



# THE PA BIBLE

## ADDITION NUMBER SIXTEEN MISMATCHING DRIVERS AND HORNS

### INTRODUCTION

Professional audio components from various manufacturers are sometimes used together; essentially a "cross breeding" of different cultures or philosophies of sound equipment design or concept. This can be done successfully if certain practice is followed. It is the purpose of this article to show what will work and what won't.

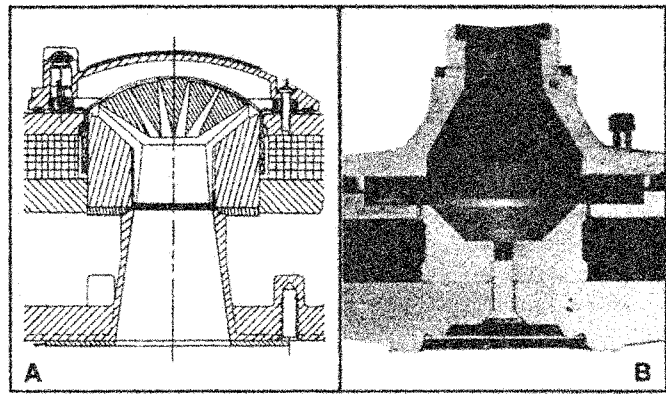
Reasons for cross-breeding of drivers and horns vary. Here are a few common ones:

- 1) **In a Jam and/or The Show Must Go On.** This is a common occurrence. Eight drivers from manufacturer "A" blow up and a nearby dealer has drivers in stock, or for rent, from manufacturer "B." With two hours to show time, a decision to "make do" and bring the show up on time always is more heroic and favored than any other alternative.
- 2) **Availability and "Equivalent Units" on a Sound System "Spec."** This is identical to (1), only on a much longer time span. Cross-breeding on a fixed installation may occur by "picking" units from a shopping list of equivalents as a bid, depending on availability, contractor's stock, price, etc. Last-minute inability of a manufacturer to ship when promised may force a cross-bred system into existence.
- 3) **Listener Preference.** A customer, consultant or contractor may actually prefer the combination of a driver from manufacturer "A" and a horn from manufacturer "B" as a "best sound" combination. This is not unusual, but it does reflect a subjective opinion which may be singular. In a similar vein, certain combinations may exhibit a preferred performance, such as frequency response or power handling. Some or all of these may find their way into a specification.
- 4) **Some Existing Equipment on Hand.** A customer may want to upgrade his system with, say, new horns but doesn't want to buy new drivers when the old ones work just fine. He could buy the new horns, sell the old ones off and bolt on his old tried-and-proven drivers which he loves the sound of.

Sound familiar? It doesn't happen every day, but it does happen with some regularity. This article will attempt to clear up some mythology and misconceptions about the bizarre practice of cross-breeding high-frequency drivers and horns. It will also present recommendations for acceptable practice, based on available EV hardware.

### LOUDSPEAKER MECHANISMS

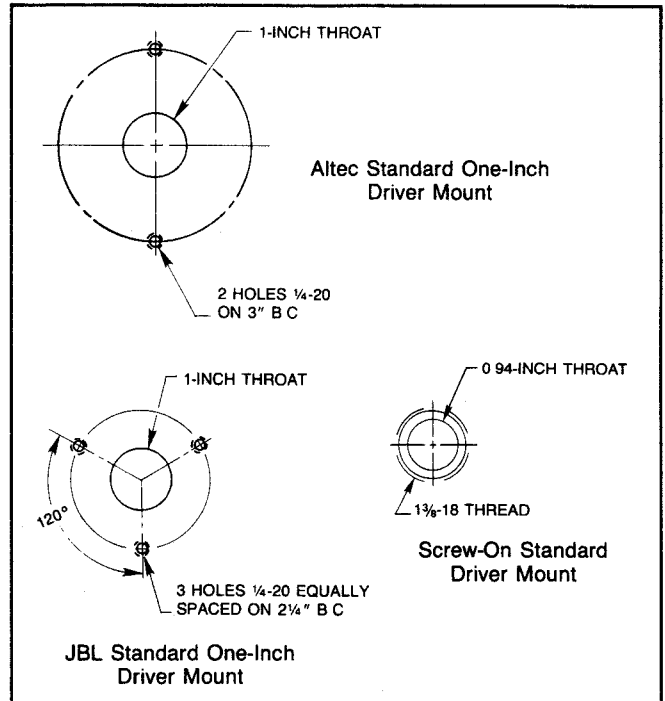
Most "wide-range" professional compression drivers are similar in mechanism. Metallic, spherical diaphragms (aluminum, titanium, beryllium) are mounted in close proximity to a solid spherical-surface member, called the phase plug, which has slots or openings in it. These slots, on the spherical surface of the phase plug, join together inside the driver and "conduct" the sound generated by the moving diaphragm to the driver throat and its exit. The smaller the length of the sound paths on the surface of the phase plug, the better the high-frequency performance. All compression drivers have phase plug "throat" or entrance areas which are about 10% of the "effective piston area" of the diaphragms. This is the net sum of all the individual slot or slit areas. Figure (1) shows typical compression driver construction.



**FIGURE 1**  
**Compression Driver Cross Sections**  
A) Conventional Concave-Drive B) Convex-Drive (after DH2)

### "SMALL-FORMAT" DRIVERS

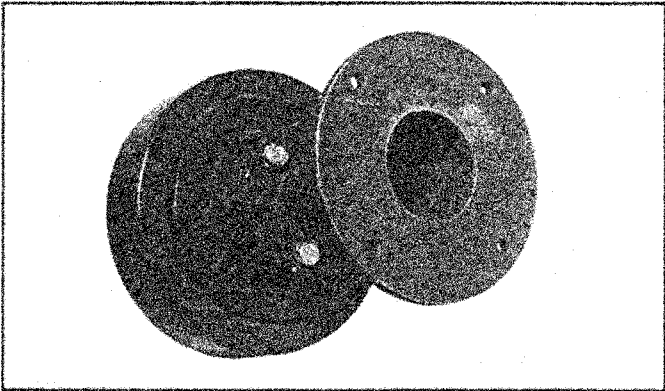
Most "small-format" drivers are either one-inch bolt-on or one-inch screw-on, which is to say that the actual effective acoustic exit aperture is a one-inch diameter hole. These conventions are shown in Figure 2.



**FIGURE 2**  
**One-Inch Throat Configuration**

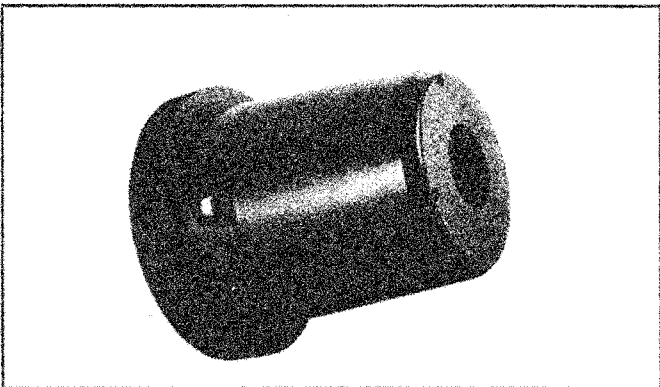
Most "small" pro drivers have between 1.75 (JBL, Altec) and two-inch (EV) diameter effective pistons. There is some use of these drivers on small-format horns, where the horn merely bolts or screws onto the horn, and that's that. There's no real problem here. The EV ADH-1 will convert a one-inch screw-on driver, like the DH1506, to a one-inch flange mount configuration. However, there seems to be more of a proliferation of "adapters" for so-called "one-inch drivers" than for any other format. An example is shown in Figure 3. This is probably because:

- a) there are more varieties of large-throat-format horns "out there"; and,
- b) in low-SPL applications, such as churches, a small-format driver will fit the bill and is generally more cost-effective than a large-format unit.



**FIGURE 3**  
**Driver with Adapter "Plumbing" for One-Inch to Two-Inch Conversion**

A useful exception to this is a design philosophy developed at EV. We have lived for years with various "ADH" adapters, or acoustical plumbing, as a "necessary evil" of different throat formats. When we introduced the HP horn series with a standard two-inch throat (actually 1<sup>15</sup>/<sub>16</sub>) we were again faced with the prospect of throat adapters, knowing full well the problems herein; the main one is expense of installation due to extra time needed to unpack an extra carton, sort out screws, gaskets and hardware, actually mount the adapter, etc. We concluded that the best solution was to just build the throat so it extended to a two-inch exit within the driver and *forget* adapters. This resulted in the unusual design of the DH2 (Figure 4). Not unexpectedly, this concept has been eagerly accepted by our existing and growing customer base.



**FIGURE 4**  
**DH2: No Adapter**

**SOUND CHARACTERISTICS OF SMALL- AND LARGE-FORMAT DRIVERS**

Small diaphragms have less low-frequency (400-800 Hz) output *capability* than larger ones according to the following equation:

$$\text{Peak } W_{\text{out}} = 0.00472 f^2 X_{\text{max}}^2 S_D T \text{ (watts)}$$

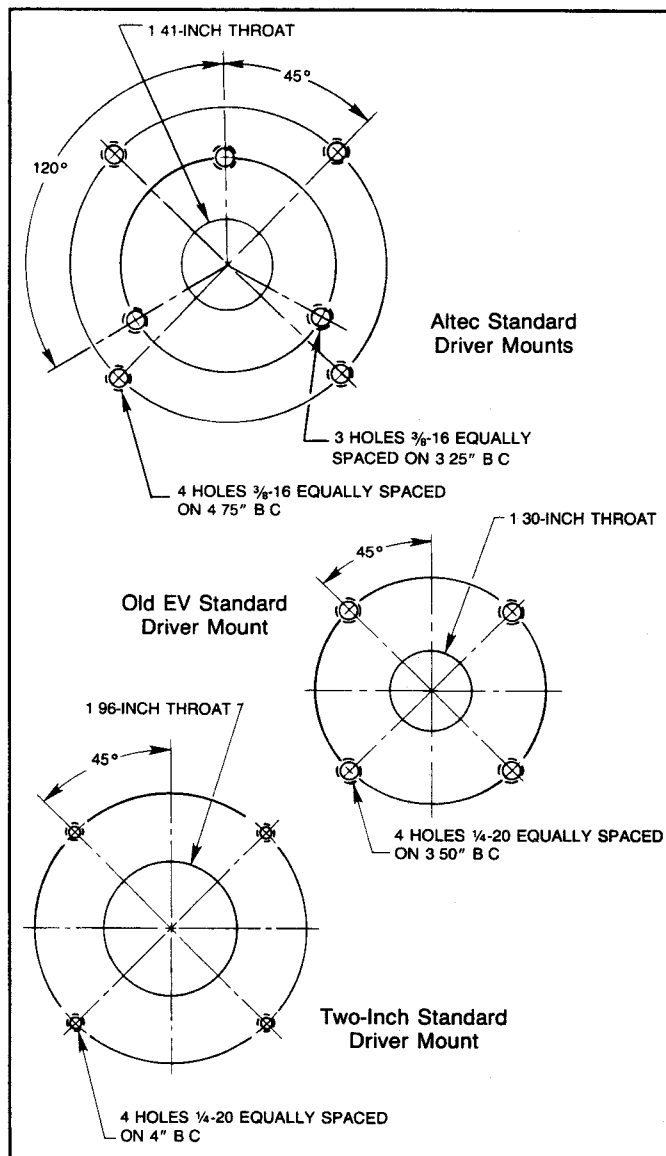
$f$  = frequency (Hz)  
 $X_{\text{max}}$  = diaphragm-to-phase-plug spacing (in.)  
 $T$  = compression ratio =  $S_D/S_T$   
 Where  $S_T$  = throat area (in.<sup>2</sup>)  
 $S_D$  = diaphragm area (in.<sup>2</sup>)

Small-diaphragm drivers also tend to have stiffer suspensions or higher principle resonances, giving them less *relative* low-frequency

response. Lastly, a smaller diaphragm begins to "break up" at higher frequency (in the 10-20,000 Hz region). Therefore, they sound smoother and tend to have smoother frequency-response curves. Actually, most larger drivers tend to have better high-frequency *level* or output around 10,000 Hz or so, but smaller diaphragms tend to be smoother. Larger diaphragms, on the other hand, tend to have a "fuller" vocal sound at high levels because of their greater low-frequency output and response capability, especially when used with a 500 Hz crossover. The point here is that you make your choice and accept the corresponding tradeoffs, whether you like it or not.

**LARGE-FORMAT DRIVERS**

High-frequency drivers whose coils are larger than about 2<sup>3</sup>/<sub>4</sub> inches fall into the "large-format" class. This more generally manifests itself as a certain size of exit aperture. A throat which is larger than one inch generally qualifies as "large format." Unlike one-inch throats, there are at least three conflicting large-format-bolt pattern/exit-aperture combinations: Altec/Yamaha, "old EV" and "standard two-inch" (new EV, TAD, JBL, Gauss, etc.). These are shown in Figure 5.



**FIGURE 5**  
**Large-Format Throat Configuration**

Behind each of these throats is a relatively large diaphragm, representing a specific philosophy of driver design. Here are some differences:

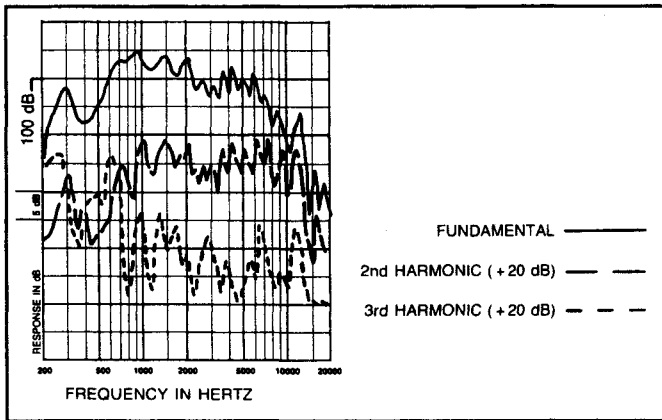
Driver	Diaphragm Construction	Compression Ratio	Coil Diameter	Throat Diameter
EV DH1	Aluminum w/Polyimide Suspension	10	3"	1.93"
EV DH2	Integral Titanium	10	2"	1.93"
Altec 288	Integral Aluminum	10	2.83"	1.414"
Altec 291	Aluminum w/Kapton Suspension	10	2.83"	1.414"
JBL 2445J	Integral Titanium	10	4"	1.93"
TAD 4001	Integral Beryllium	10	4"	1.93"
JBL 2482	Integral Phenolic	10	4"	1.93"

Here are what amount to a wide variety of different opinions on what music should sound like when it comes out of a compression driver. If you think in terms of musical instruments, they all should sound very different, being made of materials which have entirely different resonant character. However, of the "wide-range" devices here which are useful to above 15,000 Hz or so, differences tend to disappear dramatically when set into a balanced sound system in a reasonably sized auditorium. As an "acoustic appliance" all the popular items do a creditable job. However, when you try to

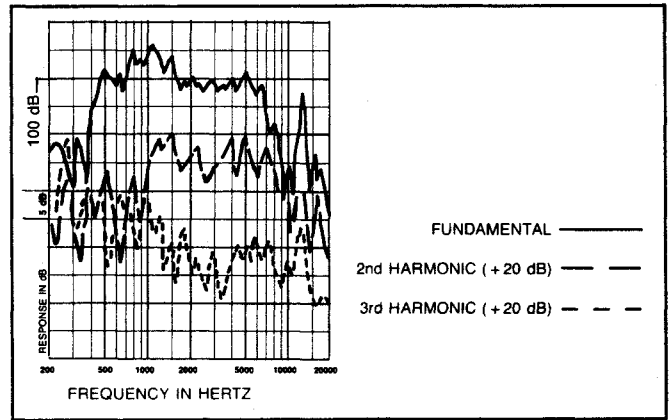
interchange drivers and horns, several possibilities of "mismatch" present themselves. These are as follows:

- a) Driver exit smaller than horn entrance.
- b) Driver exit larger than horn entrance.
- c) Driver "flare rate" different from horn with the same size throat.

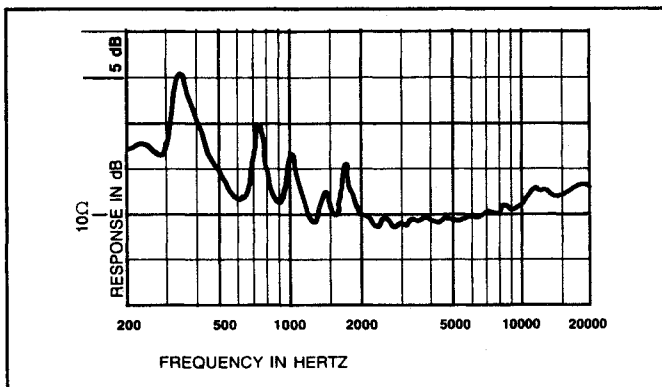
All these combinations can lead to less-than-ideal behavior, due to the unplanned-for driver-horn interface. The first two can lead to high-frequency reflections which are harmonic or repeat themselves at regular musical intervals; "bumps" in response above a certain high frequency. Here are some examples of this. Figures 6 and 7 show the performance and impedance of a well-known driver/horn combination. Response and distortion are not unusual for a "constant-directivity" horn design, this combination being intended for 800-Hz-and-above use. The same driver (Altec 288-8K) is now fitted to an EV HP9040 2-inch throat horn, an area mismatch of about 2:1. The performance and impedance of this combination are shown in Figures 8 and 9. Note that a huge loss of output (a "hole") develops between 5,000 Hz and 12,000 Hz and that distortion levels (remember, percent distortion is *relative* to the fundamental) jump considerably in this region. The rest of the range is relatively normal. For a contrast, Figures 10 and 11 show the behavior of a correctly matched 2-inch driver/horn combination, the EV DH1 on the same HP9040. Compared to Figures 8 and 9, the gaping hole is gone and a smooth response is in its place. Distortion levels are generally lower here, depending on range, these being a function of the driver design.



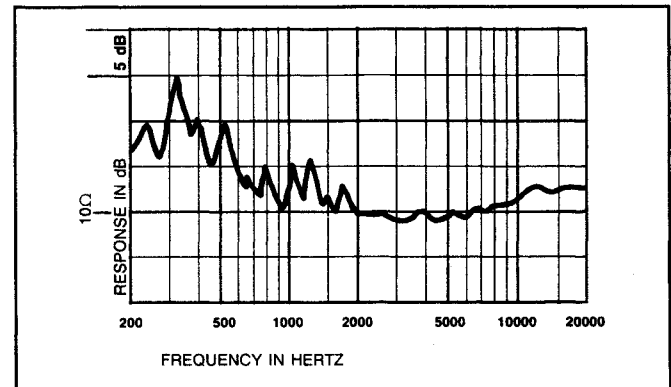
**FIGURE 6 — Response & Distortion; Altec 288-8K Driver on Altec MR-94 Horn (1 watt, 10 feet)**



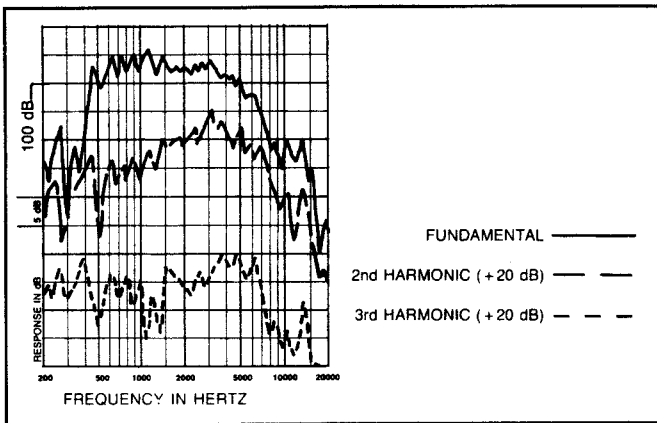
**FIGURE 8 — Response & Distortion; Altec 288-8K Driver on EV HP9040 Horn (1 watt, 10 feet)**



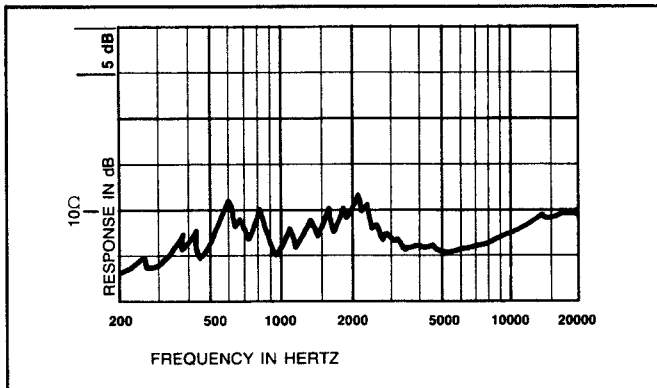
**FIGURE 7 — Impedance Altec 288-8K Driver on Altec MR-94 Horn**



**FIGURE 9 — Impedance Altec 288-8K Driver on EV HP9040 Horn**

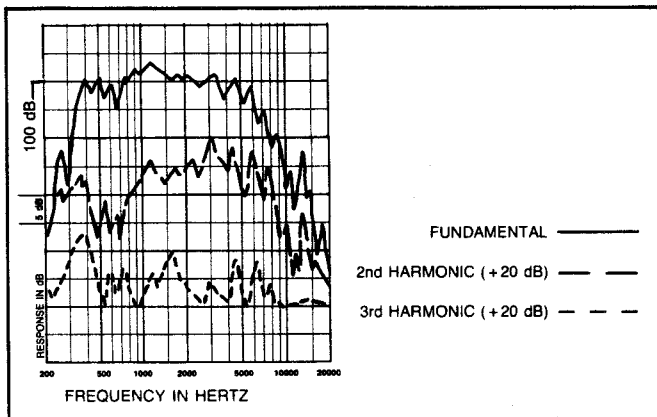


**FIGURE 10 — Response & Distortion; EV DH1 Driver on EV HP9040 Horn (1 watt, 10 feet)**

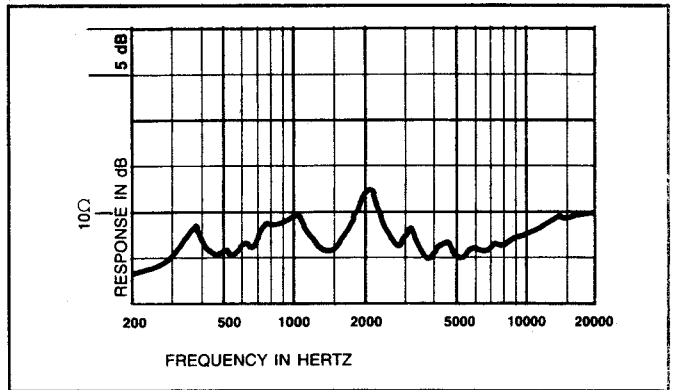


**FIGURE 11 — Impedance EV DH1 Driver on EV HP9040 Horn**

Try a horn whose throat is smaller than that of the driver. In this case, we used "the original CD horn," the EV HR9040 and, again, the DH1. This is another 2:1 area mismatch, but in the opposite way as in the Altec/HP horn example. Figures 12 and 13 show the performance of this combination, which is quite a bit worse than the other mismatch. Starting at 2,000 Hz, you can see a nasty, periodic "musical-horn"-type of behavior. Note the distortion. It also is very peaky and "high-Q" in nature, indicative of a relatively nasty sound. Also, the "step-down" mismatch gives an overall wide-band loss of level on the order of 3 dB. Interestingly, the overall harmonic distortion is lower here than the "matched" DH1/HP9040, this being due to overall output loss from the driver/horn combination. This combination will sound "nasty" but possibly tolerable.



**FIGURE 12 — Response & Distortion; EV DH1 Driver on EV HR9040 Horn (1 watt, 10 feet)**



**FIGURE 13 — Impedance EV DH1 Driver on EV HR9040 Horn**

Lastly, a "mismatch" of horn flare and flare through the driver will mostly affect "ripple" at the low end of the horn. The high end will be largely unaffected by this, so long as the "interface" between driver and horn is matched, per the previous discussion.

### THROAT ADAPTERS

Throat adapters are generally conical-expansion connectors which make a small-throat driver compatible with a large-throat horn. They are rarely used the other way. The "step-down" will cause an overall loss of level and will result in upstream and downstream reflections similar to those generated in Figure 12. For most uses, a conical throat adapter can be said to have a low "cutoff" frequency. If  $D_1$  is the largest diameter,  $D_2$  is the smallest and  $L$  is the length of adapter, then the cutoff frequency  $f_c$  is found as follows:

$$f_c = \frac{.255c}{L} l_\eta \left( \frac{D_1}{D_2} \right) \text{ Hz}$$

where "C" is the speed of sound in air, in the same linear units as  $D_1$ ,  $D_2$ ,  $L$ , and  $\text{Sec}^{-1}$ .

This "cutoff" will give about a one dB loss at that low frequency and more and more loss below that. Generally, throat adapters seem to receive more bad press than is warranted. If properly designed, they are of good use. Use the equation to check this out re: low end. If they are made accurately and are mounted and aligned properly, they will not affect response, even at high frequencies.

### CONCLUSIONS

What have we learned here? First of all, we can see that severe driver mismatches, such as the ones shown, will still produce sound over a wide frequency range. In the case of a "step-up" in driver-to-horn area, we can get a large loss of high frequencies, as a single "dip" or "suckout." In the case of a "step-down" mismatch, harmonically-related peaks and dips result and an overall loss of efficiency or level will result. In both cases, audibly deteriorated performance will result.

So what do you do when you're out in the field and there is nothing but Altec 1.4-inch drivers and EV 2-inch horns (or vice-versa) and the promoter is threatening to sue? Obviously, the show must go on. Drill out new holes and bolt them together; they'll work! They will produce wideband sound, possibly correctable using equalization, and you can get by in a squeeze. It will be usable. If you have your choice and must match incompatible drivers and horns, purchase an (ADH) adapter and don't take a chance. The following are available EV horn-driver adapters which can be of great help:

- ADH-1: 1 inch Bolt-on to 1.3 inch Bolt-on
- ADH-2: 1 inch Screw-on to 1 inch Bolt-on
- ADH-3: 1 inch Screw-on to 1.3 inch Bolt-on



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