Knowles®

TB6

TECHNICAL BULLETIN

EFFECTS OF ACOUSTICAL TERMINATION UPON RECEIVER RESPONSE

"A FUNNY THING HAPPENED TO ME ON THE WAY TO THE HEARING AID..."

"... my response characteristics were changed." If any of Knowles receivers could talk, that's what they would say. They would also say that this change in the response curve is not unique; it happens to all receivers. In most cases, it's not bad, either (although it can be misleading). By understanding what happens when they change a receiver's environment, engineers can multiply their design opportunities.

There are three factors which affect how any receiver will perform. The first of these is up to Knowles: the basic design, including physical size and the "motor" and diaphragm system. The other two, acoustical termination and the impedance of the signal source, are up to the design engineer. This bulletin tells what happens when acoustical termination is varied.

EFFECT OF ACOUSTICAL TERMINATION ON RESPONSE

The response curves for a typical receiver indicate that coupler type and coupling tube length and diameter (including orifice restrictions) have a marked influence on the frequency response characteristic. Varying these parameters gives the design engineer a degree of control over the general response shape, principally in the high-frequency range. Since none of the test setups duplicate (except by chance) the acoustic termination of a hearing aid under actual use conditions, the selection of the parameters for testing and evaluation is purely arbitrary. However, the results under various test conditions give the engineer some idea of what will happen if he changes tubing length (such as by altering the placement of components within the aid), selects tubing of a different diameter, or incorporates some form of acoustic resistance, such as a damping plug, in his design. Once he is aware of the influence of parameters such as tubing length, the designer can then vary the placement of components (reversing microphone and receiver locations, for example) to take advantage of that influence.

TUBING LENGTH AFFECTS FREQUENCY OF PEAK RESPONSE

In any investigation of the influence of coupling tube length on acoustic performance, the obvious starting point is zero, that is, with the receiver coupled directly to a 2cc cavity. Figure 1 shows the response of a typical receiver under this test condition, directly connected to an HA-3 coupler. For comparison, response curves for the same receiver coupled via two different tube lengths are also shown.

Note that, when a tube is added or tube length is increased,the peaks in response resulting

KNOWLES ELECTRONICS, INC.
1151 Maplewood Drive,
Itasca, Illinois 60143, U.S.A.
Phone: (708) 250-5100
Fax: (708) 250-0575

KNOWLES ELECTRONICS CO.
73 Victoria Road, Burgess Hill,
West Sussex. RH15 9LP, England.
Phone: (0444) 235432
Fax: (0444) 248724

from transmission line characteristics shift downward in frequency. This shift usually results in a change in response at a given frequency. Thus, if an arbitrarily fixed distortion measurement criteria (500 Hz. input, etc., for example) is used, *measured* distortion may change drastically as a result of only a small change in tube length. In listening tests, however, these differences are frequently difficult to detect.

Although frequency shift is the principal result of a change in tubing length, some difference in amplitude may also ensue. As the curves show, this difference is particularly significant in a change from a tube of some length to direct (zero tube length) coupling.

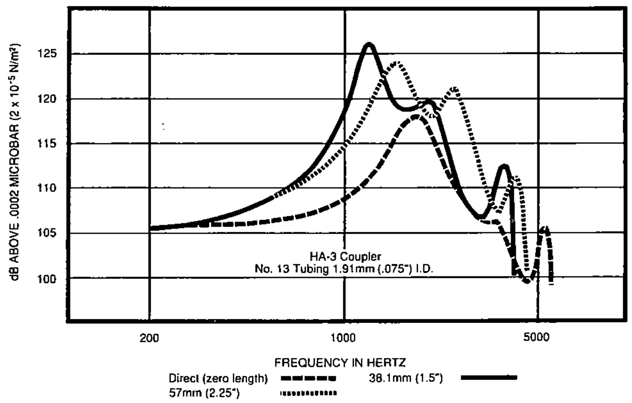


FIGURE 1. Effect of Tubing Length

LARGER DIAMETER YIELDS INCREASED 1000-2000 HZ RESPONSE

In general, varying the inside diameter of the coupling tube will influence the amplitude of the response curve in the 1000-2000 Hz. range. Low frequency response is not greatly affected, nor is there a wide shift in frequency of response peaks.

Figure 2 shows the effect of larger tubing diameter. Note that enlarging the inside diameter resulted in a boost of as much as 5 dB in the 1000-2000Hz. range mentioned.

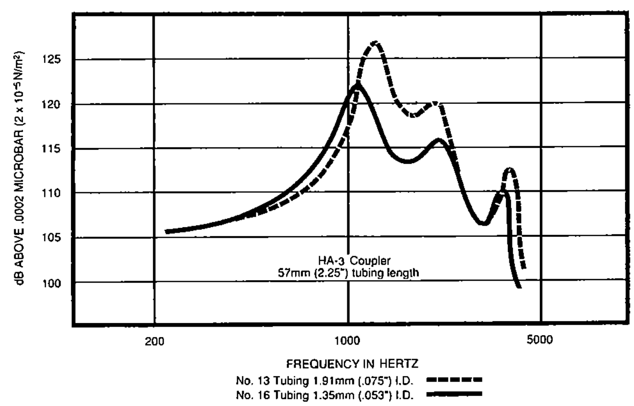


FIGURE 2. Effect of Tubing Diameter

WHAT HAPPENS WHEN BOTH LENGTH AND DIAMETER ARE VARIED?

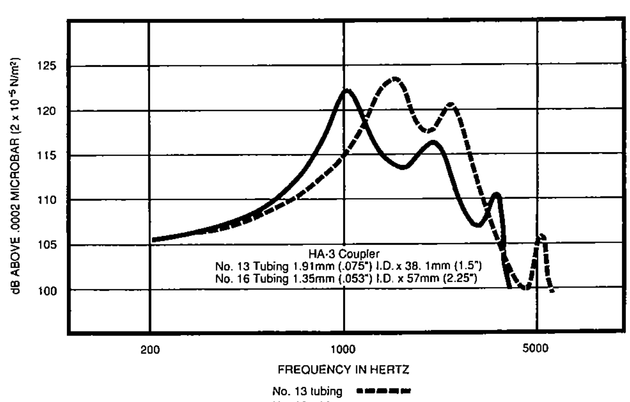


FIGURE 3. Effects of Tubing Length and Diameter Combined.

Results of varying both length and diameter (Figure 3) are consistent with the results obtained when only one or the other is varied: the pass band responses for the long, small-diameter tube shift downward in frequency; the large-diameter tube has the expected greater sensitivity in the 1000-2000 Hz range.

In general, tests indicate that a particular response variation will occur at a lower frequency if the ratio of transmission line length to cross-sectional area is increased.

Knowles®

TB6

FILTERS PRODUCE RESULTS SIMILAR TO THOSE OF DECREASE IN TUBE DIAMETER

As one might suspect, the introduction of some form of restriction in the acoustical termination produces results very similar to those obtained when tube diameter is reduced. Thus, the primary effect is a

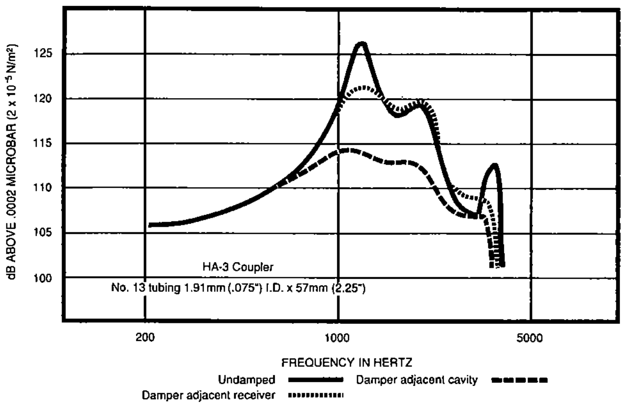
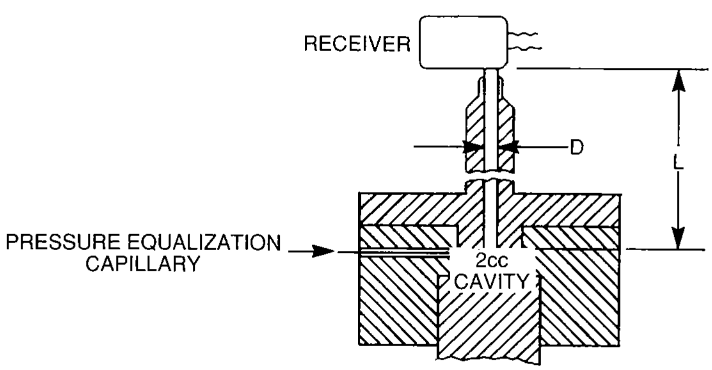


FIGURE 4. Effects of Damping.

reduction in the magnitude of the first response peak, which in the case of a typical receiver again means a decrease in response in the 1000-2000 Hz. range.

However, the magnitude of this reduction, while dependent on the acoustical resistance of the damping plug or orifice restriction, is also influenced by its position in the tubing (Figure 4). As the response curves show, introduction of a filter near the receiver sound outlet produces a subtle smoothing of the first response peak, but introduction of the same filter at the end of the coupling tube (an operation frequently performed by a dealer, beyond the control of the hearing aid designer) radically changes response characteristics in this frequency range.

Acoustical filtering of this type is commonly achieved, at the time of final fitting of the aid, by inserting lamb's wool, an orifice restriction, or, as in the tests of Figure 4, a plug of sintered metal (a small cylinder of brass or stainless steel particles sintered together). However, it is well to remember that results similar to those obtained with the plug near the receiver outlet can also be achieved by incorporating an orifice restriction or similar acoustical resistance in the design of the hearing aid proper.



HA-3 COUPLER
(ANSI S3.3 - 1960)

WHAT DOES IT ALL MEAN?

As smaller receivers are produced, the influence of acoustical termination on frequency response and distortion increases significantly. Performance parameters contributed by the receiver are fixed in the basic design. Thus the hearing aid designer, through his choice of receiver acoustical termination, controls the receiver's final performance characteristics and consequently the hearing aid response balance and band pass. The effect of the source impedance presented by the output circuit is discussed in detail in Technical Bulletin TB7 "Effects of Source Impedance upon Receiver Response."