LIA24815

LEAD INDUSTRIES ASSOCIATION, INC.

292 MADISON AVENUE

NEW YORK 17, N. Y.

March 30, 1962

SUBJECT: LEAD ASBESTOS ANTIVIBRATION PADS

To Members of the Lead Industries Association, Inc:

Attached is a preliminary report on the evaluation of lead asbestos antivibration pads resulting from research conducted through the Expanded Research Program of L.I.A.

As explained in the introduction, the data in this report are in no sense to be considered final and definitive, since further research is underway to verify the data and to clear up some of the apparent anomalies, as well as to support the data with field tests on actual installations.

We have therefore printed only a limited number of this preliminary report, which we are sending to all members to be used with discretion should they have inquiries on this subject.

We also plan to use it carefully in dealing with engineers who are contemplating the use of these pads, pending the final report, which we hope will be available around the end of this year.

Very truly yours,

Executive Vice President

RLZ:mk
Enc.

Look Ahead with Lead

LEAD INDUSTRIES ASSOCIATION, Inc.
292 Madison Avenue
New York 17, N. Y.

Preliminary Report

EVALUATION OF LEAD-ASBESTOS ANTI-VIBRATION PADS

This preliminary report, issued March 15, 1962, covers the initial research by the Expanded Research Program of Lead Industries Association, Inc., and will be followed by supplementary data in the near future.

EVALUATION OF LEAD-ASBESTOS ANTI-VIBRATION PADS

Preliminary Report

INTRODUCTION

Lead, alone and in combination with asbestos, has been used to reduce the transmission of vibration in structures since before World War I. Lead and asbestos pads one inch thick underlie the foundations of the Waldorf-Astoria Hotel in New York, for example. Similar pads have been used to support heavy machinery such as cooling towers and printing presses. Lead has been used as the bedding surface of anti-vibration pipe hangers. Because of accumulated experience with this use of lead, many of its antivibration properties are well known: its extreme durability, practical methods of manufacture for pads, best methods of installation, etc.

Recent studies of lead-asbestos pads were undertaken because of two current engineering trends. First, the need for maximum utilization of material in today's competitive engineering picture and, second, the desire of users and manufacturers of such pads to achieve standardization.

Despite intensive study, partly covered by this preliminary report, the maximum limits of operation for lead-asbestos pads are not well known. In terms of static loading, for example, typical practice of the 1920's called for 200 to 300 psi while the accepted norm for the same pads today is 600 to 800 psi or higher. Short-time static tests have not revealed any failure of the pad for loads up to 15,000 psi.

Regarding standardization, it is hoped that continuing studies will make it possible to appraise a vibration problem by simple, routine calculation methods and specify a standard mounting -- perhaps by "catalog number"-- which will meet the requirements.

In response to more extensive use of the pads and the growing demand for engineering data about them, the Lead Industries Association, Inc., has prepared this preliminary report. It is drawn largely from a laboratory project undertaken through the Expanded Research Program of the LIA and carried out by Lessells and Associates of Boston.

This project has raised new questions about pad behavior which require additional work. A second generation of research is now in progress to attempt to check the effectiveness of the pads at various loadings and conditions and to answer these new questions. In addition, the Association's Expanded Research Program hopes to complete field studies of the pads in building foundations and machinery mounts so that performance of the pads in practice will be known and the effects of foundation, soil structure, and other variables may be apparent.

A problem common to early studies of vibration in structures has been the accurate determination of the frequency-intensity profile of the vibration encountered. Reliable measuring equipment is bulky and complex. Some otherwise meticulous studies have employed simpler instruments and are thus based on intensity measurements of doubtful worth.

In the project reported here, an effort was made to get high reliability in the data. The difficulties in arriving at a suitable experimental set-up, and the further difficulty of accurately measuring the small values of the variables may have led to appreciable error in some of the findings. Inspection of the data would lead to the conclusion that the results reported for the higher static loadings (400 and 800 psi) are probably better than those for the lower loadings.

Furthermore, the tests reported here intentionally simulated the simplest possible arrangement of the pad, structure, and vibration path. Any practical application of the pads would probably involve a number of complicating factors.

For these reasons the LIA does not represent the data contained in this report to be performance data for the pads. It is, rather, the best available indicative data on the general behaviour of lead-asbestos pads. While Lead Industries Association, Inc., cannot, at this time, make firm recommendations for use of the pads, it will be pleased to work with engineers and architects interested in using the pads and will, as always, be glad to make available its experience and best judgment in the solution of specific problems.

DESCRIPTION OF THE PADS, THE TESTS, AND THE RESULTS

The pads tested in this project were lead-asbestos anti-vibration pads of typical construction measuring 10 x 10". The nominal one-inch thickness of the pad is made up of a top layer of 1/8" lead, an upper layer of 3/8" asbestos roll fire felt, a middle layer of 12-guage galvanized steel, a lower layer of 3/8" asbestos as above, and a bottom layer of 1/8" lead. The pads were subjected to 200 psi before completely sealing the edges by lead burning. Actual thickness of the pads before test was 1 3/32".

Static Test

A short-time static loading test applied 15,000 psi to the pad without any evidence of failure. The "set" taken by the pad at 2,000 psi (short-time) was 3/16" -- final thickness being 29/32". From the static loading data (page 5) it can be seen that a typical modulus of elasticity for the pad at 800 psi static is 8,900 psi. (This modulus is computed from the first upload data using the nominal pad thickness of one inch.)

Dynamic Tests

Performance of the pads was measured by bolting them between billets to apply the prescribed static load and applying a single frequency vibratory force of up to 4,000 pounds. The full frequency range (5 to 100 cps) was used by making one run at each of a number of frequencies. Two pads were employed in each measurement. Agreement between pads was good at high static loadings and rather poor at low static loadings.

Generalized behavior data is presented in the four sets of curves on pages 6 to 9. The key values on which these plots are based are presented in Table I.

TABLE I

MODULI AND NATURAL FREQUENCIES OF LEAD-ASBESTOS ANTI-VIBRATION PADS

for Nominal 1" Pads

P_s Static Load psi	K Calculated Stiffness lb./μ in.	fn Calculated Natural Frequency cps	E Calculated Dynamic Modulus
100	0.023	48	22,760
200	0.097	69	97,000
400	0.122	56	122,400
800	0.196	50	196,300

Notes:

K value is per square inch of pad area.

Approximate values of natural frequency of stacks of pads may be obtained by dividing f_n, as given, by the square root of the number of pads in the stack.

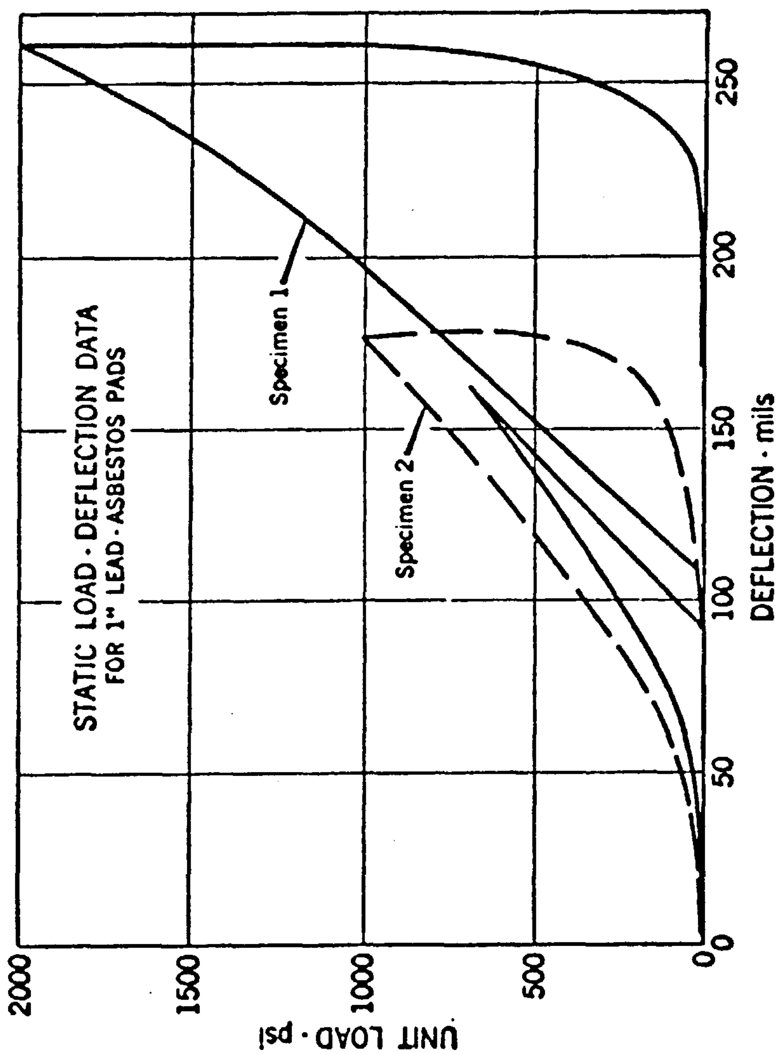
STATIC LOAD - DEFLECTION DATA
FOR 1" LEAD - ASBESTOS PADS
Specimen 1
Specimen 2
DEFLECTION - mils
UNIT LOAD - psi
0
50
100
150
200
250
0
500
1000
1500
2000

Figure 1

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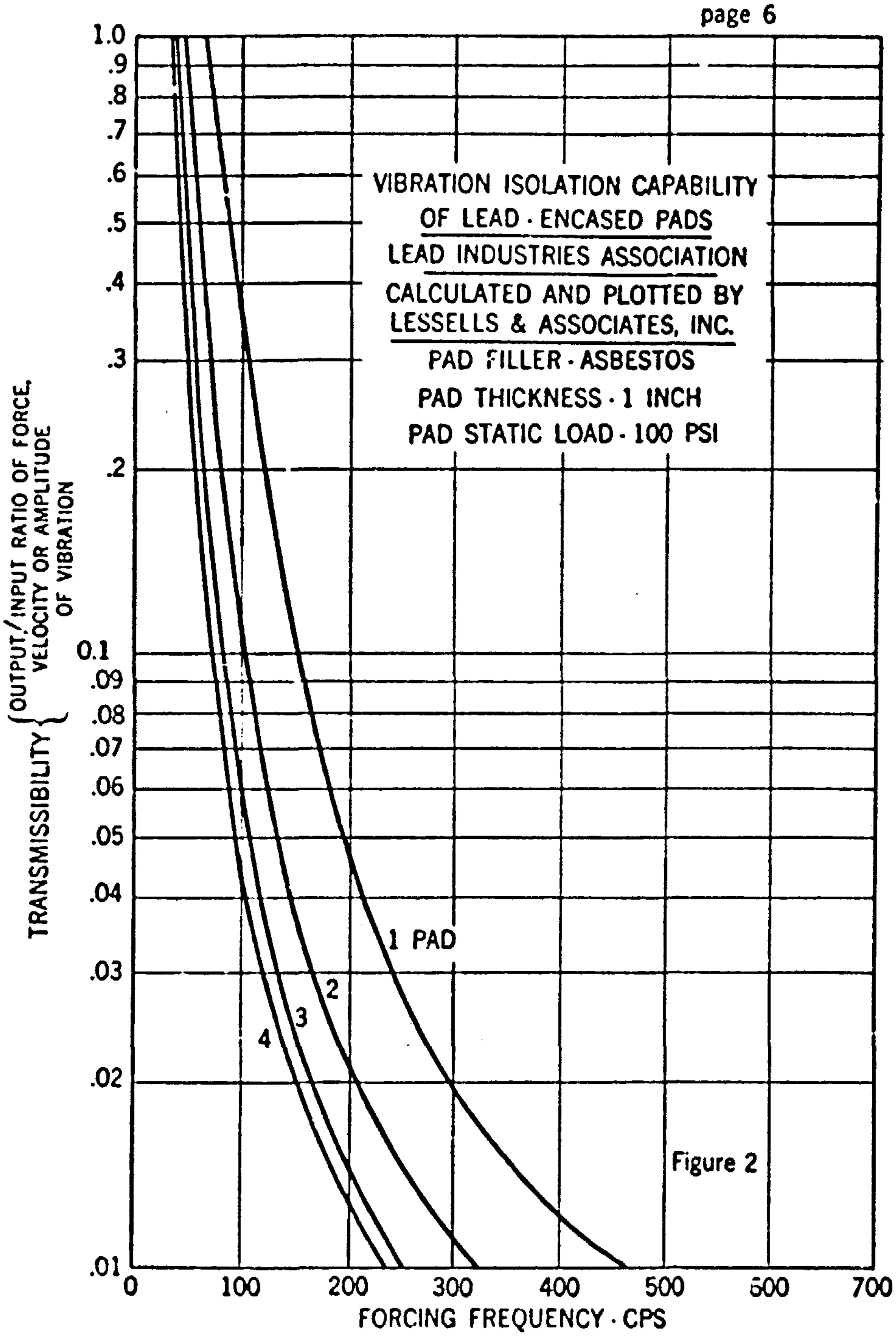
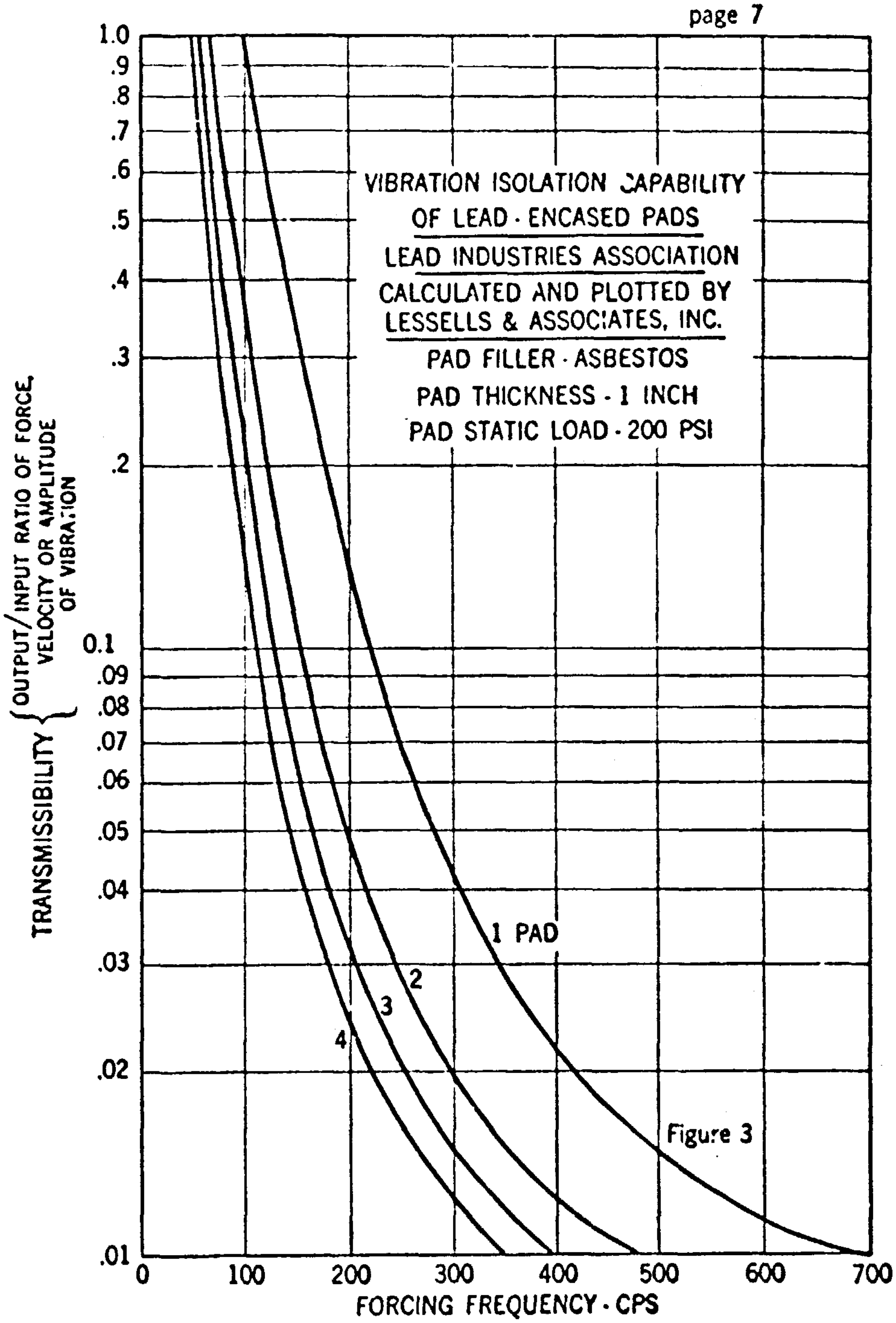
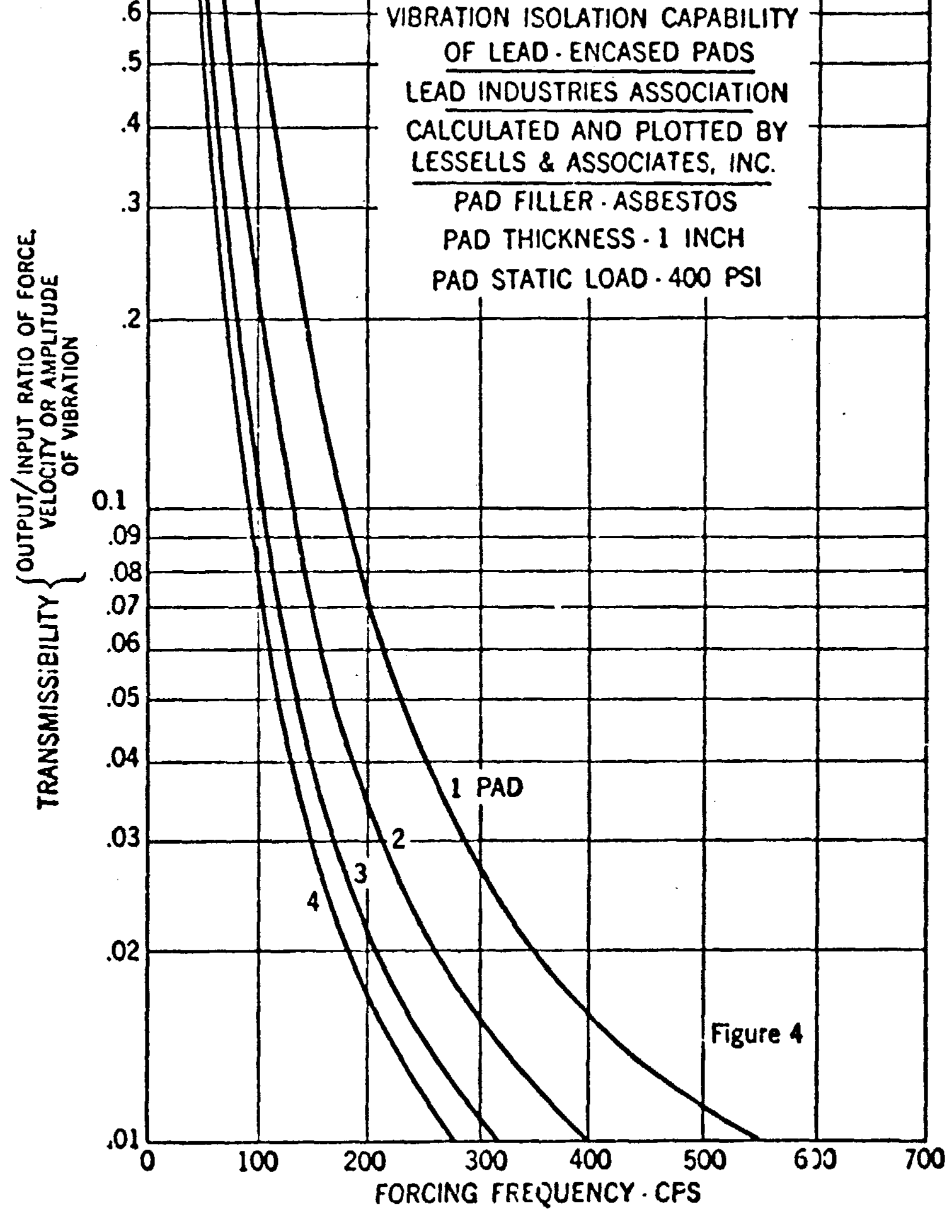


Figure 2



VIBRATION ISOLATION CAPABILITY
OF LEAD - ENCASED PADS
LEAD INDUSTRIES ASSOCIATION
CALCULATED AND PLOTTED BY
LESSELLS & ASSOCIATES, INC.
PAD FILLER - ASBESTOS
PAD THICKNESS - 1 INCH
PAD STATIC LOAD - 200 PSI
1 PAD
2
3
4
1.0
.9
.8
.7
.6
.5
.4
.3
.2
0.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
100
200
300
400
500
600
700
TRANSMISSIBILITY {OUTPUT/INPUT RATIO OF FORCE, VELOCITY OR AMPLITUDE OF VIBRATION}
FORCING FREQUENCY - CPS

Figure 3



VIBRATION ISOLATION CAPABILITY
OF LEAD-ENCASED PADS
LEAD INDUSTRIES ASSOCIATION
CALCULATED AND PLOTTED BY
LESSELLS & ASSOCIATES, INC.
PAD FILLER-ASBESTOS
PAD THICKNESS-1 INCH
PAD STATIC LOAD-400 PSI
TRANSMISSIBILITY {OUTPUT/INPUT RATIO OF FORCE, VELOCITY OR AMPLITUDE OF VIBRATION
.6
.5
.4
.3
.2
0.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
1 PAD
2
3
4
0
100
200
300
400
500
600
700
FORCING FREQUENCY-CFS

Figure 4

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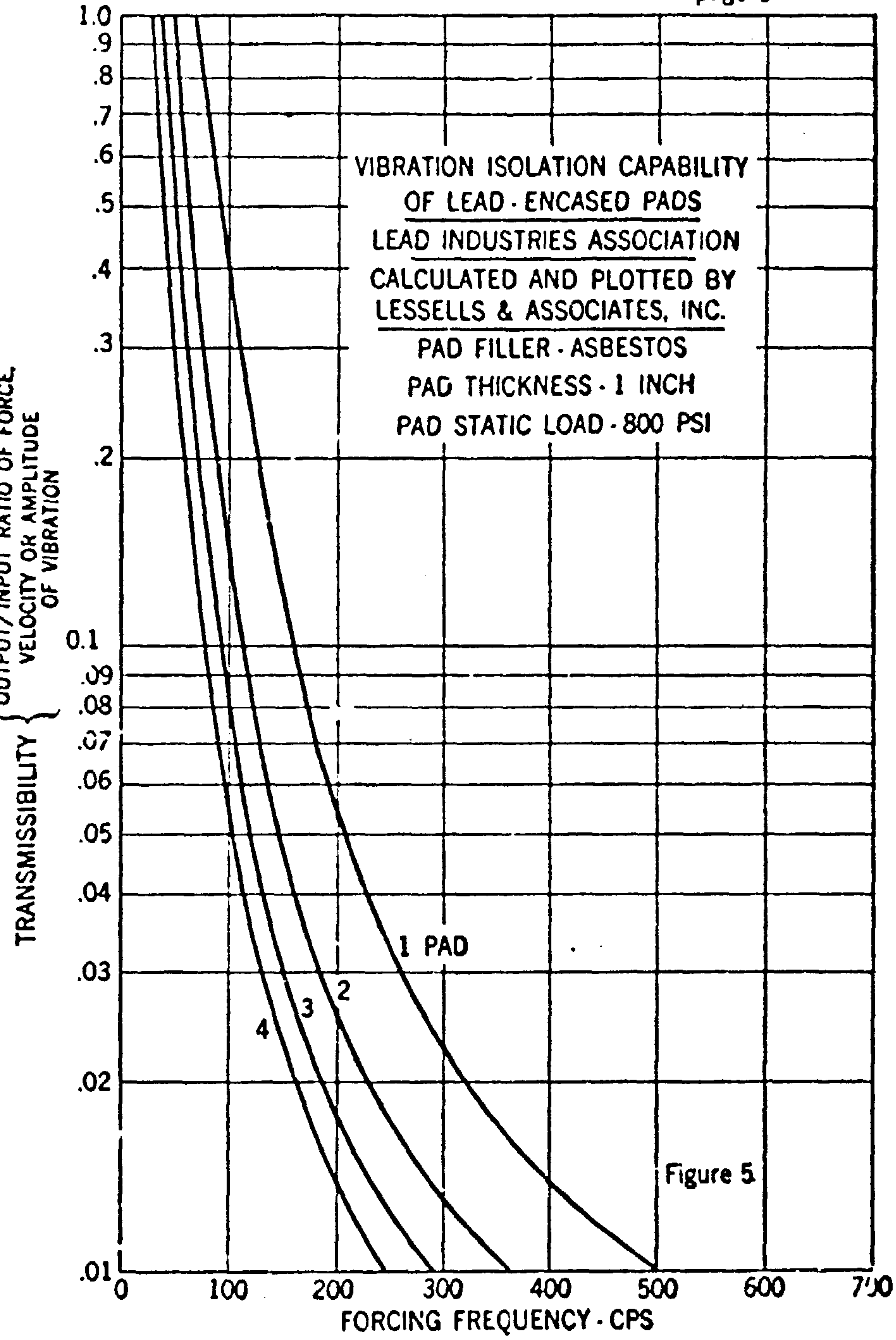


Figure 5

FREQUENCY CONSIDERATIONS

Most vibration occuring in building structures is unpredictable and complex. It is almost impossible to say beforehand what frequencies and intensities will be encountered. The profile of intensity vs. frequency for vibration caused by a railroad train has been found, in one case, to be:

Frequency Band, cps	20-75	75-150	150-300	300-600	600-1200
Intensity, db (arbitrary reference)	3	16	18	14	5

Note that the most intense vibration is in the 75 to 600 cycles per second frequency range. For standard lead-asbestos pads 1" thick loaded to 800 psi tests indicated about 85 percent isolation.

It would appear to be a simpler case when the annoying vibration is caused by a large fan, for example, of known shaft speed. It has been suggested that such a shaft speed can be divided by 60 (seconds per minute) to arrive at the fundamental vibration frequency. Tests of such equipment have invariably shown this to be false. A better approximation is to divide by 60 and multiply by the number of blades in the fan (or vanes in the pump, independent compression strokes of the compressor x 2, etc.) This will provide an indication of the lowest frequency of disturbance for the source. Integral multiples of this (x 2, x 3, etc.) will also be important. In addition, there will always be high frequency noise. So long as there is no important low-frequency resonance in the supporting structure, lead asbestos pads have tested 75 to 95 percent effective in isolating such vibration.

TYPICAL USES OF THESE DATA

Example 1 -- Building Isolation

Lead encased pads have been used for many years for isolation of buildings from objectionable vibration as might be present near railroad or subway rights-of-way or heavy traffic. For this example, assume that the vibration is in the range from 150 to 300 cps, and that the pads are loaded to a static stress of 800 psi. If two lead asbestos pads, each 1" thick are stacked, the expected transmissibility may be obtained from figure 5 (page 9). This plot shows that the percentage of vibration that will be transmitted under these conditions will range from 4.5 percent to 1.3 percent over the frequency range.

Example 2 -- Machine Isolation

These pads can be equally effective for isolating vibrating machinery from surroundings. Consider the case of large fan type blowers. One of the objectionable frequencies in this case would be associated with the number of blades in the fan and the shaft speed. Assume 12 blades and a speed of 1,200 rpm.

$$f = \frac{1200}{60} \times 12 = 240 \text{ cps*}$$

For a lead-asbestos pad loaded to 200 psi the transmissibility will be 8 percent. (See figure 3, page 17) The transmissibility for higher harmonics of this frequency will be lower than this value and can be determined in the same manner.

Example 3 -- Broad Spectrum Isolation

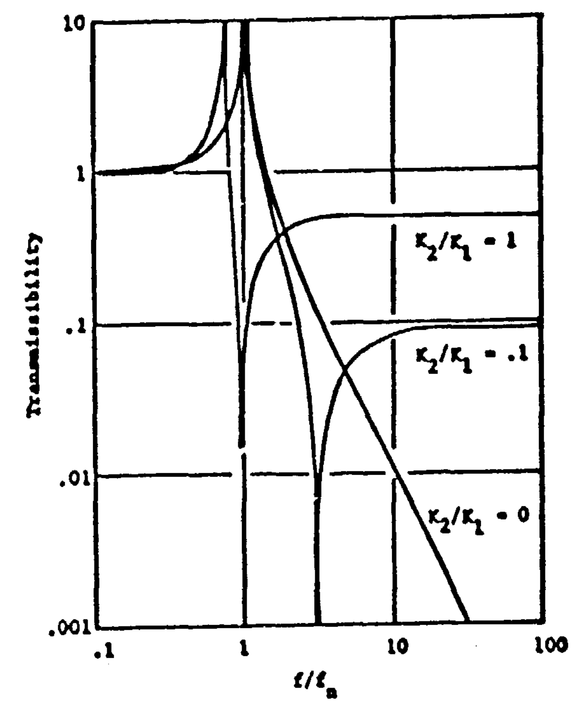
There will be applications where the impressed vibrations cover a wide range of frequencies with the lower values being below the range of application for these pads. For these lower frequencies, coil spring isolators must be used. These spring isolators will, however, transmit higher frequencies as longitudinal waves along the wound helix. If in these cases, the springs are mounted on lead asbestos pads, a broad band isolator will result.

APPENDIX

The LIA again points out that the data contained in this report should not be used for design. This appendix has been added to explain the most common source of discrepancy between the indicated behavior of lead-asbestos anti-vibration pads and the actual behavior in some cases.

In many applications of vibration isolators, the structure which supports the system is not rigid. An example of such a system is an air conditioning compressor located in a building on a floor which is above grade. If, for such systems, the floor stiffness is regarded as a massless spring, the chart in Figure 6 describes the response. This curve shows that for such systems both the frequency ratio (ratio of disturbing frequency to the natural frequency of the pad) and the ratio of stiffness of the isolator pad (K_2) to the foundation or floor stiffness (K_1) are important. For a given foundation stiffness, therefore, a low value of K_2, or pad stiffness, is desirable.

* Any unbalance of the shaft will, of course, cause vibration at 1200/60 or 20 cps. In practice, machinery in reasonably good operating condition does not show any objectionable tendency to vibrate at this low frequency.



TRANSMISSIBILITY VERSUS FREQUENCY RATIO FOR SEVERAL VALUES OF THE RATIO OF MOUNT STIFFNESS TO FOUNDATION STIFFNESS

Figure 6