EVALUATING IMPACT WRENCH VIBRATION USING THE METHOD IN PROPOSED REVISIONS TO ISO 8662-7

T. W. McDowell, R. G. Dong, X. Xu, D. E. Welcome, and C. Warren

Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, WV

Introduction

ISO 8662-7, the international standard for evaluating vibration emissions from impact wrenches, is undergoing a systematic review and revision. The revisions are designed to more closely simulate actual vibration in the workplace, ensure that the end results will fall into the top quartile of what is actually experienced by a variety of workers in different work situations, produce a vibration result that could be easily translated into risk assessment analysis, and be able to be applied to a cross-section of all threaded fastener tools [ISO 2006]. While the current standard calls for single-axis vibration measurements to be made while the tool acts against a braking device, the revised procedure specifies that triaxial vibration measurements be made over the course of a series of 30-sec trials that involve the seating of 10 nuts onto plate-mounted studs or bolts.

In order to provide information toward the improvement of the impact wrench testing method, NIOSH constructed the proposed test rig and conducted impact wrench evaluations using the revised procedure. The objectives of this study were to compare methods for quantifying impact wrench vibrations and perform a general evaluation of the proposed revisions to ISO 8662-7.

Methods

Six male experienced impact wrench operators used 15 impact wrenches in the simulated work task. Three samples each of four pneumatic models (A through D) and one battery-powered model (model E) were used. The test rig consisted of two steel plates vertically mounted on a concrete block. The plates featured channels and holes to accommodate 10 steel bolts arranged in 2 evenly spaced rows. Each bolt was fitted with a nut, two Belleville washers, and a matching flat washer. Triaxial vibration measurements were made over the course of a series of 30-sec trials that involved the seating of 10 nuts onto the bolts. Each operator completed five 10-nut trials with each of the 15 tools for a total of 75 trials in a test session.

For the four pneumatic tools, vibration was measured at the tool handle and at the front portion of the tool housing. For the smaller battery-powered tool, only handle vibration was measured. Vibration data were collected for each one-third octave band with center frequencies from 6.3 to 1250 Hz.

Results and Discussion

As expected, the within-tool acceleration values varied less than the within-operator values. ANOVAs for ISO-weighted (ISO 5349-1) and unweighted acceleration each revealed that both tool and operator are significant factors, as well as their interaction ($p < 0.001$). However, as indicated in Table 1, an evaluator rank-ordering the tools by acceleration would draw different conclusions depending on whether or not ISO weighting was applied. Thus, it may be best to report both acceleration values.

As shown in Figure 1, there is a strong correlation between ISO-weighted acceleration measured at the tool handle and that measured on the motor housing ($R^2 = 0.875$, $p < 0.001$). This relationship holds true for unweighted acceleration. Thus, for tool-screening purposes, it may not be important to measure vibration at multiple tool locations.

Table 1.—Vibration measured at the tool handle for each subject and tool type

ISO-weighted acceleration (m/s^2)

Tool	Model B		Model A		Model E		Model D		Model C	
Operator	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	2.7	0.2	5.5	0.5	7.1	0.3	6.5	0.3	8.0	1.0
2	2.7	0.1	6.0	0.4	6.6	0.6	6.8	0.6	7.9	0.7
5	3.2	0.3	6.3	0.3	6.4	0.8	7.7	0.1	8.8	0.8
1	2.6	0.3	6.4	0.8	6.5	0.5	8.2	1.4	8.9	2.5
6	3.2	0.5	7.1	0.7	7.3	0.8	7.7	0.7	10.3	1.5
4	3.0	0.2	7.6	0.5	8.3	0.8	9.9	0.8	9.7	0.7
Average	2.9	0.3	6.5	0.5	7.0	0.6	7.8	0.6	8.9	1.2

Unweighted acceleration (m/s^2)

Tool	Model B		Model A		Model E		Model D		Model C	
Operator	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	27.0	3.3	100.6	9.3	202.4	3.3	173.5	10.0	129.2	6.8
2	26.4	1.5	114.0	10.4	153.0	16.4	209.6	10.8	134.1	17.6
5	35.3	1.9	119.0	5.8	147.3	21.1	209.0	5.9	155.5	15.7
1	30.1	6.4	109.0	20.4	145.6	14.9	219.0	34.4	161.6	37.8
6	30.8	1.6	138.5	3.2	161.1	15.4	228.7	11.2	210.4	32.3
4	29.2	1.9	130.5	3.8	191.1	26.6	251.6	20.9	192.2	18.9
Average	29.8	2.8	118.6	8.8	166.7	16.3	215.2	15.5	163.8	21.5

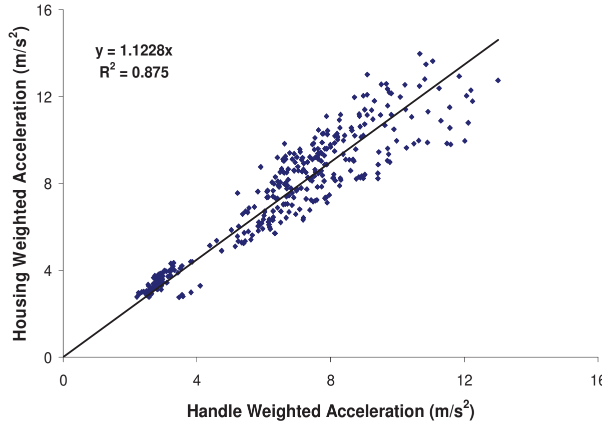

Figure 1.—Handle versus housing vibration.

Both the current and proposed impact wrench assessment standards call for testing by three tool operators. However, a power analysis [Montgomery 2001] revealed that three tool operators may not be enough for reliable tool screening. Based on the acceleration variance observed in this study, at least five tool operators would be required to reliably rank-order all five tool models using this revised procedure ($\alpha = 0.05$, $\beta = 0.20$, $p < 0.05$).

It is generally recognized that work posture and applied hand forces can significantly affect hand-transmitted vibration exposure [Griffin 1997]. In light of these observations, it may be useful to modify the impact wrench test procedure in an effort to reduce variability in the results. For example, to better control work posture, the operator could stand on a platform with adjustable height. Thus, elbow and shoulder angles could be more standardized. To help evaluate the influence of applied forces, a force plate could be added to the platform to measure ground reaction forces.

While this test setup may not provide reasonable simulations for all work tasks involving impact wrenches, the apparatus and test procedure seem to generate appropriate data for tool screening for a wide variety of impact wrench models and many common workplace operations.

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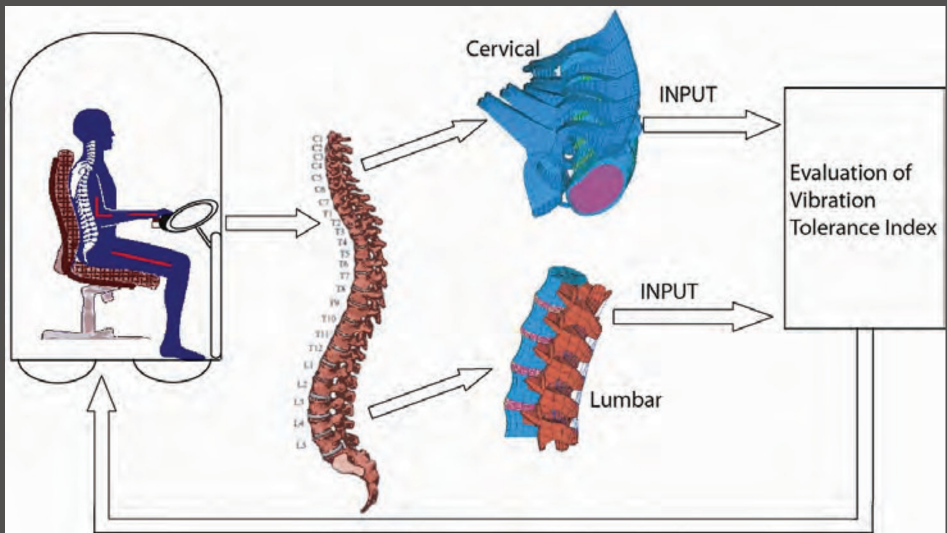

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