Standards for Speakers

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IN JUNE 1979 I presented a paper to the International Association of Sound Archives' Annual Conference in Salzburg, Austria.[1] The subject was the establishment of standards for re-recording processes. This topic was again presented in May 1980 in Ottawa, Canada, to the Annual Conference of the Association for Recorded Sound Collections. The response to these presentations made it clear that concepts fundamental to sound reproduction fidelity were of interest to members. But equally clear was the fact that the technical orientation of the members was extremely diverse.

Many persons charged with the care of record collections have as primary interests the musical content, or discography. Others concentrate on re-recording processes and sound-reproducing systems. In either case, listening to recordings requires the use of a playback system. A proper sound system therefore becomes a critical consideration for all audio archivists, regardless of their personal interest in technology.

This presents us with the problem that we now have technically- and nontechnically-oriented people all trying to decide what to use for a reproducing system in an archive. It would seem in the best interest of all parties concerned to open a dialogue regarding sound reproduction fidelity.

A discussion of all the factors influencing sound fidelity would be impractical in this presentation. Therefore, this paper is limited to one of the most controversial areas of concern: speaker selection. Hardware,

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such as amplifiers, preamplifiers, cartridges, turntables, etc., will be assumed a constant and excluded from the scope of this paper.

Guidelines for Speaker Choice

The first goal of any archivist is preservation—i.e., to keep intact the original item. A curator who would paint a red hat on the *Mona Lisa* or cut off part of the painting to suit his own tastes would surely be considered criminal. Similar defacements nonetheless occur daily in the field of audio preservation, due to a lack of standards for the reproduction of the sound. Speaker systems are a main contributor to this problem. There is no agreed-upon standard for speakers in an archive; consequently, "red hats" are painted on the sound, and some parts are cut off and distorted, in a large part due to the idiosyncracies of the speaker. If archives are to avoid this distortion of the truth, an examination of the way speakers should be selected for an audio archive seems to be in order.

The speaker is still considered the weakest link in the reproducing chain, and consequently competition in solving this problem thrives, each manufacturer making claims of superiority. A visit to any audio showroom quickly reveals the complexity of the problem. The consumer is confronted with rooms filled with different speakers. Narrowing the choice can be as frustrating for the audiophile as it is for the novice.

The consumer can—and usually does—make his decision on a subjective basis. Personal preference is the guide. After all, saving sound for posterity is not the normal concern. With so many speakers to choose from, he may like the sound of one speaker for some musical selections and yet prefer a different speaker for other music. It is not unusual to see buyers going from room to room and store to store, trying to decide what speaker to purchase. Nor is it unusual to see the same person repeat this pattern year after year for as long as money and enthusiasm hold out. This subjective approach, however, should not be used by the audio archivist.

The archivist should be objective. Personal taste in a speaker should not take precedence over the ability of the speaker to produce the full spectrum of sound on a recording in an unbiased fashion. Speaker selection for an archive should be governed by the fundamental rule that the sound emanating from the speaker (acoustic output of speaker) is equivalent to the signal fed into the speaker (electrical input to speaker), or simply, acoustic output equals electrical input.

Very few speakers approach that ideal, so the choices are actually very narrow in comparison to the variety of speakers manufactured.

Some objective criteria can be used to make this judgment. As suggested in an earlier paper advocating the establishment of re-recording standards,[2] a speaker's ability to meet these criteria should be decided by consensus of the International Association of Sound Archives (IASA) and Association for Recorded Sound Collections (ARSC) technical committees. Since that consensus process is not yet a reality, the following guidelines can help narrow the possibilities. Five variables will be discussed:

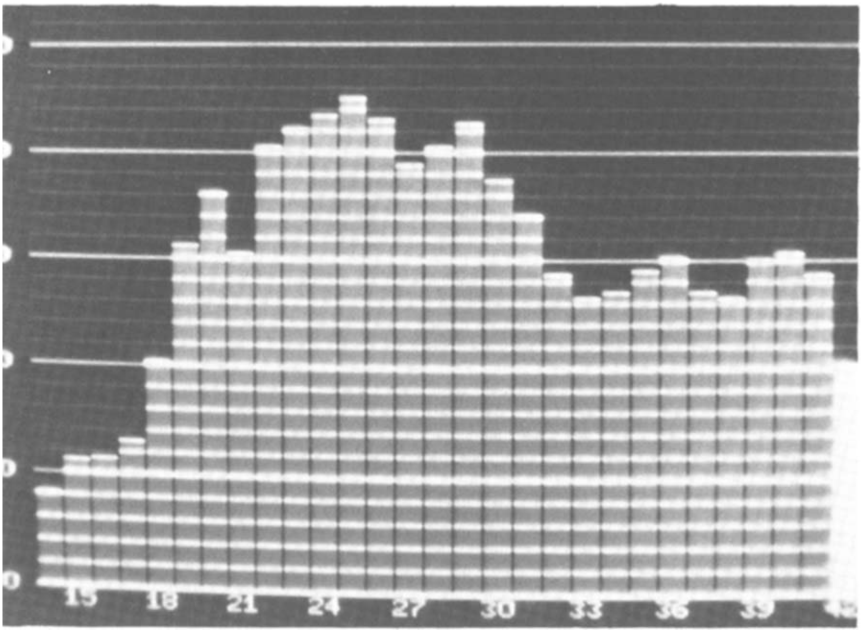
1. frequency response,
2. flat response,
3. intermodulation distortion,
4. arrival time, and
5. placement.

Frequency Response

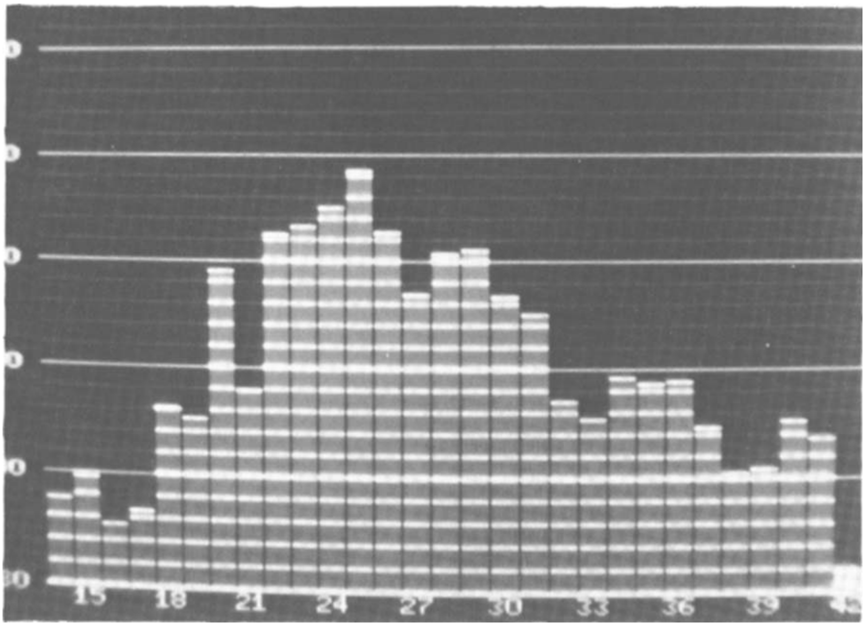
Frequency response is the most commonly used measurement appearing in audio literature to describe the performance of audio equipment. Such is the case for speakers. An audio archivist should use this descriptive measurement as one of the primary guides in speaker selection. But first an understanding of frequency response measurements is in order.

For the average consumer, an explanation of frequency response by an engineer or salesman can often be more confusing than helpful, causing the person to believe that the topic is unapproachable without a degree in electrical engineering. Fortunately, this is not true. Consider the instruments in an orchestra for a moment, categorizing the instruments that produce the lowest notes (low range), highest notes (high range), and the notes in between (middle or midrange). Typical response might be the bass drum and tuba for the low range, piccolo and triangle for high range, and trumpet and clarinet for midrange. Repeating this process with a chorus, the classification of bass, tenor, alto, and soprano are obvious.

Assuming this exercise was no problem, then you already understand the reproduction of the audio spectrum in terms of lows, middles and highs. Frequency response measurement is nothing more than a mathematical expression of sound waves on a scale ordered from the lowest audible frequency to the highest. The bass drum fundamental (lowest tone) frequency would be approximately 50 cycles per second, or 50 hertz (named in honor of German physicist Heinrich R. Hertz); the tuba, 40 hertz; the piccolo, 450 hertz; the triangle, 500 hertz; the trumpet, 180 hertz; and the clarinet, 150 hertz. Approximate values for voices are:



Recorded Signal—Electrical Input



Speaker Reproduction—Acoustic Output

Fig. 1. Example of poor speaker reproduction of recorded signal

bass, 98 hertz; tenor, 130 hertz; alto, 195 hertz; and soprano, 250 hertz. In addition to the fundamental frequency, each of these instruments produces a range of higher frequencies.

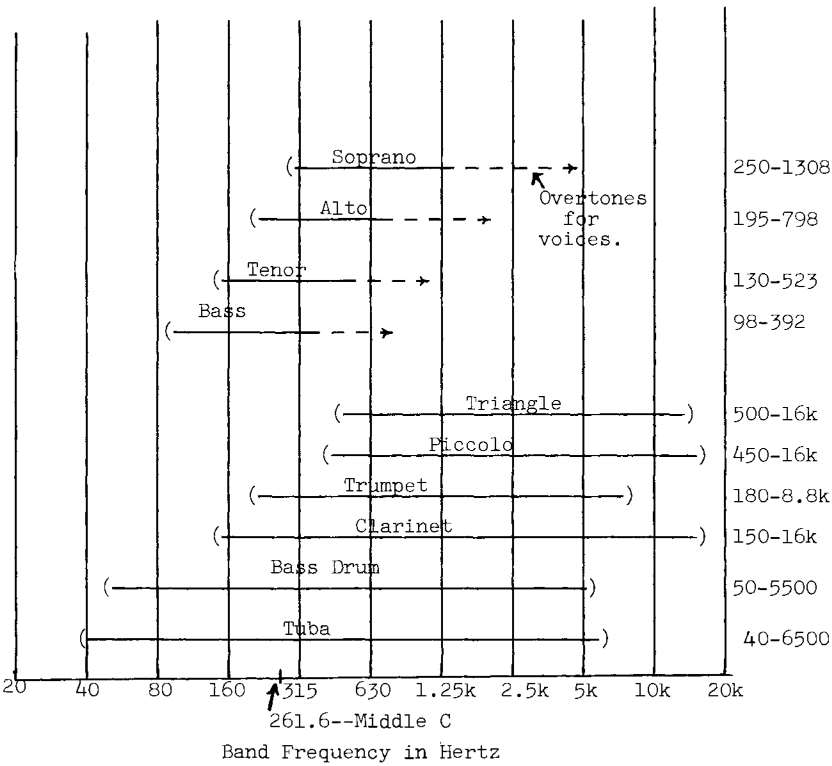


Fig. 2. Frequency ranges of instruments and voices (data obtained from Tremaine, *Howard M. Audio Cyclopedia,* 1st ed. Indianapolis: H.W. Sams, 1959, pp. 7, 14.)

The general audible range for humans is 20-20,000 hertz. It is this range of frequencies that influences our perception of sound. A speaker designed for accurate reproduction of the sound spectrum should be capable of reproducing all of these frequencies. It is logical to assume that if the specifications for a speaker included a 20-20,000 hertz response, then it is a good speaker. True, that range is a good starting point, but the frequency response must also be carefully examined with respect to its linearity.

Flat Response

In figure 3, frequency is compared to the loudness (or amplitude) of sound. Sound level is measured in units called decibels (db). If tones of 20, 100, 500, 1000, 10,000 and 20,000 hertz were turned up to the same volume level of 70db, they would be plotted on the same horizontal axis on the scale. Likewise, if the remaining frequencies from 20 to 20,000 hertz were also plotted at 70db, the infinite series of dots would eventually form one straight horizontal line. This straight line would represent what is referred to as "flat" response.

Flat response in a speaker means that if all frequencies were fed into the speaker at the same amplitude, the speaker would reproduce them at equal amplitudes. If 1000 hertz measures 70db, then all others should measure 70db. On the other hand, if 1000 hertz measured 70db, 100 hertz 55db, and 5000 hertz 80db, then the levels of the original sound are obviously not being reproduced equally at all frequencies.

If 70db is assumed the reference level, the 55db level at 50 hertz would make the fundamental in a bass drum all but disappear, while the 80db level at 5000 hertz would make a piccolo sound inordinately shrill. Such speaker deviations from flat response would seriously alter the listener's perception of the original sound. An archivist or other listener would therefore have a false impression of the sound on the recording. Specifications for speakers should include the ±db variance from flat response. Frequency range alone is not sufficient. If the ± deviation is not included in the specification, be wary. For example, a speaker advertisement could state a frequency response of 30-15,000 hertz. That seems good. But if the measured response deviates by a figure like ±15db, the speaker would be extremely poor. If the ± variation is listed and two speakers claim the same range, but speaker A is ±2db from flat response and speaker B is ±6db, then A would be the better choice, other things being equal. The first two criteria for speaker selection are, in short, a sufficient frequency range and flat response of that range.

Intermodulation Distortion

Range and linearity are important, but of little consequence if the reproduction is distorted. Speakers generally have the highest percentage of distortion of the components in a high-quality sound system. Unlike amplifier advertisements which proudly display distortion characteristics in hundredths of a percent or better, speaker ads rarely even include distortion figures.

Some speaker specifications will include percentage of distortion for single frequencies, but most recordings reproduce many frequencies

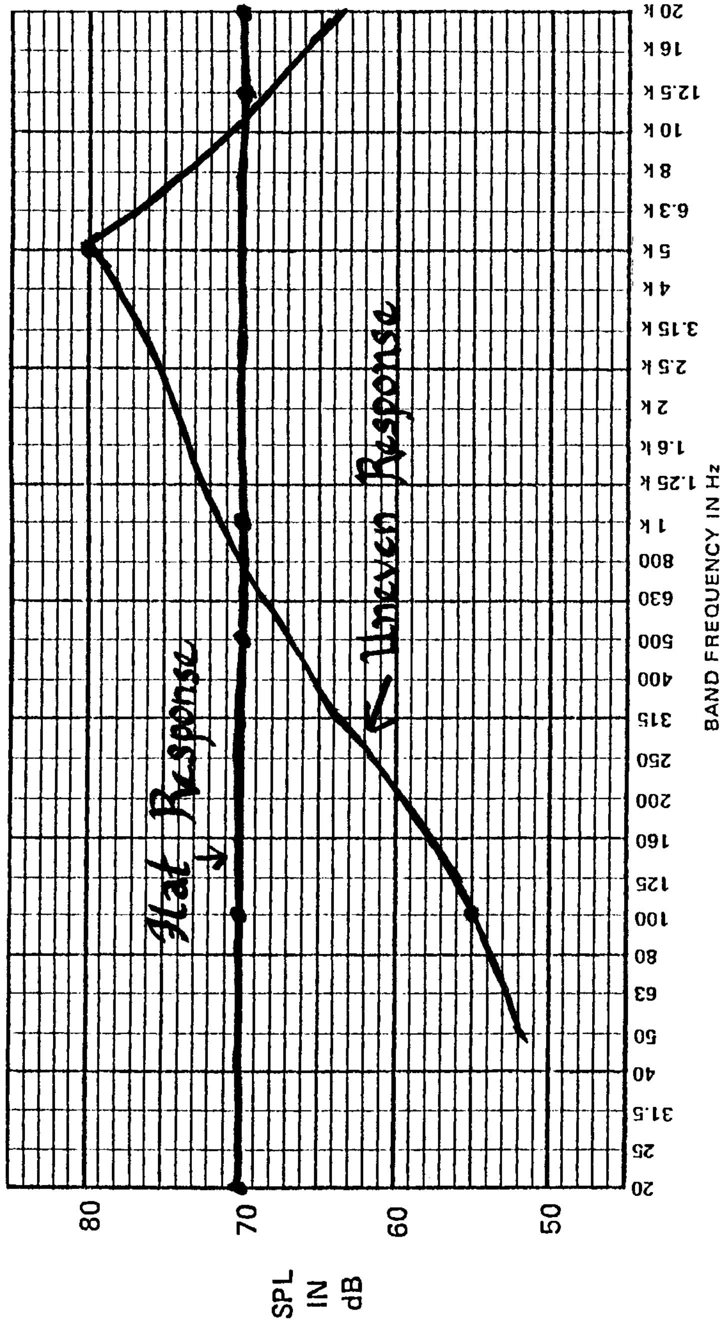


Fig. 3. Flat response *v.* uneven response

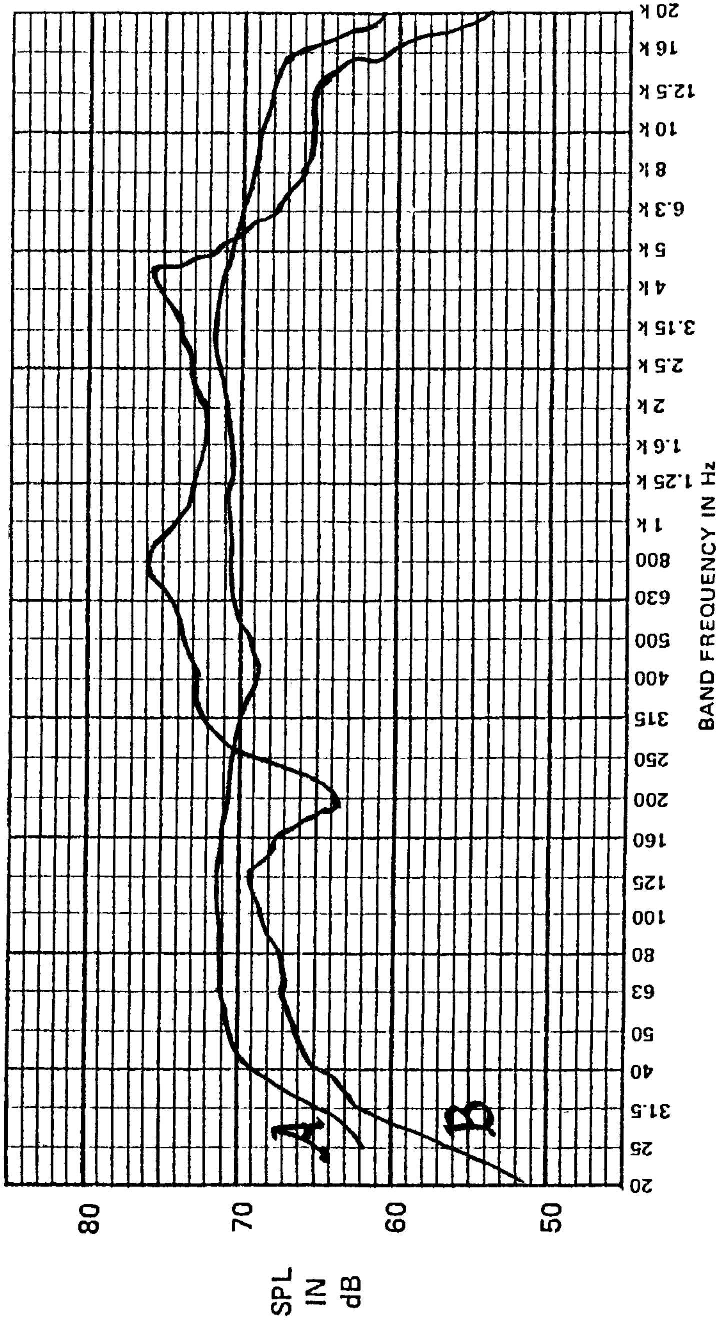


Fig. 4. Response of Speaker A *v.* Speaker B

simultaneously. The influence of one frequency on another is therefore important. Unfortunately, this simultaneous reproduction of frequencies is not a simple task for a speaker. The anomalies of a speaker can cause the original frequencies to interact negatively and generate nonharmonic frequencies unrelated to the original signal. This form of distortion is called intermodulation (IM) distortion. It interferes with the definition of the sound and can cause listening fatigue. When listed, a rating of less than 0.5 percent IM distortion would be considered good for a speaker.

Arrival Time

In an effort to minimize intermodulation distortion and increase frequency response, multiple speakers are put in one cabinet with each assigned a range of frequencies to cover. A three-way system, for example, would have a low-range speaker (woofer), a midrange speaker, and a high-range speaker (tweeter). This type of combination allows the manufacturer to design specialized speakers that do a better job in their respective ranges than a single speaker forced to reproduce the entire audio spectrum.

This does not mean the more speakers the better. A well-engineered single speaker could outperform a cheaply and/or poorly designed multiple-speaker system. However, assuming that the multiple-speaker system is basically well designed, its capacity to reproduce the total sound spectrum is superior to that of a single speaker.

One design problem of multiple speakers that has been overlooked by manufacturers for years is the arrival time of the various frequencies to the listener. In a multiple-speaker system, the physical separation of each of the speakers in the system causes the fundamental frequencies and overtones to reach the listener's ears at different time intervals than existed in the original recording environment. Differences in time, as well as amplitude, of the frequencies are thereby created by the speaker system. Recreation of the original performance is distorted in these respects. Fortunately, a few speaker systems are now being designed to produce more natural arrival times, thereby increasing the authentic reproduction of the sound. Perception of arrival time distortion does vary with frequency, but a difference of one millisecond or less between speakers is a good reference point.[3]

Placement

The objective of this article has been to list some of the important criteria in speaker selection. Assuming the ideal speaker can be found, a major nemesis still remains—the room in which the speaker is placed. The size, shape, surfaces, and objects within a room all have an effect on sound reproduction. The placement of the speaker within the room can also have serious repercussions on speaker fidelity.

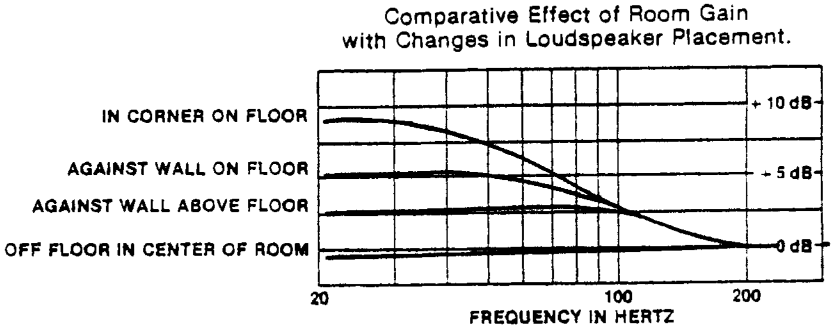


Fig. 5. Used by permission of McIntosh Laboratory, Inc., Binghamton, N.Y.

As shown in figure 5, the low frequency response of a speaker is substantially different in different room locations. The discussion of an ideal listening room deserves a great deal more attention that is possible here, but what must be realized is that if the speaker selected is inherently accurate, the number of variables to worry about is reduced by one. A good speaker specification should state which location is optimal for the most accurate response.

Conclusion

Sound archivists must recognize that in addition to discographic (audiographic would be a better term) responsibility, an obligation exists to contend with the technical problems of the audio medium. This paper has concentrated on one of those problems—the speaker system. Speakers selected to reproduce sound objectively should:

1. have a wide frequency range—approximately 25-16,000 hertz or better;
2. have a flat response—±3db or less;
3. have low intermodulation distortion—0.5 percent or less;

4. have minimal differences in speaker arrival time—one millisecond or less; and
5. be properly placed for best response.

The guidelines are governed by the basic premise that authenticity comes from objectivity. Those who have assumed the task of sound preservation owe it to future generations not to distort the reality of that sound.

References

1. Storm, William D. "The Establishment of International Re-recording Standards." *Phonographic Bulletin*, no. 27, July 1980, pp. 5-12.

2. Ibid.

3. Blauert, J., and Laws, P. "Group Delay Distortions in Electroacoustical Systems." *Journal of the Acoustical Society of America* 3(May 1978):1481.