

# A NOVEL 3-D HAND-ARM VIBRATION TEST SYSTEM AND ITS PRELIMINARY EVALUATIONS

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## Introduction

Vibration exposure at workplaces is generally multi-axial. The health effects of vibration exposure also likely depend on the vibration direction. Therefore, there is a wide interest in the simulation of multi-axial vibration in laboratory experiments. Advances in technology have led to the development of a new 3-D test system for studying hand-transmitted vibration exposure and health effects. The purposes of this paper are to introduce the system and to present the results of its preliminary evaluations.

## Test System

As shown in Figure 1, the system is basically composed of three vibration generators, a multi-axis vibration control system, instrumented handle, handle fixture, and shaker-fixture linkages (stingers).

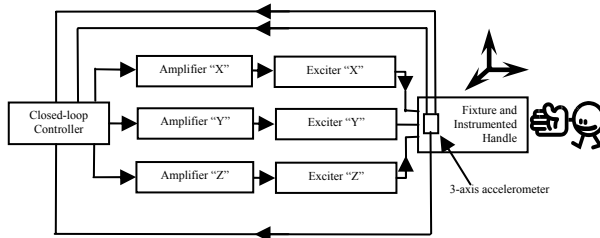


Figure 1: System block diagram

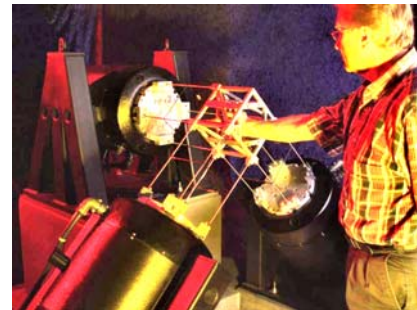


Figure 2: Configuration of the 3-D system

Figure 2 shows the array of three vibration generators (MB Dynamics, Energizer BLACK-500 lbs) and their associated support bases and foundation developed by MB Dynamics (Cleveland, USA), which create the 3-axis simultaneous motion. These electrodynamic exciters are powered by power amplifiers which provide current proportional to the analog drive signal from a controller. The controller (JAGUAR Multi-Input/Multi-Output closed-loop vibration controller) was provided by Spectral Dynamics, San Jose, California, USA). NIOSH-designed instrumented handle was equipped on the system.

## System Evaluation Methods

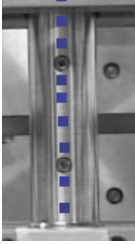


Figure 3:  
Vibration  
Distribution  
measurement

Several preliminary experiments have been performed to examine the characteristics of the system and its performance. A laser vibrometer (Polytec PI, H-300) was used to examine the distribution of sinusoidal acceleration on the handle vibrating at 2g in three directions, as shown in Figure 3a. The system was used to simulate 3-D sinusoidal vibration, a broadband random vibration from 7.5 Hz to 500 Hz, and a cutting saw vibration spectrum.

## Evaluation Results

Figure 4 shows the distribution of the vibration on the handle. The maximum difference of the distribution along the handle longitudinal direction in the frequency range (<500 Hz) of concern was less than 9%.

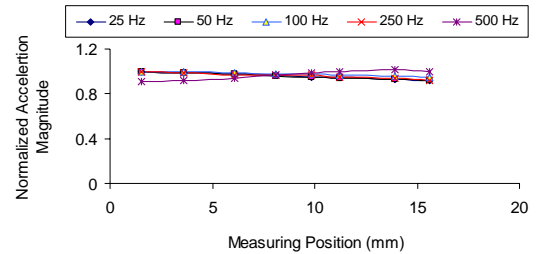
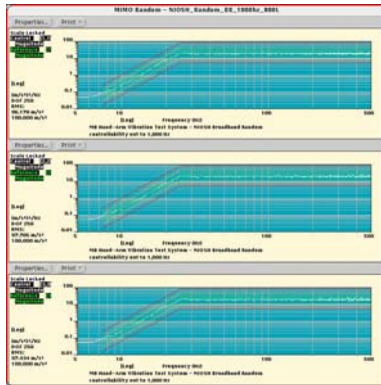


Figure 4: Vibration distribution on the handle

As an example, Figure 5 (a) and (b) display the Control and Drive plots demonstrating full performance. Overall noise levels due to the 10 g's RMS vibration on each axis exceeded 96 dBA in a 52 dBA ambient environment absent the vibration.



(a) Control signal



(b) Drive signal

Figure 5: System performance

## Conclusion

These preliminary results suggest that it is acceptable to use the 3-D test system to simulate the sinusoidal, broadband random, and time-history vibrations.