European Metrology Programme for Innovation and Research

Delivering Impact

Protecting health through new ultrasound measurements

Occupational health and safety agencies aim to protect workers from excessive levels of noise at the workplace which can damage hearing. Many industrial processes can generate ultrasound which is generally above the range of human hearing. However, ultrasound can be perceived particularly at high sound pressure levels. As no ratified methodology existed to measure ultrasound its effect on humans was not well known, potentially putting the health of workers at risk.

Europe's National Measurement Institutes working together

The European Metrology Programme for Innovation and Research (EMPIR) has been developed as part of Horizon 2020, the EU Framework Programme for Research and Innovation. EMPIR funding is drawn from 28 participating EURAMET member states to support collaborative research between Measurement Institutes, academia and industry both within and outside Europe to address key metrology challenges and ensure that measurement science meets the future.

Challenge

Around 22.6 million people in the EU live with untreated, disabling hearing loss. As well as its social effects it also costs the European economy around €185 billion each year, €25 billion more than the EU budget for 2018. In Germany four to five million workers are exposed to harmful occupational noise and the German social accident insurance institutions for industry and the public sector pay pensions in excess of €100 million annually due to noise-induced hearing loss.

To reduce both the social and economic burden they make thousands of measurements each year for preventative healthcare. In this they are supported by the Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA) that, as well as producing standardization and legislation, provides relevant workplace training on how to make measurements. For some time, the IFA had been concerned about the lack of standardised measurements for airborne ultrasound, which is sound above the frequency of human hearing (>16 kHz). Despite the increased proliferation of devices that generate ultrasound, such as industrial cleaners, welders and voice alarm systems, little was known about its effect on human health or upon the routine measurements for audible sound. As accurate measurements of noise are essential to protect workers there was an urgent need for improved metrology in this area.

Solution

The EMPIR project *Metrology for modern hearing assessment and protecting public health from emerging noise sources* developed new methodologies for measuring levels of occupational ultrasound. Based on an existing German guideline and the international standard ISO 9612 for audible sound measurements two laboratory reference workplaces were established, one at project partner IFA and another at Germany's National Metrology Institute, PTB.

Designed to simulate practical measurements the workplaces were used to perform systematic, three-dimensional, high spatial resolution scans of the ultrasound field of an ultrasonic welding machine. This included effects of environmental factors such as the influence on the field around a person present. From the results obtained a new measurement procedure for ultrasound was drafted. This was then applied in field tests at nineteen workplaces around Germany routinely using eight different types of ultrasound generating machines. Exposure patterns of various types of high frequency sound experienced by workers were then assessed, ranging from single, short, pulses to continuous ultrasound emissions.

Impact

As a result of the EMPIR project the IFA can make accurate measurements, as well providing training, on ultrasound in the workplace. In addition, PTB and IFA have developed an ultrasound level meter for field use along with a suitable testing and calibration unit for the new device. This meter not only allows accurate measurements on the levels of audible sound and ultrasound in a rapid, 10-minute process, it is capable of extracting faulty values on audible readings caused by ultrasound interference giving a more reliable measure of the real effect of noise in the workplace.

As well as providing calibration services for audible equipment, including microphones for which the measurement range was extended to 100 kHz, PTB now offers higher-level measurement services for ultrasound. This includes investigating potential hazards to hearing from complicated ultrasound fields such as those generated by advanced haptic displays that deliver text and graphical information using the sense of touch. For the first time a practical framework for measuring ultrasound has been established in Europe. Not only will this help reduce the economic burden of workplace incidents to insurers but, more importantly, help protect EU citizens from the danger to health caused by damaging, excessive workplace noise.

New hearing and noise assessments for public health

The EMPIR project *Metrology for modern hearing assessment and protecting public health from emerging noise sources* developed three new ear simulators for the calibration of audiometric equipment covering the age ranges 3 months to adult. A new calibration method suitable for the short-duration stimuli typically employed in modern hearing assessment was also developed. Two reference workplaces were built to study the effect of occupational exposure to airborne ultrasound. After testing the methodology in real world settings, it now forms part of regular training on the assessment of ultrasound in workplaces in Germany. The physiological mechanisms of perception of infrasound and ultrasound were studied using audiological and neuroimaging. This included investigating the impact of combined infrasound and audible sound, the effect of binaural hearing on loudness of infrasound. The effect of infrasound and ultrasound on brain activity and personality was examined in a well-defined longitudinal study with more than 70 participants. Combined these results will help improve hearing assessment tests for children and have a positive impact on public safety, especial around the area of airborne ultrasound.

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