MICHIGAN STATE
UNIVERSITY

March 10th, 2013

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 LIBERTY ski poles.

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 ski poles. Tests showed an optimum amount of 10 grams produced an average vibration reduction of 30.24%.

Sincerely,

Xing Xing
PhD Student
Michigan State University College of Engineering

COLLEGE OF
ENGINEERING

Department of Mechanical Engineering

VIBEX Testing in LIBERTY ski poles

Test conducted at Vibrations Lab @ MSU, East Lansing

March 10th, 2013

Project Description:

Based on recent interest shown by Liberty Corporation to reduce vibration on ski poles, it was decided to test ski poles with and without VIBEX. Results of the test are to be provided to Permawick.

Equipment:

- VIBEX HP produced by Permawick
- LIBERTY ski poles 125
- 2 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 ski pole was suspended and struck vertically with an impact hammer at the right end where is the position contacting with the ground. Two accelerometers were placed on the handle, as shown in Figure 1.

The first test configuration is without VIBEX. VIBEX was then inserted at the location 3 inches to the handle. 5 grams and 10 grams VIBEX were inserted respectively.

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

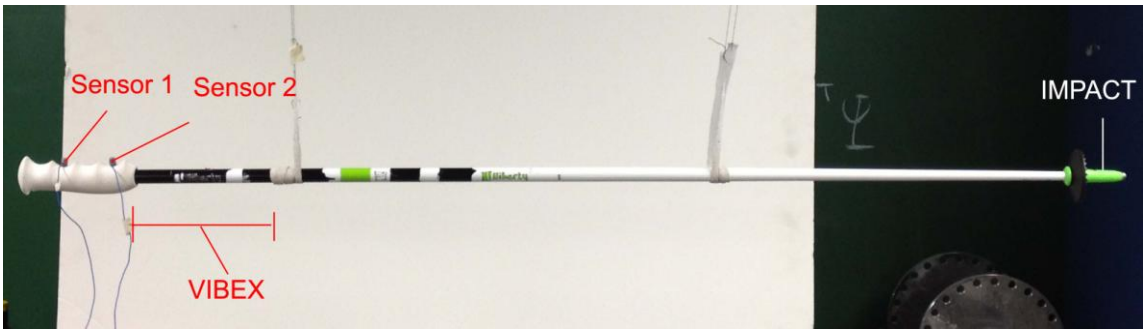

Figure 1: Experimental Setup

Results and Discussion:

Figure 2 display the fast Fourier transforms (FFTs) 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 red lines represent the test with

10 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.

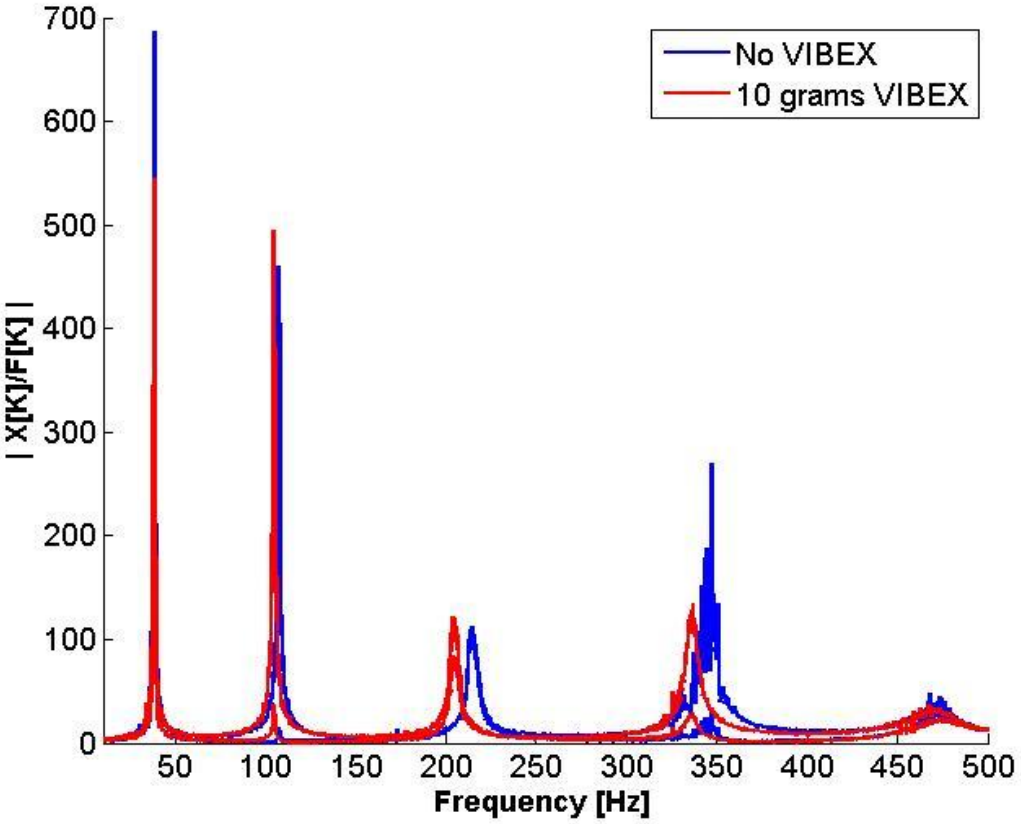

Figure 2. FFT of all sensors

Table 1: Maximum Amplitudes at Main Frequencies

Sensor#	VIBEX Cases	40Hz	110Hz	216Hz	348Hz
Sensor1	NO VIBEX	945.610	459.803	112.694	32.251
	10 grams VIBEX	545.072	494.134	121.674	29.341
	15grams VIBEX	628.347	537.137	185.828	39.014
Sensor2	NO VIBEX	540.097	15.191	121.418	269.692
	10 grams VIBEX	296.904	36.486	83.931	134.134
	15grams VIBEX	347.162	51.229	114.382	161.020

Table 2: Average reduction

VIBEX Cases	Average Amplitude	Reduction
NO VIBEX	312.094	×

10 grams VIBEX	217.709	-30.24%
15grams VIBEX	258.015	-17.33%

Table 1 shows the amplitudes of the sensors at each natural frequency. Table 2 shows the average amplitudes across the three main frequencies of the sensors and across all the sensors. The third column shows the percent reduction based on the average amplitudes. 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 2 shows that the main frequencies are around 40Hz , 110Hz, 216Hz and 348Hz. It can be seen both in Figures 2 and table 2 that when VIBEX was inserted, the maximum amplitudes of the sensors are reduced. An average percent reduction of 30.24% was obtained when 10 grams was inserted, while an average percent reduction of 17.33% was obtained when 15 grams was inserted.

Summary:

- VIBEX reduced the vibration in the handle of the ski pole when it was inserted to the handle.
- An average reduction of 30.24% was obtained when 10 grams VIBEX was inserted at the location 3 inches from the handle.

Things to Note

- The values for the amplitudes have no unit. Because the values obtained from the sensors are with the units voltage, and then we use the value of sensors divided by the amplitude of the impact force(which is also with unit voltage), which means it just indicates a number showing the vibration amplitude is high or low, and what we care about is the percent reduction calculated from the amplitudes.
- 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:

Xing Xing Phone: 517-432-1085
Email: xingxing@msu.edu
Graduate Research Assistant, Dynamic Systems Lab, Vibration Research, Michigan State University.

Venkat Ramakrishnan:
Email: venkat@msu.edu Phone: 517-432-1085
Graduate Research Assistant, Dynamic Systems Lab, Vibration Research, Michigan State University.

Dr. Brian Feeny:
Email: feeny@egr.msu.edu Phone: 517-432-1085
PhD, Mechanical Engineering, Dynamic Systems Lab, Vibration Research, Michigan State University.