Treating Complex Shipboard Noise Problems Requires Customized Approach

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Introduction
Contemporary boat builders are placing increased importance on reducing noise in interior living quarters. Until recently, however, nearly all attempts have focused on containing engine noise. But this approach ignored other mechanisms that interact to generate unacceptable sound levels.

Treating shipboard noise and vibration problems today requires considering the variety of power sources and construction materials used in modern boat building. To be both effective and cost-effective, solutions often must be tailored to address specific problems inherent in various areas of the craft. E-A-R™ has successfully employed this customized approach on nearly all classes of marine craft. E-A-R has works with OEMs to develop noise control packages using a the proletary portfolio of energy- absorbing materials, that address the complex, interdependent sources of shipboard noise.

Customizing treatments
Through extensive acoustic analysis of shipboard sound fields, using in field measurements, E-A-R has been able to identify key sources and paths of interior noise. This analysis includes measuring sound pressure, sound intensity and structural vibration under cruise conditions. These measurements have shown that the dominant noise components of interior noise in marine applications are both airborne and structureborne. That is, external sources are transmitted both through the air to the receiver and through the structural members of the ship. Focusing on structure-borne noise, the vibrational energy travels through the hull structure and into the interior compartment, where a portion of this energy is radiated as sound.

To address the problematic structureborne noise, treatments must be aimed at dissipating vibratory energy before it is radiated by the structure as airborne sound. The best and often least expensive noise control is achieved by working as closely to the source of the noise or vibration as possible. This means attacking structureborne vibration with damping materials before it is radiated as airborne noise.

By carefully selecting materials to address the most intense noise sources and paths, it is possible to design cost- effective treatments that are more weight-efficient and provide better performance than traditional systems.

Rules of thumb for treatment
Here are general guidelines for employing proven techniques and high proprietary materials. Information on E-A-R™ materials engineered specifically for these applications is provided below.

Hull damping
Problem: Vibrational energy is transmitted to the hull via the propulsion system. This energy enters the hull through either fluid disturbance at the hull (prop cavitation and exhaust gases) or hard connections from the propeller shaft (strut connections, shaft penetration and engines).

Solution: To address both the hydrodynamic and mechanically induced structural vibrations, high-performance damping tiles should be applied to the inboard side of the shell at 80%-100% for the prop plane, strut connections, shaft penetrations, exhaust ports and engine beds. Tiles should be centered between the frames and girders. The tile-to-substrate thickness ratio should be 0.5 to 1.0, depending upon the substrate material.

Tank damping
Problem: Vibrational energy that enters the hull through the power system propagates along the hull and into tanks, bulkheads and floorboards. These surfaces are typically large, flat and lightweight, serving as efficient radiators of vibrational energy. A portion of this energy is then radiated as airborne noise.

Solution: To reduce the energy transmitted and

radiated by the large surfaces, damping tiles or sheets should be applied directly to the exposed tank surfaces at 50% - 100% coverage, and the damping tile-to-substrate thickness ratio should be 0.5 to 1.0, depending upon the substrate material.

Engine room treatments

Problem: Airborne noise is radiated directly from the engines and impacts the surfaces (bulkheads, ceilings and hull sides) within the engine room/compartment. A portion of this airborne energy is transmitted through the surface into adjacent compartments, while the rest of the energy is reflected into the engine room/compartment. The energy reflected builds up, increasing overall sound levels within, by adding to the noise radiating directly from the engines.

Solution: Engine room noise requires 100% coverage with acoustic and barrier composites to prevent sound transmission through bulkheads and ceilings, to increase effective absorption in the engine room, and prevent sound pressure buildup and flanking noise. For effective engine room treatment, all airborne noise should be contained.

For smaller boats, foam/barrier/foam composites should be applied to engine compartment surfaces adjacent to passenger areas. One and two-inch foam absorbers with aluminized facings are suitable for other areas as well. A thicker absorber has better low frequency noise attenuation while maintaining equivalent high frequency attenuation.

Larger boats need custom bulkhead and ceiling build-ups incorporating damping, sound blocking (barriers) and absorptive materials. High performance damping sheets should be applied within the bulkhead/ceiling to reduce sound radiation from these large surfaces and reduce transmission to adjacent rooms. The airborne sound treatment would then be applied as previously described.

Other Noise Sources

Bow thruster: The bow thruster tube and surrounding hull area should be damped with high-performance damping tiles, followed by application of a blanket/barrier wrap.

Generator sets: A decoupled barrier/absorber composite should be applied to the interior of generator-set enclosure panels.

Wall partitions: Wall partitions can be structurally damped with sheets of solid material damping system. This will prevent sound radiation from these structures, while increasing their sound transmission loss. This equates to lower sound levels in the compartment plus greater inter-compartment privacy.

Air ducts: Solid damping sheets can be used to damp the exterior of metal air duct panels adjacent to living quarters. This construction should be wrapped with a blanket/barrier.

Vibration and shock isolation: Pumps, motors and other equipment can be isolated from structurally defined surfaces with highly damped mounts or pads.

Instruments and gauges can be shock mounted using energy-absorbing grommets.

IN-DEPTH TECHNICAL KNOW-HOW PROVIDES CUSTOMIZED SOLUTIONS

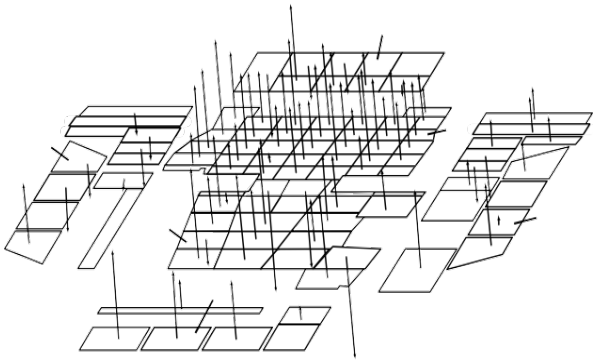
E-A-R engineers regularly conduct field tests, as well as in-house lab evaluations, to help customers find the optimum noise control solution package for their OEM product designs.

Generally, E-A-R technical experts first evaluate the product in operation, to determine and rank the energy sources and patterns and to provide baseline sound-pressure level measurements.

To design and retrofit a customized, total noise control package for an 86-foot luxury yacht, E-A-R™ engineers first conducted field tests of the yacht's existing treatments.
The yacht's complexity dictated a comprehensive acoustic intensity analysis to be conducted on all interior surface to determine the which surfaces introduced the dominate portion of acoustic energy into the living spaces

With yet another analytical technique, the engineers separated airborne and structureborne noise paths, and determined that structureborne noise was the primary problem.

Based on the data developed, treatment was customized for each problem area. By pinpointing which area required the most aggressive treatment, E-A-R noise control experts minimized the overall package cost and weight while maximizing noise reduction performance.



Location	Description	Total Area (m^2)	Intensity (dBA)	Total Power (dBA)
A	Dining Floor	13,660	+71.0	+82.4
B	Lounge Floor	15,452	+61.7	+73.6
C	Port Wall	10,246	-57.0	-67.2
D	Stbd. Wall	12,383	+61.6	+72.6
E	Fwd. Wall	6,600	+55.7	+63.9
F	Aft Wall	6,092	+66.2	+74.0

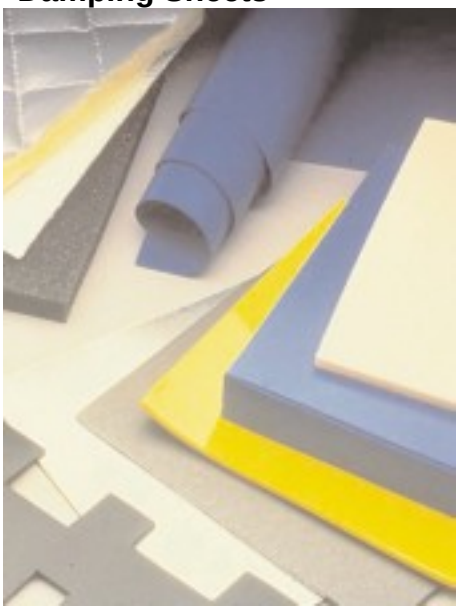
The arrows on this acoustic map depict the power and direction of sound being introduced by specific sections of the walls, floor and ceiling of the yacht's main lounge/dining area, portrayed here like an unfolded box. These and other measurements are used to customize treatments throughout the yacht.

WIDE RANGE OF PRODUCTS MEETS BOAT BUILDERS' UNIQUE NEEDS

E-A-R's extensive line of high performance materials provides economical, weight efficient noise and vibration control solutions for numerous marine applications.

ISODAMP™ HMD Damping Tiles
HMD damping material is specifically designed to damp energy on high thickness steel. Available in thicknesses from 0.25 inch to 0.75 inch, HMD tiles exhibit high mechanical strength and environmental resistance. Compatible with numerous adhesive systems, they are applied as labor saving extensional damping to thick, heavy substrates.

ISODAMP C-1002 Constrained Layer Damping Sheets



These are highly damped vinyl elastomers when incorporated into constrained layer damping systems, effectively control structural vibration of substrates such as steel, aluminum, plywood, foam core, and honeycomb composites, with significant weight savings over similar-performance extensional systems. They are soft and flexible, for ease of installation, yet they are strong and resistant to fluids, oils, ozone and flame. Available in a range of thicknesses, in sheets, rolls or custom die-cut configurations, these sheet damping materials are compatible with many adhesive systems that work with vinyl, including E-A-R pressure sensitive adhesive (PSA).

ISODAMP C-2003 Damping Materials
Also distinguished by their high strength, flexibility, and resistance to fluids and chemicals, these vinyl- based damping sheets are recommended for extensional damping of lighter-weight substrates such as those found on HVAC systems, doors and wall partitions. They are highly durable, withstanding impacts, rough handling and harsh environments. Available in three thicknesses, with standard PSA backing, they are easily cut and installed.

Weighted Barrier
When placed between the noise source and receiver, E-A-R's non-lead, flexible barriers provide one of the most effective ways to block airborne sound. WB weighted barrier feature a non-lead vinyl barrier to increase the sound transmission loss through structure.

TUFCOTE™ Faced Foams and Composites
TUFCOTE polyether urethane foams offer high performance acoustical absorption and exceptional durability. A tough 1-mil polyester facing provides resistance to dirt, grease and water build-up and improves low-frequency sound absorption properties. The foams can be supplied in sheets, rolls or custom die-cut parts, with or without PSA backing. Two- and three-layer TUFCOTE foam barrier/absorber composites combine damping materials or barriers with the foam, providing maximum noise transmission loss and sound absorption performance in a single, easy-to-install product. Facings and substrates are bonded to the foam chemically, rather than with adhesives or high heat. TUFCOTE products are widely used to line engine compartments and equipment enclosure