OPEN DOOR FLIGHT TEST INVESTIGATION OF CABIN NOISE EXPOSURE IN THE NRC BELL 412 HELICOPTER

Sebastian Ghinet, Andrew Price, Marc Alexander, Anant Grewal, Viresh Wickramasinghe, Eric Chen
NRC Aerospace, Flight Research Laboratory, Ottawa, Canada

1 Introduction

Military helicopter missions involving rappelling, search and rescue, as well as the delivery of payloads and weapons require flight with cabin doors open. The cabin acoustic environment is comprised of noise that is mechanically and aerodynamically generated. In this aircraft configuration cabin noise levels may exceed the limits of aircrew hearing protection equipment. Aircrew cabin noise exposure was investigated in the National Research Council of Canada (NRC) Bell 412 research helicopter with its cabin doors open. The results were compiled to determine the acoustic performance of aircrew hearing protection equipment.

2 Flight test procedure

The objective of the flight test was to characterize the cabin noise exposure of aircrew during typical helicopter maneuvers with cabin doors open. The NRC Bell 412, a civilian variant of the Royal Canadian Air Force's CH-146 Griffon tactical/utility helicopter, was instrumented for the investigation. The aircraft cabin retained its standard manufacturer acoustic treatments. Noise measurements were recorded at three cockpit and aft cabin stations.

Requirements for test instrumentation, as well as procedures for the measurement and reporting of cabin interior sound pressure levels under steady flight conditions were obtained from ISO 5129 [1], ISO 9612 [2], and CSA Z107.56-06 [3] standards. In accordance to ISO 5129, the interior of the aircraft was unaltered with reference to the normal mission configuration. Seat backrests were set to their most upright position, while the number of occupants in the test aircraft was kept to the minimum (3) required to conduct the tests. To eliminate interference of sound propagation, there were no obstructions between the microphone locations and the aircrew positions. The positions of crew members included the pilot-in-command (right seat, cockpit), flight test engineer (left seat, cockpit), and the data acquisition operator (center seat, aft cabin).

Flight test sorties encompassed standard helicopter maneuvers categorized into three groups. Ground interface maneuvers included ground running, take-off, and landing on a paved tarmac. Stationary flight involved hovering in helicopter ground effect at an altitude of 50 feet. Steady airspeed maneuvers included climbing, level, and descending flight. The maximum flight speed and altitude attained during testing were 80 knots and 1800 feet, respectively. Flight conditions for each maneuver were maintained for a minimum of 60 seconds to provide steady acoustic environments suitable for recording. The duration of each sortie was approximately 45 minutes. The test aircraft and instrumentation suite are shown in **Figure 1**.

Figure 1. NRC Bell 412 (Top); Seating Position Microphones (Left); Acoustic Data Acquisition System (Right)

2.1 Flight test instrumentation

Instrumentation integrated into the aircraft included microphones and a recorder. Flight state parameters (such as air data, inertial data, rotor torque and speed) were recorded by the NRC Bell 412 research data acquisition system.

The Teletronics Technology Corp. (TTC MSSR-2010-SAR-2) portable battery-powered recording system was used for acoustic data acquisition. Three PCB Piezotronics microphones (ICP type PCB 378B02 with preamplifier type 426E01) were used for acoustic measurement. These microphones were calibrated according to standard test procedures using a GRAS Type 42AC sound calibrator.

The seated position microphone was located on the seat centreline. In accordance with MIL-STD-1294A, it was oriented with the vertical axis pointed upwards, located at a distance of 0.15m from the headrest, and 0.8 meters above the unoccupied seat cushion. The pilot microphone position was located at the seated pilot head height. With the pilot present and seated, it was located within 0.1 meters of the helmet position. The standing crew microphone position was located at 1.12 meters above the floor, which was equivalent to a seated crew forward leaning position. This microphone location replaced an unrealizable standing position (i.e. 1.65 meters above the floor) due to lack of clearance for a standing crew in the Bell 412 cabin.

2.2 Airworthiness considerations

During this flight test, aircrew wore the SPH 5CF flight helmet. For safety reasons, no sensors were attached directly to aircrew. The TTC MSSR-100C series Miniature Data Acquisition System was deemed a non-essential item for normal flight operations. Additional airworthiness considerations related to the data acquisition system were detailed in Ref [7].

3 Results

3.1 Cabin noise exposure

Sound Pressure Levels at the three cabin-crew stations were measured during a flight test sortie. Pilot noise exposure was evaluated using Insertion Loss data measured in the SPH 5CF flight helmet in accordance to procedures specified in ANSI/ASA S12.42-2010 [5] using the GRAS Acoustic Fixture 45CB.

Both un-weighted and A-weighted Sound Pressure Level (SPL) spectra at the pilot's helmet position in the cockpit for each flight condition are depicted in **Figure 2**. The low frequency region was dominated by the 4/rev harmonic of the main rotor tone. The maximum measured SPL of 120 dB occurred in the 20 Hz 1/3-octave band during both 80 knots level and descending flight conditions. Note that the most significant difference between the closed and open aft cabin door results occurred at the 4/rev frequency which was approximately 10 dB higher in the latter case. The measured A-weighted SPL data revealed a maximum of 92 dBA in the 3.15 kHz band during climbing flight conditions.

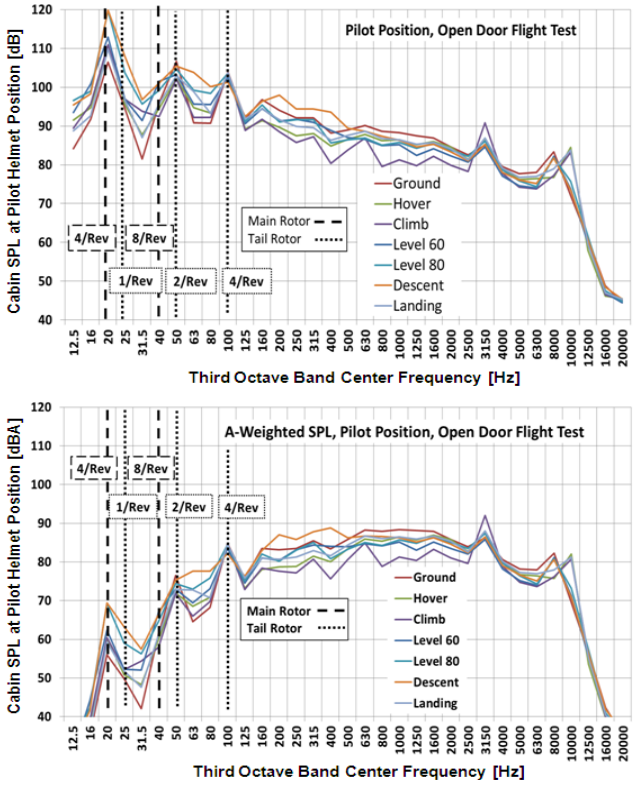

Figure 2. Cockpit Noise Spectra Near the Pilot's Helmet: (Top) Un-weighted SPL, (Bottom) A-weighted SPL

Using the Insertion Loss data for the SPH 5CF flight helmet which was collected during reverberant room testing (**Figure 3),** the maximum sound pressure level exposure for the pilot wearing this flight helmet was estimated to be 72 dBA. This indicates that the helmet provides acceptable attenuation of cabin noise with the helicopter configured with its cabin doors open, and demonstrates that the helmet complies with Canada Labour Code Part II which specifies that the sound level exposure in an aircraft over an 8 hour period should be less than 87 dBA.

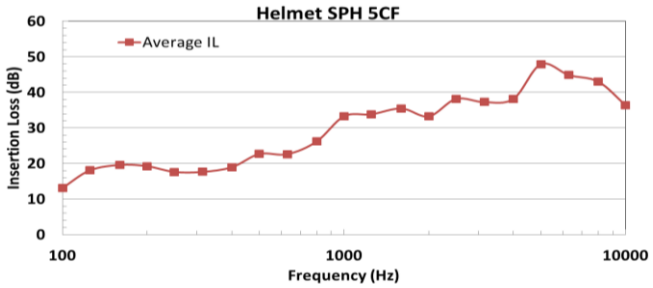

Figure 3. Insertion Loss of the SPH 5CF Flight Helmet.

4 Conclusions

In this investigation, the noise exposure of aircrew was characterized during typical maneuvers with helicopter cabin doors open. Noise levels in the NRC Bell 412 helicopter were measured at cockpit and aft cabin stations. At low frequencies, acoustics were dominated by the 4/rev main rotor tone for most flight conditions. The maximum SPL (120 dB in the 20 Hz 1/3-octave band) was measured during both level and descending flight. In the higher frequency range, the maximum A-weighted SPL (92 dBA at the 3150 Hz band) was measured during climbing flight. Pilot noise exposure for the SPH 5CF flight helmet, estimated using Insertion Loss data, demonstrated that this helmet provided acceptable attenuation cabin noise in compliance with the Canada Labour Code, Part II.

Acknowledgments

The authors are grateful to NRC Aerospace helicopter test pilots Stephan Carignan and Timothy Leslie for their valuable contributions during this investigation.

References

[1] ISO 5129:2001, Acoustics - Measurement of sound pressure levels in the interior of aircraft during flight.

[2] ISO 9612:2009, Acoustics - Determination of occupational noise exposure - Engineering method.

[3] CSA Z107.56-06, Procedures for the measurement of occupational noise exposure.

[4] MIL-STD-1294A, Acoustical noise limits in helicopters

[5] ANSI/ASA S12.42-2010, Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real-Ear or Acoustic Test Fixture Procedures.

[6] Canada Labour Code, Department of Justice Canada

[7] S. Ghinet, A. Price, M. Alexander, A. Grewal, V. Wickramasinghe, Y. Chen, "Closed door flight test investigation of cabin noise exposure in the NRC Bell 412 helicopter," Canadian Acoustics Week, 2014.