TESTING OF HEALTH CANADA'S ACOUSTIC CHAMBER AT THE CONSUMER AND CLINICAL RADIATION PROTECTION BUREAU BASED ON ISO STANDARD 3745:2003

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1. INTRODUCTION

Third party acoustical certification testing was performed in Health Canada's acoustic chamber at the Consumer and Clinical Radiation Protection Bureau in Ottawa, Ontario. Testing was performed prior to installation of a fire suppression system to document baseline acoustical conditions. The installation required considerable modification to the chamber, including drilling holes through both acoustical absorbing wedges and the ceiling. Also sprinkler heads were installed at the edge of some wedges.

Tests were made using the pure tone method prescribed in Annex A of ISO 3745 (2003) (Standard) [1]. This paper describes the results of the free field performance testing and discusses the characteristics of the sound sources.

1.1 Chamber Description

The chamber is constructed as a room within a room, with concrete inner and outer walls, 25 cm and 15 cm thick, respectively, separated by a 127 cm air gap. The inner room sits on 56 vibration isolating springs mounted on rubber pads. The springs have a resonance frequency for rocking oscillations of 1.5 Hz. The inner chamber weighs approximately 1000 tons. The walls, floor, and ceiling are lined with flat-tipped fibreglass wedges designed for a cut-off frequency of 50 Hz. The interior (wedge tip to wedge tip) is approximately 13 m long, 9 m wide and 8 m high. The chamber is anechoic in design with removable concrete floor tiles to convert to a hemi-anechoic chamber. A B&K 9654 robot is suspended from the chamber roof at a height of approximately 5.3 m above the floor. The robot consists of stepper motors travelling along a frame of 5 cm square tubing.

2. METHOD

Measurements were conducted with a Gras Model 40 BE 1/4 inch microphone and Model 26CB preamplifier connected to a Bruel & Kjaer Type 2260 Precision Integrating Sound Level Meter.

Two sound sources were used to cover the design frequency range of the chamber (50 Hz to 10 kHz): a dynamic loud speaker and a compression driver. The sound sources were positioned in a hole in the reflecting floor near the centre of the chamber. The compression driver was mounted to the underside of the concrete tile floor through a 5/16 inch hole to improve its directional properties. The source outlets were flush with the floor surface to eliminate potential image sources.

The signal was supplied from a Dell Precision M65 laptop through a Tascam GE20B equalizer and a Stewart PA50B power amplifier. The measured signal was at least 20 dB greater than the background noise. Measurements were recorded for 7 to 10 seconds at each position.

Measurements were taken along six radial traverses, extending 0.5 m from the effective acoustic centre of the source to 0.5 m distance to the walls, ceiling, and corner. Traverses were performed using pure-tone signals at 1/3 octave band centre frequencies. The microphone was moved at 10 cm intervals.

For each traverse measurements, source strength [1] was calculated from:

$$a = \frac{N r_0^2 + \sum_{i=1}^{N} r_i^2 - 2 r_0 \sum_{i=1}^{N} r_i}{\sum_{i=1}^{N} r_i q_i - r_0 \sum_{i=1}^{N} q_i} \qquad \textbf{(1)}$$

where, for each traverse, $q_i = 10^{-0.05 L_{pi}}$, Lpi is the sound pressure level at the ith measurement position in decibels, r_i is the distance of the ith measurement position from the centre of the measurement hemisphere.

The sound source must meet the requirements in Table 1 to minimize the uncertainties in chamber characterization which can arise from a directional source. Ideally the test source should behave like a point source with a uniform sound distribution [1].

Table 1. Allowable deviation in directionality of the test source

One-third-octave band frequency (Hz)	Allowable deviations in directionality
≤ 630	± 2.0
800 to 5,000	± 2.5
6,300 to 10,000	± 3.0

Qualification of the chamber requires that the differences between the measured and theoretical levels do not exceed the values in Table 2 [1]. The theoretical free-field decay of sound, from a point source, follows the inverse square law of 6.0 dB per doubling of distance. Reflection and scattering effects from the wedges or any other surface in the room will yield deviations from the inverse square law.

Table 2. Maximum allowable difference in hemi-anechoic rooms between measured and theoretical free-field levels

One-third-octave band frequency (Hz)	Allowable difference (dB)
≤ 630	± 2.5
800 to 5,000	± 2.0
> 6,300	± 3.0

3. RESULTS

3.1 Sound Source Directionality Check

As a check on source directionality, for each traverse, source strength was calculated from Eq. (1), for points between 0.5 m and 1.5 m, assuming $r_0=0$. Figure 1 shows the maximum deviation in source strength (half the difference between maximum and minimum source strength levels), across all traverses, in each frequency band of interest. These deviations are compared to the deviations limits in Table 1.

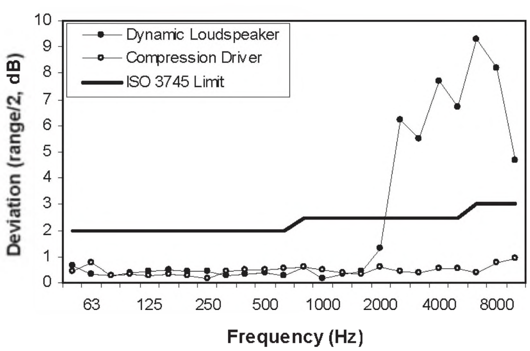

Fig. 1: Measured deviations (range/2) in directivity for the dynamic loudspeaker and compression driver compared to ISO 3745 limits for a hemi-anechoic test room.

Based on the results in Figure 1, it is evident that the dynamic loudspeaker directivity effects are more prevalent at the higher frequencies, above 2 kHz. Deviations are less than 2 dB for frequencies 2 kHz and below. Above 2 kHz deviations continue to climb to 9 dB at 6300 Hz and then decline to 5 dB at 10 kHz.

Directional effects of the compression driver are subtle, with deviations less than 1 dB over most of the frequency range of interest. At 8 kHz and 10 kHz, deviations increase to approximately 1 dB. Below 500 Hz, the compression driver does not yield sound pressure levels high enough to meet the signal to noise requirements of the Standard.

Drawing results from both speakers, the maximum deviation from omnidirectionality is less than 2 dB for all frequencies of interest (50 Hz to 10 kHz). The dynamic loudspeaker was used to cover the frequency range from 50 Hz to 1 kHz, and the compression driver was used for the frequency range from 1.25 kHz to 10 kHz

3.2 Chamber Qualification

The measured and theoretical levels met the allowable limits shown in Table 2, with the exception of the upward traverses near the robot frame, in the higher frequency bands. The deviation from theoretical levels was likely due to reflections off of the robot frame. Limits in the higher frequency bands were exceeded by up to 4 dB, 10 cm from the robot frame. Measurement results are shown in Figure 2 for 50 Hz and 10 kHz.

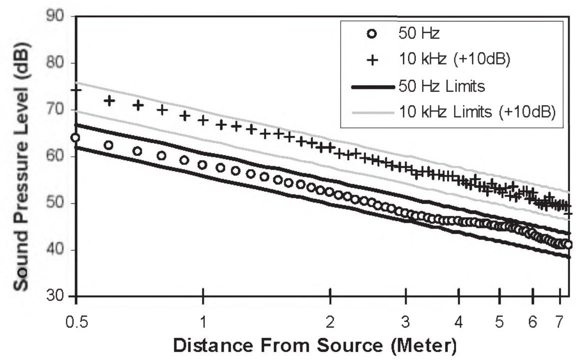

Fig. 2: Measurement results for Up and Over Traverse at 50 Hz and 10 kHz.

4. CONCLUSIONS

Two sound sources were used to cover the design frequency range of the chamber, 50 Hz to 10 kHz. The sources were in accordance with the directionality and signal to noise requirements of ISO 3745, within the respective frequency ranges used.

These tests showed that, over its useable volume, the chamber complied with the ISO 3745 pure tone option for chamber characterization in all 1/3 Octave bands over the design frequency range of 50 Hz to 10 kHz.

These tests were performed pre-installation of a fire suppression system. Testing is planned in the future to determine if the installation has caused any changes in the acoustical conditions of the chamber.

REFERENCE

[1] ISO 3745 (2003). Acoustics - Determination of sound power levels of noise sources using sound pressure - Precision methods for anechoic and hemi-anechoic rooms. International Organization for Standardization.