USE OF TUNGSTEN TO REDUCE VIBRATION EXPOSURE IN AIRCRAFT MANUFACTURING

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Introduction

Riveting operations in aircraft manufacturing involves the use of power tools for manually drilling holes for the rivets, power drills for the setting of the holes for the rivets, as well as rivet guns to drive and set the rivets. To close the rivet, the rivet is driven against a metallic bar commonly called a "bucking bar". The bucking bars are typically held firmly to increase the quality of the riveting, as well as keep the bucking bar from "dancing" against the metal piece being riveted. Thus, employees in aircraft manufacturing involved in riveting are exposed to hand-arm vibration from several sources, and epidemiological evidence suggests that vibration-related musculoskeletal disorders are associated with long term exposure to riveting tasks in the aircraft manufacturing of aircraft.[1,2] Recently, tungsten technology has been introduced into aircraft manufacturing for bucking bars, which are heavier than traditional steel bucking bars of the same size. Rivet guns with tungsten pistons instead of steel pistons have also recently been introduced with the objective of reducing vibration exposure to the riveter. The objective of this study was to assess vibration characteristics of steel and tungsten bucking bars and rivet guns to identify the combination that simultaneously reduced the combined exposure to both the "riveter" and "bucker".

Methods

Vibration (10g tri-axial accelerometer, Biometrics S2-10G-MF Series 2) was measured from eight experienced employees using seven different rivet guns on size 6 rivets, with the same person bucking for all subjects. Vibration was also measured on two different bucking bars for these same eight subjects, with the same person driving the rivets using the various rivet guns. The rivet guns consisted of three E4 steel piston guns with different RPMs (Guns A-E4, B-E4, C-E4), an E4 vibration dampened rivet gun (Gun D-E4D), an E3 steel piston rivet gun (Gun E-E3) and an E3 and E4 tungsten piston rivet guns (Guns F-E3T and G-E4T). The bucking bars were made of 90% tungsten (1694g) and cold-rolled steel (843g), and were the same shape and size. A two-way repeated measures analysis of variance was performed on the vibration (mean frequency weighted resultant acceleration) on both the rivet gun side and the bucking bar side, and mean rankings were used to assess the vibration simultaneously for the rivet gun and bucking bars to investigate which combinations provided the lowest vibration exposure.

Results

Frequency weighted resultant acceleration was significantly lower on the E3 tungsten (F-E3T) rivet gun than the E4 steel piston (B-E4) and the E4 tungsten piston (G-E4T) rivet guns (Figure 1). When measuring vibration on the bucking bar, the E4 (A-E4) steel piston rivet gun resulted in lower vibration on the bucking bars than the E4 tungsten piston (G-E4T) and E4 vibration dampened (D-E4D) rivet guns (Figure 2). Additionally, use of tungsten bucking bars resulted in a 35% decrease in resultant frequency weighted acceleration than when using steel bucking bars.

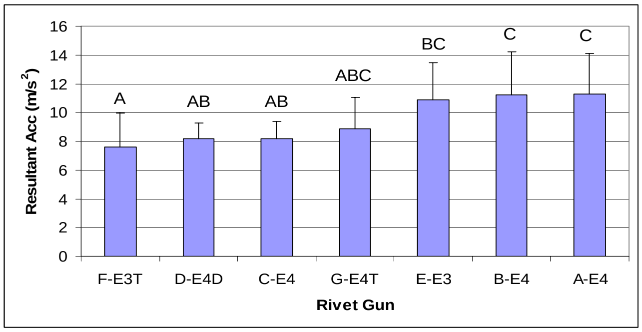

Figure 1. Resultant vibration measured on the rivet gun

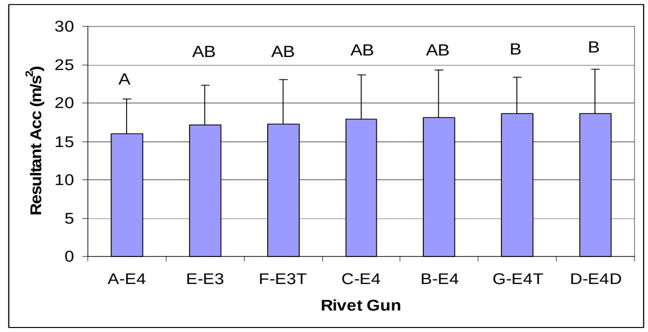

Figure 2. Resultant vibration measured on the bucking bar as a function of rivet gun used.

Discussion

Differences in vibration magnitudes were observed, however, the differences depended on whether the vibration was measured from the rivet gun or on the bucking bar. The vibration measured on the rivet guns indicated that the E3 (F-E3T) and E4 (G-E4T) tungsten piston rivet guns resulted in lower magnitudes, whereas E4 steel piston guns (B-E4 and A-E4) had higher magnitudes. Using tungsten bucking bars substantially decreased the vibration to the "buckers" compared to using steel bucking bars. However, the rivet guns that produced the lowest vibration to the riveter (dampened: D-E4D; tungsten: G-E4T) resulted in the highest vibration experienced on the bucking bar (Figure 3). Using the rankings on vibration levels for the tungsten bucking bar and different rivet guns to assess vibration exposure to the "riveters" and "buckers" simultaneously, using the E3 tungsten piston rivet gun (F-E3T) appears to reduce the vibration levels when considering both the riveting side and bucking bar side simultaneously when driving size 6 rivets. In conclusion, use of tungsten technology has the potential to reduce vibration exposure to riveters and buckers in certain riveting tasks.

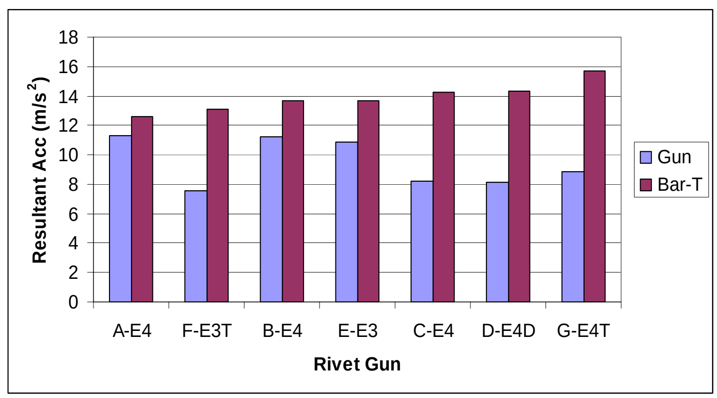

Figure 3. Resultant vibration measured on the rivet gun and the tungsten bucking bar.

References

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2. Burdorf, A., Monster, A. 1991, Exposure to vibration and self-reported health complaints of riveters in the aircraft industry, Annuals of Occupational Hygiene, 35(3), 287-298.