TECHNICAL BULLETIN M/L- 650

HOW TO MEASURE THE ISOLATION EFFECTIVENESS OF PRESS ISOLATORS

This bulletin describes the proper procedure for measuring and evaluating the effectiveness of press isolators in reducing floor and foundation vibration resulting from the operation of a stamping press.

In order to accurately evaluate the effectiveness of press isolators, accurate vibration measurements must be made along with meaningful comparisons of the results. Trained personnel must correctly use suitable instrumentation. Comparisons of vibration levels should only be made for comparable test cases where the variables have been controlled, as described in this bulletin.

The measurements will *not* be accurate and invalid conclusions will be drawn if proper instrumentation, procedure(s) and machine setup is not followed.

A typical set-up for measuring floor vibration is shown in Figure 1.

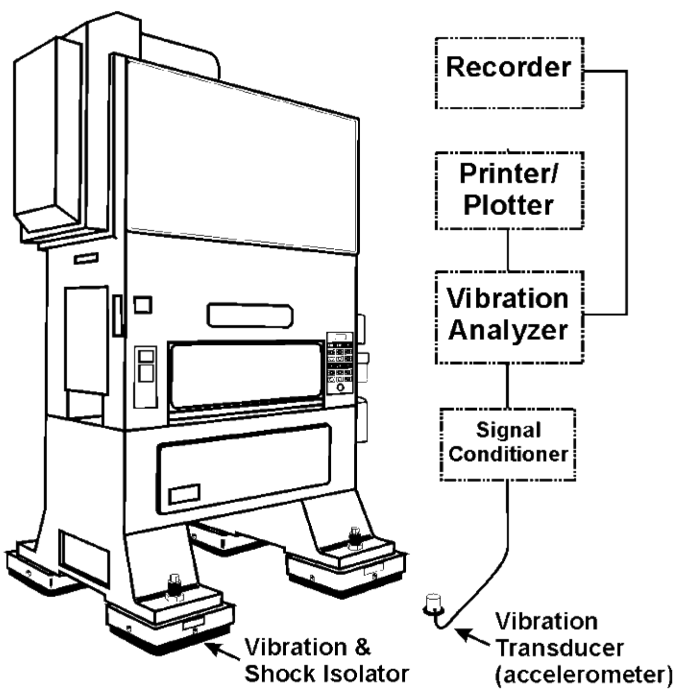


Figure 1

The comparative effectiveness of two different installation methods can be measured by first recording the vibration response on the floor or foundation near the press feet when the press is hard-mounted. (See Figure 2). The press is then reinstalled on the isolators and the vibration measurements are repeated. Placing the accelerometer directly on the foundation near the press foot is best for measuring the full spectrum of the transmitted vibration.

<u>VALID MEASUREMENT: HARD-MOUNTED VERSUS ISOLATED</u>

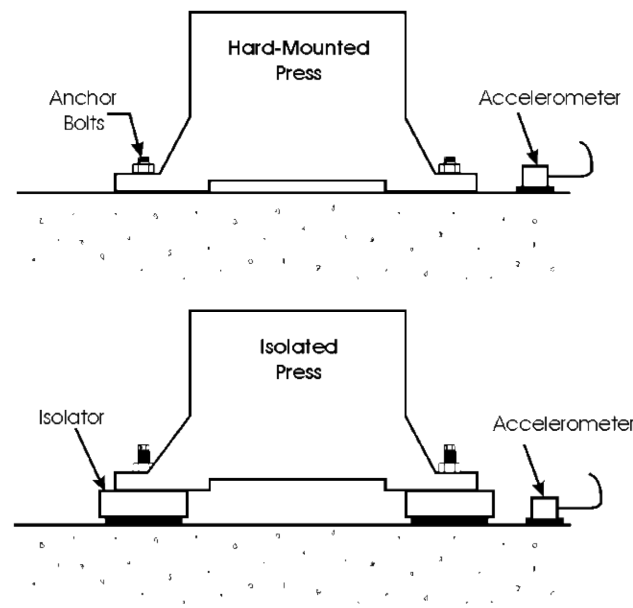


Figure 2

By comparing the vibration responses, the results can be reported as an additional percent reduction of floor vibration for one method versus the other.

It is not valid, however, to measure the effectiveness of the installation method by comparing the vibration response of the press structure (e.g. press leg or foot) to the response of the concrete floor/foundation. (See Figure 3). This is true because the press structure has different structural dynamic characteristics than the floor/foundation. Each has its own unique set of natural frequencies, mode shapes and damping characteristics.

Therefore, each exhibits its own unique impulse vibration response due to the equal and opposite impact force that occurs between the press feet and the floor/foundation and they are not directly comparable.

INVALID MEASUREMENT: NOT A PROPER COMPARISON

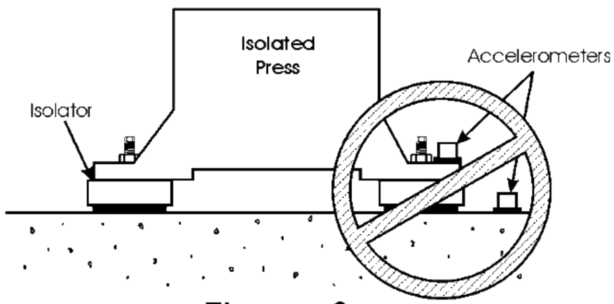


Figure 3

PRESS AND FOUNDATION DYNAMICS

Mechanical presses convert rotary energy stored in the flywheel to linear motion that performs work. This aspect of press dynamics is easily understood. When presses perform blanking operations, the linear energy is temporarily stored in the press structure until the material fractures. Most presses are constructed with four tie rods holding the crown to the bed. As load is applied to the material by the tooling, the tie rods are stretched. When the material fractures, the tooling punch goes through the material and the stretched tie rods are suddenly released from the stretched condition. This sudden release is referred to as a shock. The press structure snaps back together and the tie rods are then compressed. This compression is referred to as reversal loading. The press structure oscillates from this stretched to compressed condition until the energy stored during the cycle is dissipated as high frequency, internal vibration within the press structure.

The interface between the press and the foundation is referred to as the mounting method. The internal vibration of the press is partially coupled to the foundation through the mounting method. When the press structure oscillates after snap-through, the foundation experiences the high frequency vibrations as an impact force. This impact force occurs each time the dies close and the press makes a part.

The function of isolators is to prevent the transmission of the press vibration (impact force) from damaging the surrounding environment and plant personnel. The primary mode of press vibration is the stretching and contracting of the press tie rods and press structure. Most cast and tie rod construction presses vibrate at the primary mode frequency of 50 to 120 Hz. See Chart 1 for actual measurements taken on a spring mounted stamping press.

The function of the isolator is to isolate the very damaging shock of the primary press mode (50 to 120 Hz). A properly built and maintained press should not generate significant vibrations at lower frequencies from the dynamic components such as the flywheel, motor, and feeding system. Because the foundation will vibrate at its natural frequency due to the vibrations transmitted, any vibration measurement on the foundation should contain a strong component between 12 to 40 Hz. See Chart 2 for actual vibration measurements taken on a 400-ton press.

The maximum acceleration and velocity measured on the foundation near the machine feet should be significantly reduced when installed on the isolators compared with the hard-mounted condition. The isolators should significantly reduce the primary mode of the press vibrations and force, occurring at 50-120 Hz.

SELECTING INSTRUMENTATION

There are many different types of instruments for measuring vibration. For the purpose of evaluating the effectiveness of isolators, not all types of vibration instrumentation are capable of measuring the vibration of a plant floor and the surrounding areas.

It is important to understand the dynamic characteristic of the entire measurement system (i.e. from the mounted transducer resonant frequency to the signal processing capability of the amplifier and read out instrument). This measurement system must be capable of capturing and recording impulsive (or transient type) signals accurately and without amplitude and phase distortion over a broad frequency range.

2443 Braga Drive · Broadview, Illinois 60155-3941 USA · 708-345-2050 · Toll Free 1-800-842-7668 · Fax: 708-345-2225
www.vibrodynamics.com · vibro@vibrodynamics.com

Listed in the following sections are the equipment capabilities recommended by Vibro/Dynamics Corporation.

TRANSDUCER

The vibration transducer should be an accelerometer, which produces an electrical signal that is proportional to the vibration acceleration of the measurement surface.

A good accelerometer for this purpose would be a seismic type, quartz compression, ICP® accelerometer.

Typical specifications include:

- 1 V/g sensitivity,
- 2.5g maximum, mounted resonant frequency of 3,500 Hz, and
- 100g overload limit. It may have a frequency response as follows:
  +/- 5% for .025 - 800 Hz
  +/- 10% for .01 - 1,200 Hz

A general purpose accelerometer with .10 v/g sensitivity may also be used. Typical specifications are 40,000 Hz resonant frequency and frequency response up to 10,000 Hz.

Seismic accelerometers produce a more accurate measurement for levels below 1g. General purpose accelerometers are better for extremely high g levels like those in close proximity to a hard-mounted press doing severe blanking operations.

ICP accelerometers require a power supply. Some ICP supplies include a gain x 10 option, which is desirable if making measurements far away from the source.

Velocity and displacement transducers do *not* have adequate frequency or dynamic range, and therefore *should not* be used for this type of test. Floor vibrations caused by the operation of machinery are extremely complex and are made up of a large number of frequencies. If the machines that cause the floor to vibrate are impact type machines such as stamping presses, the most severe vibration that occurs in the floor, when the press is hard mounted, occurs in the higher frequency ranges (80 to 1,000 Hz).

A primary function of press isolators is to reduce the magnitude of harmful transmitted impact forces between the press feet and floor, which result in floor or foundation responses that consist of high frequency vibrations.

Therefore, the only way to evaluate the effectiveness of the isolators is to use acceleration sensitive transducers, and to display the comparative data in units of acceleration. Do not integrate the signals for velocity or double integrate for displacement since this in effect reduces the weighting of the high frequencies.

AMPLIFIERS AND SIGNAL CONDITIONERS

The instruments used to amplify the signal must process the vibration signal without distortion.

Typical specifications:

- Bandwidth from DC up to 10000 Hz.
- +/- 5% for .15 - 10,000 Hz with noise output of 0.2 mV (peak-peak) or less.

DATA ACQUISITION, DISPLAY AND RECORDING EQUIPMENT

The vibration data must be analyzed for amplitude and frequency content. Although some analysis can be done with a simple oscilloscope, this is not practical. A computer-based data acquisition and recording system is desirable.

Data Acquisition System requirements:

- Analog to digital conversion of the input signal to at least 12 bits resolution.
- Bipolar voltage input with programmable gain for accepting signals ranging from a few millivolts up to +/- 3 Volts.
- Bandwidth and error margins equal or better than the accelerometer.
- Ability to store acquired signals in nonvolatile memory, typically on the hard drive of a computer.
- Display waveform of vibration acceleration amplitude versus time (like an oscilloscope) and have the ability to measure amplitudes with cursors.
- Spectrum Analyzer function. Compute and display FFT spectrum in the time domain (vibration acceleration magnitude versus frequency). It should have greater than 400

lines of spectral resolution and the capability to measure the FFT frequencies and amplitudes with data cursors.
- Capability to print charts to paper (printer/plotter) or to an electronic file (i.e. PDF file).

Recorder (Optional)
- A recorder may be employed to gather the raw sensor data.
- The recorder typically stores data digitally using 8mm DAT media or other similar media format.
- The recorder input section must conform to the same specification above for amplifiers and data acquisition.
- The recorder must be capable of reproducing the original signal with less than 1% error.

CALIBRATION

All instrumentation in the measurement system should be properly calibrated. The input sensitivity should be selected so that data is displayed in easy-to-read values of acceleration units. The data of acceleration magnitude versus frequency can be displayed on either a linear or logarithmic scale. The same scale must be used for both sets of measurements (i.e. the press hard mounted and then mounted on isolators).

When recording vibration acceleration using a logarithmic scale (i.e. in dB units), the equivalent values of vibration acceleration must be reported.

MEASUREMENTS

The measurement of vibration should be in units of peak acceleration, with the data plotted in the time domain (i.e. peak amplitude versus time) and acquired using a sufficiently fast digital sampling rate to obtain accurate peak values. (Note: The sampling rate is not sufficient if, by selecting a faster rate for a subsequent measurement of essentially the same signal, the result is a significantly greater peak value.) An averaged result of several actual peak values (i.e. maximum and/or minimum) should be reported along with a determination of the duration of a typical impulse response (transient) signal.

The data should also be plotted in the frequency domain (i.e. peak magnitude versus frequency) to determine the frequency content of an average of several signals. The (PSD) Power Spectral Density (g^2/Hz) measurements can be used if needed, since they allow for a relative comparison of energy at particular frequencies without dependence on frequency resolution. This could be important if measurement comparisons are made among data collected using different sampling rates, which yield different frequency resolutions. Also note that magnitudes are squared for PSD's. However, peak spectral magnitude (g) can be compared at any frequency as long as the comparative spectra have identical frequency resolutions.

In the case of a stamping press, you must capture the impulse response of the floor directly resulting from and immediately following the closing of the dies. Each transient signal to be averaged should be captured by the FFT analyzer such that it fills the sampled time period as much as possible without being cut off, and that the maximum possible sampling rate is used. The internal trigger level must be set such that the position of each successive signal within the time record is consistent.

Some additional examples of actual measurements made using a Spectrum Analyzer are shown in Charts 3 and 4 at the end of this paper.

REPORT

In addition to the usual subjects covered, such as purpose, test procedures and results, a vibration test report should also include a description of the test equipment used with the manufacturer, model numbers and the corresponding frequency response of each component.

Also included should be details of transducer mounting methods and locations and orientation, filtering or weighting functions used, calibration procedures, digital signal processing techniques used such as sampling rate, frequency resolution and number of averages, etc.

2443 Braga Drive · Broadview, Illinois 60155-3941 USA · 708-345-2050 · Toll Free 1-800-842-7668 · Fax: 708-345-2225
www.vibrodynamics.com · vibro@vibrodynamics.com

ADDITIONAL CONDITIONS REQUIRED FOR OBTAINING VALID DATA

In order to obtain valid data, the conditions under which the measurements are made must be controlled. Some of the conditions necessary to produce valid data are as follows:

1) The same conditions must exist with the press on isolators as with the press hard mounted. (Ideally, the *same* press should be used.)
2) In both tests, the press must be running identical parts from identical material and using the same or identical dies and shut-height, so that the resulting stamping force is identical. Record press frame loading if load monitors are available and calibrated.
3) Both presses must be operating with the same stroke length and the same speed.
4) Both presses must be constructed identically. (Ideally, the same press.)
5) No rigid connections should exist between the test press and the surrounding building (i.e. piping, conduit, part bin, conveyors, walkways, etc.). Otherwise, for the press mounted on isolators, vibration could be transmitted to the building structure via the path of the rigid connection hence the isolators would be "short-circuited."
6) The floors/foundations and supporting soil conditions (i.e. type, compaction and water content) under both presses must be identical.
7) The measurements should be conducted as close in time as possible to avoid changes in such things as soil water content, building construction, plant layout and other conditions, which could affect readings.
8) Identical instrumentation must be used for all comparative measurements. (See section: "Selecting Instrumentation").
9) Ambient vibration must be measured without the test press operating. In general, the level of ambient vibration should be no more than 10% of (or 20dB less than) the vibration level measured while the test press is operating.
10) All machinery and other equipment causing excessive ambient vibration must be turned off during the measurements.
11) The accelerometer must be securely attached to the vibrating surface. Do not hand hold the accelerometer or attach it by means of double-stick tape, as this affects its high-frequency response. It is preferred to stud mount the transducer to the vibrating surface, and tighten it to the manufacturers recommended torque value. For concrete surfaces this can be accomplished by first cementing (cyanoacrylate ester or epoxy) a small metal disk, having a tapped hole for a stud, to the concrete surface to be measured. Then, using the proper mounting stud with a thread depth-limiting collar, the accelerometer can be mounted to the disk and tightened with the proper torque. It is important that the threads of the mounting stud do not bottom in either the mounting surface or the accelerometer base.

    A magnetic base can be used for steel measurement surfaces as long as good solid contact is made without rocking. The magnet must also be strong enough to ensure that the resulting mounted natural frequency is great enough for the frequency range of interest.

    Refer to the literature available from the accelerometer manufacturer about this important subject.
12) The accelerometer should be located in the same position on the measurement surface for both before and after isolator are installed.
13) In addition to the above conditions, the isolator must be selected and specified for the test press in accordance with the isolator manufacturer's guidelines. Also, the isolators must be properly installed and adjusted according to the manufacturer's instructions.

Original JF 1973;
Revised HR/SV/WF 6/2006
Revised HR/SV 9/2006

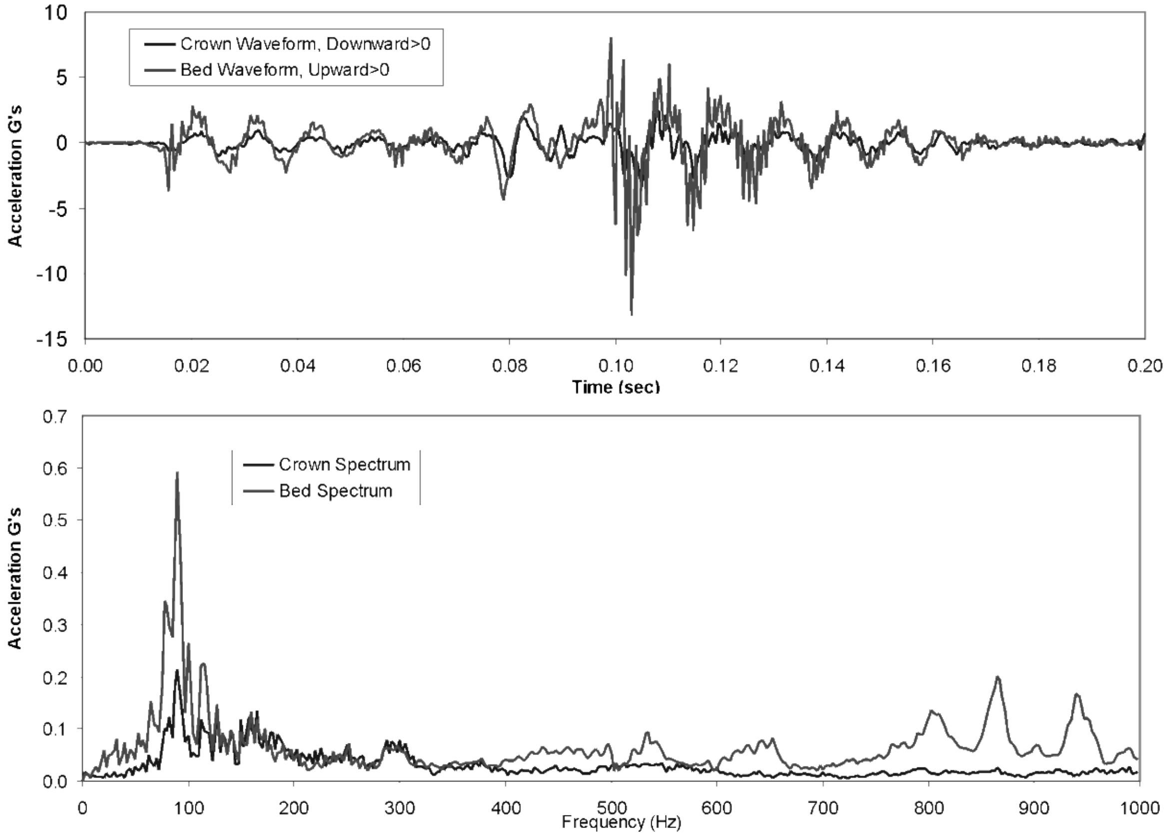


CHART 1

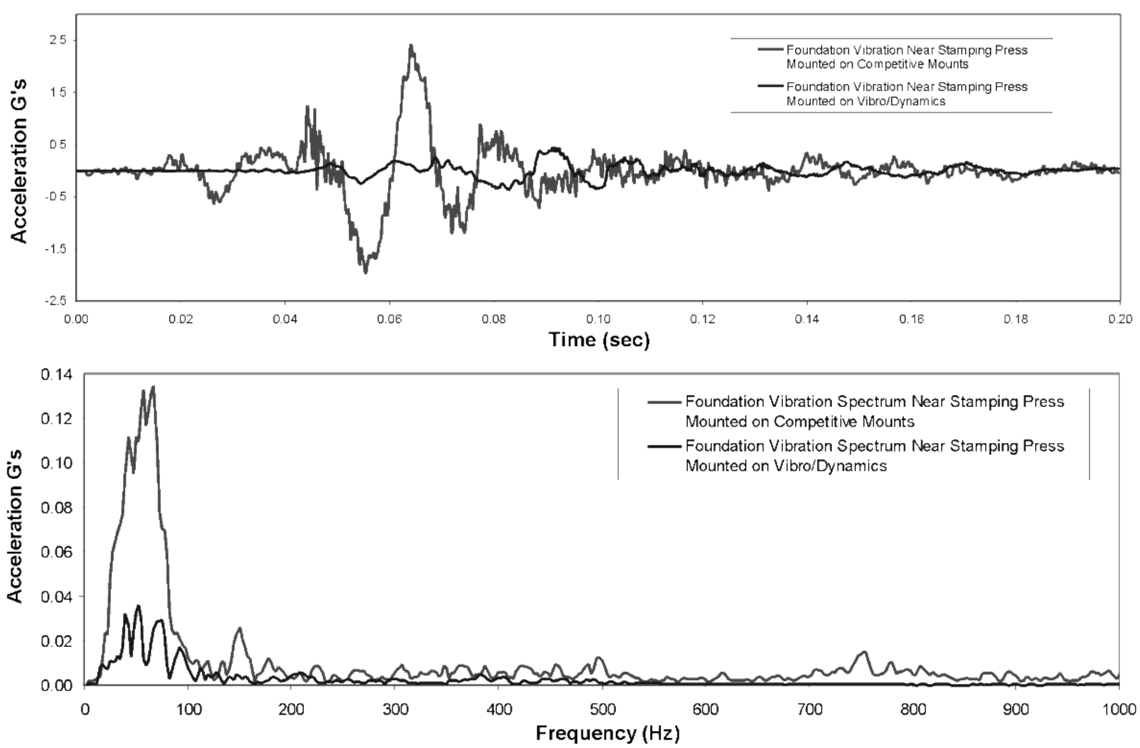


CHART 2

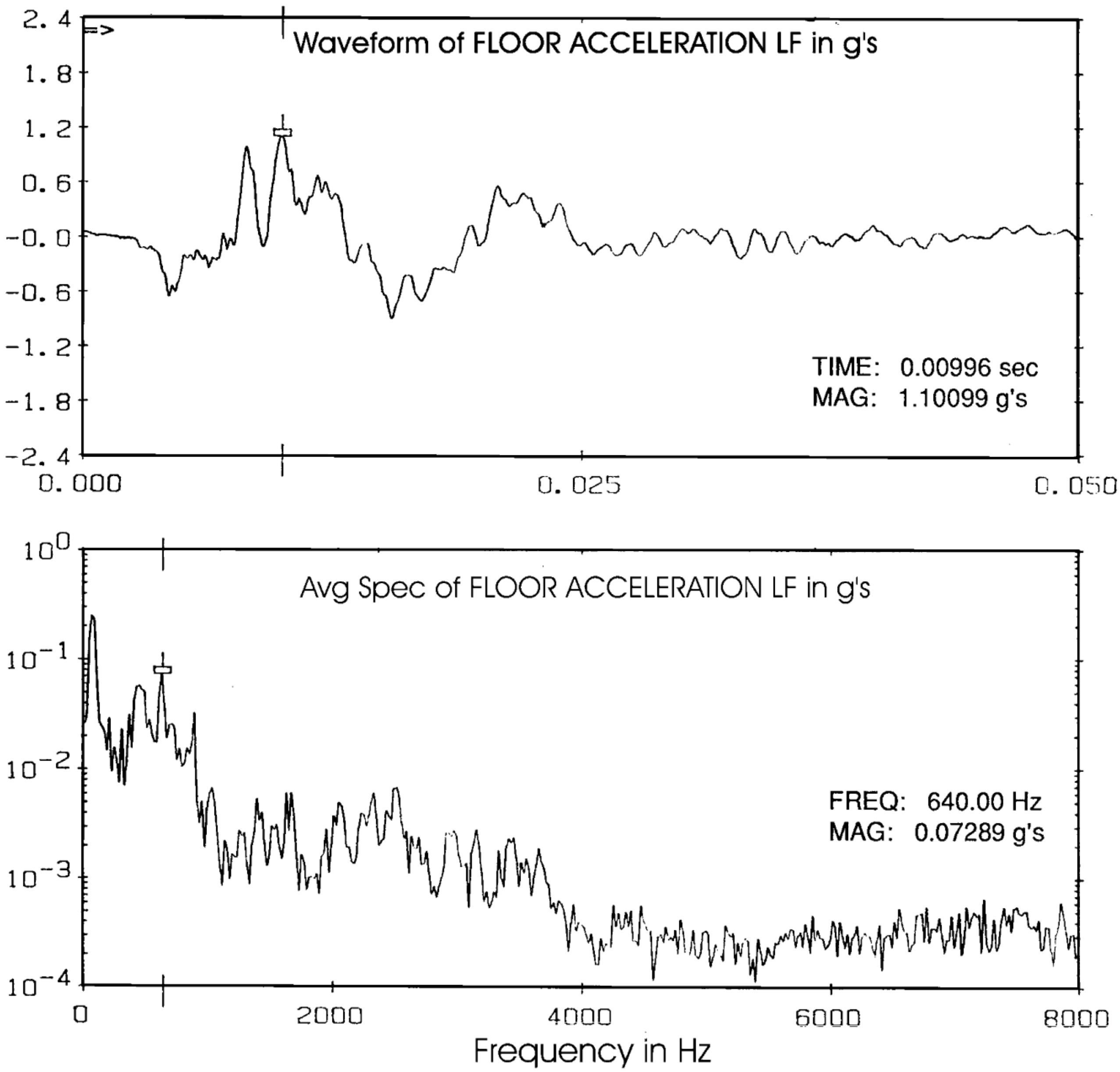
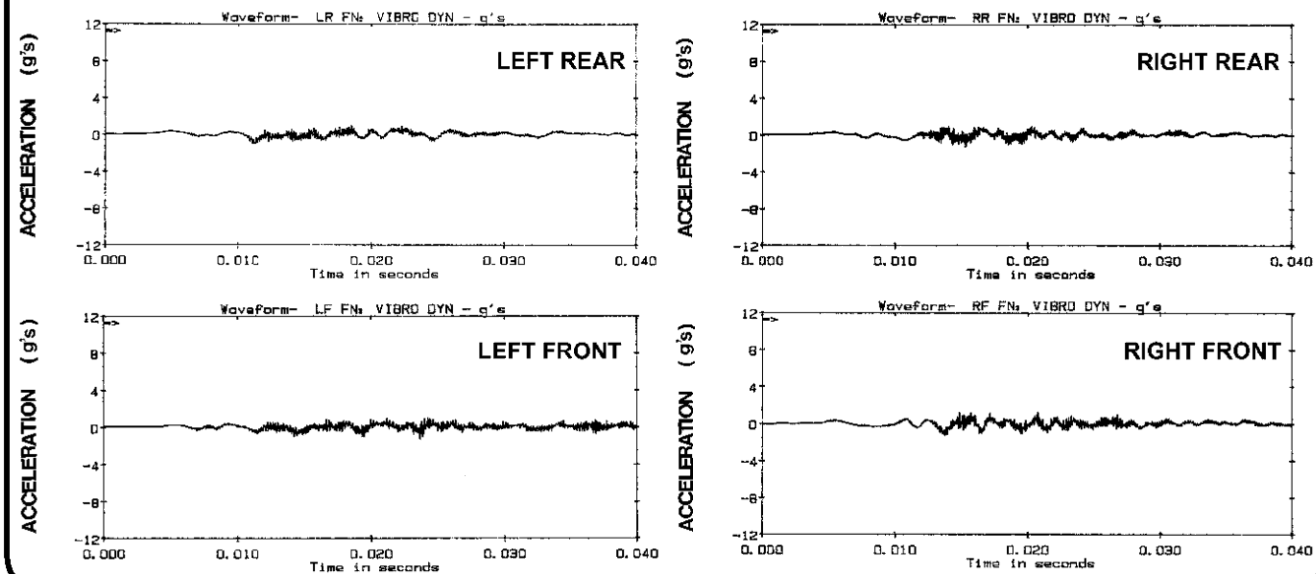

Waveform of FLOOR ACCELERATION LF in g's
TIME: 0.00996 sec
MAG: 1.10099 g's
2.4
1.8
1.2
0.6
-0.0
-0.6
-1.2
-1.8
-2.4
0.000
0.025
0.050
Avg Spec of FLOOR ACCELERATION LF in g's
FREQ: 640.00 Hz
MAG: 0.07289 g's
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
2000
4000
6000
8000
Frequency in Hz

CHART 3

VIBRATION COMPARISON ON THE FOUNDATION NEAR A NIAGARA BP2-300-60-36 PRESS.

VIBRO/DYNAMICS LCM1230/44 2.5E10



1" THICK FELT PAD

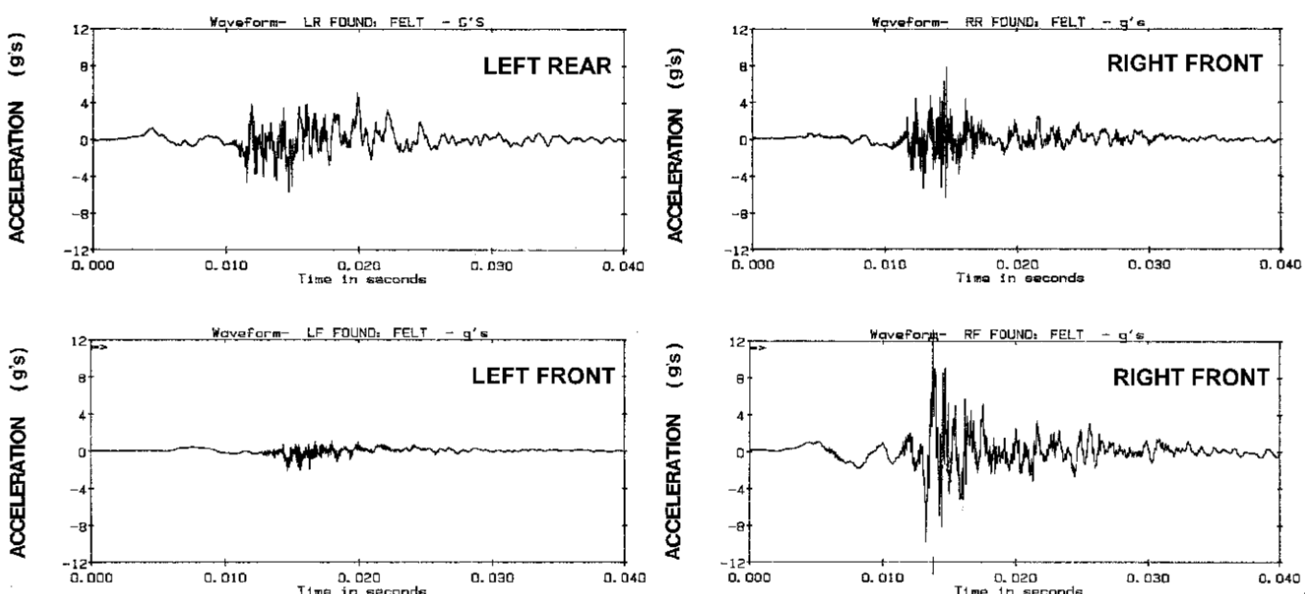


CHART 4

2443 Braga Drive · Broadview, Illinois 60155-3941 USA · 708-345-2050 · Toll Free 1-800-842-7668 · Fax: 708-345-2225
www.vibrodynamics.com · vibro@vibrodynamics.com