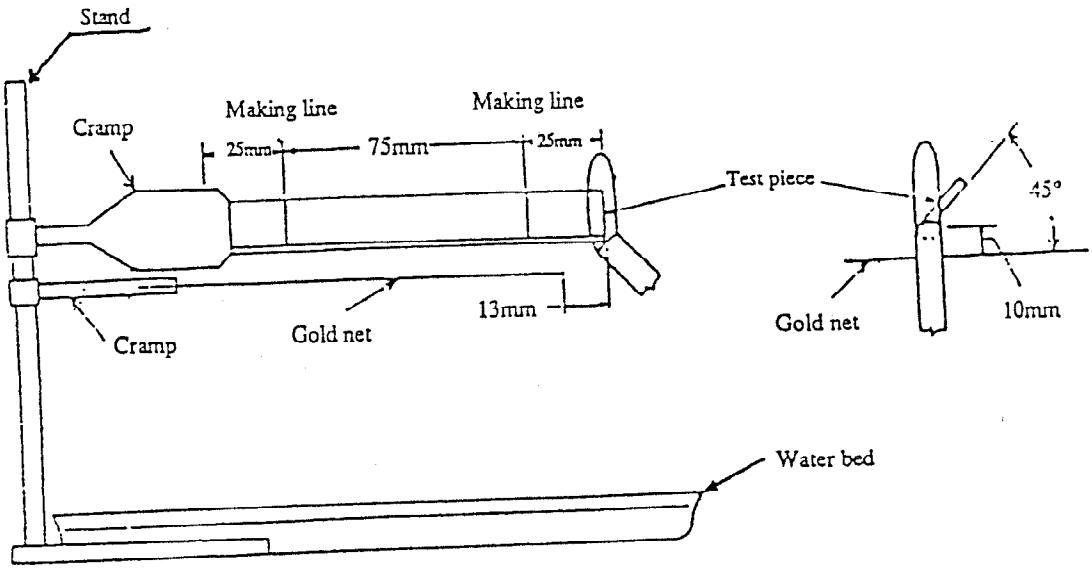
28.2 Test Piece

Test piece shall be 125 ± 5 mm in length, 12.5 ± 0.2 mm in width and the original thickness of the product. However, if the thickness of the product exceeds 12 mm, cut off the excess so it is 12 mm. Test piece is sampled directly from the product or from the oil-added rubber sheet in the same condition as that of the product.

28.3 Testing Device

To support the test piece, attach two clamps. Under the test piece, install 100 x 100mm of mesh gold net with the device shown in Figure 56, which consists of a stand and bunsen burner approximately 10mm in outer diameter. It also is desirable to install a water bed under the gold net, for safety.

Figure 56. Testing device



28.4 Testing Method

28.4.1 Condition adjustment and test condition

After maintaining the condition of the test piece for 24 hours at 20 ± 2°C and a relative humidity of prior to the test, perform the test in a windless room under the same temperature and humidity conditions.

28.4.2 Combustion characteristic after aging

After Aging the test piece by maintaining it for 240 hours in an air-circulating constant temperature container at 80 ± 2°C perform the test according to 27.4.1.

28.4.3 Operation

Fix the test piece by a clamp as shown in Figure 56, slanted 45 degree horizontally in the length direction and vertically in the width direction. Subsequently, adjust the flame of the gas burner to 25.4mm of blue flame. Remove the flame after it's tip contact the bottom of the free end of the test piece slightly for 30 seconds. After removing the flame, measure the time for the self-extinguishing of the test piece, with a stopwatch.

28.4.4 Evaluation

If it self-extinguishes in 60 seconds, the oil-added rubber is considered to have self-extinguishing characteristics.

28.5 Recording

The following shall be recorded in the test score reports:

(1) Measuring time (sec) and existence of self-extinguishing characteristics

(2) Number of test pieces
(3) Direction (classification in length and width)
(4) Testing temperature and humidity
(5) Sampling method of test piece and it's figures
(6) Other necessary items

29. Electrical Resistance Test

29.1 Purpose

This test is performed to measure the electrical resistance of oil-added rubber.

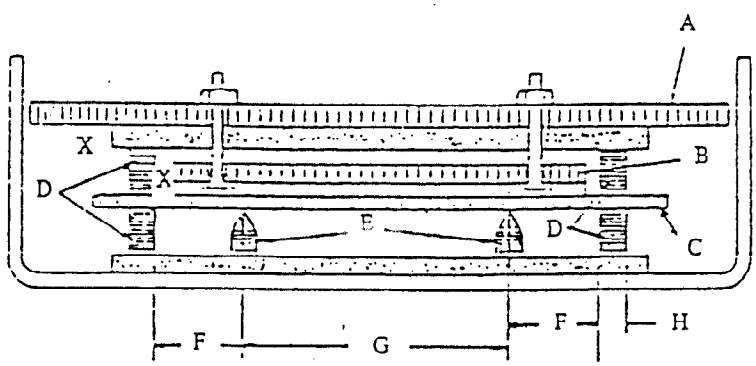
29.2 Test Piece

Test piece shall be 10 - 150mm in width and 70 - 150mm in length. Width shall be adjusted within ±1%. Also, the thickness of the cut off test piece shall be 2.0 ± 0.2. However, no foreign traces shall be attached to the test piece.

29.3 Testing Device

Testing device shall conform to ASTM D991. Electrode device is shown in Figure 57.

Figure 57. Electrode device



A : weight to assist the contacting force of the current electrode and test piece (300N per 1m of width) (26)

B : weight to assist the contacting force of the current electrode and test piece (60N per 1mm of width) (27)

C : test piece

D : current electrode

E : voltage electrode

F : distance between the current electrode and voltage electrode (minimum 20mm)

G : distance between voltage electrodes

H : width of current electrode, 5 - 8mm

X : insulation

Note (26) Approximately 4.5 kg (10 ℓ b) for 150mm wide test piece

(27) Approximately 0.9 kg (2 ℓ b) for 150mm wide test piece

29.4 Testing Method

29.4.1 Condition adjustment and testing condition

(1) The time from the addition of oil to the test shall be 16 hours or more and 4 weeks or less. Also, the test of the product shall be done within 2 months from it's receipt.

(2) For those test pieces having unnecessary bendings or sampled from the product, anile for 3 hours at 23 ± 2°C to remove those factors affecting the stress test.

(3) Shape adjustment of the test piece shall be done for 16 hours or more. Testing temperature and relative humidity shall be 23 ± 2°C and under 65% respectively. Shape adjustment of the test piece shall be done in a dessicator. Also, the test piece anlled in room temperature shall be kept in a sealed container during the shape adjustment.

29.4.2 Testing procedure

(1) Set the condition adjusted test piece in an electrode device. Pay attention not to bend the test piece. Also, the calendar grain is allowed in the verify position of the standard plate but not in the contacting position with the current electrode.

(2) After connecting to a DC power supply, adjust the current in the test piece when the power loss between the voltage electrodes is 0.1W. However, the current for each voltage shall not exceed the following values:

Voltage	Current mA
3	50
6	25
10	15
30	5
75	2
150	1
300	0.5

(3) If the current stabalizes for 5 seconds, measure the voltage and current between the voltage electrodes. Each value shall be as close to 1% as possible at that time.

(4) Measure the thickness and width of the test piece.

(5) Perform the measurement for three test pieces.

29.5 Calculation Method

For each test piece, obtain the volume resistance ratio by the following formula:

$\rho = V\ w\ dk / 1\ \ell$

where, ρ : Volume resistance ratio Ωm

V: Voltage V

I : Current A

w: Width of test piece

d : Thickness of test piece

ℓ : Distance between voltage electrodes

k : Coefficient depends on the unit of w, d and ℓ

K = 0.001 for mm

K = 0.054 for in

29.9 Organizing Method of Result

Test score shall be expressed by the average of the calculated values of three test pieces.

29.7 Recording

The following shall be recorded in the test score :

(1) Temperature during condition adjustment and testing

(2) Relative humidity during condition adjustment and testing

(3) Size of test piece

(4) Current on test piece (unit : A)

(5) Voltage between electrodes

(6) Volume resistance ratio (unit : Ωm, KΩm, MΩm)

Standard Quoted

KES A-A003	(Concluding method of number)
KES C-L006	(Fuel oil resistance rubber component materials)
KES C-H001	(Non-combustion characteristic of vehicle interior components)
KS B 2805	(O-rings)
KS B 5314	(Liquid-in-glass thermometers for testing of petroleum products)
KS D 3503	(Rolled steel for general structural purposes)
KS D 5201	(Copper and copper alloy sheets, plates, strip and coiled sheets)
KS K 0910	(Gray scale for assessing staining)
KS M 2611	(Gasoline for industrial purpose)
KS M 2612	(Automotive gasoline)
KS M 2670	(Glassware for testing apparatus of petroleum products)
KS M 8010	(Acetone)
KS M 8103	(Sulfuric acid)
KS M 8153	(Toluene)
JIS K 6301	(Physical testing method for vulcanized rubber)
JIS K 8517	(Potassium ichromate)
JIS K 8518	(Sodium dichromate dihydrate)
JIS K 8594	(Petroleum benzene)