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Role of Driver Hearing in Commercial Motor Vehicle Operation: An Evaluation of the FHWA Hearing Requirement

Introduction

The Federal Highway Administration (FHWA) currently requires that all commercial motor vehicle (CMV) drivers have a specified minimum level of hearing to drive in interstate commerce. This tech brief summarizes an FHWA study of the same title that evaluates the validity of the current CMV driver hearing requirements and the ability to hear as a critical requirement for safe driving.

Purpose

This study sought to answer many of the questions concerning truck driver hearing, noise exposure, and hearing-critical tasks. A hearing requirement for CMV drivers implies that commercial truck driving is a hearing-critical job, for reasons such as: crash avoidance (car horns, train whistles), detection of in-cab auditory warning signals, and face-to-face and CB communication.

There is a need to establish a more scientific and empirical basis for Federal CMV driver hearing requirements. Some form of hearing requirement would be necessary if research found driving tasks that are safety-critical and dependent on hearing. Researchers had three main goals:

- to determine whether the current FHWA hearing requirement for CMV drivers is justified,
- to ascertain the level of hearing necessary to operate a commercial vehicle safely; and
- to determine whether such hearing requirements will be necessary in the future.

In completing the study, researchers also evaluated truck-cab noise as a cause for driver hearing loss, both temporary and permanent.

Methodology

This research project consisted of four phases: a literature review; an extensive task analysis; empirical measurement of driver hearing, truck-cab noise, and noise exposure; and audibility predictions.

The literature review concentrated on the topics of commercial truck driving and hearing, the effects of occupational noise exposure, and truck-cab noise. An extensive segment of the literature review focused on the effectiveness of the forced-whisper test, one of the current screening methods for testing CMV driver hearing under



FHWA requirements. The next phase of the study was a task analysis. Researchers first reviewed truck driving task analysis literature, much of which did not consider the role of hearing or noise in the driving task. Then they conducted structured interviews with 11 subject matter experts (SMEs). The input from the SMEs was used to create an extensive task analysis questionnaire that was distributed to 80 CMV drivers.

The measurement phase of this project sought to determine the noise level in truck cabs, including engine idle noise and noise in the sleeper berth. Researchers took spectral measurements in several trucks under different highway-speed driving conditions during actual commercial runs. They also used dosimetry to determine the noise doses experienced by truck drivers during normal commercial runs of 8–18 hours; noise doses were measured in 9 sleeper berths. During this phase, researchers performed pre-and post-day audiograms for a group of 10 drivers to determine whether truck drivers experience temporary hearing loss after a normal driving shift.

The fourth and final study phase used the empirical data collected in phase three to predict the audibility of both speech and auditory signals that would be encountered during normal truck driving. Speech audibility was calculated for 16 listening conditions (such as radios on, windows open, engine idle, etc.) for both live and CB speech. Several warning signals were also evaluated for audibility, including a backup alarm, a siren, a train horn, and eight interior warning signals.

Findings

Literature Review

Researchers reviewed a wide range of literature; their findings included:

- Persons who operate private vehicles with hearing impairment may have better or worse safety records than the non-hearing impaired, depending on the study referenced.
- Based on the results of several studies, there appears to be a relationship between noise, hearing level, and industrial accident rates. High noise levels may lead to higher accident rates.
- Noise levels in truck cabs as reported over the last 25 years have dramatically decreased.
- There is evidence that noise can affect driver physiological functions, psychological functions, illness rates, and job performance.

Figure 1.
Mean pre- and post-workday audiograms
for 10 drivers, left ear.

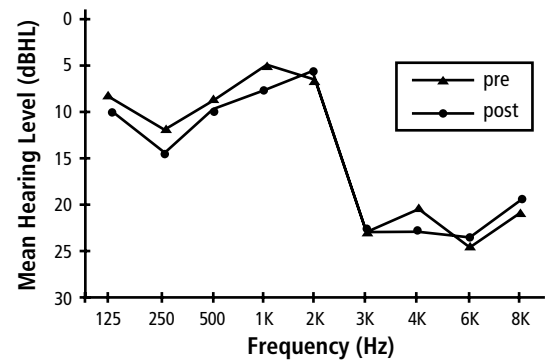
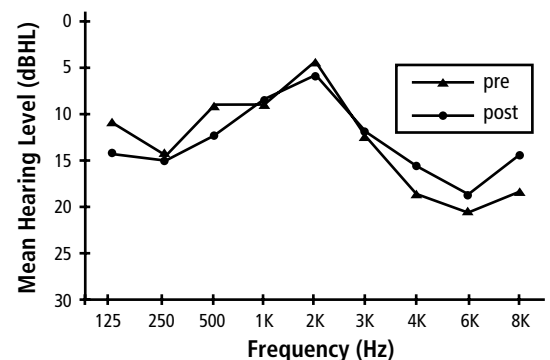


Figure 2.
Mean pre- and post-workday audiograms
for 10 drivers, right ear.



Based on this extensive review of literature, researchers also concluded that the forced-whisper test is not as reliable or valid as a hearing test based on pure-tone audiometry.

A truly unbiased, comprehensive study of the validity and reliability of the forced-whisper test has not been attempted for over 50 years, during which the field of audiology has made great strides. Audiometers have become more widely available, and there are many people trained in their use. While the forced-whisper test is still a viable tool, pure-tone audiometry tests are a more precise and objective way to evaluate hearing.

Task Analysis Results

The task analysis questionnaire was completed by 80 CMV drivers. Questionnaire data produced a list of mechanical problems that can be detected by hearing. These data also provided researchers with a tool to compile a final list of hearing-critical, routine truck driving tasks, including:

- Maneuvering in highway, city, and rural traffic
- Entering and exiting limited access highways
- Passing another vehicle
- Upshifting, downshifting, braking, accelerating, and parking
- Merging into traffic
- Emergency stopping

Based on the number of commercial driving tasks identified as hearing-critical, and on the number of hearing-critical incidents reported by CMV drivers completing the questionnaire, this research suggests that commercial truck driving should be classified as a hearing-critical job.

Empirical Measurements

When measuring truck-cab noise, researchers found that the overall broadband sound pressure level for the 9 trucks evaluated was 89.1 dBA for 8 conditions of highway driving. The sleeper-berth mean dBA was 81.6 dBA, and for engine idle conditions, cab noise was 68.7 dBA. The truck-cab average of 89.1 dBA was very close to the Occupational Safety and Health Administration (OSHA) permissible exposure limit of 90 dBA for an 8-hour day. Interior noise levels in commercial motor vehicles are not regulated by OSHA, but these regulations provide the best available metric for evaluating the risk of hearing loss due to noise exposure.

Dosimetry was used to determine the noise doses experienced by 10 truck drivers during normal commercial runs of 8-18 hours. Sleeper-berth doses were much lower than front seat doses. The 8-hour and projected 10-hour noise doses experienced by the drivers in the study were not excessive as measured against OSHA requirements for the general industry.

However, the exposure levels were different for team drivers who might be exposed to noise continuously, as they rest and their partners drive. Team drivers who spend most of their non-driving time in the cab rather than the sleeper berth might be exposed to noise levels that exceed recommended levels. The noise doses were measured with rest breaks, meal breaks, and refueling breaks included, so they represented realistic projections of actual truck trip noise doses.

When pre-and post-workday audiograms were performed for a group of 10 drivers, results indicated no temporary hearing loss, or temporary threshold shift, after a normal driving shift. The pre- and

Audiometric Frequency	Minimum Hearing Level Recommendations (Better Ear)
500 Hz	45 dBHL
1,000 Hz	45 dBHL
2,000 Hz	40 dBHL
3,000 Hz	40 dBHL
4,000 Hz	40 dBHL

*Current FHWA standards require an average hearing level of 40 dBHL at 500 Hz, 1,000 Hz, and 2,000 Hz. dBHL = decibel hearing threshold level.

post-workday audiograms were very similar, as shown in figures 1 and 2.

Researchers did measure a noise-induced permanent threshold shift (NIPTS) when pre-work audiograms for a group of 30 CMV drivers were compared to threshold data for non-noise exposed males of the same mean age. The comparison showed significantly higher thresholds at 3000, 4000, and 6000 Hz for the drivers. But due to the prevalence of noisy hobbies and previous occupations among the two groups, no conclusions were reached as to whether the NIPTS was caused by truck-cab noise.

Audibility Predictions

The results of the audibility predictions showed that an acceptable level of intelligibility can be achieved some of the time, but that speech communication, both live and by CB radio, is degraded under noisier truck-cab conditions. Intelligibility scores for the noisier conditions are unacceptably low, and vocal efforts for live speech would need to be at an unsustainable level for reliable communication.

When researchers evaluated internal and external warning signals for audibility, they found that the probability of truck drivers hearing signals such as train horns and sirens was very low. Signals were found to exceed masked threshold of truck noise less than half the time, and were almost never audible under noisier conditions, meaning that CMV drivers may be hearing less than 50 percent of external warning signals.

Recommendations

Truck Manufacturers

This research found truck-cab noise to be unacceptably high for three reasons:

Researcher

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Availability

The publication is now available. Copies can be obtained from the National Technical Information Service, Telephone: (703) 605-6000. Order No: PB98-114606.

Key Words

hearing, hearing standard, noise exposure, hearing-critical task, truck-cab noise, audibility predictions, forced-whisper test, task analysis, hearing loss.

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- The overall mean broadband sound pressure level for truck-cab noise is very near the OSHA permissible exposure limit of 90 dBA for 8 hours.
- Truck-cab noise degrades communication in the truck to unacceptable levels under many conditions.
- Noise levels often mask both interior and exterior warning signals, thus impacting public safety.

For these reasons, researchers recommend that truck manufacturers make every effort to decrease truck-cab noise in future models. Since this is a public health concern, noise reducing features should become standard features in truck design. This research also encourages manufacturers to ensure that in making the cab quieter, they do not reduce the driver's ability to hear external warning signals. Every effort should be made to reduce the transmission of noise at the source: the engine.

Truck manufacturers could also ensure that truck-cab warning and advisory signals contain their primary energy in the frequency range from 700 to 3000 Hz, so that individuals suffering from a noise-induced hearing loss are still able to hear the signals. To make in-cab auditory displays more audible, manufacturers can reduce the noise level in the cab, or increase the presentation level of the signals.

Hearing Evaluations

Lacking empirical evidence that the forced-whisper test correlates with appropriate hearing level requirements, the preferred choice for evaluating CMV driver hearing is pure-tone audiometry, which can objectively assess hearing ability. Questionnaire results suggest that as many as half of all CMV drivers are already receiving this type of hearing test. This research suggests that pure-tone audiometry tests are more objective than the forced-whisper test, and could be substituted, with levels set according to empirical measurements of signals needed to perform the truck-driving task safely.

Because hearing loss may exist at different frequencies, the FHWA currently evaluates hearing at several levels (500–2000 Hz). This study suggests that there may be some benefit from testing CMV driver hearing at frequencies up to 4000 Hz. The pure-tone audiometric test can more accurately assess hearing ability at specified frequency levels.

The overall conclusion of this report is that an FHWA hearing requirement is necessary. There are both intentional signals and incidental sounds that CMV drivers need to hear in order to drive safely. **Table 1** presents the minimum recommended hearing levels for the frequencies between 500 and 4000 Hz. These are based on a hearing level at 13 decibels below the masked threshold of the quietest truck-cab noise condition.

Further Research

Further research in this area should concentrate on the development of an audiometric database for truck drivers. A high proportion (84 percent) of the drivers surveyed in this study reported having hobbies or previous occupations with high levels of noise exposure. Therefore, it is difficult to be certain that these drivers are suffering hearing loss as a result of their driving activities. In conjunction with this database study, the researchers recommended that a study of truck-cab noise be conducted every 2 or 3 years to determine whether truck-cab noise is increasing or decreasing.

Another research project might involve an analysis of the forced-whisper test to determine the variability and reliability of this test when used with various examiners and patients. Research may also attempt to explore a correlation between pure-tone audiometric tests and forced-whisper tests.