AEROSPACE – AEROACOUSTICS AND STRUCTURAL DYNAMICS

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# CABIN NOISE ASSESSMENT OF THE NRC DASSAULT FALCON AIRCRAFT THROUGH FLIGHT TESTING

Volume 1 of 1

Report No: LTR-FRL-2016-0067

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## Executive Summary

The NRC Dassault Falcon 20 is a small business jet powered by two General Electric CF700 jet engines. Currently the Falcon serves as a customizable research facility with a focus on research pertaining to microgravity. As such, standard Flight Research Laboratory operations with the NRC Falcon include flying parabolas. The NRC Aeroacoustics and Structural Dynamics group was tasked with evaluating the noise levels associated with the standard operation of the NRC Falcon 20 aircraft.

Cabin noise measurements were performed on the NRC Falcon in-flight during a variety of representative flight conditions. The data was analyzed in the narrow frequency bands and 3$^{rd}$ octave bands in accordance with ISO 5129 standard. Previously evaluated hearing protector noise attenuation data for the David Clark 40699G-01 headset was used in combination with the Sound Pressure Levels measured at different locations in the cabin to calculate the exposure limits of aircrew during the different flight conditions in accordance with the Canadian Aviation Occupational Health and Safety Regulations.

It was found that the primary tonal components of the noise environment are due to the N1 and N2 fan speeds of the two engines. Additional low frequency noise components were measured with the largest portion attributed to a “beat” phenomenon arising when two noise sources occur at similar but ultimately slightly different frequencies, primarily due to two engines operating at slightly different speeds.

All aircrew (pilots and cabin occupants) onboard the NRC Falcon wear standard David Clark headsets for hearing protection and communication. It was found that, with the exception of the Mic4 location, all aircrew equipped with properly fitted hearing protection will not be exposed to their maximum allowable noise exposure limit within a 24 hour period according to the Canadian Aviation Occupational Health and Safety Regulations. For aircrew with properly fitted hearing protection, located at the Mic4 location, during the Take-Off and Acceleration to 300 KIAS conditions, they will reach their maximum noise exposure in 10 cumulative hours. Worded differently, an occupant seated at the Mic4 location with properly fitted hearing protection will need to experience 10 hours of the take-off flight condition within one 24 hour period to reach their maximum noise exposure dose.

Without hearing protection, in accordance with the Canadian Aviation Occupational Health and Safety Regulations, aircrew seated at the starboard side of the rear cabin (Mic4 position) will reach their maximum noise exposure in a cumulated 9 minutes 36 seconds of the Acceleration to 300 KIAS condition. The remaining positions will reach their maximum noise exposure at 24 minutes or later depending on the flight condition.

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# 1. INTRODUCTION

The evaluation of noise levels experienced by aircrew is essential for the determination of noise exposure and the selection of optimum hearing protectors. Research operations such as micro-gravity, environmental measurements and aerial photography may produce a variety of different flight conditions in addition to the standard steady level flight completed by most business and commercial jets. It is important to evaluate the potential for adverse health effects with regards to personnel hearing during this range of flight maneuvers.

The NRC Dassault Falcon 20 is a small business jet powered by two General Electric CF700 jet engines. Currently the Falcon serves as a customizable research facility with a focus on research pertaining to microgravity. This report presents the results of the flight measurement performed on the NRC Dassault Falcon 20 jet registration C-FIGD, on July 9$^{th}$ and July 10$^{th}$, 2015. Sound Pressure Levels (SPL) were measured at six aircrew stations within the cabin and cockpit of the aircraft during a standard microgravity flight profile. The results were compiled to determine the noise exposure of aircrew in accordance with the Canadian Aviation Occupational Health and Safety Regulations.

NRC aircrew (pilots and cabin occupants) are often subject to flight tests lasting up to 3 hours while completing a research project. Due to the varied and demanding nature of research projects, Hearing Protectors (HP) may or may not be in use for the duration of the flight. Consequently, it becomes important to understand the noise environment of the aircraft cabin and cockpit to quantify any associated risk of adverse health effects related to hearing.

**Figure 1: NRC Dassault Falcon**

# 2. HEARING PROTECTION SOLUTIONS

The hearing protection performance of a variety of commercial and military hearing protectors have been assessed in the Hearing Protectors Performance Evaluation Facility at NRC. The insertion loss performance in various frequency bands was quantified and used in conjunction with various aircraft frequency spectra. The evaluated hearing protectors include the Gentex SPH-5CF, Gentex HGU-56P-CF and Gentex MK10R helmets as well as the 40600G-15, 40600G-20, 40699G-01, 40725G-01 and 40411G-19 David Clark Headsets.

The majority of the David Clark headsets were fitted with Active Noise Reduction (ANR) electronic circuits for active noise control. Analysis included measurements with both the ANR turned on and the ANR turned off. Therefore both the passive (ANR off) and active (ANR on) insertion loss performance of the headsets was quantified.

For details of the hearing protection test procedure and performance of the various hearing protectors please refer to LTR-FRL-2015-0045 (Cabin and Exterior Noise Assessment of the RCAF CH-147F Helicopter Through Flight and Ground Testing) Section 2 [1].

The 40699G-01 David Clark headset with ANR turned off was selected for representative analysis and reporting purposes. Typical use of the NRC Dassault Falcon employs the David Clark H10-13h headset without ANR. The 40699G-01 David Clark headset average Insertion Loss (IL) may be viewed below in Table 1 and Figure 2.

**Table 1: 40699G-01 Headset IL**

| Frequency [Hz] | Insertion Loss [dB] | Std Dev. [dB] |
|---|---|---|
| **100** | 7.02 | 2.20 |
| **125** | 13.78 | 2.16 |
| **160** | 16.14 | 1.46 |
| **200** | 19.36 | 0.67 |
| **250** | 22.11 | 0.71 |
| **315** | 23.95 | 0.64 |
| **400** | 26.77 | 0.79 |
| **500** | 30.33 | 0.85 |
| **630** | 32.77 | 0.73 |
| **800** | 33.40 | 0.57 |
| **1000** | 36.37 | 0.73 |
| **1250** | 39.95 | 0.87 |
| **1600** | 40.76 | 1.10 |
| **2000** | 39.08 | 1.16 |
| **2500** | 38.29 | 1.96 |
| **3150** | 40.44 | 1.86 |
| **4000** | 46.92 | 2.16 |
| **5000** | 43.64 | 1.00 |
| **6300** | 41.11 | 1.53 |
| **8000** | 39.59 | 1.32 |
| **10000** | 36.02 | 2.59 |

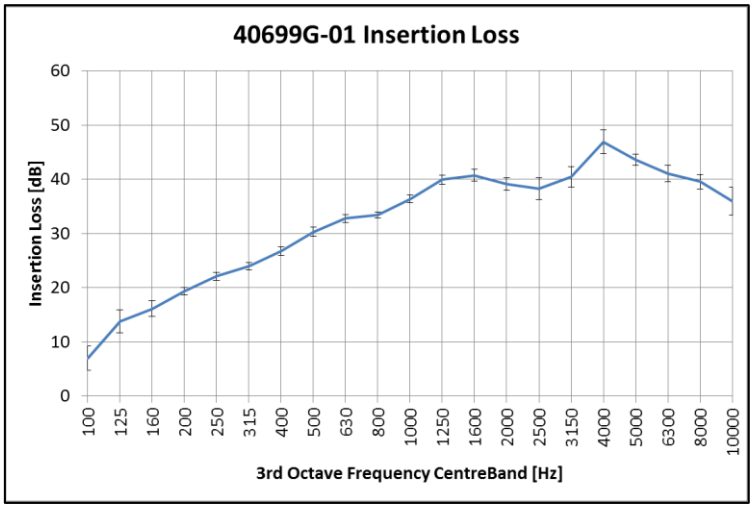



**Figure 2: 40699G-01 David Clark Headset Average Insertion Loss**

# 3. FLIGHT MEASUREMENT PROCEDURE

A portable Data Acquisition System (DAS) was installed onboard with a suite of microphones, coaxial cables and microphone mounts to record in-flight noise measurements. Additionally, a custom DAS rack was used for collecting engine and flight instrument data from the aircraft. The two systems operated independently.

The in-flight measurements were performed during static flight conditions in accordance with ISO 5129:2001 [2] and ISO 9612:2009 [3]; additionally CSA Z107.56-06 [4], and the Canadian Occupational Health and Safety Regulations [5] were referenced.

The overall acoustic sensitivities of the measurement system were determined using a GRAS Type 42AC piston phone sound calibrator (Class 1) prior to and after the flight measurements.

## 3.1. Aircraft Interior Preparation

The NRC Dassault Falcon has many different interior configurations as a broad spectrum of different types of research has been completed onboard. A large number of research projects are related to the operation of various mechanisms as well as personnel training in micro-gravity. Sometimes the equipment undergoing test/evaluation is also a noise producer; such noise sources are beyond the scope of this test program. To provide some context as to the cabin variation: Seats may be removed to accommodate a testing apparatus, equipment racks may be installed or a more conventional passenger jet configuration may be adopted. The installation of large reflective surfaces (such as an equipment rack) or absorptive material (such as a cushioned seat) will both have large effects on the noise environment in an enclosed cabin.

ISO 5129 requires an aircraft interior unaltered with respect to its normal mission configuration. To that end a cabin configuration including multiple passenger seats, one floor to ceiling equipment rack and a section of cabin with removed seats was selected to reflect a typical NRC FRL research mission as shown in Figure 3.

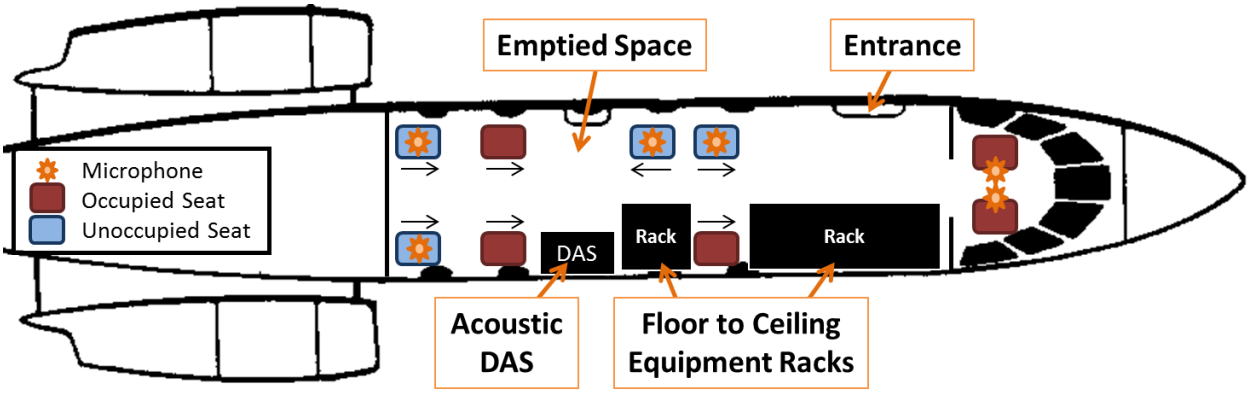



**Figure 3: NRC Dassault Falcon Cabin Configuration for the Acoustic Noise Measurement**

The flight measurement crew was limited to five aircrew. The aircrew tasks (and positions) include the pilot-in-command (cockpit, portside seat), the co-pilot (cockpit, starboard seat), the flight engineer (forward cabin, starboard seat), a test occupant (rear cabin portside seat) and the acoustic DAS operator (rear cabin, starboard seat).

In accordance with ISO 5129, the measurement microphones were affixed with custom designed mounts and windscreens to reduce measurement interference. A total of six PCB Piezotronics microphones (PCB 378B02) were used for the acoustic measurement.

Four microphones, labelled Mic 1 through Mic 4, were positioned at unoccupied cabin locations. These microphones were located on the seat centreline and oriented with their vertical axis pointing up. Referencing MIL-STD-1294A [6], the microphones were placed 0.15 m forward of the headrest and 0.8 m above the unoccupied seat cushion. The mounting method for microphones located in the cabin is shown in Figure 4 [Left]. The unoccupied seats had their backrests set to the most upright position with a microphone and stand installed. The orientation of the cabin seats (forward facing or aft facing) has been depicted in Figure 3 by arrows placed next to the seat location. Two microphones labelled Mic 5 and Mic 6 were positioned 0.1 m from the typical ear position of the pilot and co-pilot where speech communication is normally received. The mounting method for the microphones located in the cockpit is shown in Figure 4 [Right]. All six microphone locations are depicted in Figure 5.

**Figure 4: [Left]: Cabin seat microphone installation with the windscreen removed [Right]: Cockpit seat microphone installation**

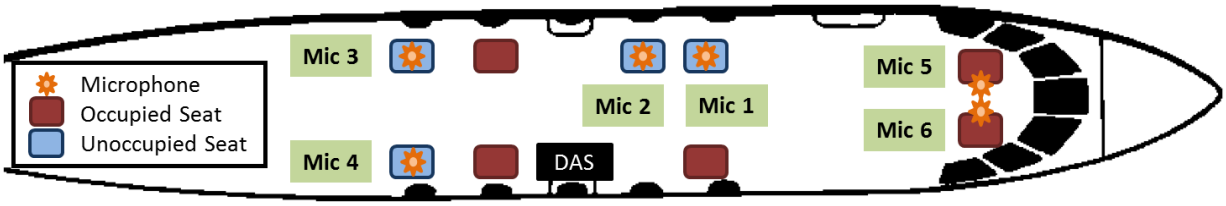



**Figure 5: Microphone Locations**

The portable DAS used for data collection was installed midway in the cabin on the starboard side. The mounting method for the DAS is shown in Figure 6.

**Figure 6: Mounting method for the Acoustic DAS**

The six measurement microphones were calibrated using a G.R.A.S. Type 42AC Pistonphone calibrator, serial number: 249332. The ground level pressure was 99.7 kPa. A complete list of the instrumentation and equipment involved in the flight measurement has been shown in Table 2.

**Table 2: Instrumentation Calibration List**

| Ch # | Description Mfg. & Model | Serial # | Calibration Equipment | Calibrated Sensitivity |
|---|---|---|---|---|
| M4 | Microphone, PCB, 378B02 | 112238 | Pistonphone | 50.40 |
| M5 | Microphone, PCB, 378B02 | 112243 | Pistonphone | 46.28 |
| M6 | Microphone, PCB, 378B02 | 112246 | Pistonphone | 49.89 |
| M7 | Microphone, PCB, 378B02 | 116051 | Pistonphone | 49.45 |
| M8 | Microphone, PCB, 378B02 | 117872 | Pistonphone | 45.48 |
| M9 | Microphone, PCB, 378B02 | 117886 | Pistonphone | 50.65 |
| - | Laptop, Dell | CSTT 0130 | - | - |
| - | DAS, TTC | FRL14035 | - | TTC-MSSR |

The instrumentation calibration quality form has been included on page 20 as Figure 9. This form contains additional information including the calibration data and calibration expiration date.

### 3.2. Flight Measurement Plan

The adopted flight sequence was chosen to represent a typical NRC Dassault Falcon microgravity research flight profile. Additionally, a number of common maneuvers that were suspected of increased noise levels (such as acceleration and deceleration in-air) were included.

The various flight conditions have been listed in Table 3. The conditions are organized in the order they were completed on the flight test day. Conditions 6, 9, 10 and 13 (Steady Level Flight and Parabolas) are common conditions of interest for research projects.

Each flight condition aimed for 60 seconds of steady-state data acquisition. However, some flight conditions are inherently transient (Parabolas, Take-Off, Landing etc), therefore data was acquired continuously.

Additionally, Table 3 contains information collected by the independent NRC flight data recorder. Throughout the flight measurement a maximum airspeed of 414 knots, a maximum altitude of 17210 ft and a maximum engine pressure ratio of 1.59 were recorded.

It should be noted that the values contained within Table 3 are only representative of the recorded flight parameters. Every parameter fluctuated throughout the flight condition as adjustments were made. The steady state conditions such as R6: Steady Level Flight and R7: Acceleration to 300 KIAS represented conditions with mostly stable engine parameters. Other conditions, including R4: Take-Off and R9: Parabola (1) exhibited larger variations of flight parameters throughout the test condition.

**Table 3: In-Flight Measurement Procedure**

| Run # | Description | Altitude [ft] | Airspeed [kts] | Left N1 [%] | Right N1 [%] | L EPR | R EPR |
|---|---|---|---|---|---|---|---|
| **1** | Engine Run Up | - | - | - | - | - | - |
| **2** | Taxi, cockpit window open (1) | 390 | - | 57.64 | 52.62 | 1.065 | 1.064 |
| **3** | Taxi, cockpit window closed (1) | 398 | - | 52.47 | 45.48 | 1.063 | 1.063 |
| **4** | Take-off | 384 | 146 | 102.1 | 101.6 | 1.585 | 1.545 |
| **5** | Climb | ~2358 | 217 | 97.49 | 96.39 | 1.452 | 1.431 |
| **6** | Steady Level Flight (1) | 15993 | 276 | 91.72 | 92.07 | 1.414 | 1.396 |
| **7** | Acceleration to 300 KIAS | 15999 | 352 | 98.01 | 98.84 | 1.560 | 1.541 |
| **8** | Deceleration to 200 KIAS | 15942 | 341 | 91.1 | 88.84 | 1.227 | 1.209 |
| **9** | Parabola (1) – Set up → | [~10K – | 334 | 88.48 | 86.89 | 1.437 | 1.462 |
| | Parabola (1) – Micro-Gravity → | ~18K] | 300 | 85.35 | 81.68 | 1.235 | 1.139 |
| **10** | Parabola (2) – Set up → | [~10K – | 318 | 100.2 | 99.83 | 1.509 | 1.548 |
| | Parabola (2) – Micro-Gravity → | ~18K] | 262 | 83.35 | 81.51 | 1.215 | 1.155 |
| **11** | Descent (1) | ~10622 | 310 | 81.22 | 82.19 | 1.128 | 1.111 |
| **12** | Descent (2) | ~7432 | 270 | 81.24 | 81.11 | 1.114 | 1.116 |
| **13** | Steady Level Flight (2) | 2146 | 168 | 82.51 | 78.48 | 1.151 | 1.120 |
| **14** | Approach (1) | 1428 | 156 | 79.78 | 69.51 | 1.109 | 1.080 |
| **15** | Low and Over | 948 | 138 | 80.8 | 71.77 | 1.114 | 1.084 |
| **16** | Approach (2) | 1752 | 144 | 83.94 | 81.99 | 1.178 | 1.156 |
| **17** | Landing | 421 | 111 | 48.62 | 46.53 | 1.062 | 1.063 |
| **18** | Taxi, cockpit window closed (2) | 381 | - | 51.88 | 47.66 | 1.063 | 1.063 |
| **19** | Taxi, cockpit window open (2) | 397 | - | 52.39 | 46.15 | 1.063 | 1.063 |

*N1, turbine stage 1 fan speed. *EPR, engine pressure ratio.

# 4. FLIGHT MEASUREMENTS DATA ANALYSIS

The Sound Pressure Levels (SPL) at six cabin and cockpit stations were measured during the flight measurement campaign during 19 different conditions. Different analysis methods were employed to analyze the collected acoustic data.

The Power Spectral Density (PSD) of each condition was first considered for higher resolution narrow frequency band analysis. The Overall Sound Pressure Levels (OSPL) at each station were calculated.

The un-weighted, windscreen corrected, SPL in 1/3$^{rd}$ octave bands was investigated for each flight condition. Additionally this information was provided for each condition in tabular format for further analysis and the application of eventual weighting techniques.

The A-weighted SPL in 3$^{rd}$ octave bands were investigated for each crew station during each flight condition. Afterwards, each flight condition was analyzed in the context of aircrew wearing hearing protection by using the insertion loss of the 40699G-01 David Clark headset. These results are shared as “hearing unprotected” and “hearing protected by 40699G-01” to represent the exposure of an individual onboard the Falcon without a headset and with a headset respectively.

The OSPL were calculated as well for A-weighted SPL frequency spectra (both with and without the 40699G-01 insertion loss). These A-weighted OSPL were used to calculate the maximum duration limit of exposure per occupant per 24 hour period. A value is shared in H:M:S (Hours:Seconds:Minutes). This value is the maximum amount of time any one individual may remain exposed to that specific noise environment before accumulating a “potentially hazardous exposure level of sound on board the aircraft” [5]. This time is cumulative with other flight conditions. For example:

> *Flight Condition A has a maximum exposure duration of 2 hours.*
> *Flight Condition B has a maximum exposure duration of 1 hour.*
> *An occupant may remain exposed to…*
> - *Condition A for 2 hours (100% Exposure), OR*
> - *Condition B for 1 hour (100% Exposure), OR*
> - *Condition A for 1 hour (50%) and Condition B for 0.5 hours (50%), OR*
> - *Condition A for 0.5 hours (25%) and Condition B for 0.75 hours (75%)*
> - *Etc*

Continue to section 0 for the detailed analysis of each flight condition. In this section the overall SPL will be evaluated for the various flight conditions.

## 4.1. Overall Sound Pressure Levels without Hearing Protection

The OSPL data for aircrew without hearing protection at each measurement station during each of the 19 flight conditions have been displayed in Figure 7. The OSPL displayed in Figure 7 represent a worst case scenario of aircrew exposed to the noise environment of the aircraft without hearing protection. Moreover, the presented OSPL are also applicable in other situations such as:

- Aircrew with improperly fitted hearing protectors
- Aircrew who temporarily removed their hearing protectors (due to discomfort, readjustment, to listen to an aircraft noise source to verify functionality etc)

It is important to recognize that the aforementioned cases do not represent the entirety of situations for which the data displayed in Figure 7 is applicable. Any situation wherein aircrew are exposed to potentially harmful levels of noise should be addressed appropriately to mitigate the possibility of hearing damage. This includes the installation of research equipment producing potentially harmful levels of noise as this will significantly alter the Falcon cabin interior noise environment and potentially reduce the cumulative maximum noise dose exposure limit for different flight conditions.

The data presented in Figure 7 can be used to calculate the noise exposure of any individual based on the flight sequences and location of the individual. The black horizontal lines superimposed on the figure represent the Canadian Aviation Occupational Health and Safety noise dose limits for a set sound pressure level of broadband continuous noise. At 90 dB, an aircrew will receive their full noise exposure dose within 4 hours.

It can be observed in Figure 7 that an aircrew stationed at the Mic4 station without properly fitted hearing protection will be at risk of hearing damage after 9 minutes and 36 seconds of cumulated flight condition 7 (Acceleration to 300 KIAS).

It is significant to note that the relatively large variations (4 dB) in noise levels between the Mic3 and Mic4 locations occurred during conditions R4: Take-Off and R7: Acceleration to 300 KIAS. R4 and R7 represent high power engine conditions. Furthermore, the two parabolas (R9 and R10) require interchanging high power and low power engine conditions; these conditions also exhibited a variation of 2 dB between the Mic3 and Mic4 locations. While the entire aircraft cabin and cockpit are naturally dependent on the engine power settings, the Mic4 location in particular exhibited a higher sensitivity to the engine power settings. The floor to ceiling equipment rack installed on the starboard side of the cabin is likely a significant factor in this sensitivity increase by providing a reflecting surface to create an open enclosure along the aisle. Contrary to this configuration, there are more available routes for the noise energy to dissipate on the port side of the cabin (Mic3). The potential sensitivity of the cabin noise

environment to the inclusion of the equipment rack further supports the necessity of assessing research equipment of concern installed onboard the Falcon jet on a case by case basis.

It can be observed that the Pilot and Co-pilot microphone locations (Mic5 and Mic6) consistently exhibited the lowest sound pressure levels (with a few exceptions). This is intuitive as the Mic5 and Mic6 locations are located the furthest from the aircraft engines and additionally are isolated from the cabin shell vibration and resonant modes. One notable exception was recorded during condition R2: Taxi, cockpit window open (1).

The final point of interest can be seen at condition R14: Approach. Mic5 did not follow the downward trend of the other microphone locations. The Mic5 (portside cockpit) location contains an additional noise spike at 2915 Hz as seen in Figure 88 - Figure 91. This noise spike is also observable to a lesser extent at the Mic6 (starboard cockpit) and Mic1 (forward cabin). This spike is due to the radar altimeter indicator beep as the aircraft passed down through approximately 200 feet altitude. The indicator beep lasted less than 2 seconds but was in close proximity to Mic5 and thus significantly affected the Mic5 noise environment recording.

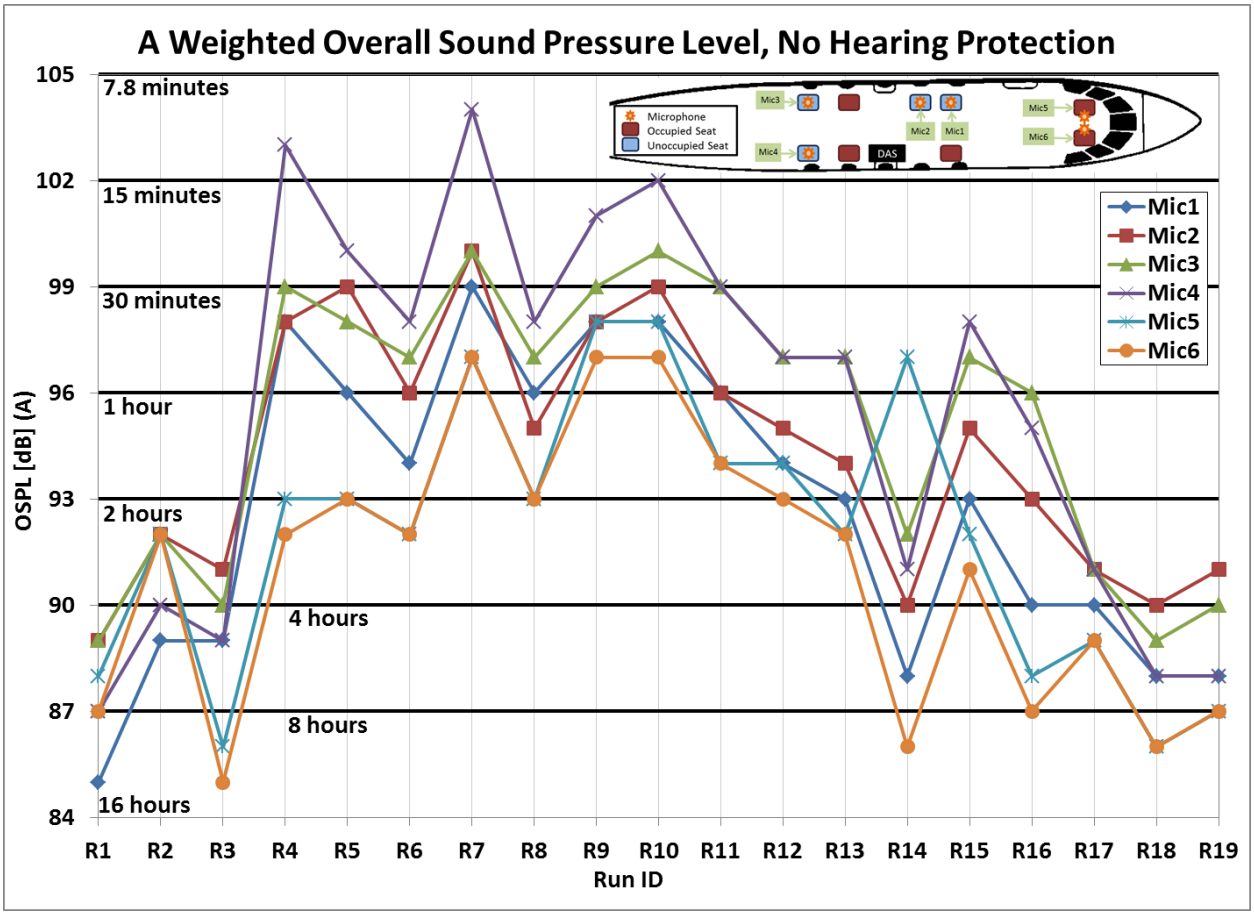



**Figure 7: A-Weighted Overall Sound Pressure Levels, No Hearing Protection**

## 4.2. Overall Sound Pressure Levels with Hearing Protection

The OSPL data for aircrew wearing the 40699G-01 headset at each measurement station during each of the 19 flight conditions have been displayed in Figure 8. This presented data is only applicable when aircrew are wearing properly fitted hearing protection.

It can be observed in Figure 8 that an aircrew stationed at the Mic4 station with a properly fitted 40699G-01 David Clark headset will be at risk of hearing damage after 10 hours for cumulated flight condition R4 (Take-off) and R7 (Acceleration to 300 KIAS). However, as these conditions commonly form a minor portion of the total flight duration, it would not be expected that the aircrew would be exposed to potentially damaging noise exposure limits.

The primary condition of interest is the R10: Parabola (2) condition. As the NRC Falcon jet routinely performs multiple parabolas for various research projects, these may form a significant portion of the flight duration. However, it should be noted that 16 hours of parabolas to reach the maximum exposure limit is not a realistic order of magnitude.

The difference in sound pressure levels, discussed previously, between the Mic3 and Mic4 location can be observed for aircrew wearing the 40699G-01 David Clark headset. More precisely, the difference in sound pressure levels has increased to 7 dB during condition R7 (Acceleration to 300 KIAS) as it can be observed in Figure 8. This is due to the fact that the 40699G-01 headset is more effective at attenuating high frequency noise energy. As the most dominant noise energy is contained within the 160 Hz 1/3$^{rd}$ octave band, it was not attenuated to the same extent as the higher frequency bands by the 40699G-01 headset.

It can be observed that the Mic3 (forward cabin), Mic5 and Mic6 (cockpit locations) all experienced a noise environment that was attenuated to below 81 dB for every flight condition. According to the Canadian Aviation Occupational Health and Safety regulations, there is no maximum time limit exposure for these locations. The Mic1 and Mic2 positions exhibited 82 dB only at one flight condition each, with their remaining conditions all at 81 dB or lower.

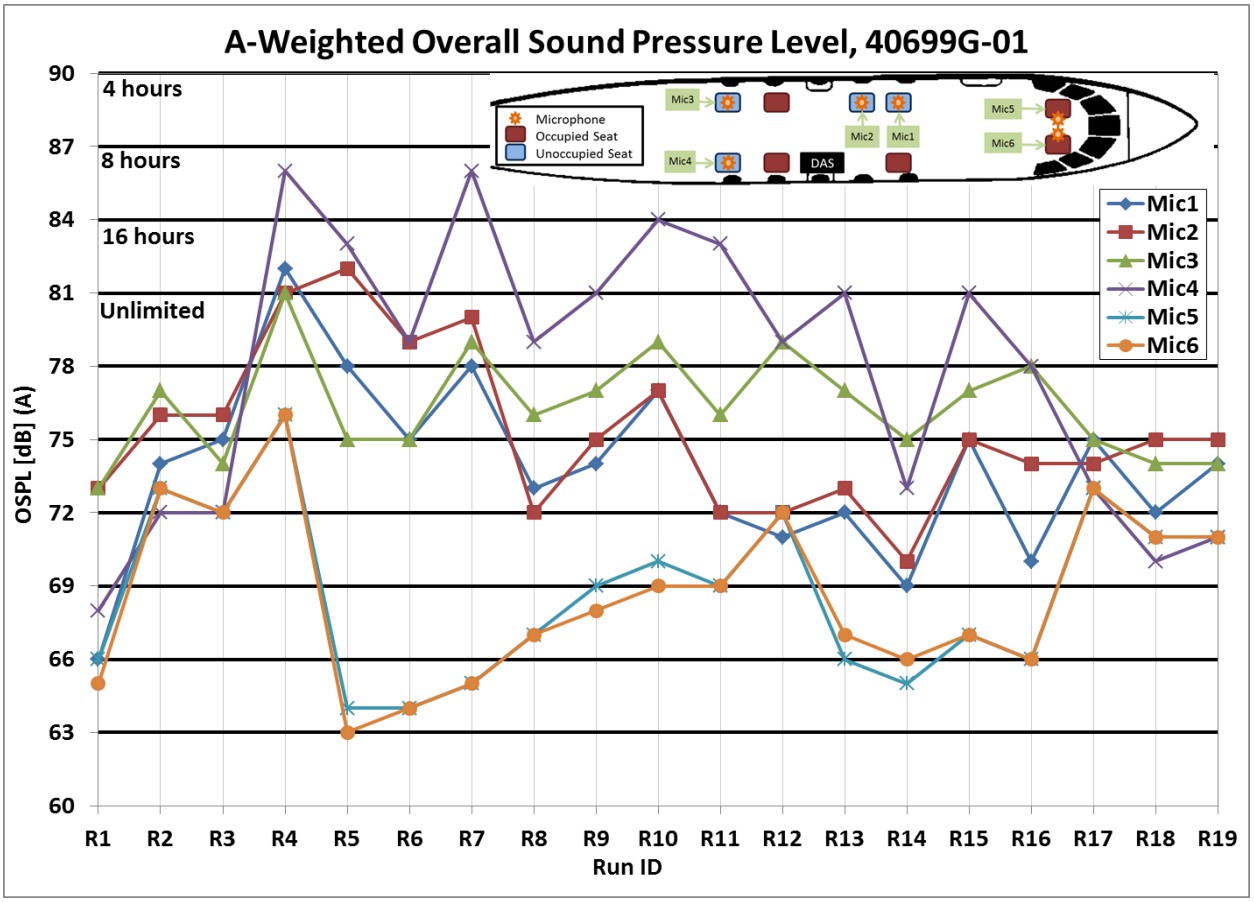



**Figure 8: A-Weighted Overall Sound Pressure Levels, 40699G-01 David Clark Headset**

Two dominant noise sources consistently appear for each flight condition. These noise sources are observable in the Power Spectral Density plots shown in Section 0.

The first noise source occurs at 1-2 Hz. It is likely that this noise source is associated with the slight RPM difference between the NRC Falcon's portside and starboard jet engines. This phenomenon is referred to as a "beat". Beats occur when the difference in frequency between two noise sources is small. For example, should the NRC Falcon's portside jet engine's low pressure fan be operating at 7500 RPM (125 Hz) while the starboard jet engine's low pressure fan was operating at 7560 RPM (126 Hz) a "beat" would occur at a frequency of modulation of (126 – 125)/2 = 0.5Hz which is perceived by the human ear as a the double frequency of the modulating sine e.g. 126 – 125 = 1Hz. This is explained by the insensitivity of the human ear to the sound phase. This is further corroborated by the fact that this 1-2 Hz frequency noise source is more prevalent in steady state flight conditions. During a steady state flight condition, the engines will have more opportunity to settle into a steady RPM.

During the take-off, landing, parabolas or any other conditions where the engine speed fluctuates, the "beats" are less prevalent. All pilot and cabin crewmember locations

experienced this phenomenon at a comparable sound pressure level (all values were within a range of 2 dB unweighted for the majority of the runs). At 2 Hz the wavelength is an order of magnitude longer than the aircraft's largest dimension and therefore each crewmember location would experience similar noise levels. However, it is generally accepted that the audible human range for a human is 20 Hz – 20 kHz; additionally, A-weighting is used as a standard weighting curve for analysis (as per ISO 5129). After A-weighting is applied, the risk of hearing damage associated with the NRC Falcon jet 2 Hz noise source becomes negligible.

The second dominant noise source manifested itself as two single tones with the first located within the range of ~100 to ~150 Hz varying depending on the flight condition; while the second tone was located within the range of ~200 to ~280 Hz. These two tones correspond with the low pressure and high pressure stages of the NRC Falcon engine. The NRC Falcon has two General Electric CF700 turbofan jet engines with two fan stages and two fan stage maximum continuous rotation speeds of 16,500 RPM and 9000 RPM.

The relationship between engine speed and the noise tones is most evident during the take-off flight condition as seen in Figure 28. This condition demonstrates a variation in engine speeds (reducing the effect of the "beat" phenomenon discussed earlier) but also demonstrates primarily high engine speeds. During this condition, the first tone was located at 152.75 Hz (9.165 RPM) with an amplitude in excess of 100 dB for the cabin occupants and approximately 96.5 dB for the two pilot locations. The second tone was located at 279.25 Hz (16,755 RPM) with an amplitude range of 90 – 105 dB for the cabin occupants and 80 dB for the pilot locations.

The N1 values shared in Table 3 represent the current RPM of the high speed gas turbine compressor as a percentage of the maximum continuous RPM (16,500 RPM). The left and right N1 values were 102.13% (16,851 RPM) and 101.58% (16,761 RPM) respectively for the R4: Take-Off condition. Both of these values are well within 1% of the measured tone located at 279.25 Hz (16,755 RPM).

It appears that the amplitude of these tones is not simply or directly correlated to the engine speed. After applying A-weighting, these two tones represent a dominant source of noise energy for the aircrew occupants.

# 5. EXAMPLE FLIGHT PROFILE CUMULATIVE MAXIMUM NOISE EXPOSURE

Based on the measured OSPL for each microphone location during each flight condition, the cumulative maximum noise exposure dose may be calculated in accordance with CSA Z107.56-06 [4], CSA Z94.2-14 [7] and the Canadian Aviation Occupational Health and Safety Regulations [5]. Based on the duration and flight profile of the Falcon flight measurement performed on July 10th and based on previous experience, the following example flight profile is proposed:

**Table 4: Example Flight Profile**

| | Flight Condition | Duration (minutes) | Description |
|---|---|---|---|
| 1 | Engine Start | 10 | Time spent after start-up before taxiing |
| 2 | Taxi | 5 | Taxi to runway and await take-off clearance |
| 3 | Take-Off | 1 | - |
| 4 | Climb | 5 | Approximate time spent to reach 16,000 ft |
| 5 | Steady Level Flight | 10 | Travel to flight test area |
| 6 | Parabolas | 30 | Perform 30 minutes' worth of flight testing |
| 7 | Steady Level Flight | 15 | Return to airport, also includes time spent in circuit |
| 8 | Descent | 5 | At some time, descent to circuit height will occur |
| 9 | Landing | 1 | - |
| 10 | Taxi | 5 | Clear runway and return to hanger for shutdown |
| 11 | Shutdown | 0 | - |

The OSPL data for the relevant flight conditions for each microphone location may be used in conjunction with the method outlined in CSA Z94.2-14: "Hearing protection devices – Performance, selection, care and use" [7] and CSA Z107.56-06 [4]. The standards outline the Octave-band procedures to calculate the cumulative maximum exposure dose when accounting for A-weighting and hearing protection.

The equivalent A-weighted sound level $L_{Aeq}$ is defined as the following [4]:

$$L_{Aeq,t} = 10log_{10}\left(\frac{1}{100}\sum P_i 10^{\frac{L_{eq,i}}{10}}\right)$$

- $P_i$ represents the estimated average percentage of time spent on the $i^{th}$ activity
- $L_{eq,i}$ represents the measured A-weighted sound level for the $i^{th}$ activity

The $L_{Aeq,t}$ is an indicator for the overall exposure of an individual who was exposed to a number of discrete independent noise conditions. As the various flight conditions have unique noise spectrums the $L_{Aeq,t}$ is a metric to assess the combination of these different flight conditions.

In accordance with CSA Z107.56-06 [4], the respective noise dose for a given $L_{Aeq,t}$ is calculated as follows:

$$\text{Dose} = 100\left(\frac{T}{8}\right)10^{\frac{(L_{Aeq,t}-L_c)}{10}}$$

- *T* represents the duration of the measurement in hours (cumulative duration of all the flight conditions)
- $L_c$ represents the criterion sound level in dB(A); a constant sound level which, if it continues for the criterion duration, will result in an individual's allowable noise exposure. 85 dB(A) is typical for most jurisdictions [4]. 87 dB(A) is in accordance with the Canadian Aviation Occupational Health and Safety Regulations [5].

The noise dose represents the percentage of noise exposure an individual has reached while working in a specific noise environment. Based on the flight profile outlined in Table 4, the noise dose for each microphone location was calculated with and without hearing protection. In accordance with the Canadian Aviation Occupational Health and Safety Regulations an $L_C$ of 87 dB(A) was used in the noise dose calculation.

**Table 5: Calculated Noise Dose with and without Hearing Protection for Table 4**

| Noise Dose | Mic1 (Portside Fwd-Cabin) | Mic2 (Portside Mid-Cabin) | Mic3 (Portside Aft-Cabin) | Mic4 (Starboard Aft-Cabin) | Mic5 (Portside Cockpit) | Mic6 (Staboard Cockpit) |
|---|---|---|---|---|---|---|
| **Without Hearing Protection** | 131% | 161% | 200% | 281% | 111% | 94% |
| **With the 40699G-01 Headset** | 1% | 2% | 1% | 4% | 0% | 0% |

Based on the results of Table 5, aircrew and flight crew equipped with properly fitted hearing protection will not experience their maximum cumulative noise exposure dose within a 24 hour period. This conclusion is stated with the following caveats:

1. The results assume the flight profile outlined in Table 4
2. The cabin noise environment flight profile only contains conditions identical to or with lower intensity than the flight conditions measured in this report
3. The 40699G-01 David Clark headset hearing protection (or similar) is properly fitted and worn throughout the entire flight
4. The noise level to which the aircrew and flight crew were exposed in this measurement did not account for the sound pressure levels added by the intercommunications system

Additionally, based on the results of Table 5, it is likely that aircrew and flight crew will reach and exceed their maximum noise exposure dose within one flight while not equipped with hearing protection. It is this report's recommendation that flight crew and air crew operate with hearing protection while onboard the NRC Dassault Falcon 20.

It must be noted that the Dassault Falcon 20 aircraft is a civilian commercial aircraft with the intention that the passengers in the cabin do not require hearing protection during standard use of the aircraft. The results of this measurement campaign, however, show that hearing protection is required to avoid exceeding the maximum allowable cumulative noise exposure dose for a relatively standard microgravity flight. Based on further investigation, it is likely that the NRC Dassault Falcon interior cabin experiences a higher noise level than the original configuration because a large portion of the interior cabin furnishings and insulation have been removed for research purposes.

Removal of chair coverings, carpet and floor coverings, and interior wall insulation surfaces reduces sources of absorption for acoustic energy. The additional installation of equipment racks and mechanical systems will provide both additional noise sources and more reflective surfaces to increase the acoustic energy within the cabin. Finally, maneuvers such as parabolic flight are inherently louder than steady level flight conditions for most cabin locations. This type of extreme flight maneuvers and alterations of the cabin interior from the original configuration may have contributed to an increased level of cabin sound pressure levels.

# 6. CONCLUSION AND REMARKS

This report presented the compiled results of a flight measurement onboard the NRC Dassault Falcon 20 aircraft with the objective of evaluating the noise exposure of aircrew and research project personnel at cabin and cockpit locations. The sound pressure levels were evaluated at 6 distinct cabin and cockpit locations for a total of 19 representative flight conditions.

Power Spectral Density (PSD) results were initially evaluated for a detailed high resolution understanding of the aircraft noise environment behaviour. Next, the A-weighted Sound Pressure Levels (SPLs) at each workstation were investigated in 1/3$^{rd}$ octave bands. A standard representative David Clark Headset (40699G-01) was selected for contextual analysis. The Overall Sound Pressure Levels (OSPL) were also calculated, which in turn were used to calculate the noise exposure maximum time durations as defined in the Canadian Aviation Occupational Health and Safety Regulations.

Without hearing protection, in accordance with the Canadian Aviation Occupational Health and Safety Regulations, a crew member seated at the Starboard Aft-Cabin location (Mic4 position) will reach the maximum noise exposure limit in 9 minutes 36 seconds cumulated during flight segment R7: Acceleration to 300 KIAS. The remaining positions will reach their cumulative permitted maximum noise exposure at 24 minutes or later depending on the flight condition. This condition represents the worst case scenario in regards to the acoustic noise spectrum recorded during the NRC Falcon noise measurement campaign. It is not expected that research operations will commonly operate at conditions similar R7: Acceleration to 300 KIAS for extended periods of time.

While wearing hearing protection, specifically the David Clark 40699G-01 headset (without active noise control), in accordance with the Canadian Aviation Occupational Health and Safety Regulations, an aircrew seated at the Starboard Aft-Cabin location (Mic4 position) will reach their maximum noise exposure in 10 hours cumulated during flight segments R4: Take-Off and R7: Acceleration to 300 KIAS conditions. The remaining microphone positions exhibited unlimited exposure limitations for all flight conditions with two minor exceptions at R4 and R5.

While it is necessary to calculate personnel noise exposure based on the amount of time spent within each flight condition, it was observed that aircrew of the NRC Falcon could operate during any flight condition for periods of time longer than 24 hours without reaching the maximum exposure duration at any of the workstations indicated as Mic1, Mic2, Mic3, Mic5 and Mic6 positions when the occupant is wearing properly fitted hearing protection.

At extremely low frequencies (on the order of 1-2 Hz), the NRC Falcon exhibited the presence of a significant source of noise energy. This was likely associated with a RPM

difference between the two engines. It did not appear to be directly associated with the recorded EPR or N1 parameters, but appeared to be most prevalent in steady state conditions. While this low frequency hum was quite distinct, after the application of A-weighting as required by standard ISO 5129:2001(E), the Canadian Aviation Occupational Health and Safety Regulations and other noise calculations standards, it was shown to not represent a hearing safety risk.

Specific Power Spectral Density (PSD) plots for each flight condition showed, at frequencies above the “beating” behaviour at 1-2 Hz, that two dominant tones are present and directly related to the low pressure and high pressure compressor stages of the NRC Falcon CF700 jet engine. These tones vary in frequency based on the recorded engine parameter values of the aircraft during each flight condition. The correlation between the recorded N1 values and the second tone’s location is highest during steady state flight conditions.

The amplitude of these tones represent a significant source of noise energy and can be observed as being the dominant of the SPL of hearing un-protected and protected A-weighted spectra.

An example flight profile for typical use of the NRC Dassault Falcon 20 was drafted based on this flight measurement and previous experience. Based on this example flight profile, it is likely that air crew and flight crew without hearing protection will reach their cumulative maximum noise exposure dose for a 24 hour period within a single flight. When equipped with a properly fitted David Clark 40699G-01 headset, the noise dose was reduced considerably. It is unlikely that aircrew and flight crew equipped with properly fitted hearing protection of similar or better performance to the 40699G-01 David Clark Headset will exceed their cumulative maximum noise exposure dose through typical use of the NRC Dassault Falcon 20 aircraft in accordance to the limits set by the Canadian Aviation Occupational Health and Safety Regulations. Therefore, it is recommended that all flight crew and air crew wear hearing protection while onboard the NRC Dassault Falcon 20 at all times.

The recommendation for hearing protection onboard the NRC Dassault Falcon 20 is due to the fact that the modified cabin configuration for research purposes experiences higher sound pressure levels than the original commercial configuration. The unique noise environment of the NRC Dassault Falcon 20 cabin is a product of the removal of various furnishings and acoustic absorptive materials, the installation of various noise generating equipment systems and the nature of the extreme flight profiles flown during microgravity research projects.

# 7. REFERENCES

[1] S. Ghinet, "Cabin and Exterior Noise Assessment of the RCAF CH-147F Helicopter Through Flight and Ground Testing," National Research Council, Ottawa, 2015.

[2] International Organization for Standardization, "Acoustics - Measurement of Sound Pressure Levels in the Interior of Aircraft During Flight," ISO 5129:2001(E), Switzerland, 2001.

[3] International Organization for Standardization, "Acoustics - Determination of occupational Noise Exposure - Engineering Method," ISO 9612:2009, Switzerland, 2009.

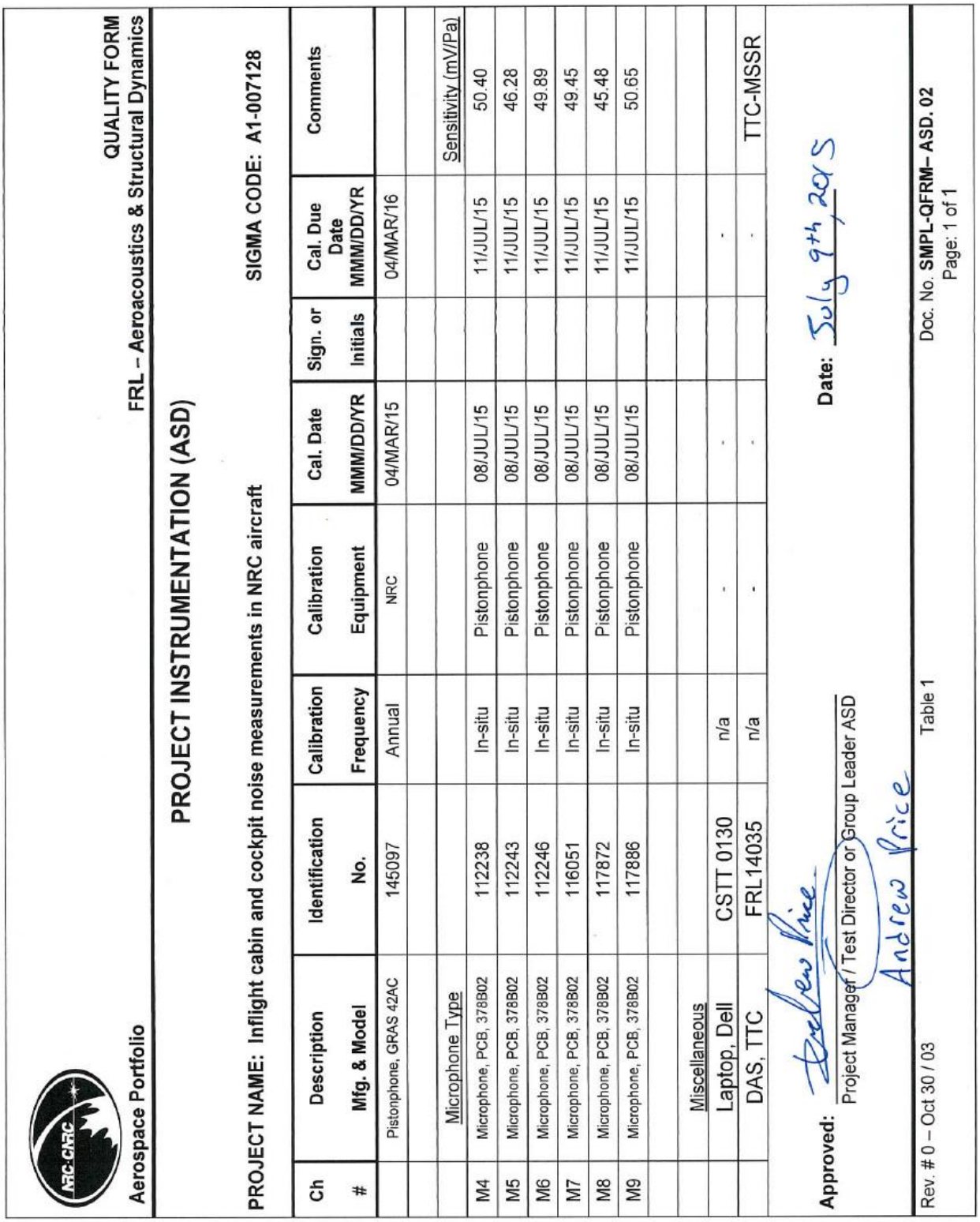
[4] Canadian Standards Association, "Measurement of Occupational Noise," CSA Z107.56-06, Canada, 2006.

[5] "Aviation Occupational Health and Safety Regulations - Part 2: Levels of Sound," Minister of Justice, Canada, 2015.

[6] MIL-STD-1294A, "Acoustical Noise Limits in Helicopters," Military Standard, Department of Defense, United States of America, Washington, D.C., 1985.

[7] Canadian Standards Association, "Hearing Protection Devices - Performance, selection, care, and use," CSA Z94.2-14, Toronto, Ontario, Canada, December 2014.

# 8. PROJECT INSTRUMENTATION QUALITY FORM



NRC·CNRC
Aerospace Portfolio

QUALITY FORM
FRL – Aeroacoustics & Structural Dynamics

**PROJECT INSTRUMENTATION (ASD)**

**PROJECT NAME: Inflight cabin and cockpit noise measurements in NRC aircraft** **SIGMA CODE: A1-007128**

| Ch # | Description Mfg. & Model | Identification No. | Calibration Frequency | Calibration Equipment | Cal. Date MMM/DD/YR | Sign. or Initials | Cal. Due Date MMM/DD/YR | Comments |
|---|---|---|---|---|---|---|---|---|
| | Pistonphone, GRAS 42AC | 145097 | Annual | NRC | 04/MAR/15 | | 04/MAR/16 | |
| | | | | | | | | |
| | Microphone Type | | | | | | | Sensitivity (mV/Pa) |
| M4 | Microphone, PCB, 378B02 | 112238 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 50.40 |
| M5 | Microphone, PCB, 378B02 | 112243 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 46.28 |
| M6 | Microphone, PCB, 378B02 | 112246 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 49.89 |
| M7 | Microphone, PCB, 378B02 | 116051 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 49.45 |
| M8 | Microphone, PCB, 378B02 | 117872 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 45.48 |
| M9 | Microphone, PCB, 378B02 | 117886 | In-situ | Pistonphone | 08/JUL/15 | | 11/JUL/15 | 50.65 |
| | | | | | | | | |
| | Miscellaneous | | | | | | | |
| | Laptop, Dell | CSTT 0130 | n/a | - | - | | - | |
| | DAS, TTC | FRL14035 | n/a | - | - | | - | TTC-MSSR |

**Approved:** Andrew Rice **Date:** July 9th 2015

Project Manager / Test Director or Group Leader ASD

Andrew Rice

Rev. # 0 – Oct 30 / 03 Table 1 Doc. No. **SMPL-QFRM– ASD. 02**
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**Figure 9: ASD Project Instrumentation Quality Form**

# 9. DETAILED ANALYSIS OF FLIGHT MEASUREMENTS

This section reviews each flight segment measurement in greater detail. This section contains primarily 3rd octave data and power spectral density data as well as a description of their prominent features. For access to the measured time traces or narrowband data please contact the Aeroacoustics and Structural Dynamics group of the Flight Research Laboratory NRC.

## 9.1. [R1]: Engine run up

The PSD results are shown in Figure 10. Tonal behavior with the highest PSD level located at 123.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 11. This segment exhibits a maximum SPL of 103 dB in the 125 Hz 1/3rd octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 12. This segment exhibits a maximum SPL of 86 dB(A) at the 125 Hz 1/3rd octave band. A maximum overall SPL of 89 dB(A) was measured at both the mid (Mic 2) and rearmost (Mic 3) portside cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 13. This segment exhibits a maximum SPL of 73 dB(A) at the 125 Hz 1/3rd octave band. A maximum overall SPL of 73 dB(A) was measured at both the mid (Mic 2) and rearmost (Mic 3) portside cabin locations.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 14. A maximum duration of 5 hours cumulated during flight segment [R1]: Engine run up during a 24 hour period for hearing-unprotected aircrew was exhibited at the mid (Mic 2) and rearmost (Mic3) portside cabin locations.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 15. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 5 hours without hearing protection at any location within the cabin during this flight segment to reach their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

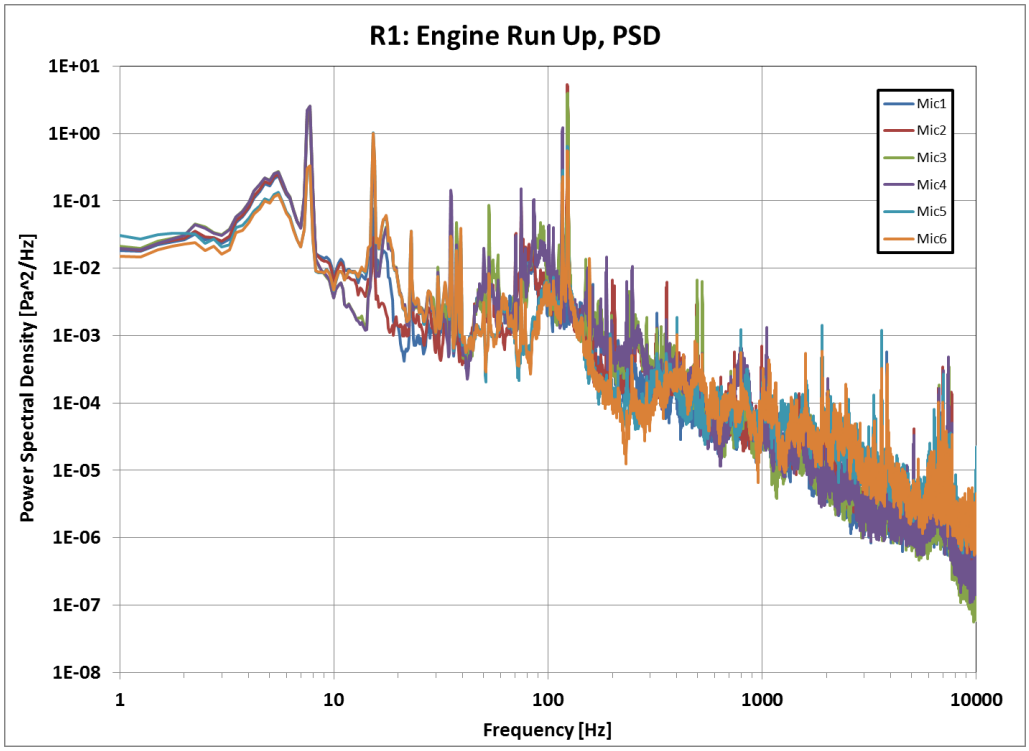


**Figure 10: Power Spectral Density for Run 1: Engine Run Up**

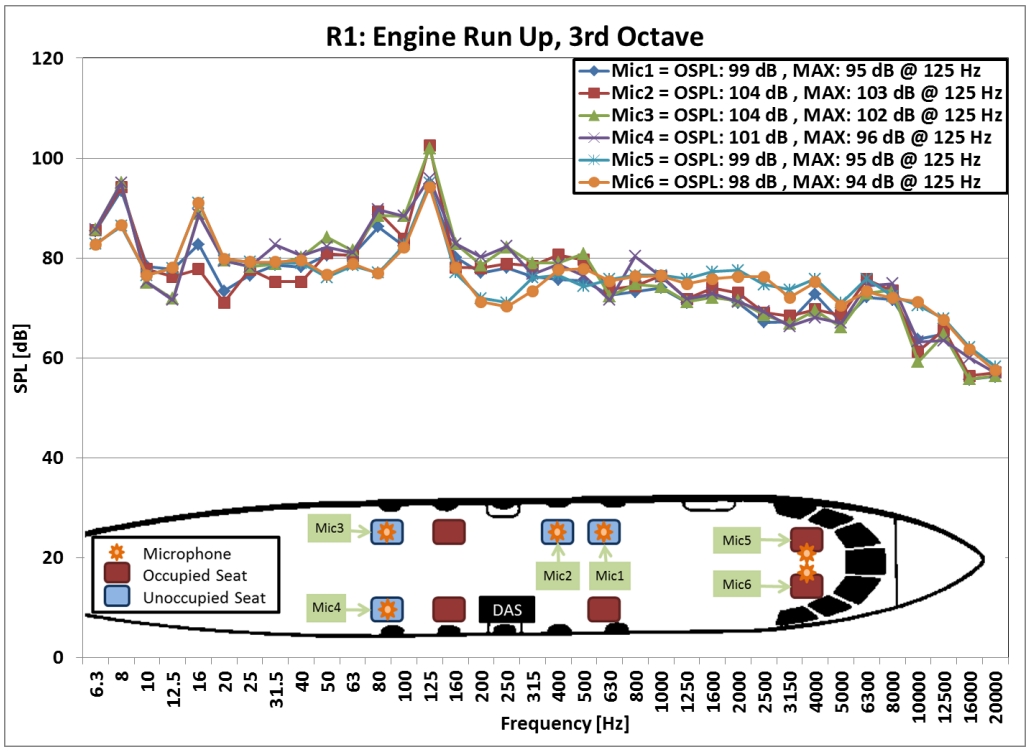


**Figure 11: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 1: Engine Run Up**

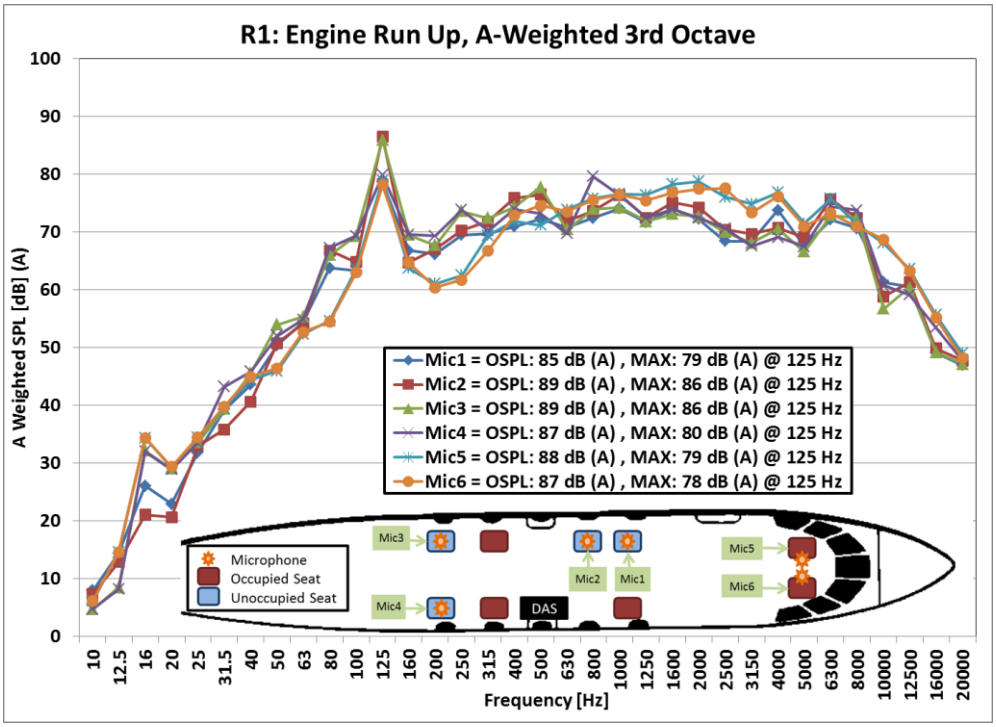


**Figure 12: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 1: Engine Run Up**

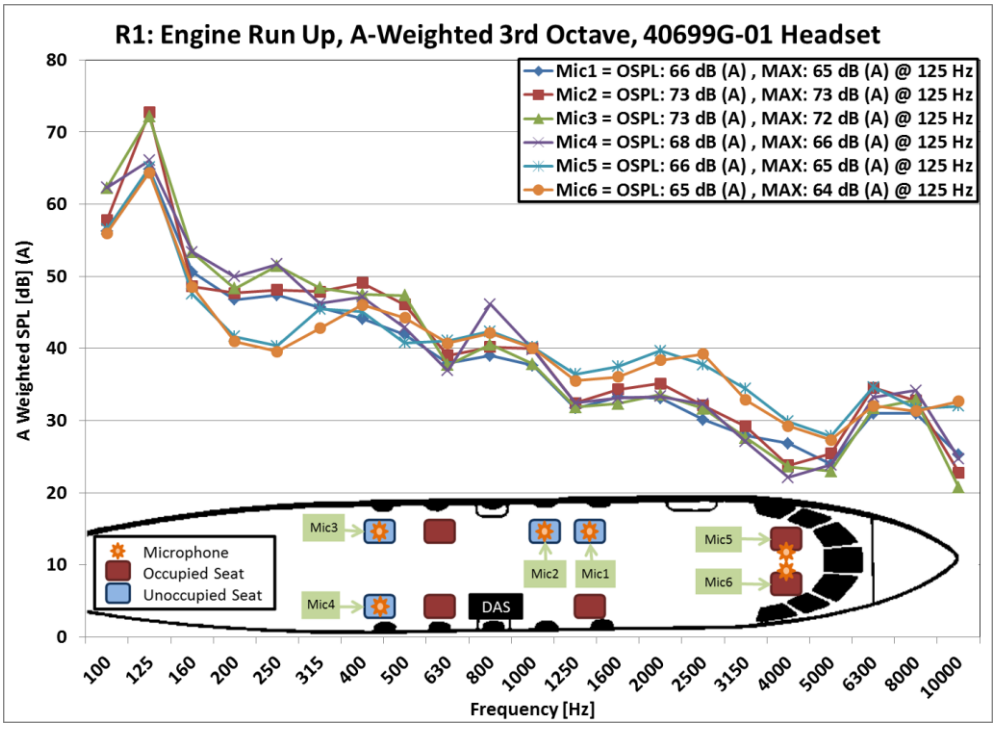


**Figure 13: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 1: Engine Run Up**

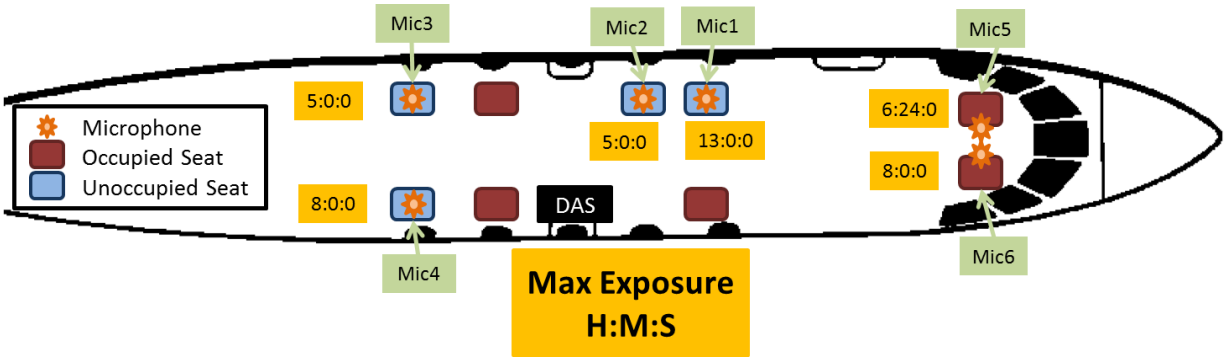


**Figure 14: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 1: Engine Run Up**

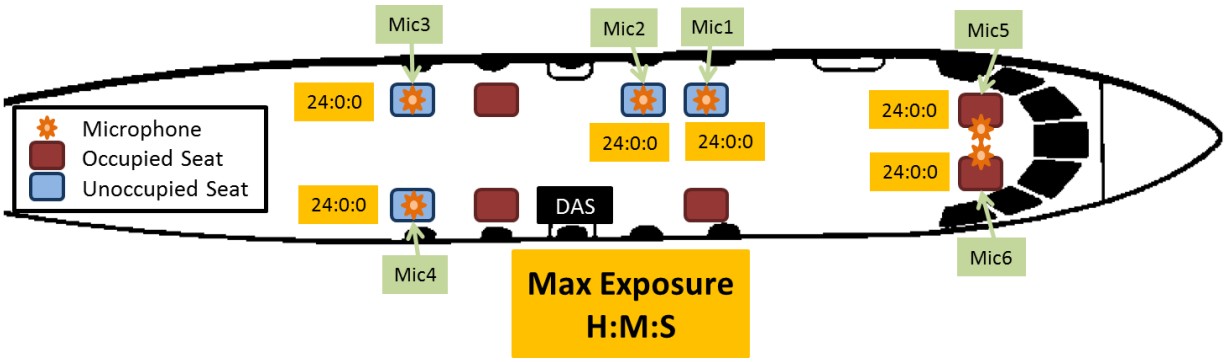


**Figure 15: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 1: Engine Run Up**

**Table 6: Engine Run Up 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| **Frequency [Hz]** | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 85.351 | 85.555 | 85.731 | 85.716 | 82.791 | 82.632 |
| **8** | 93.492 | 94.206 | 95.059 | 95.006 | 86.370 | 86.640 |
| **10** | 78.328 | 77.742 | 75.091 | 75.169 | 76.524 | 76.529 |
| **12.5** | 77.757 | 76.243 | 71.877 | 71.594 | 77.953 | 78.040 |
| **16** | 82.745 | 77.780 | 88.853 | 88.725 | 91.095 | 91.057 |
| **20** | 73.396 | 71.114 | 79.498 | 79.389 | 79.724 | 79.865 |
| **25** | 76.526 | 77.675 | 78.297 | 78.239 | 79.190 | 79.206 |
| **31.5** | 78.644 | 75.235 | 78.772 | 82.639 | 78.915 | 79.209 |
| **40** | 78.166 | 75.235 | 80.138 | 80.456 | 78.985 | 79.537 |
| **50** | 80.555 | 80.922 | 84.153 | 82.231 | 76.112 | 76.621 |
| **63** | 80.589 | 80.396 | 81.494 | 81.059 | 78.501 | 78.867 |
| **80** | 86.267 | 89.237 | 88.474 | 89.711 | 77.071 | 76.931 |
| **100** | 82.372 | 83.879 | 88.391 | 88.406 | 82.640 | 82.089 |
| **125** | 94.719 | 102.598 | 102.020 | 95.929 | 94.990 | 94.231 |
| **160** | 80.129 | 78.138 | 82.849 | 82.905 | 77.079 | 78.070 |
| **200** | 77.037 | 77.950 | 78.567 | 80.210 | 71.922 | 71.257 |
| **250** | 78.084 | 78.842 | 82.156 | 82.392 | 71.065 | 70.289 |
| **315** | 76.225 | 78.431 | 78.956 | 76.790 | 76.020 | 73.366 |
| **400** | 75.693 | 80.662 | 79.051 | 78.709 | 76.626 | 77.622 |
| **500** | 75.443 | 79.636 | 80.883 | 76.422 | 74.327 | 77.805 |
| **630** | 72.601 | 73.728 | 72.349 | 71.606 | 75.763 | 75.398 |
| **800** | 73.209 | 74.399 | 74.746 | 80.351 | 76.568 | 76.323 |
| **1000** | 74.010 | 76.396 | 74.219 | 76.245 | 76.566 | 76.443 |
| **1250** | 71.051 | 71.801 | 71.209 | 71.791 | 75.808 | 74.849 |
| **1600** | 73.009 | 74.057 | 72.104 | 72.855 | 77.277 | 75.795 |
| **2000** | 71.009 | 72.997 | 71.463 | 71.214 | 77.551 | 76.232 |
| **2500** | 67.091 | 69.060 | 68.670 | 69.289 | 74.707 | 76.236 |
| **3150** | 67.182 | 68.422 | 66.859 | 66.310 | 73.634 | 72.110 |
| **4000** | 72.739 | 69.697 | 69.516 | 68.043 | 75.801 | 75.151 |
| **5000** | 67.064 | 68.576 | 66.099 | 67.007 | 70.978 | 70.474 |
| **6300** | 72.193 | 75.779 | 72.917 | 74.477 | 75.849 | 73.275 |
| **8000** | 71.681 | 73.456 | 73.534 | 74.856 | 72.367 | 72.019 |
| **10000** | 63.781 | 61.309 | 59.219 | 63.255 | 70.528 | 71.206 |
| **12500** | 64.861 | 65.583 | 64.692 | 63.438 | 67.864 | 67.528 |
| **16000** | 55.719 | 56.436 | 55.791 | 60.030 | 62.198 | 61.752 |
| **20000** | 56.249 | 57.054 | 56.410 | 57.075 | 58.265 | 57.481 |
| **OSPL [dB]** | **99** | **104** | **104** | **101** | **99** | **98** |

## 9.2. [R2]: Taxi, cockpit window open (1)

The PSD results are shown in Figure 16. Tonal behavior with the highest PSD level located at 6.00 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 17. This segment exhibits a maximum SPL of 107 dB in the 6.3 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 18. This segment exhibits a maximum SPL of 90 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 92 dB(A) was measured at both the mid (Mic 2) and rearmost (Mic 3) portside cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 19. This segment exhibits a maximum SPL of 76 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 77 dB(A) was measured at the rearmost (Mic 3) portside cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 20. A maximum duration of 2 hours 30 minutes cumulated during flight segment [R2]: Taxi, cockpit window open (1) during a 24 hour period for hearing-unprotected aircrew was exhibited at the mid (Mic 2) and rearmost (Mic3) portside cabin locations.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 21. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 2 hours 30 minutes without hearing protection at any location within the cabin during this flight segment to reach their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

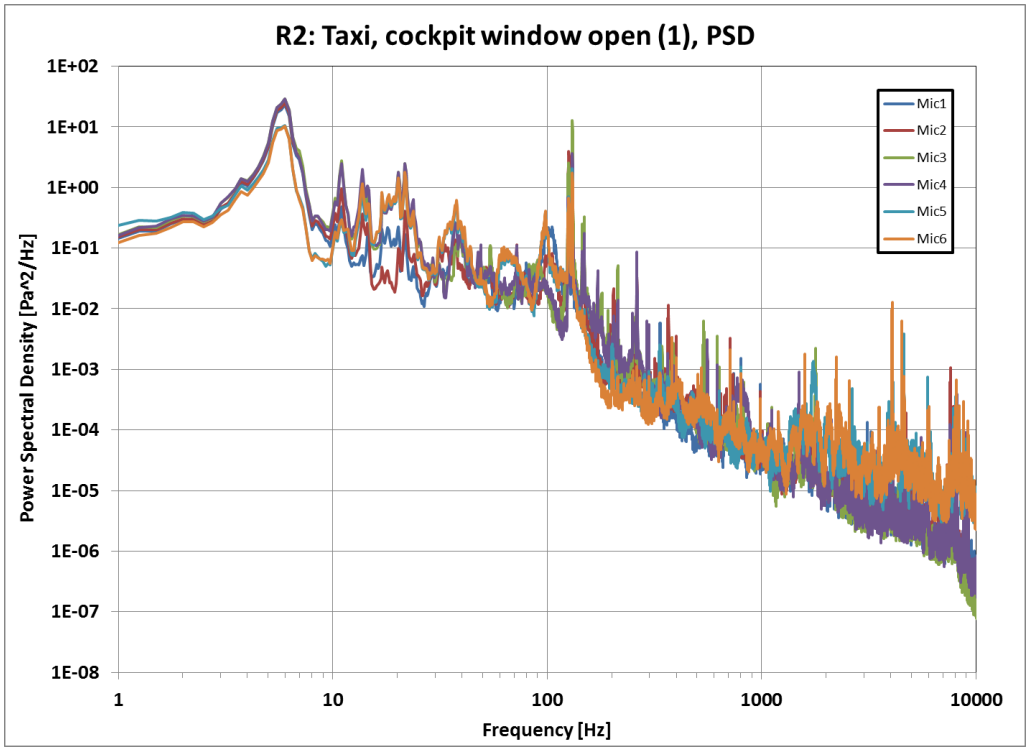


**Figure 16: Power Spectral Density for Run 2: Taxi, cockpit window open (1)**

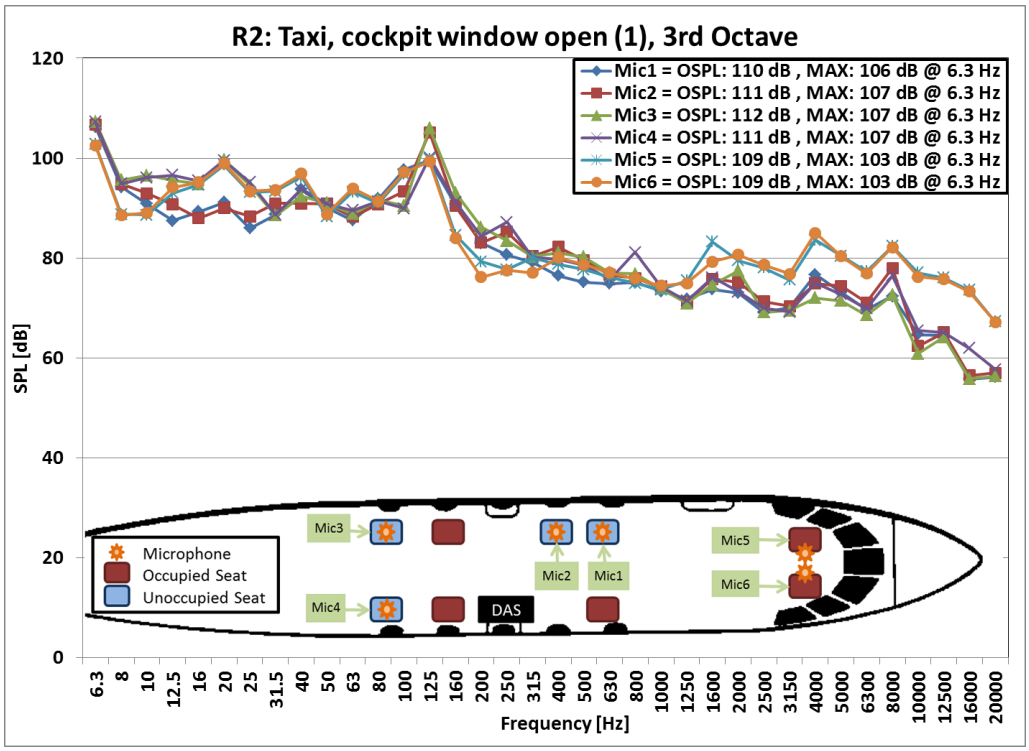


**Figure 17: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 2: Taxi, cockpit window open (1)**

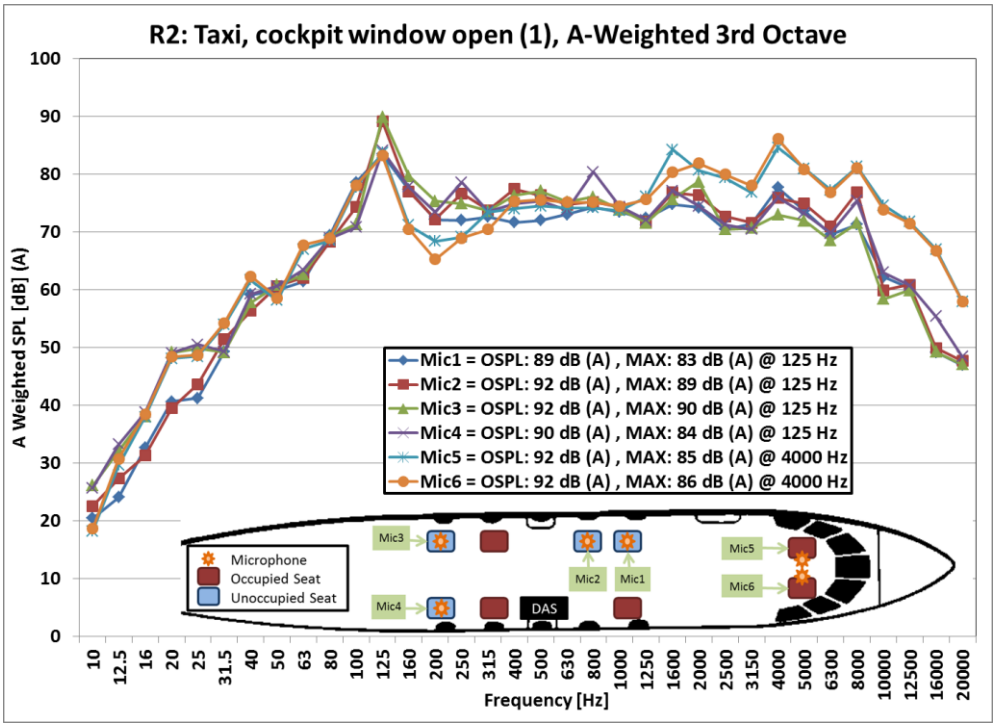


**Figure 18: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 2: Taxi, cockpit window open (1)**

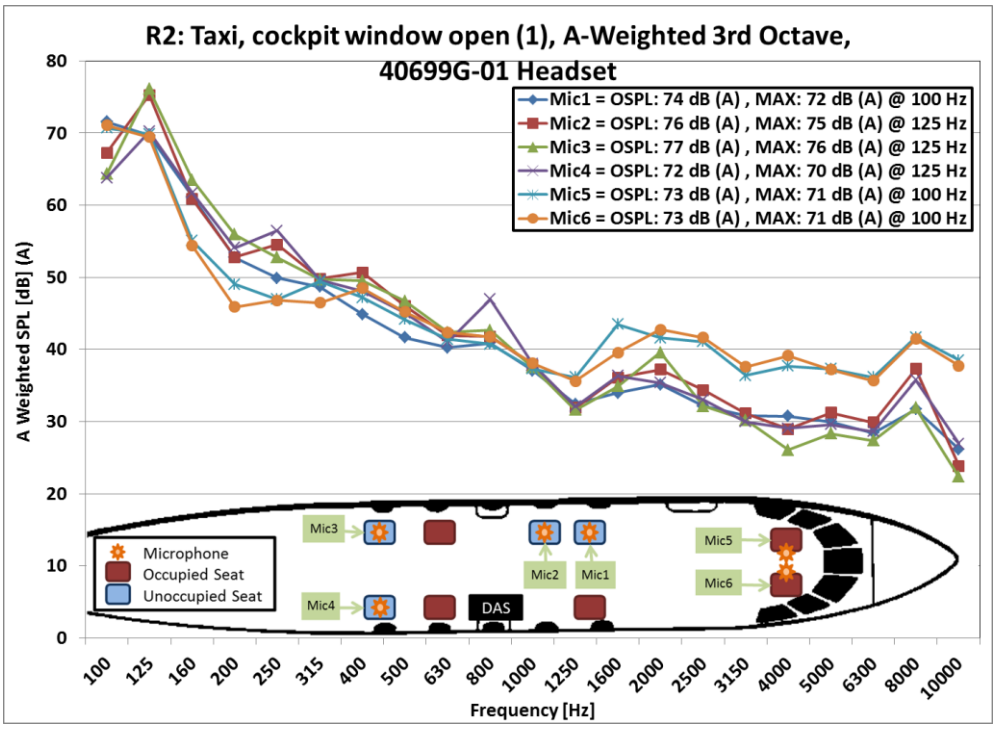


**Figure 19: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 2: Taxi, cockpit window open (1)**

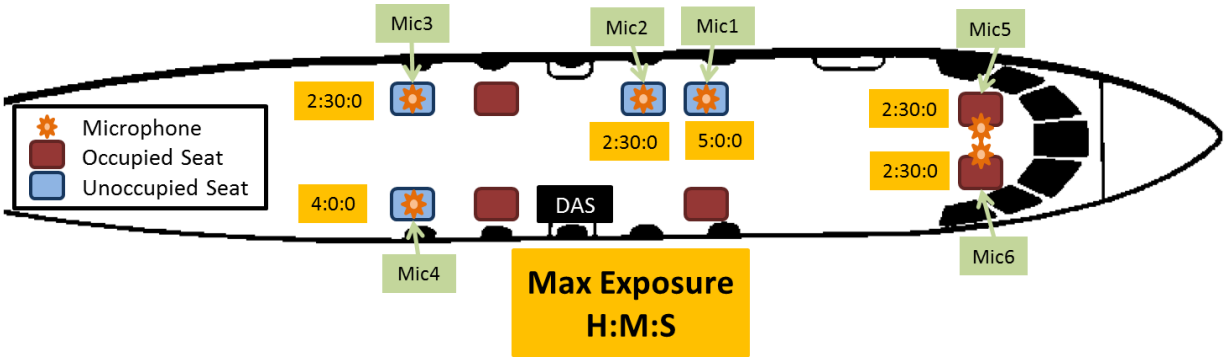


**Figure 20: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 2: Taxi, cockpit window open (1)**

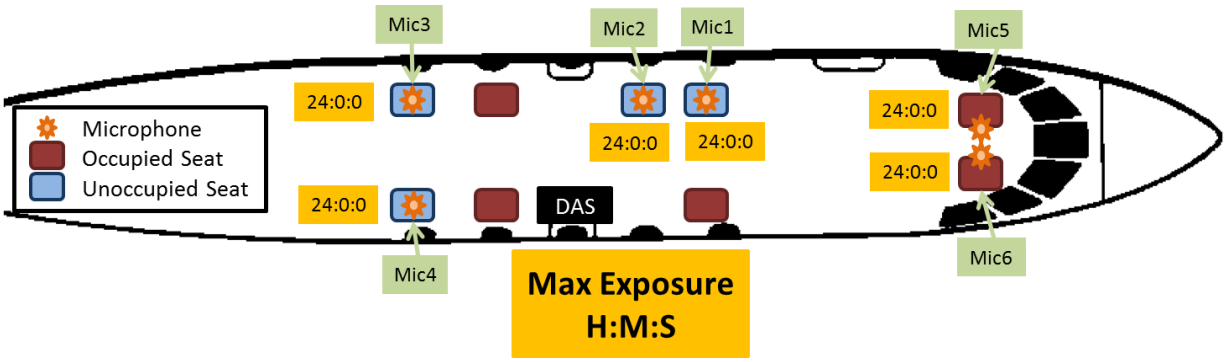


**Figure 21: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 2: Taxi, cockpit window open (1)**

**Table 7: Taxi, cockpit window open (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 106.331 | 106.732 | 107.339 | 107.210 | 102.788 | 102.584 |
| **8** | 94.210 | 94.795 | 95.560 | 94.879 | 88.797 | 88.571 |
| **10** | 90.846 | 92.959 | 96.537 | 96.099 | 88.635 | 89.068 |
| **12.5** | 87.470 | 90.734 | 95.553 | 96.628 | 93.006 | 94.169 |
| **16** | 89.302 | 88.000 | 94.770 | 95.440 | 94.666 | 95.137 |
| **20** | 91.145 | 89.988 | 99.622 | 99.576 | 98.595 | 98.899 |
| **25** | 85.925 | 88.348 | 94.498 | 95.191 | 93.126 | 93.380 |
| **31.5** | 88.710 | 90.889 | 88.545 | 88.720 | 93.331 | 93.624 |
| **40** | 93.727 | 90.942 | 92.379 | 93.817 | 96.249 | 96.876 |
| **50** | 90.116 | 90.837 | 91.022 | 90.840 | 88.323 | 88.771 |
| **63** | 87.572 | 88.232 | 88.819 | 89.576 | 93.225 | 93.940 |
| **80** | 91.828 | 90.754 | 91.564 | 91.354 | 91.009 | 91.350 |
| **100** | 97.682 | 93.374 | 90.459 | 89.912 | 96.797 | 97.175 |
| **125** | 99.552 | 105.180 | 105.987 | 100.109 | 99.750 | 99.299 |
| **160** | 90.713 | 90.408 | 93.057 | 91.195 | 84.576 | 83.917 |
| **200** | 82.986 | 83.073 | 86.180 | 84.347 | 79.291 | 76.176 |
| **250** | 80.621 | 85.244 | 83.458 | 87.173 | 77.688 | 77.517 |
| **315** | 79.217 | 80.367 | 80.247 | 80.173 | 79.977 | 77.021 |
| **400** | 76.439 | 82.231 | 81.095 | 79.684 | 78.750 | 80.069 |
| **500** | 75.189 | 79.552 | 80.226 | 78.590 | 77.666 | 78.733 |
| **630** | 74.909 | 76.621 | 77.062 | 75.694 | 76.088 | 77.051 |
| **800** | 75.077 | 75.989 | 76.840 | 81.136 | 74.948 | 75.922 |
| **1000** | 73.409 | 74.191 | 73.855 | 74.331 | 73.676 | 74.462 |
| **1250** | 71.764 | 71.231 | 70.947 | 71.447 | 75.486 | 74.985 |
| **1600** | 73.753 | 75.836 | 74.640 | 76.104 | 83.220 | 79.308 |
| **2000** | 73.016 | 75.116 | 77.480 | 73.258 | 79.470 | 80.644 |
| **2500** | 69.130 | 71.326 | 69.128 | 69.982 | 78.039 | 78.638 |
| **3150** | 70.103 | 70.355 | 69.478 | 69.203 | 75.634 | 76.817 |
| **4000** | 76.664 | 74.870 | 71.985 | 74.992 | 83.599 | 85.055 |
| **5000** | 73.095 | 74.367 | 71.460 | 72.710 | 80.443 | 80.364 |
| **6300** | 69.625 | 71.063 | 68.594 | 69.847 | 77.350 | 76.899 |
| **8000** | 72.398 | 77.985 | 72.603 | 76.466 | 82.385 | 82.158 |
| **10000** | 64.680 | 62.369 | 60.883 | 65.445 | 77.053 | 76.274 |
| **12500** | 64.528 | 65.127 | 64.213 | 65.007 | 76.046 | 75.734 |
| **16000** | 55.782 | 56.473 | 55.843 | 61.950 | 73.621 | 73.325 |
| **20000** | 56.227 | 56.991 | 56.350 | 57.713 | 67.270 | 67.184 |
| **OSPL [dB]** | **110** | **111** | **112** | **111** | **109** | **109** |

## 9.3. [R3]: Taxi, cockpit window closed (1)

The PSD results are shown in Figure 22. Tonal behavior with the highest PSD level located at 125.75 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 23. This segment exhibits a maximum SPL of 105 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 24. This segment exhibits a maximum SPL of 89 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 91 dB(A) was measured at the mid (Mic 2) portside cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 25. This segment exhibits a maximum SPL of 75 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 76 dB(A) was measured at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 26. A maximum duration of 3 hours 12 minutes cumulated during flight segment [R3]: Taxi, cockpit window closed (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 27. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 3 hours 12 minutes without hearing protection at any location within the cabin during this flight segment to reach their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

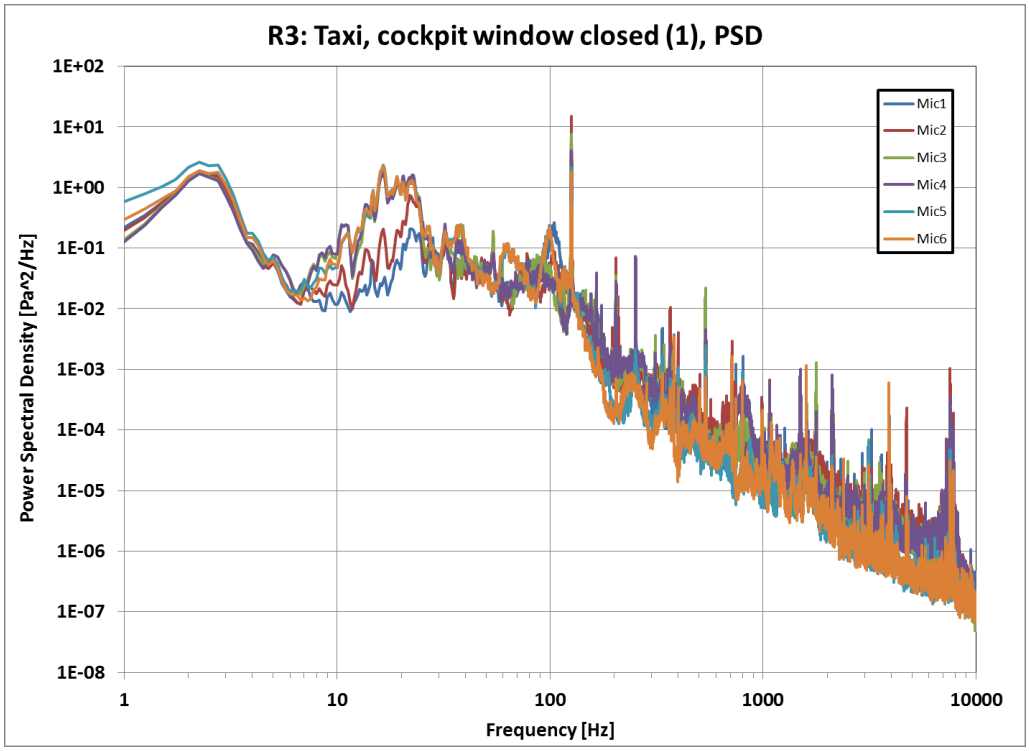


**Figure 22: Power Spectral Density for Run 3: Taxi, cockpit window closed (1)**

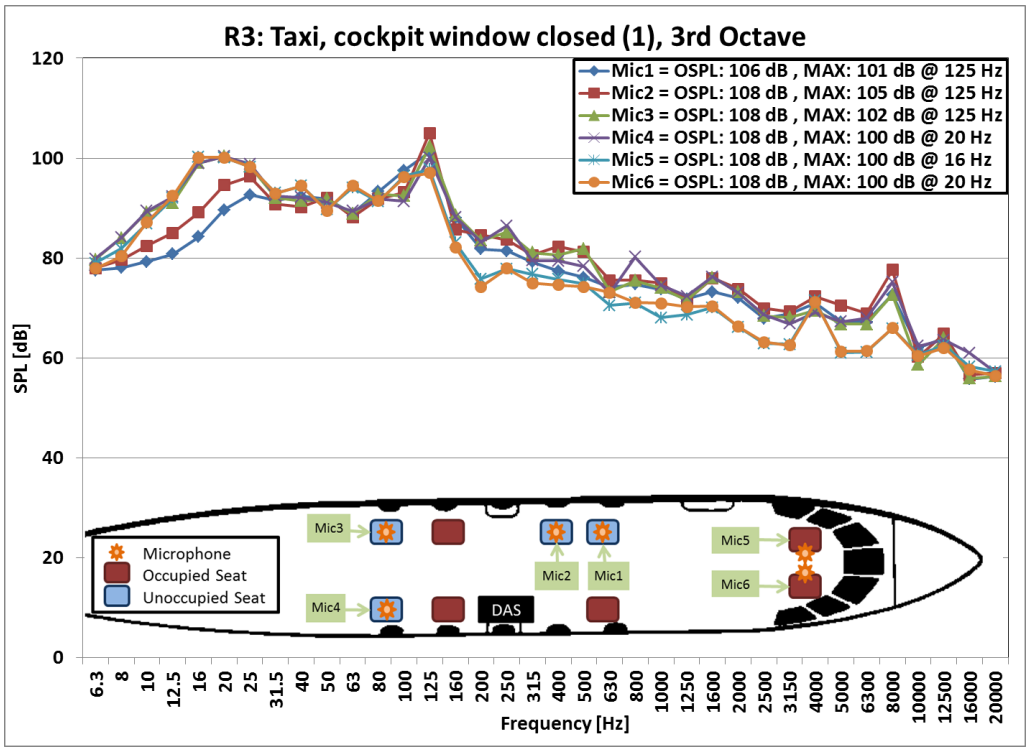


**Figure 23: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 3: Taxi, cockpit window closed (1)**

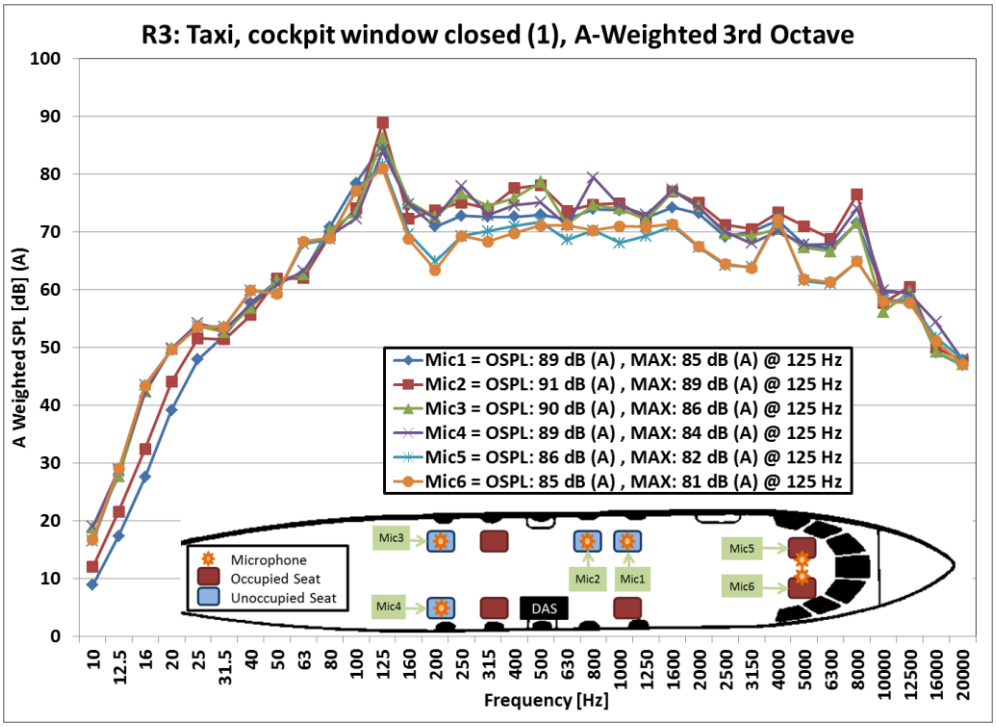


**Figure 24: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 3: Taxi, cockpit window closed (1)**

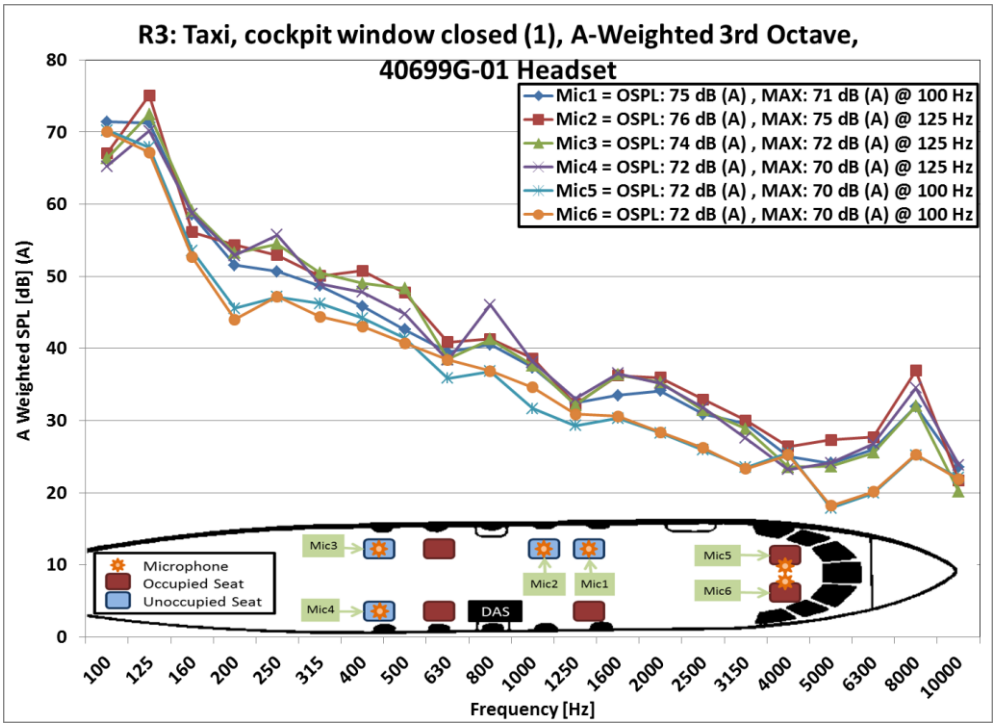


**Figure 25: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 3: Taxi, cockpit window closed (1)**

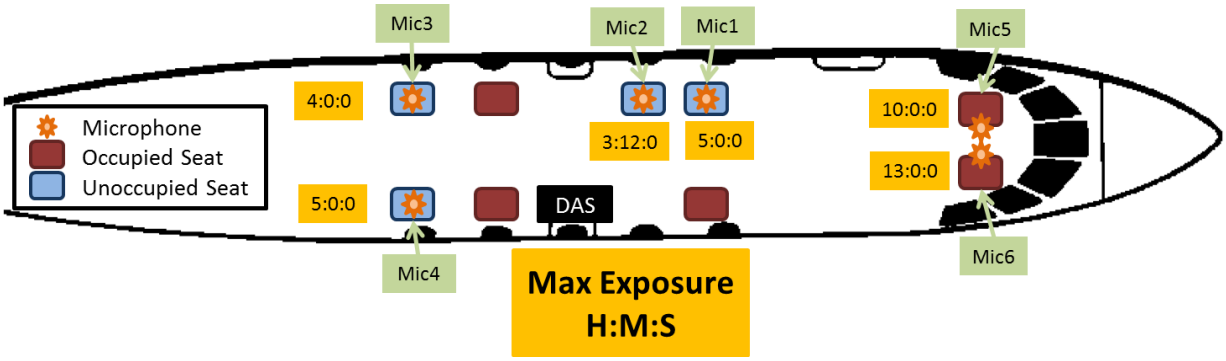


**Figure 26: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 3: Taxi, cockpit window closed (1)**

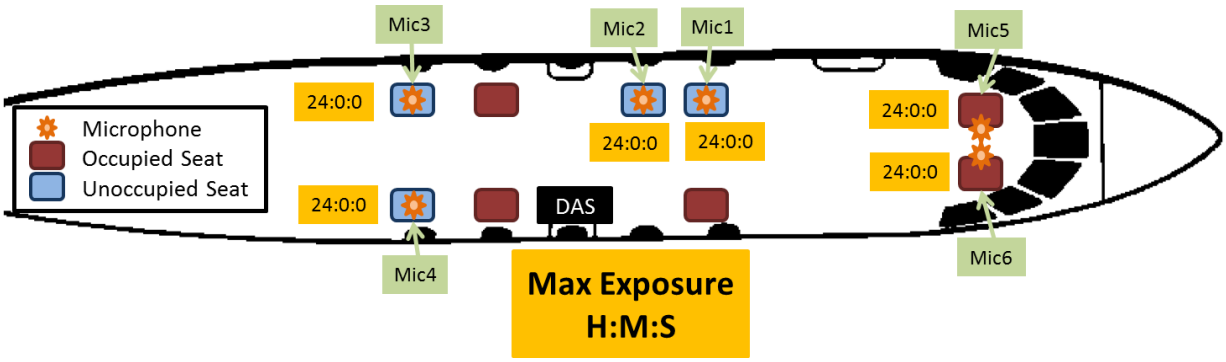


**Figure 27: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 3: Taxi, cockpit window closed (1)**

**Table 8: Taxi, cockpit window closed (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 77.541 | 77.951 | 79.701 | 79.875 | 78.998 | 77.890 |
| **8** | 78.043 | 79.636 | 83.984 | 84.062 | 81.891 | 80.324 |
| **10** | 79.275 | 82.422 | 89.227 | 89.422 | 86.893 | 87.188 |
| **12.5** | 80.759 | 85.021 | 91.052 | 92.316 | 91.986 | 92.407 |
| **16** | 84.251 | 89.147 | 99.056 | 98.969 | 100.210 | 100.095 |
| **20** | 89.659 | 94.575 | 100.367 | 100.334 | 100.092 | 100.098 |
| **25** | 92.623 | 96.280 | 98.377 | 98.855 | 98.264 | 98.262 |
| **31.5** | 91.461 | 90.810 | 92.079 | 92.421 | 93.028 | 92.907 |
| **40** | 92.354 | 90.199 | 91.457 | 92.161 | 94.424 | 94.428 |
| **50** | 91.840 | 92.098 | 91.830 | 91.086 | 89.665 | 89.506 |
| **63** | 88.893 | 88.188 | 88.830 | 89.415 | 94.088 | 94.510 |
| **80** | 93.263 | 91.844 | 92.782 | 91.765 | 91.252 | 91.401 |
| **100** | 97.531 | 93.144 | 92.448 | 91.368 | 96.399 | 96.160 |
| **125** | 101.128 | 104.975 | 102.359 | 100.051 | 97.783 | 97.038 |
| **160** | 88.077 | 85.652 | 88.606 | 88.209 | 83.058 | 82.162 |
| **200** | 81.801 | 84.614 | 83.488 | 83.173 | 75.818 | 74.273 |
| **250** | 81.400 | 83.675 | 85.180 | 86.463 | 77.858 | 77.888 |
| **315** | 79.215 | 80.565 | 81.038 | 79.478 | 76.755 | 74.928 |
| **400** | 77.424 | 82.321 | 80.593 | 79.402 | 75.752 | 74.594 |
| **500** | 76.137 | 81.249 | 81.842 | 78.311 | 74.918 | 74.276 |
| **630** | 74.142 | 75.532 | 73.204 | 73.051 | 70.516 | 73.077 |
| **800** | 74.725 | 75.522 | 75.441 | 80.226 | 71.039 | 71.054 |
| **1000** | 73.715 | 74.952 | 74.011 | 74.501 | 68.052 | 70.957 |
| **1250** | 71.834 | 71.614 | 71.490 | 72.383 | 68.666 | 70.228 |
| **1600** | 73.232 | 75.990 | 76.117 | 76.286 | 70.045 | 70.345 |
| **2000** | 72.014 | 73.823 | 73.193 | 73.000 | 66.161 | 66.285 |
| **2500** | 67.883 | 69.900 | 68.413 | 68.728 | 62.912 | 63.187 |
| **3150** | 68.849 | 69.279 | 68.111 | 66.813 | 62.747 | 62.545 |
| **4000** | 70.984 | 72.321 | 69.469 | 69.146 | 71.409 | 71.150 |
| **5000** | 67.206 | 70.473 | 66.788 | 67.260 | 61.014 | 61.331 |
| **6300** | 67.212 | 68.922 | 66.763 | 68.007 | 61.149 | 61.364 |
| **8000** | 72.659 | 77.606 | 72.694 | 75.190 | 65.902 | 65.959 |
| **10000** | 62.013 | 60.200 | 58.631 | 62.376 | 60.563 | 60.403 |
| **12500** | 63.909 | 64.798 | 63.940 | 63.606 | 62.462 | 62.043 |
| **16000** | 55.782 | 56.530 | 55.900 | 61.000 | 58.315 | 57.651 |
| **20000** | 56.247 | 57.010 | 56.356 | 57.239 | 57.291 | 56.403 |
| **OSPL [dB]** | **106** | **108** | **108** | **108** | **108** | **108** |

## 9.4. [R4]: Take-off

The PSD results are shown in Figure 28. Tonal behavior with the highest PSD level located at 152.75 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 29. This segment exhibits a maximum SPL of 115 dB in the 160 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 30. This segment exhibits a maximum SPL of 102 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 103 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 31. This segment exhibits a maximum SPL of 86 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 86 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 32. A maximum duration of 12 minutes cumulated during flight segment [R4]: Take-off during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 33. The rearmost (Mic 4) starboard side cabin location exhibited a maximum duration of 10 hours for aircrew protected with the 40699G-01 David Clark headset. All other locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 12 minutes without hearing protection at any location within the cabin during this flight segment to reach their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for up to 10 hours to reach their maximum daily exposure limit. The David Clark headset provides adequate protection for this flight segment.

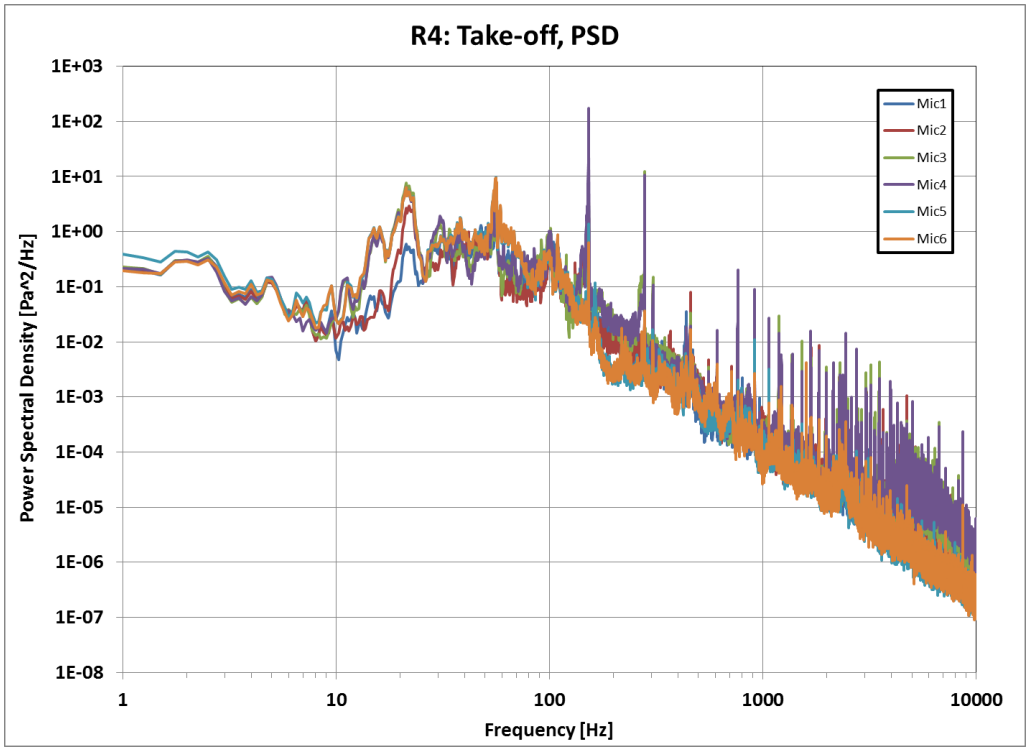


**Figure 28: Power Spectral Density for Run 4: Take-off**

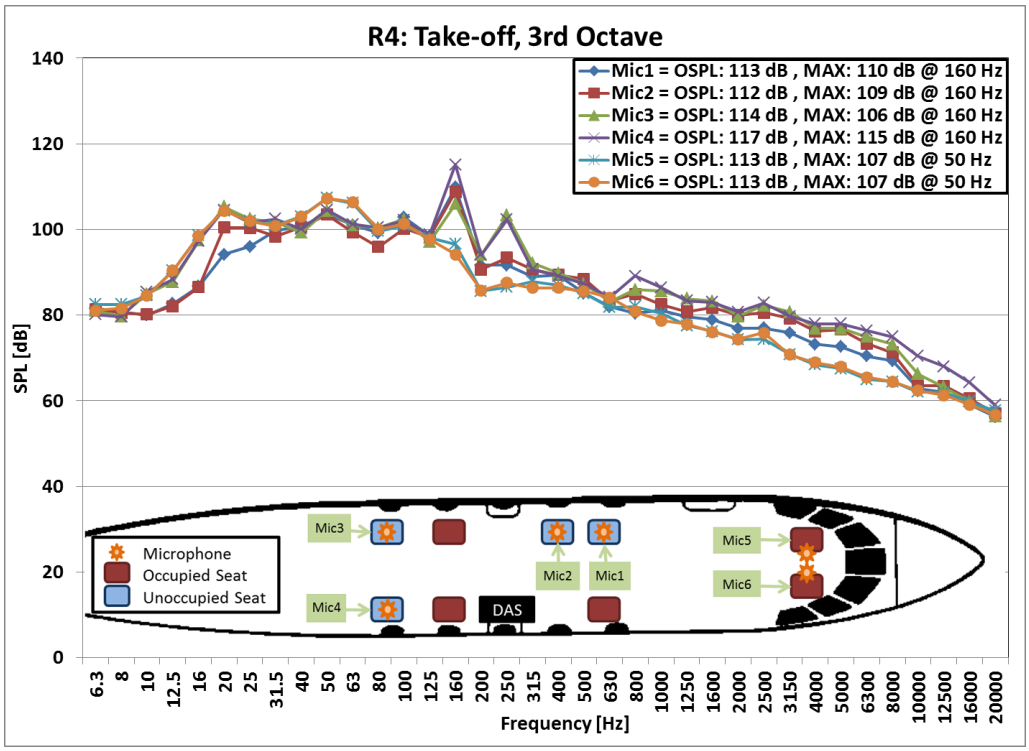


**Figure 29: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 4: Take-off**

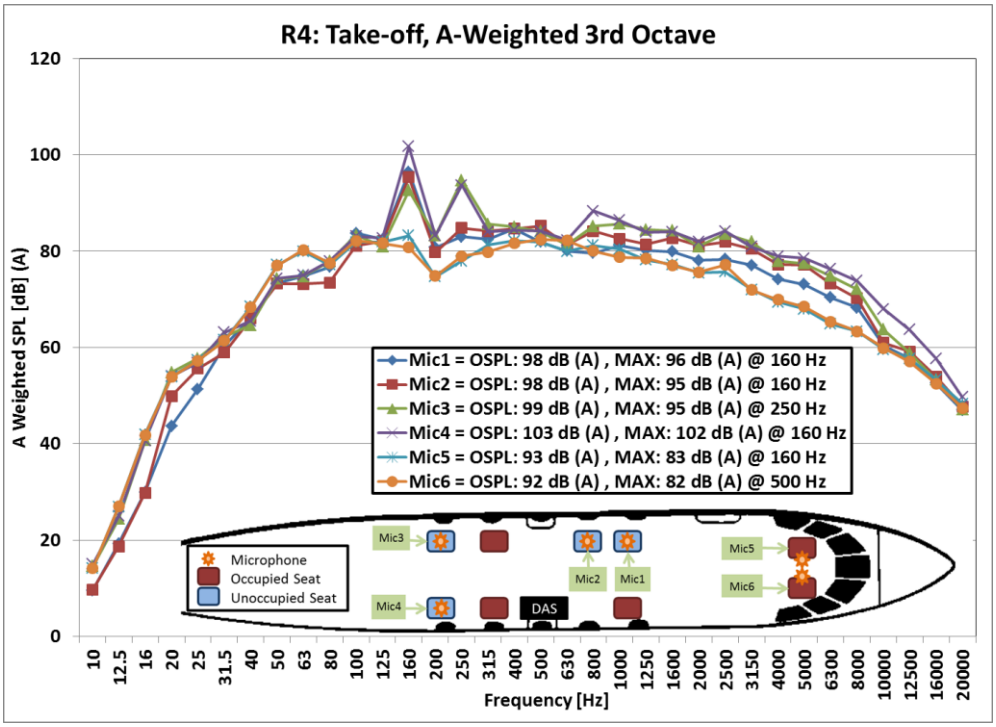


**Figure 30: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 4: Take-off**

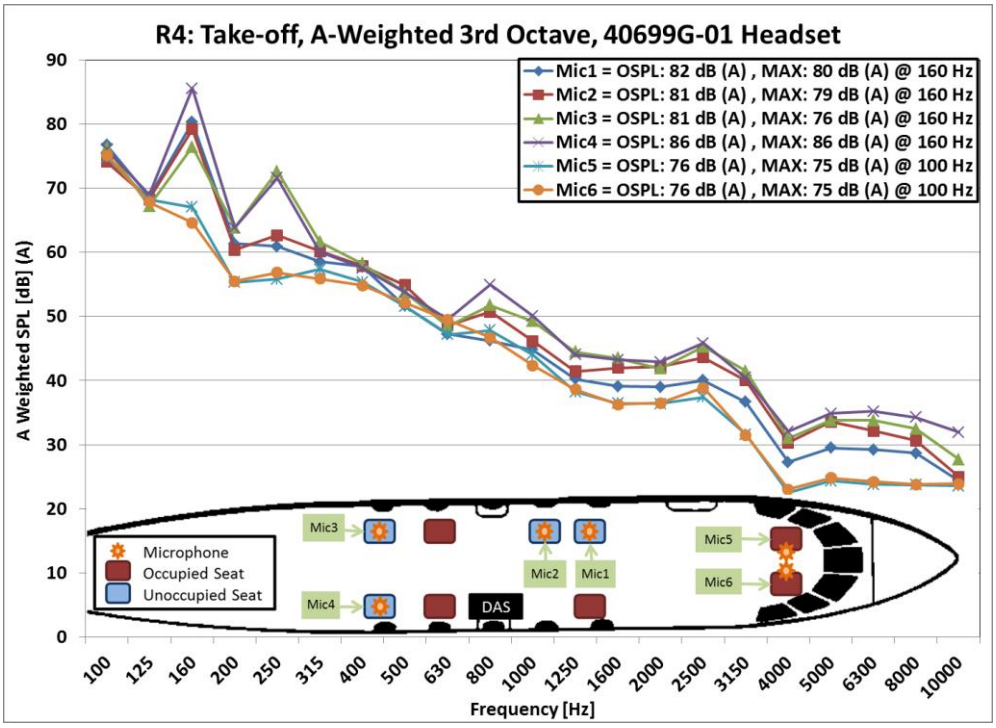


**Figure 31: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 4: Take-off**

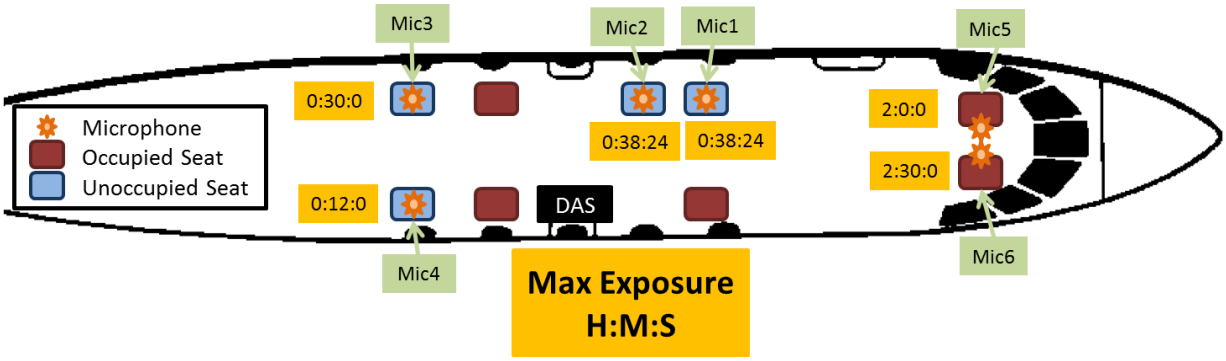


**Figure 32: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 4: Take-off**

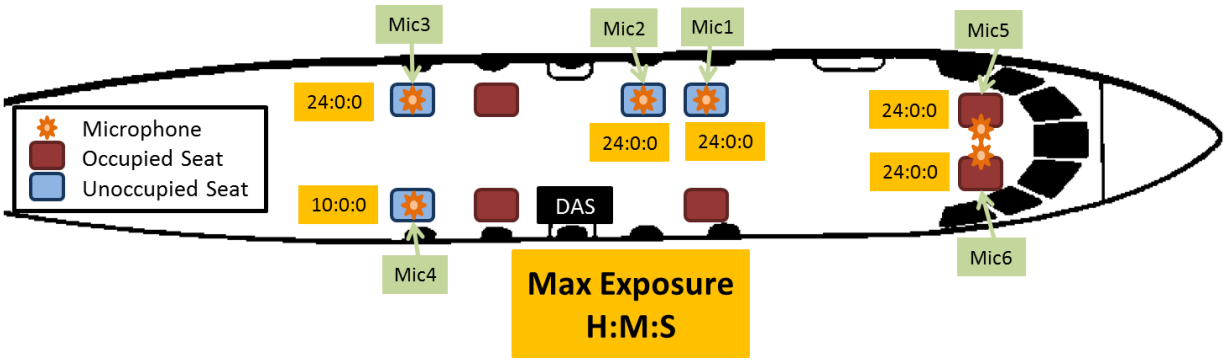


**Figure 33: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 4: Take-off**

**Table 9: Take-off 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 81.548 | 81.301 | 81.027 | 80.138 | 82.547 | 81.096 |
| **8** | 80.835 | 80.597 | 79.776 | 79.615 | 82.467 | 81.621 |
| **10** | 80.006 | 80.152 | 84.977 | 85.402 | 84.532 | 84.528 |
| **12.5** | 82.665 | 82.129 | 87.785 | 88.393 | 90.369 | 90.422 |
| **16** | 86.682 | 86.510 | 97.432 | 97.386 | 98.645 | 98.531 |
| **20** | 94.192 | 100.420 | 105.302 | 104.524 | 104.436 | 104.391 |
| **25** | 96.050 | 100.335 | 102.442 | 101.529 | 102.014 | 101.944 |
| **31.5** | 99.753 | 98.323 | 101.679 | 102.499 | 100.914 | 100.772 |
| **40** | 100.750 | 100.610 | 99.245 | 100.120 | 103.080 | 102.944 |
| **50** | 103.524 | 103.444 | 104.421 | 104.527 | 107.336 | 107.211 |
| **63** | 101.060 | 99.351 | 100.979 | 101.192 | 106.194 | 106.442 |
| **80** | 99.192 | 95.966 | 100.352 | 100.470 | 99.618 | 100.016 |
| **100** | 102.806 | 100.199 | 102.417 | 102.171 | 100.925 | 101.258 |
| **125** | 98.520 | 98.160 | 97.065 | 98.801 | 98.044 | 97.707 |
| **160** | 109.816 | 108.725 | 105.983 | 115.115 | 96.586 | 94.161 |
| **200** | 91.625 | 90.631 | 94.105 | 94.086 | 85.569 | 85.741 |
| **250** | 91.628 | 93.377 | 103.328 | 102.321 | 86.537 | 87.553 |
| **315** | 89.052 | 90.718 | 92.174 | 90.628 | 87.862 | 86.400 |
| **400** | 89.356 | 89.425 | 89.842 | 89.137 | 86.945 | 86.398 |
| **500** | 85.143 | 88.441 | 87.271 | 87.348 | 85.106 | 85.623 |
| **630** | 81.906 | 83.238 | 83.152 | 84.168 | 81.855 | 84.104 |
| **800** | 80.381 | 84.917 | 85.941 | 89.151 | 82.015 | 80.869 |
| **1000** | 81.167 | 82.540 | 85.636 | 86.424 | 80.408 | 78.741 |
| **1250** | 79.578 | 80.792 | 83.837 | 83.365 | 77.588 | 77.927 |
| **1600** | 78.868 | 81.711 | 83.230 | 82.994 | 76.190 | 76.017 |
| **2000** | 76.868 | 80.000 | 79.756 | 80.761 | 74.250 | 74.394 |
| **2500** | 76.995 | 80.589 | 82.262 | 82.819 | 74.395 | 75.860 |
| **3150** | 75.901 | 79.239 | 80.739 | 79.709 | 70.832 | 70.737 |
| **4000** | 73.191 | 76.230 | 76.915 | 77.970 | 68.404 | 68.937 |
| **5000** | 72.626 | 76.674 | 76.929 | 78.007 | 67.493 | 67.939 |
| **6300** | 70.421 | 73.337 | 74.957 | 76.369 | 64.972 | 65.451 |
| **8000** | 69.344 | 71.287 | 73.168 | 74.954 | 64.443 | 64.462 |
| **10000** | 62.887 | 63.489 | 66.223 | 70.436 | 62.085 | 62.412 |
| **12500** | 62.074 | 63.477 | 63.185 | 67.990 | 61.987 | 61.330 |
| **16000** | 59.202 | 60.571 | 59.898 | 64.290 | 59.870 | 59.101 |
| **20000** | 56.279 | 57.060 | 56.443 | 59.010 | 57.651 | 56.755 |
| **OSPL [dB]** | **113** | **112** | **114** | **117** | **113** | **113** |

## 9.5. [R5]: Climb

The PSD results are shown in Figure 34. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 35. This segment exhibits a maximum SPL of 111 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 36. This segment exhibits a maximum SPL of 95 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 100 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 37. This segment exhibits a maximum SPL of 81 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 83 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 38. A maximum duration of 24 minutes cumulated during flight segment [R5]: Climb during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 39. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 24 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

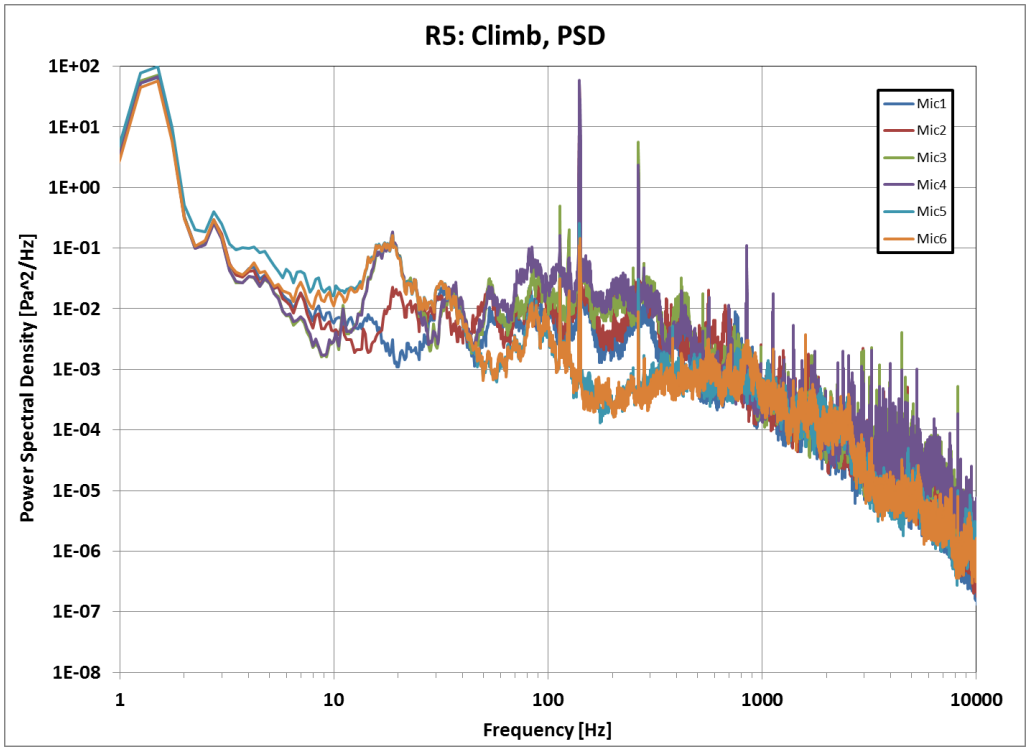


**Figure 34: Power Spectral Density for Run 5: Climb**

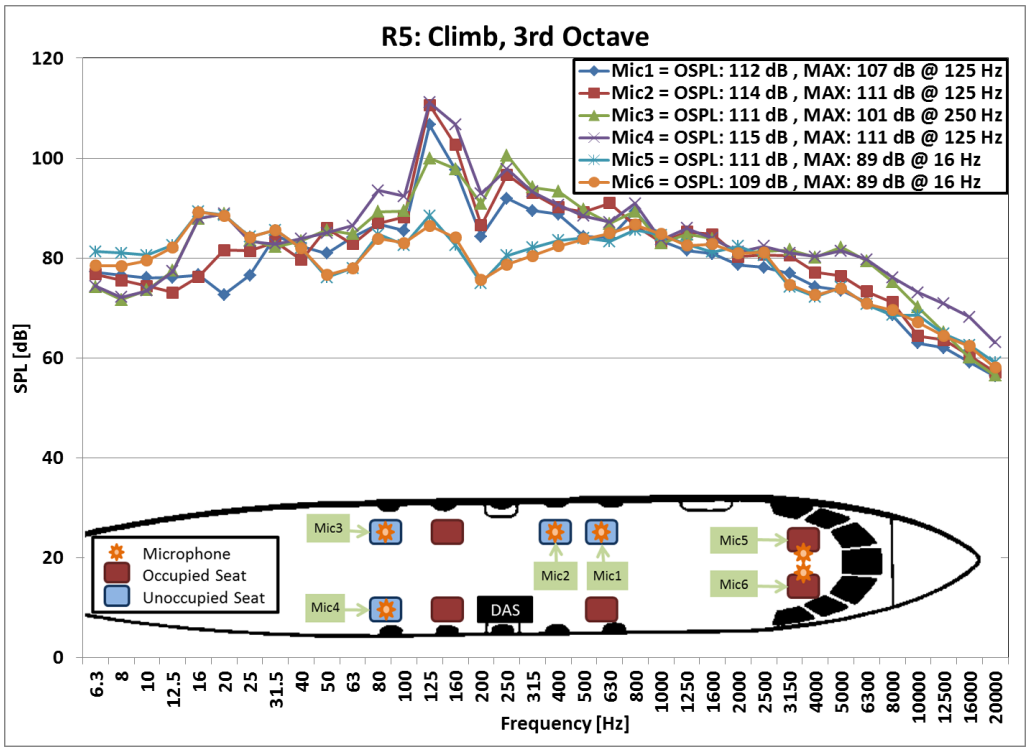


**Figure 35: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 5: Climb**

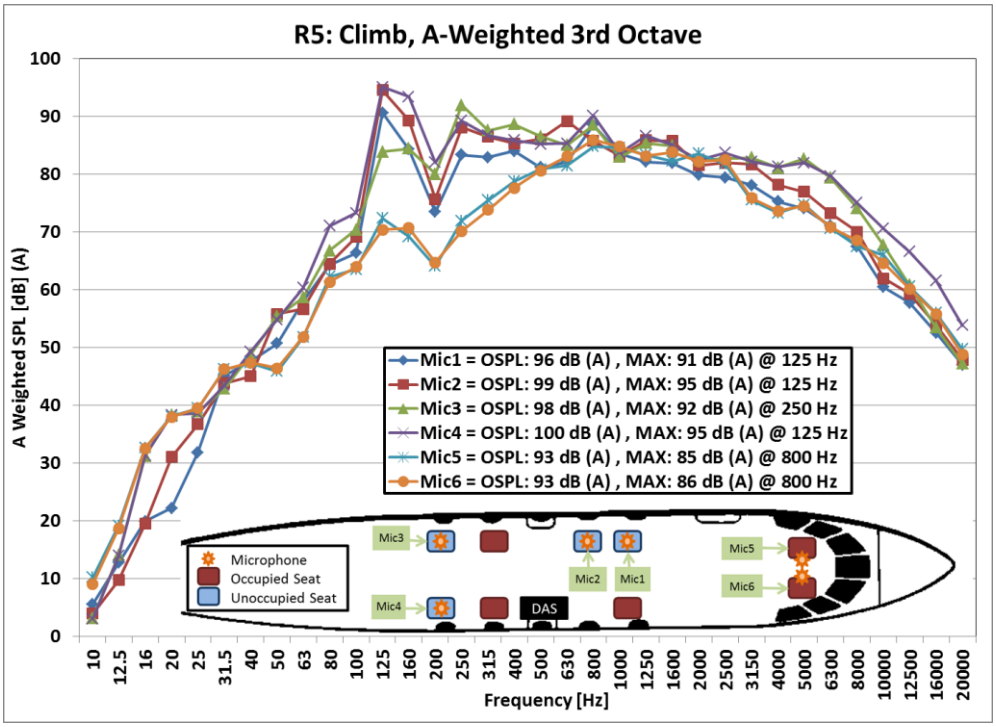


**Figure 36: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 5: Climb**

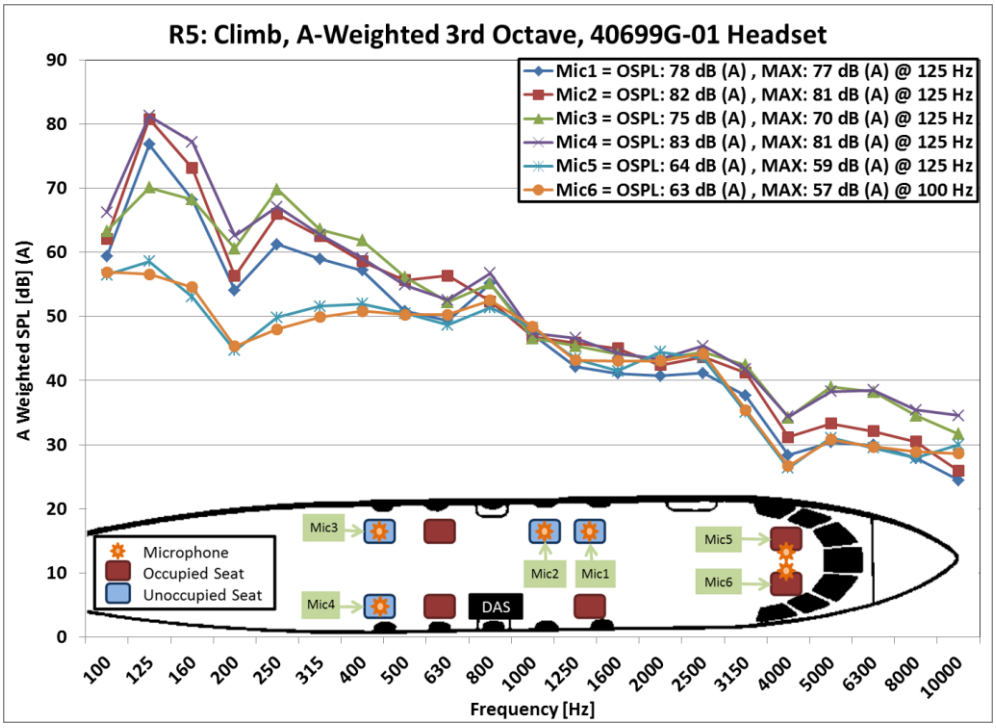


**Figure 37: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 5: Climb**

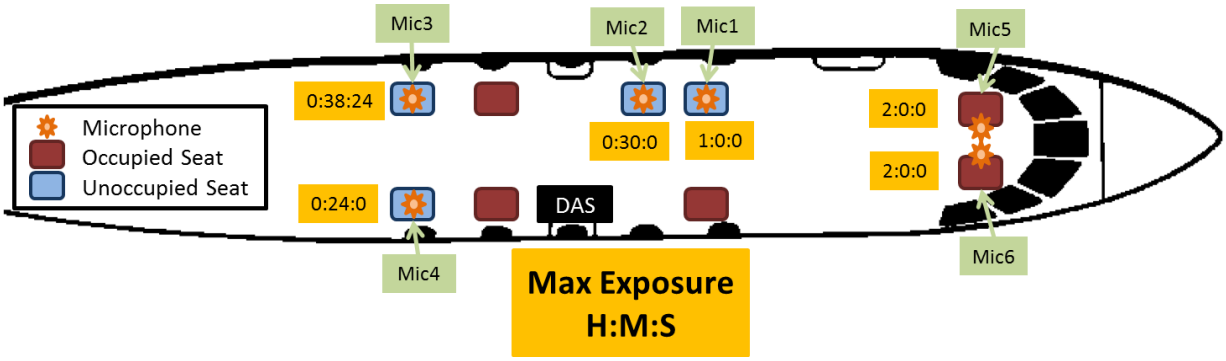


**Figure 38: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 5: Climb**

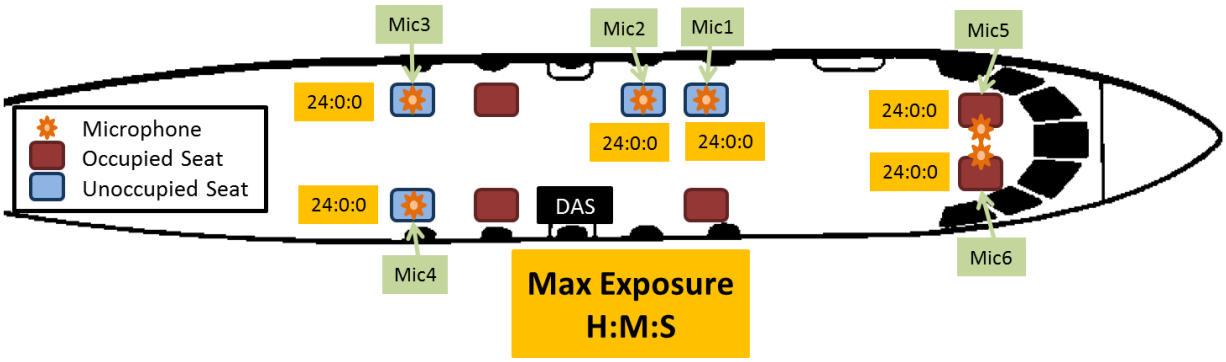


**Figure 39: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 5: Climb**

**Table 10: Climb 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| **Frequency [Hz]** | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 77.208 | 76.765 | 74.138 | 74.409 | 81.318 | 78.493 |
| **8** | 76.539 | 75.502 | 71.676 | 72.130 | 80.973 | 78.439 |
| **10** | 76.011 | 74.368 | 73.603 | 73.471 | 80.596 | 79.506 |
| **12.5** | 76.123 | 73.115 | 77.471 | 77.344 | 82.571 | 82.116 |
| **16** | 76.626 | 76.224 | 87.909 | 88.006 | 89.301 | 89.230 |
| **20** | 72.679 | 81.573 | 88.839 | 88.816 | 88.603 | 88.500 |
| **25** | 76.530 | 81.433 | 83.608 | 83.304 | 84.209 | 84.195 |
| **31.5** | 84.511 | 83.199 | 82.234 | 82.830 | 85.618 | 85.637 |
| **40** | 82.267 | 79.627 | 83.412 | 83.874 | 81.922 | 81.958 |
| **50** | 80.909 | 85.973 | 85.575 | 85.008 | 76.081 | 76.592 |
| **63** | 84.154 | 82.820 | 84.808 | 86.486 | 77.949 | 78.003 |
| **80** | 86.752 | 86.991 | 89.265 | 93.501 | 84.746 | 83.865 |
| **100** | 85.447 | 88.207 | 89.441 | 92.373 | 82.596 | 83.042 |
| **125** | 106.670 | 110.631 | 99.944 | 111.150 | 88.477 | 86.476 |
| **160** | 97.703 | 102.655 | 97.787 | 106.737 | 82.563 | 84.069 |
| **200** | 84.318 | 86.569 | 90.876 | 92.883 | 74.942 | 75.622 |
| **250** | 91.939 | 96.655 | 100.525 | 97.794 | 80.533 | 78.723 |
| **315** | 89.509 | 93.024 | 94.126 | 93.279 | 82.104 | 80.420 |
| **400** | 88.750 | 90.124 | 93.382 | 90.653 | 83.525 | 82.375 |
| **500** | 84.343 | 89.194 | 89.691 | 88.396 | 84.042 | 83.823 |
| **630** | 84.020 | 91.026 | 86.898 | 87.204 | 83.335 | 84.956 |
| **800** | 89.307 | 86.510 | 89.314 | 90.906 | 85.583 | 86.676 |
| **1000** | 83.471 | 83.220 | 82.954 | 83.685 | 84.597 | 84.784 |
| **1250** | 81.505 | 85.248 | 84.730 | 85.993 | 82.739 | 82.511 |
| **1600** | 80.868 | 84.743 | 83.857 | 83.983 | 81.231 | 82.813 |
| **2000** | 78.606 | 80.293 | 81.192 | 81.245 | 82.340 | 80.938 |
| **2500** | 78.124 | 80.635 | 81.394 | 82.379 | 80.468 | 81.171 |
| **3150** | 76.888 | 80.470 | 81.647 | 80.993 | 74.267 | 74.643 |
| **4000** | 74.246 | 77.108 | 80.108 | 80.293 | 72.249 | 72.604 |
| **5000** | 73.515 | 76.420 | 82.143 | 81.411 | 74.206 | 73.932 |
| **6300** | 71.131 | 73.302 | 79.448 | 79.727 | 70.700 | 70.864 |
| **8000** | 68.571 | 71.126 | 75.220 | 76.104 | 68.586 | 69.584 |
| **10000** | 62.931 | 64.417 | 70.157 | 73.073 | 68.470 | 67.113 |
| **12500** | 61.996 | 63.611 | 65.081 | 70.900 | 64.835 | 64.420 |
| **16000** | 59.151 | 60.530 | 60.059 | 68.206 | 62.593 | 62.369 |
| **20000** | 56.312 | 57.136 | 56.496 | 63.095 | 59.044 | 58.053 |
| OSPL [dB] | **112** | **114** | **111** | **115** | **111** | **109** |

## 9.6. [R6]: Steady level flight (1)

The PSD results are shown in Figure 34. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 41. This segment exhibits a maximum SPL of 109 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 42. This segment exhibits a maximum SPL of 92 dB(A) at the 125 Hz 1/3$^{rd}$ and 250 Hz 1/3$^{rd}$ octave bands. A maximum overall SPL of 98 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 43. This segment exhibits a maximum SPL of 79 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 79 dB(A) was measured at the rearmost (Mic 4) starboard side and the mid (Mic 2) portside cabin locations.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 44. A maximum duration of 38 minutes and 24 seconds cumulated during flight segment [R6]: Steady level flight during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 45. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 38 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

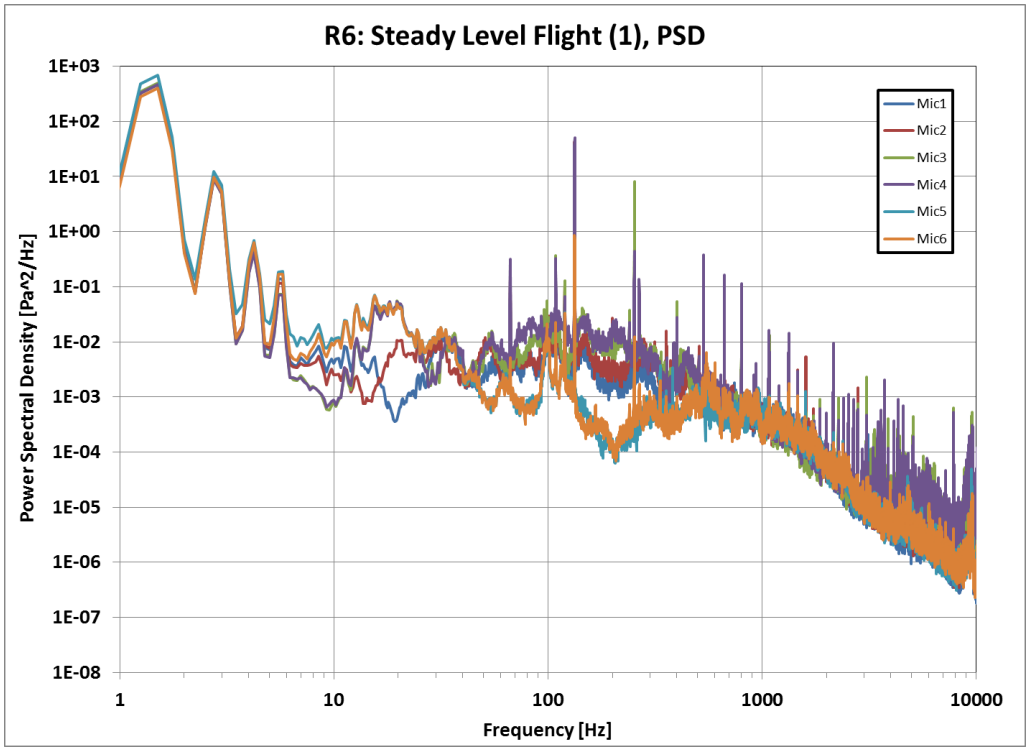


**Figure 40: Power Spectral Density for Run 6: Steady Level Flight (1)**

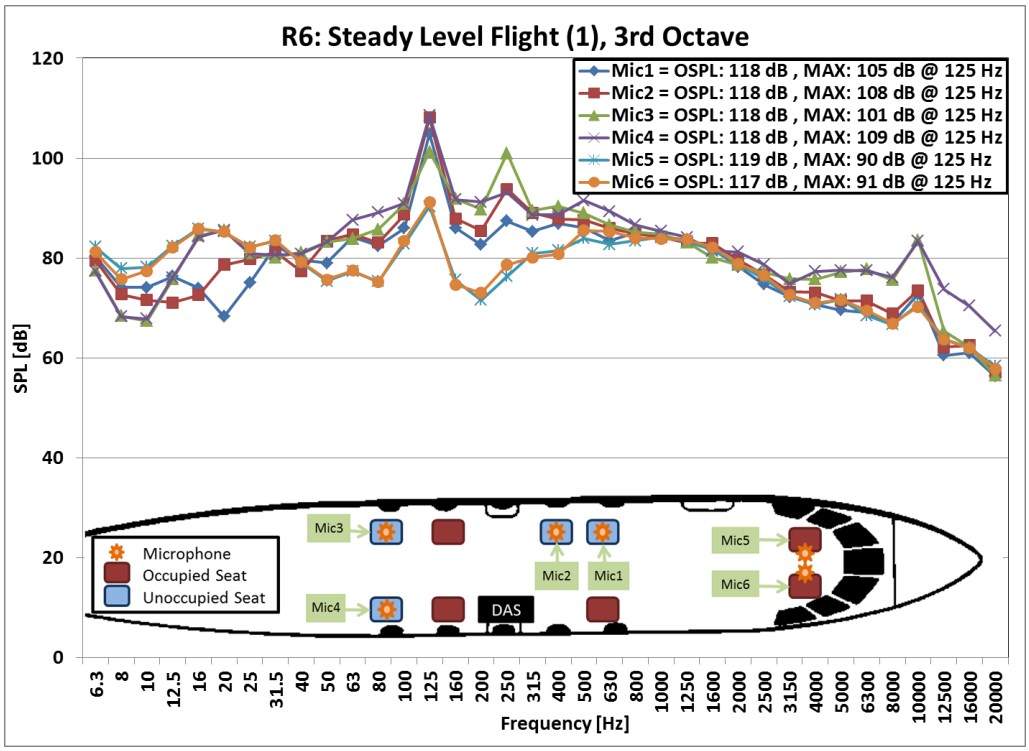


**Figure 41: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 6: Steady Level Flight (1)**

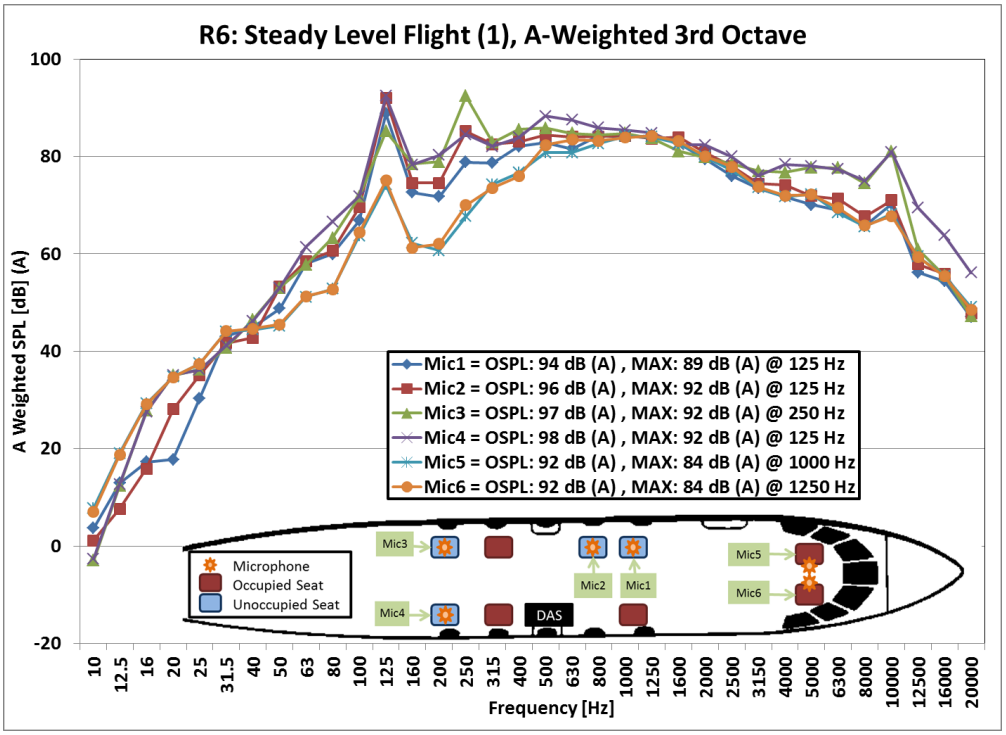


**Figure 42: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 6: Steady Level Flight (1)**

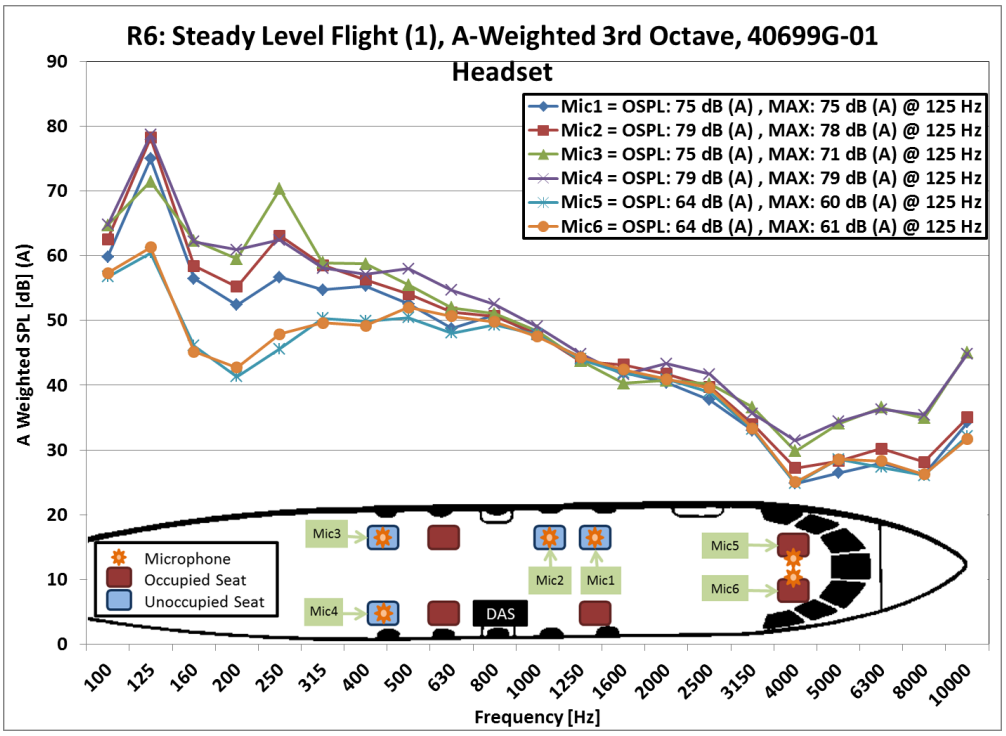


**Figure 43: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 6: Steady Level Flight (1)**

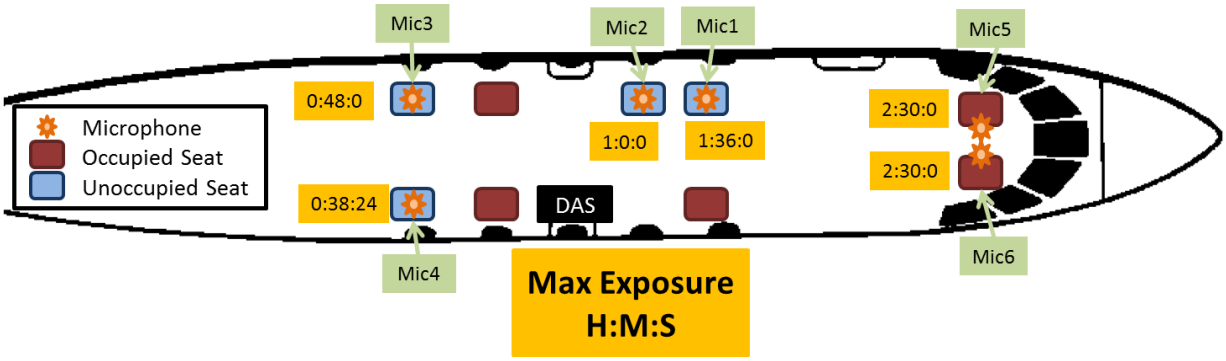


**Figure 44: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 6: Steady Level Flight (1)**

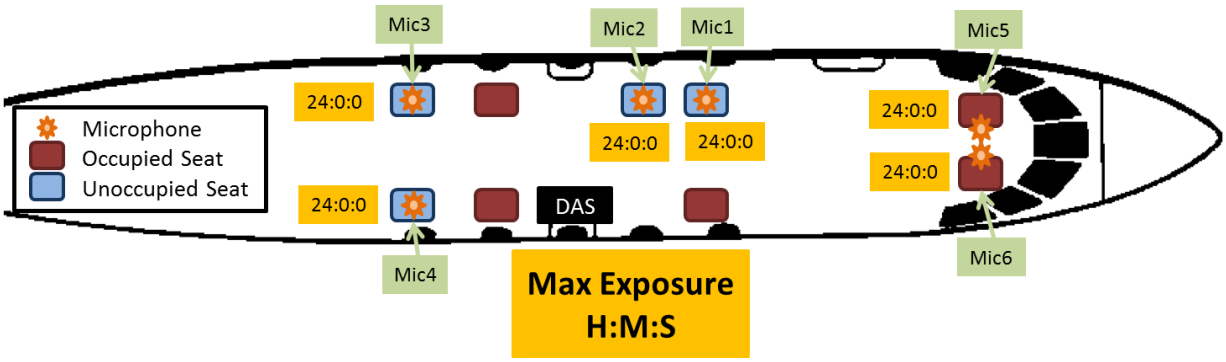


**Figure 45: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 6: Steady Level Flight (1)**

**Table 11: Steady Level Flight (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 80.308 | 79.549 | 77.497 | 77.330 | 82.243 | 81.212 |
| **8** | 74.113 | 72.758 | 68.387 | 68.278 | 77.875 | 75.740 |
| **10** | 74.073 | 71.583 | 67.421 | 67.819 | 78.197 | 77.378 |
| **12.5** | 76.311 | 71.070 | 75.802 | 76.079 | 82.452 | 82.176 |
| **16** | 73.972 | 72.569 | 84.518 | 84.218 | 85.921 | 85.783 |
| **20** | 68.285 | 78.632 | 85.542 | 85.617 | 85.245 | 85.206 |
| **25** | 75.055 | 79.776 | 80.963 | 80.882 | 82.190 | 82.150 |
| **31.5** | 82.424 | 81.109 | 80.140 | 80.649 | 83.478 | 83.517 |
| **40** | 79.639 | 77.337 | 81.145 | 80.864 | 78.996 | 79.212 |
| **50** | 78.991 | 83.421 | 83.210 | 83.211 | 75.398 | 75.715 |
| **63** | 84.175 | 84.708 | 83.893 | 87.630 | 77.342 | 77.484 |
| **80** | 82.456 | 83.108 | 85.759 | 89.088 | 75.330 | 75.197 |
| **100** | 85.943 | 88.675 | 90.814 | 90.902 | 82.831 | 83.457 |
| **125** | 104.866 | 108.094 | 101.303 | 108.517 | 90.311 | 91.150 |
| **160** | 86.015 | 87.925 | 91.835 | 91.683 | 75.627 | 74.697 |
| **200** | 82.656 | 85.470 | 89.775 | 91.182 | 71.576 | 72.990 |
| **250** | 87.394 | 93.804 | 101.008 | 93.120 | 76.305 | 78.603 |
| **315** | 85.281 | 89.081 | 89.475 | 88.647 | 80.895 | 80.169 |
| **400** | 86.899 | 87.843 | 90.324 | 88.694 | 81.480 | 80.757 |
| **500** | 86.070 | 87.580 | 89.006 | 91.488 | 83.946 | 85.525 |
| **630** | 83.448 | 85.944 | 86.612 | 89.360 | 82.701 | 85.343 |
| **800** | 85.088 | 84.875 | 85.259 | 86.711 | 83.477 | 84.010 |
| **1000** | 83.988 | 84.231 | 84.767 | 85.372 | 84.190 | 83.859 |
| **1250** | 83.711 | 83.078 | 83.121 | 84.193 | 83.388 | 83.664 |
| **1600** | 81.693 | 82.938 | 80.037 | 81.409 | 81.626 | 82.177 |
| **2000** | 78.253 | 79.625 | 78.615 | 81.183 | 78.807 | 78.848 |
| **2500** | 74.715 | 76.722 | 77.143 | 78.666 | 75.928 | 76.550 |
| **3150** | 72.252 | 73.238 | 75.833 | 74.847 | 72.399 | 72.593 |
| **4000** | 70.748 | 73.102 | 75.722 | 77.365 | 70.753 | 70.979 |
| **5000** | 69.591 | 71.409 | 77.198 | 77.535 | 71.725 | 71.689 |
| **6300** | 69.107 | 71.420 | 77.765 | 77.493 | 68.515 | 69.493 |
| **8000** | 66.882 | 68.816 | 75.585 | 76.082 | 66.725 | 66.922 |
| **10000** | 72.779 | 73.525 | 83.570 | 83.383 | 70.689 | 70.246 |
| **12500** | 60.477 | 62.175 | 65.296 | 73.765 | 63.779 | 63.694 |
| **16000** | 60.997 | 62.532 | 62.187 | 70.422 | 62.055 | 62.015 |
| **20000** | 56.311 | 57.104 | 56.488 | 65.422 | 58.373 | 57.854 |
| **OSPL [dB]** | **118** | **118** | **118** | **118** | **119** | **117** |

## 9.7. [R7]: Acceleration to 300 KIAS

The PSD results are shown in Figure 46. Tonal behavior with the highest PSD level located at 1.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 47. This segment exhibits a maximum SPL of 115 dB in the 160 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 48. This segment exhibits a maximum SPL of 102 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 104 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 49. This segment exhibits a maximum SPL of 86 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 86 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 50. A maximum duration of 9 minutes 36 seconds cumulated during flight segment [R7]: Acceleration to 300 KIAS during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 51. The rearmost (Mic 4) starboard location exhibited a maximum exposure duration of 10 hours while the remainder of the

Aircrew may operate for up to 9 minutes 36 seconds without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for 10 hours before reaching their maximum daily exposure limit. The David Clark headset provides adequate protection for this flight segment.

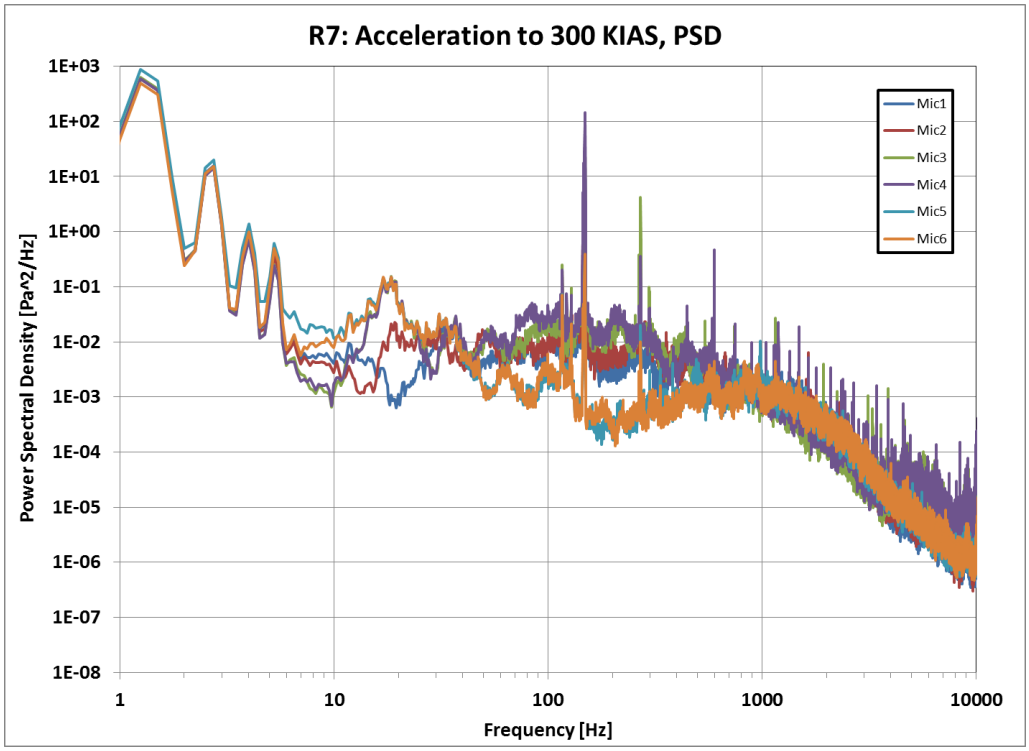


**Figure 46: Power Spectral Density for Run 7: Acceleration to 300 KIAS**

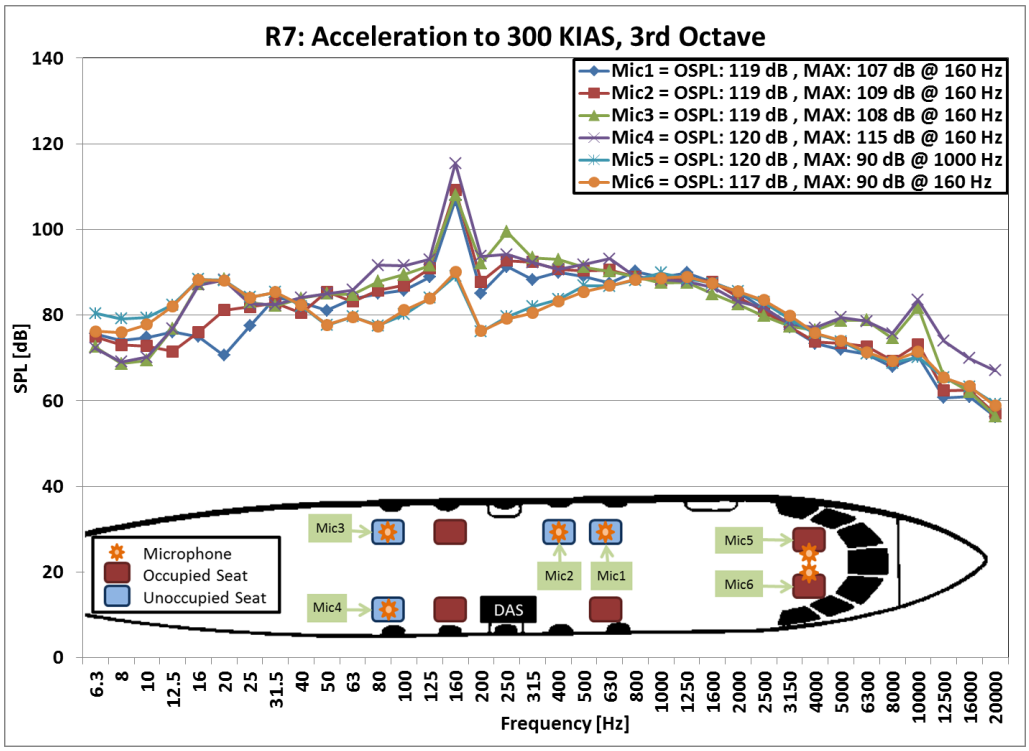


**Figure 47: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 7: Acceleration to 300 KIAS**

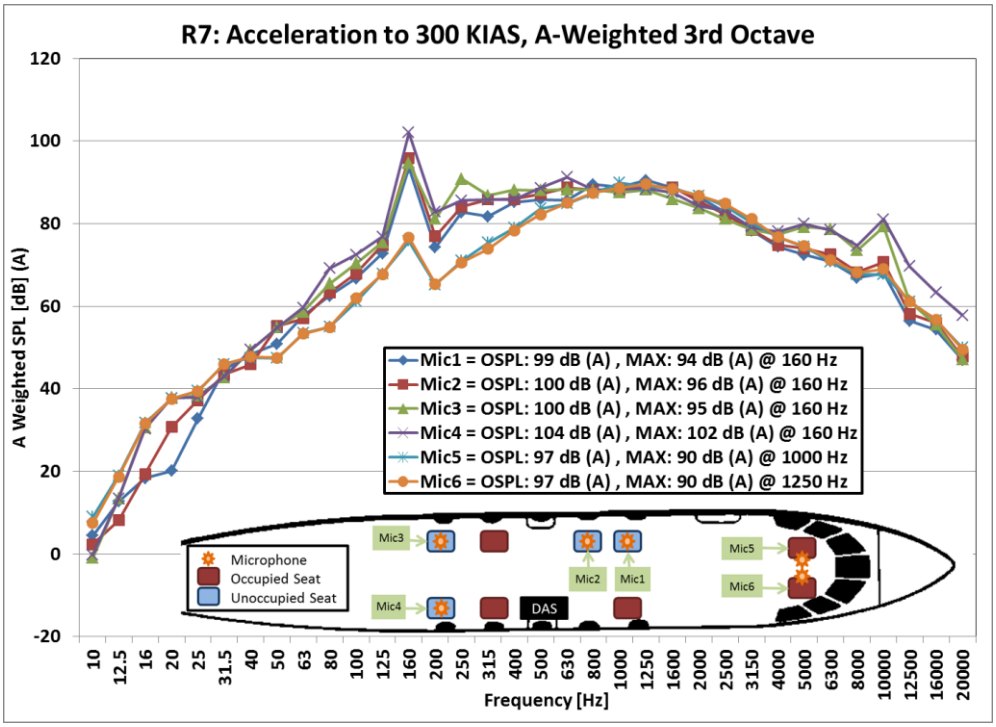


**Figure 48: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 7: Acceleration to 300 KIAS**

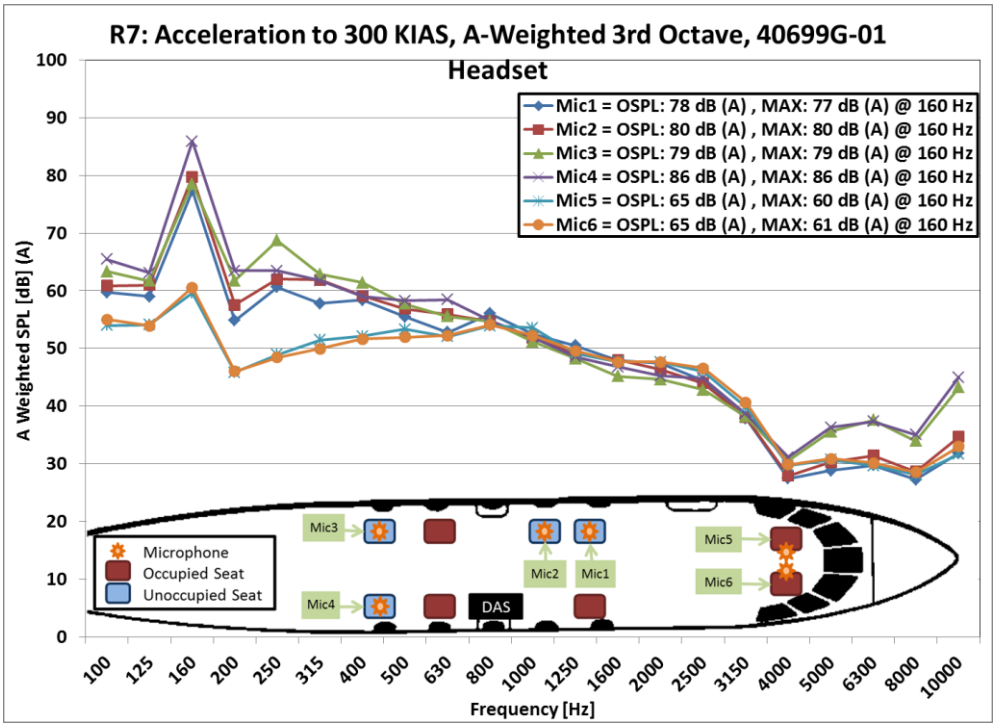


**Figure 49: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 7: Acceleration to 300 KIAS**

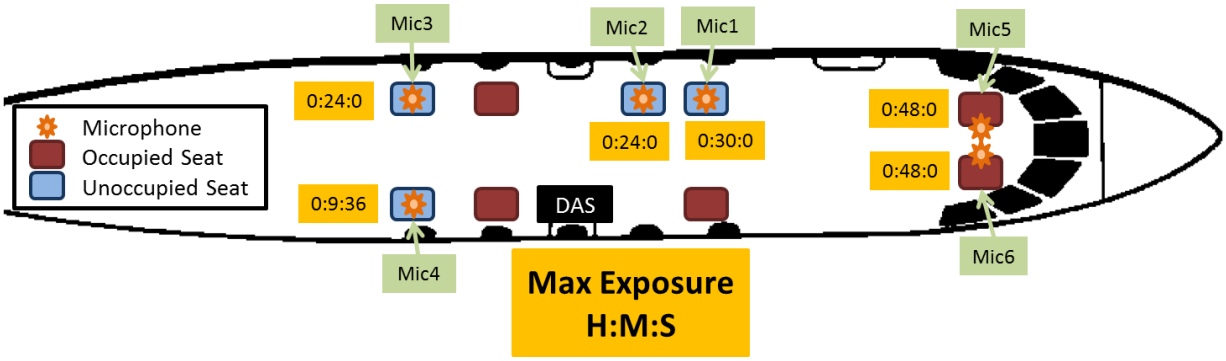


**Figure 50: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 7: Acceleration to 300 KIAS**

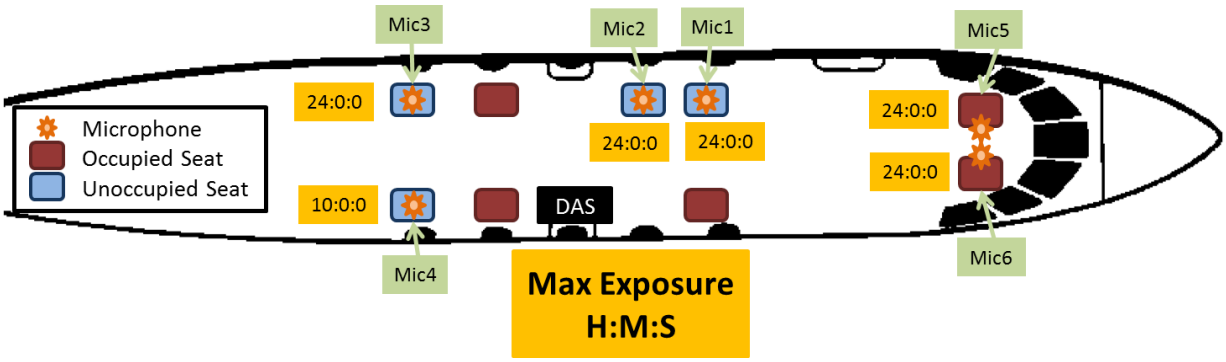


**Figure 51: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 7: Acceleration to 300 KIAS**

**Table 12: Acceleration to 300 KIAS 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 75.589 | 74.927 | 72.627 | 72.305 | 80.413 | 76.206 |
| **8** | 74.054 | 73.038 | 68.698 | 69.100 | 79.129 | 75.976 |
| **10** | 74.792 | 72.740 | 69.395 | 70.149 | 79.370 | 77.846 |
| **12.5** | 76.063 | 71.511 | 76.878 | 76.874 | 82.404 | 82.077 |
| **16** | 75.000 | 76.022 | 87.307 | 87.009 | 88.414 | 88.291 |
| **20** | 70.595 | 81.194 | 88.341 | 88.227 | 88.103 | 88.036 |
| **25** | 77.451 | 81.955 | 83.000 | 82.595 | 84.155 | 84.133 |
| **31.5** | 84.080 | 82.813 | 82.151 | 82.434 | 85.365 | 85.360 |
| **40** | 82.911 | 80.520 | 83.914 | 84.077 | 82.064 | 82.350 |
| **50** | 81.075 | 85.406 | 85.021 | 85.031 | 77.635 | 77.727 |
| **63** | 83.800 | 83.187 | 84.813 | 85.829 | 79.677 | 79.540 |
| **80** | 85.006 | 85.749 | 87.917 | 91.629 | 77.533 | 77.405 |
| **100** | 85.820 | 86.991 | 89.462 | 91.566 | 80.126 | 81.124 |
| **125** | 88.876 | 90.872 | 91.601 | 92.965 | 83.976 | 83.825 |
| **160** | 106.953 | 109.291 | 108.080 | 115.430 | 89.156 | 90.076 |
| **200** | 85.082 | 87.808 | 92.049 | 93.721 | 76.110 | 76.305 |
| **250** | 91.310 | 92.715 | 99.424 | 94.169 | 79.640 | 79.163 |
| **315** | 88.318 | 92.428 | 93.402 | 92.341 | 82.026 | 80.471 |
| **400** | 89.980 | 90.691 | 92.956 | 90.646 | 83.704 | 83.182 |
| **500** | 89.049 | 90.385 | 91.245 | 91.817 | 86.854 | 85.459 |
| **630** | 87.475 | 90.578 | 90.198 | 93.133 | 86.752 | 86.885 |
| **800** | 90.245 | 88.926 | 88.939 | 88.978 | 88.134 | 88.287 |
| **1000** | 88.878 | 88.164 | 87.521 | 88.293 | 89.913 | 88.601 |
| **1250** | 89.867 | 88.473 | 87.632 | 87.893 | 88.485 | 88.943 |
| **1600** | 87.644 | 87.785 | 84.969 | 86.541 | 87.449 | 87.408 |
| **2000** | 85.328 | 84.199 | 82.505 | 83.122 | 85.553 | 85.552 |
| **2500** | 81.412 | 80.963 | 79.813 | 81.823 | 82.988 | 83.541 |
| **3150** | 77.106 | 77.328 | 77.421 | 77.923 | 79.062 | 79.898 |
| **4000** | 73.350 | 73.826 | 76.449 | 77.064 | 75.629 | 75.777 |
| **5000** | 71.969 | 73.447 | 78.714 | 79.451 | 73.862 | 74.057 |
| **6300** | 70.971 | 72.663 | 78.818 | 78.555 | 70.901 | 71.370 |
| **8000** | 67.952 | 69.367 | 74.631 | 75.740 | 68.815 | 69.226 |
| **10000** | 70.407 | 73.217 | 81.754 | 83.509 | 70.166 | 71.513 |
| **12500** | 60.733 | 62.417 | 65.534 | 73.988 | 65.426 | 65.381 |
| **16000** | 60.955 | 62.506 | 62.102 | 69.961 | 63.235 | 63.409 |
| **20000** | 56.270 | 57.037 | 56.445 | 67.105 | 59.281 | 58.850 |
| **OSPL [dB]** | **119** | **119** | **119** | **120** | **120** | **117** |

## 9.8. [R8]: Deceleration to 200 KIAS

The PSD results are shown in Figure 52. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 53. This segment exhibits a maximum SPL of 107 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 54. This segment exhibits a maximum SPL of 91 dB(A) at the 125 Hz 1/3$^{rd}$ and 250 Hz octave bands. A maximum overall SPL of 98 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 55. This segment exhibits a maximum SPL of 77 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 79 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 56. A maximum duration of 38 minutes and 24 seconds cumulated during flight segment [R8]: Deceleration to 200 KIAS during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 57. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 38 minutes 24 seconds without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

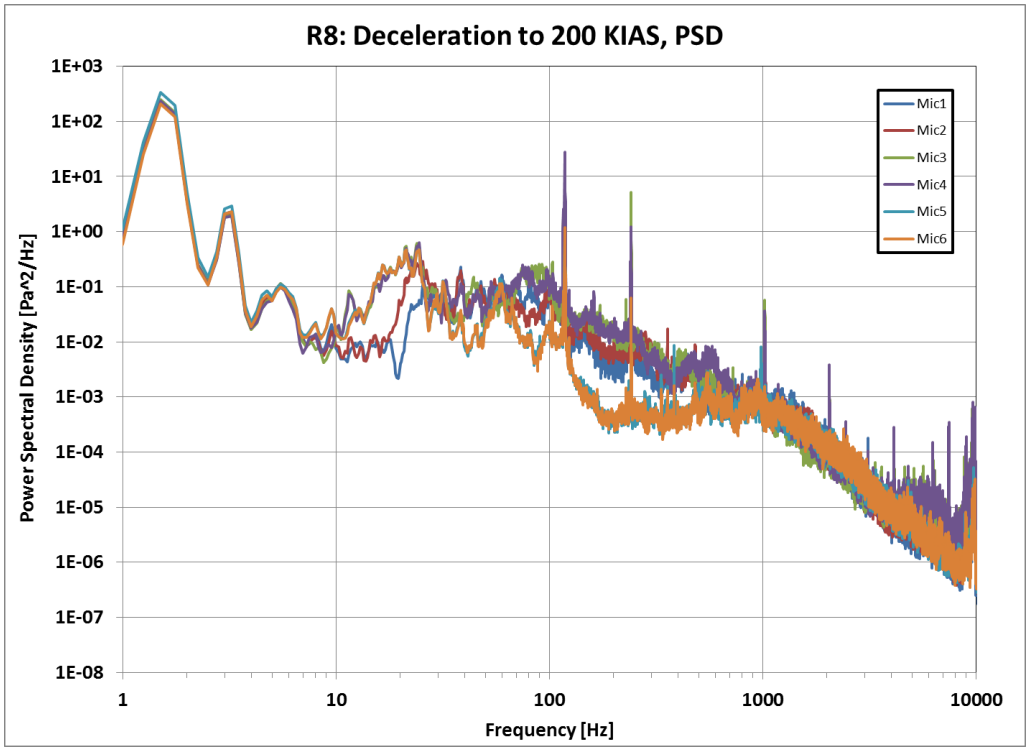


**Figure 52: Power Spectral Density for Run 8: Deceleration to 200 KIAS**

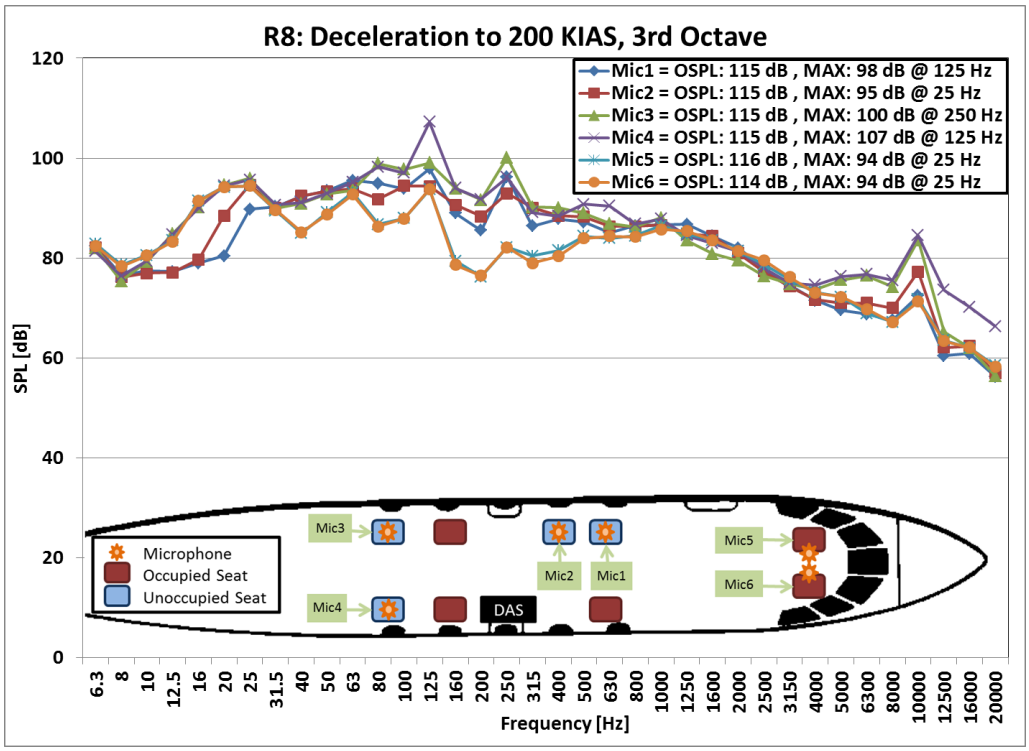


**Figure 53: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 8: Deceleration to 200 KIAS**

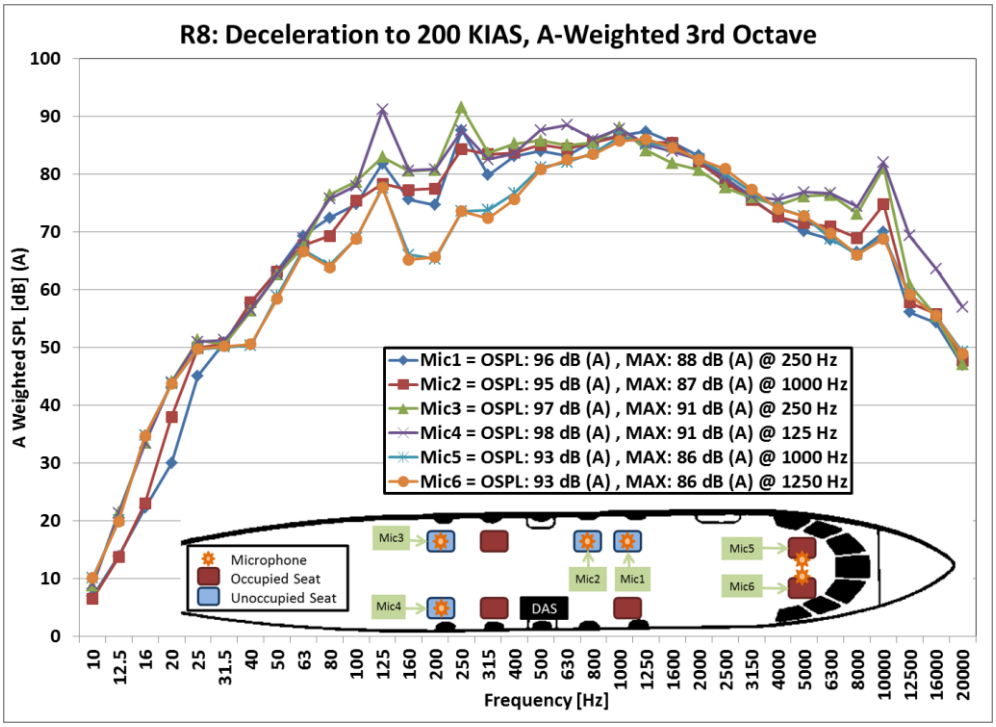


**Figure 54: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 8: Deceleration to 200 KIAS**

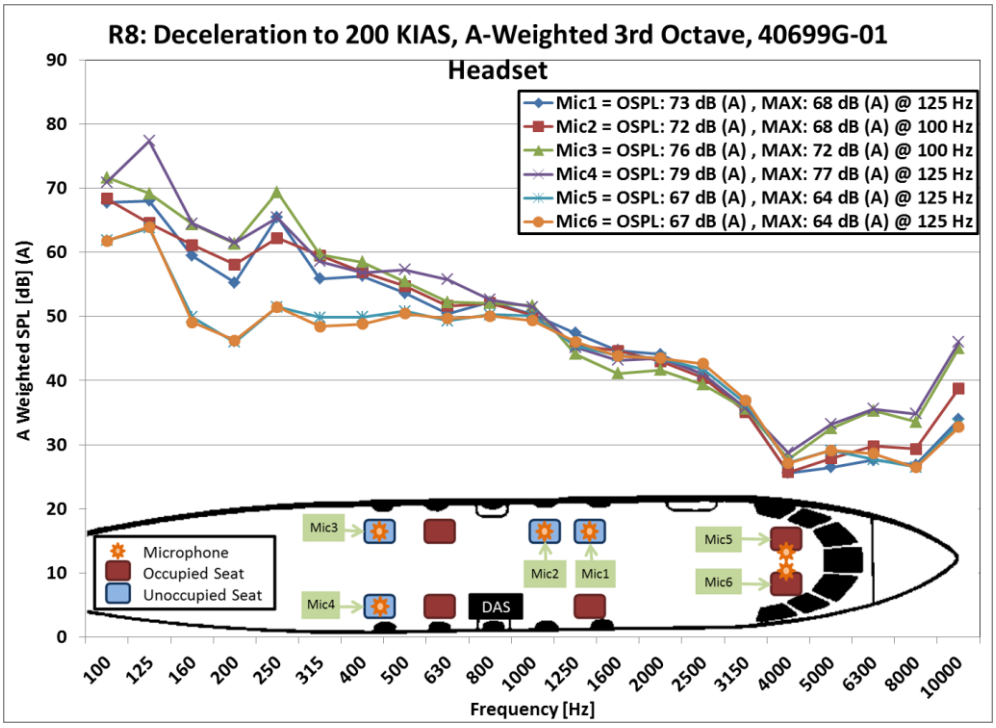


**Figure 55: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 8: Deceleration to 200 KIAS**

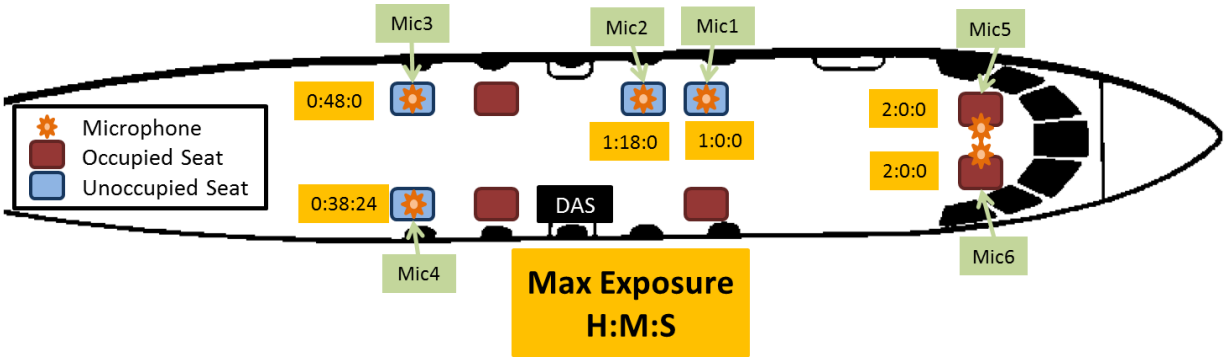


**Figure 56: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 8: Deceleration to 200 KIAS**

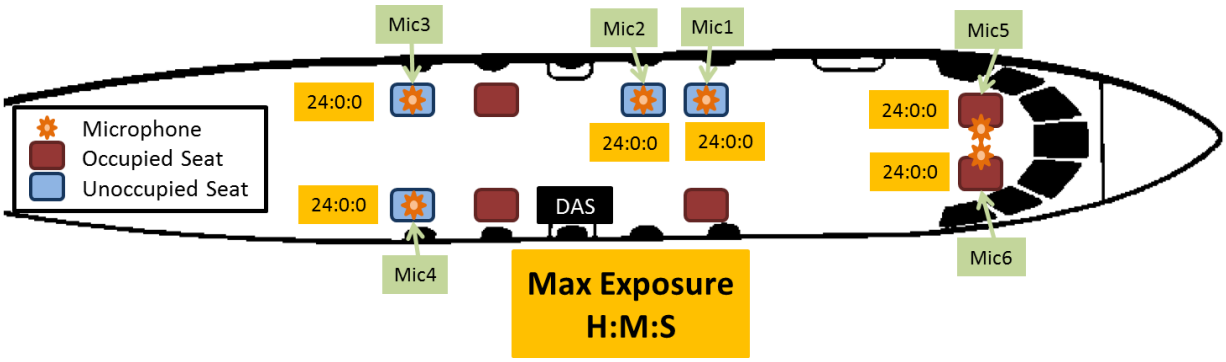


**Figure 57: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 8: Deceleration to 200 KIAS**

**Table 13: Deceleration to 200 KIAS 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 82.466 | 82.158 | 82.039 | 81.331 | 82.866 | 82.454 |
| **8** | 76.586 | 76.167 | 75.424 | 76.390 | 78.611 | 78.329 |
| **10** | 77.383 | 76.974 | 79.262 | 79.414 | 80.560 | 80.493 |
| **12.5** | 77.269 | 77.118 | 84.856 | 84.706 | 83.495 | 83.334 |
| **16** | 78.968 | 79.741 | 90.199 | 90.160 | 91.510 | 91.443 |
| **20** | 80.456 | 88.465 | 94.567 | 94.447 | 94.221 | 94.226 |
| **25** | 89.794 | 94.670 | 95.982 | 95.674 | 94.429 | 94.452 |
| **31.5** | 90.277 | 90.093 | 89.918 | 90.666 | 89.483 | 89.596 |
| **40** | 92.340 | 92.422 | 90.951 | 91.120 | 84.940 | 85.156 |
| **50** | 93.444 | 93.336 | 92.790 | 92.937 | 89.145 | 88.667 |
| **63** | 95.513 | 93.850 | 93.591 | 95.127 | 93.080 | 92.750 |
| **80** | 94.911 | 91.799 | 98.908 | 98.225 | 86.728 | 86.342 |
| **100** | 93.862 | 94.445 | 97.763 | 97.024 | 87.951 | 87.899 |
| **125** | 97.921 | 94.406 | 99.029 | 107.245 | 93.691 | 93.826 |
| **160** | 89.007 | 90.640 | 93.919 | 94.023 | 79.435 | 78.602 |
| **200** | 85.547 | 88.347 | 91.631 | 91.753 | 76.233 | 76.507 |
| **250** | 96.211 | 92.929 | 100.088 | 96.154 | 82.177 | 82.176 |
| **315** | 86.418 | 90.025 | 90.230 | 89.144 | 80.390 | 78.957 |
| **400** | 87.862 | 88.484 | 90.061 | 88.372 | 81.478 | 80.379 |
| **500** | 87.160 | 88.276 | 88.982 | 90.789 | 84.352 | 83.969 |
| **630** | 85.119 | 86.316 | 86.901 | 90.412 | 83.973 | 84.350 |
| **800** | 86.441 | 86.288 | 86.272 | 86.809 | 84.482 | 84.228 |
| **1000** | 86.684 | 86.578 | 88.051 | 87.846 | 86.435 | 85.719 |
| **1250** | 86.752 | 84.895 | 83.511 | 84.540 | 84.805 | 85.398 |
| **1600** | 84.412 | 84.397 | 80.881 | 82.916 | 83.610 | 83.562 |
| **2000** | 81.983 | 80.900 | 79.524 | 81.341 | 81.393 | 81.353 |
| **2500** | 77.821 | 77.360 | 76.365 | 77.980 | 78.696 | 79.589 |
| **3150** | 74.589 | 74.337 | 74.783 | 74.934 | 75.661 | 76.174 |
| **4000** | 71.490 | 71.624 | 73.664 | 74.620 | 73.141 | 72.992 |
| **5000** | 69.576 | 71.001 | 75.645 | 76.344 | 72.242 | 72.237 |
| **6300** | 68.773 | 70.980 | 76.490 | 76.775 | 68.920 | 69.806 |
| **8000** | 67.534 | 70.025 | 74.233 | 75.505 | 67.190 | 67.142 |
| **10000** | 72.460 | 77.269 | 83.590 | 84.501 | 71.737 | 71.284 |
| **12500** | 60.422 | 62.061 | 65.163 | 73.615 | 63.525 | 63.390 |
| **16000** | 60.864 | 62.407 | 62.012 | 70.202 | 62.027 | 62.078 |
| **20000** | 56.253 | 56.995 | 56.401 | 66.327 | 58.526 | 58.195 |
| **OSPL [dB]** | **115** | **115** | **115** | **115** | **116** | **114** |

## 9.9. [R9]: Parabola (1)

The PSD results are shown in Figure 58. Tonal behavior with the highest PSD level located at 1.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 59. This segment exhibits a maximum SPL of 108 dB in the 160 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 60. This segment exhibits a maximum SPL of 94 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 101 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 61. This segment exhibits a maximum SPL of 78 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 81 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 62. A maximum duration of 19 minutes 12 seconds cumulated during flight segment [R9]: Parabola (1) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 63. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 19 minutes 12 seconds without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

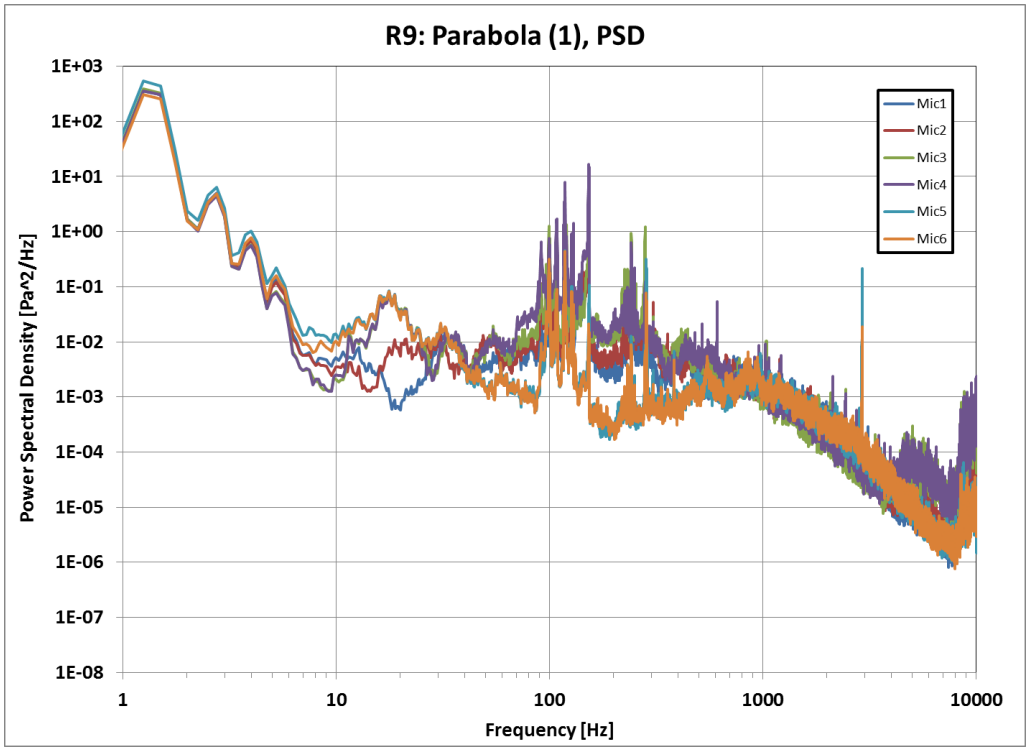


**Figure 58: Power Spectral Density for Run 9: Parabola (1)**

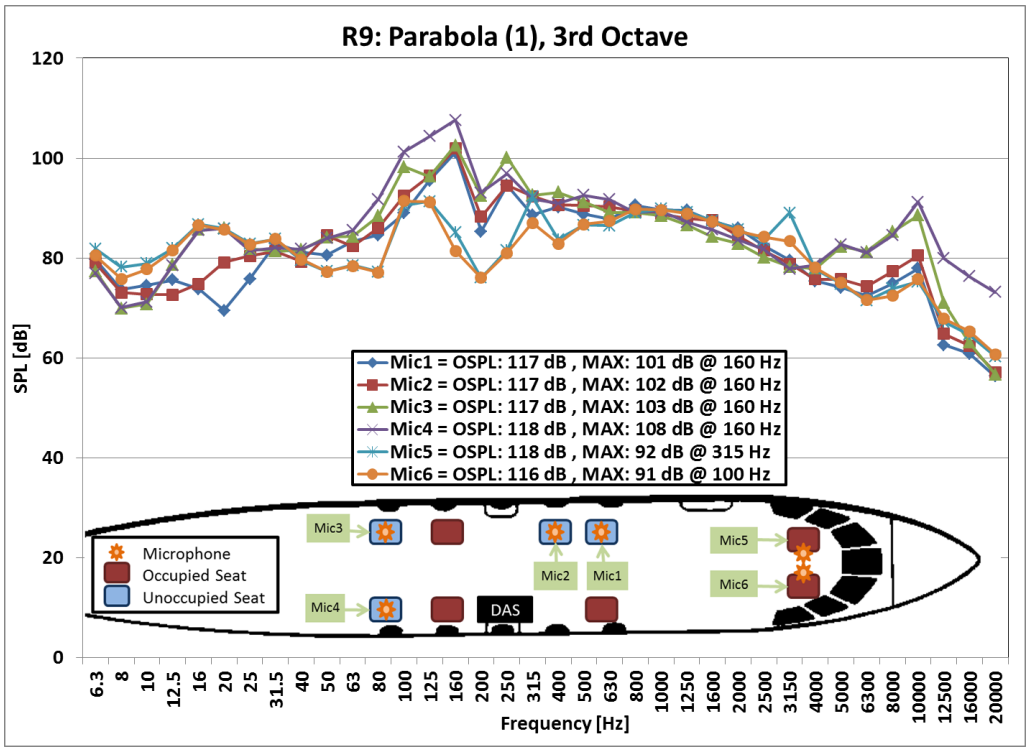


**Figure 59: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 9: Parabola (1)**

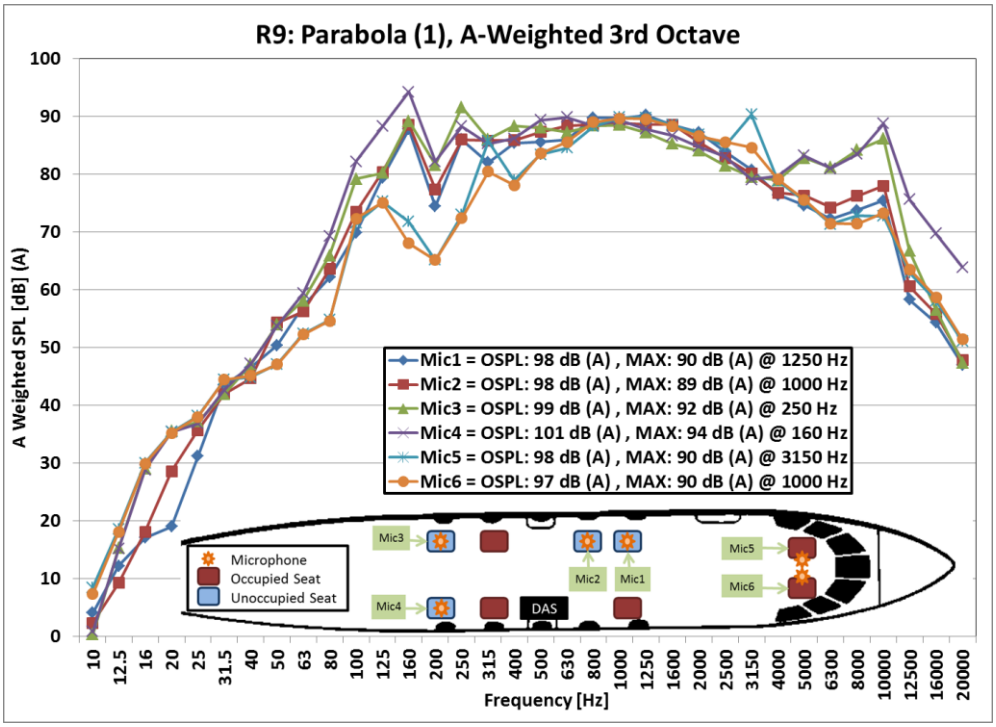


**Figure 60: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 9: Parabola (1)**

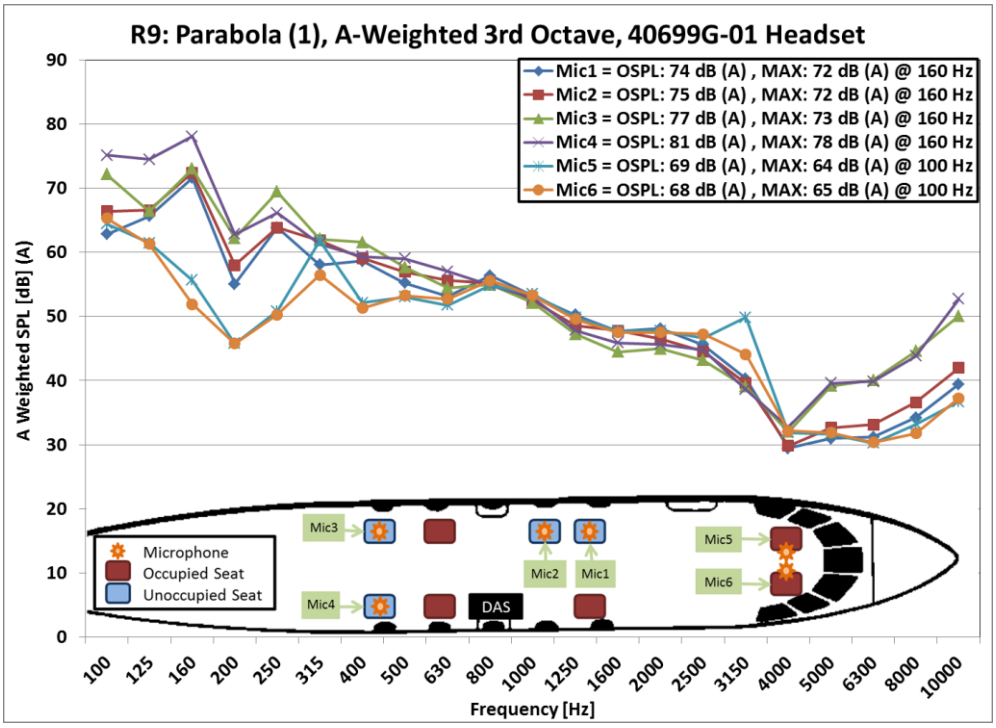


**Figure 61: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 9: Parabola (1)**

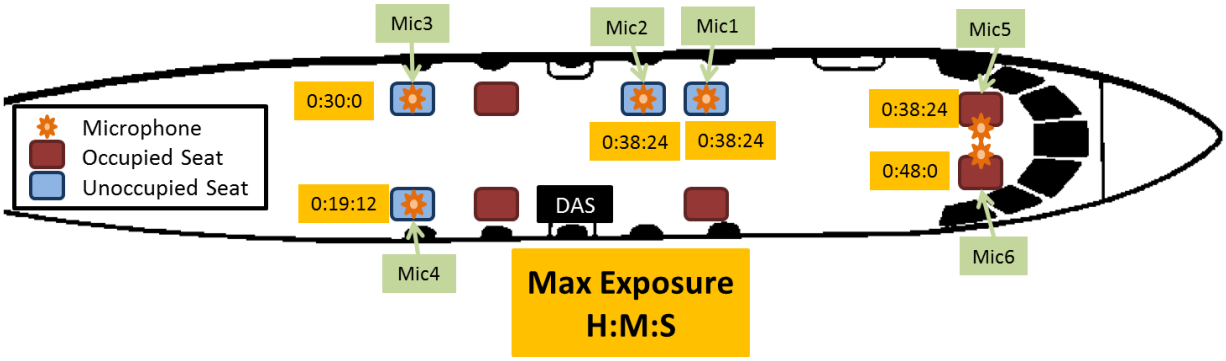


**Figure 62: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 9: Parabola (1)**

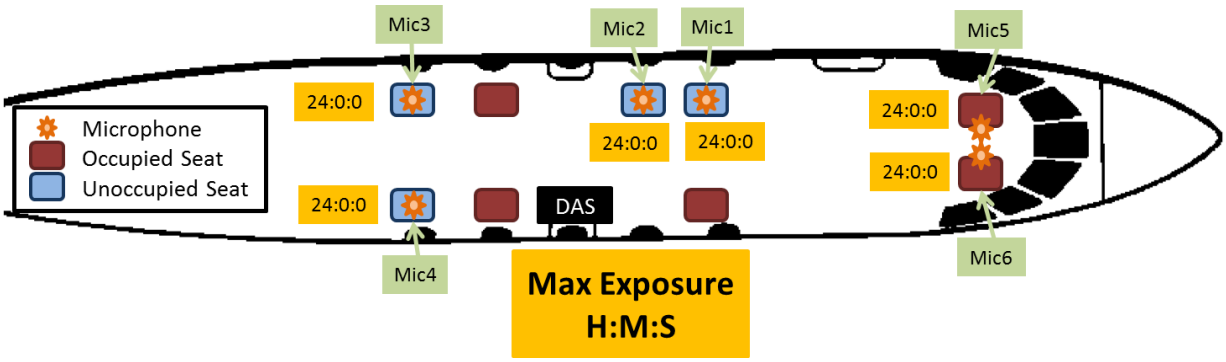


**Figure 63: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 9: Parabola (1)**

**Table 14: Parabola (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 79.687 | 79.032 | 77.391 | 76.999 | 81.845 | 80.498 |
| **8** | 73.655 | 73.110 | 69.961 | 70.076 | 78.198 | 75.850 |
| **10** | 74.509 | 72.729 | 70.769 | 71.206 | 78.903 | 77.735 |
| **12.5** | 75.594 | 72.657 | 78.660 | 78.586 | 81.970 | 81.486 |
| **16** | 73.799 | 74.806 | 85.679 | 85.512 | 86.721 | 86.622 |
| **20** | 69.529 | 79.108 | 85.985 | 85.917 | 85.892 | 85.701 |
| **25** | 75.845 | 80.415 | 81.884 | 81.509 | 82.842 | 82.706 |
| **31.5** | 82.909 | 81.336 | 81.347 | 82.058 | 83.822 | 83.834 |
| **40** | 81.143 | 79.243 | 81.674 | 81.797 | 79.464 | 79.721 |
| **50** | 80.585 | 84.520 | 84.170 | 83.925 | 77.336 | 77.269 |
| **63** | 83.298 | 82.394 | 84.287 | 85.560 | 78.586 | 78.441 |
| **80** | 84.599 | 86.042 | 88.397 | 91.761 | 77.247 | 77.095 |
| **100** | 88.954 | 92.537 | 98.259 | 101.251 | 90.581 | 91.407 |
| **125** | 95.514 | 96.462 | 96.300 | 104.335 | 91.334 | 91.177 |
| **160** | 101.149 | 101.944 | 102.543 | 107.620 | 85.167 | 81.426 |
| **200** | 85.309 | 88.251 | 92.458 | 93.076 | 76.014 | 76.048 |
| **250** | 94.564 | 94.539 | 100.134 | 96.851 | 81.553 | 80.983 |
| **315** | 88.585 | 92.367 | 92.603 | 91.815 | 92.321 | 87.010 |
| **400** | 90.185 | 90.632 | 93.119 | 90.913 | 83.700 | 82.875 |
| **500** | 88.767 | 90.461 | 91.179 | 92.555 | 86.596 | 86.780 |
| **630** | 87.783 | 90.255 | 89.128 | 91.698 | 86.434 | 87.412 |
| **800** | 90.530 | 89.401 | 89.148 | 89.100 | 89.032 | 89.767 |
| **1000** | 89.621 | 88.825 | 88.481 | 89.308 | 89.839 | 89.652 |
| **1250** | 89.560 | 87.936 | 86.580 | 87.176 | 89.175 | 88.935 |
| **1600** | 87.408 | 87.529 | 84.231 | 85.642 | 87.466 | 87.250 |
| **2000** | 85.996 | 84.375 | 82.862 | 83.568 | 85.649 | 85.386 |
| **2500** | 82.525 | 81.492 | 80.144 | 81.784 | 83.590 | 84.218 |
| **3150** | 79.546 | 78.847 | 78.296 | 77.861 | 89.068 | 83.346 |
| **4000** | 75.370 | 75.753 | 77.888 | 78.645 | 77.776 | 78.085 |
| **5000** | 74.099 | 75.755 | 82.281 | 82.709 | 74.803 | 75.035 |
| **6300** | 72.362 | 74.328 | 81.263 | 81.087 | 71.442 | 71.567 |
| **8000** | 74.867 | 77.305 | 85.265 | 84.511 | 73.852 | 72.473 |
| **10000** | 77.929 | 80.469 | 88.561 | 91.219 | 75.233 | 75.752 |
| **12500** | 62.572 | 64.845 | 71.013 | 79.906 | 67.191 | 67.824 |
| **16000** | 60.883 | 62.420 | 63.125 | 76.319 | 64.661 | 65.299 |
| **20000** | 56.332 | 57.105 | 56.670 | 73.168 | 60.325 | 60.696 |
| **OSPL [dB]** | **117** | **117** | **117** | **118** | **118** | **116** |

## 9.10. [R10]: Parabola (2)

The PSD results are shown in Figure 64. Tonal behavior with the highest PSD level located at 1.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 65. This segment exhibits a maximum SPL of 111 dB in the 160 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 66. This segment exhibits a maximum SPL of 98 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 102 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 67. This segment exhibits a maximum SPL of 82 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 84 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 68. A maximum duration of 15 minutes cumulated during flight segment [R10]: Parabola (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 69. The rearmost (Mic 4) starboard side location exhibited a maximum exposure duration of 16 hours.

Aircrew may operate for up to 15 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for up to 16 hours before reaching their maximum exposure dose from this flight segment. The David Clark headset provides adequate protection for this flight segment.

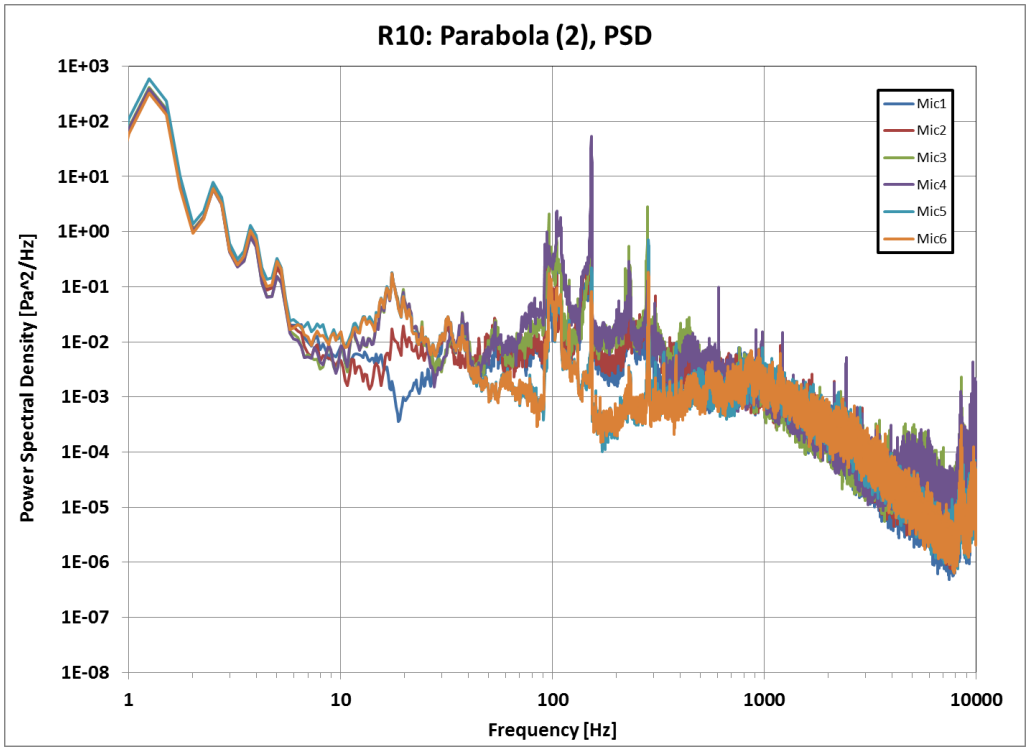


**Figure 64: Power Spectral Density for Run 10: Parabola (2)**

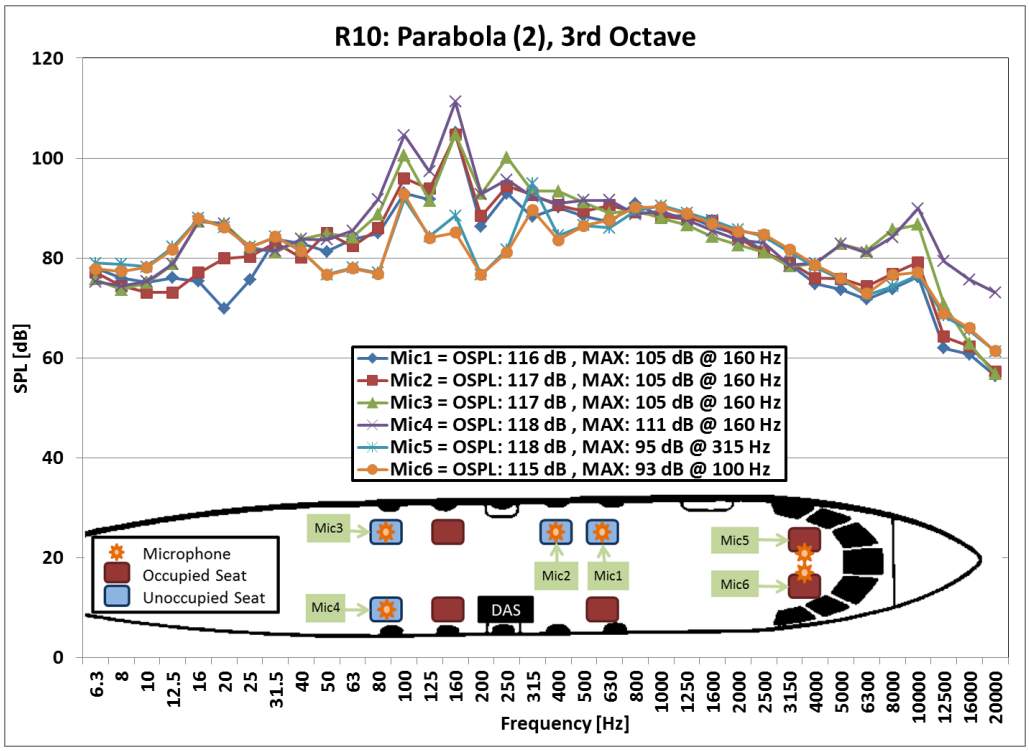


**Figure 65: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 10: Parabola (2)**

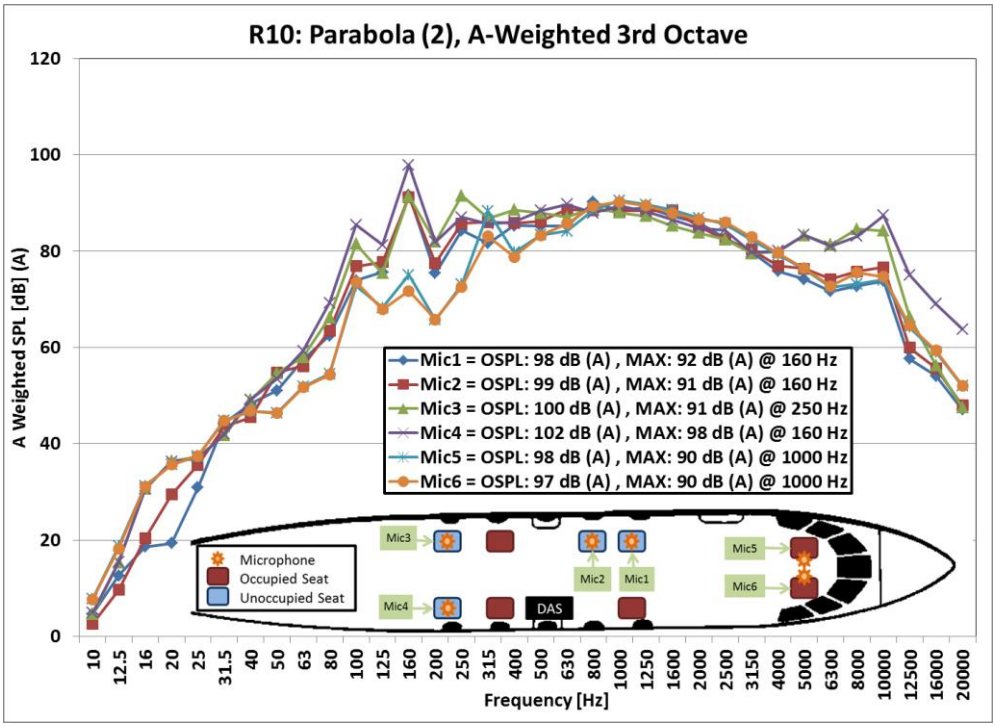


**Figure 66: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 10: Parabola (2)**

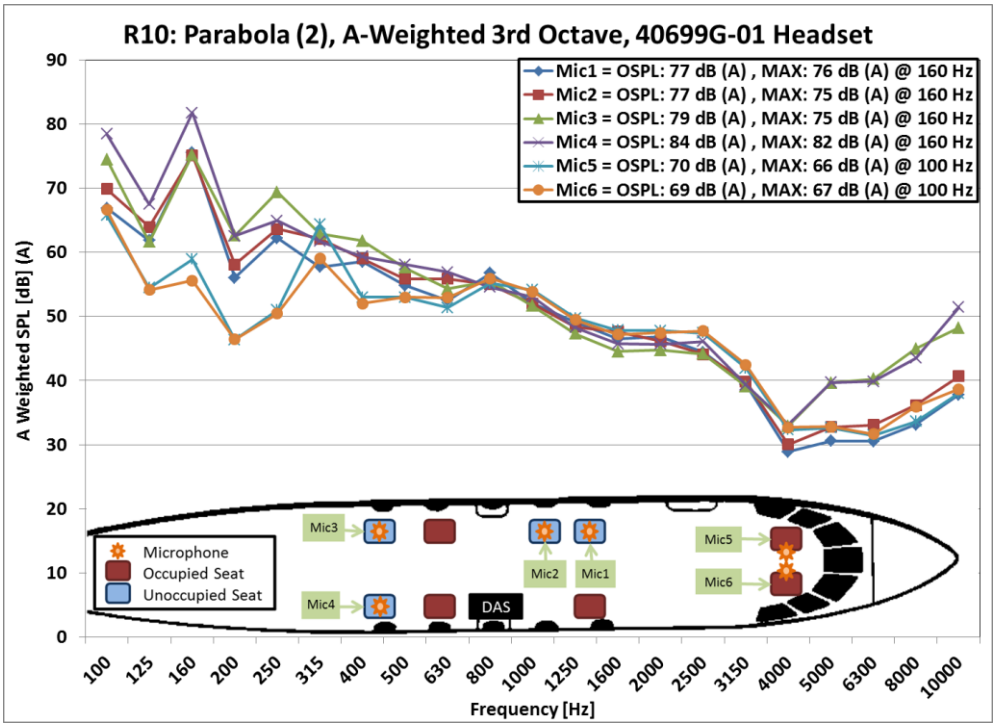


**Figure 67: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 10: Parabola (2)**

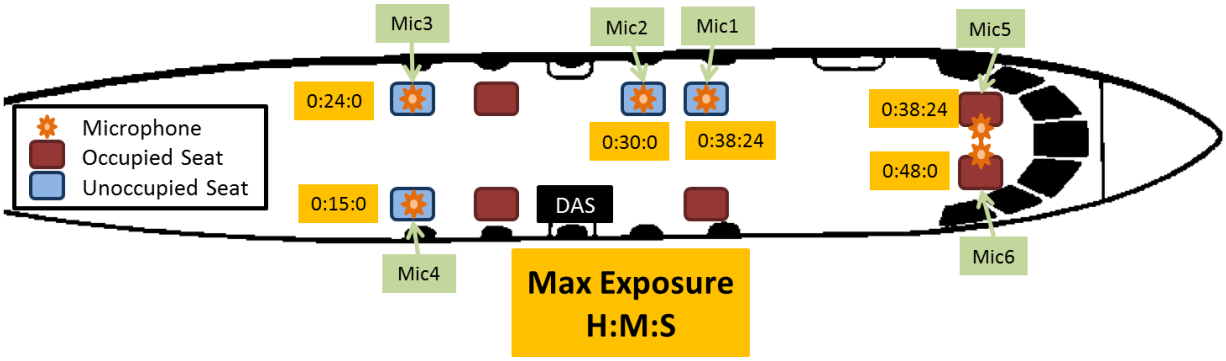


**Figure 68: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 10: Parabola (2)**

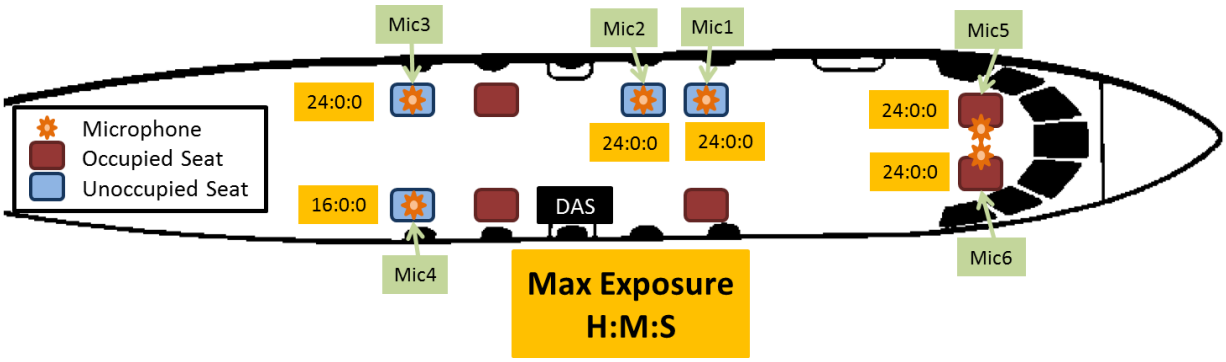


**Figure 69: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 10: Parabola (2)**

**Table 15: Parabola (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 77.986 | 77.091 | 75.773 | 75.285 | 78.959 | 77.833 |
| **8** | 75.972 | 74.387 | 73.669 | 74.408 | 78.807 | 77.321 |
| **10** | 75.111 | 73.062 | 75.032 | 75.334 | 78.293 | 78.135 |
| **12.5** | 76.020 | 73.076 | 78.781 | 78.828 | 82.194 | 81.690 |
| **16** | 75.295 | 77.071 | 87.329 | 87.303 | 87.991 | 87.853 |
| **20** | 69.835 | 79.955 | 86.898 | 86.822 | 86.203 | 86.152 |
| **25** | 75.598 | 80.317 | 82.132 | 81.690 | 82.201 | 82.168 |
| **31.5** | 83.708 | 83.038 | 81.141 | 81.437 | 84.250 | 84.211 |
| **40** | 82.888 | 80.072 | 83.744 | 83.812 | 81.324 | 81.423 |
| **50** | 81.292 | 85.048 | 84.871 | 83.686 | 76.667 | 76.586 |
| **63** | 83.719 | 82.356 | 84.190 | 85.477 | 78.052 | 77.944 |
| **80** | 84.974 | 85.992 | 88.732 | 91.770 | 77.063 | 76.801 |
| **100** | 92.979 | 95.977 | 100.579 | 104.547 | 91.855 | 92.724 |
| **125** | 91.723 | 93.833 | 91.519 | 97.342 | 84.324 | 84.020 |
| **160** | 105.078 | 104.644 | 104.756 | 111.283 | 88.441 | 85.120 |
| **200** | 86.288 | 88.373 | 92.839 | 92.778 | 76.613 | 76.686 |
| **250** | 92.903 | 94.360 | 100.087 | 95.668 | 81.691 | 81.167 |
| **315** | 88.251 | 92.666 | 93.389 | 92.262 | 94.882 | 89.638 |
| **400** | 90.094 | 90.593 | 93.359 | 90.927 | 84.557 | 83.570 |
| **500** | 88.388 | 89.382 | 91.112 | 91.592 | 86.533 | 86.496 |
| **630** | 87.155 | 90.553 | 88.949 | 91.591 | 86.022 | 87.605 |
| **800** | 90.921 | 89.222 | 89.684 | 88.734 | 89.378 | 90.125 |
| **1000** | 88.361 | 88.322 | 87.976 | 89.384 | 90.493 | 90.223 |
| **1250** | 88.446 | 87.723 | 86.627 | 87.611 | 89.075 | 88.807 |
| **1600** | 86.252 | 87.392 | 84.260 | 85.444 | 87.561 | 86.927 |
| **2000** | 84.727 | 84.054 | 82.615 | 83.566 | 85.666 | 85.338 |
| **2500** | 81.388 | 81.070 | 81.129 | 83.067 | 84.395 | 84.719 |
| **3150** | 78.669 | 79.115 | 78.316 | 78.557 | 81.167 | 81.703 |
| **4000** | 74.826 | 75.947 | 78.832 | 79.023 | 78.210 | 78.589 |
| **5000** | 73.698 | 75.858 | 82.763 | 82.822 | 75.785 | 75.933 |
| **6300** | 71.726 | 74.289 | 81.454 | 81.085 | 72.626 | 72.845 |
| **8000** | 73.815 | 76.839 | 85.664 | 84.185 | 74.303 | 76.645 |
| **10000** | 76.291 | 79.160 | 86.712 | 89.938 | 76.516 | 77.153 |
| **12500** | 61.973 | 64.266 | 70.690 | 79.313 | 68.452 | 68.904 |
| **16000** | 60.707 | 62.276 | 62.869 | 75.669 | 65.577 | 65.967 |
| **20000** | 56.416 | 57.266 | 56.802 | 73.081 | 61.272 | 61.376 |
| **OSPL [dB]** | **116** | **117** | **117** | **118** | **118** | **115** |

## 9.11. [R11]: Descent (1)

The PSD results are shown in Figure 70. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 71. This segment exhibits a maximum SPL of 109 dB in the 100 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 72. This segment exhibits a maximum SPL of 93 dB(A) at the 250 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 99 dB(A) was measured at the rearmost (Mics 3 and4) portside and starboard side cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 73. This segment exhibits a maximum SPL of 83 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 83 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 74. A maximum duration of 30 minutes cumulated during flight segment [R11]: Descent (1) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 75. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 30 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

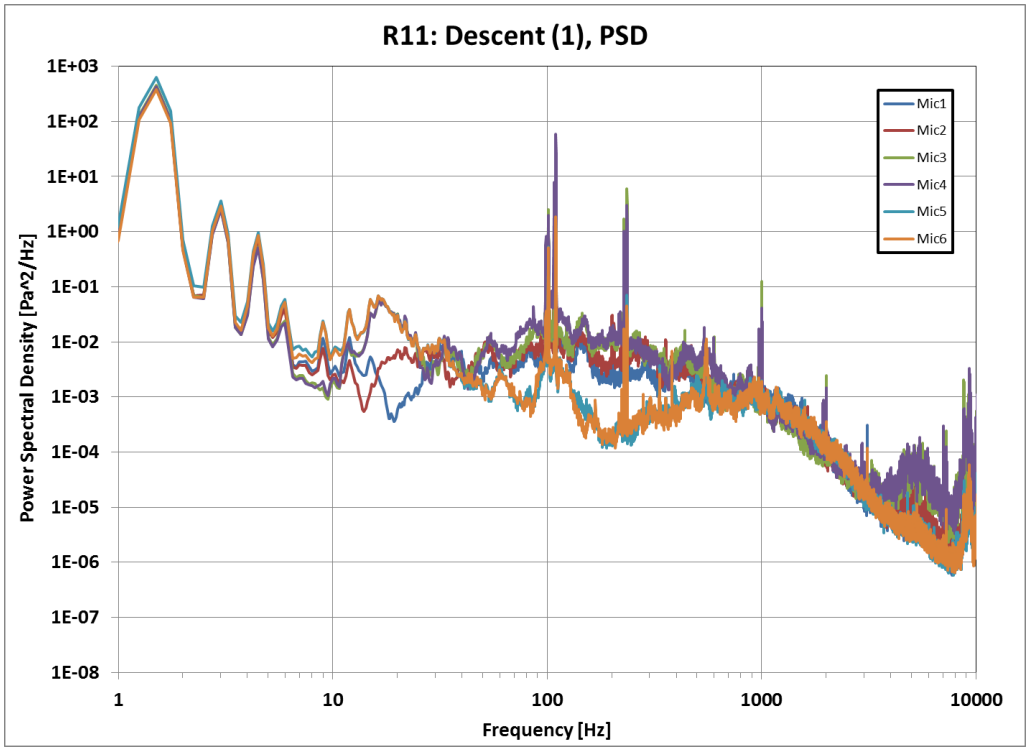


**Figure 70: Power Spectral Density for Run 11: Descent (1)**

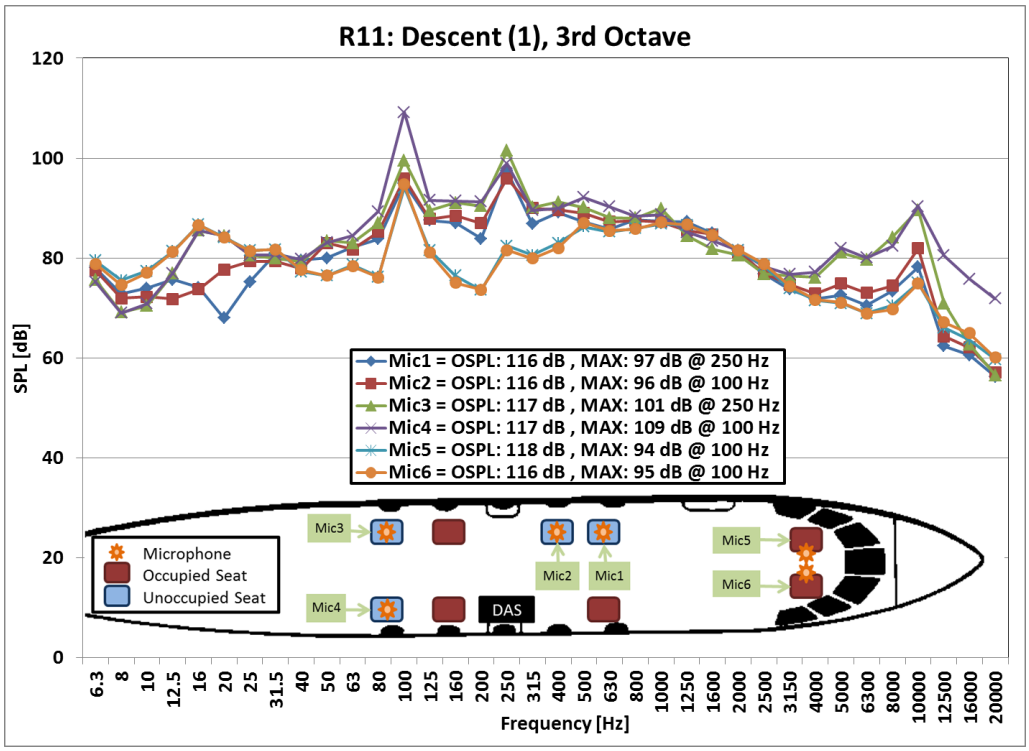


**Figure 71: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 11: Descent (1)**

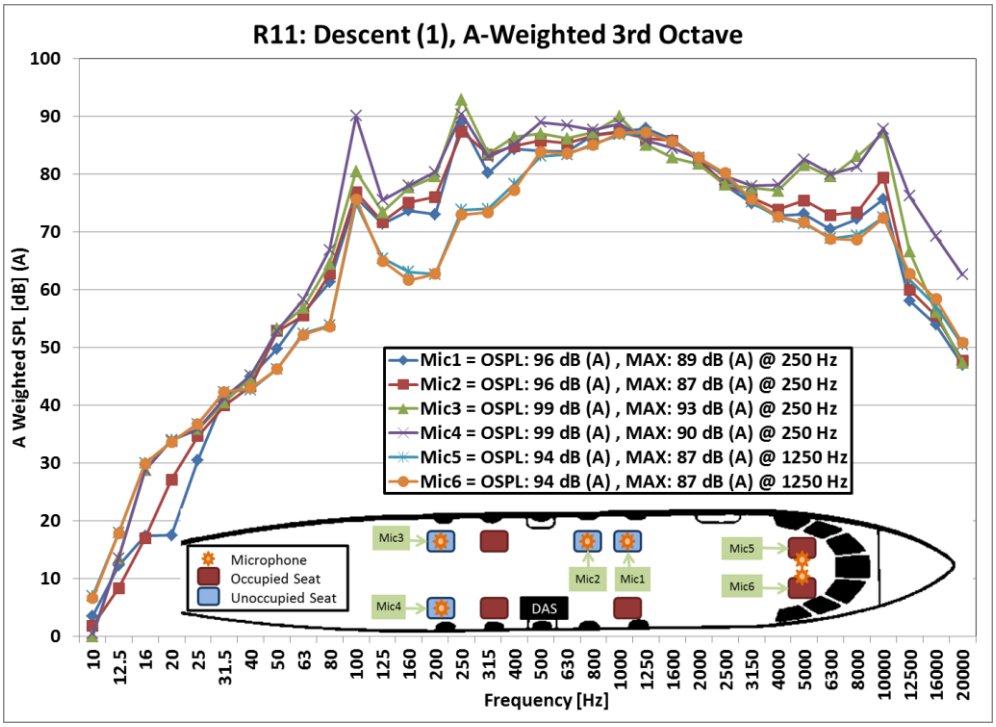


**Figure 72: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 11: Descent (1)**

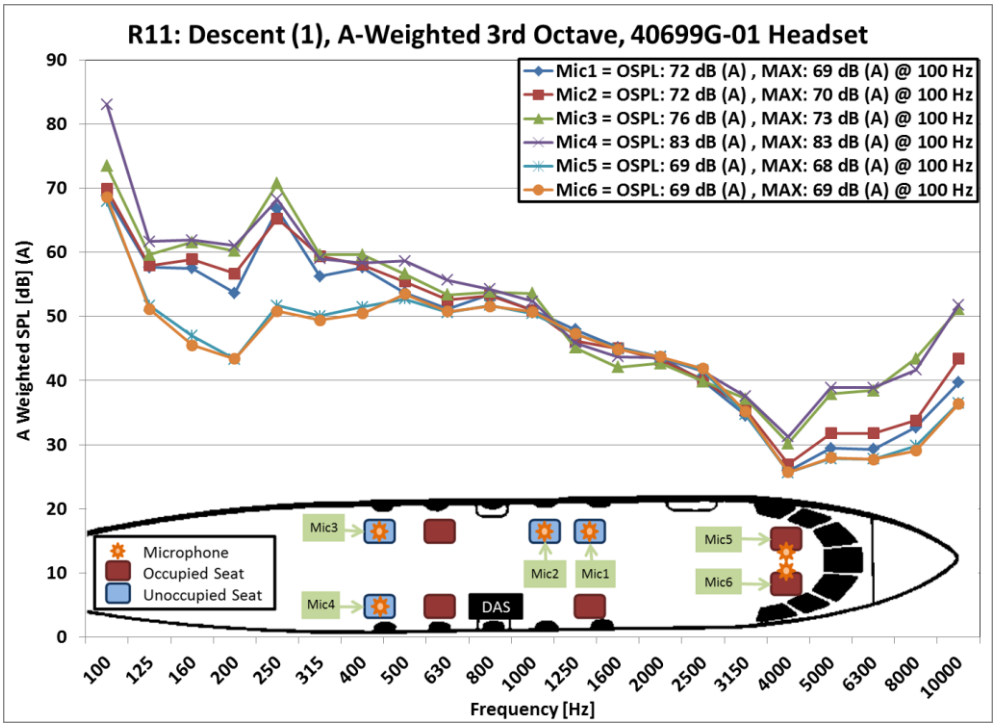


**Figure 73: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 11: Descent (1)**

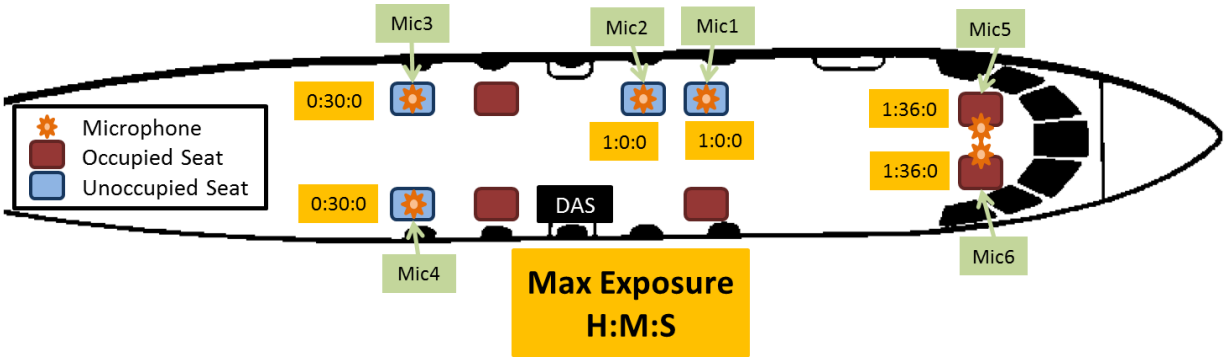


**Figure 74: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 11: Descent (1)**

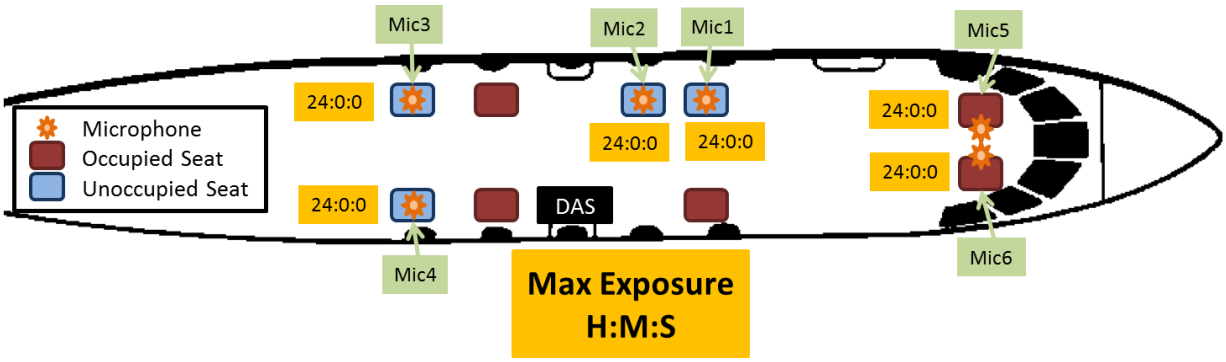


**Figure 75: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 11: Descent (1)**

**Table 16: Descent (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 78.074 | 77.518 | 75.649 | 75.241 | 79.519 | 78.808 |
| **8** | 72.869 | 71.957 | 69.162 | 68.961 | 75.528 | 74.620 |
| **10** | 73.926 | 72.249 | 70.449 | 70.846 | 77.408 | 77.015 |
| **12.5** | 75.688 | 71.773 | 76.906 | 76.947 | 81.345 | 81.239 |
| **16** | 74.107 | 73.721 | 85.522 | 85.473 | 86.694 | 86.634 |
| **20** | 68.012 | 77.665 | 84.446 | 84.480 | 84.182 | 84.121 |
| **25** | 75.221 | 79.374 | 80.564 | 80.568 | 81.499 | 81.466 |
| **31.5** | 80.893 | 79.375 | 79.906 | 80.664 | 81.741 | 81.724 |
| **40** | 79.563 | 77.898 | 79.297 | 79.788 | 77.258 | 77.595 |
| **50** | 79.987 | 83.037 | 83.466 | 83.119 | 76.479 | 76.477 |
| **63** | 82.156 | 81.691 | 83.029 | 84.443 | 78.625 | 78.377 |
| **80** | 83.784 | 85.228 | 86.974 | 89.369 | 76.281 | 76.102 |
| **100** | 94.976 | 95.986 | 99.581 | 109.157 | 94.080 | 94.763 |
| **125** | 87.509 | 87.809 | 89.506 | 91.575 | 81.544 | 81.048 |
| **160** | 87.053 | 88.465 | 91.082 | 91.426 | 76.483 | 75.019 |
| **200** | 83.888 | 86.956 | 90.452 | 91.289 | 73.581 | 73.635 |
| **250** | 97.446 | 95.965 | 101.474 | 98.930 | 82.417 | 81.553 |
| **315** | 86.789 | 89.964 | 90.154 | 89.560 | 80.591 | 79.949 |
| **400** | 89.152 | 89.618 | 91.181 | 89.946 | 83.044 | 82.027 |
| **500** | 87.212 | 88.971 | 90.163 | 92.169 | 86.267 | 87.024 |
| **630** | 85.808 | 87.221 | 88.033 | 90.307 | 85.258 | 85.446 |
| **800** | 87.597 | 87.443 | 88.006 | 88.440 | 85.961 | 85.799 |
| **1000** | 87.349 | 87.277 | 89.948 | 88.721 | 86.797 | 87.085 |
| **1250** | 87.264 | 85.521 | 84.442 | 85.201 | 86.584 | 86.648 |
| **1600** | 84.922 | 84.774 | 81.823 | 83.463 | 84.685 | 84.611 |
| **2000** | 81.510 | 81.121 | 80.543 | 81.495 | 81.610 | 81.611 |
| **2500** | 76.833 | 77.077 | 76.857 | 78.364 | 78.498 | 78.860 |
| **3150** | 73.760 | 74.690 | 76.398 | 76.736 | 73.944 | 74.383 |
| **4000** | 71.811 | 72.879 | 76.129 | 77.157 | 71.535 | 71.628 |
| **5000** | 72.561 | 74.897 | 81.043 | 82.021 | 70.939 | 71.110 |
| **6300** | 70.500 | 73.002 | 79.653 | 80.073 | 68.948 | 68.923 |
| **8000** | 73.362 | 74.452 | 84.142 | 82.341 | 70.490 | 69.747 |
| **10000** | 78.193 | 81.918 | 89.640 | 90.336 | 75.020 | 74.889 |
| **12500** | 62.414 | 64.314 | 70.908 | 80.524 | 66.047 | 67.108 |
| **16000** | 60.560 | 62.120 | 62.715 | 75.818 | 63.706 | 64.966 |
| **20000** | 56.288 | 57.056 | 56.591 | 71.902 | 59.746 | 60.085 |
| **OSPL [dB]** | **116** | **116** | **117** | **117** | **118** | **116** |

## 9.12. [R12]: Descent (2)

The PSD results are shown in Figure 76. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 77. This segment exhibits a maximum SPL of 105 dB in the 100 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 78. This segment exhibits a maximum SPL of 92 dB(A) at the 250 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 97 dB(A) was measured at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 79 This segment exhibits a maximum SPL of 79 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 79 dB(A) was measured at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 80. A maximum duration of 48 minutes cumulated during flight segment [R12]: Descent (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 81. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 48 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

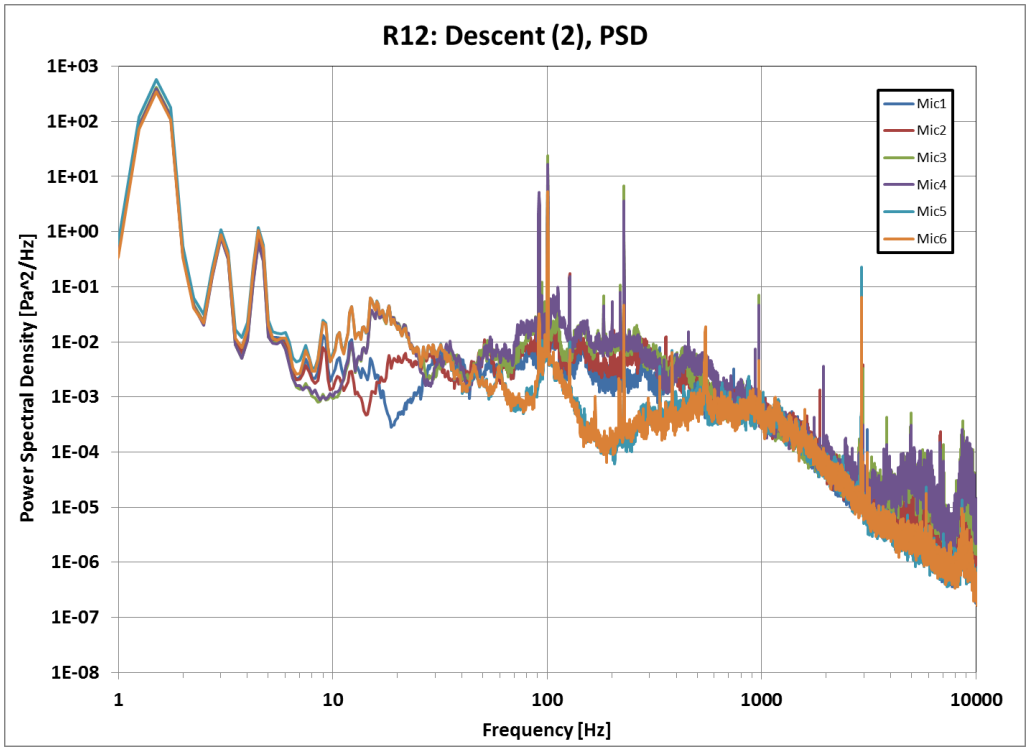


**Figure 76: Power Spectral Density for Run 12: Descent (2)**

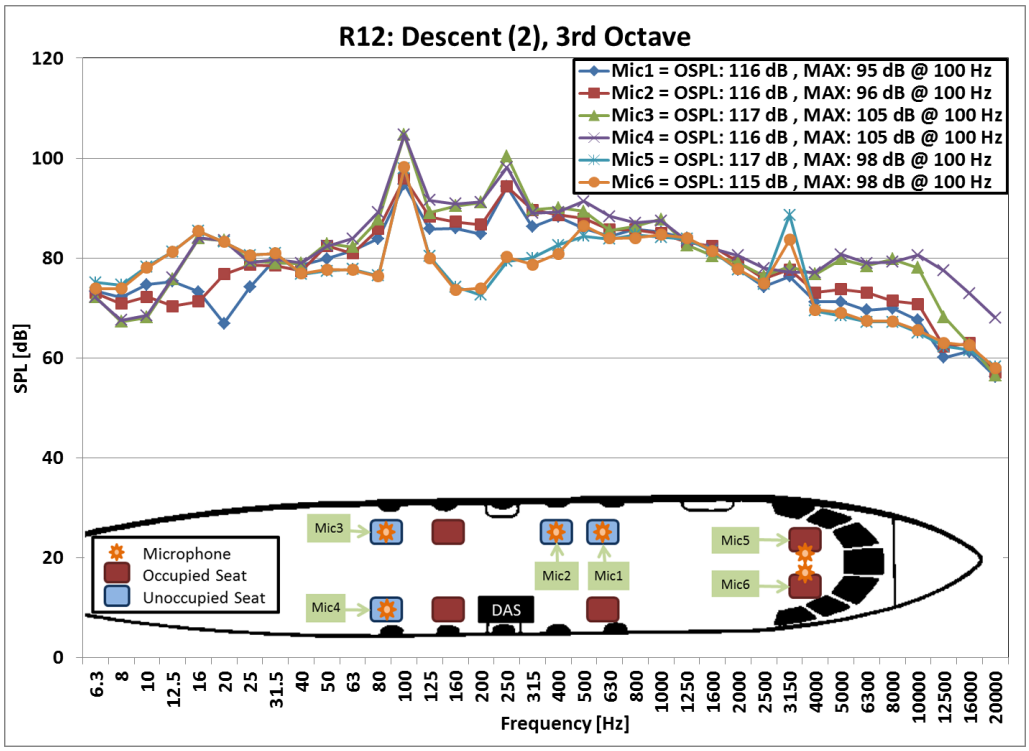


**Figure 77: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 12: Descent (2)**

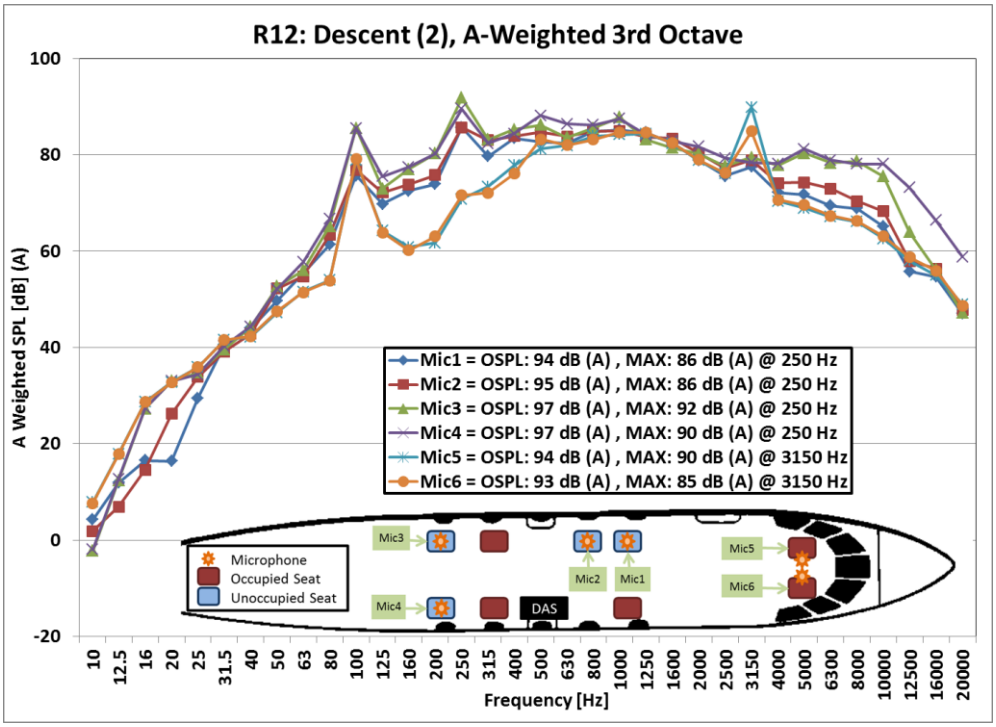


**Figure 78: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 12: Descent (2)**

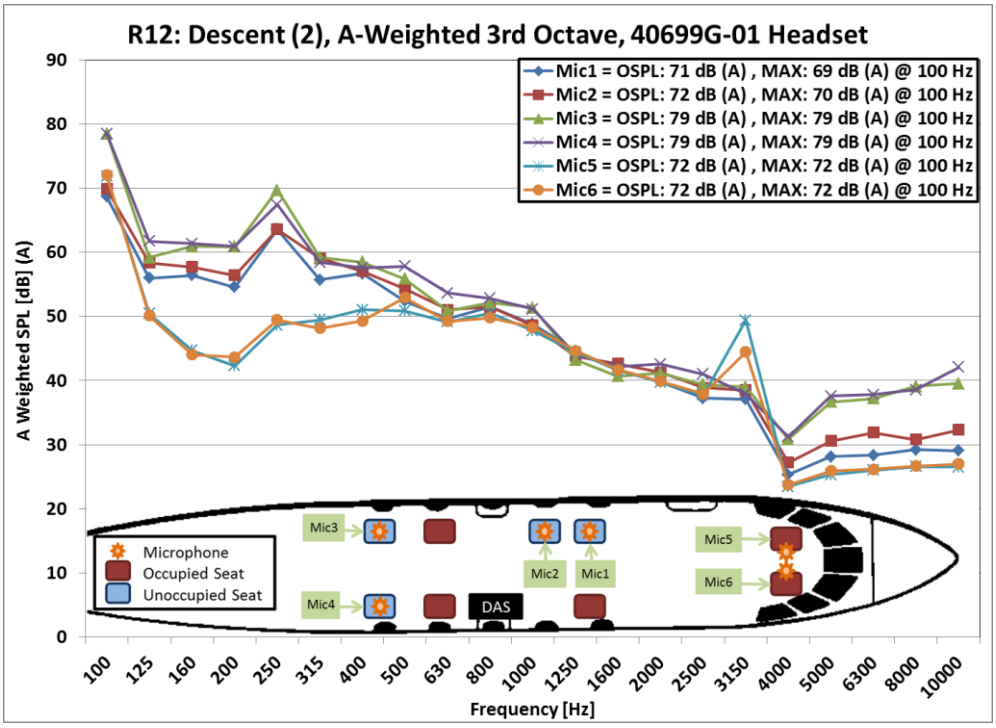


**Figure 79: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 12: Descent (2)**

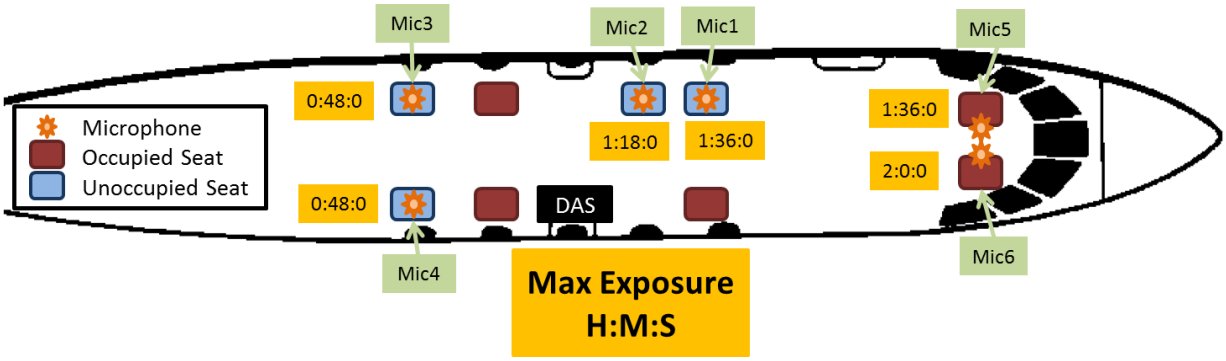


**Figure 80: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 12: Descent (2)**

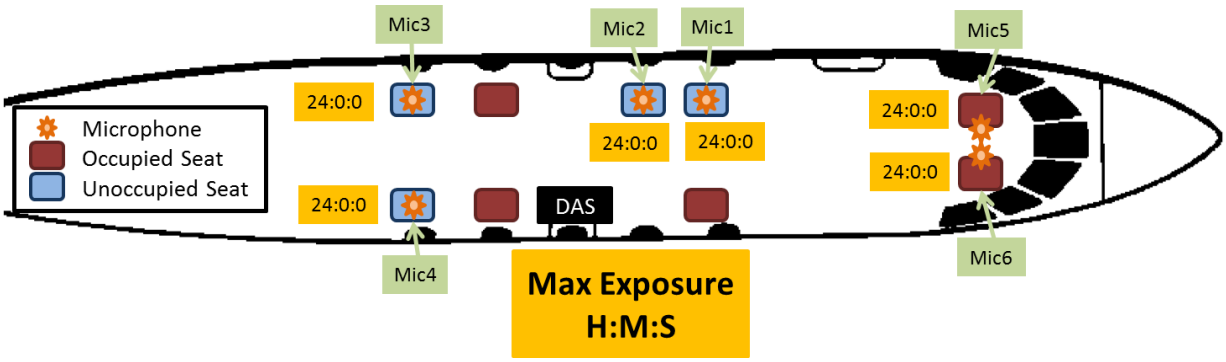


**Figure 81: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 12: Descent (2)**

**Table 17: Descent (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| **Frequency [Hz]** | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 73.397 | 73.005 | 72.261 | 72.167 | 75.101 | 73.890 |
| **8** | 72.155 | 70.899 | 67.269 | 67.555 | 74.587 | 73.908 |
| **10** | 74.681 | 72.249 | 68.150 | 68.463 | 78.299 | 78.034 |
| **12.5** | 75.303 | 70.357 | 75.796 | 76.087 | 81.309 | 81.261 |
| **16** | 73.222 | 71.325 | 83.973 | 84.066 | 85.400 | 85.359 |
| **20** | 66.880 | 76.725 | 83.538 | 83.534 | 83.263 | 83.247 |
| **25** | 74.159 | 78.609 | 79.466 | 79.071 | 80.571 | 80.574 |
| **31.5** | 79.929 | 78.519 | 78.997 | 79.688 | 80.918 | 80.921 |
| **40** | 78.611 | 77.438 | 78.891 | 78.953 | 76.772 | 76.922 |
| **50** | 79.871 | 82.412 | 82.897 | 82.336 | 77.427 | 77.724 |
| **63** | 81.507 | 80.927 | 82.211 | 83.896 | 77.746 | 77.601 |
| **80** | 83.867 | 85.850 | 87.664 | 89.182 | 76.455 | 76.348 |
| **100** | 94.814 | 95.971 | 104.628 | 104.643 | 97.994 | 98.171 |
| **125** | 85.853 | 88.258 | 89.050 | 91.595 | 80.335 | 79.975 |
| **160** | 85.940 | 87.245 | 90.422 | 90.877 | 74.233 | 73.570 |
| **200** | 84.803 | 86.671 | 91.141 | 91.176 | 72.565 | 73.933 |
| **250** | 94.269 | 94.302 | 100.427 | 98.138 | 79.375 | 80.187 |
| **315** | 86.253 | 89.615 | 89.718 | 88.985 | 79.997 | 78.686 |
| **400** | 88.265 | 88.639 | 90.056 | 89.189 | 82.587 | 80.866 |
| **500** | 85.927 | 87.898 | 89.366 | 91.337 | 84.376 | 86.441 |
| **630** | 84.290 | 85.698 | 85.519 | 88.321 | 83.808 | 83.927 |
| **800** | 85.720 | 85.655 | 86.328 | 87.006 | 84.671 | 83.986 |
| **1000** | 85.187 | 84.946 | 87.747 | 87.505 | 84.144 | 84.699 |
| **1250** | 83.971 | 83.145 | 82.586 | 83.472 | 83.770 | 83.984 |
| **1600** | 81.379 | 82.383 | 80.415 | 81.894 | 81.368 | 81.458 |
| **2000** | 77.687 | 79.145 | 79.055 | 80.475 | 77.646 | 77.797 |
| **2500** | 74.243 | 75.868 | 76.371 | 77.997 | 74.743 | 74.906 |
| **3150** | 76.320 | 77.721 | 78.250 | 77.180 | 88.640 | 83.695 |
| **4000** | 71.200 | 73.115 | 76.781 | 77.153 | 69.397 | 69.662 |
| **5000** | 71.258 | 73.732 | 79.805 | 80.729 | 68.445 | 69.063 |
| **6300** | 69.556 | 73.062 | 78.419 | 78.977 | 67.224 | 67.404 |
| **8000** | 69.918 | 71.471 | 79.781 | 79.221 | 67.232 | 67.365 |
| **10000** | 67.568 | 70.804 | 78.030 | 80.600 | 65.037 | 65.534 |
| **12500** | 60.103 | 62.230 | 68.230 | 77.495 | 62.310 | 63.036 |
| **16000** | 61.323 | 62.931 | 62.725 | 72.969 | 61.609 | 62.540 |
| **20000** | 56.307 | 57.078 | 56.490 | 68.073 | 58.263 | 57.995 |
| **OSPL [dB]** | **116** | **116** | **117** | **116** | **117** | **115** |

## 9.13. [R13]: Steady level flight (2)

The PSD results are shown in Figure 82. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 83. This segment exhibits a maximum SPL of 106 dB in the 100 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 84. This segment exhibits a maximum SPL of 89 dB(A) at the 1000 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 97 dB(A) was measured at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 85. This segment exhibits a maximum SPL of 80 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 81 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 86. A maximum duration of 48 minutes cumulated during flight segment [R13]: Steady level flight (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 87. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 48 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

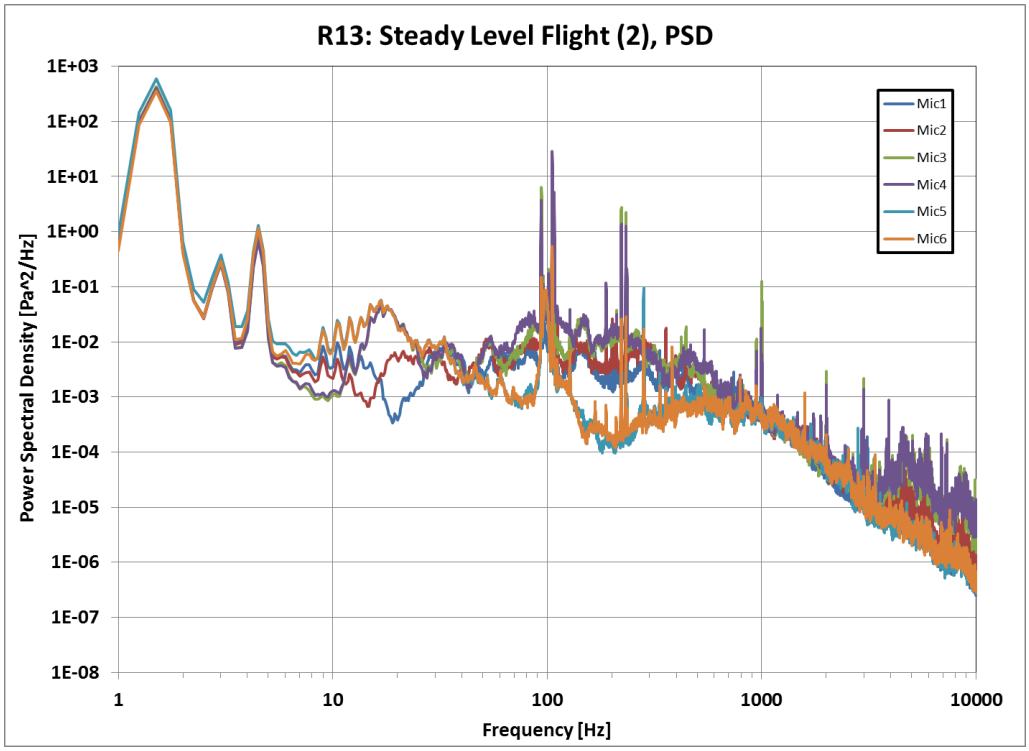


**Figure 82: Power Spectral Density for Run 13: Steady Level Flight (2)**

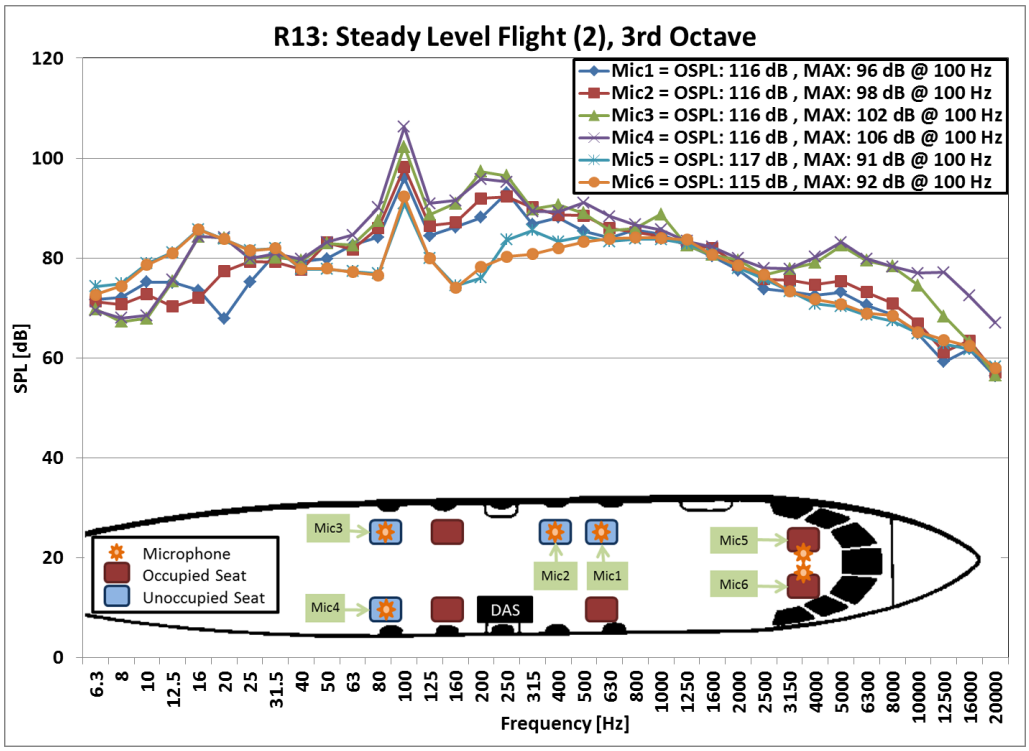


**Figure 83: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 13: Steady Level Flight (2)**

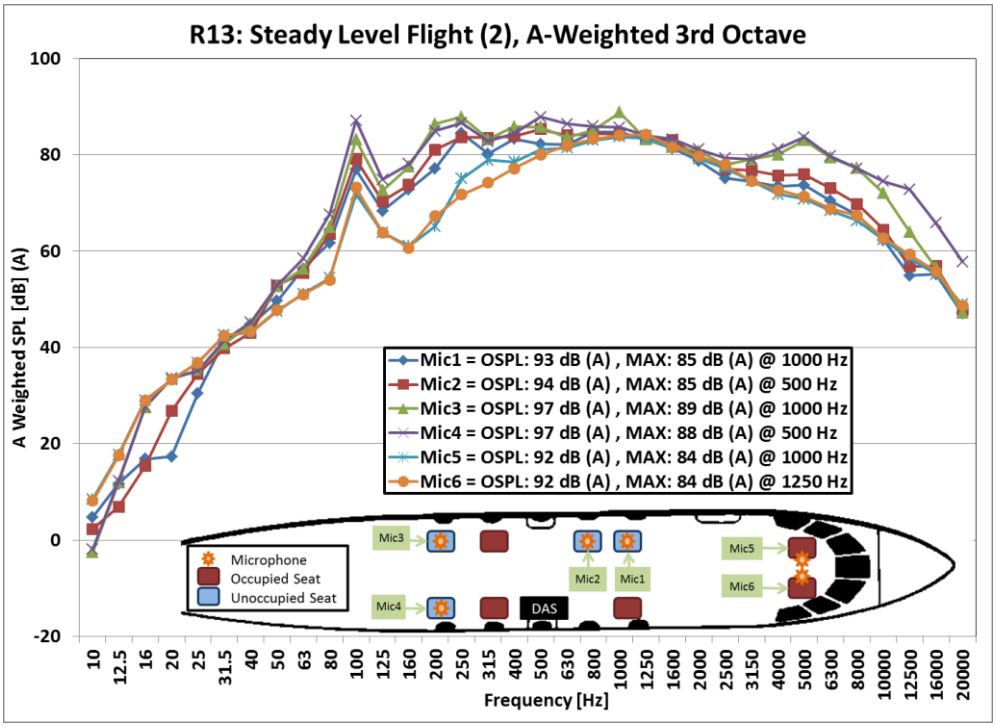


**Figure 84: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 13: Steady Level Flight (2)**

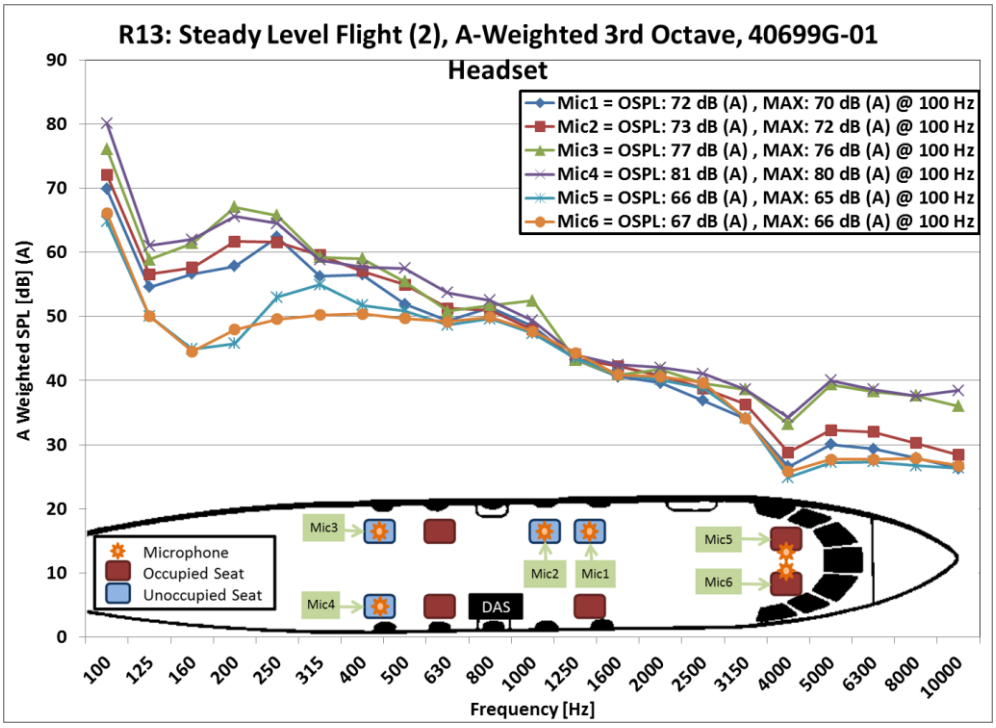


**Figure 85: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 13: Steady Level Flight (2)**

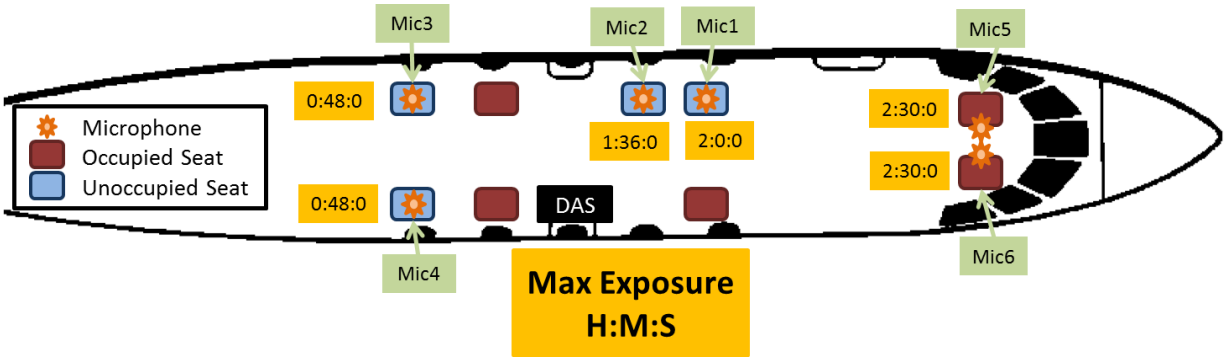


**Figure 86: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 13: Steady Level Flight (2)**

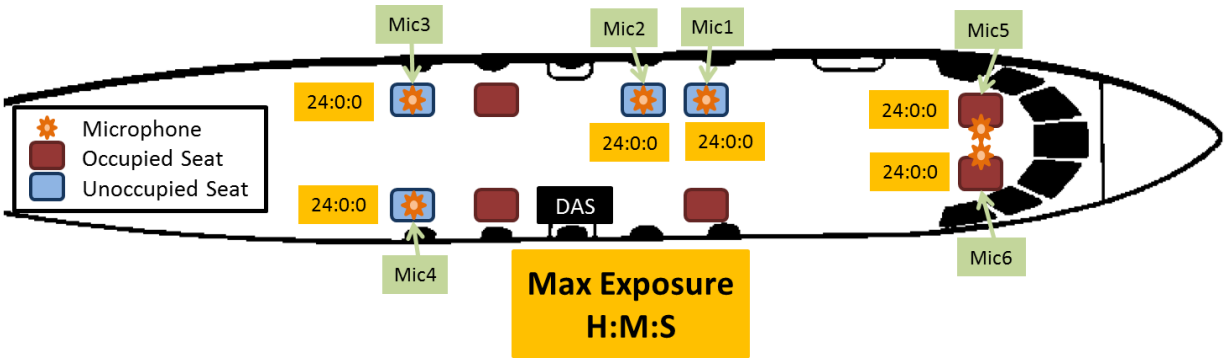


**Figure 87: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 13: Steady Level Flight (2)**

**Table 18: Steady Level Flight (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 71.674 | 71.329 | 69.805 | 69.499 | 74.318 | 72.691 |
| **8** | 72.064 | 70.737 | 67.293 | 67.998 | 74.886 | 74.393 |
| **10** | 75.153 | 72.738 | 67.944 | 68.522 | 78.951 | 78.593 |
| **12.5** | 75.124 | 70.297 | 75.370 | 75.654 | 81.142 | 80.982 |
| **16** | 73.517 | 72.050 | 84.307 | 84.343 | 85.735 | 85.671 |
| **20** | 67.838 | 77.314 | 84.045 | 84.074 | 83.836 | 83.800 |
| **25** | 75.189 | 79.249 | 80.023 | 79.845 | 81.551 | 81.538 |
| **31.5** | 80.958 | 79.195 | 80.114 | 80.936 | 81.935 | 81.905 |
| **40** | 79.288 | 77.687 | 79.494 | 79.804 | 77.741 | 77.850 |
| **50** | 79.861 | 83.113 | 82.936 | 83.161 | 77.738 | 77.936 |
| **63** | 82.554 | 81.714 | 82.548 | 84.611 | 77.318 | 77.226 |
| **80** | 84.171 | 86.054 | 87.453 | 90.121 | 76.917 | 76.527 |
| **100** | 96.007 | 98.189 | 102.251 | 106.258 | 90.939 | 92.269 |
| **125** | 84.444 | 86.456 | 88.711 | 90.911 | 79.941 | 79.950 |
| **160** | 86.162 | 87.125 | 90.929 | 91.509 | 74.443 | 74.051 |
| **200** | 88.090 | 91.958 | 97.306 | 95.842 | 76.039 | 78.187 |
| **250** | 93.078 | 92.286 | 96.431 | 95.230 | 83.691 | 80.301 |
| **315** | 86.764 | 90.094 | 89.791 | 89.363 | 85.496 | 80.770 |
| **400** | 88.093 | 88.650 | 90.607 | 89.285 | 83.331 | 81.976 |
| **500** | 85.413 | 88.495 | 88.967 | 91.042 | 84.337 | 83.196 |
| **630** | 84.004 | 85.938 | 85.483 | 88.340 | 83.322 | 83.851 |
| **800** | 85.571 | 85.150 | 85.965 | 86.680 | 83.835 | 84.079 |
| **1000** | 84.777 | 84.322 | 88.798 | 85.701 | 83.717 | 84.021 |
| **1250** | 82.559 | 82.659 | 82.545 | 83.377 | 82.855 | 83.632 |
| **1600** | 80.365 | 82.008 | 80.621 | 82.216 | 80.883 | 80.635 |
| **2000** | 77.515 | 78.649 | 79.577 | 79.916 | 78.007 | 78.502 |
| **2500** | 73.841 | 75.730 | 76.563 | 78.009 | 75.825 | 76.619 |
| **3150** | 73.279 | 75.511 | 77.841 | 77.822 | 73.403 | 73.283 |
| **4000** | 72.495 | 74.700 | 79.078 | 80.198 | 70.800 | 71.705 |
| **5000** | 73.191 | 75.409 | 82.491 | 83.169 | 70.325 | 70.820 |
| **6300** | 70.542 | 73.172 | 79.511 | 79.820 | 68.530 | 68.910 |
| **8000** | 68.608 | 70.921 | 78.322 | 78.236 | 67.423 | 68.517 |
| **10000** | 64.794 | 66.933 | 74.498 | 76.984 | 64.867 | 65.215 |
| **12500** | 59.184 | 61.172 | 68.315 | 77.096 | 62.814 | 63.577 |
| **16000** | 61.814 | 63.447 | 63.139 | 72.437 | 61.766 | 62.384 |
| **20000** | 56.313 | 57.066 | 56.474 | 67.084 | 58.177 | 57.919 |
| **OSPL [dB]** | **116** | **116** | **116** | **116** | **117** | **115** |

## 9.14. [R14]: Approach (1)

The PSD results are shown in Figure 88. Tonal behavior with the highest PSD level located at 1.50 Hz is exhibited during this run. Additionally, a high PSD level is observable at 130.25 Hz.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 89. This segment exhibits a maximum SPL of 104 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 90. This segment exhibits a maximum SPL of 97 dB(A) at the 3150 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 97 dB(A) was measured at the portside cockpit location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 91. This segment exhibits a maximum SPL of 74 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 75 dB(A) was measured at the rearmost (Mic 3) portside cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 92. A maximum duration of 48 minutes cumulated during flight segment [R14]: Approach (1) during a 24 hour period for hearing-unprotected aircrew was exhibited at the portside cockpit location (Mic 5).

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 93 All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 48 minutes without hearing protection within the cockpit and may operate up to 4 hours at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin and cockpit for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

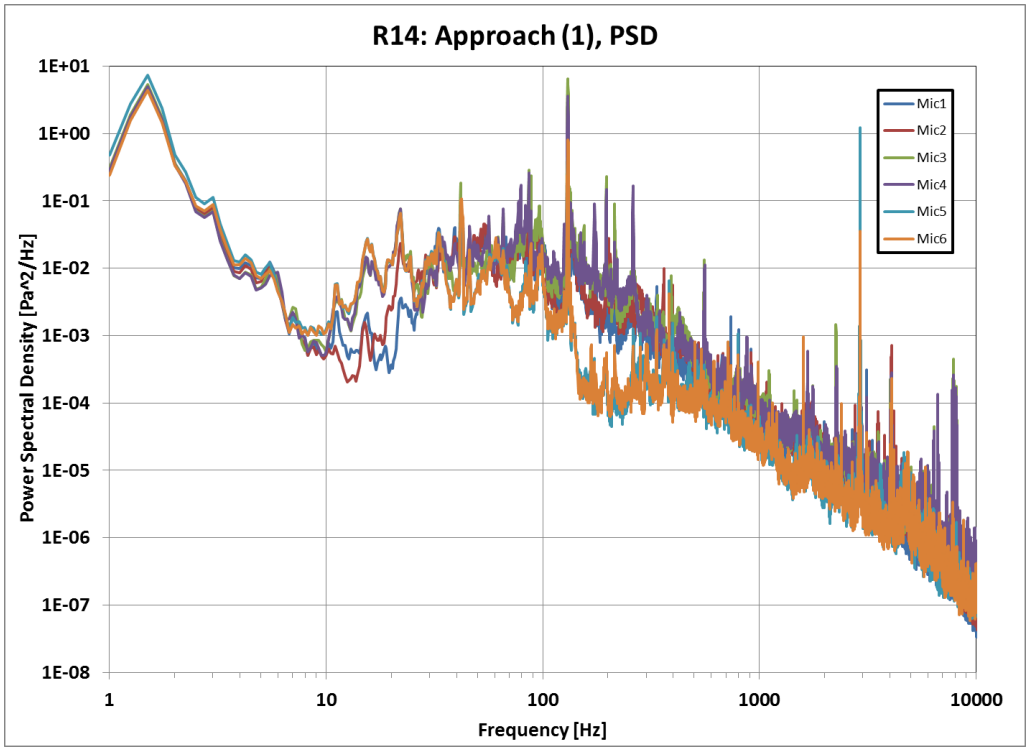


**Figure 88: Power Spectral Density for Run 14: Approach (1)**

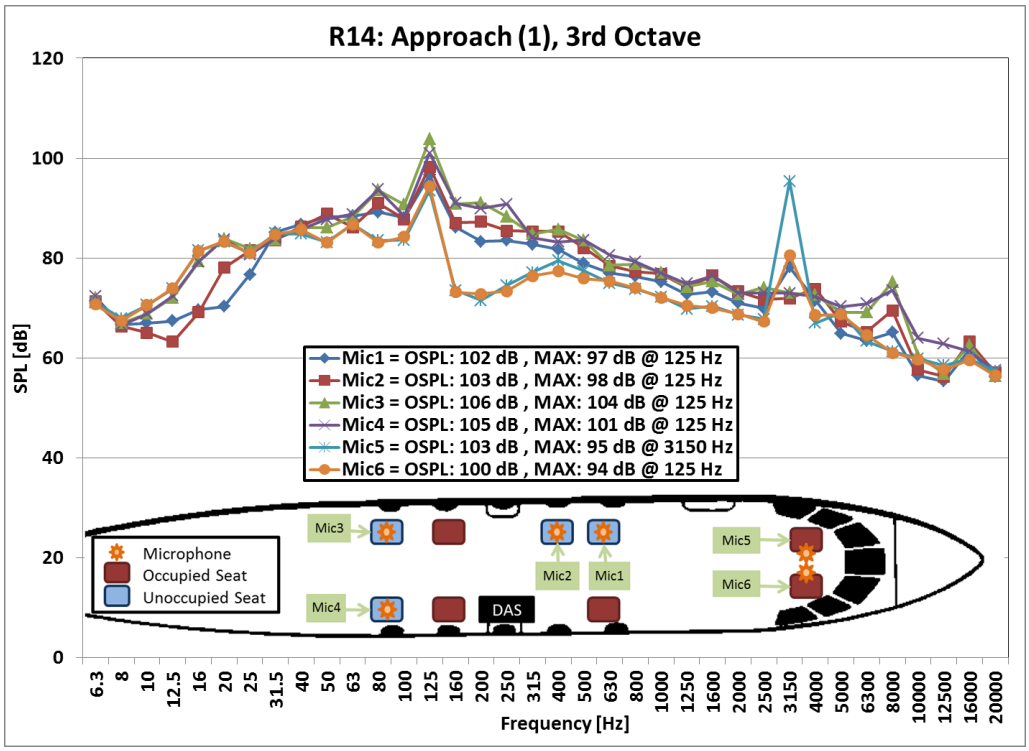


**Figure 89: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 14: Approach (1)**

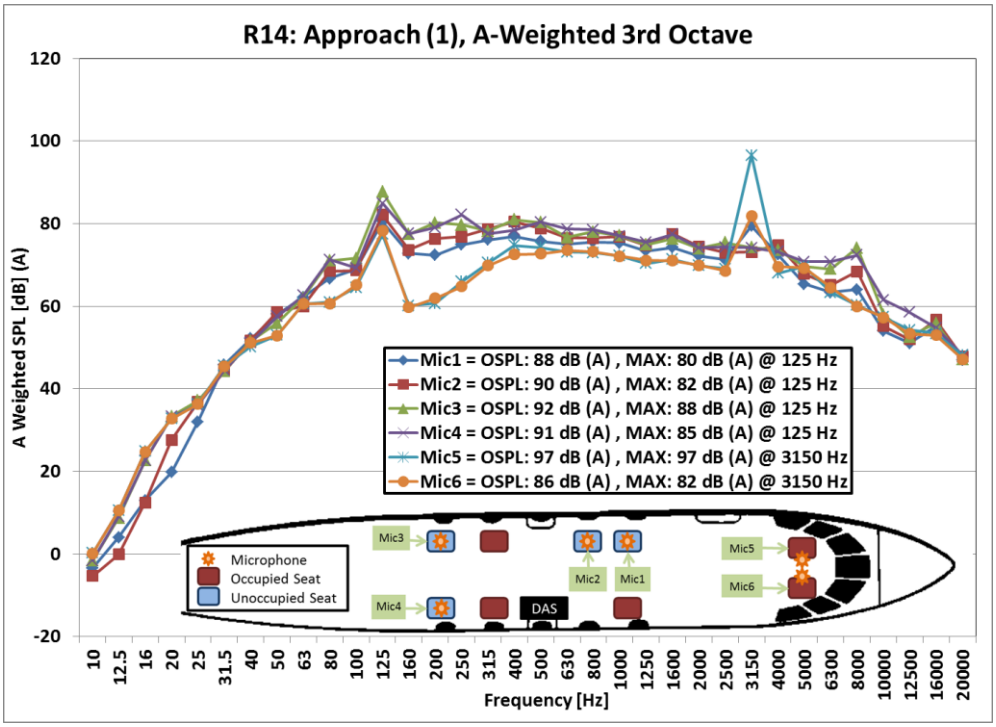


**Figure 90: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 14: Approach (1)**

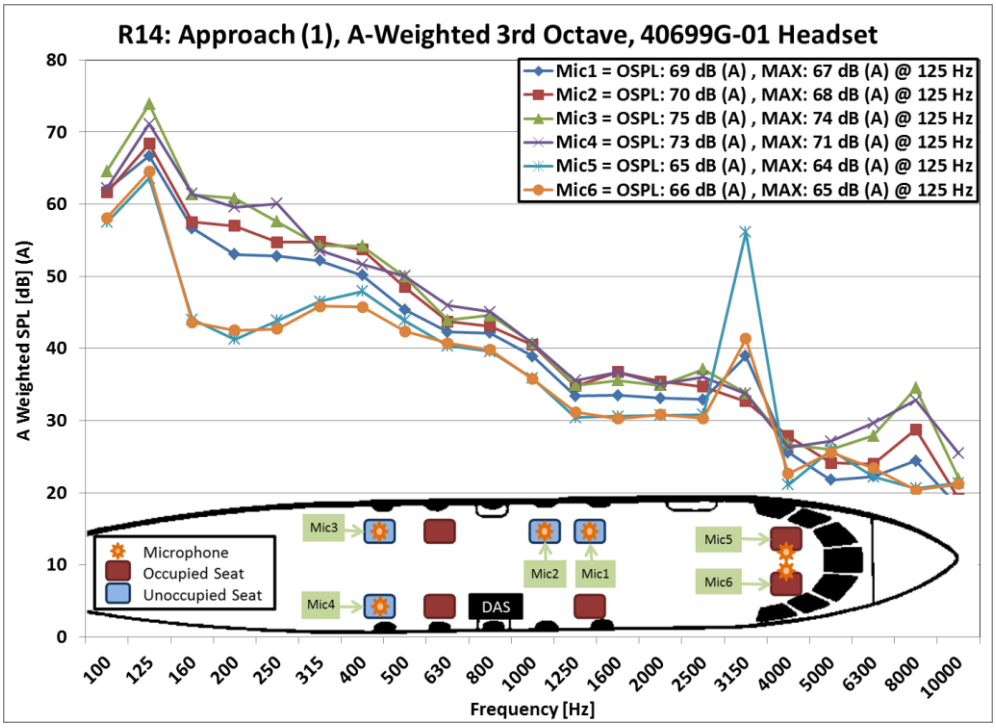


**Figure 91: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 14: Approach (1)**

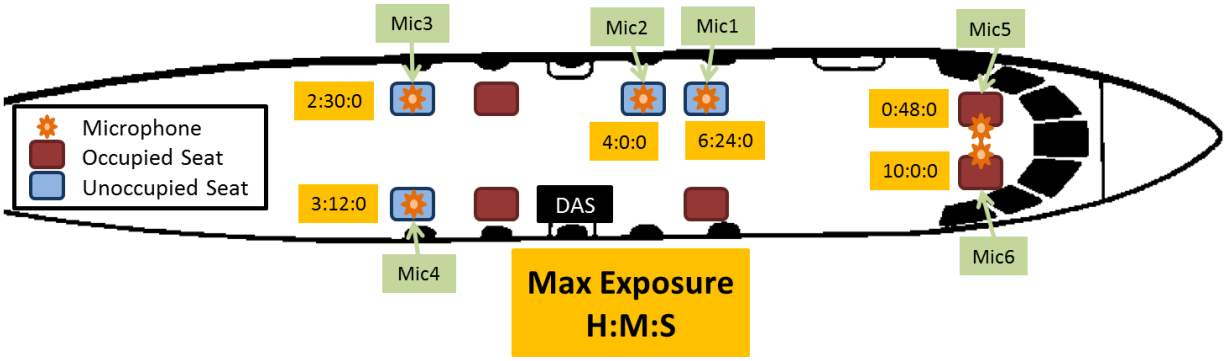


**Figure 92: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 14: Approach (1)**

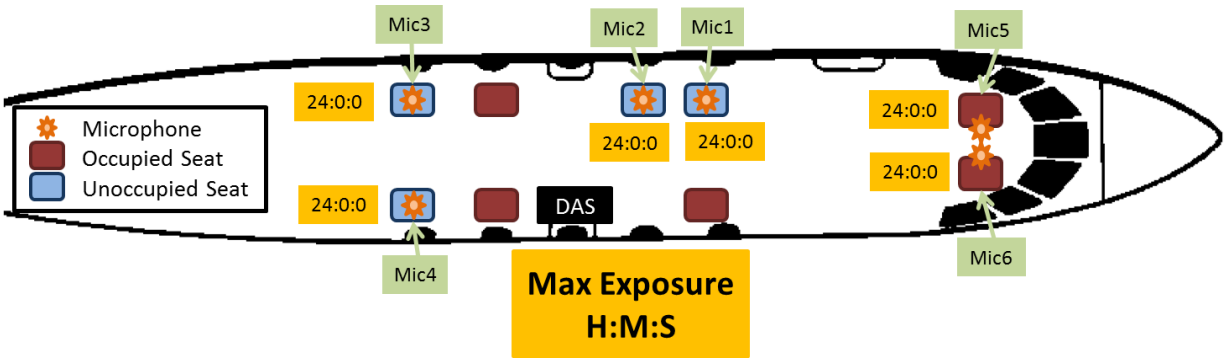


**Figure 93: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 14: Approach (1)**

**Table 19: Approach (1) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 71.391 | 71.282 | 72.033 | 72.270 | 71.095 | 70.737 |
| **8** | 66.718 | 66.342 | 67.003 | 66.546 | 67.949 | 67.423 |
| **10** | 67.011 | 65.071 | 68.867 | 68.860 | 70.576 | 70.545 |
| **12.5** | 67.397 | 63.239 | 72.085 | 72.448 | 73.867 | 73.927 |
| **16** | 69.673 | 69.124 | 79.334 | 79.307 | 81.488 | 81.426 |
| **20** | 70.289 | 78.063 | 83.843 | 83.728 | 83.224 | 83.282 |
| **25** | 76.672 | 81.523 | 81.828 | 80.727 | 81.042 | 81.022 |
| **31.5** | 85.173 | 83.621 | 83.726 | 83.980 | 84.945 | 84.767 |
| **40** | 86.767 | 86.328 | 86.106 | 85.830 | 84.805 | 85.703 |
| **50** | 88.231 | 88.861 | 86.122 | 87.751 | 83.146 | 83.055 |
| **63** | 88.394 | 86.207 | 88.199 | 88.779 | 86.777 | 86.747 |
| **80** | 89.203 | 90.982 | 93.545 | 93.742 | 83.508 | 83.112 |
| **100** | 88.079 | 87.746 | 90.677 | 88.334 | 83.583 | 84.227 |
| **125** | 96.573 | 98.246 | 103.772 | 100.998 | 93.488 | 94.383 |
| **160** | 86.202 | 87.042 | 90.845 | 90.962 | 73.551 | 73.146 |
| **200** | 83.301 | 87.232 | 91.080 | 89.879 | 71.513 | 72.804 |
| **250** | 83.492 | 85.444 | 88.290 | 90.768 | 74.565 | 73.402 |
| **315** | 82.706 | 85.317 | 84.779 | 84.113 | 77.087 | 76.399 |
| **400** | 81.699 | 85.279 | 85.754 | 83.194 | 79.506 | 77.338 |
| **500** | 78.912 | 82.011 | 83.499 | 83.576 | 77.382 | 75.905 |
| **630** | 76.950 | 78.408 | 78.567 | 80.597 | 74.993 | 75.421 |
| **800** | 76.343 | 77.283 | 78.808 | 79.274 | 73.791 | 74.021 |
| **1000** | 75.285 | 76.849 | 77.096 | 76.985 | 72.226 | 72.121 |
| **1250** | 72.743 | 74.141 | 74.258 | 74.904 | 69.772 | 70.508 |
| **1600** | 73.247 | 76.483 | 75.310 | 76.444 | 70.334 | 70.013 |
| **2000** | 71.005 | 73.293 | 72.756 | 72.920 | 68.620 | 68.749 |
| **2500** | 69.925 | 71.672 | 74.094 | 73.033 | 67.805 | 67.292 |
| **3150** | 78.206 | 71.924 | 73.012 | 72.966 | 95.351 | 80.589 |
| **4000** | 71.496 | 73.789 | 72.616 | 72.234 | 66.990 | 68.556 |
| **5000** | 64.892 | 67.292 | 69.129 | 70.254 | 69.041 | 68.732 |
| **6300** | 63.445 | 65.204 | 69.126 | 70.831 | 63.403 | 64.612 |
| **8000** | 65.107 | 69.473 | 75.210 | 73.496 | 61.303 | 61.039 |
| **10000** | 56.469 | 57.665 | 60.414 | 63.973 | 59.866 | 59.734 |
| **12500** | 55.337 | 56.270 | 56.852 | 62.818 | 58.521 | 57.621 |
| **16000** | 61.655 | 63.262 | 62.547 | 61.306 | 59.971 | 59.614 |
| **20000** | 56.297 | 57.030 | 56.398 | 57.485 | 57.374 | 56.498 |
| **OSPL [dB]** | **102** | **103** | **106** | **105** | **103** | **100** |

## 9.15. [R15]: Low and over

The PSD results are shown in Figure 94. Tonal behavior with the highest PSD level located at 1.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 95. This segment exhibits a maximum SPL of 106 dB in the 160 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 96. This segment exhibits a maximum SPL of 93 dB(A) at the 160 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 98 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 97. This segment exhibits a maximum SPL of 78 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 81 dB(A) was measured at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 98. A maximum duration of 38 minutes 24 seconds cumulated during flight segment [R15]: Low and over during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 4) starboard side cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 99. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 38 minutes 24 seconds without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

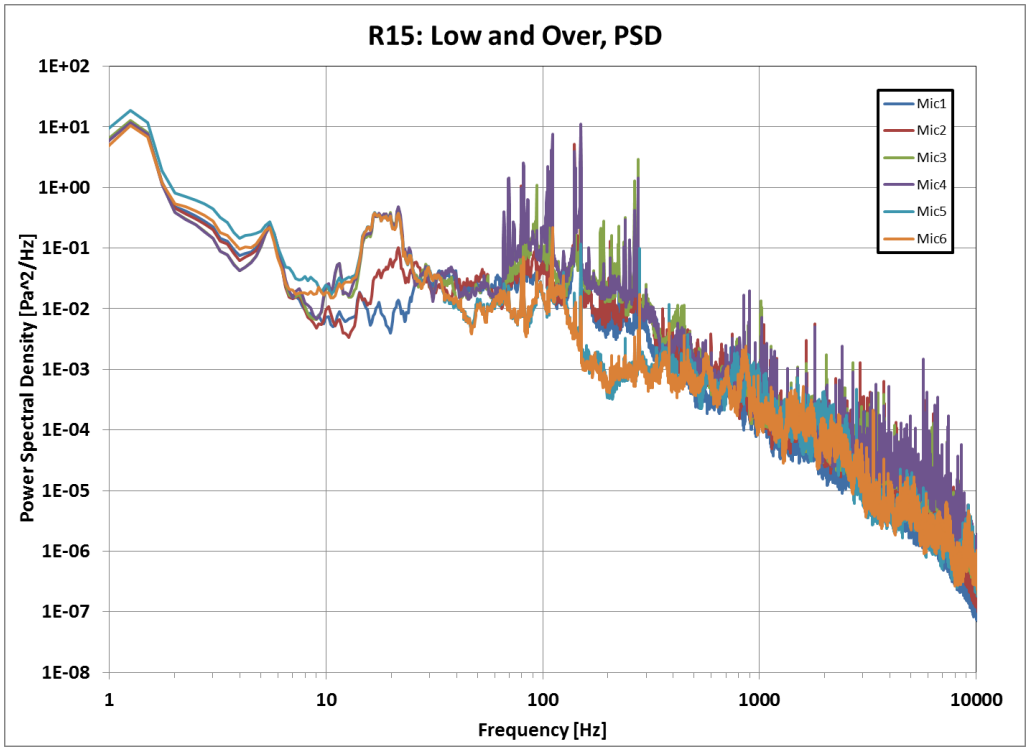


**Figure 94: Power Spectral Density for Run 15: Low and Over**

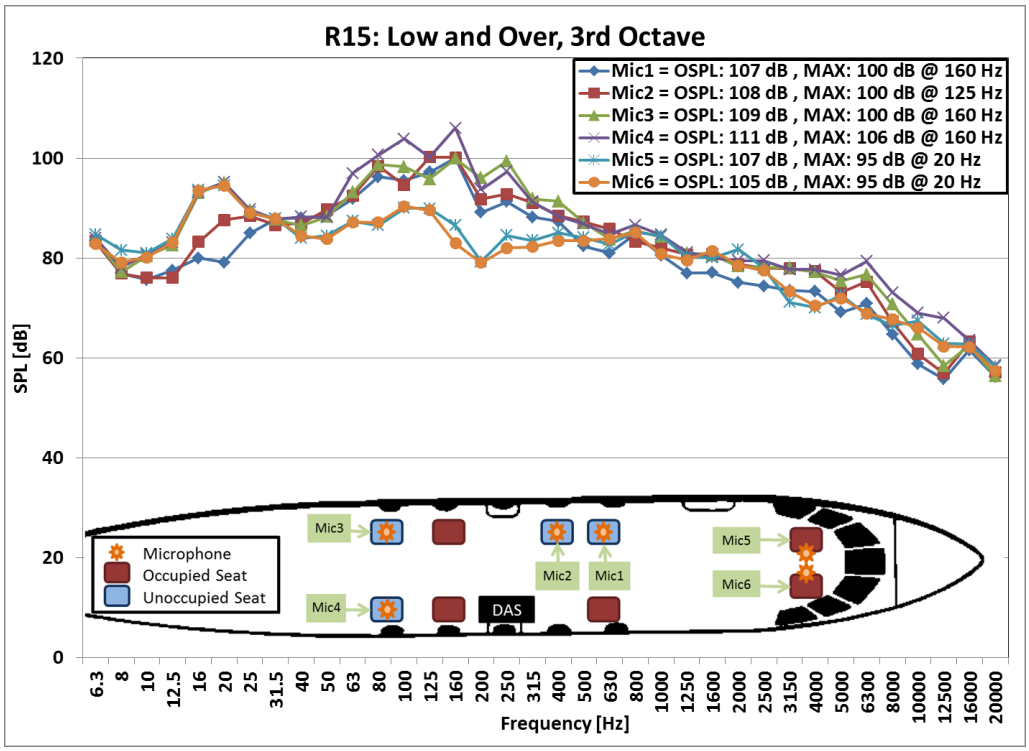


**Figure 95: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 15: Low and Over**

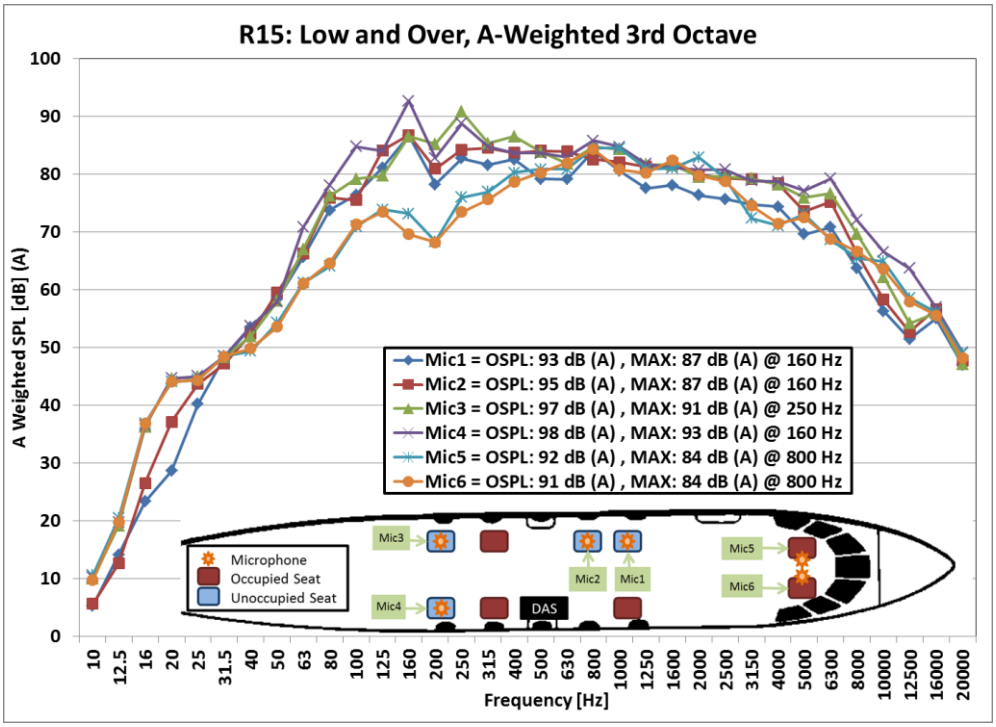


**Figure 96: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 15: Low and Over**

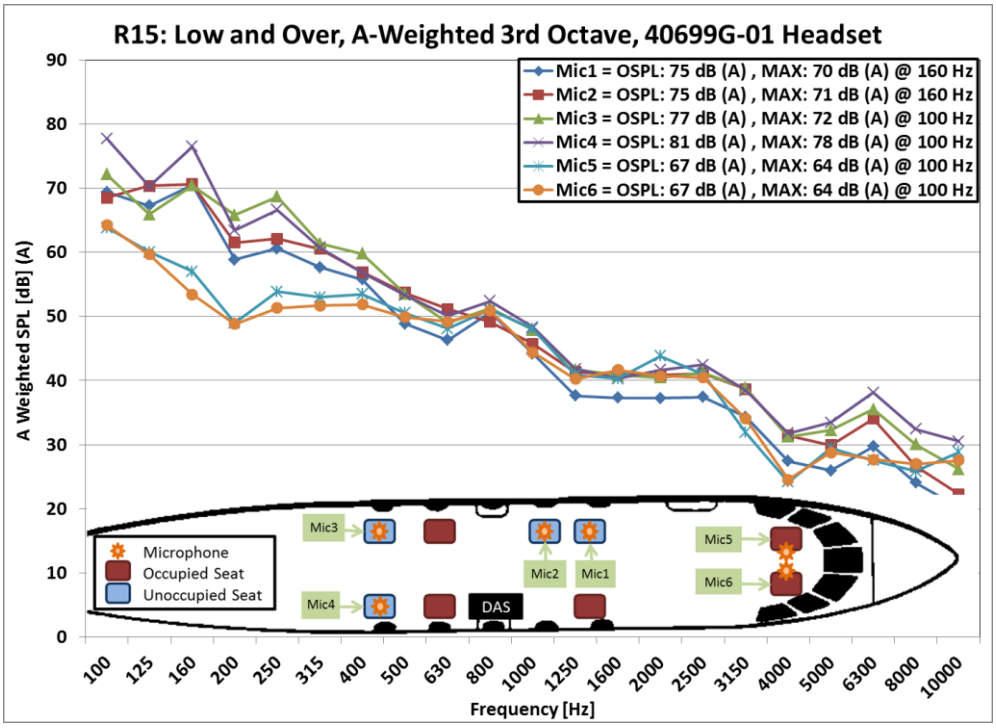


**Figure 97: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 15: Low and Over**

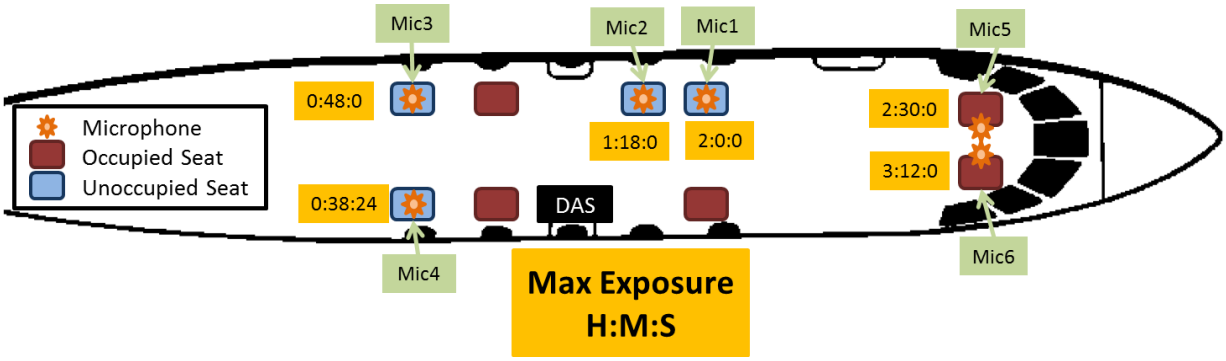


**Figure 98: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 15: Low and Over**

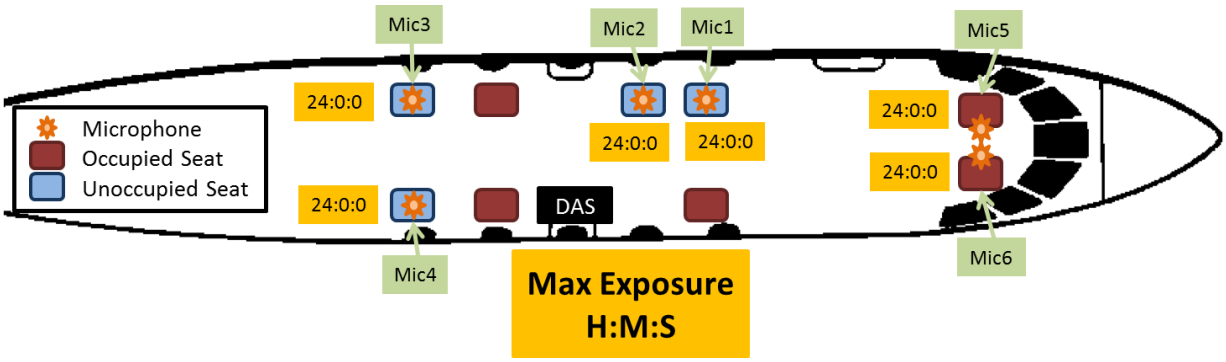


**Figure 99: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 15: Low and Over**

**Table 20: Low and Over 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 83.368 | 83.354 | 83.838 | 84.022 | 84.763 | 82.833 |
| **8** | 76.935 | 76.875 | 77.225 | 78.109 | 81.557 | 79.163 |
| **10** | 75.674 | 76.037 | 80.401 | 80.703 | 80.974 | 80.156 |
| **12.5** | 77.533 | 76.016 | 82.599 | 83.181 | 83.865 | 83.185 |
| **16** | 80.018 | 83.245 | 93.021 | 93.194 | 93.586 | 93.514 |
| **20** | 79.147 | 87.647 | 95.114 | 95.152 | 94.547 | 94.534 |
| **25** | 84.919 | 88.370 | 89.581 | 89.718 | 89.124 | 89.058 |
| **31.5** | 87.799 | 86.616 | 87.715 | 87.828 | 87.916 | 87.857 |
| **40** | 88.037 | 86.956 | 86.516 | 88.281 | 83.951 | 84.419 |
| **50** | 88.536 | 89.726 | 88.229 | 88.125 | 84.479 | 83.791 |
| **63** | 91.824 | 92.421 | 93.147 | 96.988 | 87.380 | 87.210 |
| **80** | 96.216 | 98.411 | 98.679 | 100.600 | 86.549 | 87.079 |
| **100** | 95.514 | 94.612 | 98.244 | 103.858 | 89.987 | 90.347 |
| **125** | 97.165 | 100.223 | 95.775 | 100.128 | 89.946 | 89.558 |
| **160** | 99.995 | 100.151 | 99.922 | 106.029 | 86.517 | 82.974 |
| **200** | 89.091 | 91.799 | 96.052 | 93.691 | 79.248 | 79.070 |
| **250** | 91.289 | 92.803 | 99.404 | 97.340 | 84.557 | 82.024 |
| **315** | 88.177 | 91.086 | 91.889 | 91.284 | 83.538 | 82.220 |
| **400** | 87.305 | 88.471 | 91.330 | 88.424 | 85.031 | 83.425 |
| **500** | 82.379 | 87.244 | 87.068 | 86.834 | 84.066 | 83.432 |
| **630** | 80.995 | 85.822 | 83.721 | 84.789 | 82.753 | 83.841 |
| **800** | 84.777 | 83.323 | 85.522 | 86.599 | 85.242 | 85.078 |
| **1000** | 80.545 | 82.065 | 84.265 | 84.683 | 84.432 | 80.779 |
| **1250** | 76.960 | 80.689 | 81.030 | 81.133 | 80.222 | 79.595 |
| **1600** | 77.076 | 80.853 | 80.561 | 80.087 | 80.030 | 81.420 |
| **2000** | 75.138 | 78.689 | 78.314 | 79.514 | 81.719 | 78.579 |
| **2500** | 74.375 | 78.061 | 78.216 | 79.458 | 77.968 | 77.462 |
| **3150** | 73.539 | 77.918 | 78.047 | 77.683 | 71.134 | 73.308 |
| **4000** | 73.336 | 77.368 | 77.165 | 77.685 | 70.076 | 70.443 |
| **5000** | 69.104 | 73.062 | 75.417 | 76.606 | 72.605 | 71.945 |
| **6300** | 70.887 | 75.254 | 76.721 | 79.343 | 68.744 | 68.898 |
| **8000** | 64.760 | 67.284 | 70.694 | 73.078 | 66.555 | 67.683 |
| **10000** | 58.801 | 60.794 | 64.697 | 69.018 | 67.378 | 66.042 |
| **12500** | 55.780 | 56.948 | 58.462 | 68.004 | 62.874 | 62.284 |
| **16000** | 61.602 | 63.230 | 62.519 | 63.562 | 62.726 | 62.185 |
| **20000** | 56.306 | 57.050 | 56.402 | 58.484 | 58.312 | 57.439 |
| **OSPL [dB]** | **107** | **108** | **109** | **111** | **107** | **105** |

## 9.16. [R16]: Approach (2)

The PSD results are shown in Figure 100. Tonal behavior with the highest PSD level located at 94.00 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 101. This segment exhibits a maximum SPL of 103 dB in the 100 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 102. This segment exhibits a maximum SPL of 90 dB(A) at the 250 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 96 dB(A) was measured at the rearmost (Mic 3) portside cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 103. This segment exhibits a maximum SPL of 77 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 78 dB(A) was measured at the rearmost (Mics 3 and 4) portside and starboard side cabin locations.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 104. A maximum duration of 1 hour cumulated during flight segment [R16]: Approach (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the rearmost (Mic 3) portside cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 105. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 1 hour without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

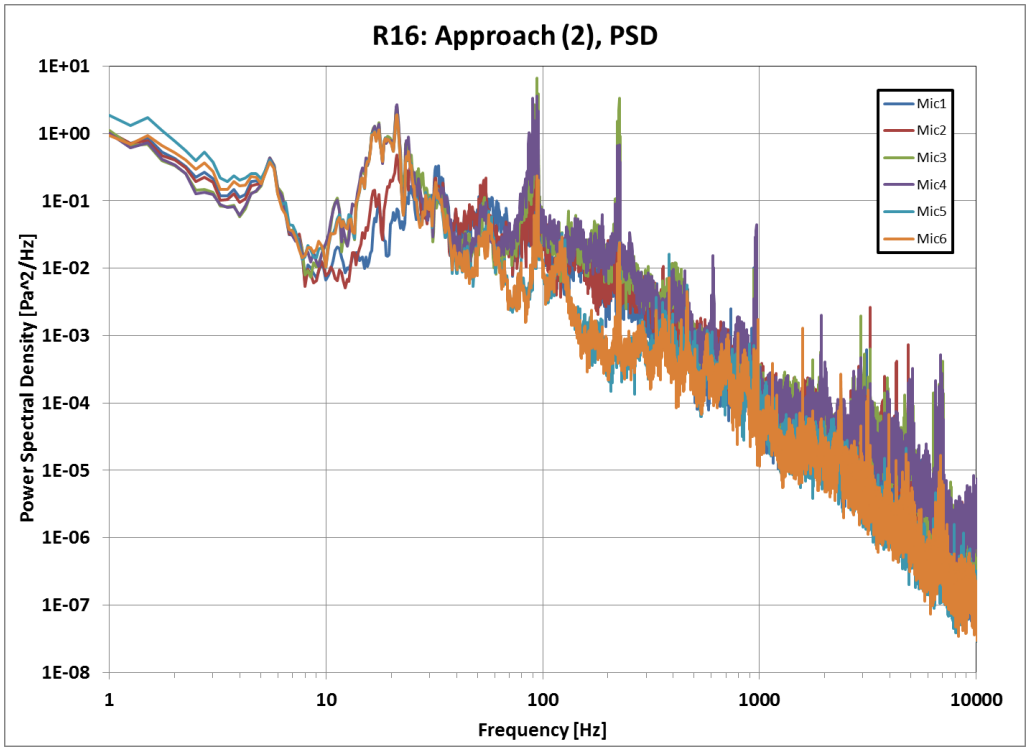


**Figure 100: Power Spectral Density for Run 16: Approach (2)**

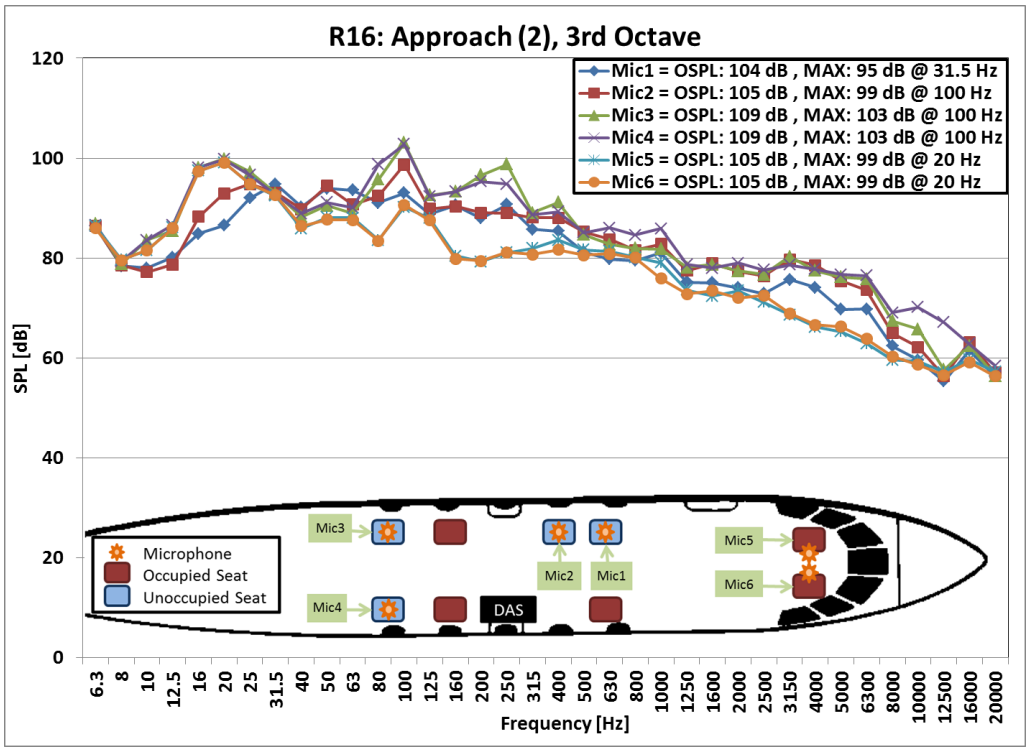


**Figure 101: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 16: Approach (2)**

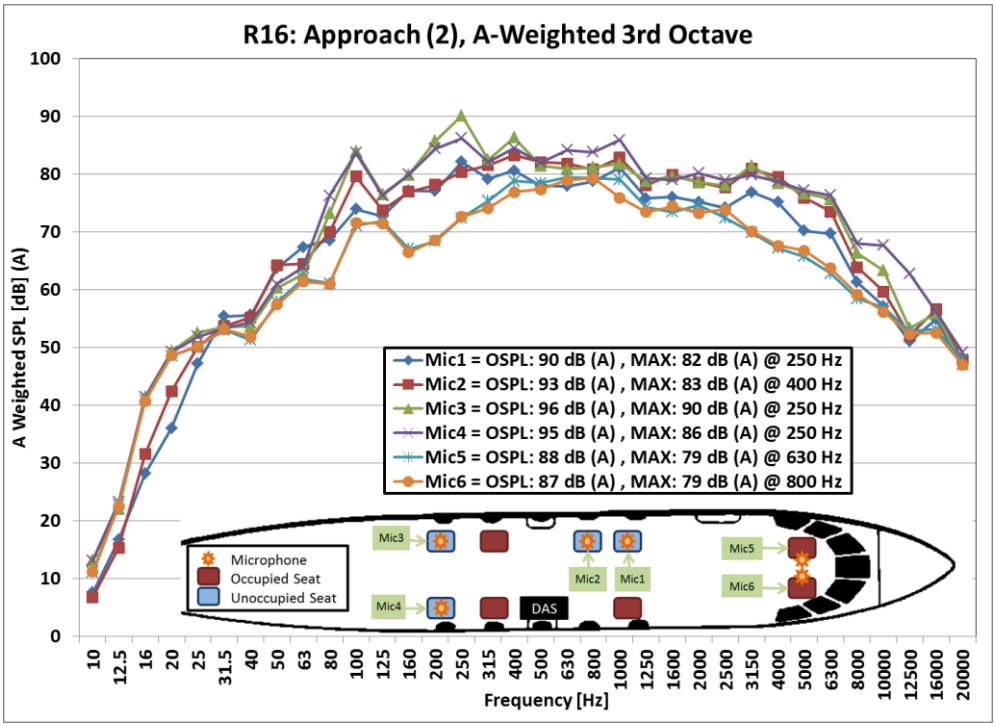


**Figure 102: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 16: Approach (2)**

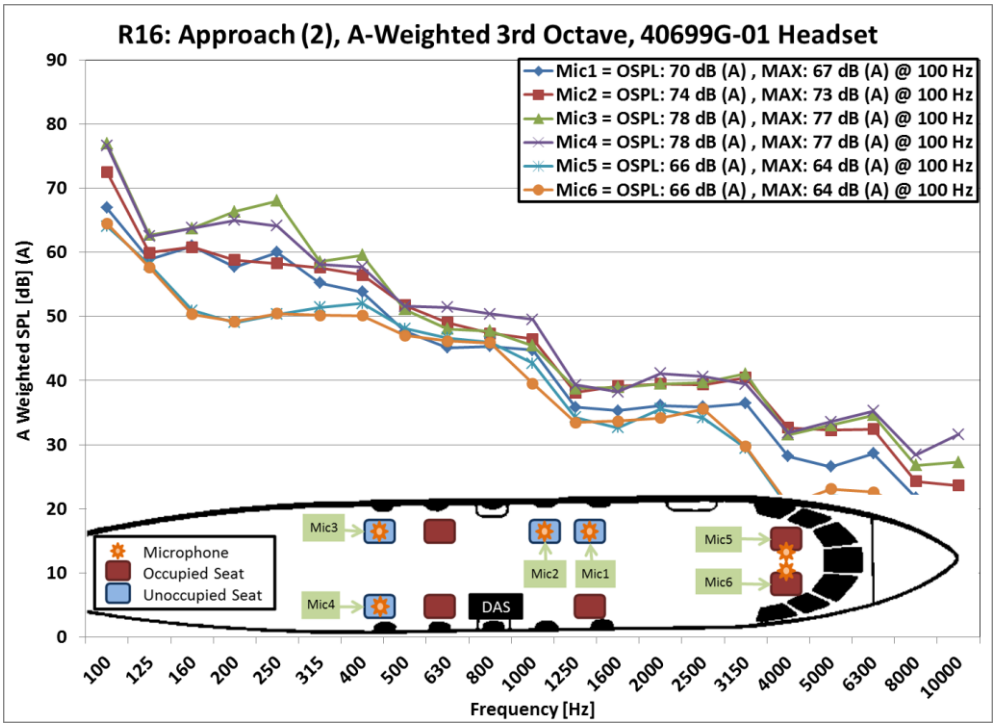


**Figure 103: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 16: Approach (2)**

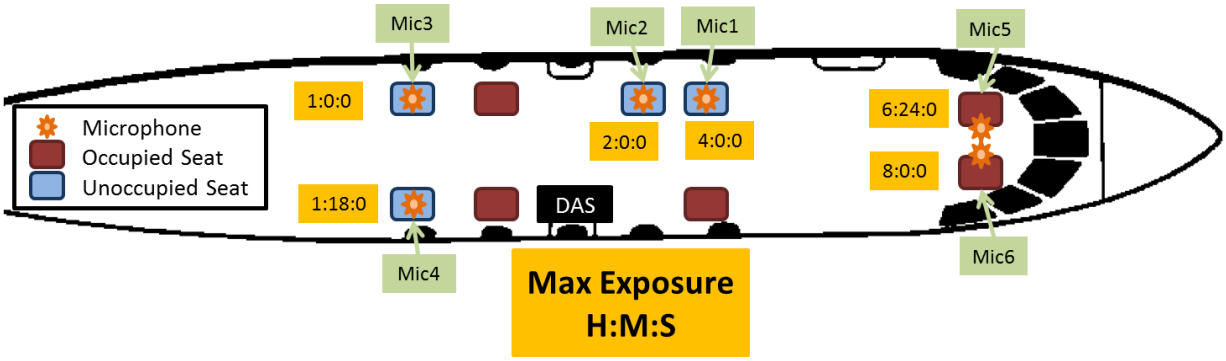


**Figure 104: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 16: Approach (2)**

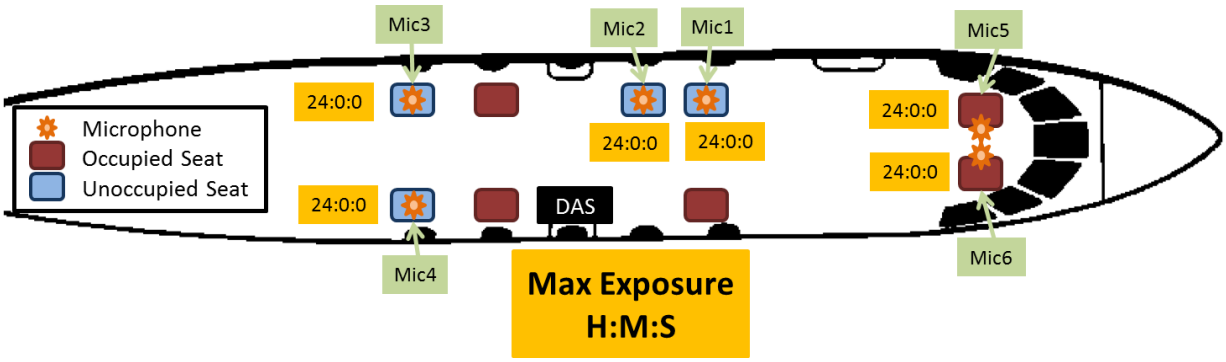


**Figure 105: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 16: Approach (2)**

**Table 21: Approach (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 86.411 | 86.418 | 86.832 | 86.608 | 86.426 | 85.972 |
| **8** | 78.439 | 78.553 | 78.774 | 79.379 | 79.705 | 79.568 |
| **10** | 77.966 | 77.196 | 83.561 | 83.600 | 81.474 | 81.601 |
| **12.5** | 80.125 | 78.734 | 85.473 | 86.600 | 86.159 | 85.958 |
| **16** | 84.856 | 88.259 | 98.094 | 98.100 | 97.492 | 97.422 |
| **20** | 86.524 | 92.922 | 99.860 | 99.760 | 99.095 | 99.106 |
| **25** | 91.970 | 94.824 | 97.272 | 96.588 | 94.868 | 94.830 |
| **31.5** | 94.771 | 93.078 | 92.957 | 92.648 | 92.415 | 92.551 |
| **40** | 90.208 | 89.767 | 88.230 | 88.925 | 85.859 | 86.419 |
| **50** | 93.949 | 94.408 | 90.496 | 91.152 | 88.097 | 87.652 |
| **63** | 93.583 | 90.696 | 88.925 | 90.074 | 88.081 | 87.607 |
| **80** | 91.043 | 92.442 | 95.716 | 98.769 | 83.578 | 83.445 |
| **100** | 93.030 | 98.666 | 103.087 | 102.747 | 90.173 | 90.618 |
| **125** | 88.782 | 89.827 | 92.582 | 92.356 | 87.982 | 87.554 |
| **160** | 90.527 | 90.323 | 93.289 | 93.311 | 80.456 | 79.859 |
| **200** | 87.977 | 89.061 | 96.594 | 95.274 | 79.287 | 79.449 |
| **250** | 90.689 | 88.952 | 98.740 | 94.814 | 81.038 | 81.171 |
| **315** | 85.747 | 88.133 | 89.083 | 88.653 | 81.970 | 80.719 |
| **400** | 85.397 | 88.037 | 91.111 | 89.284 | 83.572 | 81.660 |
| **500** | 81.222 | 85.242 | 84.642 | 85.127 | 81.623 | 80.534 |
| **630** | 79.769 | 83.708 | 82.726 | 86.060 | 81.324 | 80.836 |
| **800** | 79.523 | 81.559 | 81.935 | 84.600 | 80.129 | 80.059 |
| **1000** | 81.093 | 82.822 | 81.814 | 85.891 | 79.027 | 75.908 |
| **1250** | 75.210 | 77.478 | 78.114 | 78.680 | 73.622 | 72.823 |
| **1600** | 75.050 | 78.883 | 78.668 | 77.970 | 72.408 | 73.417 |
| **2000** | 74.002 | 77.332 | 77.376 | 79.004 | 73.461 | 72.040 |
| **2500** | 72.864 | 76.375 | 76.694 | 77.598 | 71.137 | 72.537 |
| **3150** | 75.682 | 79.680 | 80.274 | 78.634 | 68.658 | 68.949 |
| **4000** | 74.094 | 78.536 | 77.464 | 77.763 | 66.194 | 66.615 |
| **5000** | 69.706 | 75.377 | 76.149 | 76.676 | 65.242 | 66.249 |
| **6300** | 69.820 | 73.599 | 75.793 | 76.456 | 62.865 | 63.810 |
| **8000** | 62.397 | 64.965 | 67.440 | 69.077 | 59.548 | 60.276 |
| **10000** | 59.597 | 62.154 | 65.796 | 70.137 | 59.367 | 58.671 |
| **12500** | 55.361 | 56.337 | 57.612 | 67.096 | 57.146 | 56.589 |
| **16000** | 61.522 | 63.151 | 62.434 | 62.837 | 59.720 | 59.139 |
| **20000** | 56.346 | 57.069 | 56.404 | 58.456 | 57.241 | 56.335 |
| **OSPL [dB]** | **104** | **105** | **109** | **109** | **105** | **105** |

## 9.17. [R17]: Landing

The PSD results are shown in Figure 106. Tonal behavior with the highest PSD level located at 20.25 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 107. This segment exhibits a maximum SPL of 105 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 108. This segment exhibits a maximum SPL of 86 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 91 dB(A) was measured at the majority of cabin locations.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 109. This segment exhibits a maximum SPL of 73 dB(A) at the 100 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 73-75 dB(A) was measured consistently throughout the aircraft.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 110. A maximum duration of 3 hours 12 minutes cumulated during flight segment [R17]: Landing during a 24 hour period for hearing-unprotected aircrew was exhibited throughout the majority of the cabin.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 111. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 3 hours 12 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

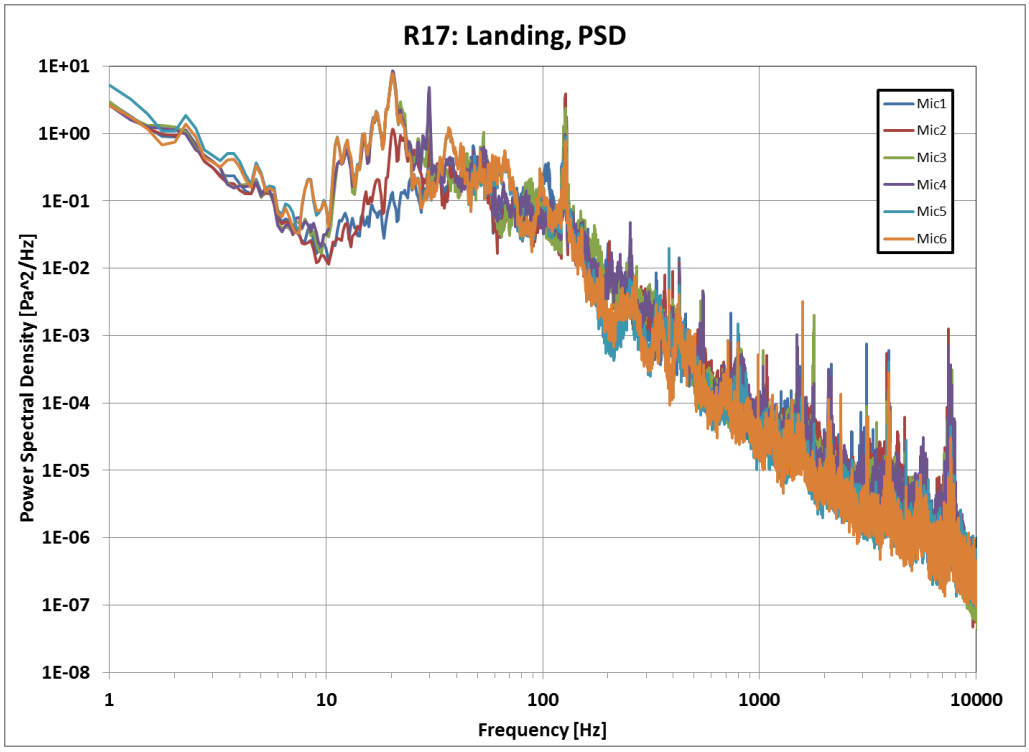


**Figure 106: Power Spectral Density for Run 17: Landing**

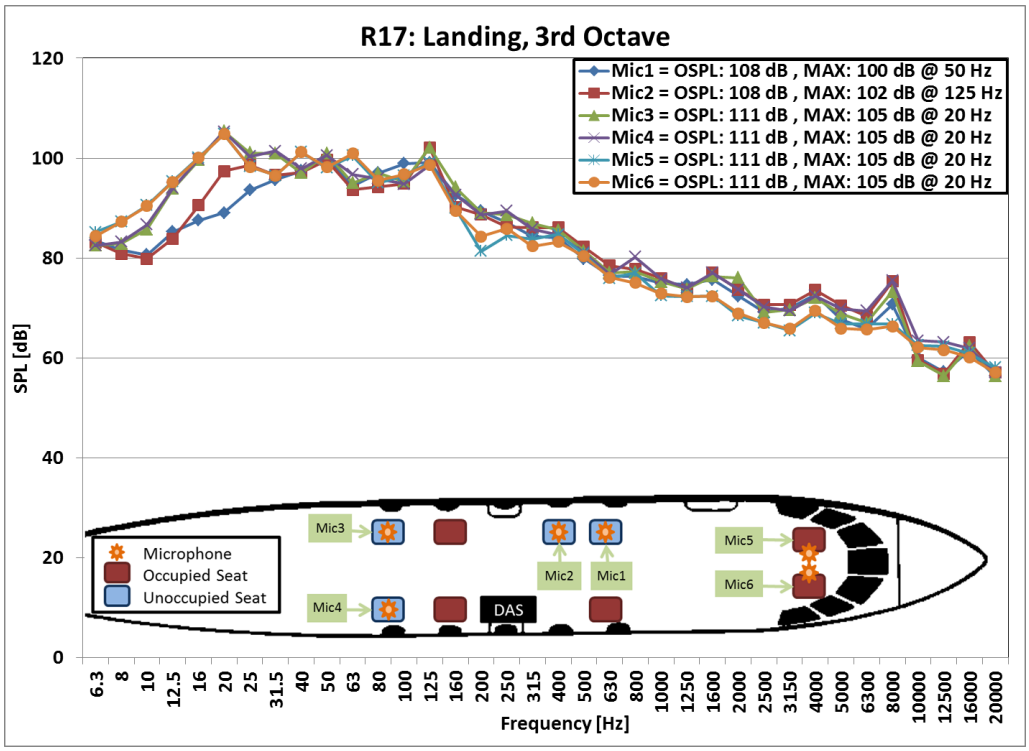


**Figure 107: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 17: Landing**

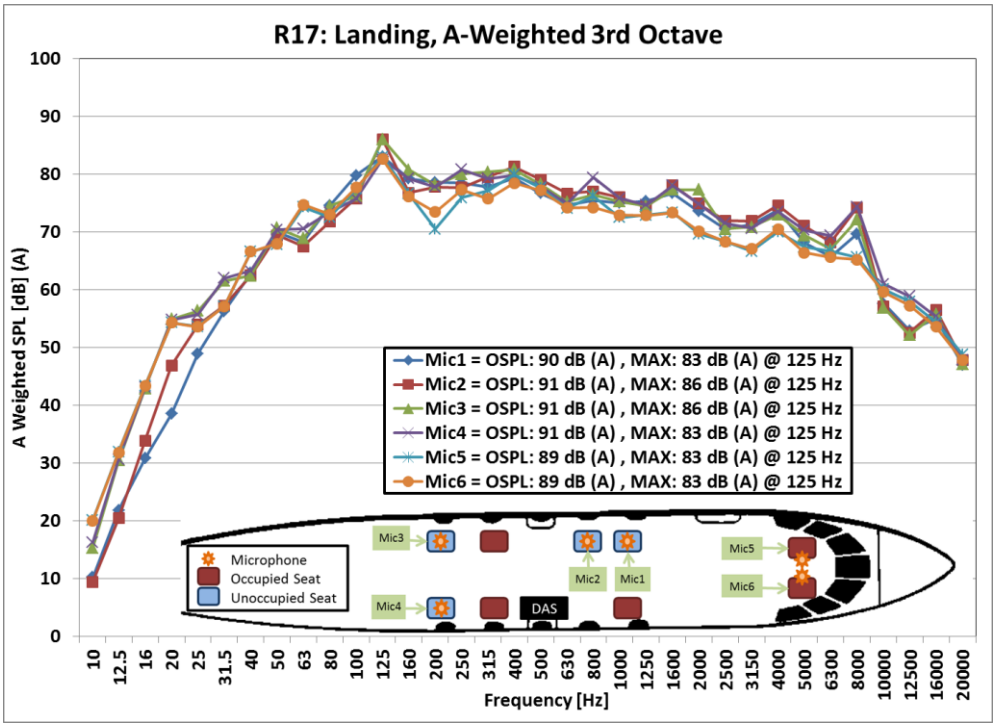


**Figure 108: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 17: Landing**

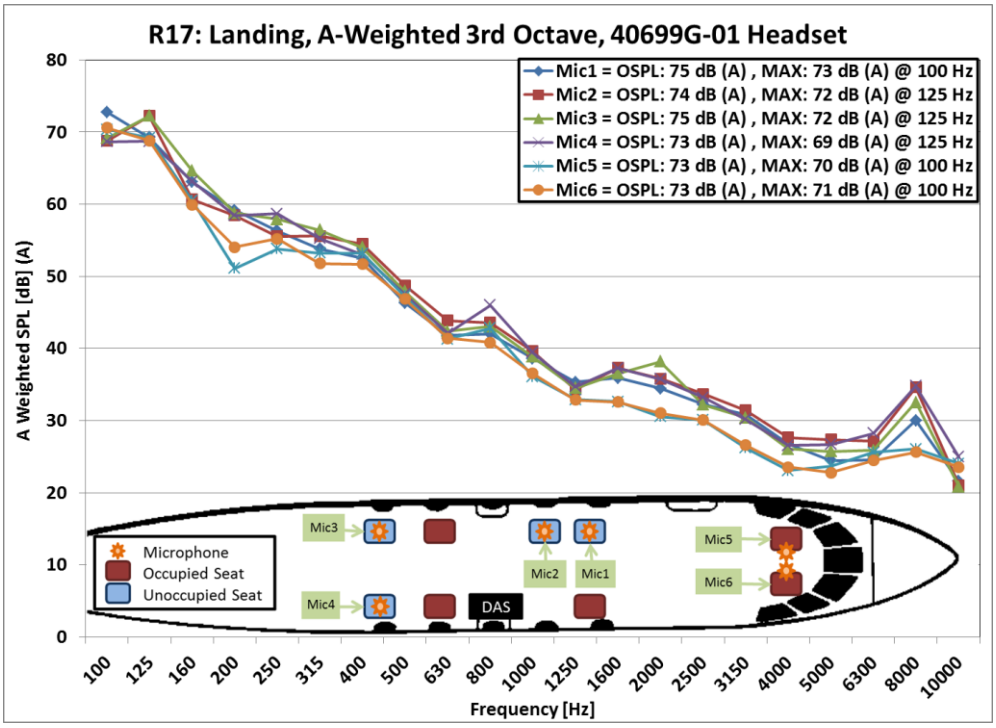


**Figure 109: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 17: Landing**

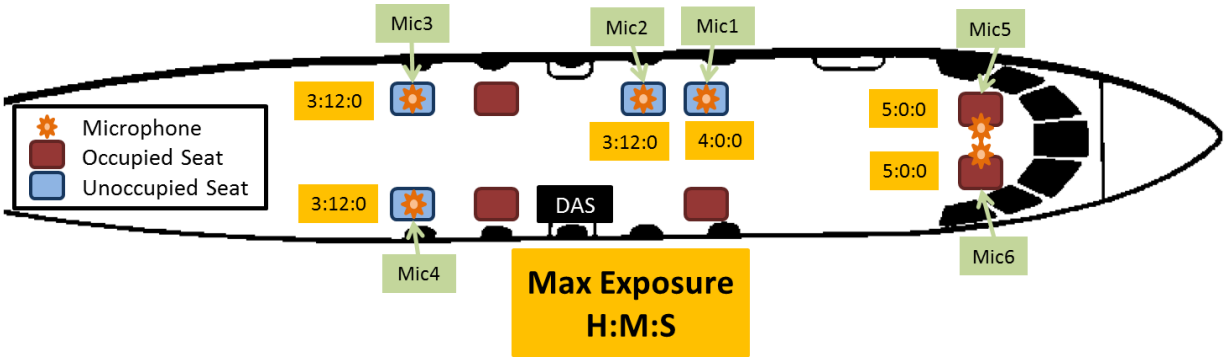


**Figure 110: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 17: Landing**

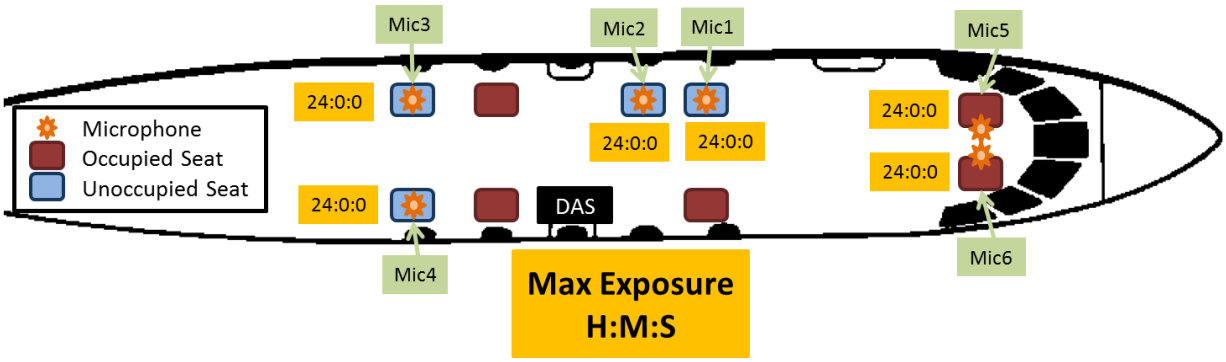


**Figure 111: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 17: Landing**

**Table 22: Landing 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 83.537 | 83.134 | 82.518 | 82.495 | 85.169 | 84.375 |
| **8** | 81.608 | 80.821 | 82.857 | 83.256 | 87.254 | 87.241 |
| **10** | 80.643 | 79.869 | 85.713 | 86.677 | 90.555 | 90.406 |
| **12.5** | 85.267 | 83.857 | 93.875 | 94.045 | 95.346 | 95.253 |
| **16** | 87.516 | 90.586 | 99.598 | 99.803 | 100.121 | 100.031 |
| **20** | 89.026 | 97.382 | 105.397 | 105.263 | 104.789 | 104.811 |
| **25** | 93.607 | 98.634 | 101.028 | 100.353 | 98.310 | 98.254 |
| **31.5** | 95.693 | 96.635 | 100.907 | 101.403 | 96.552 | 96.508 |
| **40** | 97.443 | 97.069 | 97.050 | 97.868 | 101.183 | 101.181 |
| **50** | 100.170 | 99.594 | 100.890 | 100.576 | 98.052 | 98.150 |
| **63** | 94.449 | 93.657 | 95.052 | 96.718 | 100.502 | 100.925 |
| **80** | 96.998 | 94.250 | 96.979 | 95.850 | 95.035 | 95.502 |
| **100** | 98.876 | 94.891 | 95.278 | 94.806 | 96.493 | 96.733 |
| **125** | 99.120 | 102.118 | 102.107 | 98.602 | 99.088 | 98.699 |
| **160** | 92.623 | 90.172 | 94.135 | 92.645 | 89.996 | 89.483 |
| **200** | 89.442 | 88.682 | 89.040 | 88.693 | 81.384 | 84.310 |
| **250** | 87.019 | 86.267 | 88.602 | 89.383 | 84.510 | 85.896 |
| **315** | 84.361 | 86.126 | 86.934 | 85.816 | 83.794 | 82.332 |
| **400** | 84.120 | 86.070 | 85.580 | 84.612 | 84.735 | 83.243 |
| **500** | 79.872 | 82.256 | 81.436 | 81.050 | 80.787 | 80.365 |
| **630** | 76.479 | 78.514 | 77.055 | 76.755 | 75.980 | 76.078 |
| **800** | 76.236 | 77.763 | 77.259 | 80.191 | 77.003 | 75.025 |
| **1000** | 74.989 | 75.967 | 75.237 | 75.809 | 72.476 | 72.903 |
| **1250** | 74.688 | 73.661 | 73.832 | 74.034 | 72.280 | 72.233 |
| **1600** | 75.669 | 77.053 | 76.297 | 77.035 | 72.403 | 72.343 |
| **2000** | 72.341 | 73.691 | 76.076 | 73.651 | 68.415 | 68.907 |
| **2500** | 69.208 | 70.662 | 69.171 | 70.191 | 67.066 | 67.037 |
| **3150** | 70.025 | 70.678 | 69.646 | 69.410 | 65.450 | 65.840 |
| **4000** | 72.729 | 73.588 | 71.983 | 72.474 | 68.980 | 69.461 |
| **5000** | 67.611 | 70.514 | 68.882 | 69.817 | 66.855 | 65.902 |
| **6300** | 65.797 | 68.329 | 67.075 | 69.452 | 66.778 | 65.689 |
| **8000** | 70.719 | 75.291 | 73.221 | 75.467 | 66.740 | 66.307 |
| **10000** | 60.109 | 59.582 | 59.392 | 63.483 | 62.545 | 62.095 |
| **12500** | 57.220 | 56.820 | 56.441 | 63.170 | 62.288 | 61.570 |
| **16000** | 61.527 | 63.139 | 62.409 | 61.971 | 60.971 | 60.167 |
| **20000** | 56.337 | 57.075 | 56.429 | 57.134 | 58.096 | 57.071 |
| **OSPL [dB]** | **108** | **108** | **111** | **111** | **111** | **111** |

## 9.18. [R18]: Taxi, cockpit window closed (2)

The PSD results are shown in Figure 112. Tonal behavior with the highest PSD level located at 20.50 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 113. This segment exhibits a maximum SPL of 109 dB in the 20 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 114. This segment exhibits a maximum SPL of 88 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 88-90 dB(A) was measured consistently throughout the cabin.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 115. This segment exhibits a maximum SPL of 74 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 75 dB(A) was measured at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 116. A maximum duration of 4 hours cumulated during flight segment [R18]: Taci, cockpit window closed (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 117. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 4 hours without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

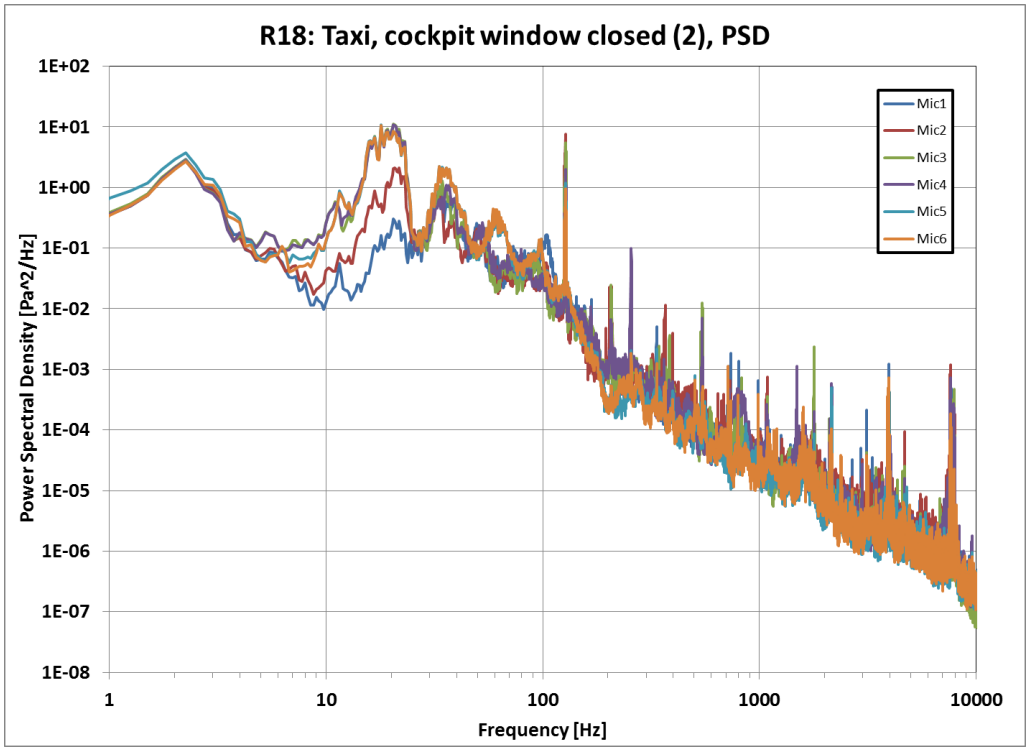


**Figure 112: Power Spectral Density for Run 18: Taxi, cockpit window closed (2)**

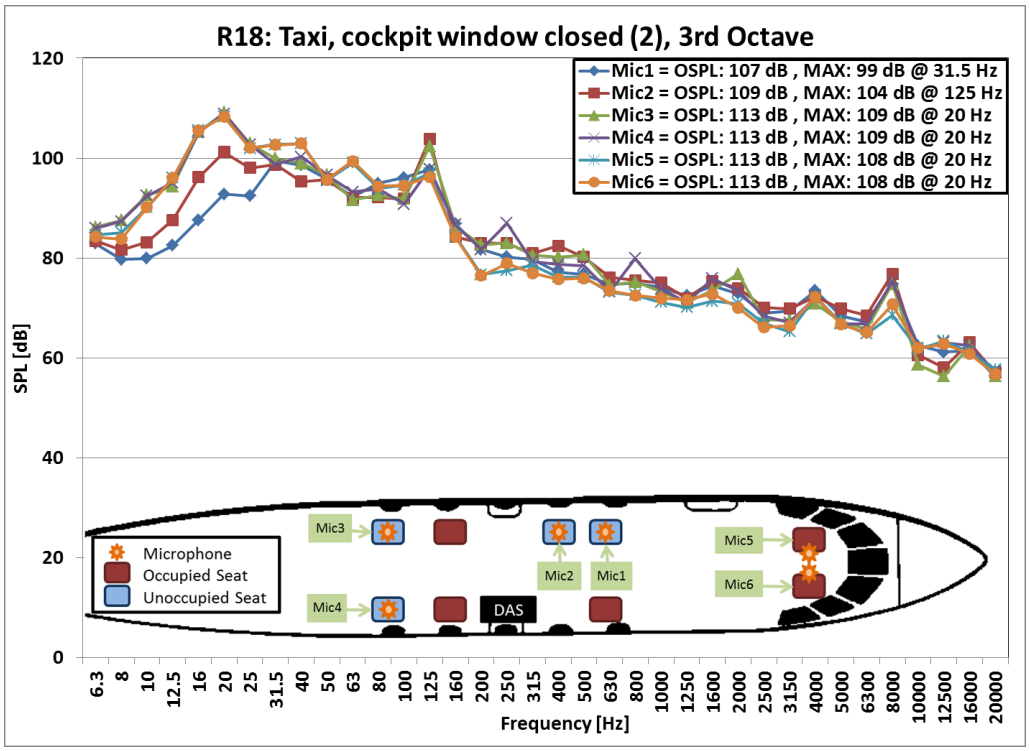


**Figure 113: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 18: Taxi, cockpit window closed (2)**

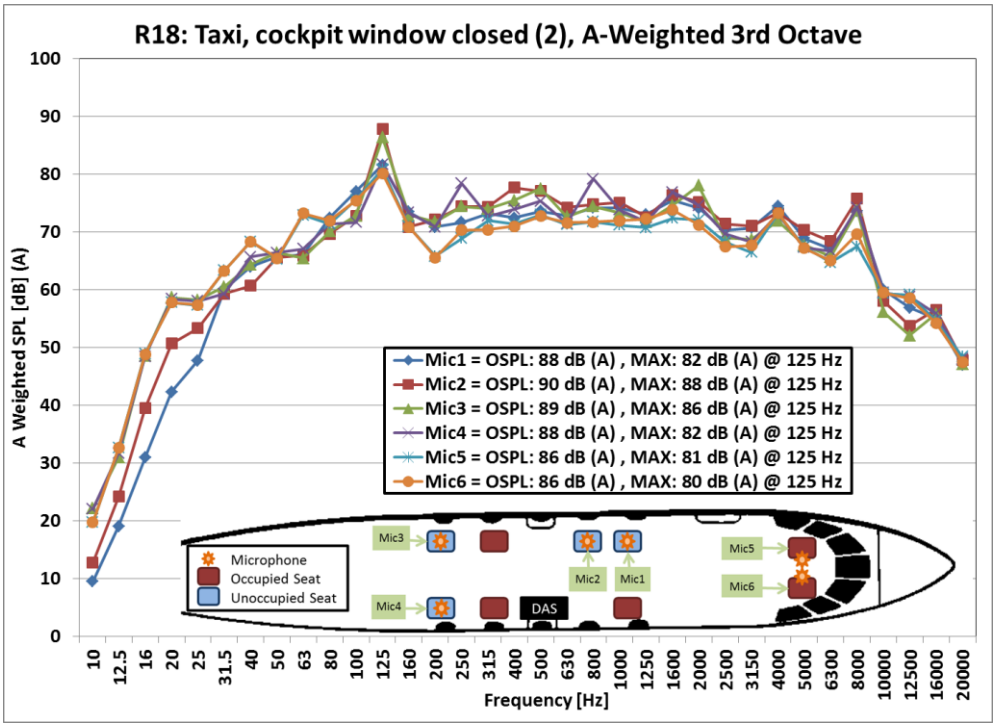


**Figure 114: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 18: Taxi, cockpit window closed (2)**

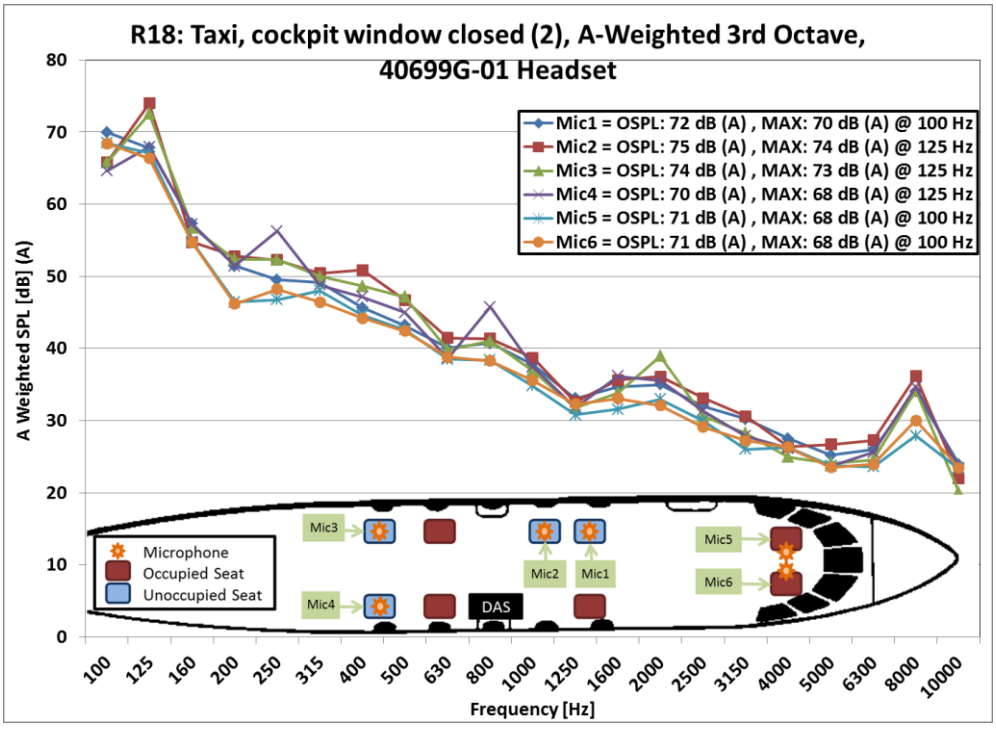


**Figure 115: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 18: Taxi, cockpit window closed (2)**

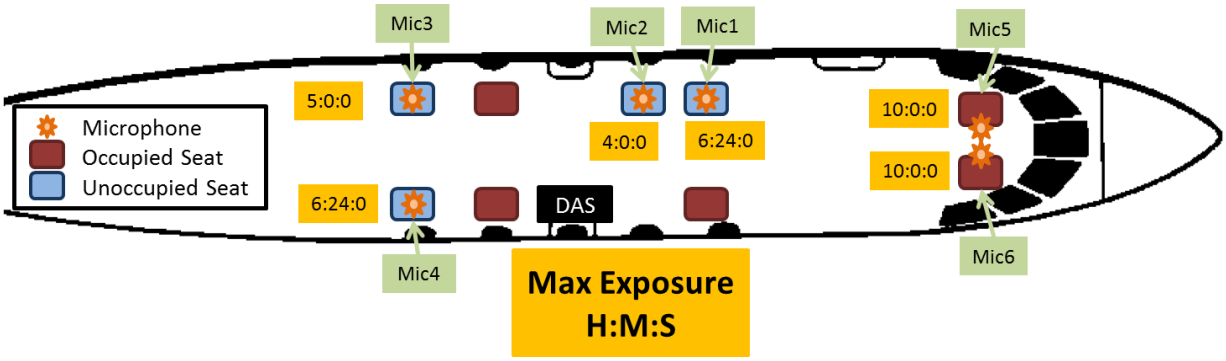


**Figure 116: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 18: Taxi, cockpit window closed (2)**

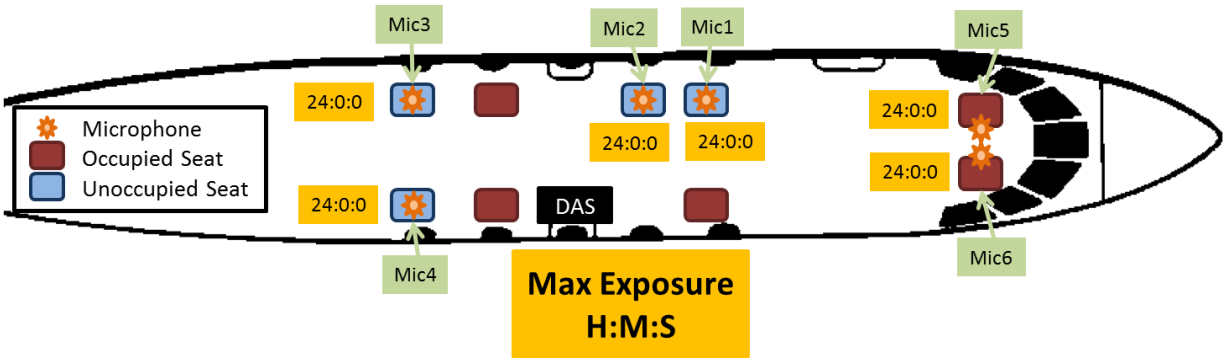


**Figure 117: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 18: Taxi, cockpit window closed (2)**

**Table 23: Taxi, cockpit window closed (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 82.951 | 83.411 | 86.177 | 85.985 | 84.599 | 84.215 |
| **8** | 79.678 | 81.618 | 87.528 | 87.296 | 85.120 | 83.822 |
| **10** | 79.894 | 83.161 | 92.573 | 92.434 | 90.127 | 90.106 |
| **12.5** | 82.479 | 87.619 | 94.404 | 95.092 | 96.038 | 96.015 |
| **16** | 87.625 | 96.166 | 105.257 | 105.170 | 105.610 | 105.523 |
| **20** | 92.809 | 101.193 | 109.120 | 108.882 | 108.288 | 108.291 |
| **25** | 92.409 | 98.005 | 102.934 | 102.719 | 102.026 | 102.038 |
| **31.5** | 99.448 | 98.678 | 99.878 | 98.701 | 102.706 | 102.645 |
| **40** | 98.580 | 95.299 | 98.944 | 100.254 | 102.909 | 102.904 |
| **50** | 95.843 | 95.727 | 96.610 | 96.623 | 95.506 | 95.644 |
| **63** | 92.268 | 92.091 | 91.605 | 93.251 | 99.071 | 99.390 |
| **80** | 94.920 | 92.173 | 92.562 | 93.826 | 93.907 | 94.406 |
| **100** | 96.086 | 91.890 | 91.874 | 90.744 | 94.617 | 94.537 |
| **125** | 97.662 | 103.850 | 102.405 | 97.806 | 96.946 | 96.235 |
| **160** | 86.823 | 84.271 | 86.293 | 86.715 | 84.309 | 84.233 |
| **200** | 81.724 | 83.039 | 82.623 | 81.728 | 76.675 | 76.461 |
| **250** | 80.221 | 82.972 | 83.016 | 86.978 | 77.489 | 78.928 |
| **315** | 79.716 | 80.960 | 80.559 | 79.334 | 78.544 | 76.958 |
| **400** | 77.224 | 82.442 | 80.215 | 78.714 | 76.149 | 75.772 |
| **500** | 76.745 | 80.240 | 80.657 | 78.505 | 76.161 | 75.934 |
| **630** | 74.734 | 76.125 | 74.506 | 73.330 | 73.166 | 73.460 |
| **800** | 74.934 | 75.563 | 75.220 | 79.942 | 72.565 | 72.490 |
| **1000** | 74.137 | 75.060 | 73.249 | 73.823 | 71.178 | 71.915 |
| **1250** | 72.412 | 71.925 | 71.091 | 71.159 | 70.142 | 71.653 |
| **1600** | 74.407 | 75.377 | 73.603 | 75.880 | 71.338 | 72.816 |
| **2000** | 72.894 | 73.987 | 76.822 | 73.407 | 70.854 | 69.997 |
| **2500** | 68.987 | 70.077 | 67.594 | 68.328 | 66.976 | 66.106 |
| **3150** | 69.445 | 69.829 | 67.492 | 67.070 | 65.280 | 66.444 |
| **4000** | 73.433 | 72.265 | 70.861 | 72.064 | 72.206 | 72.246 |
| **5000** | 68.349 | 69.833 | 67.208 | 66.826 | 66.907 | 66.673 |
| **6300** | 67.175 | 68.481 | 65.799 | 66.794 | 64.827 | 65.135 |
| **8000** | 74.733 | 76.854 | 74.843 | 75.319 | 68.576 | 70.726 |
| **10000** | 62.464 | 60.552 | 58.618 | 61.985 | 61.837 | 61.957 |
| **12500** | 61.182 | 58.039 | 56.350 | 63.095 | 63.402 | 62.836 |
| **16000** | 61.532 | 63.122 | 62.395 | 62.455 | 61.268 | 60.839 |
| **20000** | 56.331 | 57.087 | 56.423 | 57.320 | 57.664 | 56.795 |
| **OSPL [dB]** | **107** | **109** | **113** | **113** | **113** | **113** |

## 9.19. [R19]: Taxi, cockpit window open (2)

The PSD results are shown in Figure 118. Tonal behavior with the highest PSD level located at 126.75 Hz is exhibited during this run.

The un-weighted Sound Pressure Level (SPL) results are shown in Figure 119. This segment exhibits a maximum SPL of 104 dB in the 125 Hz 1/3$^{rd}$ octave band.

The A-weighted SPL results for hearing-unprotected aircrew are shown in Figure 120. This segment exhibits a maximum SPL of 88 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 91 dB(A) was measured at the mid (Mic 2) portside cabin location.

The A-weighted SPL results for aircrew protected with the 40699G-01 David Clark headset are shown in Figure 121. This segment exhibits a maximum SPL of 74 dB(A) at the 125 Hz 1/3$^{rd}$ octave band. A maximum overall SPL of 75 dB(A) was measured at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of hearing-unprotected aircrew for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 122. A maximum duration of 3 hours 12 minutes cumulated during flight segment [R19]: Taxi, cockpit window open (2) during a 24 hour period for hearing-unprotected aircrew was exhibited at the mid (Mic 2) portside cabin location.

The maximum exposure duration limits of aircrew protected with the 40699G-01 David Clark headset for a 24 hour period derived from the measured noise levels at different stations within the aircraft interior are shown in Figure 123. All locations exhibited unlimited maximum exposure durations for each 24 hour period.

Aircrew may operate for up to 3 hours 12 minutes without hearing protection at any location within the cabin during this flight segment before reaching their maximum daily exposure limit. While wearing the 40699G-01 headset aircrew may operate at any location within the cabin for an unlimited period. The David Clark headset provides adequate protection for this flight segment.

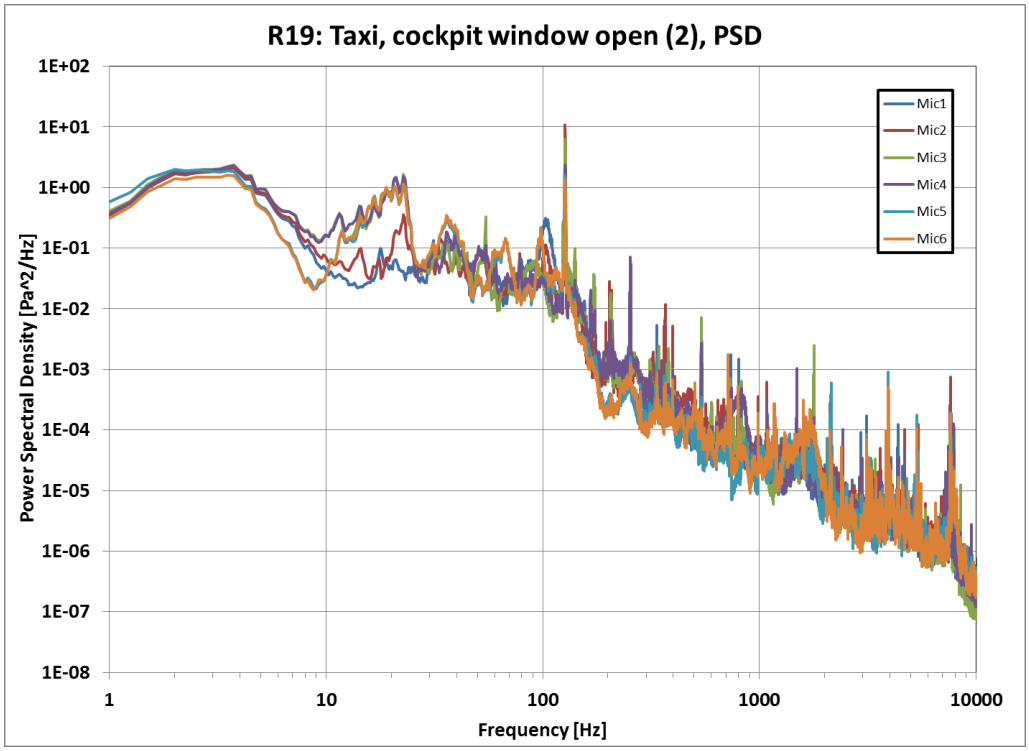


**Figure 118: Power Spectral Density for Run 19: Taxi, cockpit window open (2)**

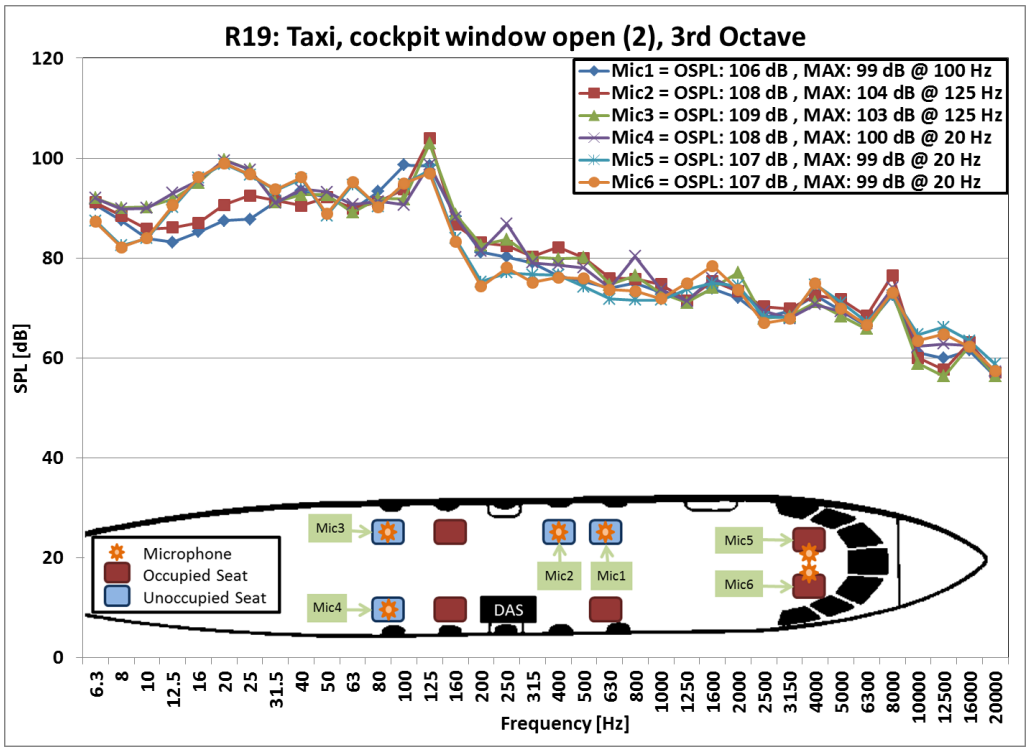


**Figure 119: Sound Pressure Level (Linear Weighting) for hearing-unprotected aircrew during Run 19: Taxi, cockpit window open (2)**

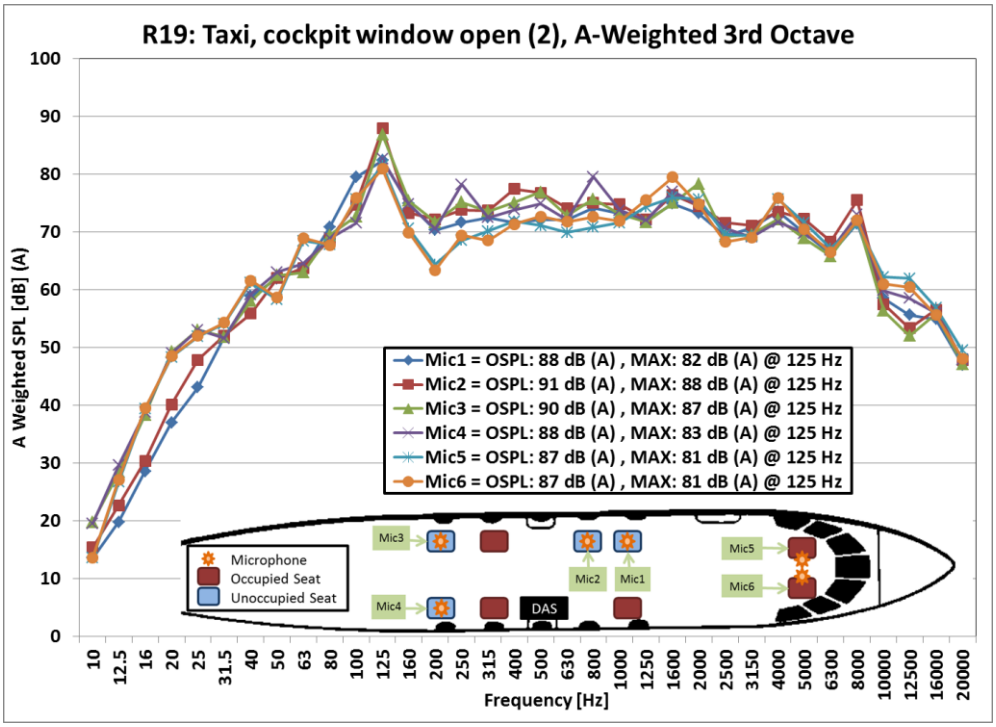


**Figure 120: Sound Pressure Level (A-Weighting) for hearing-unprotected aircrew during Run 19: Taxi, cockpit window open (2)**

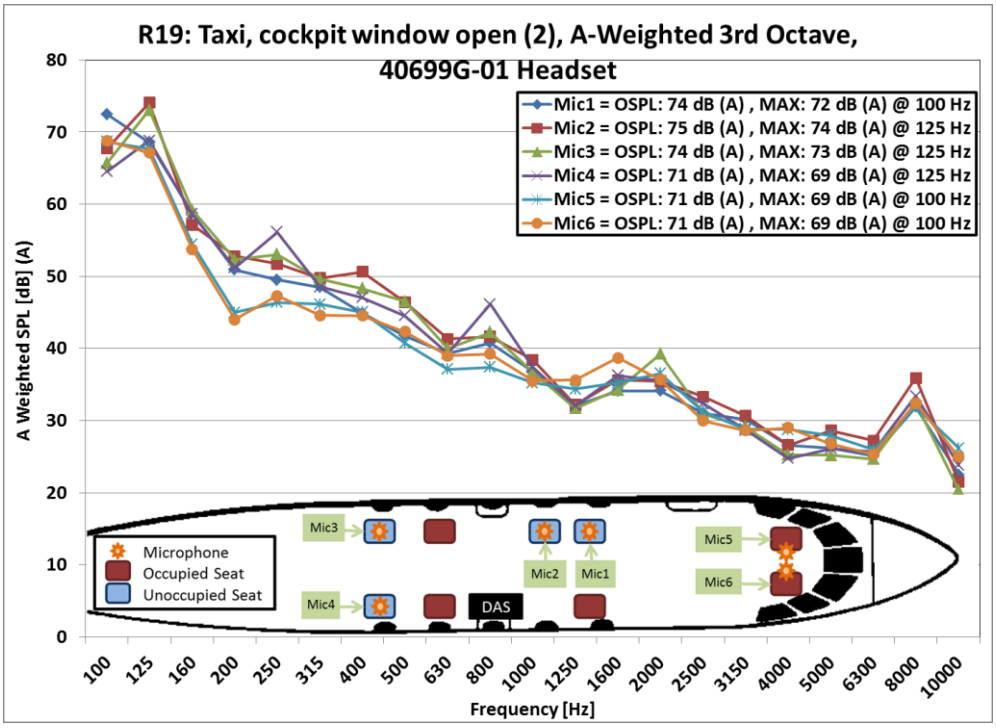


**Figure 121: Sound Pressure Level (A-Weighted) for aircrew protected with the 40699G-01 David Clark headset during Run 19: Taxi, cockpit window open (2)**

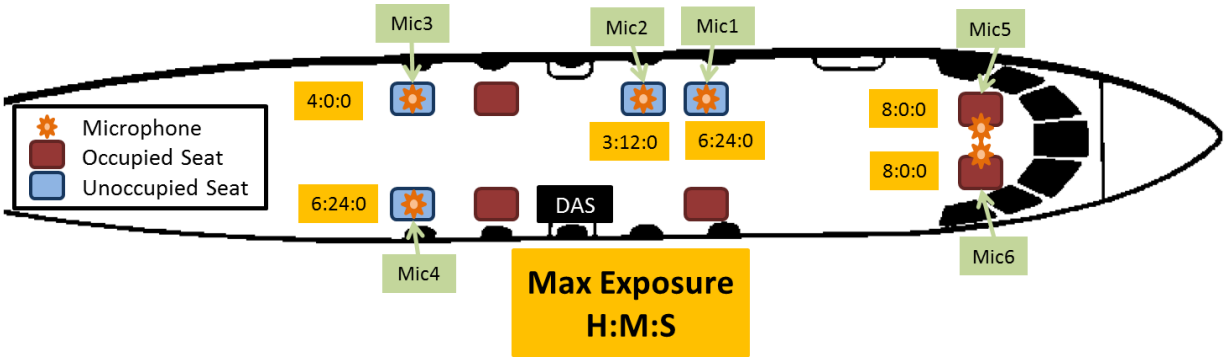


**Figure 122: Maximum duration of exposure for hearing-unprotected aircrew (H:M:S) at various aircraft stations during Run 19: Taxi, cockpit window open (2)**

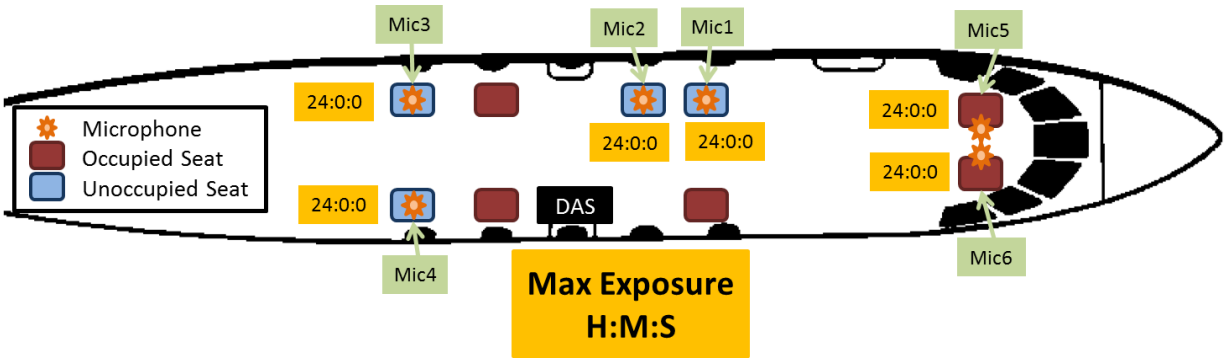


**Figure 123: Maximum duration of exposure for aircrew protected with the 40699G-01 David Clark headset during Run 19: Taxi, cockpit window open (2)**

**Table 24: Taxi, cockpit window open (2) 3rd Octave Band (Linear Weighted, Windscreen Corrected)**

| Frequency [Hz] | Mic1 [Pa] | Mic2 [Pa] | Mic3 [Pa] | Mic4 [Pa] | Mic5 [Pa] | Mic6 [Pa] |
|---|---|---|---|---|---|---|
| **6.3** | 90.711 | 91.166 | 92.017 | 91.978 | 87.473 | 87.277 |
| **8** | 87.532 | 88.477 | 90.035 | 89.826 | 82.531 | 82.167 |
| **10** | 83.982 | 85.799 | 90.171 | 89.953 | 83.977 | 84.025 |
| **12.5** | 83.176 | 86.097 | 91.804 | 93.037 | 90.101 | 90.534 |
| **16** | 85.261 | 87.068 | 95.062 | 95.523 | 96.058 | 96.164 |
| **20** | 87.498 | 90.652 | 99.722 | 99.516 | 98.826 | 98.985 |
| **25** | 87.788 | 92.528 | 97.746 | 97.702 | 96.588 | 96.708 |
| **31.5** | 91.237 | 91.477 | 91.211 | 90.979 | 93.523 | 93.690 |
| **40** | 93.451 | 90.456 | 92.616 | 93.771 | 95.810 | 96.197 |
| **50** | 92.113 | 92.177 | 92.670 | 93.192 | 88.485 | 88.804 |
| **63** | 89.643 | 89.920 | 89.142 | 90.698 | 94.641 | 95.137 |
| **80** | 93.273 | 91.228 | 91.895 | 91.387 | 90.261 | 90.233 |
| **100** | 98.587 | 93.825 | 91.781 | 90.625 | 94.785 | 94.919 |
| **125** | 98.455 | 103.963 | 102.918 | 98.671 | 97.575 | 96.992 |
| **160** | 88.256 | 86.678 | 88.747 | 88.158 | 83.966 | 83.269 |
| **200** | 81.180 | 83.071 | 82.584 | 81.466 | 75.224 | 74.286 |
| **250** | 80.205 | 82.424 | 83.726 | 86.824 | 77.078 | 78.022 |
| **315** | 79.045 | 80.285 | 80.137 | 79.071 | 76.699 | 75.117 |
| **400** | 76.425 | 82.182 | 79.859 | 78.612 | 76.600 | 76.115 |
| **500** | 75.277 | 79.970 | 80.058 | 78.060 | 74.270 | 75.863 |
| **630** | 73.994 | 75.982 | 74.679 | 73.941 | 71.799 | 73.661 |
| **800** | 74.960 | 75.824 | 76.447 | 80.330 | 71.597 | 73.413 |
| **1000** | 73.200 | 74.778 | 73.044 | 73.715 | 71.600 | 71.888 |
| **1250** | 71.407 | 71.545 | 71.065 | 71.394 | 73.715 | 74.967 |
| **1600** | 73.882 | 75.396 | 74.004 | 75.983 | 74.973 | 78.437 |
| **2000** | 71.984 | 73.288 | 77.099 | 73.406 | 74.442 | 73.569 |
| **2500** | 68.034 | 70.292 | 67.920 | 69.345 | 68.215 | 66.972 |
| **3150** | 69.415 | 69.892 | 68.328 | 67.890 | 68.072 | 67.842 |
| **4000** | 72.501 | 72.524 | 71.148 | 70.693 | 74.683 | 74.933 |
| **5000** | 69.353 | 71.756 | 68.344 | 69.257 | 71.072 | 69.948 |
| **6300** | 66.308 | 68.410 | 65.864 | 66.926 | 67.227 | 66.564 |
| **8000** | 72.571 | 76.579 | 73.167 | 74.061 | 72.516 | 73.107 |
| **10000** | 60.999 | 59.996 | 58.835 | 62.311 | 64.705 | 63.463 |
| **12500** | 59.919 | 57.653 | 56.333 | 62.831 | 66.224 | 64.737 |
| **16000** | 61.506 | 63.097 | 62.376 | 62.515 | 63.470 | 62.237 |
| **20000** | 56.332 | 57.084 | 56.435 | 57.206 | 58.793 | 57.405 |
| OSPL [dB] | **106** | **108** | **109** | **108** | **107** | **107** |