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Preliminary screening of flow behavior around airfoils using a microphone phased array

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Recently, as a part of research projects for the National Renewable Energy Laboratory (NREL) and Sandia National Laboratories, several full-scale, wind-turbine airfoils were tested at various speeds (high Reynolds numbers) and angles of attack in the Virginia Tech Stability Wind Tunnel. This unique facility is aerodynamically closed and acoustically open, which allows better aerodynamic performance than a free jet facility, while maintaining comparable acoustic performance. Flow measurements consisted of monitoring the surface pressure around the airfoils with a distribution of pressure taps on the airfoil surface. Acoustic measurements were carried out with a microphone phased array. The phased-array data was post-processed to generate acoustic maps of the noise generated by the airfoils exposed to the flow as well as their noise spectra. In addition to the tests, two-dimensional CFD computations of the flow field around the airfoils were carried out using a k-ϵ turbulent model. The acoustic maps clearly show the noise sources generated by potential turbulent flow around the airfoils. The very good correlation between the acoustic maps and the flow characteristics of the airfoils, both numerical and experimental, allows for phased-array measurements to be used as a tool for preliminary screening of the flow behavior around a given airfoil.