TECHNICAL COMMITTEE REPORT

Noise

Scott Sommerfeldt

Postal:
College of Physical and Mathematical Sciences
Brigham Young University, N181H ESC
Provo, Utah 84602-4673
USA

Email:
scott_sommerfeldt@byu.edu

William J. Murphy

Postal:
Hearing Loss Prevention Team
National Institute for Occupational Safety and Health
1090 Tusculum Avenue
Cincinnati, Ohio 45226-1998
USA

Email:
wjm4@cdc.gov

The Technical Committee on Noise (TCN) focuses on increasing and diffusing knowledge of noise generation and propagation, passive and active noise control, perception and the effects of noise, and the management of exposure to noise. The activities of the TCN embrace both the practical and theoretical aspects of noise in all areas of acoustics. Unwanted noise is pervasive in our society, and as a result, the myriad applications of interest lead to significant overlap with other technical committees within the Acoustical Society of America. Many TCN members participate in and collaborate with the technical committees on Architectural Acoustics (TCAA) and Structural Acoustics and Vibration (TCSA). Although there are numerous topics of current interest to members of the TCN, several of those are highlighted here to provide an overview of the types of problems that are being pursued.

Renewable energy sources are a topic of great interest in the United States and around the world. One of those sources being developed is the generation of electricity from wind turbines. To spur this development, production tax credits are currently given for producing sustainable energy. The effects of this policy can be seen because there are now utility-scale projects in all 50 states of the United States. As of 2014, the cumulative wind-generating capacity in the United States was 66 gigawatts, with 5,055 megawatts of capacity being installed during 2014. Although this rapid growth in capacity is striving to address the need for renewable energy, it has also led to an awareness of potential health concerns for those in the vicinity of these wind turbines.

A significant contribution to the noise radiated from wind turbines is in the range of infrasound. The blade passage frequency (BPF) of the turbine and its harmonics are significant components of the radiated sound. People in the vicinity of wind turbines have reported a number of concerns including headaches, sleeplessness, nausea, vertigo, anxiety, panic attacks, and symptoms resembling motion sickness. These reports have led to a debate as to whether these effects are real and, if they are real, just what the mechanisms are that result in these symptoms. Current efforts are looking at what acoustical measurements are appropriate for properly analyzing wind turbine noise as well as studying blade design to prevent structural problems and reduce radiated noise. When a wind farm exists, as is very common, there are also issues of interaction between adjacent wind turbines that need to be considered.

In response to the issues associated with wind turbines, the ASA issued a policy statement in May 2014: "Wind turbine acoustic emissions and their potential effects should be investigated and fully addressed in an interdisciplinary manner. The Acoustical Society of America urges that guidelines for relating wind turbine sound descriptors to probabilities of adverse effects be developed, to aid in wise wind energy planning. Methods for measuring and quantifying wind turbine acoustic emissions, particularly at very low frequencies, should be developed that support the interdisciplinary findings" (http://goo.gl/19yfDI).

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The topic of soundscapes is another area of considerable interest in the TCN. A soundscape is defined as an acoustic environment as perceived and/or experienced and/or understood by people in context. Soundscape design is becoming a powerful new tool for the measurement, analysis, and design of environmental and community noise that applies the knowledge of both science and community experts. This approach recognizes that metrics alone do not lead to proper design of acoustic spaces because human expectations are modified by the context in which sound is encountered. Thus the soundscape approach combines acoustical measurements such as sound pressure levels with subjective evaluation obtained from talking with individuals that interact within the acoustic space. Because of the context in which the noise is encountered, in some cases sound levels that might normally be considered too high are willingly accepted by those individuals.

Active noise control (ANC) continues to be an area of interest within the TCN. Simplistically, ANC can be described as the superposition of two pressure waves that leads to attenuation of the combined pressure wave. Although this is true, a simple destructive wave interference approach will generally lead to a localized control solution where a "zone of silence" can be created, but the global energy in the field will actually increase. It has been found that the zone of silence created is typically about 0.1 wavelengths in diameter, so if one considers a frequency of a few hundred hertz in air, this corresponds to a diameter of around 0.1 m. This may be perfectly satisfactory in some cases, but there are numerous applications where one would like to have a larger, even global, region of attenuation.

ANC solutions that provide localized control at discrete frequencies are now relatively straightforward to accomplish. However, achieving more global control is more challenging and requires one to be able to achieve mutual coupling or modal coupling between the unwanted noise source and the control source(s) being used to attenuate the sound field. Although these approaches are generally more difficult to implement, they have the prospect of achieving overall energy reduction, leading to attenuation of the field everywhere or nearly everywhere. For applications where global attenuation is desired, one would ideally minimize the radiated sound power. However, this is not possible to accomplish in real time. Thus these applications generally focus on looking at a model of the radiated sound power and then developing a control implementation that is strongly correlated with minimizing the sound power. Such applications include free-field radiation from fans and vibrating structures as well as attenuating the sound field inside the cabins of vehicles, from automobiles to heavy equipment to interior aircraft noise.

High-amplitude military jet noise is another topic being investigated by members of the TCN. Sound pressure levels radiated from military jets can be very high, with the overall levels at maintainer locations (to the side of the aircraft) exceeding 150 dB at times. The spending on hearing loss compensation for the United States Department of Defense has grown enormously in recent years, with military jet noise being one of the contributors to this trend. Work continues within the TCN to better understand the mechanisms with the generation and propagation of military jet noise. Historically, it was suggested that shocks are radiated from the jet plume. However, recent work has looked at the skewness of the radiated pressure waveforms, and it has been shown that the skewness increases with shock formation, indicating that the nonlinear propagation effects continue to be important even after the shocks form. Neglecting these effects leads to poor modeling of the radiated sound field at large distances.

Recent work with military jet noise has also applied near-field acoustic holography to measured jet noise near the plume of the jet. This technique has been used to successfully map out the two-dimensional radiated sound field as a function of frequency. Such work has been used to help identify effective source regions in the plume where the jet noise is radiating from and has been used to confirm earlier suggestions indicating that for higher frequencies, the effective source region moves closer to the jet nozzle, becomes more contracted, and shifts forward in the directionality of the main lobe of sound radiation.

Military noise is a primary cause of hearing loss among service members. Consequently, efforts to understand the risks of noise exposure and to protect against noise have seen new advances. Impulse noise exposures present an increased risk of hearing loss compared with continuous noise. Occupational noise-damage risk criteria have been developed assuming continuous noises that lack impulsive components. In April 2015, the Department of Defense updated the MIL-STD 1474E Design Criteria Standard Noise Limits (http://goo.gl/Tx5W8Z). MILSTD 1474E incorporates both an equivalent energy method and a model-based method to assess the risk of a particular exposure. Although these methods were originally designed for estimating the risk of damage to the unprotected ear, both approaches allow for the inclusion of a hearing protection device (HPD) to estimate the exposure risk for the protected ear. The equivalent energy method applies the impulse peak insertion loss metric to reduce the free-field exposure to account for the hearing protector. The model-based method applies a distributed-element acoustic representation of the hearing protector to account for transmission through the protector, vibration of the protector, and leakage around the protector. Although the new MIL-STD 1474E is an advance over assigning all protectors a 29-dB reduction, much more research needs to be conducted to validate the performance of hearing protection models in the presence of high-level impulse noise.

Hearing protection is another area where TCN members have advanced our understanding of noise. Over the past several years, various manufacturers have developed fit-testing systems that are fast and accurate assessments of the attenuation an individual receives from his or her HPD. Through the collaboration of manufacturers, government laboratories, academia, and commercial testing laboratories, the American National Standards Institute (ANSI) S12 Accredited Standards Committee for Noise is developing the first standard test method for assessing the personal attenuation rating (PAR) of an HPD. Unlike the noise reduction rating (NRR) that is published on the label of every protector, the PAR tells the user how well she/he has fit the product. Methods to measure PAR range from transmission loss measurements with probe tube microphones to psychoacoustic paradigms utilizing stimulus detection or loudness balance. The HPD fit-testing standard will standardize how the PAR is calculated and allow employers to determine whether their workers are adequately protected when exposed to potentially harmful noise.

Although the TCN is not one of the largest technical committees within ASA, it is a strong and vibrant community that is focused on many interesting and important problems that affect our society. Many of these problems are interdisciplinary in nature, which leads to collaborations by members of the TCN with other subdisciplines within acoustics as well as with others outside the ASA. A quick look at the recipients of ASA awards who are members of the TCN reveals a list of names of talented and respected acousticians who have contributed to the strength of the discipline and the strength of ASA (Richard Lyon, Keith Attenborough, Michael Stinson, and Gilles Daigle to name a few). There has also been a healthy influx of young talented members of the ASA to the TCN, ensuring that the future of the TCN looks to be bright indeed. It is a wonderful opportunity to associate with all of the TCN members.

Disclaimer: *The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention or the National Institute for Occupational Safety and Health.*

Biosketches

Scott Sommerfeldt is a Professor of Physics and dean of the College of Physical & Mathematical Sciences at Brigham Young University. He is the former chair of the Technical Committee on Noise and has an active research program focused on the areas of active noise control and energy-based acoustics.

William J. Murphy is a Captain in the United States Public Health Service Commissioned Corps and is the coordinator of the Hearing Loss Program for the National Institute for Occupational Safety and Health in Cincinnati. He is a Fellow of the Acoustical Society of America, the chair of the Technical Committee for Noise, and the former chair of the ASA's ANSI S12 accredited standards committee on noise. He and his wife, Debbie, have three children. He enjoys music and teaching physics and computer programming for homeschooled students in Lawrenceburg, Indiana.