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DOCTORAL DISSERTATION EXECUTIVE SUMMARY

**"Earplugs as hearing protection means for professional musicians "**

Musicians, as much as workers in other sectors of the industry, may be exposed to high sound levels. In industrial settings such sound can be eliminated by conventional methods of noise reduction. In the case of musicians for whom musical sound is the product of their work, it is not possible. One of the proposed solutions for limiting exposure to noise are specialized earplugs for musicians equipped with acoustic filters.

The aim of this dissertation was to determine whether specialized earplugs could be an effective means of limiting the exposure of musicians to high sound levels. Studies were directed to assess how earplugs for musicians reduce the high-level sounds and whether use of earplugs affects the quality of a musician's work. Only when musicians' performances are not affected by wearing earplugs such hearing protection will be accepted in musicians' professional practice.

In the dissertation, a review of the literature related to the risk to hearing due to sound produced by musical instruments or electroacoustically reinforced on the stage during popular music concerts is presented. This includes data on the sound levels common among musicians, and the effect that sound produced by musical instruments may have on hearing. This part of the work also includes a review of research on various methods of screening the sound and on hearing protectors for musicians, specifically earplugs, which musicians can use to protect against high-level sounds.

As part of the experimental work, studies on noise exposure occurring among musicians and the influence of sound produced by musical instruments on hearing were carried out through an assessment of temporary hearing threshold shifts. It was also assessed how earplugs for musicians reduce the risk of sound exposure to sounds produced by musical instruments. Finally, it was assessed whether the use of musicians' earplugs affects the quality of a musician's acoustic performance.

The measurements were focused on musicians in symphony and wind symphony orchestras, as well as on bands performing rock and jazz music. It was determined that high sound levels occurred closest to various groups of instruments in symphony and wind symphony orchestras, both during rehearsals and concerts. Maximum sound levels were most observed in the vicinity of musicians playing brass and percussion instruments. Rock and jazz bands musicians are particularly exposed to the harmful effect of sound due to the use of electro-acoustically reinforced sound systems.

The effectiveness of musician earplugs as a hearing protection was carried out by measuring temporary threshold shifts. Results demonstrated that 9 dB attenuation earplugs completely eliminated the risk of harmful sound exposure from the sound of classical music (i.e. no temporary hearing threshold shift). Without the use of earplugs, temporary threshold shifts of up to 15 dB occurred after exposure, closely corresponding to the sound exposure of a musician playing the French horn during a concert. In the case of rock musicians, temporary

threshold shifts exceeded 20 dB. The 15 dB attenuation earplugs eliminated the sound influence of rock music on hearing.

Assessments of the sounds produced by musicians wearing earplugs were carried out by measuring changes in 1/3 octave and A-weighted sound levels of performed music. The analysis of sound showed the largest changes occurring for brass instruments and saxophone. Smaller changes in 1/3 octave and A-weighted sound levels due to earplugs use occurred for woodwind instruments, xylophone, snare drum, violin and vocalist. Measurements conducted after 10 months of the musicians practice in using earplugs showed an evident reduction of changes in 1/3 octave and A-weighted sound levels for brass instruments. The use of earplugs by rock musicians did not significantly affect the 1/3 octave or A-weighted sound levels of performed pieces.

Listening tests have shown that the use of earplugs most affects the performance quality for brass instruments, saxophone and vocalist. A smaller effect of earplugs use can be seen in performances of clarinet and violin, where changes in the spectrum were also relatively small. Surprisingly, the performances of musicians using earplugs playing the flute and xylophone were more preferred by the listeners than the same performances without earplugs.

The research supports the thesis that earplugs are an effective and an acceptable means of limiting musicians' exposure to excessively high sound levels.