LOUDSPEAKERS *CAN* BE TESTED

AN EVALUATION OF THE OBJECTIVE AND SUBJECTIVE APPROACHES TO LOUDSPEAKER TESTING

By ROY ALLISON

As any close observer of the audio scene is by now aware, mysticism and illogic are not restricted solely to the followers of the eastern philosophies. An impartial observer would have to conclude that there is an unusually large proportion of people among manufacturers, equipment reviewers, and audiophiles who, while rational in other respects, tend to become quite irrational when they discuss loudspeaker systems.

Explanations for this failure of good sense are not hard to come by. Acoustics is still a relatively young science, one that, until very recently, was thought to be of little practical utility in comparison with other scientific disciplines. Universities are not set up to turn out acoustical engineers in the same way that they are organized to produce mechanical, civil, and electronics engineers, and only a few have the facilities for graduate research programs in acoustics. As a result, there are only a small number of engineering and research personnel available with any academic background in acoustics. Those who are available are most often occupied in fields not connected with high fidelity at all—noise control, underwater sound, architectural acoustics, and the like.

A "general-purpose" electronics engineer doesn't have much difficulty adapting himself to designing component amplifiers, tuners, and receivers, and though there may be some disagreement concerning what the design goals for such components should be, arguments generally center on matters of degree rather than substance. Once the amplifier designer is given a set of design goals, however, he has no doubts about his ability to make meaningful, objective tests that will tell him whether he has in fact reached these goals. The people who review and comment on the results of his work have confidence in their ability to make similar objective tests, and they have confidence also that the results of these tests are valid indicators of how well the amplifier will do in reproducing music accurately. Usually their confidence is well founded. In short, there is no basic disagreement on how to judge the performance of an amplifier.

It is quite a different matter for an engineer trained in another area to undertake the design (or evaluation) of loudspeaker systems. A considerable amount of self-education is required. All the necessary information is available in print, but it isn't always easy to choose between information and misinformation; further, once this choice has been made, it is often tedious to absorb the data and to understand their implications. Add to these problems the facts that: (1) loudspeaker tests *are* more complicated to make and interpret than tests on other high-fidelity components; (2) the test equipment and facilities required *are* more expensive and take up more space; and (3) loudspeaker systems in general *are* further away from perfection than other components. Given all the above facts, the strong tendency to treat loudspeaker design and evaluation as an art rather than a science becomes understandable. And it is also possible to understand why there are so many "authorities" who insist that there can be no standard for judgment of loudspeaker performance other than individual taste.

But if most loudspeakers fail to meet a high standard of performance, that is no reason to deny the *existence* of any standard, nor is the difficulty of evaluating a system's quality by objective test procedures a legitimate reason to deny the *validity* of objective testing. Let's return for a moment to first principles: what is a speaker system supposed to do? Is its purpose to be a "flat" reproducer, part of a chain of components that is intended to recreate faithfully sounds that were sensed by microphones at the beginning of the chain? Or should loudspeakers be designed to sound "pleasant," or "dramatic," or "brilliant"—that is, to superimpose various tone colorations of their own on all the music that is fed to them?

If you say "yes" to the last question, then logically the design of loudspeakers *must* be mostly art. The speaker designer would put himself in competition with musical-instrument makers, and the selection of a "good" loudspeaker would become entirely a matter of taste. "High fidelity" then becomes a phrase without relevance to this kind of system since the aim is not fidelity to the original, but an appeal to individual taste.

Well, what's wrong with catering to variations in taste in sound timbre? In the short run, nothing at all. But remember that the design of musical instruments has been refined through centuries to make them sound as they do. It is for good aesthetic reasons that the relatively minor acoustical differences between a violin costing $50 and one costing $50,000 are considered so important. Composers write music for the predictable sound of live instruments. If loudspeakers are *not* made to reproduce these sounds as accurately as possible, their users are sacrificing the benefits of hundreds of years of dedicated musical craftsmanship. As listeners' tastes are seasoned by musical experience they find that a consistently mellow sound becomes boring, artificially bright sound becomes irritating, and that only a close facsimile of the original musical sound gives long-term pleasure.

It has been pointed out that the sound of live music is not the same from one concert hall to another, or even from seat to seat in the same hall. Isn't this clear justification for making different-sounding speakers for the man who customarily sits in the front row and the man who prefers the second balcony? There are two major flaws in this approach. First, it is based on an incorrect premise—namely, that the difference between front-row and second-balcony sound at a live concert is mostly a matter of the relative amplitudes of the various frequency ranges. Such differences do exist, but they are much less significant in terms of aural impression than other differences: the ratio of direct to reverberant sound energy, the time delay between direct sound and first echo, and so on. No amount of juggling with frequency response can change these acoustic relationships on a recording. They are determined by the recording microphone locations.

A second flaw in the question is the assumption that a loudspeaker's frequency-response peaks or valleys are likely to provide suitable "correction" for the live-sound frequency-balance differences at various places in the concert hall. But such differences occur gradually, not abruptly. To whatever extent a listener feels the need for making such corrections, he can do it far more naturally with his amplifier's tone controls. Tone-control corrections have the advantages of being predictable, infinitely variable, of providing gradual rather than abrupt response changes, and—perhaps most important—they permit instant restoration of flat response.

It is a fact that the acoustical properties of a listening room have a major influence on the sounds produced within it. It is also true that the location of the sound source in the room has a substantial effect on just how the room will modify the sound source's output. (For a full discussion of these matters, see "Controlling Listening Room Acoustics," HiFi/Stereo Review, February 1964—a free reprint of the article is available from Acoustic Research, Inc., 24 Thorndike St., Cambridge, Massachusetts 02141.) These room influences affect *all* sound sources—all kinds of speaker systems, and even live sounds generated in the room. Is it logical to assume, therefore, that one ought to try to find speakers that will compensate for listening-room deficiencies, and thereby "match the speaker to the room"?

The answer depends on the kind of room problem we're talking about. If the difficulty lies in the presence of one or more sharp room resonances—the kind that occur at bass and lower-middle frequencies—the answer is an unqualified "no." It would be hopelessly optimistic to expect to find speaker systems with dips in response at frequencies that coincide with your room peaks, and peaks that coincide with your room dips. You have a far better chance of minimizing this kind of room problem if you start with speaker systems having a neutral personality (no sharp response aberrations), and tame the room peaks by judicious speaker placement and/or modification of the room's acoustical character.

If the room is simply too bright or too dead, if it tends to emphasize or depress a broad range of frequencies, your best choice is still a speaker system with smooth and uniform output. Very good compensation for the room's deficiencies can then be gained by suitable adjustment of the speaker system's mid-range and tweeter-level controls, by the amplifier's tone controls, or a combination of both.

How does one go about finding a speaker with a smooth and uniform output, a "neutral personality"? Are there objective instrument tests which, properly interpreted, can be used to predict the performance of a speaker system when reproducing speech or music? Yes, there are—if one makes the right kinds of tests. If there are inconsistencies between the test results and listening results, one cannot logically conclude that speaker measurements are therefore of no value. The wrong factors must have been tested—or the right factors tested wrongly.

ONCE we have agreed that a speaker system's job is to reproduce faithfully what is put into it, most of the apparent mystery in selecting appropriate test procedures disappears. If the goal is to produce an acoustic output that is precisely proportional in all respects to an electrical input, we have only to consider all the ways in which the output *could* differ from the input, and then devise valid ways to measure such differences. Through careful live-*vs.*-recorded listening tests we can discover empirically which differences are audible and which are not, and under what circumstances a certain amount of difference is audible. Then we have valid and reliable tests that are sensitive enough to measure every kind of significant difference, and we can use these tests to evaluate the performance of loudspeaker systems objectively.

Note that the key to the entire process is the validation of instrument tests by listening tests. I cannot emphasize too strongly, however, that these *must* be on-the-spot, instantaneous, direct comparisons of live sound *vs.* the reproduced sound. Trying to relate a fading memory of live music in one acoustic environment to reproduced

"*. . . Good Lord, man, have you no conscience?*"

music in another is futile. Of course, gross departures from accurate reproduction can be detected without a direct comparison. But nobody—no matter how golden eared—can, simply by comparing the sound of two speakers, determine which is only "very good" and which is close enough to the original to fool the ear completely. To make a valid judgment, the original reference sound must be available for A-B comparison.

In order to make such a distinction with any assurance of being right, one must abandon the quick-and-easy "golden-ear" or "trained-listener" concept and resort to scientific method. There are two ways to go about this, both legitimate if carried out properly. The first is the live-*vs.*-recorded comparison technique. This method cuts directly to the heart of the matter—how accurately the speaker system can reproduce the original sound—because the original is there at hand for instant aural comparison. Acoustic Research has produced dozens of public concerts in recent years at which live music was played in alternation with a special recording of the same music made previously. But this technique, when used as a tool for speaker testing, doesn't require live musicians. All it requires is a readily available, repeatable "reference" source of sound with wide dynamic and frequency range, and a good recording of the reference sound for playing through the speaker to be tested. Since the reference sound need only be repeatable on demand—not conform to any quality standard—it can even be tape-recorded music played through another speaker!

The recording of the reference source must be carefully made, of course. It must be an accurate representation of the total sound power output *vs.* frequency; and, in order to avoid doubled room reverberation in the speaker under test, the recording must be made anechoically. Rigorous descriptions of live-*vs.*-recorded test techniques have been published in technical journals. As far as I know, however, only one manufacturer (AR, Inc.) and one test organization (Consumers Union) are using this very powerful and simple evaluative system.

The second method of distinguishing between the "very good" and the "near perfect" speaker is to devote the requisite time and effort to making valid objective measurements. This approach yields quantitative data; the live-*vs.*-recorded test does not. If one expects to extract trustworthy information from objective test data, however, the test techniques must be good to start with. For example: frequency-response curves can provide very useful information. But response curves made on a speaker system in a living room are not useful, because, at most frequencies, room reflections and resonances completely swamp the speaker's response to sine-wave test-signal inputs. Moving the microphone even a short distance significantly changes the combined speaker/room response curve. Even when many microphones are used, it is impossible to know with certainty what is a room peak and what is a speaker characteristic.

To get useful response data, the speaker must be measured under anechoic conditions—in a large room with completely sound-absorbent walls, or out of doors in a large open area. To get an accurate picture of the dispersion at high frequencies and the total sound power output *vs.* frequency, the speaker's response must be measured at all angles, not just directly in front. The same procedure must also be used to check that the speaker does not have a suddenly uneven frequency response at a particular angle.

Distortion *vs.* frequency at various power-input levels, transient response *vs.* frequency, and electro-acoustic efficiency can all be measured reliably. All have a bearing on audible performance. A skilled engineer can put these test results together and come up with an accurate assessment of how well the speaker will do as a reproducer of music—as well as what its weaknesses will be. These objective tests accomplish precisely what the corresponding tests on an amplifier are designed to do: compare the input with the output, and assess the differences between them. In the case of the live-*vs.*-recorded technique, this comparison is made instantaneously, by the ear, on a qualitative basis; in the case of objective measurements, the comparison is made by test instruments on a quantitative basis. The two methods can be used separately or combined, one method checking the conclusions of the other. When they do not agree, it is most often because a *true* measurement of the speaker's "ouput" has not been made.

***Roy Allison**, a regular contributor, is responsible for product development and manufacturing at Acoustic Research, Inc., and is author of the book* High Fidelity Systems: A User's Guide.