Basic Considerations for Reverberation

EELE 217 Fall 2018

The *reverberation time* of a large room is specified by the number of seconds required for the sound pressure level to decrease 60 dB once the sound source is stopped. Reverberation time is often specified with the notation *RT60* or T_{60}. Because reverberation generally differs from one frequency range to another, it is important to specify T_{60} at a range of different frequencies in order to adequately describe a particular room.

Estimating room reverberation: The Sabine equation

The Sabine equation is a way to *estimate* the reverberation time for a large room. The *actual* measured reverberation time will likely be different than the Sabine estimate, but the equation is often useful in guiding the selection of surface treatment types and sizes.

$$T_{60} = \frac{0.161V}{\sum_i S_i a_i}$$

Sabine Reverberation Time (estimate) [seconds]

V = total volume in m^3
S_i = area of surface i in m^2
a_i = absorptivity of surface i

When located close to a sound source in a reverberant room, the sound field consists of the direct sound from the source plus the reverberant sound from the room. As one moves away from the source, the sound pressure level associated with the direct sound from the source decreases by 6dB for every doubling in distance, while the reverberant sound level remains roughly constant throughout the room. Thus, the *direct-to-reverberant* ratio changes from being dominated by the direct sound when near the source, to being mostly reverberant sound when located far from the source.

Room reverberation: the critical distance

The distance at which the direct sound level and the reverberant sound level are roughly equal is known as the critical distance for the room, often specified by the symbol r_d.

An estimate of the critical distance is given by the equation:

$$r_d = \frac{1}{4}\sqrt{\frac{\sum_i S_i a_i}{\pi}}$$

Critical Distance (estimate) [meters]

S_i = area of surface i in m^2
a_i = absorptivity of surface i

Roughly speaking, a microphone located closer to the source than the critical distance will pick up mostly the direct sound and proportionately less reverb, while a microphone located farther than the critical distance will receive mostly reverberant sound.

Table 12.5.1 **Representative Sabine absorptivities and absorptions**

Description	*125*	*250*	*500*	*1000*	*2000*	*4000*
	Frequency (Hz)					
	Sabine Absorptivity a					
Occupied audience, orchestra, chorus	0.40	0.55	0.80	0.95	0.90	0.85
Upholstered seats, cloth-covered, perforated bottoms	0.20	0.35	0.55	0.65	0.60	0.60
Upholstered seats, leather-covered	0.15	0.25	0.35	0.40	0.35	0.35
Carpet, heavy on undercarpet (1.35 kg/m^2 felt or foam rubber)	0.08	0.25	0.55	0.70	0.70	0.75
Carpet, heavy on concrete	0.02	0.06	0.14	0.35	0.60	0.65
Acoustic plaster (approximate)	0.07	0.17	0.40	0.55	0.65	0.65
Acoustic tile on rigid surface	0.10	0.25	0.55	0.65	0.65	0.60
Acoustic tile, suspended (false ceiling)	0.40	0.50	0.60	0.75	0.70	0.60
Curtains, 0.48 kg/m^2 velour, draped to half area	0.07	0.30	0.50	0.75	0.70	0.60
Wooden platform with airspace	0.40	0.30	0.20	0.17	0.15	0.10
Wood paneling, 3/8–1/2 in. over 2–4 in. airspace	0.30	0.25	0.20	0.17	0.15	0.10
Plywood, 1/4 in. on studs, fiberglass backing	0.60	0.30	0.10	0.09	0.09	0.09
Wooden walls, 2 in.	0.14	0.10	0.07	0.05	0.05	0.05
Floor, wooden	0.15	0.11	0.10	0.07	0.06	0.07
Floor, linoleum, flexible tile, on concrete	0.02	0.03	0.03	0.03	0.03	0.02
Floor, linoleum, flexible tile, on subfloor	0.02	0.04	0.05	0.05	0.10	0.05
Floor, terrazzo	0.01	0.01	0.02	0.02	0.02	0.02
Concrete (poured, unpainted)	0.01	0.01	0.02	0.02	0.02	0.02
Gypsum, 1/2 in. on studs	0.30	0.10	0.05	0.04	0.07	0.09
Plaster, smooth on lath	0.14	0.10	0.06	0.04	0.04	0.03
Plaster, smooth on lath on studs	0.30	0.15	0.10	0.05	0.04	0.05
Plaster, 1 in. damped on concrete block, brick, lath	0.14	0.10	0.07	0.05	0.05	0.05
Glass, heavy plate	0.18	0.06	0.04	0.03	0.02	0.02
Glass, windowpane	0.35	0.25	0.18	0.12	0.07	0.04
Brick, unglazed, no paint	0.03	0.03	0.03	0.04	0.05	0.07
Brick, smooth plaster finish	0.01	0.02	0.02	0.03	0.04	0.05
Concrete block, no paint	0.35	0.45	0.30	0.30	0.40	0.25
Concrete block, painted	0.10	0.05	0.06	0.07	0.09	0.08
Concrete block, smooth plaster finish	0.12	0.09	0.07	0.05	0.05	0.04
Concrete block, slotted two-well	0.10	0.90	0.50	0.45	0.45	0.40
Perforated panel over isolation blanket, 10% open area	0.20	0.90	0.90	0.90	0.85	0.85
Fiberglass, 1 in. on rigid backing	0.08	0.25	0.45	0.75	0.75	0.65
Fiberglass, 2 in. on rigid backing	0.21	0.50	0.75	0.90	0.85	0.80
Fiberglass, 2 in. on rigid backing, 1 in. airspace	0.35	0.65	0.80	0.90	0.85	0.80
Fiberglass, 4 in. on rigid backing	0.45	0.90	0.95	1.00	0.95	0.85
	Sound Absorption A in m^2					
Single person or heavily upholstered seat ($\pm$0.10 m^2)	0.40	0.70	0.85	0.95	0.90	0.80
Wooden chair, table, furnishing, for one person	0.02	0.03	0.05	0.08	0.08	0.05

Some typical criterion values for reverberation time are given in the table below:

Application	***125Hz***	***500Hz***	***2000Hz***
Classroom	0.9 sec	0.6sec	0.6sec
Church or theatre for speech or amplified music	1.3 sec	1.0 sec	1.0 sec
Church or theatre for music	1.8-2.0 sec	1.5 - 1.8 sec	1.5 - 1.8 sec
Convention facility	1.8 sec	1.5 sec	1.5 sec
Gymnasium for teaching	1.8-2.0 sec	1.5 - 1.8 sec	1.5 - 1.8 sec
Small arena (500 -2000 seats)	2.75 sec	2.0 sec	2.0 sec
Large arena (2000+ seats)	3.25 sec	2.75 sec	2.75 sec