BASIC ACOUSTICS FOR THE CABLE TELEVISION STUDIO

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This tutorial paper shows how to calculate the optimum reverberation time for a studio, based on its volume and whether it will be used for voice or music. Also given is the calculation of the actual reverberation time, based on the studio's volume, surface area, surface materials and contents. Using three typical local origination size studios as examples, methods for improving reverberation time are given.

Once a local origination studio has been constructed to minimize the transmission of external sounds through its walls, doors and windows, consideration must be given to the acoustical treatments necessary to control the reflections of sounds within the studio. If reflections are not sufficiently attenuated, the studio will have an unpleasant "hollow" sound, and in extreme cases, intelligibility will suffer. On the other hand, too much attenuation will give the studio a "flat" sound, which can be psychologically annoying to performers. A measure of this characteristic is reverberation time, with the symbol t_{60}. Reverberation time is defined as the time required for a sound's amplitude to decrease 60 dB.

The optimum reverberation for a broadcast studio being used for speech is given approximately by:

$$t_{60} = 0.3 \log V - 0.65 \qquad (1)$$

V is the studio volume in cubic feet, and t_{60} is in seconds. For a studio used for music, a reverberation time 250 milliseconds longer than this may be used.

To calculate the actual reverberation time in a studio, the equation is:

$$t_{60} = \frac{0.049\ V}{-2.3\ S \log (1-\alpha)} \qquad (2)$$

S is the total wall, ceiling and floor surface area in square feet and α is the average sound absorption coefficient (or acoustic absorptivity) of these areas. Figure 1 gives the absorption coefficients for a number of typical wall, ceiling and floor surfaces.

FIGURE 1

APPROXIMATE ACOUSTIC ABSORPTION COEFFICIENTS*

WALLS	
PAINTED BRICK WALL	.02
PLASTER	.03
UNPAINTED BRICK WALL	.04
PLATE GLASS	.06
WOOD PANELING	.07
GYPSUM BOARD ON 2 X 4 STUDS ON 16" CENTERS	.11
3/8" PLYWOOD	.16
COARSE CONCRETE BLOCK	.34
HEAVY DRAPED FABRIC	.46
FLOORS	
CONCRETE	.02
WOOD	.04
LINOLEUM ON CONCRETE	.06
UNLINED CARPET	.30
CARPET WITH PAD	.40
ACOUSTICAL TILES CEMENTED TO WALLS OR CEILING**	
1/2"	.55
5/8"	.60
3/4"	.70
1"	.75

* BASED ON MEASUREMENTS BY THE ACOUSTICAL MATERIALS ASSOCIATION LABORATORY.

** EXACT COEFFICIENTS FOR A PARTICULAR PRODUCT AND MOUNTING METHOD MAY BE OBTAINED FROM THE MANUFACTURER.

Let's see how these equations can be used to calculate the acoustic requirements in a 12' wide, 18' long and 9' high studio. Its volume is (12)(18)(9)= 1944 cubic feet, and its wall, ceiling and floor surface area is (2)(12)(18) + (2)(12)(9) + (2)(18)(9) = 792 square feet. From Equation (1), the optimum reverberation time is:

$$t_{60} = 0.3 \log 1944 - 0.65 = .337 \text{ seconds}$$

Rearranging Equation (2) gives

$$\alpha = 1 - 10^{\left(\frac{-0.0213\, V}{S\, t_{60}}\right)} \qquad (3)$$

By substituting the t_{60} calculated above and the studio's volume and floor, ceiling and wall surface area into the equation gives a required average coefficient of absorption of $\alpha = .30$.

There are, of course, a number of ways by which this value could be achieved. But let's assume a concrete floor, 1/2" acoustical tiles on the ceiling and gypsum board walls. The present average coefficient of absorption can now be found by:

$$\alpha = \frac{\Sigma S_i \alpha_i}{S} \qquad (4)$$

$$\alpha = \frac{(12)(18)(.55)+(12)(18)(.02)+(60)(9)(.11)}{792} \qquad (5)$$

$$= .23$$

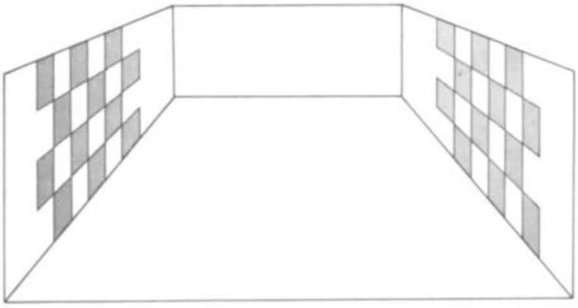
One way by which the average acoustical absorptivity could be increased from .23 to .30 would be by applying 1/2" acoustical tiles to an area, x, of the wall surface. Equation (5) would then become:

$$.30 = .155 + \frac{(540-x)(.11)+(x)(.55)}{792}$$

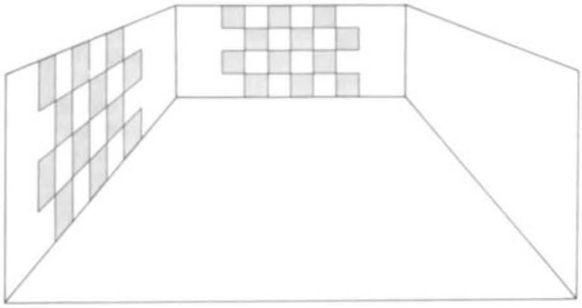
or:

$$x = 125.2 \text{ square feet}$$

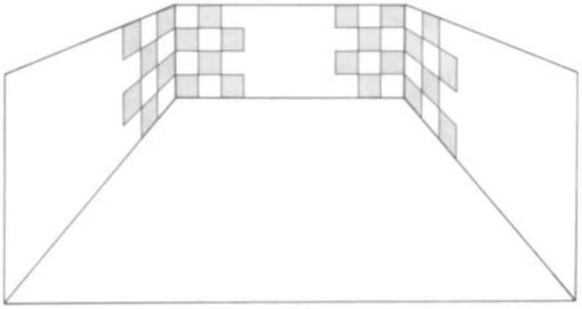
Some rules of thumb that are helpful in distributing this 125 square feet of acoustical material most efficiently are illustrated in Figure 2.



(B)

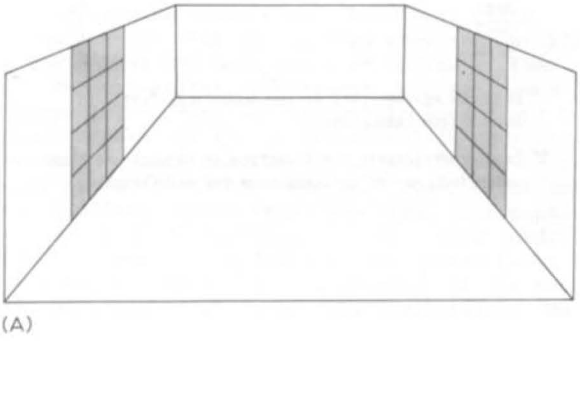


(C)



(D)

TIVE AB-SORPTIVE MATERIAL. DRAWING (B) REPRESENTS AN INCREASE IN EFFECTIVENESS OVER (A) BECAUSE THE MATERIAL HAS BEEN SPREAD OUT IN A CHECKERBOARD PATTERN OVER A LARGER WALL AREA. FURTHER IMPROVEMENT IS OBTAINED IN (C) WHEN THE MATERIAL IS PLACED ON ADJACENT, RATHER THAN OPPOSITE WALLS. IN (D) STILL ANOTHER IMPROVEMENT IS EFFECTED WHEN THE MATERIAL IS PLACED IN THE CORNERS, RATHER THAN ON THE CENTER, OF THE WALL SURFACES.



(A)

Let's look at a second example of an 8' long, 8' wide and 9' high announce booth with the ceiling and 50% of the wall area covered with 1/2" acoustical tiles and with a floor consisting of linoleum on concrete. The questions to be answered are: 1. What is the booth's reverberation time? 2. How much will the reverberation time be shortened by placing one person, a wooden chair and a small table in the booth? 3. How does this reverberation time compare with the recommended optimum?

The volume of the booth is (8)(8)(9) = 576 cubic feet, and its floor, wall and ceiling area is (2)(8)(8) + (32)(9) = 416 square feet. From Equation (4) and Figure 1:

$$\alpha = \frac{\Sigma S_i \alpha_i}{S}$$

$$= \frac{(64)(.55)+(64)(.06)+(144)(.55)+(144)(.11)}{416}$$

$$= .32$$

From Equation (2), the booth's reverberation time is:

$$t_{60} = \frac{0.049\ V}{-2.3 \times \log(1-\alpha)}$$

$$= \frac{(0.049)\ (576)}{(-2.3)(416)\ \log\ (1-.32)}$$

$$= \underline{.174 \text{ seconds}}$$

The effect which people and furnishings will have on reverberation time can be approximated by:

$$t_{60} \text{ (furnished and occupied)}$$

$$= \frac{S\alpha}{S\alpha+a}\ t_{60} \text{ (empty)} \qquad (6)$$

Where "a" is the acoustical absorption, in sabins, of the furnishings and occupants. The absorption of the person, chair and table is, from Figure 3, 4+1+1 = 6 sabins.

FIGURE 3

APPROXIMATE OCCUPANT AND FURNISHING ABSORPTIONS IN SABINS

SMALL TABLE	.3
WOOD CHAIR	.3
DESK	1.0
PERSON	4.0

From Equation (6):

$$t_{60} \text{ (furnished and occupied)}$$

$$= \frac{416(.32)}{416(.32) + 6}\ (.174)$$

$$= .168 \simeq \underline{.17 \text{ seconds}}$$

From Equation (1), the recommended reverberation time is:

$$t_{60} = 0.3 \log V - .65$$

$$= 0.3 \log 576 - .65$$

$$= \underline{.18 \text{ seconds}}$$

This is certainly close enough to the calculated .17 seconds, especially considering the tolerances on the acoustical absorptions and absorption coefficients we have used (about ± 20%).

Figure 4 shows the reverberation time versus average acoustical absorption coefficient for three typical local origination studios. The optimum reverberation time for each studio is also shown; it can be seen that most local origination studios will require an average acoustic absorption coefficient close to .3.

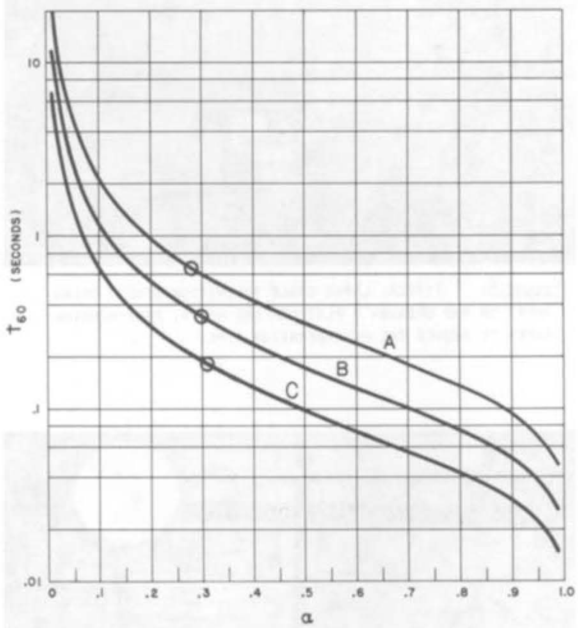


FIGURE 4: GRAPH SHOWING RELATION BETWEEN REVERBERATION TIME, T_{60}, AND THE AVERAGE ABSORPTION COEFFICIENT, α, FOR A LARGE 30 x 40 x 18 LOCAL ORIGINATION STUDIO (CURVE A), A SMALL 12 x 18 x 9 STUDIO (CURVE B) AND AN 8 x 8 x 9 ANNOUNCE BOOTH (CURVE C). THE CIRCLED POINTS ON THE GRAPH SHOW THE OPTIMUM REVERBERATION TIMES FOR THESE STUDIOS WHEN THEY ARE USED FOR SPEAKING; FOR MUSIC, REVERBERATION TIMES APPROXIMATELY 250 MILLISECONDS LONGER WOULD BE OPTIMUM.

Although these values and equations provide useful guidelines for determining the required acoustical treatment for a local origination studio, to do a rigorous acoustical analysis of a studio would require considering a number of additional factors beyond the scope of this paper, including the frequency spectrum of the sounds being created, the humidity in the room and the placement of objects and furnishings within the room.

Try these calculations on your studio. Maybe, with just a minor amount of acoustical treatment to the studio, your performers won't sound like they're inside a barrel any more.

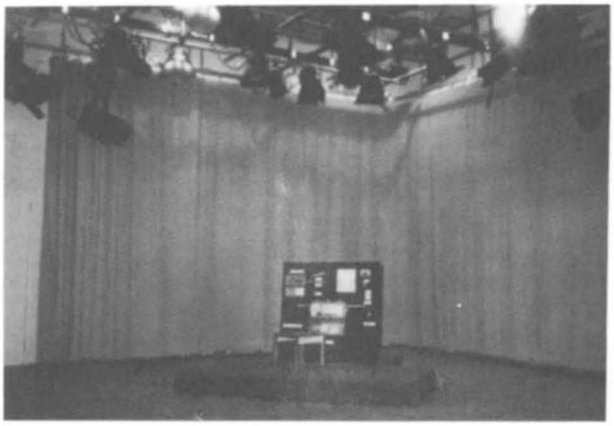


FIGURE 5: TYPICAL LARGE CABLE TELEVISION STUDIO USING CARPET ON THE SPEAKER'S PLATFORM AND HEAVY, FREE-HANGING DRAPES TO REDUCE THE REVERBERATION TIME.

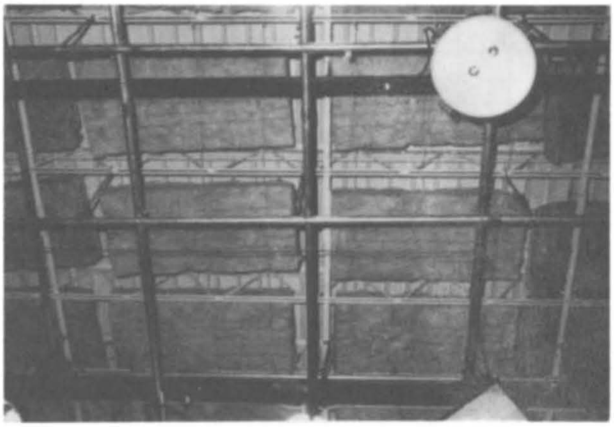


FIGURE 6: FIBER GLASS BATTS, 2' x 4' x 6", PLACED ABOVE LIGHTING BATTENS TO REDUCE REVERBERATION TIME.

REFERENCES

1. Sabine, Hale J., "Acoustical Materials", Handbook of Noise Control, 1957, Chapter 18.
2. Tremaine, Howard M., Audio Cyclopedia, Second Edition, 45-47.