AUTOMOTIVE INDUSTRY STANDARDS

Procedure for Performance Evaluation on Rubber to Metal Bonded 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 Standard 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 performance evaluation on rubber to metal bonded 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 has been taken from the following International Standards.

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

2. SAE-J1636 Feb. 93 — Recommended Guidelines for Load / Deformation Testing of Elastomeric Components

3. SAE-J1183 Feb. 98 — Recommended Guidelines for Fatigue Testing of Elastomeric Materials and Components

4. SAE-J1085 May 99 — Testing Dynamic Properties of Elastomeric Isolators

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

Procedure for Performance Evaluation on Rubber to Metal Bonded Components

1. SCOPE

This Automotive Industry Standard specifies the procedure for performance requirements of rubber to metal bonded components such as engine mounts, cab mounts, bump stoppers, etc. which are designed for vibration isolation of automobiles.

2. PURPOSE

To establish and maintain the quality of the end product to meet the service requirement by evaluating the properties/parameters of the rubber components.

3. DEFINITIONS

3.1 **Elastomer** - Macromolecular material that returns rapidly to approximately the initial dimensions and shape after substantial deformation by a week stress and release of stress.

3.2 **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.

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

3.4 **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.

3.5 **Static Stiffness** - It is a ratio of change in load from an imposed load to change in displacement from an imposed displacement for the selected segment on a hysteresis loop.

3.6 **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.

3.7 **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.

3.8 **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.

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

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

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

3.12 **Loss factor (tan δ) or loss tangent (l)** – The tangent of the phase angle between the applied force and the resultant displacement.

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

3.14 **Preload** – An external static load producing a strain in the test specimen. Preload is imposed prior to forced vibration testing.

3.15 **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.

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

4.0 GENERAL REQUIREMENTS

4.1 Performance Tests

The performance test covers conditioning of the components at the specified temperature and testing depending upon the 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/loss factor, bond strength, 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 type of environmental similar to service conditions.

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

5.0 PERFORMANCE TESTS

5.1 General conditioning procedure

Before any types of test is carried out on rubber to metal bonded 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 properties

Test set up – The test component should be mounted / oriented to vehicle mounting condition 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 static test may include servo hydraulic/mechanical test rig of required load and displacement capabilities.

The test component shall then be subjected to three conditioning deformations which is deformed at a rate of 12 ± 2 mm/min. The conditioning deformation shall be carried out using applied loads or deformations which are 5% greater than those to be used during the test.

The maximum test load shall be at least 1.5 times the static service load on the component.

The test component shall then be deflected at a rate of 12 ± 2 mm/min unless otherwise agreed, until the specified maximum load or deflection is reached. Record the Load v/s Deflection characteristics.

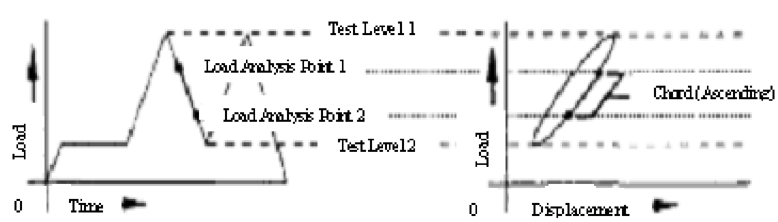

Figure 1

Stiffness Analysis Method Without Averaging Method

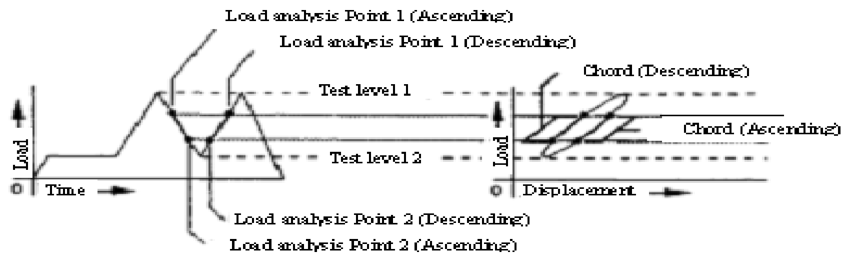

Figure 2

Stiffness Analysis Method with Averaging Method

Static stiffness can be measured during the ascending or descending portion of the test or averaged between the two. Refer Figure 1 and 2. Calculate the static stiffness.

The general acceptance criteria is that measured stiffness should be within ± 15 % of the specified stiffness declared by the O.E.M. or as agreed upon between manufacturer and O.E.M.

5.3 **Determination of component dynamic stiffness characteristics:**

5.3.1 **Determination of Dynamic stiffness**

Pre load the component at specified load. Test to be conducted with constant deflection amplitude mode depending upon the application. For dynamic stiffness apply 100 to 300 Hz. Excitation frequency with a displacement of 50-200 microns. Record the curve of load and deflection and measure the load amplitude P_o and deflection amplitude X_o. From these measurements calculate the dynamic stiffness, which is a ratio of P_o and X_o.

The general acceptance criteria is dynamic stiffness should be maximum 1.4 times the static stiffness declared by vehicle manufacturer or as agreed upon.

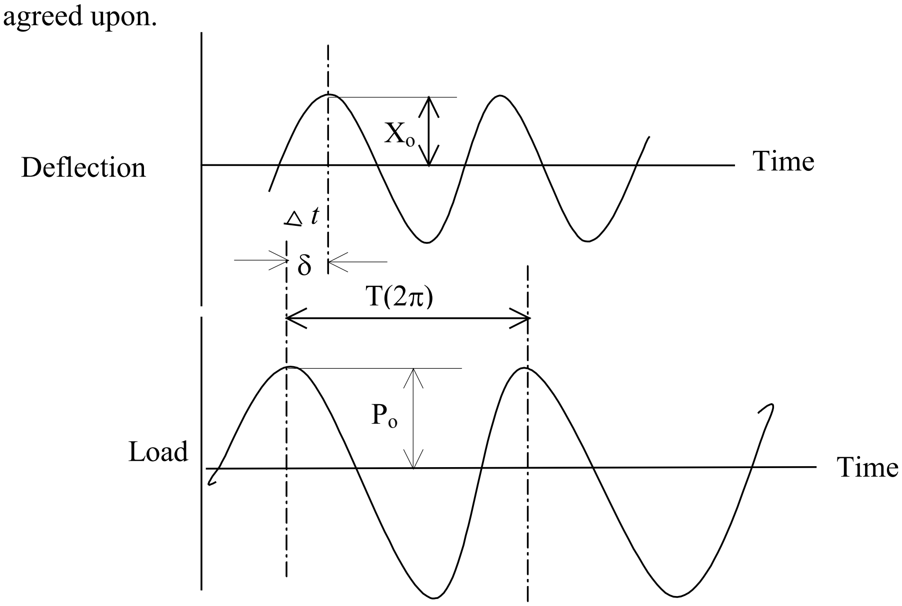

Figure 3

5.3.2 **Determination of loss factor**

Pre load the component. Apply 15-30 Hz excitation frequency with a displacement of 1-2 mm amplitude for determination of loss angle or loss factor. Record the curve of load and deflection and measure the load amplitude P_o and deflection amplitude X_o as well as phase angle δ between load and deflection. 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 $\delta = 2\pi$ (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

The general acceptance criteria is Loss factor at the engine idling speed to be a minimum 0.06.

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

5.3.3.1 **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.

5.3.3.2 **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.

5.4 **Determination of component environmental resistance properties:**

To determine extent of changes to material and rubber to metal bond 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°C ± 2°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 component shall be placed in rigid test fixture and allow the dynamic load cycles as given in Table depending upon the test specification mutually agreed between the 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 (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 condition**	**Test duration standard**
Engine mounts, Cab mounts, Bump stoppers	-0.5 to +1.5 x static service load	10^6 cycles

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 either at bonded surface or within rubber. Permanent set taken after 24 hours should not exceed a level equivalent to 20% of the maximum rubber thickness.

ANNEX : II
(See Introduction)
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Mrs. Rashmi Urdhwareshe
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* At the time of approval of this Automotive Industry Standard (AIS)