Podium Presentations

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SHOCK AND IMPACT ON NORTH AMERICAN LOCOMOTIVES EVALUATED WITH ISO 2631 PARTS 1 AND 5

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Introduction

The International Organization for Standardization (ISO) standard ISO 2631 [1,2] provides three methods for evaluation of human exposure to vibrations that contain occasional shocks or impacts. Part 1 of the standard specifies the running r.m.s. or maximum transient vibration method (MTVV) and the fourth power vibration dose value (VDV). Part 5 of the standard provides a method of computing the stress in the lumbar spine for humans exposed to multiple shocks. Alem et al [3] have reported application of these methods to data for tactical ground vehicles. This paper reports and compares VDV and spinal stress evaluations of more than 90 hours of vibration and shock measurements on North American locomotives engaged in through freight operations.

The measurements evaluated in this paper were obtained for full crew shifts on 19 freight locomotive runs on mainline track in locations from New York to California. The shifts ranged in duration from 187 minutes to 497 minutes. The average speeds for the shifts were from 21.0 mph to 54.6 mph. All measurements were made on locomotives hauling freight trains in regular revenue service.

Data Acquisition and Processing

The results reported here were computed using test data acquired from a tri-axial seat pad, accelerometer at a sample rate of 400Hz with an anti-aliasing filter corner frequency of 100Hz. The VDVs and the lateral and longitudinal spinal stress values were computed directly from the acquired test data according to the procedures specified and described in [1] and [2]. The vertical spinal stress values were computed by converting the as-acquired test data to a sample rate of 160Hz for input to the vertical spine model, as required in [2]. The conversion of the test data from the as-acquired sample rate of 400Hz to the required sample rate of 160Hz involved up sampling or interpolating the test data to an equivalent sample rate of 800Hz, band limiting the resultant data with a low-pass filter corner frequency of 60Hz and finally down sampling or decimating the 800Hz data to a sample frequency of 160Hz.

Discussion

The vertical VDVs computed according to [2] for the 19 shifts ranged from 2.68 to 9.33 $m/s^{1.75}$. In all but one case, the vertical values were greater than the values for the lateral or longitudinal directions. Note that the health guidance in [1] puts the lower boundary of the health guidance caution zone at a VDV value of 8.5 and the upper boundary at 17 $m/s^{1.75}$. The daily equivalent static compression dose computed following [2] ranged from 0.123 to 0.434 MPa. Health guidance provided in [2] states that there is a low probability of an adverse health effect if the daily dose is less than 0.5 MPa.

The daily equivalent static compression dose is plotted against the vertical VDVs for the 19 shifts in Figure 1. As expected, a linear correlation of the spinal stress with VDV is evident in the graph. Also note that although the highest VDV values exceed the lower health guidance boundary, all the compression dose values are well below the boundary for low probability of an adverse health effect with daily exposure over a lifetime of work.

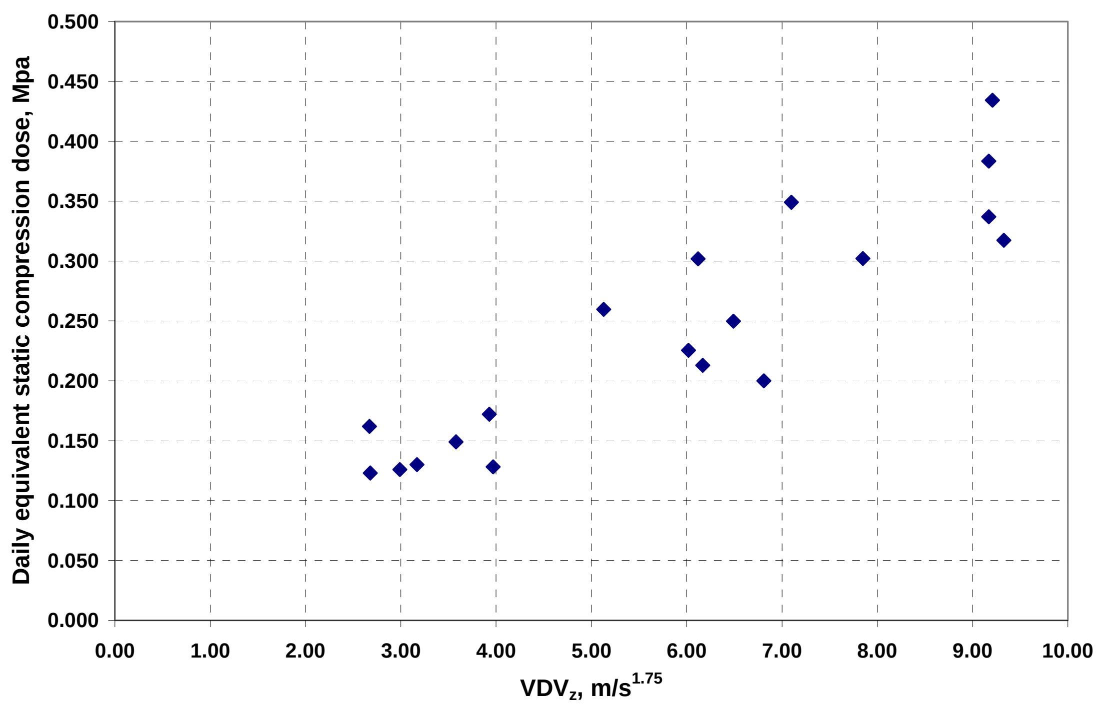

Figure 1. Daily static compression dose vs Vertical Vibration Dose Value

Conclusions

Evaluation of the data collected in the studies reported here following ISO 2631 suggests that the shock and impact exposure for locomotive crew members presents a low probability for an adverse health outcome. These results also indicate that, for locomotive shock and vibration, the health guidance for the VDV given in Part 1 of the standard is more stringent than the health guidance for spinal stress in Part 5.

References

1. International Organization for Standardization. (1997). Mechanical vibration and shock-Evaluation of human exposure to whole body vibration-Part 1: General requirements. ISO2631-1:1997

2. International Organization for Standardization. (2004). Mechanical vibration and shock-Evaluation of human exposure to whole body vibration-Part 5: Method for evaluation of vibration containing multiple shocks. ISO2631-5:2004.

3. Alem, N., Hiltz, E., Breaux-Sims, A. and B. Bumgardner. (2004). Evaluation of New Methodology for Health Hazard Assessment of Repeated Shock in Military Tactical Ground Vehicles. NATO RTO-Applied Vehicle Technology Symposium. RTO-AVT-110. Paper 7. pp 1-18.