Underwater Listening: The Acoustic Contribution of the Pool

Listening to music underwater is a unique experience that has already won over many enthusiasts. It's an extraordinary listening experience, firstly from a perceptual point of view, because the ear's mechanisms are not stimulated in the same way as when listening above water, but also from the point of view of sound propagation and therefore acoustics. A pool can behave very strangely in the presence of sound waves, and this is, in fact, the main factor that degrades sound quality. It is therefore essential to choose your pool carefully if you want to fully appreciate the benefits of underwater music. The acoustics of a body of water are determined by two essential factors: absorption and vibration. The perception of a sound source located in a fluid (water or air) is the result of the sound that reaches our ears directly, also called "direct sound," and the sound reflected by the surrounding surfaces, called "reverberated sound." The main difference between aquatic and aerial environments lies in the reverberated sound. Water has a density of 1000 kg/m^3, which is of the same order of magnitude as that of solids (concrete: 2400 kg/m^3, tiles: 2500 kg/m^3, PVC: 1350 kg/m^3, soil: 1200 kg/m^3). Energy exchange is therefore facilitated, and reverberated sound is considerably reduced. Underwater, a sound wave striking a PVC surface is absorbed by 75%. Furthermore, if we consider that waves propagate five times faster in water than in air (1500 meters per second instead of 340), the effect is instantaneous: for a 6-meter by 12-meter swimming pool, a wave has hit an average of 7 walls in 10 milliseconds and its energy is divided by 80,000, representing a loss of 118 decibels! To compare with air, a room with a volume of 90 m^3 loses approximately 60 decibels per second.
A swimming pool can therefore be considered an anechoic chamber, that is, a place without any reverberation, as it becomes imperceptible to the ear. Underwater listening is all the more interesting because the listener moves within a constant direct field of sound. They thus lose all sense of space and experience a proximity to the music that exists nowhere else.

But where does this energy diffused through the underwater speakers go? This is where the problems arise. While water and solids have similar densities that allow them to "communicate" easily, they have very little exchange with air, which is much lighter (1.2 kg/m^3). Take the example of above-ground PVC pools and some molded pools which, although buried, are not in direct contact with the ground. The air surrounding the pool prevents any exchange with the outside, and the energy is therefore trapped within the pool. Only one-thousandth of the sound wave manages to

pass through the air. The pool then begins to vibrate. This induces resonances corresponding to frequency ranges that, unfortunately, lie in the middle of the audible spectrum. The sound deteriorates because its spectral balance is completely altered. An experiment conducted in March 2008 in a Paris municipal swimming pool with 40 sound engineers and musicians revealed the presence of two frequency peaks at 100 and 600 Hz, which gave the sound a "midrange" character specific to this pool. This was due to the fact that the pump room was located directly below the pool. Not being directly on the ground, it vibrated. On the other hand, in an in-ground pool with a concrete lining or a structure anchored to the ground, the energy can propagate freely and travel for kilometers, leaving the listener with perfect sound quality. The pool's "acoustic footprint" can then be considered neutral, and the spectral balance in the water is optimal. Furthermore, taking into account the inherent incompatibility between water and air, no sound can penetrate the water's surface. The pool thus behaves as a completely isolated environment. The listener can therefore immerse themselves in a world that someone sitting on the edge wouldn't even suspect.

Therefore, it is the pool that must adapt to the sound systems, not the other way around, since these systems have already proven their worth in many situations, demonstrating that high-quality underwater sound is not a pipe dream. A concrete shell in which the pool is molded greatly minimizes vibrations. Manufacturers will thus need to be able to offer solutions, or risk seeing those most interested in the Musical Massage treatment opt for models specifically designed for underwater listening.