INTRODUCTION

Similar to truck drivers, bus drivers, and heavy equipment operators, railroad engineers spend much of their workday in a seat operating their vehicle. Long-term health is influenced by design characteristics such as comfort, suspension, and adjustability. There are numerous reported back problems by locomotive engineers and assistant engineers from the virtually all of the major railroads in the United States.

Exposure to whole body vibrations can result in injury, however the vibrations themselves and ergonomic/biomechanical adverse effects can be subtle and injury development difficult to detect by the operators. In other words, operators of vehicles are often ignorant of the fact that their everyday exposure can be injurious. The cumulative problems caused by rough riding locomotives and vibrational issues resulted in a lawsuit filed by Union Pacific (UP) Railroad Company against a major U.S. locomotive manufacturer in an attempt to recover the significant costs due to injury claims by approximately fifty UP engineers and assistant engineers.

The type of exposure in a typical railroad environment is eloquently summarized by Johanning et al (2002):

"...these data indicate that locomotive rides are characterized by relatively high shock content (acceleration peaks) of the vibration signal in all directions. Locomotive vertical and lateral vibrations are similar, which appears to be characteristic for rail vehicles compared with many road/off-road vehicles. Tested locomotive cab seats currently in use (new or old) appear inadequate to reduce potentially harmful vibration and shocks transmitted to the seated operator, and older seats particularly lack basic ergonomic features regarding adjustability and postural support."

The recognition of the problem has sparked significant research regarding the issue of locomotive cab seat design. The Association of American Railroads issued a useful final report on Locomotive Cab Seat Evaluation in 1980 and the U.S. Federal Railroad Administration has also issued numerous reports (dating back to the 1970s) regarding the need to improve locomotive cab design. Many major U.S. railroads have studied the rough-riding and vibrational problems and documented the complaints and needs for design improvement. There has been extensive engineering, medical, and epidemiology literature indicating that exposure to certain vibrations and/or poor ergonomics of seating can cause injury to the human spine and other anatomical structures.

The aim of this study is to further investigate vibrational/ergonomic problems
associated with locomotives by examining both seat design and level of vibration exposure in a sample of locomotives from U.S. railway fleets.

**METHODS**

Typical locomotive seating environments were evaluated with respect to ergonomic design. The sample of examined seats was selected to be representation of the most common types currently found in United States railway fleets. Each of the seats was examined in regards to human factors characteristics and vibrational behavior. Vibrational measurements were recorded in locomotives in accordance with ISO and ANSI standards. Measurements were taken in a range of situations, such as through-freight train rides and yard environments.

**RESULTS AND DISCUSSION**

Data can be characterized by the following numbered statements: 1) Low to moderate RMS (root-mean-squared) vibration levels; 2) High crest factors; listed in decreasing amplitude are the X, Y and Z directions 3) Low frequency side-to-side swaying/rolling that results in the body swaying or rocking; resulting in the occupant continually trying to counteract this motion; 4) Long exposure durations; 5) Most basic level seating systems present; 6) Vertical seat adjustment is oftentimes a two-person operation, requiring one person in the floor operating the pins while a second person provides lift assistance and sets the height while the pins and locks are engaged; 7) Seat fore-aft seat adjustment oftentimes relies on metal-to-metal tracks that require the weight of the seat and pedestal to be lifted and slid fore-aft; units show rust that adds to the adjustment effort; units show bent track mechanisms and missing paint that illustrate the difficulty of the adjustment and the effort that may be required if the mechanism does not freely slide; 8) Overall, poor seats with respect to suspension and ergonomic characteristics. The evaluation indicated several characteristics in which there are significant ergonomic opportunities for design improvement, such as: 1) pad/seat cushion material and contour, 2) armrest compatibility with occupant anthropometrics, 3) vibrational performance and seat suspension, 4) seat positioning and interfacing with the control console; and 5) overall seat adjustability.

**CONCLUSIONS**

Typical seats exhibited deficiencies in lumbar support, vibrational characteristics, vertical and fore/aft adjustment control design, and biomechanical soundness. The basic seating systems are typical of industries such as those found on lower-end school buses where driver exposure is usually 1-3 hours/day as opposed to 6-plus hours per day for railroad engineers. Detailed vibrational data, collected and analyzed in accordance with current national and international standards, show high crest factors and low frequency side-to-side swaying/rolling that results in the body swaying or rocking. As a result the occupant is continually trying to counteract this motion. This can lead to accelerated muscle fatigue and increase average disk pressure. These fatigued muscles are the ones that support the spinal column and help resist segmental buckling. Railroad companies and locomotive manufacturers should incorporate ergonomically-desirable features and air-ride suspensions into the design of their seats and reduce the injury risk to engineers.

**REFERENCES**