AIS-080

AUTOMOTIVE INDUSTRY STANDARDS

Procedure for Evaluation of Rubber Bushing Components

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ON BEHALF OF
AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLES RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF SHIPPING, ROAD TRANSPORT & HIGHWAYS
(DEPARTMENT OF ROAD TRANSPORT & HIGHWAYS)
GOVERNMENT OF INDIA

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Status chart of the standard to be used by the purchaser for updating the record

Sr. No.	Corr-igenda.	Amend-ment	Revision	Date	Remark	Misc.

General Remarks :

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the publication of standards and development of test facilities in parallel when the work on the preparation of the standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the permanent CMVR Technical Standing Committee (CTSC). After approval, the Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard. For better dissemination of this information ARAI may publish this document on their Website.

The present automotive standard is prepared to provide procedure for evaluation of rubber bushing components for incorporating construction, quality of the end product to meet the service requirement by evaluating the properties/parameters of the rubber components. It is recommended for safety related components.

While preparing this standard considerable assistance is taken from following International Standards:

1. British Rubber Manufacturing Association (BRMA) recommended procedures for testing of rubber to metal bonded components.

2. JIS K 6394 -1976 Testing Methods of Dynamic Properties for Rubber, Vulcanized or Thermoplastic

3. SAE J 1883 Oct. 94: Elastomeric Bushing “TRAC” Application Code

The Automotive Industry Standards Committee (AISC) responsible for preparation of this standard is given in Annex : II.

Procedure for Evaluation of Rubber Bushing Components

1. SCOPE

This guideline standard specifies the performance requirements of rubber bushings which are designed for their flexibility in torsion and axial as well as radial displacements.

2. PURPOSE

To meet stringent requirements of auto rubber components and to establish and maintain the quality of the end product by evaluating the properties/parameters of the rubber materials.

3. DEFINITIONS

3.1 **Bushing –** A cylindrical bearing or a guide.

3.2 **Elastomer –** Macromolecular material that returns rapidly to approximately initial dimensions and shape after substantial deformation by applying stress and release of stress.

3.3 **Fatigue –** The process of progressive localized permanent structural changes occurring in a material or component subject to the conditions which produces fluctuating stresses and strains at some point or points and which may cumulate in loss of load bearing ability, cracks or complete fracture after a sufficient number of fluctuations.

3.4 **Test axes –** Radial load and torsional rotations are the most commonly controlled input quantities to a bushing.

3.5 **Radial –** The translational axis on which radial load is applied

3.6 **Axial –** The translational axis coinciding with the bushing inner and outer sleeve axis.

3.7 **Normal –** The translational axis perpendicular to both the radial and axial axes.

3.8 **Torsional –** The rotational axis coinciding with the axial axis.

3.9 **B_{10} Life –** The life corresponding to 10% of the population. 10% is the probability of failure, i.e. 90% of the population will survive the specified life.

3.10 **Spring Rate** – Ratio of force to the deflection produced by that force. Spring rate = Force / Deflection. It is the property of the particular elastic body under consideration.

3.11 **Permanent Set** – The residual deformation of a component after removal of external load.

3.12 **Dynamic Stiffness** - Dynamic Stiffness is ratio of maximum dynamic force amplitude and maximum deflection amplitude.

3.13 **Service Load** – It is a actual load coming on a component during it's different service conditions.

3.14 **Load bearing capacity** – It is the strength capacity of mounts required at maximum load i.e. 1.5 times service load.

3.15 **Preload** – An static load which is experienced by the component during the service.

3.16 **Dynamic Spring Rate(k)** – The proportionality factor between the component of the applied force vector that is in phase with the displacement and the displacement vector. The dynamic spring rate is equal to the elastic component of the complex spring rate.

3.17 **Complex Spring Rate(k*)** – The effective spring rate of a part under sinusoidal dynamic stress. It is the peak to peak force across the sample divided by the peak to peak displacement. The complex spring rate can be visualized as being the vector sum of an elastic component and a viscous damping component.

3.18 **Storage spring constant/storage stiffness (k_1)** – It is ratio of amplitude of component of load in the same phase as deflection divided by deflection amplitude.

3.19 **Loss spring constant/loss stiffness (k_2)** - It is ratio of amplitude of component of load in quadrature with deflection divided by deflection amplitude.

3.20 **Loss angle** – Loss angle is the phase angle between the applied force and resultant displacement

3.21 Loss factor (tan δ) or loss tangent of the phase angle between the applied force and resultant displacement.

3.22 **Frequency** – The number of complete cycles, whose periods of forced vibrations per unit time caused and maintained by a periodic excitation, usually sinusoidal.

4. GENERAL REQUIREMENTS

4.1 Performance Tests

The performance test covers conditioning of the components at the specified temperature and testing depending upon operating conditions. Various performance test which are required to be carried out are static characteristics at low achievable frequency (normally 0.1 Hz), dynamic characteristics at different frequencies including dynamic stiffness, loss angle, fatigue life with different types of loading based on operating conditions.

4.2 Environmental Tests

The purpose of environment resistance testing is to determine the extent of changes to the materials and rubber to metal bond forming the product, as a result of exposure to particular types of environmental similar to service conditions.

The environmental test covers resistance to heat and cold, fluids such as petroleum products, hydraulic oil, humidity. These tests are generally carried out in special chambers simulating the required conditions.

5. PERFORMANCE REQUIREMENTS

5.1 General conditioning procedure

Before any types of test is carried out on bush components the following conditioning procedures shall be followed. The minimum time between vulcanization and testing shall be 24 hours and it shall not exceed 90 days. Components after any necessary preparation shall be conditioned at a temperature of 23 ± 2 ^{0}C for at least 3 hours before tests are carried out. Test temperature should maintain at 23 ± 2 ^{0}C.

5.2 Determination of component static stiffness characteristics:

Static test to be carried out using test machines, which can able to give displacement with force/torque requirements. The machine should be capable to record displacement and load readings. Rubber bushes are to be mounted with the help of mandrills and sleeves in such a way that bushing can take radial, axial and Torsional loads.(i.e. X,Y and Z Directions)

5.2.1 Static Torsional Stiffness Test

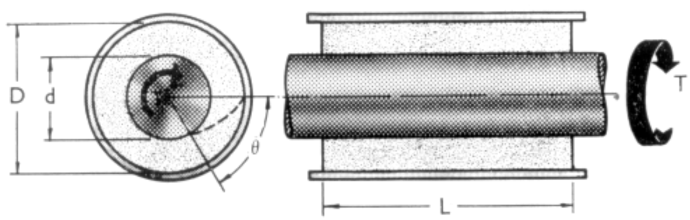

Figure 1

Mount the specimen and rotate inner mandrill keeping outer sleeve stationary as shown in Figure 1. Plot the static curve of deflection V/s. load readings. Torsional stiffness is a ratio of torque and rotation of inner shaft to outer.

5.2.2 Static Axial Stiffness Test:

Mount the specimen and pull inner mandrill keeping outer sleeve stationary as shown in Figure 2. Plot the static curve of deflection V/s. load readings. Axial stiffness is a ratio of Force and deflection. The axial deflection "x" of a bush arises primarily from shearing of the rubber although there may be contribution from bending.

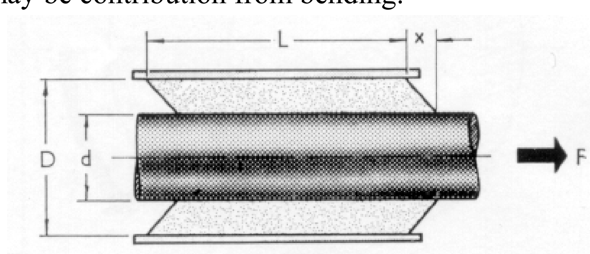

Figure 2

5.2.3 **Static Radial Stiffness Kr:**

Mount the specimen and load the outer sleeve radially as shown in Figure 3. Plot the static curve of deflection V/s. load readings. Axial stiffness is a ratio of Force and deflection.

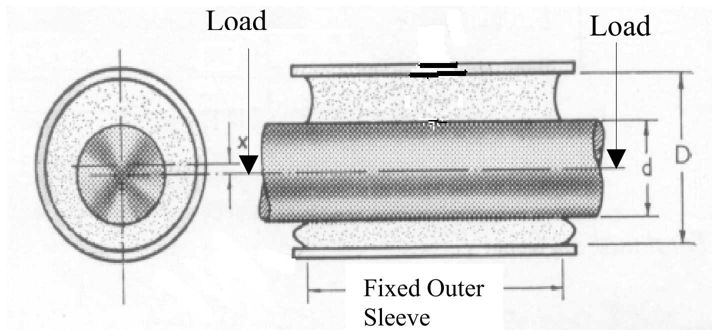

Figure 3

5.3 Determination of Component Dynamic Stiffness Characteristics

5.3.1 **Test Pieces**

The shape and dimensions of the test pieces shall be the 2 types shown in Figure 4.

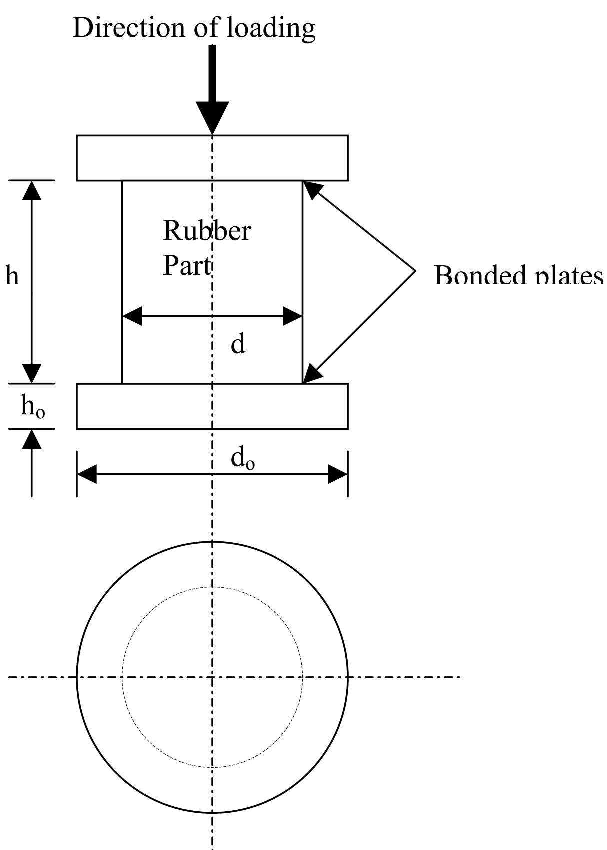

Figure 4

Classification of test piece	**Rubber Part**		**Bonded Plate**	
	Diameter ‘d’	Thickness ‘h’	Diameter ‘d_o’	Thickness ‘h_o’
N1 Type	25.0 ± 0.25	25.0 ± 0.25	30	5
N2 Type	50.0 ± 0.5	50.0 ± 0.5	55	6

The test piece shall in general be tested at 16 hours or over and within 28 days after vulcanization.

5.3.2 **Test set up**

The test component should be mounted on the platen in such a manner that no relative movement can occur between the platen and the adjacent portion of the fixture. The geometry and loading procedure for each fixture should be clearly specified. The test equipment for the dynamic test to include servo hydraulic/mechanical test rig of required load and displacement with accuracy of ± 1%.

5.3.3 **Test frequency**

The test frequencies shall be selected from the frequencies viz. 0.1,0.3,1.0,3.0,10,30,100,300 Hz.

Mean strain shall be selected from the following Table:

Classification of deformation	**Mean Strain (%)**					
Compression or tension	0	5	10	15	20	--

5.3.4 **Strain Amplitude**

Strain amplitude can be selected from the following Table.

Classification of deformation	**Strain Amplitude (%)**					
Compression or tension	0.1	0.3	1.0	2.5	5	--

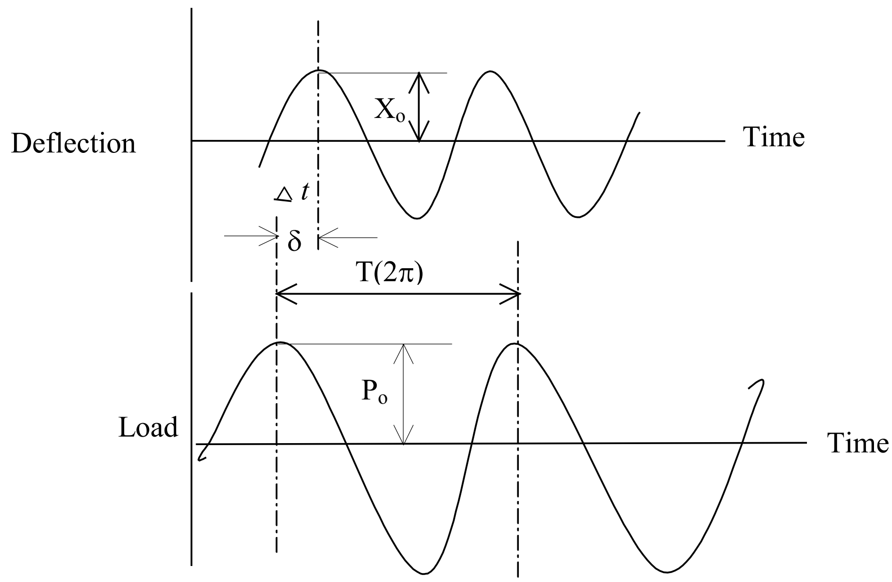

Figure 5

Record the curve of load and deflection and measure load amplitude P_o and deflection amplitude X_o as well as phase angle between load and deflection according to Figure 5. Determine the phase angle from one period T and phase difference (time) Delta t. From these measurements calculate the spring constant and loss factor by following formulae.

Complex Spring Rate(k*) Ik*I = P_o/X_o

Loss angle δ = 2π (Delta t/T) rad = 360 (Delta t/T) degrees

Storage spring constant/storage stiffness (k_1) = Ik*I cosδ

Loss spring constant/loss stiffness (k_2) = Ik*I sinδ

Loss factor (tan δ) or loss tangent(l) = k2/k1 = tanδ

5.4 Determination of Bond Strength

5.4.1 **Test Apparatus**

The means of load application shall generally be power driven and the machine shall be equipped with a moving platen capable of speed 25,50 and 100 mm/minute (to be selected by agreement between purchaser and supplier according to size of component under test). The machine shall be equipped with a device to indicate the maximum applied force.

5.4.2 **Determination of Bond Strength by Ultimate Strength Test Method**

This method does not give a direct measurement of true stress to rupture the rubber to metal bond. This method however give convenient techniques for assessing the relative strengths of the bonds for a given type of components in relation to minimum recommended ultimate strength criteria.

The test component should be mounted in the test machine taking care to ensure that the tension force is correctly distributed over the cross section under the test. The component should be deformed at the selected rate of separation until failure occurs. The maximum tensile force normal to bonded surface shall be recorded and the separated component to be examined. The test results shall be expressed in MPa calculated by dividing the maximum force by the projected of the smaller bonded interface. In case of rupture of rubber it must be recognised that the adhesion value is higher than that reported.

5.5 Determination of Component Environmental Resistance Properties

To determine extent of changes to rubber bushing components by exposing to environmental resistance properties like heat and cold, service fluids, and salt spray corrosion. The test condition like time, temperature, type of media etc. can be decided as mutually agreed between the supplier and user.

Total time of test could be 72 hours. Exposure to heat could be 70 ^{0}C ± 2 ^{0}C. Component should be examined at intermediate periods. Component could be immersed in mineral oil depending upon the application.

A failure criterion for acceptability is after the exposure to the environment testing that is necessary to examine the component for the changes in the stiffness properties which may affect service performance. These changes may be due to change in the rubber and/or the bond, metal, part etc. The percentage variation in stiffness before and after environment test should be within 20%. The extent of cracking of free surface of rubber shall be assessed by the naked eye.

ANNEX - I

GENERAL REQUIREMENTS FOR DURABILITY EVALUATION BY FATIGUE TESTING METHOD

The bushing shall be placed in rigid test fixture and allow load cycles as per service conditions or mutually agreed between supplier and vehicle manufacturer. Test equipment shall be capable of ±1.0 % control load or displacement. Direction of loading will be either single axis or multi axis depending upon the service conditions. Test frequency to be 1.5 to 2.0 Hz or select frequency and amplitude such that temperature rise within body of component shall not exceed 70 °C. The test may be carried out at constant force amplitude or at constant deformation amplitude or variable load and deformation (i.e. block cycling). The test frequency and the test duration depends on dynamic loading conditions. Record permanent set after 24 hours of the test.

Test condition component	**Loading conditions**	**Test duration standard**
Bushing for suspension arms etc. e.g. Rear axle fitment bush, wishbone bush, Front/Rear shock absorber buffer, Assembly top cup, Rubber bumper, power train mounts	The fatigue test to be carried out with simultaneous loading in radial and torsional direction on the component. Radial load to be given in sinusoidal cycle of 0.5 to 1.5 times static service load. Torsional load to be given in ± specified degrees or from 0 degree to specified degree as agreed upon.	10^6 cycles

To test minimum 10 samples to arrive at B_{10} life to confirm the product variation and quality. The general acceptance criteria is the component stiffness and permanent set taken after 24 hours should not change more than 20% of original value. It shall not show any evidence of failure within rubber bush. Permanent set taken after 24 hours should not exceed a level equivalent to 20% of the maximum rubber thickness.

ANNEX : II

(See Introduction)

COMMITTEE COMPOSITION *

Automotive Industry Standards Committee

Chairman	
Shri B. Bhanot	Director The Automotive Research Association of India, Pune
Members	**Representing**
Shri Alok Rawat	Ministry of Shipping, Road Transport & Highways, New Delhi
Shri Sushil Kumar	Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises, New Delhi
Shri. Chandan Saha	Office of the Development Commissioner Small Scale Industries, Ministry of Small Scale Industries, New Delhi
Shri K. K. Goel Shri K. K. Vashistha (Alternate)	Bureau of Indian Standards, New Delhi
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Shri G. P. Banerji	Automotive Components Manufacturers Association

Member Secretary
Mrs. Rashmi Urdhwareshe
Deputy Director
The Automotive Research Association of India, Pune

* At the time of approval of this Automotive Industry Standard (AIS)