MARKETING BULLETIN

Sound Reduction & Reverberation Calculations

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Example Calculation - Sound Reduction by Increased Absorption

Given: Factory Building - Average Sound Level 92 dBA.
Concrete Block (painted) Building 140' x 50' x 20' high
Concrete Floor
Roof Deck - 2" TECTUM™ Roof Deck or 1$^1/_2$" Steel Deck
Wood Doors - 1 of 240 s.f. and 2 of 24 s.f. each
16 Windows - 12 s.f. each
Machinery, etc. - absorption 150 sabins
Personnel - 12 men

To Find Calculated Reduction in Sound Level

1. List average absorption coefficient or NRC for each material (see pg 3 and 4).
NRC = The average of the four middle frequencies

		NRC
a.	Block Walls (painted)	0.07
b.	Concrete Floor	0.02
c.	2" TECTUM Roof Deck	0.60
	or 1$^1/_2$" Regular Steel Deck	0.01
d.	Doors	0.09
e.	Windows	0.16
f.	People - Average absorption about 4 sabins each	

2. Total Absorption (in Sabins) is equal to the Surface Area x the Absorption Coefficient

	Item	Area	Abs. Coeff.	Sabins
a.	Block Walls	7500 s.f.	0.07	525
b.	Concrete Floor	7000	0.02	140
c.	2" TECTUM Roof Deck	7000	0.60	4200
	or 1$^1/_2$" Regular Steel Deck	7000	0.04	280
d.	Doors	288	0.09	26
e.	Windows	184	0.16	29
f.	People - 12 x 4 Sabins each			48
	Total Sound Absorption with TECTUM Roof Deck			5248
	Total Sound Absorption with Steel Deck			1048

3. Calculated Change in Sound Level

$$= 10 \text{ Log } 10 \quad \frac{5248}{1048} = 10 \text{ Log } 10 \quad = 5.01$$

$$= 10\ (0.690)$$

$$= 6.9 \text{ or } 7 \text{ dB}$$

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The Noise Control Solution

4. Sound Level with TECTUM Roof Deck = 92 - 7 = 85 dB

5. Other Roof Decks. Similar calculations show that 2" TECTUM roof deck would be 5 dBA quieter than plywood and 6 dBA quieter than precast concrete.

6. The use of TECTUM sound absorbent wall panels can reduce the noise level still further. They can be mounted on the walls adjacent to the production equipment or may be used around a particularly noisy machine.

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REVERBERATION TIME CALCULATION SHEET

Job:____ Date: ____________________

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Type of Room (Gymnasium, Auditorium, Pool, Deck, Sanctuary, etc.) ____________________

Room Dimensions: L = ______________ W = ________________ H = _______________

Room Volume: (Vol. = L x W x H) _______ x _______ x_______ = _________ Cu. Ft. = V

	Type of Material	Absorption Coefficient	Area Sq. Ft.	Total Absorption
Ceiling	______________	____________	________	__________
Floor	______________	____________	________	__________
Walls	______________	____________	________	__________
	______________	____________	________	__________
	______________	____________	________	__________
Other	______________	____________	________	__________
Surfaces	______________	____________	________	__________
	______________	____________	________	__________

Total Existing Absorption (add all totals above) =__________ sabins = A

Estimated Existing Reverberation Time, $T = \frac{0.05 \times V}{A}$ = ______________ seconds = T

Desired Reverberation Time, DT = __________seconds (you pick this)

Absorption Required, $AR = \frac{0.05 \times V}{DT}$ = ____________sabins = AR

Estimated Add'l Units of Absorption Needed AU - Absp. Req (AR) - Exist. Absp. (A)

AU = AR - A = ______________ = ______________ sabins

Estimated TECTUM* Panel Required for Additional Absorption Needed _________________________

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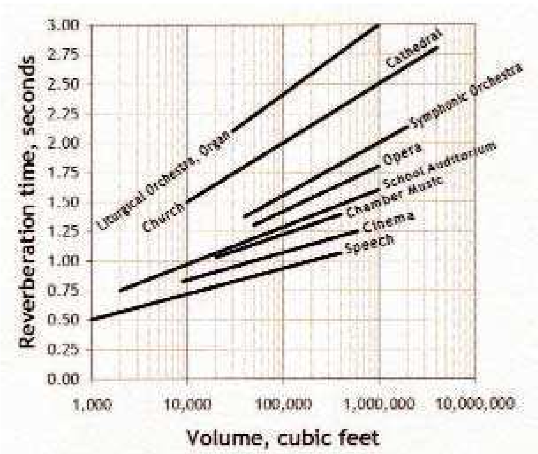
CAUTION: Actual field results may vary from estimated and calculated values. Calculations are based on recognized acoustical principles. Contact an acoustical consultant for additional information.

Reverberation

When the vocalist cuts off his note, the sound at the source will end immediately. The time delay in the ending of the direct sound from this note at the listener's position will be a function of the distance between the vocalist and the listener.

However, the sound waves which are already in the room will continue to travel back and forth between room surfaces, and a listener will hear them as a continuation, or echo, of the sound after it has stopped at the source. The sound waves lose energy by absorption at each successive reflection, and since this energy is no longer supplied by the source, the sound will die out gradually.

This prolongation of the sound after the source has stopped, due to continued multiple reflection, is termed reverberation. If sound dies out very slowly, a room is described as "live" or "excessively reverberant," and if it dies out very rapidly, a room is called "dead."



Recommended Optimum Reverberation Times for Various Room Uses.

Reverberation is an important factor governing hearing conditions and it has an important bearing on the "noisiness" of working areas.

Of special importance is its effect on the understanding of speech. If sound dies out very slowly in an auditorium used for speaking, the prolongation of each speech sound causes an overlapping and confusion of successive words or syllables which may render intelligibility extremely difficult or impossible. In rooms where quiet surroundings are desired, reverberation is annoying because it prolongs distracting noises.

Reverberation Time

The amount of reverberation in a room is measured by its reverberation time. This is defined as the number of seconds required for the energy of the reverberant sound in the room to die out to one millionth (or 1/10) of the value it had at the moment the source was cut off, which is the time it takes the sound to decay 60 dB.

The reverberation time is a basic acoustical property of a room which depends only on its dimensions and the absorbing properties of its surfaces and contents. In a typical room with normal acoustical treatment, the reverberation time is essentially the same throughout the room, regardless of the position of either the source or the listener; however, for unusual room designs, this may not be true.

The reverberation time as just defined corresponds roughly to the number of seconds which a sound of "average" initial loudness can be heard by a person with normal hearing acuity before it dies out to inaudibility under completely quiet conditions. This may vary typically from a fraction of a second in a very dead room to the order of 5 to 15 seconds in a very live room. Unfortunately in real life situations, most sounds are not of "average" initial loudness, and the background is never completely quiet. Therefore, it is difficult to roughly estimate reverberation time of a space by a subjective observation.

The reverberation time of a room, like the reflected sound energy, varies inversely with the room absorption, as defined above. However, reverberation time also varies directly with the volume and geometry of the room, being in general longer in large rooms and rooms with oblique angled surfaces. This follows from the fact that in a large room sound on the average travels farther between room surfaces, and therefore reflections and the accompanying absorption occur less frequently. Other complications occur in real life. Room shape can also enter into the picture. Long hallways or large rooms with low ceilings have grossly different reflection patterns than spaces that are more nearly cubic in shape.

Coefficients of General Building Materials and Furnishings

Complete tables of coefficients of the various materials that normally constitute the interior finish of rooms may be found in the various books on architectural acoustics. The following short list will be useful in making simple calculations of the reverberation in rooms.

Coefficients

Absorption Coefficients of Interior Finishes	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
Brick (unglazed), unpainted	0.03	0.03	0.03	0.04	0.05	0.07	0.04
Same, painted	0.01	0.01	0.02	0.02	0.02	0.03	0.02
Carpet, heavy on concrete	0.02	0.06	0.14	0.37	0.60	0.65	0.30
Same on 40oz. Hairfelt or foam rubber	0.80	0.24	0.57	0.69	0.71	0.73	0.55
Same with impermeable latex on 40oz. Hairfelt or foam rubber	0.08	0.27	0.39	0.34	0.48	0.63	0.37
Concrete Block, coarse unpainted	0.36	0.44	0.31	0.29	0.39	0.25	0.36
Same, Painted	0.10	0.05	0.06	0.07	0.09	0.08	0.07
Fabric, velour 10oz. Per sq. yd. hung straight							
In contact with wall	0.03	0.04	0.11	0.17	0.24	0.35	0.15
10oz. Per sq. yd. draped to half area	0.07	0.31	0.49	0.75	0.70	0.60	0.55
18oz. Per sq. yd. draped to half area	0.14	0.35	0.55	0.72	0.70	0.65	0.60
Floor - concrete or terrazzo	0.01	0.01	0.02	0.02	0.02	0.02	0.02
Asphalt, rubber or cork tile on concrete	0.02	0.03	0.03	0.03	0.03	0.02	0.02
Wood	0.15	0.11	0.10	0.07	0.06	0.07	0.08
Wood parquet in asphalt on concrete	0.04	0.04	0.07	0.06	0.06	0.07	0.06
Glass - Large panes heavy duty glass	0.18	0.06	0.04	0.03	0.02	0.02	0.04
Ordinary window glass	0.35	0.25	0.18	0.12	0.07	0.04	0.15
Gypsum board, 1/2" nailed to 2x4's 16" o.c.	0.29	0.10	0.05	0.04	0.07	0.09	0.06
Marble or glazed tile	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Openings, stage (depending on furnishings)			0.25 - 0.75				
Deep balcony, upholstered seats			.5 - 1.00				
Grills, ventilating			.15 - .50				
Plaster, gypsum or lime smooth finish on tile or brick	0.01	0.02	0.02	0.03	0.04	0.05	0.03
Plaster, gypsum or lime, rough finish on lath	0.14	0.10	0.06	0.05	0.04	0.03	0.06
Same with smooth finish	0.14	0.10	0.06	0.04	0.04	0.03	0.06
Plywood paneling 3/8" thick	0.28	0.22	0.17	0.09	0.10	0.11	0.14
Water surface as in a swimming pool	0.01	0.00	0.01	0.02	0.02	0.03	0.01
Air sabins per 1000 cubic feet at 50% RH				0.90	2.30	7.20	
Steel (Metal Roof Deck)							0.01

Absorption of Seats and Audience

Values given are in Sabins per square foot of seating area or per unit

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	NRC
Audience seated in uphostered seats per sq. ft. of floor area	0.60	0.74	0.88	0.96	0.93	0.85	0.88
Unoccupied upholstered seats (cloth) per sq. ft. of floor space	0.49	0.66	0.80	0.88	0.82	0.70	0.79
Unoccupied upholstered seats (leather) per sq. ft. of floor space	0.44	0.54	0.60	0.62	0.58	0.50	0.58
Wooden pews occupied per sq. ft. of floor area	0.57	0.61	0.75	0.86	0.91	0.86	0.78
Chairs, metal or wood seats each unoccupied	0.15	0.19	0.22	0.39	0.38	0.30	0.29
People = 4 Sabins each							