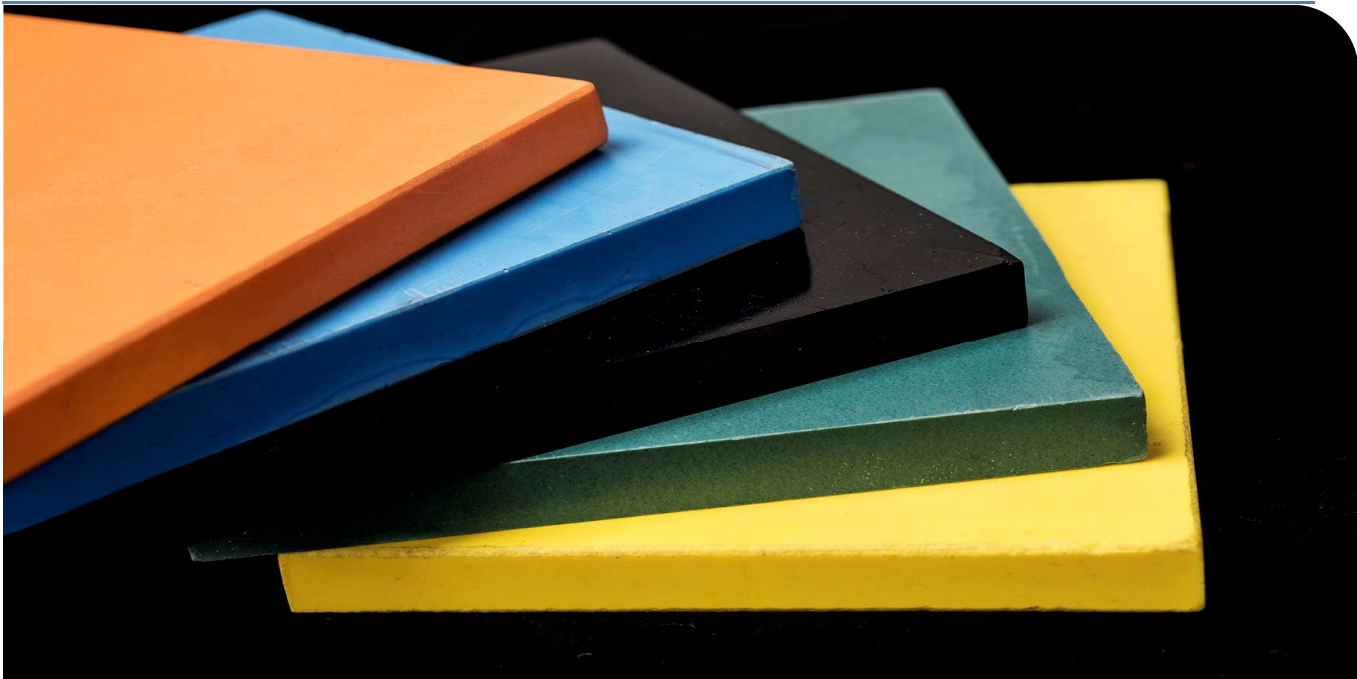


Uses of passive acoustic materials



Passive acoustic materials can be used for a wide variety of applications within an underwater acoustic or ultrasonic device. This document considers several use cases and highlights which material properties are relevant to each scenario.

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INTRODUCTION

When describing passive acoustic materials, numerous quantities may be evaluated. The scientific literature in this area contains a multitude of terms, many of which define similar (if not identical) physical attributes; this can lead to confusion. This document strictly follows the terminology used in [1], which is the first international document in this field to specify a consistent formalism. A number of these definitions are duplicated herein (see Definition of terms) for convenience.

It is important to note that some use cases may require a material to accomplish several tasks. In such cases, the compromise in performance between various relevant attributes is necessary.

DEFINITION OF TERMS

Absorption per unit length (α)

α is the component of attenuation coefficient (defined in IEV 801-23-35) that does not arise from scattering and is due only to absorption of acoustic energy within the sample. It can be expressed as a function of frequency such that

$$\alpha = \alpha_0 |f^y|$$

where α_0 is the absorption constant (dB/ (MHz^y m)), f is the frequency in MHz and y is the frequency exponent (in general not an integer)

Echo reduction (ER)

ER is the reduction in pressure amplitude of an ultrasonic plane wave resulting from its reflection from an interface between two media, given by

$$ER = -20 \log_{10} \left(\frac{p_r}{p_i} \right)$$

Where, p_r is the pressure amplitude of the reflected longitudinal wave, and p_i is the pressure amplitude of the incident longitudinal wave.

Insertion loss (IL)

IL is the reduction in pressure amplitude of an ultrasonic plane wave resulting from the insertion of a sample in the acoustic path, given by

$$IL = -20 \log_{10} \left(\frac{p_s}{p_{ns}} \right)$$

where, p_r is the amplitude of the received pressure wave with the sample in the path (with sample), and p_i is the amplitude of the received pressure wave without the sample in the path (no sample)

NB. Care should be taken as insertion loss is sometimes incorrectly labelled transmission loss. However, transmission loss is a more general term describing loss of signal between a source and a receiver. The IEV 801-23-39 defines transmission loss as "reduction in sound pressure level between two designated locations in a sound transmission system, one location often being at a reference distance from the source". As such it may include contributions from the directivity functions of both source and receiver as

well as acoustic spreading. These are functions of the experimental configuration and not the material under investigation.

Phase velocity (v_p)

v_p is velocity in the direction of propagation of a surface of constant phase and is commonly defined as

$$v_p(\omega) = \frac{\omega}{k}$$

where, ω is the angular frequency, and k is the wavenumber.

Acoustic impedance (Z)

Not defined within [1], but of relevance here is characteristic acoustic impedance which is determines that ratio of pressure to particle velocity within a material and is often expressed as

$$Z = \rho \cdot v_p$$

where, ρ is density.

NB. Reflection and transmission coefficients (and hence ER and IL) are intrinsically linked to the acoustic impedances of the materials on either side of an interface.

ANECHOIC

Purpose	An anechoic material's principal purpose is to reduce the amplitude of a wave reflected from its surface. For layers that are thin relative to acoustic wavelength, a reflection may occur from whatever is behind the anechoic. In this case it is also important to consider what happens to the acoustic signals as they pass through the material
Primary measurands	Echo reduction
Secondary considerations	Insertion loss, Absorption
Use case(s)	Measurement tank lining Reducing reflections from measurement tank fixtures Radiation force balance targets
Typical material(s)	> 1 MHz: F28, F36, F28P, HAM A < 1 MHz: F48, SF5048, Alberich tile

DECOUPLING

Purpose	A decoupling material's principal purpose is to prevent acoustic and/or ultrasonic signals from passing from one area to another. A highly reflective material provides decoupling but does nothing to reduce (potentially unwanted) acoustic reflections. An alternative approach is to ensure signals can pass into the decoupling material and are then strongly absorbed as they pass through it.
Primary measurands	Insertion loss
Secondary considerations	Absorption
Use case(s)	Vibration isolation Reduction of sonar self-noise Transducer backings
Typical material(s)	F48, F28, TBW650, F30, F40, R3

ENCAPSULANT

Purpose	Encapsulants protect sensitive piezo-electric and electronic components from the underwater environment in a manner that is acoustically transparent to waves passing through them. Encapsulants should also have a phase velocity that is matched to water to prevent lensing effects.
Primary measurands	Phase velocity, density, and acoustic impedance
Secondary considerations	Absorption coefficient
Use case(s)	Acoustic windows
Typical material(s)	F21, F7, F13, F3S

STRUCTURAL BOUYANCY

Purpose	In many underwater applications, neutral buoyancy is highly desirable. However other system components (often metallic ones) prevent this. Structurally buoyant materials are less dense than water yet are also rigid and can withstand hydrostatic pressure. This enables heavier components to be fabricated from much lighter materials in a manner consistent with neutral buoyancy
Primary measurands	Density
Secondary considerations	Hydrostatic crush depth, rigidity
Use case(s)	Sonar system housings Diver propulsion and imagery systems Carapace materials and housings on underwater remotely operated and autonomous platforms
Typical material(s)	F30, F40, F50, R3

Bibliography

- [1] IEC, *63081 Ultrasonics – Methods for the characterisation of the ultrasonic properties of materials.*, 2019.