MICHIGAN STATE
UNIVERSITY

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To: Whom It Concerns

Attached is the Michigan State University, College of Engineering Dynamics and Vibrations Laboratory report on the effects of VIBEX (a damping product manufactured by Permawick Corporation) on a baseball bat.

The report contains results from tests that were conducted by Michigan State University. It was found that VIBEX has a positive effect on reducing vibrations in the handle of a baseball bat.

Sincerely,

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COLLEGE OF
ENGINEERING

Department of
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VIBEX Testing on a Baseball Bat

Test conducted at Vibrations Lab @ MSU, East Lansing

Jan. 31, 2012

Project Description:

Based on recent interest shown by baseball bat manufactures, it was decided to test a baseball bat with and without VIBEX. Results of the test are to be provided to Permawick.

Equipment:

- A metal baseball bat
- 4 shear-type accelerometers (352B10/10AC) manufactured by PCB Piezotronics
- 16 channel signal conditioner (481A02) manufactured by PCB
- Eight 2-channel AR GXPA TEAC modules for data recording manufactured by Tritech
- Gateway Laptop w/ required software for post processing data (TEAC GX Navi and Matlab)

Procedure:

The baseball bat was suspended and struck horizontally with an impact hammer on the sweet spot. Six accelerometers were placed along the length of the baseball bat, as shown in Figure 1. Sensors 1, 2 and 3 are in the direction parallel to the impact direction (direction 1), while sensors 4, 5 and 6 are in the direction perpendicular to the impact direction (direction 2).

The first test configuration is without VIBEX. And then different amounts of VIBEX were inserted at the center of the handle, as shown in Figure 1. The cases for 10 grams, 15 grams and 20 grams were tested. Fig.2 shows the cross section of the handle after cutting, and it shows that VIBEX was fully filled into the tube.

5 sets of data were recorded for each test configuration to ensure accuracy of the results. Data was sampled at 5000 Hz with the low pass filter set to 2000 Hz.

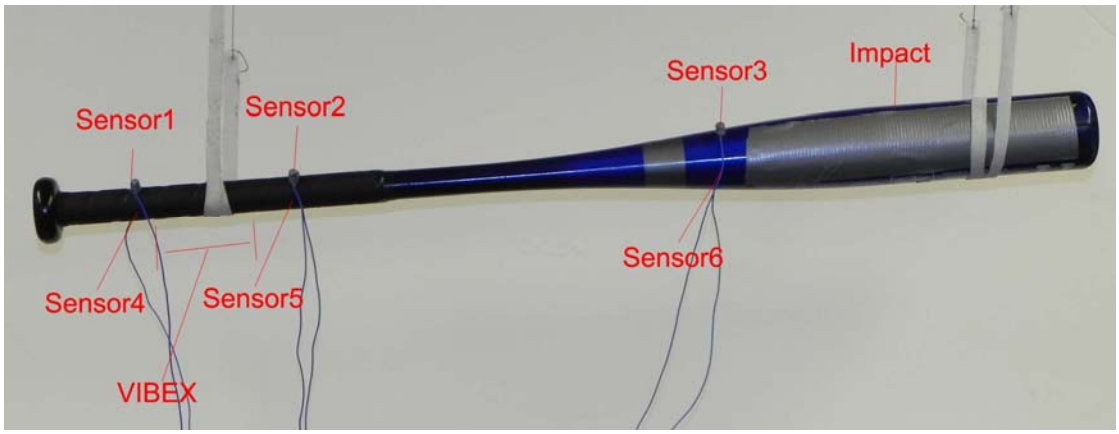

Figure 1: Experimental Setup

Figure 2 Cross section of the handle after cutting

Results and Discussion:

The figures below display the fast Fourier transform (FFT) of the data collected. On the horizontal axis is the frequency, which is the rate of oscillation in cycles/second (Hz) units. The vertical axis displays the amplitude associated with a given frequency in the signal, normalized by the impact force, on a linear scale. The blue lines represent the test performed without VIBEX. The pink lines represent the test with 10 grams VIBEX. The green lines represent the test with 15 grams VIBEX. The red lines represent the test with 20 grams VIBEX. For the case of an impact excitation, a reduction in the peak of the FFT can mean that either the length of time that the vibration can be felt is reduced, or the amplitude of vibration is reduced, or both. In the figures below each line represents one sensor. Additionally, for the figures below, one test was taken from each set of tests to allow the results to be clearly seen. In Table 1, however, we have taken the averages of all of the tests to give more comprehensive results.

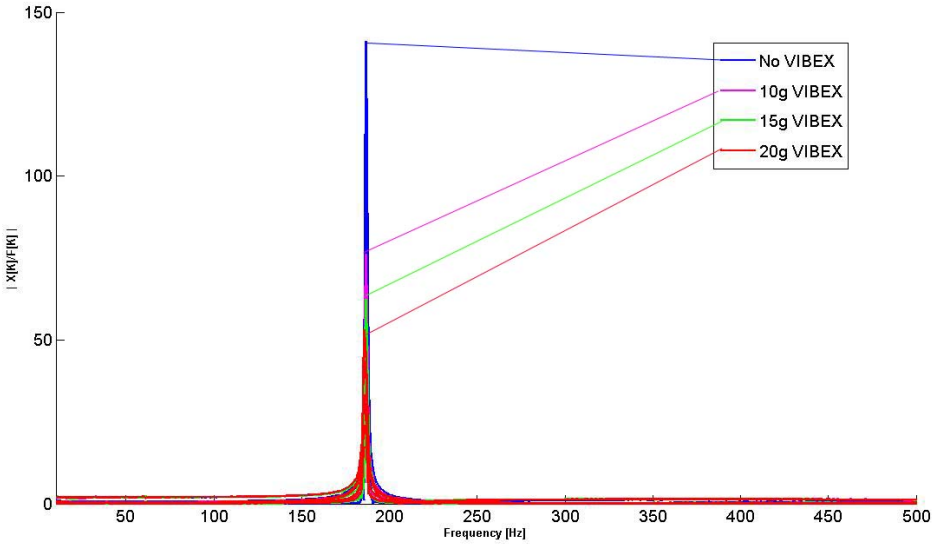

Figure 3. FFT of all sensors

Table 1: Maximum Amplitudes at Main Frequencies

		Relative Amplitudes at 189Hz	Reduction Percentage
Sensor1	Without VIBEX	141.19	×
	10 grams VIBEX	74.28	-47.39%
	15 grams VIBEX	62.07	-56.04%
	20 grams VIBEX	50.54	-64.20%
Sensor2	Without VIBEX	105.12	×
	10 grams VIBEX	61.94	-41.07%
	15 grams VIBEX	50.12	-52.32%
	20 grams VIBEX	43.48	-58.63%
Sensor3	Without VIBEX	132.31	×
	10 grams VIBEX	76.07	-42.51%
	15 grams VIBEX	62.53	-52.74%
	20 grams VIBEX	53.21	-59.79%
Sensor4	Without VIBEX	45.31	×
	10 grams VIBEX	36.73	-18.93%
	15 grams VIBEX	27.95	-38.31%
	20 grams VIBEX	33.16	-26.82%
Sensor5	Without VIBEX	32.26	×
	10 grams VIBEX	24.08	-25.35%
	15 grams VIBEX	19.71	-38.90%
	20 grams VIBEX	17.22	-46.61%
Sensor6	Without VIBEX	40.46	×
	10 grams VIBEX	29.50	-27.08%
	15 grams VIBEX	23.91	-40.92%
	20 grams VIBEX	24.03	-40.61%

Table 2 : Average reduction in two directions

Average Reduction		
	Parallel to impact	Perpendicular to impact
10 grams VIBEX	-43.66%	-23.79%
15 grams VIBEX	-53.70%	-39.38%
20 grams VIBEX	-60.88%	-38.01%

Table 1 compares the amplitudes of the sensors at each natural frequency, and indicates the percent reduction when VIBEX is applied. Table 2 shows the average percentage reduction in two directions for each VIBEX amount. It should be noted that the units for the vertical axis label X[k]/F[k] are not explicitly stated but for the reduction calculation we take a ratio which produces a nondimensional result.

Figure 3 shows that the main frequency is around 189Hz. It can be seen both in Figures 3 and table 1 that when VIBEX is applied to the baseball bat, the maximum amplitudes for all of the sensors are reduced. And with an increase of the amount of VIBEX, the reduction increases. Table 1 and Table 2 also show that the vibration amplitude in direction 1 is larger than the one in direction 2, as the relative amplitude values of sensors 1, 2 and 3 are larger than those of sensors 4, 5 and 6 at 189 Hz. The percentage reduction in direction 1 is also larger than that in direction 2.

Summary:

- VIBEX significantly reduces the vibration in the handle of baseball bat.
- The percent reduction increases when more VIBEX was inserted, up to 20 grams.
- A maximum average reduction of 60.88% is obtained when 20 grams was inserted.
- Further testing on optimization studies may be possible at the customer's request.

Things to Note

- The location of accelerometers has an influence on the responses read by the accelerometers. Care was taken to ensure very similar sensor locations on tests in each case, and the location error is assumed to be negligible.
- The tests were plotted for frequencies less than 500 Hz. Higher frequencies can be examined if desired.

Research, Testing and Results conducted by:

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