The BUNKER

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Concept

It was our desire to construct an environment that would allow us to listen to music. That was the first priority. The second was, we also wanted to audition the products that we sell without distraction and without the room actually being part of the equation.

Design

The design of the room has evolved over several years. Practical knowledge based on experience, the works of Dr. Floyd Toole, Loudspeakers & Rooms for Stereophonic Reproduction, Ninth International Conference, Audio Engineering Society, 1991; David B. Weems, Designing, Building & Testing Your Own Speaker System, 1990; and Great Sound Stereo Speaker Manual, 1990; Alfred W. Barber, Handbook of Hi Fi/Audio Systems and Projects, 1983: Alton F. Everest and Ron Streicher, The New Stereo Sound Book, 1991; The Encyclopedia Britannica; Robert Harley, The Complete Guide to High End Audio, 1994; and the suggestions and ideas many colleagues helped in the design of the facility.

Construction

The floor is 10 to 18 inches of solid steel reinforced silicone injected concrete. The walls are 9" concrete block. The block is surfaced on 16" centres with 1" industrial polyurethane foam, then a layer of 5/8" weather proof gypsum board, another layer of polyurethane foam, then a layer of 5/8" weather proof gypsum board. All air holes and construction deficiencies were finally filled with expandable polyurethane foam.

The rear wall was then covered with 1 x 6 clear BC cedar and 5/8" plywood angled from the ceiling at 106 degrees. The space behind the cedar and the wall has been left empty with no additional damping.

The ceiling is 1" x 6" clear BC cedar on 16" centres. The joists are 2" x 8" and are tied every 24". It is completely reinforced both laterally and vertically. Above the cedar we have between 6" and 16" of 6" thick fibreglass pink batt insulation. The sound transmission classification for this type of construction would be greater than 80 on average. Every ceiling light fixture and the sprinkler heads have been silicone damped and structurally isolated from the ceiling.

The 2-man doors are solid core, foam filled steel doors. They are magnetically sealed in steel frames. The side door is covered with 4" of Unifoam S82N. The French doors are solid oak with bevelled glass. Each glass panel has been silicone damped. The glass is covered with the same cotton drape as the opposite long wall.

The rear wall is covered in Unifoam S82N, from 1" to 8".

Execution

The bunker has a cubic volume of 3783.56 cubic feet. The beam occupies 14.4 cubic feet and the equipment display occupies 138.7 cubic feet. The front and rear walls are 16.2' and the side walls are 27.8' and 27.9'. The outside walls are 8.3' high, the inside walls are 9.10' height giving an average height of 8.7'.

Axial resonant modes occur through any room and we can calculate for potential problems. These modes occur when the distance between the room's walls equals half the wavelength of sound and at multiples of half a wavelength. Room resonance modes can severely effect bass response creating large dips or peaks in the frequency response. Robert Harley in his book 'The Complete Guide to High End Audio', explains: "A listening room's resonant frequencies are determined by the distance between the room's walls. The farther apart the walls are, the lower the resonant frequency. Specifically, the lowest resonant frequency, called the fundamental resonance, occurs when the room's length equals half the wavelength of sound. Put another way, a resonant mode will occur when the sound's wavelength is twice the length of the room. Other resonant modes occur at twice this frequency, three times this frequency, and so on. Whenever the length of the room is a multiple of half the sounds wavelength, a resonant mode will occur." Resonant modes also occur within the room from both the width of the room and the height.

The calculation for resonant modes is as follows; F1 = 1130/2L. F1 is the first resonant mode and 1130 is the speed of sound at sea level in feet per second, and 2L is 2 times the rooms length, height or width. Considering the Bunker has an average length of 27.75' the fundamental resonant frequency of the room will be (F1 = 1130/2 x 27.75) 20.36cps. We have calculated the other modes in order to eliminate any problems they may create. Resonant modes and reverberation time are 2 critical considerations when designing a listening room. Solutions to one problem seriously effect the other and a balance is sought every time a decision is made.

Reverberation time or decay time is defined as the time required for a sound in a given environment to fall from its original level to a level 60db down. This phenomena is described as the room's RT/60 factor. When in a room you must consider the RT/60 factor when listening to any source. We have all considered this factor when we describe a room as 'bright' or 'dead'.

There is no absolute, perfect, cast in stone decided RT/60 number that is correct for any room. Every room is different and every audible bit of information changes because of the room, atmospheric conditions, altitude and the number of people in the room and the source material. However, it is safe to predict certain phenomena when listening. If a room has a RT/60 that is too long, then we will experience a church like condition, almost an echo. If we were to speak or listen to music in this kind of environment for long, surely our nerves would be frayed. Alternately, if the RT/60 number is too low, the room would be equally as unpleasant. The spoken word would fall from our mouths and not reach the intended audience. The resulting feeling is that the room lacks warmth and there is no depth to the audio information. So what is the ideal number? Ideal for what? Ideal for whom? Speech is most intelligible in a room having an RT/60 of ¾ of a second. A large orchestra in a hall should have an RT/60 of 2 to 3 seconds. The problems are obvious. How do we cope with problem in our room? We certainly must communicate in it and we want to listen to music. Some of us may even want to listen to symphony orchestra.

Sound travels at the rate of 1130 feet per second. Sound is influenced by objects that it hits. Remember that sound waves are similar to light waves in as much as the angle of inclination is the same as the angle of reflection. Sound is absorbed by some things, reflected by others and diffused by many things. The bunker has been carefully designed to deal with these various parameters. To lessen the effect of resonant modes and to create the appropriate reverberation time, we made sure that the Bunker contained no right angles. The room is constructed of several different materials. A tapered beam 11” x 6” x 4” x 28’ spans the entire room acting as a large diffuser. Remember inclination and reflection. The absence of any right angles allows the sound to reflect from the surface in none parallel terms. This prevents standing waves and promotes a more balanced acoustic environment.

We generally quote frequency response from 20hz to 20,000hz. This range of frequencies react differently to different substances. High frequencies, above 3000hz are generally easier to deal with. We have used 100% short hair wool in the carpet. No strand is longer then ½”. High frequency information tends to follow each individual strand and dissipate more evenly. The carpet weight is 80 oz. per square yard. The under-pad is chipped foam urethane, 5/8” thick. The chips are of different density and absorb a wider frequency range then a solid foam pad.

One long wall is treated with a 100% cotton drape measuring 16’ x 8’. The fashioned pleats act not only as an absorber, they effectively diffuse higher frequencies. Even the valance has been tailored to a convex shape. The other long wall has 2 high frequency absorbers placed on the wall and in conjunction with the cotton drapes on the French doors, prevent unwanted reflections.

The equipment display stand acts as a diffuser. There are no right angles and the side panels are of different lengths to reduce standing waves. The top portion of the unit has been left open. Sound travels through the unit and is trapped in the Unifoam S82N which has been attached to the entire wall. Unifoam S82N is a flexible polyester urethane fine cell foam designed as an acoustical absorber. The thickness varies from 1” to 8” and effectively absorbs frequencies from 60 to 6300 cps. This ‘bass trap’ gives the room outstanding low frequency qualities.

After the basis room was constructed, measurements were taken to determine the resonance modes and the RT60 value. The various elements that are mentioned above were valued, tested and installed. Several adjustments had to be made during the installation.

The results are quite outstanding. The RT60 value is somewhat variable and currently measures .6 of a second. The room is exceptionally solid with no perceptible vibration. The opening below the French doors acts as a ‘port’ and can be tuned as required.

All the speaker wire and interconnects are from Audioquest. The speaker connections are all made with XLR connectors, all gold plated and silver soldered.

The room has occupancy sensors for lighting and an ONKYO infra red control. There are 5 preset lighting programmes from which to choose.

Our installation includes the most recent MTI switching system, making audio and video comparisons instantaneous.

No expense was spared. We created the room we wanted and needed.

Please enjoy it.

BUNKER

AXIAL RESONANT MODES

	LENGTH 27.75	WIDTH 16.17	HEIGHT 8.58
F1	20.36	35.05	65.85
F2	40.72	70.10	131.70-
F3	61.08	105.15	197.55
F4	81.44	140.20	263.40
F5	101.80	175.25	329.25
F6	122.16	211.02	
F7	142.52	245.35	
F8	162.88	280.40	
F9	183.24	315.45	
F10	203.60		
F11	223.96		
F12	244.32		
F13	264.68		
F14	285.04		
F15	305.40		

F1-1130/2L

LENGTH	WIDTH	HEIGHT
101.80	105.15	197.55
142.52	140.20	263.40
203.60	245.35	
244.32	280.40	
264.68		
285.04		

WAVELENGTH of SOUND

FREQUENCY			FREQUENCY		
(Gz)	(m)	(in)	(Hz)	(mm)	(in)
100	3,4	134	2500	136	5,3
150	2,26	82	3000	113	4,5
200	1,7	67	4000	85	3,4
300	1,13	45	5000	68	2,7
400	0,86	34	8000	42,5	1,7
500	0,68	28	10000	34	1,3
800	0,43	16,8	12000	28	1,1
1000	0,34	13,2	15000	23	0,88
1500	0,23	8,9	18000	19	0,74
2000	0,17	6,7	2000	17	0,66