Active Boom Noise Damping in Rooms and Cabins

Problem: Most rooms/cabins have dimensions that favor standing waves (resonant modes) which are in the range of vibration frequencies of the propulsion engines, gensets, or other machinery onboard watercrafts. Undesirable and unfortunate coupling of the room acoustic modes with the machinery vibration frequencies results in boom/rumble in the room. *Such low-frequency noise, which is more felt than heard, lead to discomfort and fatigue of the room occupants*. Despite the fact that low-frequency noise in a cabin barely contributes to the dBA rating of the cabin, such noise is the major source of annoyance.

Acoustical tiles, fiberglass, heavy drapery, thick carpets, and other absorptive materials are ineffective at low-frequencies and do not remedy the boominess of the room.

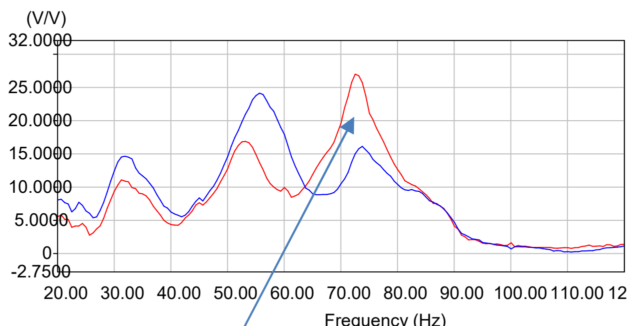

Figure 1 Frequency response function of the cabin, with the cabin entrance closed (red) and open (blue)

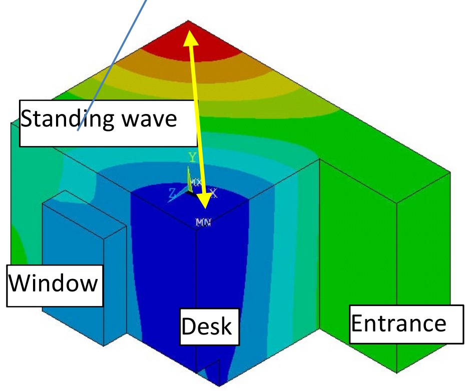

Figure 2 Corner to corner standing wave in the cabin, occurring at around 75 Hz

In a recent study, sound measurements in the study room of a luxury vessel indicated a strong presence of 75 Hz tone in the room when one of the gensets was running.

The acoustic analysis of the room indicated the presence of an standing wave (acoustic mode) at around 75 Hz; Figure 1 shows a frequency response of the room and Figure 2 depicts the layout along with the pressure distribution in the room at the 75 Hz mode; note that the owner's head, sitting at his desk, is located in the high intensity region of the 75 Hz tone. With the genset on, the 75 Hz firing frequency of the diesel was coupling with the 75 Hz resonance of the room resulting in an annoying/tiring, tonal boom noise.

Room Acoustics: Sound reflecting from surface to surface can interfere at certain frequencies, resulting in standing waves (acoustic resonance). Each room produces a complex set of acoustic modes, whose natural frequencies are determined by the room geometry and dimensions. A room may be viewed as a complex resonator, having distinct acoustic modes (standing waves), at low frequencies. The resonant frequencies and the corresponding shapes of the standing waves in a room depend primarily on the shape and size of the room.

Due to the long wavelength of sound at lower frequencies the modal density (the number of modes in a frequency interval) at these frequencies is by far lower than that at high frequencies, resulting in distinct discrete modes. This, along with the ineffective low-frequency absorption of the furniture, floor/ceiling covering, and wall treatments make the resonant modes highly noticeable and a major issue at low frequencies.

Solution: Damping can be added to the low-frequency acoustic modes using reactive absorbers tuned to the resonant frequency of the target modes. The problem with such solution is that reactive absorbers are large and unattractive. An alternative to the use of such passive solution is to add acoustic damping to the low-frequency modes of the room, actively. *DEICON, Inc. has developed an **active control** strategy* for reducing the boominess of small rooms/cabins at low frequencies. DEICON's ***Active Acoustic Damping System*** is a *patented*, feedback control scheme tunable to individual mode(s) of a cabin, adding damping to that (those) mode(s). This active damping solution is small in size and easily re-tunable. In another application, the first mode of a larger room, at around 32 Hz, was targeted for damping. Figure 3 shows a frequency response function of the room with and without DEICON's active damping system. Clear from the measured data, the active system effectively damps the 32 Hz mode, quieting the low-frequency tonal rumble associated with that mode.

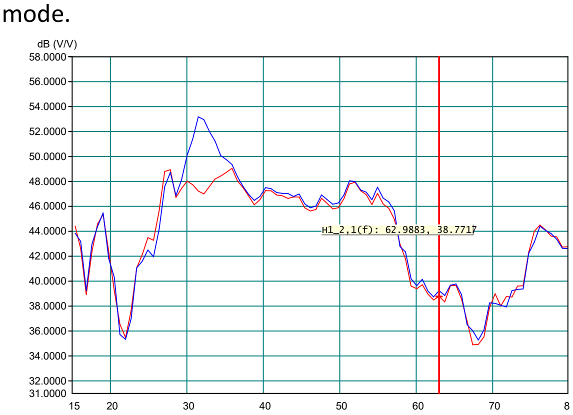

Figure 3 Frequency response function in a room without (blue trace) and with (red trace) DEICON's active boom noise damper