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# Rivet Hammer Vibration Study

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# Rivet Hammer Vibration Study

## Honsa Ergonomic Technologies, Inc.

## Background

Rivet bucking tasks in manufacturing/industry transmit vibration to the operator's hand and arm through both the rivet and the bucking bar. Long-term exposure to vibration has been associated with symptoms of musculoskeletal disorders.[i] The National Institute for Occupational Safety and Health (NIOSH) concluded that vibrating hand tools can cause vibration syndrome, a condition also known as vibration white finger and as Raynaud's phenomenon of occupational origin. Vibration syndrome has adverse circulatory and neural effects in the fingers.

The ANSI standard[ii] has established a Daily Exposure Limit Value (DELV) of 5.0 m/s$^2$ (over an 8-hour exposure). Workers exposed to a hand-transmitted vibration at or above the DELV are expected to have a high health risk according to studies. The standard thus recommends that workers not be exposed to the vibrations above the DELV. NIOSH recommends that jobs be redesigned to minimize the use of vibrating hand tools.[iii] Where jobs cannot be redesigned to reduce operator vibration exposure, tools should be redesigned to minimize the transmission of vibration to the operator's hands and arms.

## Methodology

This study measures the vibration exposure transmitted to the hand by four rivet hammers manufactured by Honsa Ergonomic Technologies, Inc. (Milan, IL). All vibration measurements were conducted on aircrafts in actual use applications to test vibration during real world use. The purpose of this study was to reproduce the study[iv] done at Tinker Air Force Base in 2010 but with tools that were not previously tested. The independent variables for the study were the rivet hammer and the operator. Multiple subjects were used to run the tool in various applications. Table 1 lists the four different Honsa tools that were tested.

**Figure 1: Testing**

**Table 1: Specifications for Rivet Hammers Tested**

| Model | Serial Number | Piston | Number of Operators Running Tool |
|---|---|---|---|
| HTOP38 12 | 1111 | Steel | 7 |
| HTOP38 12T | 1112 | Tungsten | 3 |
| HTOP38 13T | 1114 | Tungsten | 2 |
| HTOP38 10 | 0183 | Tungsten | 1 |

The dependent variable was the vibration at the tool handle. All vibration measurements were collected via PCB Model SEN021F Larson Davis triaxial ICP® accelerometer, (Cincinnati, OH). A mechanical filter, comprising layers of foam, was used on all tools to minimize or eliminate the DC shift that could occur from the measurement of vibration of percussive tools.

Using zip ties, the accelerometers were installed on mounting blocks and mounted to the tool handles in the same orientation for each rivet hammer. The typical tool accelerometer mounting technique is shown in Figure 2. Triaxial vibration data collection commenced with the command "start" and lasted up to 60 seconds per trial. Upon the "start" command the operator ran the hammer on as many rivets in a row as possible. The triaxial vibration data was collected using the HAVPro by Quest Technologies. The data collected from this system was converted to ISO-weighted acceleration.

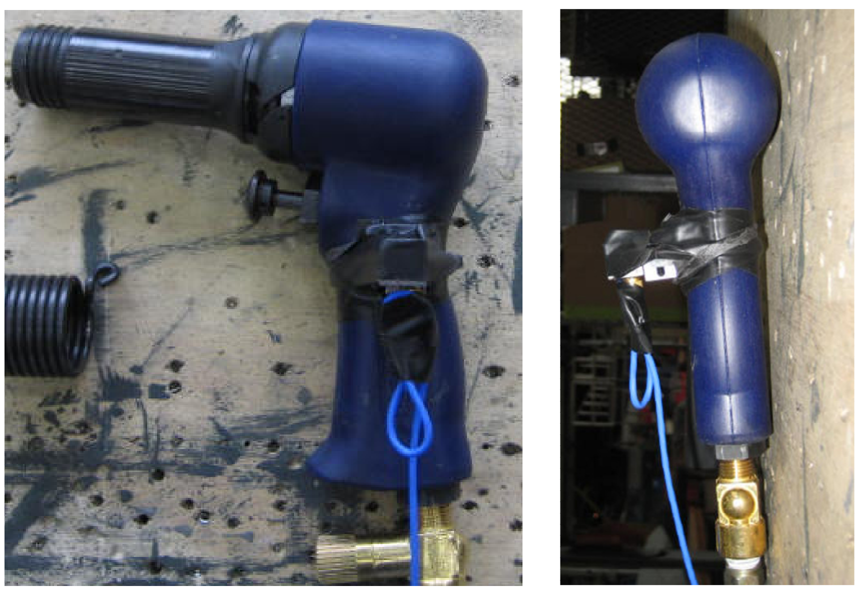

**Figure 2: Accelerometer Attached to Rivet Hammer**

# Results

Data was analyzed based on the ISO-weighted tool handle vibration measurements ($a_{hw(rms)}$) recorded and analyzed in accordance with ISO 5349-2, 2001[v], ANSI S2.70-2006[ii], and the study at Tinker Air Force Base [iv] except the tools did not complete 3 trials each with 3 operators with 5 rivets in a row due to the type of work being performed at the base. The study was completed on aircrafts in real world situations but the work being done was repair work so the tools were ran anywhere from 1 – 6 rivets in a row with various male operators, ranging in age from 18 to 63, and anywhere from 3 to 20 trials per operator. The rivets tested were a variety for sizes: 1/8", 3/16", 1/4", and 5/16" and varied between aluminum and steel. More data was gathered than that in previous studies. The ISO-weighted tool handle acceleration averages for each rivet hammer are shown in Table 2, along with daily exposure estimations, or A(8) values.

**Table 2: Weighted Vibration Exposure in the Order Tested**

| Tool | Measured Vibration ($m/s^2$) | Weighted Vibration Exposure ($m/s^2$)* | | | | |
|---|---|---|---|---|---|---|
| | | 7 hrs | 6 hrs | 4 hrs | 2 hrs | 1 hr |
| HTOP38 12 | 3.099 | 2.9 | 2.7 | 2.2 | 1.5 | 1.1 |
| HTOP38 12T | 3.513 | 3.3 | 3.0 | 2.5 | 1.8 | 1.2 |
| HTOP38 13T | 3.183 | 3.0 | 2.8 | 2.3 | 1.6 | 1.1 |
| HTOP38 10† | 4.593 | 4.3 | 4.0 | 3.2 | 2.3 | 1.6 |
| CP 4X†† | 4.222 | 3.9 | 3.7 | 3.0 | 2.1 | 1.5 |

The ANSI standard recommends a Daily Exposure Limit Value (DELV) of 5.0 $m/s^2$ or less.
* Weighted vibration exposure based on use in hours per day.
† The HTOP38 10 tool was ran without a warm up period resulting in higher values. All other tools were run for at least one hour before testing.
†† The CP4X were not tested for enough trials to have significant data.

# Conclusions and Recommendations

Based on the experiment, we were able to test the tools as used in the real world but were unable to test to a set procedure due to the variations of work required during repair tasks. Various tasks were tested by various operators and consistent results were found for all four Honsa tools. Vibration exposure is well under the ANSI DELV of 5.0 $m/s^2$ for all the rivet hammers when used up to 8 hours per day. For many work environments, exposure to vibrating tools for an entire day is uncommon and not recommended.

The study shows lower values for the weighted vibration when tested in the field versus the laboratory (previous testing). Field testing produces lower values for multiple reasons:

- The amount of pressure applied on the tool in the field varies by application since the lab test requires a constant and measured force (25 lb for the test subject used).
- The lab test was designed as a screening tool versus an exposure test; therefore, it's better at comparing one tool to another versus creating an exposure value. This study tested the individual tools instead of comparing one tool to another.
- Field use was conducted with various experienced rivet hammer operators who have each come up with their own technique.

Tools should not be selected based on field or laboratory measurements alone. Criteria such as tool versatility, operator feedback, productivity, initial cost, and maintenance fees should also be considered during selection.

[i] Jorgensen, M. and Viswanathan, M. Ergonomic Field Assessment of Bucking Bars During Riveting Tasks. Proceedings of the Human Factors and Ergonomics Society 49th Annual meeting, 2005. 1354-1358.

[ii] ANSI, ANSI S2.70: Guide for the Measurement and Evaluation of Human Exposure to Vibration Transmitted to the Hand (Revision of ANSI S3.34-1986). 2006, American National Standards Institute (ANSI): New York.

[iii] Center for Disease Control and Prevention, Vibration Syndrome (1983). DHHS (NIOSH) Publication No 83-110.

[iv] Department of the Air Force. Memorandum For: 72 AMDS/SGPG; Tinker AFB, OK 73145. 16 September 2010.

[v] ISO, ISO 5349-2: Mechanical Vibration – Measurement and Evaluation of Human Exposure to Hand-Transmitted Vibration – Part 2: Practical Guidance for Measurement at the Workplace. 2001, International Organization for Standardization: Geneva, Switzerland.