Sound-Proofing: The Quest

CLDMs, Mass Loaded Vinyl, and other products & techniques

By John H. Brandt

Background:

I am mainly involved in Recording Studio Design and other Music Listening rooms. I also design Performance Venues, Home Theater, as well as Conference Rooms, Lecture Halls, and consult/design Industrial noise control applications. I do not sell any of these products but do specify many of them in my designs.

The Quest: The following will explain/describe the methods and reasons **why** I will specify a particular product and/or **why** I will not recommend them in particular cases.

It is very important that you read through this entire paper so that you can think objectively about all the data that has been presented.

I shall begin by describing and explaining the method and process that we use for Sound Transmission Loss (STL) testing. The resulting data is delivered in a single number format call STC (Sound Transmission Class).

This STC rating is determined by analyzing data obtained by International Standard measurement rules, i.e.; ASTM and ISO standards. STC only covers the frequency range from 125 Hz thru 4 kHz; the frequency range of speech. ***It is very important to take into account the fact that we are dealing with Music and its frequency range covers the full scale of human hearing.***

For further reading and understanding on this subject you can download a paper written by Eric Desart on my publications page, “STC_MTC_OITC_RW.pdf”

The table below shows the recommended maximum time of exposure to certain noise levels in accordance with the Ontario (Canada) Ministry of Labor. This is only used as an example. Similar regulations and recommendations have been drafted by most countries.

Table 1 – Maximum Allowable Exposure (based on the equivalent sound exposure level in section 139 of the Regulation for Industrial Establishments (Reg. 851))

Duration	Steady Sound Level (dBA)
8 hours	85
4 hours	88
2 hours	91
1 hour	94
30 minutes	97
15 minutes	100

Music performance spaces can often produce noise levels in excess of 110 decibels. See chart below:

The following chart is from The University of Iowa, sound awareness page: (http://www.uiowa.edu/~ui-safe/music-sound-levels.html)

SOUND LEVEL (dBA)	EXAMPLE
129	Rock or Jazz Music
118	Piccolo
114	Flute
112	Amplified Guitar
111	Steel Drum
110	Orchestra or Symphony
108	Trumpet
105	Pop Music
104	Cello
102	Oboe
100	Bass Drum
99	Opera
92	Classical Music
90	Piano
82	Single Clarinet

The next chart shows a Table with corresponding SPL & Sound Intensity (energy multiple)

Table of sound levels L (loudness of noise) with corresponding sound pressure and sound intensity			
Sound sources (noise) Examples with distance	**Sound pressure Level L_p dB SPL**	**Sound pressure p N/m² = Pa Sound field quantity**	**Sound intensity I W/m² Sound energy quantity**
Jet aircraft, 50 m away	**140**	**200**	100
Threshold of pain	**130**	**63.2**	10
Threshold of discomfort	**120**	**20**	1
Chainsaw, 1 m distance	**110**	**6.3**	0.1
Disco, 1 m from speaker	**100**	**2**	0.01
Diesel truck, 10 m away	**90**	**0.63**	0.001
Kerbside of busy road, 5 m	**80**	**0.2**	0.000 1
Vacuum cleaner, distance 1 m	**70**	**0.063**	0.000 01
Conversational speech, 1 m	**60**	**0.02**	0.000 001
Average home	**50**	**0.006 3**	0.000 000 1
Quiet library	**40**	**0.002**	0.000 000 01
Quiet bedroom at night	**30**	**0.000 63**	0.000 000 001
Background in TV studio	**20**	**0.000 2**	0.000 000 000 1
Rustling leaves in the distance	**10**	**0.000 063**	0.000 000 000 01
Hearing threshold	**0**	**0.000 02**	0.000 000 000 001

As you can see from the information presented above, a rock band at 130 decibels can be One Million times louder than a vacuum cleaner at 1 meter (about 3 feet) distance. Also the sound (noise) spectrum of music extends to sub-harmonic frequencies (not heard, but felt).

Herein lies the challenge; How does one control and/or contain this powerful low frequency energy? The solution to this challenge is complicated by the varied situations involving music performance, recording, and listening. We need to list the requirements (see below) for successful noise isolation so that we can devise a subjective solution because **one size does NOT fit all**. Following a common *rubber stamp* solution often creates more problems than it solves.

1. Location:
   a. Is the building residential or commercial?
   b. Is the proposed facility a stand-alone structure or is it connected to other buildings/houses?
   c. Will the proposed facility be located on the ground floor of the building or upper floors? If upper floor, which one?
   d. What are the building materials used in the structure?
   e. Are there nearby noise sensitive neighbors?
   f. Are there nearby noise producing neighbors?
   g. If e. & f. answers are yes, Please describe; who, what, when, where, & how?
2. Requirements:
   a. What is the proposed use of the facility or room?
   b. What is the highest level of noise to be produced in the facility or room?
   c. What is your permissible level of distraction? That is a loaded question but usually a room is rated by NC (Noise Criteria) or NR (Noise rating) and this one number system describes 'how quiet' a room will be. I.e.; the recommended level in a recording studio should be NC-15 to NC-20, or NR-25.
   d. Will this facility be for personal or professional use?
3. Budget & Labor:
   a. What is your budget for this project?
   b. Will you be doing the work yourself (DIY) or hiring professionals?
   c. If you are building DIY, what is your skill level?

NOTE: It is important to determine your skill level if you are to succeed at creating acoustic isolation and while it is NOT rocket science, it might be a good idea to hire a professional to do the design and/or the work.

4. Other requirements:
   a. Electrical and noise?
   b. HVAC? Heating & Cooling as well as fresh air ventilation is critical in a perfectly sealed, acoustically isolated enclosure. Connecting two rooms with ventilation ducts can completely ruin an otherwise good acoustic isolation shell. Requirements for isolation and air flow noise must be considered.

c. Environmental noise such as wind, rain, thunderstorms and even commercial aircraft passage overhead should also be taken under consideration.

Once you have hard data and answers to the questions/requirements above, you can begin to sort out what needs to be done to accomplish the task.

CLDMs

In terms of isolating walls I will offer the following testing data so that we can compare a couple of test cases. I was not able to obtain completely accurate reference testing data, - for example testing of certain CLDMs (Constrained Layer Damping Materials, ie; Green Glue, Quiet Wave, Quiet Glue, etc.) or MLV (Mass Loaded Vinyl). It could be that the manufacturer(s) would prefer to have results skewed in their favor. (I am not saying that this is a bad thing, - it's simply human nature – just be aware.)

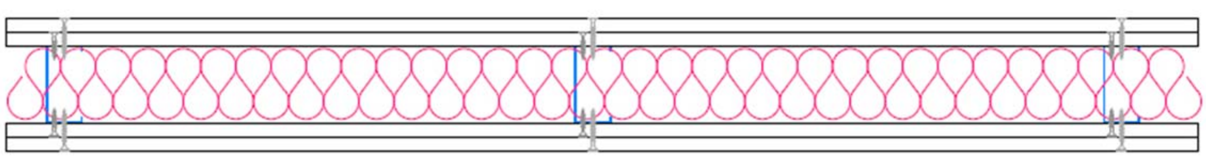
For example;

The Green Glue company has two reference files available; Green-Glue-OL06-0634.pdf (double steel reference assembly), and Green-Glue-OL06-0635.pdf (staggered reference assembly), however neither of these are applicable since there were no identical assemblies tested (with Green Glue) so that we can see the comparison. Therefore;

Reference test Assembly: (You can find this information on page 151 of **ir761** from NRC-CNRC and available on my publications page)

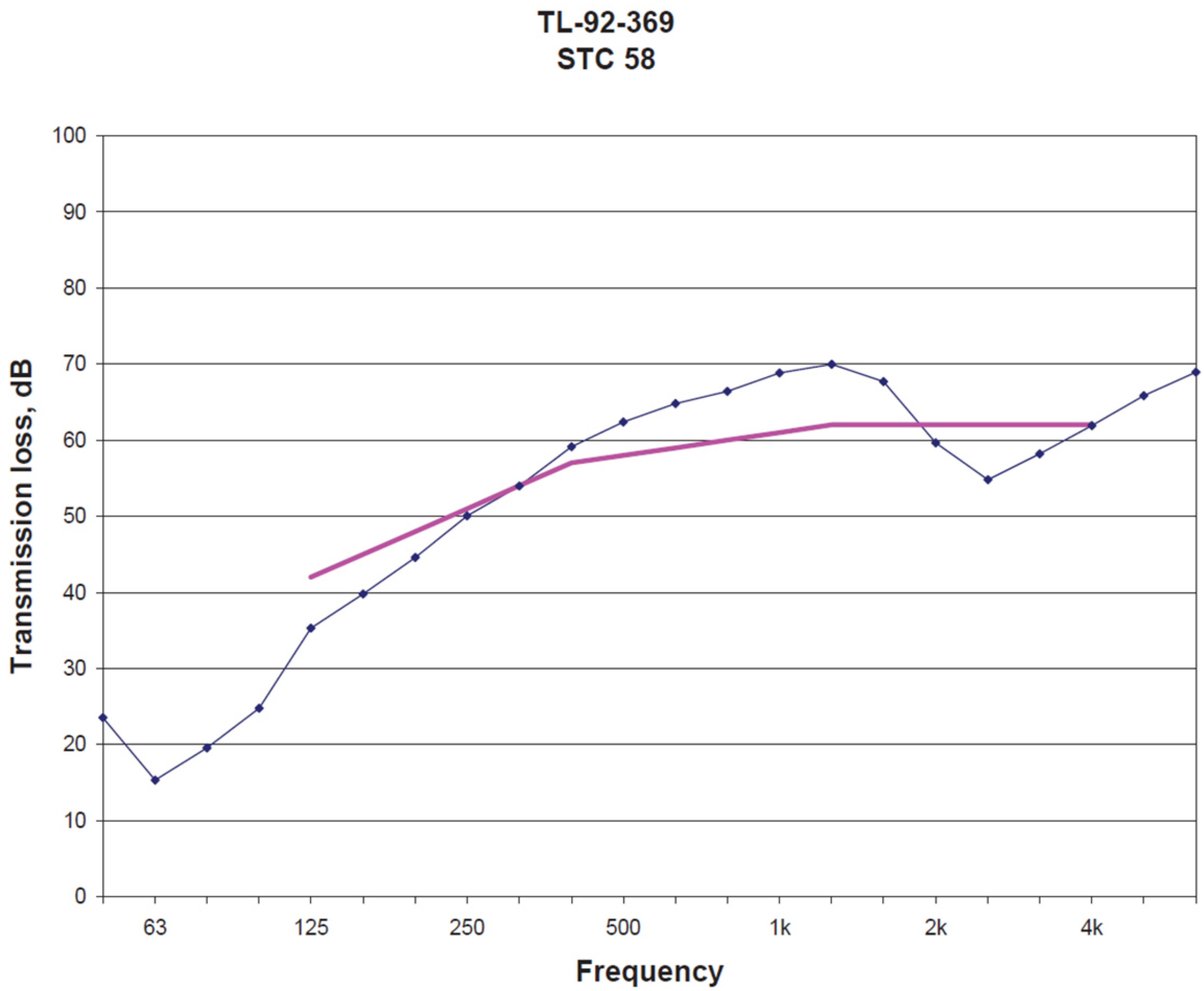
The reference tests were performed by the Institute for Research in Construction of the National Research Council Canada (IRC/NRCC). Wall specimens were mounted in a removable test frame between the two chambers, without rigid contact to either reverberation chamber. The wall test opening measured 3.05 m x 2.44 m - **area = 7.442 m2** (10 ft. x 8 ft. = 80 square feet). The volume of the source room was 65 m3. The volume of the adjacent receiving room was 250 m3.

Reference Assembly Description:
Single layer of 16 mm (5/8") type X gypsum board
Single layer of 16 mm (5/8") type X gypsum board
90 mm (3 17/32") steel studs at 610 mm (24") on center
90 mm (3 17/32") of glass fiber insulation in cavity
Single layer of 16 mm (5/8") type X gypsum board
Single layer of 16 mm (5/8") type X gypsum board



This assembly produces a result in the lab of STC-58. This is in a laboratory setting with floor and ceiling flanking paths reduced to their minimum. It is not realistic to assume that you will obtain this degree of isolation in the field.

The Resulting STC chart:

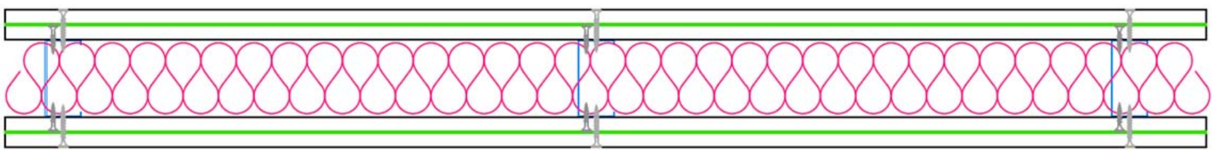


Next we will examine the data produced for the Green Glue company at Orfield Laboratories. This testing was done in a different lab and with a different sample size. In all fairness, these small differences must be taken under consideration in this comparison and this comparison must not be taken as 'the facts'. (If only the Green Glue company would release the reference data so that we all could see the accurate reference, we would not need to 'assume'.)

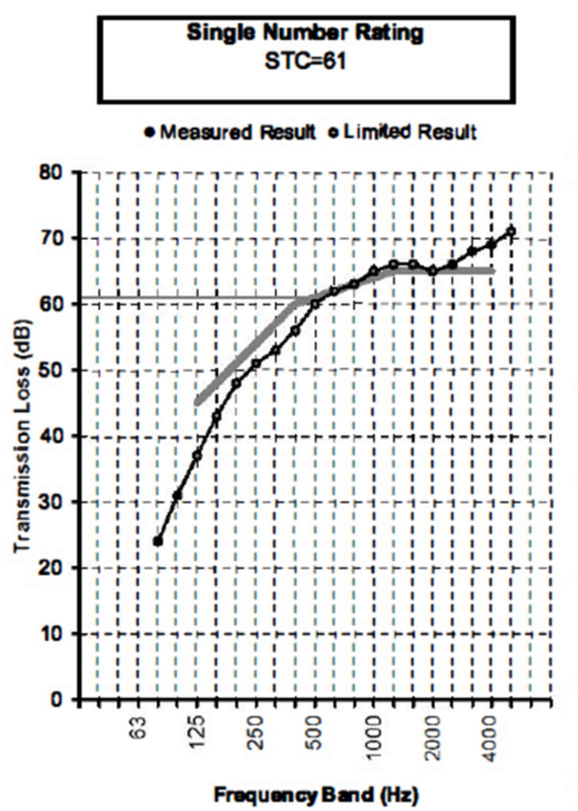
Green Glue assembly: (You will find this information in Green-Glue-OL06-0942.pdf available from most Green Glue distributors online)

These tests were performed at Orfield Laboratories. Wall specimens were mounted in a removable test frame between the two chambers, without rigid contact to either reverberation chamber. The wall test opening measured 2.46 m x 2.44 m - **area = 5.99 m2** (8' ¾" x 8 ft. = 64.5 square feet). The volume of the source room was 93 m3. The volume of the adjacent receiving room was 234.5 m3. (NOTE**: ** Smaller test samples will often produce higher STC results since there are fewer seams in the panels.**)**

Assembly Description:
(listed in order from source room side to receiver room side)
0.625" (5/8") gypsum drywall; 2" Screws @ 12" O.C.
Green Glue @ 58 oz. (2 tubes) per 4x8 sheet (116 oz. total)
0.625" (5/8") gypsum drywall
3-5/8" 25 gauge steel studs @ 24" O.C.
3.5" R13 glass fiber batts
0.625" (5/8") gypsum drywall
Green Glue @ 58 oz. (2 tubes) per 4x8 sheet (116 oz. total)
0.625" (5/8") gypsum drywall; 2" Screws @ 12" O.C.



The Resulting STC chart:



So, according to the above, we have a 3-point gain with the Green Glue.

These are identical tests with identical assemblies except for the different **size** assemblies and in different labs - but it is all that I have to compare and objectively, I must be skeptical. There have been times when I have used Green Glue and it produced the desired effect. But usually, in professional builds, I have not found that it is cost-effective in materials plus labor and usually opt to simply add another layer of gypsum board or plaster skim-coat on block walls for the added mass and subsequent increase in sound transmission loss.

Mass Loaded Vinyl

Sound is reflected and attenuated by mass. A dense, heavy mass is preferable and a mass that is limp, not rigid or stiff, is even better. This is the reason that stud spacing in construction will change the sound transmission loss. 60 cm on center or 24” stud spacing will obtain better isolation results because the wall is not as rigid as a stud wall that is 40 cm or 16” on center.

In the past, LEAD sheeting was used in blankets for enclosing noise sources, draped around equipment, suspended between equipment and quiet areas, or lagged to the equipment casing. Today we do not use lead in this fashion for its obvious dangers and toxicity.

Enter mass loaded vinyl. PVC is mixed with heavy barium and extruded in sheets. This is environmentally friendly, non-toxic, and does the job. There are many applications for this great product. I have already listed the major uses for MLV above. Many manufacturers of this product sell it to DIY’ers for sound-proofing their homes and businesses. I am not convinced that MLV is the most cost & labor effective solution. Here is why:

In most cases, it is applied directly on the studs with one or two layers of gypsum board against it. The wall cavity is filled with fiberglass or other insulation material which will press the MLV sheet tightly against the gypsum board. Though the MLV will always remain flexible, in this configuration it will be heavily damped and will **not** be limp. Therefore, its only purpose is to add mass.

MLV sheets are usually available in surface densities of 1psf and 2psf (4.9kg/m² and 9.8kg/m²).

Costs vary but the following is an average price available online:
1psf - $1.15 - $1.40 per square foot
2psf - $2.16 - $2.58 per square foot

Gypsum board is by comparison: common thickness and densities (USG data)
½” (12.5mm) - 1.6psf - $0.32 per square foot
5/8” (16mm) - 2.2psf - $0.40 per square foot

Apples to apples would be MLV - $1.40 ft² vs. Gypsum board - $0.20 ft². This would be for 1 pound per square foot and produce the same result in sound transmission loss. The cost of using MLV is 7 times the cost of gypsum board.

The use of MLV under flooring is similarly wasteful.

Companies that sell mass loaded vinyl display the STC of the raw materials in a way that one would never use the product. I have yet to see comparison testing of gypsum board walls with and without MLV added. The Green Glue company has two tests with MLV; Green-Glue-OL05-0822.pdf & Green-Glue-OL05-1054.pdf, however there is no comparison testing available and I can't presently find any other testing of similar partitions without the MLV for reference.

Now, if we are talking about 'sound-proof' curtains or limp partitions; MLV is the ONE thing that definitely fits the bill. Sticky-backed MLV is GREAT for quieting the thin metal case of the standard PC. Got a humming metal fixture? Pop some sticky-backed MLV on it. Good stuff!

- But not for sound-proofing walls.

Wall Cavity Insulation (Absorption)

Absorptive material inside the cavity of a single stud partition (wood with resilient furrings or steel) or a staggered wood stud partition increases the STC rating by 5 to 9 points depending on the type of sound absorptive material used. For double wall partitions, an increase of 10 to 13 points can be obtained depending on the amount of glass fiber insulation added to the cavity.

At low frequencies, the increase in the transmission loss of a partition obtained by adding absorptive material inside its cavity is **equivalent** regardless of the material used. Above 250 Hz, mineral fiber and blown cellulose give the best results; mineral fiber insulation provides slightly better transmission losses than glass fiber, especially around the wall panel's resonant frequency. Please note again that the improved transmission loss occurs above 250Hz, and in a normally high STL partition built to contain music this gain will be imperceptible, therefore using denser material at higher cost is NOT necessary.

With the exception of sprayed cellulose, the best transmission losses were obtained when the entire cavity of the partitions were filled with a sound absorptive material. When the entire cavity is filled, caution must be taken not to use a material that is too dense or too thick otherwise a mechanical coupling could occur between the two sides of the partition which could result in a degradation of the sound isolating performance of the partition, as was observed in the case of a partition whose cavity was filled with sprayed-on cellulose. Never compress fiberglass into a partition cavity.

Conclusion: Use only light-weight fiberglass (R13 to R30, or similar) insulation in partition cavities.

If you have any comments, suggestions, or corrections, please contact me john@jhbrandt.net

- John H. Brandt