The challenges of measuring windshield self-generated wind noise using a practical rotating bar apparatus

By David Robinson, Cirrus Research

Designing a suitable windshield for outdoor noise measurement capable of reducing self-noise whilst not attenuating the measured noise significantly is a challenge for manufacturers of outdoor acoustic equipment. The requirement for limiting self-noise is often specified in standards or tenders, but the method of testing is rarely stipulated, which can lead to uncertainty as different measurement methodologies can provide distinctly differing results.

Ideally testing would be performed at accredited test facilities, which have limited availability so Cirrus tested various options for performing in-house tests, before deciding on developing a rotating bar apparatus. Results from the completed solution were then compared against real life outdoor tests and wind tunnel tests to verify the practicality and accuracy of the results.

Options available for wind speed testing

The obvious way for measuring self-noise generated in a microphone or windshield is a specialised wind tunnel adapted to reduce noise to acceptable levels. After contacting and discussing our requirements with a number of wind tunnel providers it was obvious that most were unsuitable due to the noise levels generated by the fans and the metal ducting.

An alternative option, which Cirrus recently investigated and quickly eliminated, is to support the preamp and windshield assembly on a vehicle and drive at the required speeds whilst measuring noise levels. Road and tyre noise was evident on the sound recordings and the noise levels measured were close to the threshold limits we needed to achieve, suggesting that the test method was creating more noise than the windshield.

Another option for measuring windshield performance is by measurement outdoors, whilst also measuring wind speed. This allows very little control of the test conditions and relies on extended testing to capture a range of wind speeds, making it unsuitable for a designer wishing to test numerous foam sizes, shapes, densities and designs for bird spikes. This is obviously the most suitable method for making real world measurements as it includes typical turbulence conditions and as such was used to compare final results.

After experimenting with the options, it appeared the most practical in-house method for testing self-noise of windshields is to develop a rotating bar apparatus.

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Requirements for self-noise measurements

The requirements for our in-house test system were derived from looking at a number of standards and tenders we had seen recently.

ISO 20906:2009 *Unattended monitoring of airport sound* states that A-weighted noise must not exceed 65dBA at wind speeds of 10m/s (36km/h), whilst some tenders state a level of 60dBA at 8.9m/s. Whilst it is often specified that measurements above 10m/s should be discarded, a system capable of operating at 15m/s would be suitable.

Rotating bar apparatus

The main concern with developing a wind test system is that it will create its own noise. With a rotating bar system, noise will be generated by the motor, gears, bearings and the air interaction upon the rotating bar.

A 3-phase AC induction 1400 rpm motor was used, having no commutators/brushes to generate noise meant that noise would predominately be from the bearings. The motor was coupled to a 10:1 worm drive gear, and the whole assembly mounted in a wooden enclosure, with an acoustic labyrinth arrangement for air inlet and exhaust. Transmission to the rotating bar shaft was made through a rubber v-belt and pulleys, with a slight amount of grease applied to reduce noise.

An extruded aluminium bar typically used in an architectural solar shading system was used for the rotating bar. This was elliptical, 100mm wide, 25mm high and capable of supporting the estimated mass of the preamp and windshield. The typical length of the bar spun from the centre point was 2.6m, requiring a spin rate of approximately 0.63Hz to achieve a speed of 10m/s. Although operators should not be in the near vicinity of the equipment whilst running, the v-belt provides the ability to arrest the bar with minimal effort and therefore damage.

Tests were performed in a local gymnasium, which although not ideal acoustically, provided low ambient noise levels less than 35 db(A). An anechoic chamber would be preferred. Speed of the windshield was measured by timing 10 or 20 rotations and confirmed with a small anemometer. The background noise of the bar and motor were also measured to during operation, and although varies with speed and load were typically less than 40 dBA for the required measurement range. Results using the rotating bar prove very repeatable, with identical setups providing measurements within 1 dBA of each other. See Figure 1.

Whilst the rotating bar equipment proved successful at operating as planned, there are challenges. The belt drive approach does limit the maximum speed of operation with some oversized windshields due to the drag causing the belt to slip.

Testing and comparison against other methods

Initial tests were performed using a range of available foam windshields, consisting of 200mm spheres with differing pore sizes 10, 20, 45 and 80 ppi and two 80mm spheres of 45 and 90ppi foam.

All measurements were made using a Cirrus Optimus SLM and repeated on both the rotating bar equipment and the wind tunnel at the University of Salford's acoustical laboratory. The wind tunnel facility at Salford provides considerable silencing of the fan noise with a 600x800mm metal duct. Ideally the wind tunnel would incorporate an anechoic chamber section to minimise noise reflections in the test area, but whilst it is accepted the wind tunnel facility at Salford was not designed specifically for this purpose the author believes it is amongst the most suitable facilities available within the UK.

Results from the comparison tests for 10 and 80ppi foams are shown in Figures 2 and 3, showing that the spun bar test results are approximately 7dB down from the duct testing over the range of wind speeds tested.

Both sets of results were then compared to outdoor measurements made over several months for the 20ppi foam. Compensating for the foam insertion loss (less than +/-1 dB between 63 to 4kHz) the rotating bar test results correlated better with the outdoor measurements than the wind tunnel confirming that a rotating bar method provides a practical and valid method for measuring self-noise of a windshield.

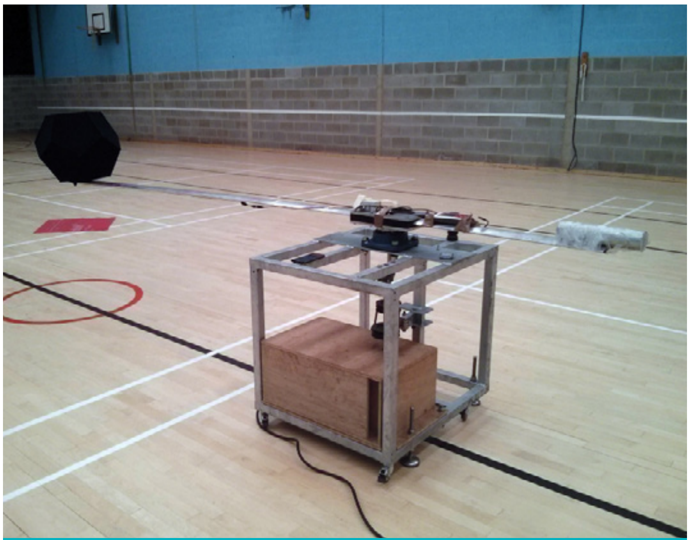

Figure 1 - The rotating bar equipment in the local gymnasium

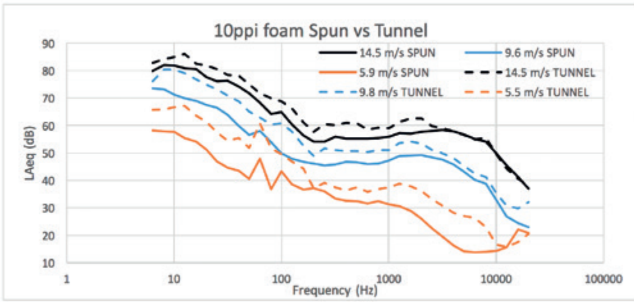

Figure 2 - 10 ppi foam Spun vs Tunnel

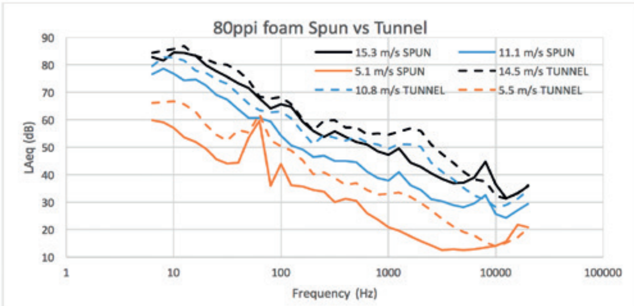

Figure 3 - 80 ppi foam Spun vs Tunnel

A method of testing self-noise is just the initial step for a manufacturer, and helps identify potential issues such as peaks seen at certain frequencies in the results shown. A reliable and repeatable method of testing enables investigation and optimisation of the windshield, which is an ongoing task for manufacturers with ever demanding requirements.

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