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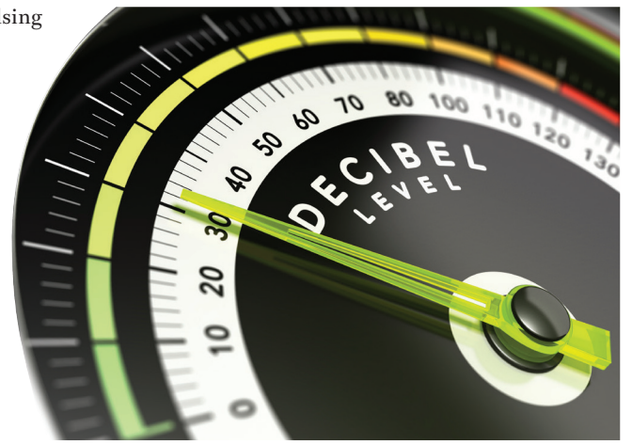
SOUND EFFECTS

Your health could be at risk on board.

by Sara Ventiera

Engines roar. Generators emit a loud, pulsing buzz. Sound and vibration are just part of life on a yacht. Between the engine room, radio earpieces, and the whir of vacuums, blenders, and other appliances, there's almost always some sort of noise humming in the vessel's background.

But those sound waves and vibrational frequencies can result in unintended health consequences. Research is dedicated to evaluating the effects of noise and reverberation, and those findings may offer some insights on the potential damages of living and working on a regularly swaying ship.



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SOUND

A recent Centers of Disease Control Morbidity and Mortality Weekly Report revealed that 40 million American adults have lost hearing due to noise, half of whom became impaired outside the workplace from day-to-day subjection to things like sirens, loud music, leaf blowers, and other thunderous sounds. The report concluded that 24.4 percent of people ages 20 to 69 were suffering some hearing deficits – even though most of the study participants claimed to have good or excellent hearing.

About a quarter of those surveyed were found to have "audiometric notches" – degradation in the softest sounds that humans can hear – in one or both ears. That suggested a high prevalence of noise-induced hearing loss, even higher among the males sampled. Of those who reported exposure to loud sounds at work, nearly one-third had a notch.

At 85 decibels (db), extended exposure can lead to hearing loss. That includes common appliances like vacuum cleaners (60 to 85 db), hair dryers (60 to 95 db), garbage disposals (75 to 90 db), food processors (80 to 90 db), or electric drills (95 db). Just 14 minutes of exposure to sounds at 100 db (think lawn mower, outboard motor, generator, or a sporting event) can cause damage. At 110 decibels (rock concert, nearby car horn, riveting machine), it takes just two minutes to cause harm. At 120 decibels (siren, chainsaw), it takes just one minute.

Even low-level sounds – a blender or vacuum – that radiate at one constant pitch can destroy the cells in the inner ear that listen to or vibrate at that particular sound, says Dr. Danny Riley with the Department of Cell Biology, Neurobiology & Anatomy and Physical Medicine & Rehabilitation at Medical College of Wisconsin. That's why places like Starbucks and Jamba Juice surround blenders with plexiglass enclosures, he says. "They shut the door and turn on [the] blender, [so] you don't hear high-frequency sound that will damage your ears." A cheaper, easier alternative, he says, is to wear ear protection when using those types of appliances. In engine rooms, experts recommend doubling up on protection with both earplugs and earmuffs.

Losing hearing is bad enough, but the effects of noise go well beyond auditory impairment. Sound pollution has been proven to negatively affect the immune, cardiovascular, endocrine, and nervous systems. A 2014 paper published in *Environmental Health Perspectives* found that exposure to traffic noise may account for around three percent of coronary heart disease deaths in Europe every year. That's because sound elevates stress hormones, including cortisol, adrenaline, and noradrenaline. Over time, those hormones can lead to high blood pressure, stroke, and heart failure. While many people get used to sound, "The biological effects are imperceptible, so that even as you become accustomed to the noise, adverse physiological changes are nevertheless taking place, with potentially serious consequences to human health," wrote Deepak Prasher, University College London professor of audiology. Night noise – like a loud running engine or generator – is even worse. It has been proven to disturb sleep and impair cognitive performance leading to diminished productivity and impaired learning.

VIBRATION

Sound is generally a result of vibration. And vibration has its own set of health effects. There are two main types of vibration that medical researchers have thoroughly examined: Whole Body Vibration (WBV) and Hand-Arm Vibration (HAV).

Whole Body Vibration is most applicable to yachts. It's usually caused by poorly designed or maintained vehicles, platforms, or machinery, and is known to cause or compound motion sickness, bone damage, varicose veins, heart conditions, stomach and digestive ailments, respiratory, endocrine and metabolic disruptions, impairment of vision and/or balance, reproductive organ damage and lower back pain, including injury to vertebrae, discs, and ligaments. The longer a worker is exposed to WBV, the higher the risk of

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Our ears vibrate similarly to the original vibrational source, which allows us to hear numerous different sounds.



health consequences and muscular disorders.

When it comes down to it, "There is not much knowledge on whole-body vibrations on board ships and their health effects," says Dr. Anker Jensen, Department of Occupational Medicine, Hospital of South Western Jutland in Denmark. "Usually, the horizontal movements (X and Y axis) are regarded as more important due to the resulting muscular stabilization of the spine, resulting in muscular strain and vertical muscular pressure." Jensen was asked to present on WBV at a congress on Maritime Medicine in Denmark, as he's worked on WBV in connection to other exposures (as with tracked vehicles). He searched the web for information on the subject and was unable to locate concrete research.

Based on Jensen's findings in other occupational fields, he thinks that the engine and propeller vibration paired with movement of the water and ship could lead to muscle strain and increased force on the spine as well as, depending on the intensity of the vibration, abdominal discomfort, chest pain, and visual disturbances.

Hand-Arm Vibration (HAV) results in localized effects, most often when the vibration enters the body directly through the hands. Generally, HAV is caused by long-term exposure from using handheld tools, producing a range of conditions and injuries, such as sensory nerve damage, muscle and joint damage in the hands and arms (like tennis elbow), and white finger or "dead finger" damage to the hands, resulting in loss of color and pain in the fingers.

Jensen cited a hospital registry study in his paper that "Demonstrated a significantly elevated relative risk for carpal tunnel syndrome for fishermen and for non-officers at sea." The report claimed that exposure to HAV could lead to neuropathic conditions, including carpal tunnel syndrome, osteoarthritis, and muscle weakness. But, he notes, "This finding could also be explained by exposures other than vibrations, such as heavy pulling and lifting." Like WBV, real data on HAV in maritime crew is scarce.

Although the condition's name would lead you to believe HAV is reserved for upper body extremities, HAV can also develop on toes and feet as a result of standing on vibrating surfaces. The latter could be a concern for engineers who spend long periods in the engine room while machinery is running. White feet, loss of color, and pain in the feet has been reported in the mining industry, but specific cases have not been reported on ships.

Injury to the body from exposure to vibration depends on exposure time, surface or tools frequency, and vibration size. Effects are more likely to occur faster in cold, wet conditions – fishing is the perfect storm for HAV. According to Riley, symptoms start with some tingling and numbness in the hands similar to that feeling you get after using a weed whacker or chainsaw. "For the occasional user, that will go away after a half hour or so," he says. "Take an individual who has a lawn service using a similar tool, and does [this] every day as a job; by the end of the summer, they can end up with a condition that starts to become progressive."

When that feeling persists, say, through the weekend, get examined by a medical expert. For impact tools, like polishers and sanders, Riley said that antivibration gloves can help mitigate the transfer of energy. Percussive tools, however, like nail guns, jackhammers, or rivet guns produce a shock wave that vibrates at the upper end of human hearing range, a loud *bang, bang, bang*. Those high-frequency shock waves travel into the body faster, which can result in rapid HAV onset. In his research, Riley has seen injury to sensory nerve fibers in as little as 12 minutes' use of percussive tools.

To lessen the impact, Riley suggests holding any tools with a loose grip and let the tools do the work. "The tighter you hold onto a vibration source, the more transfer of energy from that source into the body," he says.

MITIGATING EFFECTS

Although wearing earplugs and being careful with tools can help crew avoid hearing loss injury, there's not much that can be done about vibration and sound coming through the vessel; however, shipbuilders and industry professionals do their best to minimize both during the design process.

In the engine room, mechanical components are soft mounted to prevent vibration transfer to the hull. In the accommodation space, floating floors are used to isolate reverberation and noise. Sound-dampening materials and insulation are used on bulkheads.

At this point, shipbuilders have it down to a science. Christensen Yachts, for example, targets a sound level of 60 db in the VIP cabin when the engines are running, which are generally set just in front of the engine rooms. In the salon and dining room (situated above the engine room), the goal is 55 to 60 db when engines are running. The farther away from the engine room, the lower the noise. In the owner's cabin, typically on the main forward, the company prefers a 50-decibel rating. "We indicate in our contract specifications decibel levels we try to maintain as target level," says Christensen interior architect Kc Harrison. "We make that clear up front in variations throughout the boat. I don't ever recall someone saying, 'That's too loud; we need it to be quieter than that.' I think libraries are at like forty-five."

EXISTING SOURCES

Rich Merhige, president of Advanced Mechanical Solutions, works to increase comfort on board. A significant portion of business comes from vessels aiming to troubleshoot annoying sounds or vibrations. "Captains will feel something isn't right, feel a vibration they hadn't felt before," says Merhige. "Nobody wants a noisy, vibrating boat."

There's a range of mechanical issues that contribute to higher sound and stronger vibration, but exhaust issues are a common theme for Merhige. It's a challenge to isolate the noise and vibration on those systems. "For comfort, humans prefer one millimeter a second or less of vibration," he says. "A bad exhaust can get from three to five millimeters per second. It's almost like an earthquake. It's like, 'run!', a survival instinct kicks in." Because it's so difficult to determine a vibration source, Merhige's team uses special instrumentation to troubleshoot. He often gets calls about mechanical items that have been overlooked in surveys. Common items that develop issues are the torsional vibration coupling between the engine and vibration gear and aged engine mounts.

Those soft-mounted systems that Christensen uses to reduce noise started coming onto the market in the past couple decades. Those isolation systems are often overlooked in maintenance. "It falls into a gray area," says Merhige.

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Noisy navy sonar has unintended consequences – the disorienting sound drives beaked whales to beach themselves, and it makes humpbacks extend the length of their songs by 29 percent.

"It's not included in engine maintenance or gear box maintenance." The lifespan on those products is about 10 to 15 years. When they reach that limit, the rubber starts to deteriorate, so it doesn't isolate vibration the way it's supposed to. That movement throws off the alignment. "You get a double whammy," says Merhige. Moral of the story: start checking the mounts around the 10-year service mark.

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ON THE HORIZON

Years ago, Christensen used rock wall to insulate sound. It's effective, but heavy. "One of the ways to knock noise down is through mass," says Harrison. Then Harrison discovered that Thinsulate, the synthetic insulating fiber used in outdoor gear, was just as good for interior acoustics at just a fraction of the weight.

While noise and vibration must be addressed at the source, Clear Group International, the only yacht interior design company accredited by International Wellness Institute, takes comfort a step further, using a scientific approach to individual health and wellbeing in a given space. One of the sustainability-driven company's tenets is to mitigate noise so individuals feel better aboard the vessel. CEO Joyce Clear looks to land-based technology to do so, and has been using cellulose-based acoustical and thermal panels made from lightweight, renewable, and recycled fibers like Silk Metal and Bonded Acoustical Cotton. They can be built into furniture, walls, between walls, or wrapped around engine rooms. These panels fall under the category of passive noise control, which use different materials to absorb or dampen sound.

Mufflers are another example of passive noise control. Clear says she recently saw "really cool new muffler technology at FLIBS" that are more effective at reducing sound than previous versions.

Since ventilation passes are a big source of sound transfer, Clear advises her clients to route ducts in a convoluted path to lessen noise. "You want bends, [which] will stop the sound," says Clear. "It's like a wind tunnel – with curves and bends, it's less windy."

Active noise control systems, which reduce sound by introducing a second sound wave to counteract the original wave, are also becoming increasingly advanced, says Clear. Used on things like air purifiers as well as heating, ventilation, and air-conditioning systems, these active noise control machines essentially work like large-scale noise-canceling headphones.

According to Clear, noise- and vibration-reducing technology can be the key to a healthier, happier, and safer vessel for owners and crew. "If you've been able to achieve the quietest boat," she says, "you reduce the crews' stress level significantly, increase productivity, and achieve greater mental performance, which means better concentration and safety."

