INVESTIGATION OF GROUND AND MAINTENANCE CREW NOISE EXPOSURE FOR THE ROYAL CANADIAN AIR FORCE CH-147F HELICOPTER

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1 Introduction

Helicopter ground and maintenance personnel, in addition to helicopter aircrew, are exposed to high noise levels while working inside and around aircraft. The noise environment may include tonal rotor noise, high frequency engine, transmission and hydraulic systems noise as well as broadband noise. Prolonged exposure may lead to hearing loss if the designated hearing protection is inadequate or improperly fitted. A thorough interior and exterior noise level measurement campaign was conducted on the Royal Canadian Air Force's CH-147F helicopter. A number of representative operational states for maintenance and tarmac conditions were investigated and referenced to the Canadian Aviation Occupational Health and Safety Regulations. The results were analyzed to determine the acoustic performance of ground maintenance crew hearing protection equipment.

2 Flight Test Procedures and Equipment

The objective of the flight test was to measure interior cockpit and cabin noise levels, exterior tarmac noise levels and aircrew whole body vibration exposure during typical aircraft manoeuvres. The CH-147F Chinook helicopter was outfitted with nine interior microphones, 18 interior accelerometers and eight exterior microphones were held on the tarmac. The aircraft was operated in open door and closed door configurations. The ground measurements took place in the open door configuration.

ISO 5129 [1] and MIL-STD-1294A [2] were the primary standards followed for the measurement procedure. The two standard procedures outlined requirements for microphone locations, measurement conditions and testing procedures. Details of the flight test plan and microphone configuration may be reviewed in Ref [3].

2.1 Instrumentation

The microphones were mounted at a standing height as per ISO 5129 on fixed hard-mount stands and fitted with windscreens. Each stand and cable combination was managed by a ground crew member whilst in the vicinity of the running aircraft. The approximate locations of the sensors are shown in Figure 1 and Figure 2. The microphone locations are labelled in Figure 1. The eight locations on the starboard side of the helicopter are the exterior ground measurement locations. The remaining locations are interior measurements which will not be discussed in this paper.

The helicopter exterior noise data was collected using an LMS SCADAS front end, eight ICP Piezotronics 378B02 microphones and a Dell precision M6500 laptop workstation. Post processing was completed in LMS Test.Lab.

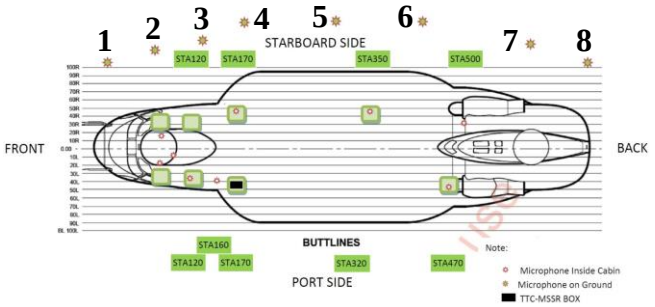

Figure 1: CH-147F Measurement Locations [3]

Figure 2: Exterior Noise Measurement

3 Results

A number of measurements were completed during the aircraft's standard start up procedure. It was found that the microphones situated near the stern of the aircraft experienced higher sound pressure levels (SPL).

3.1 Measurement Conditions

The measurement conditions of interest are shown in Table 1.

Table 1: Measurement Conditions

ID	Description
1	Exterior Background Noise
2	Auxiliary Power Unit (APU) ON, Avionics ON
3	APU ON, Engine Setting: Idle
4	APU ON, Engine Setting: Flight
5	APU OFF, Engine Setting: Flight

3.2 Aircraft Exterior Noise Levels

Condition 4 (APU ON, Engine Setting: Flight) exhibited the highest noise levels. The 3rd octave band results for Condition 4 have been shown in Figure 3.

Figure 3: Condition 4, Linear Weighting

The Mic5 and Mic6 positions were dominantly louder in the lower frequencies of the measurement. These locations were underneath the tips of both the front and rear rotors whose nominal rotation speed was 225 RPM. The Mic7 and Mic8 experienced greater broadband high frequency noise as they were nearest the engine outlet.

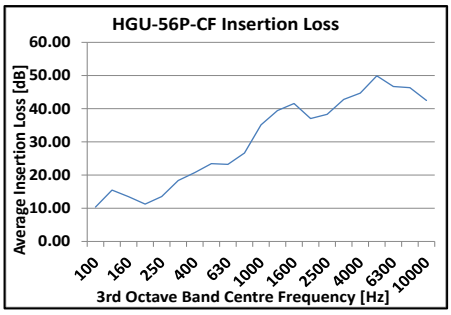

Figure 4: HGU-56P-CF Insertion Loss [5]

The performance of the HGU-56P-CF helmet was tested in the NRC acoustic chamber facilities and the mean insertion loss has been shown in Figure 1. The helmet exhibited better attenuation at higher frequencies.

The results from Figure 3, with A-weighting, helmet attenuation and windscreen correction factors applied, are shown in Figure 5. The helmet insertion loss attenuates the majority of the high frequency engine noise. The majority of the remaining noise is associated with the low frequency main rotor harmonics.

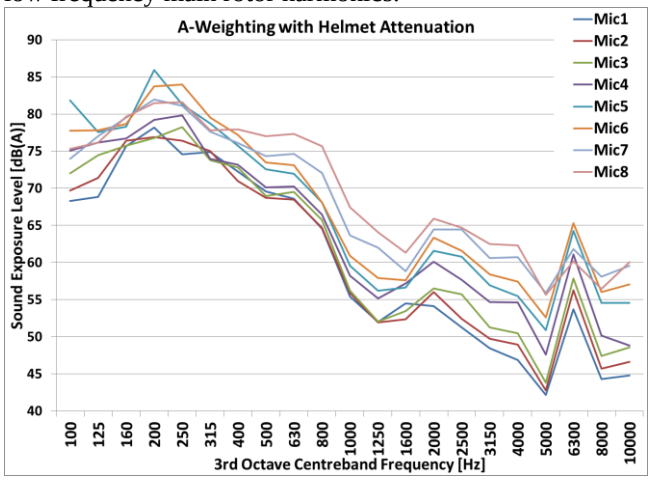

Figure 5: Condition 4, A-Weighting and Helmet Attenuation

The overall SPL for Condition 4 with linear weighting, A-weighting and the HGU-56P-CF helmet attenuation at the eight microphone positions surrounding the helicopter have been shown in Table 2.

Table 2: Condition 4 Overall SPL

Mic #	L-Weighted [dB]	A-Weighted [dB(A)]	Helmet [dB(A)]
1	112.97	105.73	83.48
2	114.82	106.96	84.08
3	117.59	108.18	84.61
4	120.72	111.29	86.33
5	123.37	113.50	89.81
6	123.14	115.14	88.86
7	120.32	115.07	87.75
8	119.65	115.60	88.63

The highest overall SPL (after applying the attenuation of the helmet) was 89.81 dB(A) at the Mic5 position during Condition 4. In accordance with the Canadian Aviation Occupational Health and Safety Regulations (within the Canada Labour Code) a worker may be exposed to 90 dB(A) for a maximum of four hours [4].

Without helmet attenuation the highest overall SPL was 115.60 dB(A). At 116 dB(A) a worker reaches their maximum exposure limit in 36 seconds [4]. Therefore, a correctly fitted helmet is vital under these circumstances.

4 Conclusions

The HGU-56P-CF helmet satisfies the Canadian Labour Code for work around the Canadian Forces CH-147F aircraft with a few caveats:

1. A more detailed assessment of a standard work day's activities (and their associated noise) may be required to ensure safe working limitations.
2. The HGU-56P-CF is currently providing attenuation on the order of 20 dB. Improper fittings or adjustment and removal due to discomfort will greatly impact a worker's exposure level and safety.

Considering the high level noise environment, active noise cancellation may be added as a simple solution to improve the HGU-56P-CF helmet attenuation in the low frequency range as the main rotor harmonic noise is static and tonal within the low frequency regime.

Acknowledgments

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References

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[5] S. Ghinet, "Acoustic Test Evaluation of DND Pilot Helmets," Flight Research Laboratories, Aeroacoustics Lab NRC, Ottawa, 2014.