Acoustic Research Model AR90 Loudspeaker System

Manufacturer's Specifications

Type: Floor-standing, full-range system.

Drive Units: Two 10-in. (250-mm) acoustic-suspension woofers; one 8-in. (200-mm) lower midrange cone; one 1½-in. (38-mm) upper midrange hemispherical dome, and one ¾-in. (19-mm) hemispherical dome tweeter.

Crossover Frequencies: 200 Hz, 1200 Hz, and 7000 Hz.

Impedance: 4 ohms nominal, 3.2 ohms minimum.

Controls: Three 3-position switches for lower midrange, upper midrange, and high range level control.

Efficiency: One watt will produce 87 dB SPL at one meter on axis.

Recommended Amplifier Power: 50 watts minimum per channel.

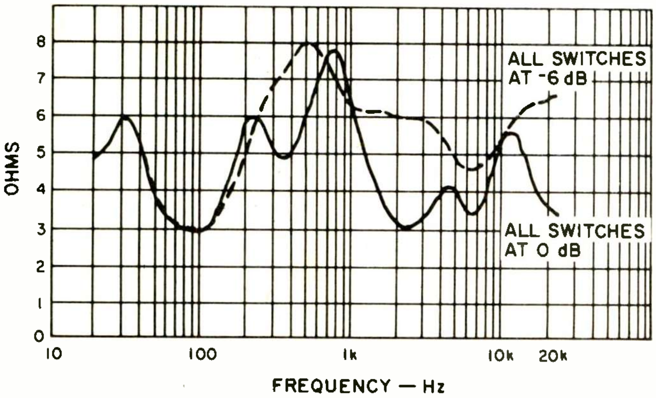
Dimensions: 14½ in. (368 mm) W x 15¼ in. (386 mm) D x 43⅜ in. (1102 mm) H.

Weight: 82 lbs. (37 kg).

Price: $550.00 each.

The Acoustic Research AR90 is a full-range, floor-standing loudspeaker system. Assembled in a vertical configuration, the AR90 stands 1.1 meters tall (43 inches) and weighs a hefty 37 kg (82 lb.). The top and sides are finished in walnut veneer with the front and lower sides covered with black cloth grilles. This system is slightly smaller and much less expensive than Acoustic Research's top-of-the-line AR9, but it clearly embodies the same design philosophy.

Fig. 1 — Magnitude of impedance for the two extreme equalizer settings.



The AR90 is a four-way loudspeaker system. A 19-mm (¾-in.) dome tweeter covers the frequency range above 7 kHz, a 38-mm (1½-in.) upper-midrange dome driver handles 1200 to 7000 Hz, while a 200-mm (8-in.) driver handles 200 Hz to 1200 Hz, and two 250-mm (10-in.) woofers are mounted on the lower sides of the enclosure and cover frequencies below 200 Hz. These woofers face the sides of the enclosure and are intended to use the wall against which the loudspeaker is placed for augmenting bass without incurring cancellation effects.

Connection to the speaker is made to binding posts placed in a recessed cavity on the rear of the enclosure. Three 3-position switches are also mounted in this cavity and allow the user to adjust the level of the lower midrange, upper midrange, and tweeter by 3-dB steps.

An extremely well-written reference manual is supplied with these speakers, and even the least technical user should be able to set up the AR90 with no difficulty whatsoever. For the more technically minded, the manual explains how to troubleshoot the system and even tells how to remove and replace the drivers in case of problems. A full 5-year warranty is provided with each speaker. Although the speaker is rather tall and quite heavy, the center of gravity is low enough to resist toppling by all but the most forceful pushing at the sides. It should therefore be reasonably safe around toddlers.

Technical Measurements

The magnitude of impedance load which the AR90 presents to a power amplifier is shown in Fig. 1. Since there are nine possible equalization switch positions, there will be nine separate impedance characteristics. Only the two most extreme positions are plotted, that is the positions which presented the highest and lowest values of impedance to the amplifier. The curve marked "0 dB" is the measured impedance for all equalizer switches in their indicated 0 dB position; the other curve is for all switches set to the -6 dB indicated position.

Figure 2 is a complex polar plot of the impedance from 20 Hz to 20 kHz for the 0 dB position. The lowest measured impedance value is 3.0 ohms, which is close to AR's stated minimum of 3.2 ohms. From the standpoint of power amplifier limitations, the most likely frequency where difficulty might occur is around 1.3 kHz, where the impedance is around 4.5 ohms with a 28 degree lag in phase angle. If the AR90s are positioned more than a few meters from the power amplifier, I recommend the use of large gauge wire in order to minimize not only power loss, but also modification in frequency response because of relatively low impedance. AR, for example, recommends 16-gauge wire for a run of up to 40 feet.

The measured one-meter-axial anechoic frequency response is shown in Figs. 3 and 4. Both measurements are made with the equalizer switches in their 0 dB position. The amplitude of SPL, Fig. 3, shows a gradual reduction of response with increasing frequency above 1 kHz. This is a very minor effect and amounts to about 3 dB per decade. The anechoic low-bass frequency response, taken on axis, shows a drop relative to the mid bass. This is presumably traceable to the AR philosophy of adjusting the response for more uniform low-bass spectral energy response when the speaker is placed along the wall of the listening room. Although the low bass is achieved from two 250-mm (10-in.) drivers directed to the sides, the one-meter anechoic response below 150 Hz showed essentially no directional characteristic within plus or minus 90 degrees of the frontal axis. In other words, the low frequency anechoic fall-off of Fig. 3 is due to the nature of free-field measurement and not of microphone position.

The one-meter-axial phase response is shown in Fig. 4. The measuring microphone was placed one meter from the front of the AR90 enclosure, and the air path delay is 2.907 milliseconds for this spacing. The measured tweeter delay is 3.071 milliseconds; the measured upper midrange delay is 2.976 milliseconds, and the measured lower midrange delay is 3.234 milliseconds. The phase measurements of Fig. 4 consist of three curves, corrected for each of these delays to show the absolute phase shift of the frequency response when corrected for driver delay. The reference for phase shift in these measurements is the zero degree condition where a positive-going sound pressure wave is produced by a positive-going terminal voltage, when airpath delay and driver delays are removed. With minor exceptions, each driver is essentially minimum phase, but the ensemble system, which defines the AR90, is of nonminimum phase type due to the variation of time delay throughout the frequency range. This time-delay variation does contribute to some of the irregularity in direct-sound frequency response, particularly at the frequencies where the acoustic transition between drivers takes place. (Editor's Note: AR feels that while such phase differences do exist, ones of this magnitude do not contribute significantly to listening irregularities.)

The more interesting frequency response, from the standpoint of listening quality, is the three-meter room response shown in Fig. 5. For this measurement the AR90 was placed in its recommended listening position in a room and the microphone was positioned three meters in front of the speaker and one meter above the carpeted floor, simulating a normal listening location, and this plot shows the frequency spectrum of the first 13 milliseconds of direct sound which arrives at the microphone location. This plot essentially shows the timbre coloration of the earliest sound arrivals for broadband impulsive program material.

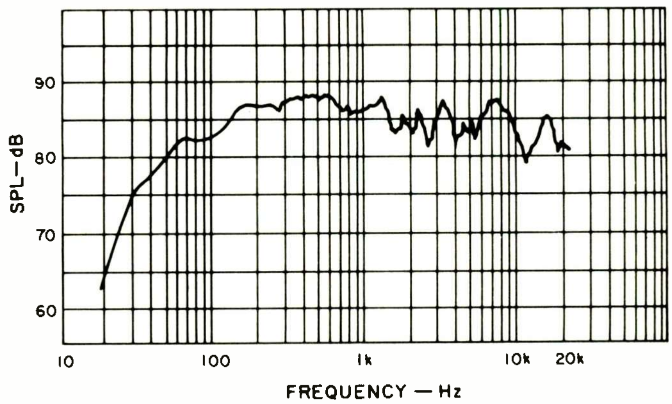


Fig. 3 — Amplitude of the one-meter-axial anechoic frequency response with all equalizer switches set at "0 dB" for one average watt input.

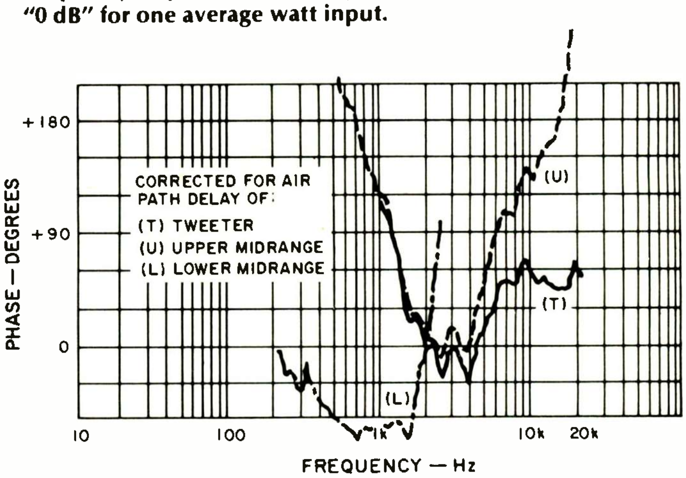
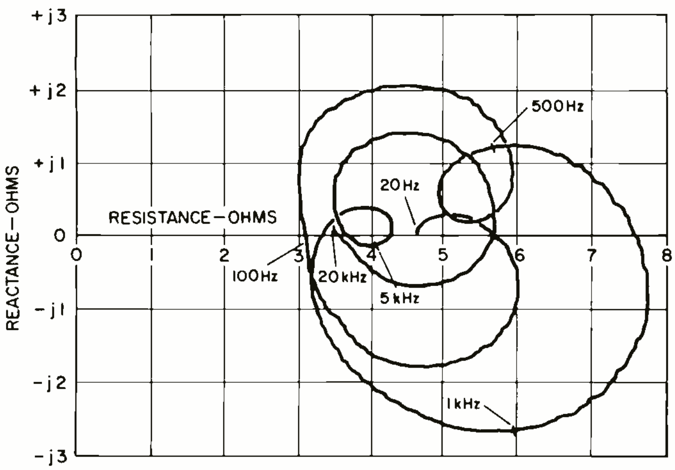


Fig. 4 — One-meter-axial phase response corrected for the indicated driver locations and with all equalizer switches at "0 dB."

Fig. 2 — Complex terminal impedance with all equalizer switches set at "0 dB."



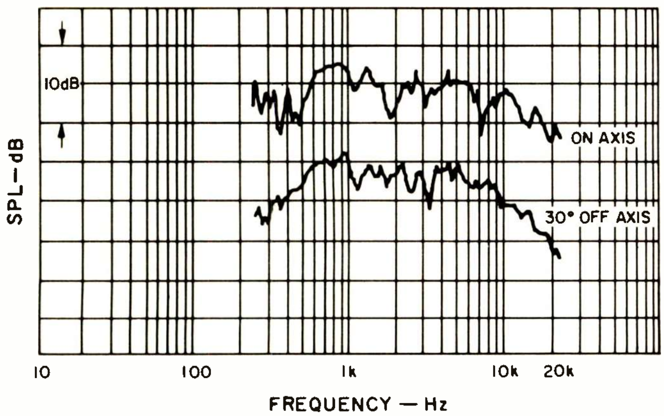


Fig. 5 —Three-meter room response with all equalizers set at "0 dB."

Two curves are shown in Fig. 5. The top curve is the sound measured directly in front of the AR90 at the three-meter location and the lower curve is the sound when the microphone is moved 30 degrees off axis, so that the AR90 is in a conventional left-channel-stereo listening position relative to the microphone location. The curves are displaced 10 dB for clarity of presentation.

As might be anticipated, the highest frequencies are slightly more attenuated off axis than they are when listening directly in front of the speaker. The on-axis room response is essentially the same as the anechoic frequency response for components above about 600 Hz. Some floor and ceiling scatter show up below that frequency and may be due to the broader dispersion pattern of the mid-bass driver which handles frequencies up to 1200 Hz. The normal stereo listening position, lower curve, shows a similar rise in energy at around 1 kHz with a fall-off having less floor scatter below that frequency. The high-frequency beaming, which we noted in the earlier listening test, is evident in the difference between these two curves, and the improvement in higher frequency accuracy when a treble boost of 3 dB at 9 kHz was added in the listening test can be justified by the measured room response. On the whole, this is a relatively smooth room response; however, these measurements show that some mild high-frequency and low mid-bass boost may be needed to balance the spectrum of percussive program material.

Horizontal and vertical polar energy responses are shown in Figs. 6 and 7 respectively. This is a measurement of the total sound energy from 20 Hz to 20 kHz as a function of listening angle relative to the geometric axis of the loudspeaker. As might be expected, except for a drop in the highest frequencies, the horizontal angular dispersion is quite good within the normal plus and minus 30 degree angular positions for stereo listening, since the speaker drivers are arranged in a vertical line. In order to gain some idea of the directional properties for various AR90 equalizer settings, these measurements were made for four settings: (1) all switches up and in their 0 dB position, (2) -6 dB for the high frequency equalizer, all others 0 dB, (3) -6 dB for both high and midrange, with low midrange at 0 dB, and (4) -6 dB for all switches. The only pattern change which can be discerned, other than total reduction in energy, is a fingered pattern at severe off-axis positions due to the tweeter apparently scattering off the grille assembly.

The vertical polar response shows a definite upward launching of sound energy with substantial energy variation in the 30 degree span above the central axis. A simultaneous measurement of anechoic frequency response (not shown) revealed a significant change in response over this range of elevation angles. This change is not due to grille assembly, but to the path-length differences between various drivers in this four-way system when those drivers overlap in frequency response.

These polar measurements indicate a fair amount of timbre alteration of the direct sound as a function of listening angle in the vertical plane. Substantial objects, such as large pieces of furniture which can reflect sound, should not be placed closer than about two feet to the side and front of the AR90s, nor should these speakers be positioned directly beneath deeply projecting shelves, if the most accurate sound is desired.

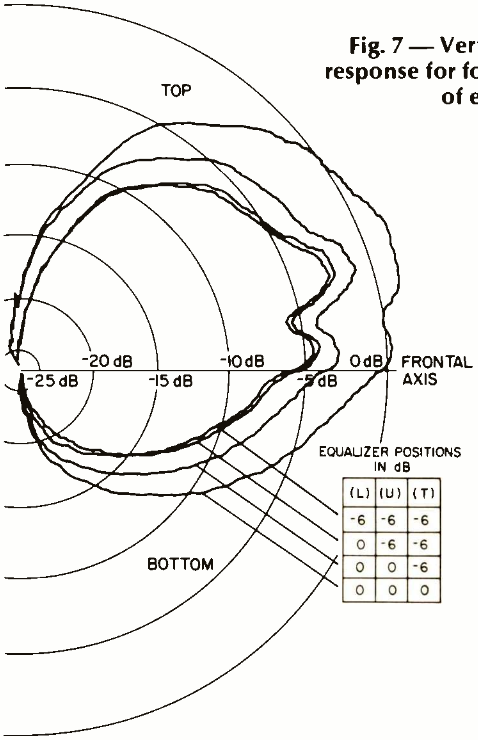


Fig. 7 — Vertical polar energy response for four combinations of equalizer settings.

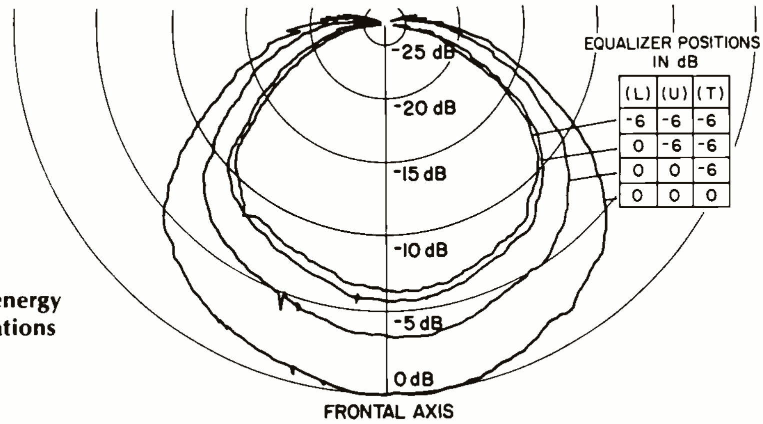


Fig. 6 — Horizontal polar energy response for four combinations of equalizer settings.

Harmonic distortion for the tones of E_1 (41.2 Hz), A_2 (110 Hz), and A_4 (440 Hz) is shown in Fig. 8. Because the low-bass speakers handle frequencies below 200 Hz, the A_4 measurement is an indication of the power handling capability of the 120-mm (8-in.) lower midrange driver, while the lower frequencies are handled by the two woofers. The distortion in these drivers is quite low, and the onset of distortion with increasing drive levels is a smooth rising curve.

Because the low-bass unit does not handle frequencies above 200 Hz, our normal IM test, where we evaluate the influence of low E (41.2 Hz) on upper musical tones, is of limited utility. Our earlier listening test had revealed some upper midrange harshness which might be due to crossmodulation effects, so an appropriate spectrum analysis was made to locate the possible source of such sonic effect, and a distinct crossmodulation was encountered in the upper midrange frequencies. The most prominent of these is shown in the IM results in Fig. 9. A tone of middle C (261.6 Hz) mixed

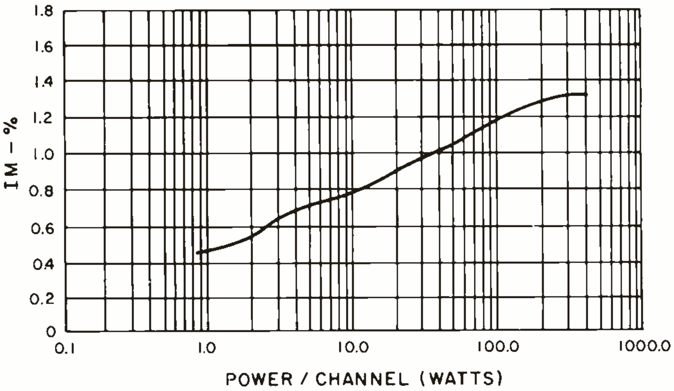


Fig. 9 — IM distortion produced by mixing C_4 or 261.6 Hz and E_5 or 659.3 Hz in equal levels.

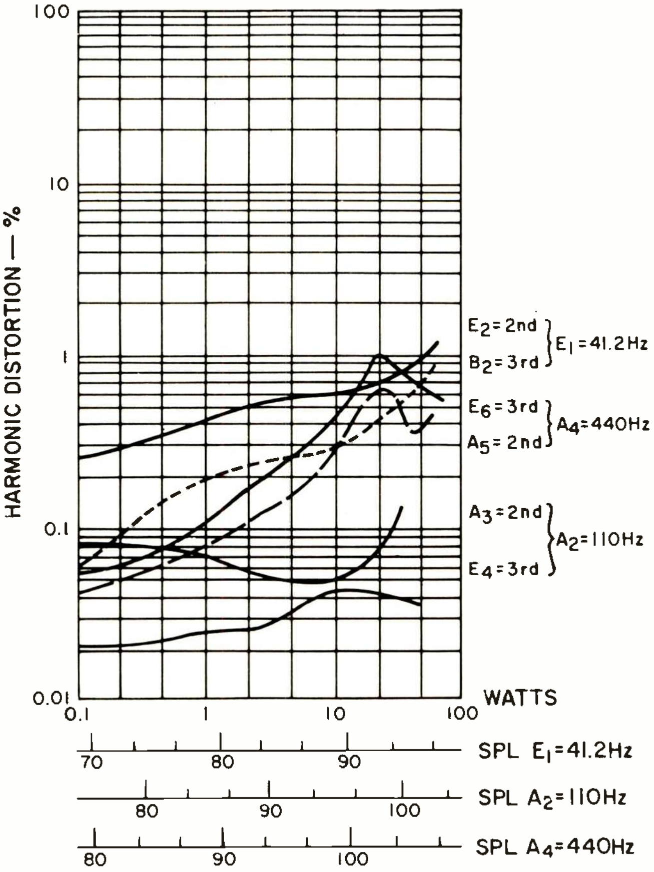


Fig. 8 — Harmonic distortion for the musical tones E_1 or 41.2 Hz, A_2 or 110 Hz, and A_4 or 440 Hz.

in equal level with E in the octave above middle C (659.3 Hz) produced crossmodulation terms of 1057 Hz (which is twice C_4 minus E_5) and 1579.9 Hz (which is twice C_4 plus E_5). The net energy of these crossmodulation terms as a percentage of the generating tones is plotted in Fig. 9 for various average power levels from 10 milliwatts to 40 watts. Note that the percentage of this crossmodulation is still below 1.5 percent at 40 watts input.

Measurements of the AR90's linearity in acoustic transfer gain were made at frequencies of middle C and A_4. A perfect speaker will produce an increase in sound pressure level exactly corresponding to an increase in drive voltage over a wide range of signal voltage levels. The AR90 scored extremely well in this test with only a slight drop in acoustic transfer gain at 50 average watts and no perceptible gain variation down to levels of less than 0.1 watt.

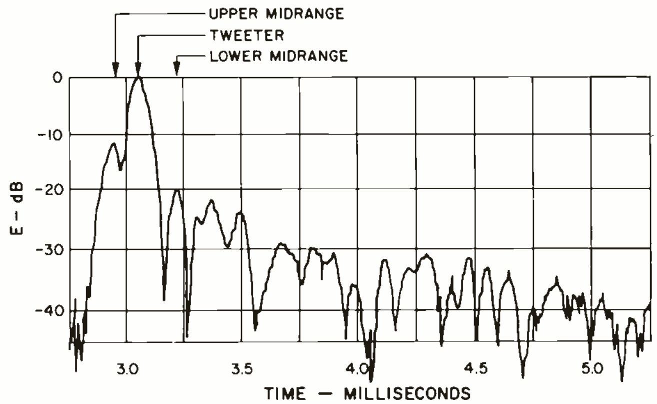
The AR90 also scored well in the crescendo test, with less than a tenth of a dB drop in acoustic level for these same tones, middle C and A_4, when the speaker was suddenly forced to handle broad-band noise which was 20 dB higher in average power than the power in the single tone. This test simulates the condition of an inner musical voice in a loud orchestral passage. The level of the inner voice should not change simply because there are other louder sounds present, and up to average powers of 100 watts, the AR90 passes this test quite well.

Both of these tests are searching for conditions which might lead to stereo image wander due to changes in program dynamic level. Many speakers have difficulty with this test, but the AR90 scored extremely well.

The one-meter-axial energy-time curve for the AR90 is shown in Fig. 10. This is a direct measure of the time spread of the impulse response of the system. The microphone is placed one meter from the front of the speaker. The first sound is due to the upper midrange, the 2- to 4-kHz range, and is evident in this measurement as the first energy peak at 2.976 milliseconds. The second energy peak at 3.071 milliseconds is due to the tweeter and represents energy above the 5-kHz range. The third peak at 3.234 milliseconds is due to the lower midrange driver. Since the measurement is that of the total energy from 20 Hz to 20 kHz, the tweeter is dominant in this plot due to the fact that it handles the largest bandwidth.

This test reveals a time difference in the sound coming

Fig. 10 — Energy-time curve.



from the various drivers. There is some sound which scatters from the front of the enclosure, but this scattered sound is of low level and diffused in time relative to the first sound due to the speaker elements themselves. The energy-time contributions after 3.5 milliseconds are principally due to these scatter terms plus a general woofer decay.

Listening Test

A number of listening positions were tried with the AR90, and it was finally determined that the most accurate conditions prevailed when these units were placed against a back wall and well away from side walls. After considerable experimentation with the various equalizer switch positions, I decided to leave them in their 0 dB position and do any necessary spectral touchup with conventional preamplifier tone control setting.

In this conventional stereo listening position, the bass is well balanced with respect to the rest of the reproduced spectrum. There is a mild bass peak somewhere around 100 Hz and then a shallow dip in the octave below middle C which I was not able to correct with conventional tone controls. There is a bass dominance when one is well to the side of these speakers. For normal listening positions, however, this should not be a problem, but when walking around a room, as one may do at a party where the AR90s provide musical entertainment, the effect might well be noticeable. This occurs principally in the low-bass region and appears due to the drivers which are positioned on the side of the enclosure.

There is a mild amount of high frequency beaming in this system. Normally, I would recommend rotating the speakers so that they point toward the preferred listening position, but this does not work well with the AR90 due to the position of the low-bass drivers on the side of the enclosure. A better idea is to leave the enclosures flat against the wall and slightly raise the high frequency response with tone-control equalization. I found that such a treble boost, amounting to about 3 dB at 9 kHz, improved the balance of the highest frequency components to my ear.

In my opinion, the stereo image of these speakers has good lateralization but relatively poor depth, that is the illusion of depth was, for me, difficult to achieve, as I had the impression that much of the imaging was pulled forward and compressed in depth.

These speakers can handle extremely wide dynamic range material with no sign of breakup at the highest level. I did, however, sense two level-dependent problem areas: A mid-range harshness somewhere in the 1- to 5-kHz range which was most noticeable on female vocals, and the illusion that orchestral strings seemed to move and slightly change timbre, both with increasing level.

Some musical instruments, such as brass and horns, are reasonably accurately reproduced in my opinion, but other instruments, notably the piano, fall short of this standard.

Overall, there are several areas in which the AR90 measured well. These include relative smoothness in our three-meter room test, good horizontal dispersion, and low harmonic distortion. Two other areas of note were linearity of output with input gain and the crescendo test. To my ear, the system is reasonably well balanced overall, though a mild boost appeared to help the highest frequencies. I also sensed that the stereo stage was fairly well presented and that brass was the best reproduced instrumental class.

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