Engineering News

ALTEC LANSING 1515 S. Manchester Avenue, Anaheim, California

A Division of LTV LING ALTEC, INC.

ALTEC LANSING

TECHNICAL LETTER NO. 198

NEW WAYS TO LOOK AT NEEDED AND POTENTIAL ACOUSTIC GAIN

By Don Davis©

A Fresh Look at D_o Loss

The amount of acoustic gain you have been designing into sound reinforcement systems has been determined from the formula for needed acoustic gain (NAG).

(eq 1)

$$20 \log_{10} \frac{D_o}{2} = NAG$$

After reviewing hundreds of completed reports on Acousta-Voice* system installations (are you doing your part in this vital program?), a more accurate and reliable method of deriving NAG has been devised based on two important considerations:

1. Critical distance (D_c) should be the limit on the distance from the talker to the most distant listener (D_o). (See Technical Letter No. 196.) $D_o > D_c$ should therefore be expressed as D_c in equation 1.
2. We found less need than formerly thought necessary to "move the listener's ears" as close as two feet from the talker in many spaces with good acoustical environment such as quiet, "well behaved" rooms.

The New Concept

Your real interest is to provide the most distant listener's ears with a signal identical in level and tonal balance (but not necessarily the same ratio of direct-to-reverberant sound) to what they would easily hear without strain at a short distance from the talker in a given acoustic environment lacking a sound reinforcement system. This distance is the Equivalent Acoustic Distance (EAD). At a cocktail party the EAD could be less than two feet, but in a quiet country church it may often be as much as 10 to 15 feet, even for a quiet talker. Three factors can shorten the EAD:

1. Higher ambient noise level.
2. Longer reverberation decay time.
3. Weaker program source.

Until now, EAD has been arbitrarily defined as two feet, and distance ratios have been arranged for multiplication and division before conversion to logarithmic numbers as in the old formula for potential acoustic gain (PAG):

(eq 2)

$$20 \log_{10} \left[\frac{D_1}{D_s} \cdot \frac{D_o}{D_2}\right] = PAG$$

* T.M. of LTV Ling Altec, Inc. - Patent Pending

☐ NEW RELEASE
☐ REPRINT RELEASE WITH NO CHANGES
☒ REPRINT RELEASE WITH CHANGES
SEE ✓

The new concept first converts each distance to a logarithmic number. Those numbers that were formerly multiplied can be added and the numbers that were formerly divided can be subtracted. Restated in the new concept, the PAG formula becomes:

(eq 3)

$$\Delta D_1 + \Delta D_o - \Delta D_s - \Delta D_2 = PAG$$

Where Δ is $20 \log_{10}$.

This method can also be used in determining dB loss for a number of open microphones (NOM). The formula can be changed from

(eq 4)

$$10 \log_{10} NOM = dB$$

to the method expressed by the new concept:

(eq 5)

$$\Delta NOM = dB$$

Where Δ, in this case, is $10 \log_{10}$.

APPLYING THE NEW CONCEPT

This method of substitution derived from the new concept can be applied to calculate NAG, PAG, distance from talker to microphone (D_s) and distance from loudspeaker to most distant listener (D_2). The nomographs in Figures 1, 2 and 3 may be used to change distance and NOM values to their respective logarithmic equivalents in dB.

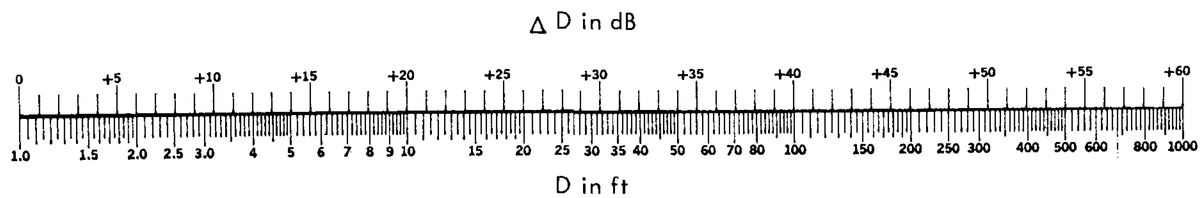

Figure 1. Scales for Conversion of D in Feet to Positive ΔD in dB

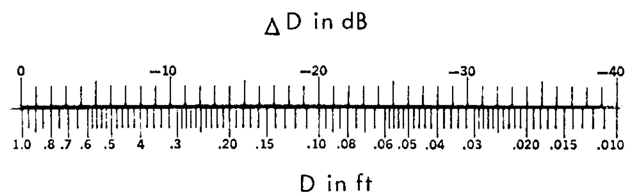

Figure 2. Scales for Conversion of D in Feet to Negative ΔD in dB

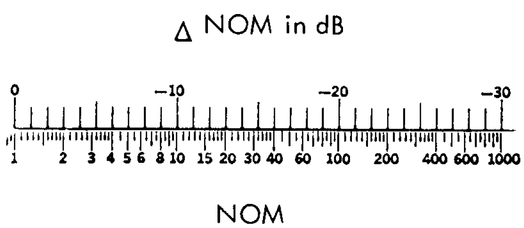

Figure 3. Scales for Conversion of NOM to ΔNOM in dB

Calculating NAG

NAG is found in five simple steps.

1. Measure D_o.
2. Determine desired EAD (by experiment or from past experience).
3. Note number of microphones that will be simultaneously open.
4. Use Figures 1, 2 and 3, as applicable, to find ΔD_o, ΔNOM, etc.
5. Apply these factors in the NAG formula.

(eq 6)

$$\Delta(D_o > D_c = D_c) \quad - \quad \Delta(EAD) \quad - \quad \Delta(NOM) + 6\text{ dB} = NAG$$

Example:

Assume D_c is 20 feet, D_o is 80 feet, EAD is 6 feet and NOM is 2. Then converting the factors to dB and applying the formula:
(eq 7)

$$(+26\text{ dB}) - (+15.5\text{ dB}) - (-3\text{ dB}) + 6\text{ dB} = 19.5\text{ dB} = NAG$$

The resultant NAG shows that not less than 19.5 dB of acoustic gain must be developed at the loudspeaker location. The NAG formula also fills two other needs:

1. It includes the extra gain necessary to compensate for the open microphones.
2. It adds the extra gain that will be deleted to stabilize the system.

Since the extra gain to cover these factors is included in the 19.5 dB figure, PAG calculations need not include it. PAG must be equal to or greater than NAG to obtain sufficient acoustic gain (SAG); PAG $\geq$ NAG = SAG. The acoustic gain formula can therefore be used to calculate the maximum D_s and the maximum D_2 that will meet the NAG.

Calculating D_s

The maximum D_s that will meet the NAG is found in six simple steps.

1. Measure distance from microphone to loudspeaker (D_1).
2. Measure D_o.
3. Measure D_2.
4. Determine NAG.
5. Use Figures 1, 2 and 3, as applicable, to find ΔD_1, ΔD_2, etc.
6. Apply these factors in the acoustic gain formula.

(eq 8)

$$\Delta(D_1 > D_c = D_c) + \Delta(D_o > D_c = D_c) - NAG - \Delta(D_2 > D_c = D_c) = \Delta(D_s > D_c = D_c)$$

Example:

Assume a high-level system with the loudspeaker above and ahead of the talker, and where D_1 is 30 feet, D_2 is 75 feet, D_o is 80 feet and NAG is 19.5 dB; then converting the factors to dB and applying the formula:
(eq 9)

$$(+26\text{ dB}) + (+26\text{ dB}) - 19.5\text{ dB} - (+26\text{ dB}) = 6.5\text{ dB} = D_s\text{ in dB}.$$

Locate +6.5 dB on the upper scale in Figure 1 and read directly below on the bottom scale 2.15 feet. This is the maximum D_s that can meet the NAG.

Calculating D_2

The same method of substitution can be used to find D_2 when D_s is already known.

Example:

Assume D_s is 4 feet and the other factors are the same as in the previous examples. Apply the factors in the acoustic gain formula.
(eq 10)

$$\Delta(D_1 > D_c = D_c) + \Delta(D_o > D_c = D_c) - NAG - \Delta(D_s > D_c = D_c) = \Delta(D_2 > D_c = D_c)$$

Then converting the factors to dB and applying the formula:
(eq 11)

$$(+26\ dB) + (+26\ dB) - 19.5\ dB - (+12\ dB) = +20.5\ dB = D_2 \text{ in dB.}$$

Locate +20.5 dB on the upper scale in Figure 1 and read directly below on the bottom scale 10.5 feet. This is the maximum D_2 that can meet the NAG. The result of this calculation clearly shows that these conditions would require a distributed sound system to meet the NAG.

Calculating PAG

Examples:

Applying the factors obtained for (eq 9) to (eq 3), PAG does indeed equal NAG.
(eq 12)

$$(+26\ dB) + (+26\ dB) - (+6.5\ dB) - (+26\ db) = 19.5\ dB = PAG = NAG.$$

Applying the factors obtained for (eq 11) to (eq 3), PAG again equals NAG.
(eq 13)

$$(+26\ dB) + (+26\ dB) - (+12\ dB) - (+20.5\ dB) = 19.5\ dB = PAG = NAG.$$

Using the ALTEC Inverse Square Law Calculator

The following procedure can be used to substitute your ALTEC Inverse Square Law Calculator for the nomographs in Figures 1, 2 and 3.

Place the NOM or D_n under the arrow in the window marked $- 20 \log_{10}$ [   ] $\left[\frac{D_1}{D_s} \cdot \frac{D_o}{D_2}\right]$

Read the dB figure in the window marked dB [   ] POTENTIAL ACOUSTICAL GAIN

The dB figure obtained for distances will be a direct reading.

The dB figure obtained for NOM values will be twice the actual value because the coefficient of NOM is $10 \log_{10}$ instead of $20 \log_{10}$. The sign of the number should be changed from positive to negative for inclusion in respective equations.

Conclusion

It is well worth your time to learn to calculate and obtain dB readings for D_n, NAG, PAG, EAD, etc., using both the old and new methods. You will soon receive a new "Loudspeaker Location Survey Form" arranged to be used with this new method. Put your calculator, the new survey form and this new method to work. They are useful tools and powerful allies in establishing your territorial technical supremacy.