Hevea Rubber Technologies (P) Ltd.

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Internal Document for Testing Procedure for Elastomeric Bearings

Document Details: Testing of Elastomeric Bearings.

Product: Elastomeric Bearings

Testing Location: Hevea Rubber Technologies Pvt. Ltd

Reference Specification : IRC 83 Part 2: 1987 (2011 Edition)

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1. Physical Properties	IS
a. Hardness	IS 3400 (2)
b. Tensile Strength	IS 3400 (1)
c. Elongation at Break	IS 3400 (1)
d. Compression set	IS 3400 (10)
e. Accelerated Ageing	IS 3400 (4)
f. Adhesion Strength Test	IS 3400 (14)

Test Name	**Hardess testing**

Test Procedure
IRHD Tester is placed over the bearings or the test pieces and the measurement is read directly from the gauge of the tester. The test will be satisfactory if the hardness read is 60±5

Test Name	**Tensile Strength**

Test Procedure
Dumbells are prepared from the test compound as per specification given in IS 3400
This is fixed on to the tensile testing machin and stretched at a constant rate of transverse till the test piece breaks. The load (Breaking force in Newtons) at which the test piece breaks is noted and the following calculations are computed

$$\text{tensile strength} = \frac{\text{(load at break)}}{\text{(original width) (original thickness}}$$

Breaking Force in Newton
Area - Initial cross sectional area in mm

3 Readings are taken and average arrived at, Test will be deemed satisfactory if TS>17 Mpa

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Test Name	**Elongation**

Test Process

Test is conducted in the same manner as for tensile strength. Length of the narrow portion at the breaking point is noted and the following calculations are made

$$\% \text{ Elongation} = \frac{L - L_o}{L_o} \times 100$$

Where L = Length in millimeters between bench marks at break
Lo= The intial length in millimeters between bench marks

Test will be deemed satisfactory if the elongation at break is 400% or more

Note the same machine is used for testing the aged piece (for Tensile and Elongation) and Adhesion piece

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Test Name	**Compression Set**

Test Process

Test buttons are prepared from test compound. 3 test buttons are compressed up to 75% of the initial thickness inside a metal fixture. This is placed inside an ageing oven at 100°C for 24 hours. After the ageing is over, the pieces are taken out and the thickness is measured

The following calculation is made

$$\text{Compression Set \%} = \frac{t_o - t_i}{t_o - t_s} \times 100$$

Where t_o =	Initial Thickness in mm of test pieces
t_i=	thickness of test pieces in mm after recovery
t_s=	height of the spacer in mm

Test will be deemed satisfactory if the Compression set obtained is less than 35%

Ageing Oven

Compression Set Apparatus

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Test Name	**Accelerated Ageing**

Test Process

Dumbbells and buttons are placed inside an ageing oven and are subjected to a temperature of 100^{o}C for 72 hours. After ageing is completed, hardness, tensile and elongation tests are done on the dumbbells

The Test will be deemed satisfactory if the following results are achieved.

Change in Hardness	+15	Note for DMRC +5
Change in Tensile Strength	–15%	
Change in Elongation	–30%	

Ageing Oven

Tensile Testing

Hardness Testing

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Test Name	**Adhesion Strength**

Test Process

A 6mm thick rubber test piece is moulded on to a metal piece. The width of the rubber piece will be 25mm and length 125mm which will adhere to an area of 25 mm^2 of the face of the metal. The metal piece dimensions are 1.5mm thick x 25 mm width x 60mm long
The test piece with metal attachment is fixed on the tensile testing machine and load is applied. The maximum force required to cause separation over the distance of 25 mm is recorded.

Calculation is as follows
The breaking force from the tensile testing machine is noted in kgF 'A'
The value is then converted to Newton by multiplying it with 9.81 and then multiply by 1000 to convert the value to KN
Hence 9.81x1000xA is the breaking force for 25 mm of the material.

25 = 9.81x1000xA
1000 = ?

Applying unitary method

$$\text{Adhesion in KN/meter} = \frac{9.81 \times 1000 \times A}{25}$$

The test will be deemed satisfactory if the separation takes place after a force of 7 KN/Meter

UTM Machine'

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2. Chemical Properties	ASTM
a. Specific Gravity	ASTM D - 297
b. Ash Content	ASTM D 297
c. Polymer Identification	IS 3400 (10)
d. Polymer content	(Indirect)

Test Name	**Specific Gravity**

Specific gravity of the test piece will be determined by Hydrostatic method
The weight of the specimen in air and then in water is taken and the density is calculated as follows

$$\text{Density, } D = \frac{0.9971 \times A}{A - (B - C)}$$

Where A – mass of specimen in gms
B – mass of specimen and wire in water in gms
C – mass of supporting wire in gms

Test Name	**Ash Content**

Weigh 1 gm of specimen of sample and keep it in an ignited crucible. This is placed inside a muffle furnace and heated up to 550^{o}C for one hour. The door of the furnace is opened 3 to 5 cm and heating is continued for 30 more minutes. The crucible is then removed from the furnace and cooled in a dessicator and then weighed.

$$\% \text{ Ash} = \frac{(A - B)}{C} \times 100$$

Where A – weight in gms of ash plus crucible
B – weight in gms of crucible
C – weight in gms of specimen

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Test Name	**Polymer Identification**

Test Process

Shake a 0.2 gm sample with 2 cm^3 of Iodine Solution. If the violet colour fades noticably in 2 to 3 minutes. CR is indicated. Burn the sample in contact with a clean copper wire. A persistent green flame indicates chlorine.

Test Name	**Polymer Content**

Test Process

The rubber Content of the specimen is calculated by subtracting the sum of non-rubber constituents from 100%

% Polymer - 100% – (% of Acetone +% of Carbon + % of ash)

a) Acetone Content

1 gm of homogenous rubber compound is weighed and wrapped in a filter paper. This is placed in an extraction apparatus containing acetone and then extracted for 12 to 16 hours (6 to 8 extractions per hour). The extract is then dried and cooled and then weighed.

$$\text{Solvent extract \% by weight} = \frac{W1}{W2} \times 100$$

Where W1 = Weight in gms of the matter extracted
W2 = Weight in gms of the test portion

b) Carbon black Content

0.5 gm of acetone extracted specimen is placed in a beaker and 30 ml of concentrated nitric acid is added. This is heated on a water bath till the reaction subsides completely and carbon black has settled completely. Cool and filter through asbestos matted gooch crucible by gentle suction. When all carbon black has been transferred, wash it with concentrated nitric acid and hot water till the filterate is acid free. The filterate is then washed with aceton. Dry the crucible in an oven at 100 $\pm$ 5°C for about 1 hour. Cool in a desicator and weigh (W2). The Crucible is then placed in a muffle furnace at 900°C for about 1 hour to burn off carbon black. Cool to room temperature and weigh again (W3).

$$\text{\% of Carbon Black} = \frac{W2 - W3}{W} \times 100$$

Where W weight in gms of specimen before acetone extraction
W2 weight in gms of specimen before ashing
W3 weight in gms of specimen after ashing

c. Ash Content
As given earlier

II Material Properties of Mild Steel

Test Name	**Physical Properties**

The 3mm or 4 mm specimen is cut in to dumbell shapes and loaded on to the Universal Testing Machine (UTM-STEEL). The load is applied to the specimen in a transverse manner. The reading on the computer will be noted when the specimen breaks.

The operator will take the Gauge length (intial and Final), width (Initial and Final) and thickness (intial and Final). These readings are then fed on to the computer system. The computer will generate the following readings using the above mentioned meqs

Ultimate Tensile Strength	IS 2062	Min 250 Mpa
Yield Stress	IS 2062	Min 410 Mpa
Elongation	IS 2062	Min 23%

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III Testing of Elastomeric Bearings – Finished Lot

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5	Shear Modulus	Clause 918.4.1.3	Page 16, Appdx cl.8,9
6	Stripping Strength	Clause 918.4.1.3	Page 16, Appdx cl.11
7	Test for Ultimate Compressive Strain	Clause 918.4.1.3	Page 16, Appdx cl.12

1 Visual Inspection

All Bearings of the lot are visually inspected for absence of any defects in surface finish shape or any other supervisual defects

2 Dimensional Analysis

All bearings are inspected for overall plan dimensions, including length breadth, thickness and parallelism.

Length of the bearing	0 to 6 mm	Measured using a tape
Breadth of the bearing	0 to 6 mm	Measured using a tape
Thickness of the bearing	0 to 5%	Measured using vernier calliper
Parallelism of the bearing Side 1	1 in 200 mm	Measured using a Parallelism meter
Parallelism of the bearing Side 2	1 in 100 mm	Measured using a Parallelism meter

Length & Breadth **Thickness** **Parallelism**

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3 Axial Load Testing

All bearings are subjected to axial load corresponding to 15 Mpa applied in steps and held constant while visual examination is made to check for defects like misalignment of reinforcing plates, poor bond of laminates / steel interface variation in height, surface defects and low stiffness.
Deflections under loads between 5 Mpa and 15 MPA are measured and variation in stiffness of any individual bearing from the mean of the measured valus of all such bearings of the lot shall not be larger than 20% of the mean value

4 Test for Determination of Elastic Modulus

Two bearings from the lot is selected at random. The bearings are loaded on to the universal testing machine. The bearings are then conditioned at a load of 20 Mpa

As Mpa is depended on the Area the calculation for converting tons (which is read at the dial gauge) is as follows

$$\text{Stress in MPA} = \frac{\text{Stress in tons} \times 1000 \times 9.81}{\text{Plan Area of the Bearing}}$$

(Converting tons to KG to N)
(Area in mm^2)

Plan Area is the area of the steel laminates as the force is primarily exerted in this region. Note that there will always be 6mm cover to the sides.

Once the bearing is loaded up to 20 MPA, the stress is held constant for a period of 10 mins
The load is then reduced to 2 MPA and then dial gauges are fixed on to the 4 sides of the test set-up.

The load is increased at a rate of 1 MPA per minute and the deflection is measured using the dial gauges
Readings at 2,5,10,15 and 20 MPA is noted and tabulated.
The values are then plotted in a graph of STRESS Vs STRAIN
The Stress by Strain values between 10 and 20 are taken from the slope of the graph

$$\text{Elastic Modulus} = \frac{20 - 10 \text{ MPA}}{\text{Strain at } 20 - \text{Strain at } 10 \text{ MPA}}$$

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Shape Factor

Shape factor is the most important factor for elastomeric bearings. As per IRC 83 Part 2 the shape factor must necessarily be between 6 and 12.
Below 6 the compressive stiffness is very low and above 12 it is deemed as uneconomical
However in countries such as Japan and US the bearings are having shape factors up to 15

To calculate shape factor one must use the following formula

$$\text{Shape Factor} = \frac{\text{Plan Area of the elastomeric bearing}}{\text{Area of 1 surface allowed to bluge freely}}$$

$$= \frac{\text{Plan Area of the elastomeric bearing}}{\text{Perimeter of the bearing x thickness of 1 internal layer}}$$

To compute the ideal value of elastic modulus one has to use the formula mentioned below

$$\text{Ideal Value of Elastic Modulus} = \pm\ 20\%\ \text{of}\ \frac{1}{\left(\frac{0.2}{S^2} + 0.0005\right)}$$

Check if the observed value of elastic modulus will be within the prescribed value of Elastic Modulus

Universal Testing Machine

Note: The same universal testing m/c is used for axial load test, elastic and shear modulus test, stripping strength test & Ultimate compressive strain

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5 Test for Determination of Shear Modulus

The two bearings that were randomly selected is subjected to a vertical load of 5 MPA
Then a shear force is applied at a rate of 0.5 MPA per minute. The load is gradually increased
The bearing is then pushed from an initial position to value corresponding to strain =1

It is to be noted that at such low forces the steel laminates within the bearings will not show any shear movement. Hence for this test we only take the height of the elastomer

Height of the elastomer = Height of the bearing - thickness of steel plate x no. of plates

Hence if the bearing height is 65 and there are 5 laminates of 3 mm thick the height of elastomer will be 50mm. While during shear modulus test the bearing will be pushed to 50mm

At regular intervals of strain shear stress is noted. As per IRC the shear stress value at 0.2 , 0.4 , 0.6 , 0.8 and 1 is noted

Stress of 1 bearing is obtained by dividing the Horizontal for 2H by 2

Shear Modulus G is then obtained by

$$G = \frac{\text{Stress at 1} - \text{Stress at 0.2}}{1 - 0.2}$$

The value of G is to be within 0.8 to 1.2 MPA

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The following two tests are destructive tests

6 Stripping Strength Test

The bearings that were used for testing is then cut in to 2 pieces at 45 degree angle
The bearing is then placed in to a fixture and applied a vertical load of 4 MPA. This is to ensure that no slippage is happening while the load is being tested.
Horizontal force of 3 MPA is applied to check if there are any failures between the bonding of elastomer and steel laminate.

Test result shall be deemed satisfactory if there is no separation at the interface of rubber and metal.

Test Set-up as per IRC

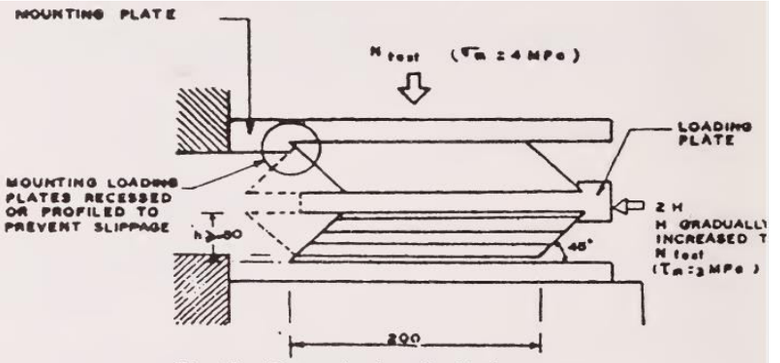

Fig. 12. Determination of adhesion strength

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7 Ultimate Compressive Strain

A Square piece of minimum 100x150 is cut from the bearing and then applied a vertical load of 60 MPA.

The test will be deemed satisfactory if there are no cracks (indicated by a loud noise) on the steel plates or if there are no irreversible squeezing of elastomer and metal plates at 60 MPA.