COMFORT EVALUATION FOR MINE SHUTTLE CAR SEAT DESIGNS

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Introduction

Industrial equipment exposes individuals to whole-body vibration (WBV) and mechanical shock. This exposure can negatively impact their health, safety, comfort, and working efficiency and performance. Accordingly, proper seat design is an important consideration in reducing the adverse effects of WBV exposure to vehicle operators. Since the human body is sensitive to low frequency WBV, ride quality is a basic and important element of good seat design. When designing a suitable seat, it is essential to understand vibration exposure environment of workers and how well they can tolerate this environment [1]. This is particularly true in the mining industry.

Mayton et al. [2] reported on a low-coal shuttle car seat design that underwent limited, yet successful underground mine trials. Building on this work, a follow-up study compared NIOSH and existing seat designs on low- and mid-coal seam shuttle cars. The NIOSH seat designs included viscoelastic foam, which has properties similar to those found in a mechanical spring/damper suspension system. The seats also included an adjustable lumbar support and a fore-aft seat adjustment. The NIOSH seat designs contrast with the existing seat design, which have little or no lumbar support and include inexpensive foam padding of the type commonly used in furniture.

This paper will focus on the seat designs for the mid-coal seam shuttle car and compare subjective comfort data collected from five vehicle operators with ISO 2631 – based reduced comfort boundary (RCB) analysis of recorded vibration levels.

Methods

Experimental data were collected using three different tools: triaxial accelerometers, pre-amplifiers, and filters connected to a data recorder; a visual analog scale (VAS); and a short questionnaire.

Researchers recorded quantitative or objective vehicle vibration data to determine the input and output acceleration at the operator cab floor and operator seat interface. Qualitative or subjective data, collected with the VAS, allowed researchers to obtain the operators' immediate impressions of shock, vibration, and discomfort levels for the vehicle ride on each of the seat designs. Each shuttle car operator made six round trips with the vehicle each seat. The shuttle car operator marked the VAS on the first, third, and sixth round trip of the trials for each seat. A round trip consisted of traveling to the coal face with *no load* and returning to the load discharge location with a *full load* of coal.

Results

Total overall average ratings for the five vehicle operators of the mid-coal seam shuttle car, showed that operators sensed from 45 to 87% <u>less</u> discomfort with NIOSH seat designs compared to the existing seat design. Using a 95% CI, researchers computed a strong positive correlation for discomfort.

Figure 1 illustrates the RCB analysis method for one of two NIOSH seat designs.

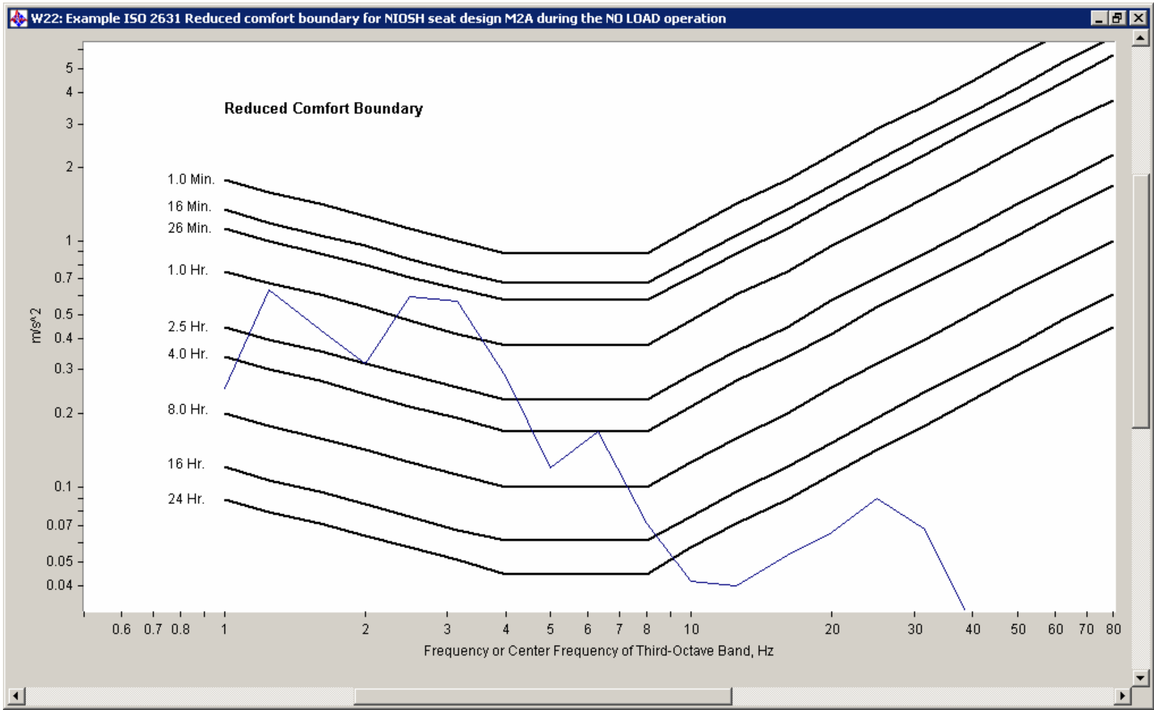

Figure 1. ISO 2631 RCB analysis for NIOSH seat design during *no load* operation.

Discussion

The RCB analysis during *no-load* operation showed that NIOSH seat designs, compared to the existing seat design, generally provided an increase in allowable exposure time for the vehicle operator, in the 4 to 8 Hz range. During *full-load* operation, the RCB analysis showed little difference in allowable exposure time for either the NIOSH or the existing seat designs. The natural frequency of the vehicle decreases for *full-load* operation as shown by the equation, $\omega = \sqrt{k/m}$ where, ω is the natural frequency, k is the spring constant, *and* m is the mass. Foam- or air-filled tires provide primary damping or attenuation of jars/jolts when the vehicle mass is increased with the *full load* of coal. Seat performance in attenuating of jars/jolts is thus secondary. The RCB acceleration-based analysis appears inadequate for correlating operator perceptions of discomfort. Vehicle operators' perceptions of discomfort are based more on the energy they sense transmitted to their bodies through the seat from the floor of the vehicle. So, the use of the absorbed power analysis reported by Mayton et al. [3], on the other hand, may provide a better means of correlating operator perceptions of vibration energy rather than the acceleration levels of the ISO 2631 RCB method.

References

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