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THE SPECIFICATION AND DEVELOPMENT OF A STANDARD TESTING PROCEDURE FOR PERFORMANCE EVALUATION OF ELASTOMERIC ISOLATORS FOR MACHINERY APPLICATIONS

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INTRODUCTION

Testing procedures for evaluating the performance of vibration isolators had not been generally standardized, where international test standards or procedures are yet to be formulated [1]. The urgent need of international standards on the determination of the low frequency dynamic properties of vibration isolators, in order to serve the solution of pure vibration problems has been recently highlighted [2]. Although there are no existing standard test procedure for performance evaluation of elastomeric isolators, there however exist some test standards and recommended practices for the evaluation of the dynamic properties of elastomers i.e. BS 903: A24 [3], ISO 4664 [4], ASTM D2231-71 [5] and SAE J.1085a [6].

A critical review of these standards and their relevance to the evaluation of elastomeric isolators' vibration isolation performance is undertaken. The specification for the performance testing of elastomeric vibration isolators used under compression loading is proposed with the purpose to provide some insights into the development of a standard testing procedure to evaluate the isolation performance of elastomeric vibration isolators used in machinery applications.

REVIEW OF EXISTING STANDARDS

The test specifications of ISO 4664 [4], BS 903:Part A24 [3], SAE J.1085a [6] and ASTM D2231-71 [5] are tabulated in Table 1. All test standards specified input excitation of sinusoidal waveform consistent with the vibration produced by industrial machinery which is of complex waveform made up of individual sinusoidal waveform of different frequencies.

The mode of deformation of the test sample specified in ISO 4664 [4] and BS 903:Part A24 [3] is in shear. SAE 1085a [6] specified the mode of deformation in shear and compression, whilst the ASTM D2231-71 [5] specified the mode of deformation in shear, tension and compression. As the elastomeric isolators of interest in this study were for use under compression loading, only the latter two test methods were further examined. SAE J.1085a [6] specified a cylindrical test specimen of 25.4 mm in height for compression loading, whilst ASTM D2231-71 [5] specified a cylindrical test specimen with a cross sectional area of 12.5 cm^2. It is however almost impossible to relate the dynamic stiffness of the test specimens to the dynamic stiffness of the isolators which are usually of complex shape, due to the difficulty in determining the shape factors of these isolators.

SAE J.1085a [6] specified that the compression preload should correspond to that existing in the intended application, whilst ASTM D2231-71 [5] specified a preload of 0, 5, 10, 15 and 20 %. For machinery vibration isolation applications, elastomeric vibration isolators are however less effective if used under preload less than 10 % due to the higher natural frequency of the isolation system obtained which might be in the vicinity of common industrial machinery speed. This in turn would result in less reduction in the transmitted vibration.

SAE J.1085a [6] further specified a dynamic amplitude excitation of 0.5 mm peak-peak, whilst ASTM D2231-71 [5] specified that the dynamic amplitude should have either one of the following values; 0.1, 0.3, 1.0, 2.5 or 5 % of the height of the test specimen in the direction of loading. These values however do not represent the range of vibration amplitudes of industrial machinery. Furthermore the values specified by the latter test method depends on the height of the isolators. Typical machinery vibration levels can be obtained from Mitchell [7] which gives a range of vibration displacement from 0.025 μm peak-peak to 0.25 mm peak-peak, as measured on the casing.

The frequency of the excitation specified in SAE J.1085a [6] is 15 Hz, whilst ASTM D2231-71 [5] specified that either one of the following frequency should be used; 0.1, 1, 10, 60, 100 or 200 Hz. The normal operating speeds of industrial machinery is usually 1500/1800 rpm (25/30 Hz) or 3000/3600 rpm (50/60 Hz), or multiple of such speed when used with a speed reduction (or increase) devices.

Several of the test specifications in existing test standards were therefore found to be irrelevant to the conditions under which elastomeric vibration isolators are used for machinery vibration isolation applications.

PROPOSED TESTING SPECIFICATIONS

The testing procedure proposed here requires the dynamic properties of the elastomeric isolator as a component be measured instead of measuring its material properties of the elastomer test sample [8]. The proposed specification for the performance testing of elastomeric vibration isolators used under compression loading is given in Table 2, where the excitation dynamic amplitude is of sinusoidal waveform.

The upper limit of compression preload specified was 20 %, although the recommended design limit has been given as 15 % [9]. This was necessary as to take into account further deformation due to creep. Although ideally the dynamic amplitude required to cover the range of vibration amplitudes as common to industrial machinery is between 0.025 μm peak-peak to 0.25 mm peak-peak, due to the servo hydraulic nature of the test machine used in this study, such a small amplitude could however not be obtained. The smallest amplitude that could be obtained with confidence in measured data was 0.05 mm peak-peak. Furthermore machinery generating such a low amplitude of vibration does not warrant the use of vibration isolators. The range of frequency of the test was between 1 to 100 Hz where the isolators were tested at increments of frequencies in order to enable the transmissibility curve to be plotted.

The transmissibility curves of a 60 durometer Super 'W' pad for different loading conditions is shown in Fig. 1. The values of transmissibility for other loading conditions within this range can be easily interpolated from these curves with a certain degree of confidence. Fig. 2 compares the transmissibility of different types of elastomeric isolators of 50 durometer hardness and subjected to similar loading condition. The performance of different types of isolators can thus be compared from these curves.

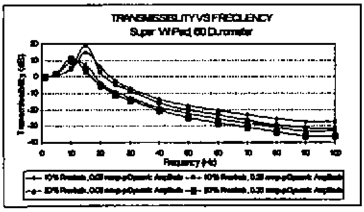

Fig. 1: Transmissibility of a 60 durometer Super 'W' pad for different loading conditions

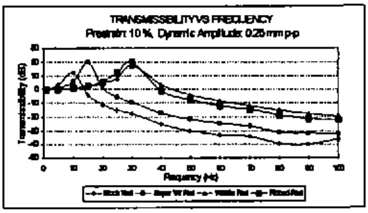

Fig. 2: Transmissibility of some 50 durometer elastomeric vibration isolators.

SUMMARY

The test specifications of some existing standards for the evaluation of the dynamic properties of elastomers have been critically examined and found to be irrelevant to the actual conditions under which elastomeric vibration isolators are commonly used for machinery vibration isolation applications. A testing specification for evaluating the dynamic properties of elastomeric vibration isolators was proposed. The performance of these isolators can be evaluated from the computed transmissibility using the values of measured dynamic properties. This testing procedure enables the evaluation and comparison of the performance of different types of elastomeric vibration isolators to be made under more realistic conditions.

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Table 1: Test specifications of some existing standards.

Specifications	Test Standard and Recommended Practice			
	ISO 4664	BS 903: A24	SAE J1085a	ASTM D2231-71
Waveform	Sinusoidal	Sinusoidal	Sinusoidal	Sinusoidal
Mode of deformation	Shear	Shear	Shear and compression	Shear, compression and tension
Test specimen	Double shear test piece t = 4 mm	Double shear test piece t < 12 mm	Double shear test piece : Rectangular A = 20cm^2, Compression cylindrical t = 25.4 mm	Double shear test piece : Rectangular A = 20cm^2, Compression cylindrical A = 12.5 cm^2
Preload	-	-	(Corresponds to existing in the intended application)	0, 1, 5, 10 and 15 %
Dynamic amplitude	0.06 ± 0.006 mm	2 & 10 %, 2.5, 1.00, 0.25, 0.10, 0.06 % (Dynamic amplitudes correspond to the frequencies given below)	0.5 mm peak-peak	0.1, 0.3, 1, 2.5 and 5 %
Frequency	10 ± 0.5 Hz	15, 30, 50, 100, 150 and 200 Hz	15 Hz	0.1, 1, 10, 60, 100 and 200 Hz

Table 2: Proposed test specifications for elastomeric vibration isolators.

Prestrain	Dynamic amplitude	Frequency range
10 %	0.05 mm peak-peak 0.25 mm peak-peak	1 Hz - 100 Hz
20 %	0.05 mm peak-peak 0.25 mm peak-peak	1 Hz - 100 Hz