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# Acoustics for Yachts

How to create an acoustic “slice of paradise” on the high seas

by Bonnie Schnitta, Anthony Cannella, Trish Kern and Greg Greenwald

Noise is a subjective experience: It has distinctive effects on individuals based on their sensitivities to sound. The physiological effects of noise vary from person to person. For example, a hearing-impaired person may be susceptible to further harm when exposed to excessive noise levels. Recently, a SoundSense client with a hearing problem asked if the noise from his yacht could potentially harm his hearing. After a quick reading with a spectrum analyzer and an interview, we realized that the noise levels were, indeed, hazardous to his existing condition.

As we discussed potential solutions, the client revealed that he owned multiple yachts. On this particular vessel, though, the noise also seemed to affect his wife as well, causing her to become slightly seasick. “Noise” is defined as unwanted sound. Interestingly enough, its etymological origin is the Latin word for “nausea.” This semantic correlation is imperative in yacht design, as certain untreated structures can result in vibrations, which can cause seasickness. The noise level and type of sound also can cause secondary health concerns that affect one’s overall well-being. Understanding some of the easy fixes to many of these problems can provide a better yachting experience.

As with any application, there must be a focus on acoustic separation or isolation to prevent intrusive noises from entering the yacht. This also reduces the amount of sound emanating from room-to-room and from floor-to-floor. At a minimum, the noise levels should be brought to below 70 dB(A) from the engine room. Living areas should have much lower noise levels, particularly for sleeping areas.

Once acoustic separation is sufficiently addressed, relative to the client’s acoustic needs, each room must be reviewed for acoustic decay time and wave-interaction patterns. Correcting the acoustic environ-



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ment will provide the perfect aural setting for each space, depending on its intended use. The right acoustic treatment will prevent unwanted sounds from becoming amplified; will make a small room feel larger; will project cleaner tones from an audio system; will allow for appropriate speaker placement (not where theory mandates); and will make the surround-sound system “surround” the listener in the truest sense.

Most noise and vibration sources originate externally and internally and include:

- Hydrodynamics of the hull and its appendages: rudders, stabilizer fins, hull surface and interruptions;
- Propeller hydrodynamics, including prop wash and cavitation;
- Flow-induced noise and vibrations, or

vortex shedding from the mast or keel;

- Main engine(s) and transmission(s);
- Heating, ventilation and air-conditioning motors, fans and ductwork;
- Hydraulic system pumps, motors, valves, piping and other components;
- Propulsion system components, including main driveshaft and bearings;
- Other systems and machinery: generators, deck equipment, filtration systems.

While acoustic treatment should begin at the shipyard while the yacht is being built, many solutions can be applied after delivery. An important consideration is to ensure that noise-control solution do not affect yacht speed or fuel efficiency.

## Acoustic Separation or Isolation

The acoustic isolation or separation needed between areas that require a level of quietude—such as a spa, music room, stateroom or salon, or between the home theater and adjoining rooms—are critical for the enjoyment of the yachting experience. While extraneous noise in a house or an apartment may be disruptive, noise from an adjacent room—such as footfall noise—can ruin a movie or a music-listening session.

On a yacht, intrusive engine-room noise frequently disturbs the listening and viewing experience. In fact, engine-room noise can corrupt the quality of the audio system.

On the next page, we've outlined some basics of engine-noise reduction.

The hull and the engine room must be treated as engines and pumps transmit low-frequency sound, which can couple into surrounding structures and resonate throughout. Many commercially available products can eliminate "structure-borne" noise:

- Spray dB Damp to minimize metal structural resonance.
- Wrap ducts that exit to the floor, above or below, with absorptive material.
- Utilize proper flexible ducts or hose connections.
- Install proper machine base deflection springs (review for mechanical specs and springs by a qualified engineer is necessary for proper load and deflection).
- Install decoupler clips with resilient channels and a "class A" fire-rated composite barrier and absorber on the critical perimeter walls and ceiling of the mechanical room to inhibit machinery low-frequency noises from coupling into the walls and ceiling. The ATI, which is a light material that blocks and absorbs sound, can be used as an alternative. A recent application using the ATI produced a significant weight savings, while achieving a 10 dB reduction.

• Attach pipes and conduits to Kendorf, which is connected to the wall with acoustic wall studs (do not rigidly connect these items to the walls or ceiling).

• Minimize the transmission noise from floor to floor—especially from in the engine-room area—by placing an acoustic carpet underlayment on the floor. SoundSense's Vibramat, for example, has a high transmission loss in the lower frequencies with damping qualities.

**HVAC/Fan/Projector/Exhaust Noise**

Extraneous noise from a yacht's heating or cooling units, as well as the plumbing system, can disturb a movie, music listening and sleep. Replacing a noisy fan with silent version is the easiest solution. Active noise

cancellation, an alternative, emits a reverse-phase signal into the environment at frequencies matching the noise of disturbance, which effectively absorbs its energy and canceling its sound.

Any pipe with a long drop, as well as any pipe that's installed in a wall adjacent to a cabin or stateroom, should also be acoustically addressed. Pipes should be secured to the structure with flexible acoustic connectors only. Also, the sound of running water through PVC pipes should be addressed in acoustically sensitive rooms such as bedrooms, media rooms, dining rooms, massage rooms, etc. In addition, recessed speakers must be equipped with acoustic enclosures made with material that prohibits sound from transferring to another room.

**Acoustic Leakage**

Recessed lighting, outlets and switches are conduits for sound to transmit. But even smaller voids in the acoustic configuration can cause degradation. For example, a 1-square-inch hole in the wall can result in more than a 10 dB efficacy reduction. Caulking edges, junctures and cracks is essential for an acoustically enclosed room.

**Acoustics Throughout the Yacht**

Each enclosed space exhibits reverberation, or sound persistence, due to repeated boundary reflections after the source of sound has stopped. After bouncing off reflective surfaces, acoustic waves can make a room uncomfortable. The effects include:

- Excessive reverberation causes overlap-

ping syllables and tones, which reduce the intelligibility of speech and music;

- High, or long, reverberation times can elevate sound levels, creating a noisy room;
- The reflection of acoustic waves off of surfaces within the space can strike another wave in opposite phase, causing a standing wave. A standing wave is nature's version of noise cancellation, which can negatively affect the environment's audio systems.

Mathematically locating and applying acoustic materials—absorbers, reflectors and diffusors—at various locations on or within the boundaries of the room can correct reverberation in a room. Many designers can solve excessive reverberation with fabric-wrapped, compressed fiberglass or acoustic diffusors. When doing so, it's important to remember that there are new and innovative ways to achieve an acoustically correct environment.

With every yacht, and every space within the yacht, there's always a personal aesthetic assigned to the design. We all have our own personal vision for how to transform a room into a little slice of paradise—and this vision should always include sound. Sound is a pressure wave not only heard, but also felt.

By providing an acoustically perfect environment, the room will not only sound great but will "feel" great as well. Our passion is to provide our client's with a slice of paradise through perfect acoustics. •

