SUPERIOR PRODUCTS
INTERNATIONAL II, INC.

SUPER THERM®
NOW A PROVEN "SOUND PROOFING BARRIER"

SUPER THERM® provides a heat barrier to provide a comfortable environment and reduce energy consumption, and SUPER THERM® now offers sound reduction and deadening for apartments, office buildings, schools, industrial buildings, railway facilities, and much more.

SOUND TESTING BY VTEC LABORATORIES:

STC Testing for SUPER THERM® conducted by VTEC Laboratories on November 22, 2005, is attached.

Most sound that the human ear can detect is reflected in the mid range frequencies Hz. SUPER THERM® works best in these frequencies for use on walls of apartments, hospitals, office buildings, etc. The low frequency is a fog horn which is not the normal range of sound.

The overall rating at the bottom of each page is gauged by the performance on the low frequency and this dictates the rating although this frequency is not normally what you hear in a building. Midrange sound vibration or frequencies are the main frequencies of sound.

Looking at the frequencies and knowing how SUPER THERM® works at the midrange frequencies, SUPER THERM® performs into the range of sound deadening required by building codes. Above 40 rating is good with the 50 rating as the desired.

SOUND TESTING BY HOT-COLD AIR & FIRE CONTROL:

Sound Testing for SUPER THERM® conducted by Hot-Cold Air & Fire Control (Pat Saulson, PhD.) is attached.

INTERIOR WALLS

Coated with two coats of SUPER THERM® provided sound insulation as shown in Table 1 of the testing materials.

Sound was reduced an average of 50.2% by using SUPER THERM® on the interior walls of a house.

EXTERIOR WALLS

SUPER THERM® is being tested now for sound insulation on the exterior walls. Preliminary tests show a 23% sound reduction.

Eagle Specialized Coatings And Protected Environments
18523 Fraser Hwy, Surrey, BC, CANADA V3S 8E7
Tel: (604) 576 - 2212
Fax: (604) 576 - 7773

SOUND TEST RESULTS STC

These are the test results on the sound testing.

The mid range frequencies Hz are where most sound that the human ear can detect. In this are is where SUPER THERM works best. For use over walls for apartments, hospitals, office buildings, etc. is ideal.
The low frequency is a fog horn which is not the normal range of sound.
The overall rating at the bottom of each page is gauged by the performance on the low frequency and this dictates your rating when this is not what you hear in a building. Midrange sound vibration or frequencies are the main sound travel.

But, looking at the frequencies and knowing how SUPER THERM works at the midrange frequencies, SUPER THERM performs into the range of sound deadening needed by the building codes.

Above 40 rating is good with the 50 rating as the desired.

J.E.

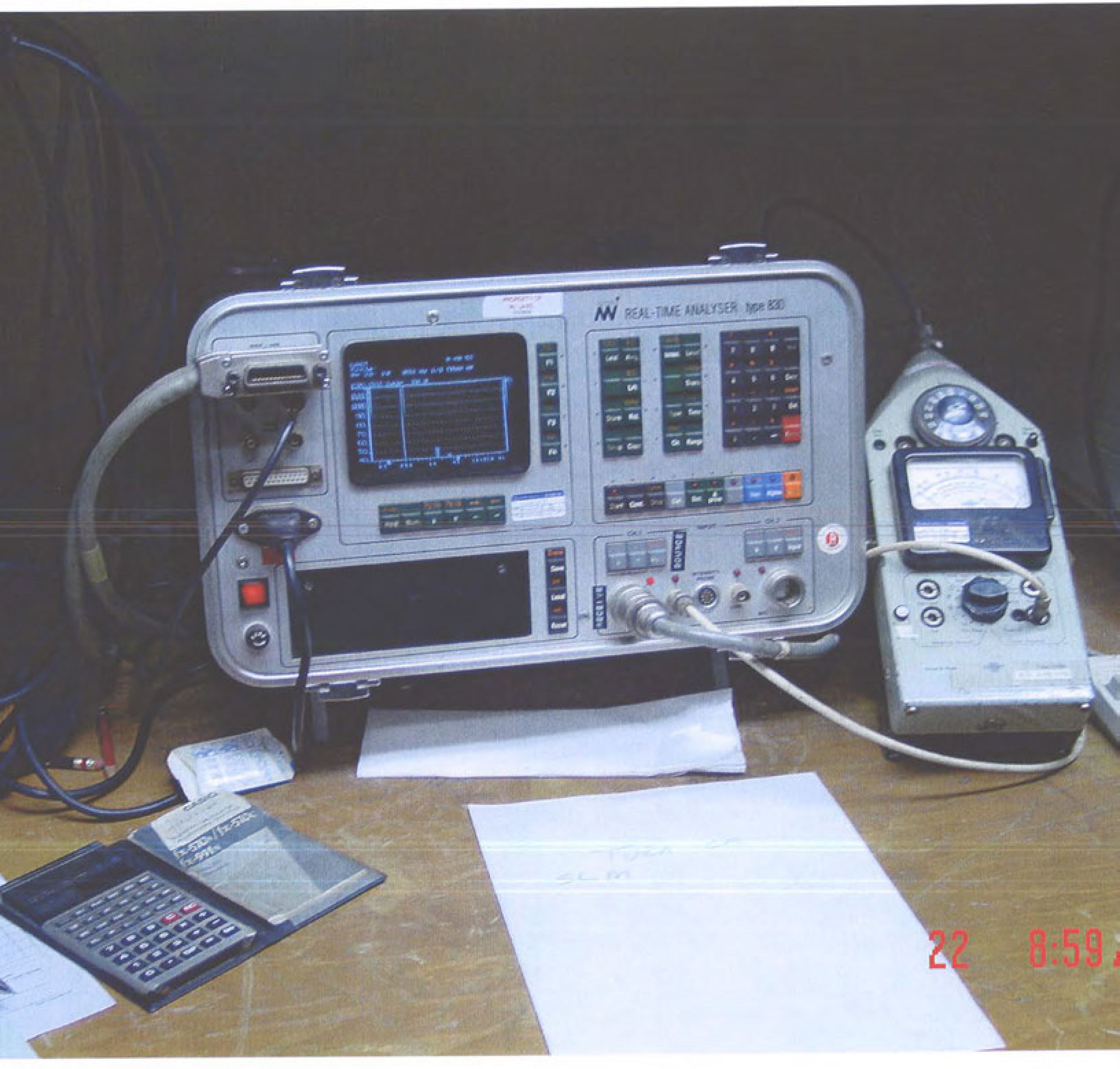
Sound Testing
Explanation of Results

STC is the methodology established by ASTM, which combines TLs into one number for comparisons

STC expressed in dB. If we know the input sound volume in dB, then we can say TL 40 means that 40dB was reduced from input sound volume by Super Therm.

The sound reduction at each 1/3 octave is independent of the starting dB at that octave. You should get about the same attenuation regardless of the starting sound level for that frequency.

Therefore, when the number is given for each frequency in STC, this is the dB drop in sound. If the STC is 40 for that frequency, then that means it is a 40 dB drop in that frequency.


REAL-TIME ANALYSER type 830
22 8:59


22 8:40 AM

SOUND TESTING RESULTS ABOUT THE SAME AS FIBERGLASS

http://www.sizes.com/units/sound_transmission_class_stc.htm

Shows STC for fiberglass about the same as Supertherm.

Some Typical STC Ratings

2 × 4 on 16" or 24" centers, 3/8-5/8 inch wallboard, rock wool or fiberglass batting	STC 30 to 42
Same as above with plaster instead of wallboard	STC 40 to 54
Staggered stud 2 × 4's on 2 × 6 plate, 2 sheets of 5/8 inch plasterboard on each side, 2" fiberglass inside	STC 51

Caveats

The STC system is useful for comparing different ways of building a partition, but it is not a guarantee of a certain level of isolation. It tends to give too much credit to materials which absorb high frequencies, such as sheetrock, and too little to materials and forms of construction which absorb the lower frequencies

http://www.sota.ca/stc_info.htm

The above URL shows lab versus field STC rating comparison. Notes that building code for separating dwellings needs to be 51. Also indicates Super Therm would not be enough to stop loud music alone, which is McDonough's application in Hong Kong.

In practice, the STC of the laboratory sample represents the optimum condition, and is rarely achieved in actual construction. The difference between the actual or Field STC (FSTC) and the laboratory STC is a result of leaks and flanking paths, in other words, sound entering a wall in a common assembly is also entering the floor, traveling through the floor and breaking out in the adjoining space, by-passing the wall. A similar effect is found if sound is allowed to enter air return plenum spaces above or below walls. The degree to which these flanking paths are disconnected will determine how closely the field test results approach the laboratory results.

STC -Lab	Field STC	Subjective description of effectiveness
26-30	20-22	Most sentences clearly understood
30-35	25-27	Many phrases and some sentences understood without straining to hear
35-40	30-32	Individual words and occasional phrases clearly heard and understood
42-45	35-37	Medium loud speech clearly audible, occasional words understood
47-50	40-42	Loud speech audible, music easily heard

52-55	45-47	Loud speech audible by straining to hear; music normally can be heard and may be disturbing
57-60	50-52	Loud speech essentially inaudible; music can be heard faintly but bass notes disturbing
62-65	55	Music heard faintly, bass notes "thump"; power woodworking equipment clearly audible
70	60	Music still heard very faintly if played loud.
75+	65+	Effectively blocks most air-borne noise sources

Table 1: Subjective interpretation of effects of STC as measured (assumes normal/quiet background level - NC 35)

Note: The actual effect perceived effect of STC depends on the background noise levels, room volumes, surface areas, sound absorption values and spectral content of the sound source.

WHAT IS STC?

The actual behavior of two partitions with the same STC rating can be dramatically different, as the STC is weighted in favor of the part of the sound spectrum that represents the human voice. In practice, one of the most annoying transmitted sounds between dwelling units tends to be the bass in music, a part of the sound spectrum far removed from the voice range. So, an eight inch concrete block wall rated at STC 50, that can block 20 dB more sound in some bass frequencies would be a better choice than an STC 50 drywall partition for an application where music or mechanical noise will be a problem.

Changes in the National Building Code 1990, now require that partitions separating dwelling units meet an STC 50 requirement, and the building code provides sample ratings for several types of wall constructions. Unfortunately, test ratings of the same wall section vary from test to test, and in field situations, walls cannot be expected to perform as well as the test sample in laboratory conditions. This drop in performance can leave the builder liable for additional construction to bring up the performance of the wall if the tenants obtain field test results from the dwelling units that confirm a reduced STC.

For example, a wall section listed by the NBC 1990 as meeting the STC 50 requirement has staggered 2 x 4 wood studs on a 2 x 6 plate with batt insulation filling the cavity and a single layer of drywall either side. In laboratory tests, the STC rating of that particular wall section varies from STC 47 to STC 51. In field tests, the wall might get only about STC 46, even with caulking at the plates. Any cracks in the wall or holes for electrical or mechanical servicing will further reduce the actual field result, leaving the builder responsible for upgrades. Rigid connections between wall surfaces can also seriously degrade the wall performance. The higher the target STC, the more critical are the sealing and structural isolation requirements. The builder's best options for getting a satisfactory STC result are to specify partitions with a laboratory rating of STC 54 or better. If in doubt at an early stage in the construction, testing can be done to rate the construction and upgrades recommended before costly finishing is in place.

STC TESTING
FOR
SUPERIOR PRODUCTS INTERNATIONAL II
ON
SINGLE WALL EXTERIOR COATED
VTEC #100-2251-1
TESTED: NOVEMBER 22, 2005

December 9, 2005

Client: Superior Products International II
10835 W. 78th Street
Shawnee, KS 66214

Attn: J.E. Pritchett

Subject: Measure sound transmission loss per ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions."

Determine sound transmission class per ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

DISCLAIMER:

This is a factual report of the results obtained from the laboratory test of sample products. The results may be applied only to the products tested and should not be construed as applicable to other similar products of the manufacturer. The report is not a recommendation or disapprobation by VTEC Laboratories Inc., of the material tested. While this report may be used for obtaining product acceptance, it may not be used in advertising.

NOTICE:

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I. INTRODUCTION

The sound transmission loss of a partition in a specified frequency band is the ratio, expressed on the decibel scale, of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. The ratio of two like quantities proportional to power of energy is expressed on the decibel (dB) scale by multiplying its common logarithm by ten.

II. TEST METHOD

The measurements were made in accordance with ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions." The sound transmission class, STC, was determined in accordance with ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

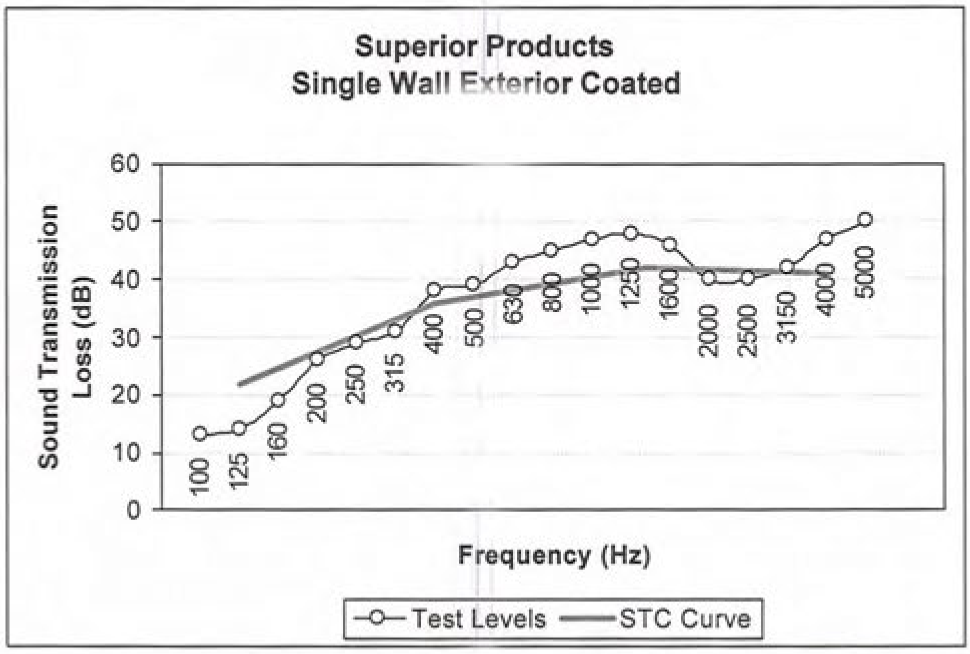
III. TEST SPECIMEN

The test specimen was a sheetrock and steel stud wall 8′ by 8′ by 5-7/8″ thick, consisting of 3-1/2″ "Supertherm" Batch 081805B coated steel studs, with 5/8″ thick sheet rock on both sides. The sheetrock toward the source room was coated with Supertherm Batch 081805B. The wall was installed for testing in an 8′ by 8′ test opening between the source room and the receiving room. After the walls were installed, the crack around the perimeter of the wall and the crack between the sheet rock panels were sealed with "Duxseal". The wall was submitted for testing by VTEC Laboratories Inc., and was identified as "Test Wall no. 1, Single Wall Exterior Coated". The weight of the specimen was 297 pounds. The test area was 64 square feet.

IV. RESULTS

Frequency (Hz)	TL	Deficiencies	Frequency (Hz)	TL	Deficiencies
100	13		800	45	0
125	14	-8	1000	47	0
160	19	-6	1250	48	0
200	26	-2	1600	46	0
250	29	-2	2000	40	-2
315	31	-3	2500	40	-2
400	38	0	3150	42	0
500	39	0	4000	47	0
630	43	0	5000	50	

Sound Transmissin Class, STC: 38



Neil Schultz
Executive Director

Amirudin Rahim
Technical Director

STC TESTING
FOR
SUPERIOR PRODUCTS
ON
EXTERIOR AND INTERIOR WALLS
BOTH COATED ON EXTERIOR SIDE
VTEC #100-2251-2
TESTED: NOVEMBER 22, 2005

December 9, 2005

Client: Superior Products
10835 W. 78th Street
Shawnee, KS 66214

Attn: J.E. Pritchett

Subject: Measure sound transmission loss per ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions."

Determine sound transmission class per ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

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I. INTRODUCTION

The sound transmission loss of a partition in a specified frequency band is the ratio, expressed on the decibel scale, of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. The ratio of two like quantities proportional to power of energy is expressed on the decibel (dB) scale by multiplying its common logarithm by ten.

II. TEST METHOD

The measurements were made in accordance with ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions." The sound transmission class, STC, was determined in accordance with ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

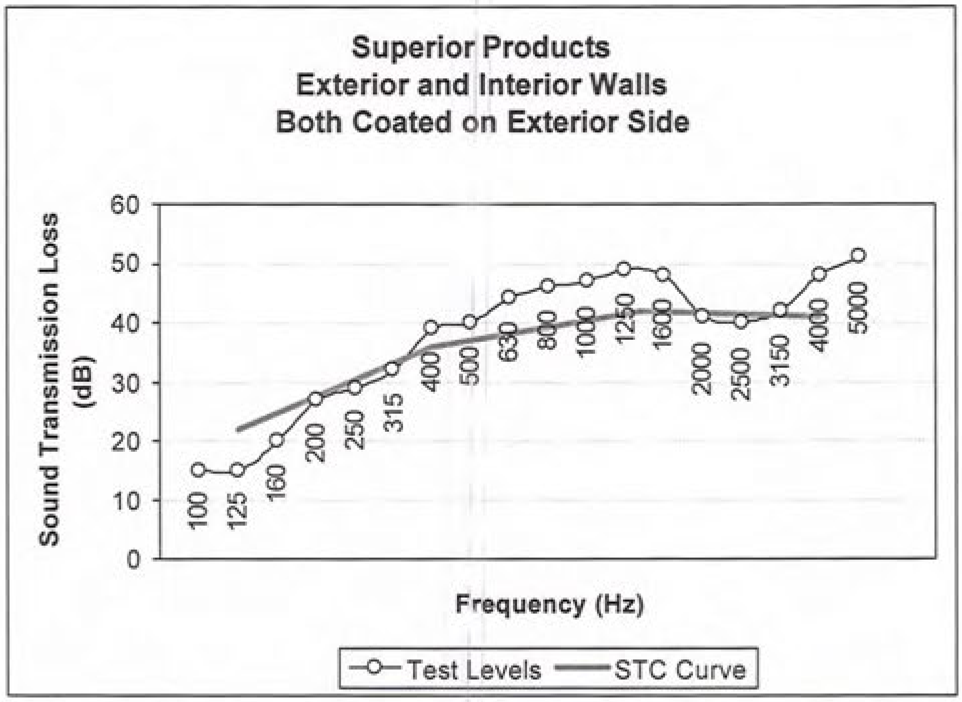
III. TEST SPECIMEN

The test specimen was a sheetrock and steel stud wall 8′ by 8′ by 5-7/8″ thick, consisting of 3-1/2″ thick "Supertherm" coated steel studs, with 5/8″ thick sheet rock on the exterior side. The sheetrock on both sides of the wall were coated with Supertherm. The wall was installed for testing in an 8′ by 8′ test opening between the source room and the receiving room. After the walls were installed, the crack around the perimeter of the wall and the crack between the sheet rock panels were sealed with "Duxseal". The wall was submitted for testing by VTEC Laboratories Inc., and was identified as "Test Wall no. 2, Exterior and Interior Walls Coated on exterior side". The weight of the specimen was 301 pounds. The test area was 64 square feet.

IV. RESULTS

Frequency (Hz)	TL	Deficiencies	Frequency (Hz)	TL	Deficiencies
100	15		800	46	0
125	15	-8	1000	47	0
160	20	-6	1250	49	0
200	27	-2	1600	48	0
250	29	-3	2000	41	-2
315	32	-3	2500	40	-3
400	39	0	3150	42	-1
500	40	0	4000	48	0
630	44	0	5000	51	

Sound Transmissin Class, STC:	39



Neil Schultz
Executive Director

Amirudin Rahim
Technical Director

STC TESTING
FOR
SUPERIOR PRODUCTS
ON
EXTERIOR AND INTERIOR WALLS
BOTH COATED BOTH SIDES
VTEC #100-2251-3
TESTED: NOVEMBER 22, 2005

December 9, 2005

Client: Superior Products
10835 W. 78th Street
Shawnee, KS 66214

Attn: J.E. Pritchett

Subject: Measure sound transmission loss per ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions."

Determine sound transmission class per ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

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I. INTRODUCTION

The sound transmission loss of a partition in a specified frequency band is the ratio, expressed on the decibel scale, of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. The ratio of two like quantities proportional to power of energy is expressed on the decibel (dB) scale by multiplying its common logarithm by ten.

II. TEST METHOD

The measurements were made in accordance with ASTM E90, "Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions." The sound transmission class, STC, was determined in accordance with ASTM E413, "Standard Classification for Determination of Sound Transmission Class."

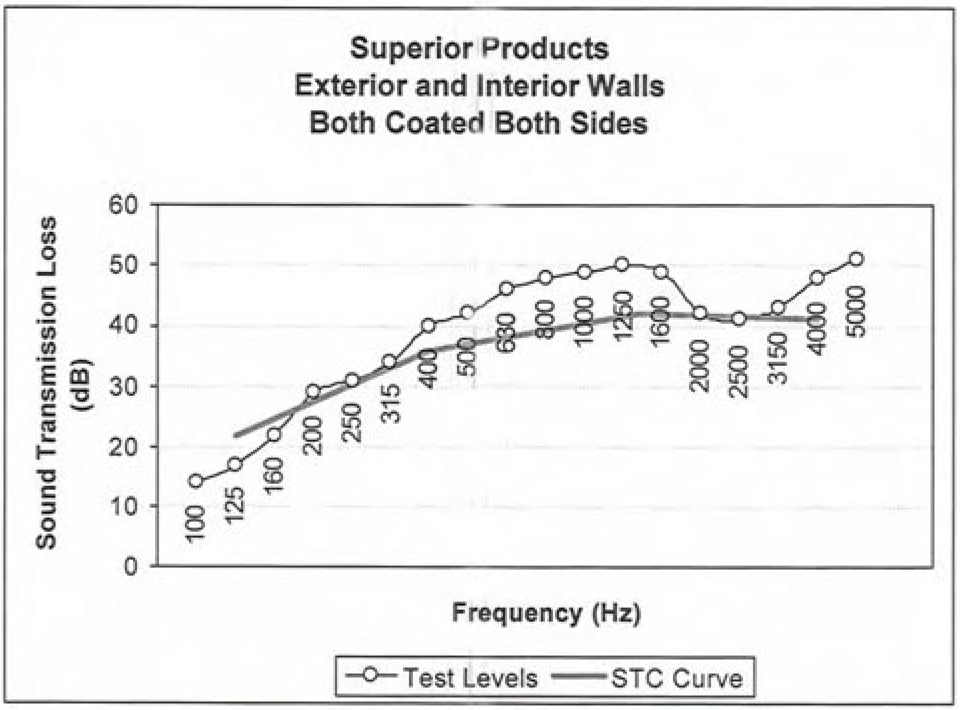
III. TEST SPECIMEN

The test specimen was a sheetrock and steel stud wall 8′ by 8′ by 5-7/8″ thick, consisting of 3-1/2″ thick "Supertherm" coated steel studs, with 5/8″ thick sheet rock on both sides. The sheetrock on both sides of the wall were coated with Supertherm. The wall was installed for testing in an 8′ by 8′ test opening between the source room and the receiving room. After the walls were installed, the crack around the perimeter of the wall and the crack between the sheet rock panels were sealed with "Duxseal". The wall was submitted for testing by VTEC Laboratories Inc., and was identified as "Test Wall no. 3, Exterior and Interior Walls Coated on both sides". The weight of the specimen was 309 pounds. The test area was 64 square feet.

IV. RESULTS

Frequency (Hz)	TL	Deficiencies	Frequency (Hz)	TL	Deficiencies
100	14		800	48	0
125	17	-8	1000	49	0
160	22	-6	1250	50	0
200	29	-2	1600	49	0
250	31	-3	2000	42	-3
315	34	-3	2500	41	-4
400	40	0	3150	43	-2
500	42	0	4000	48	0
630	46	0	5000	51	

Sound Transmissin Class, STC:	41



Neil Schultz
Executive Director

Amirudin Rahim
Technical Director

Hot-Cold
Air
& FIRE CONTROL

Super Therm was developed as a ceramic coating insulation. In collaboration with the National Aeronautics and Space Administration's Technology Utilization Office, J.E. Pritchett created a water-based paint composed of four ceramic compounds embedded in a foundation of four resins.

Two reflective ceramics act to deflect radiant heat and reduce surface heat build up. A third ceramic stops hot/cold conduction by providing a microscopic dead air space between the surface and substrate. In the foundation, two acrylic resins provide elasticity, adhesion, and water resistance. A third urethane resin creates a moisture and ultraviolet barrier. The last polymer additive ensures a slow dry time to prevent cracking as well as add a silky finish. This resin/ceramic combination has been shown to reflect both heat and fire, withstand elements for 30 to 40 years, endure 180 degree temperature, bend without cracking, and resist water and ultraviolet light.

It was suggested by the founders of Hot-Cold Air and Fire Control, that Super Therm might also show acoustical insulation properties. In this first preliminary series of tests, a bedroom wall was painted with two coats of Super Therm. Sound level comparisons from an outside air-conditioning unit were made between adjacent untreated bathroom wall and a Super Therm painted bedroom wall. Sound meters were placed on the inside of each wall approximately four feet apart, separated by an interior wall. Both meters were located approximately six feet from the outside air-conditioning unit.

In the first series of tests, run for five days, monitors were programmed for five-hour periods from 1 am to 6 am, a time when the internal noise level was assumed to be the lowest. The noises coming through the outside walls of the house were assumed to be predominantly from the air-conditioning unit cycling on and off and any ambient nocturnal sounds. A second test series was preformed in which the monitors were programmed for 24 hour periods, for four consecutive days when the house was empty.

The wall was painted on May 20th and sound reports were tracked beginning on May 28th, seven days after application (since Super Therm requires a seven-day cure time). The sound meters used were designed for comparative purposes, using microphone impulses set on an arbitrary linear scale beginning at zero. Average sound levels for each day for the treated and untreated walls are contrasted in Table 1: <u>Comparison of acoustical insulation ability between a Super Therm treated wall and an untreated wall</u>.

Table 1: Comparison of acountical insulation ability between a Super Therm treated wall and untreated wall

Day	Time Period	Super Therm Wall (value range)	mean	Untreated Wall (value range)	mean	% Variance
5/28	5 hours	(19-20)	19.3	(23-25)	23.9	24%
5/31	5 hours	(16-18)	16.9	(21-22)	21.2	25%
6/1	5 hours	(13-16)	15.0	(19-25)	20.8	39%
6/2	5 hours	(10-17)	13.4	(19 21)	19.7	47%
6/3	5 hours	(9-13)	10.1	(19-20)	19.2	90%
6/10	24 hours	(10-24)	11.5	(16-]7)	16.3	42%
6/11	24 hours	(9-10)	10.2	(16)	16.0	57%
6/12	24 hours	(9-11)	10.0	(15-17)	16.0	60%
6/13	24 hours	(9-10)	9.4	(15-16)	15.8	68%

Results indicate that Super Therm does have acoustical insulation ability. Percent variances of effectiveness between test periods may be the result of noise generated within the house. Since Super Therm is reflective by design, any noise occurring in the bedroom would be reflected within the room and transmitted to the microphone. This would result in a few excessively high readings in the 5 or 24-hour periods (most notably, the reading of 17 on 6/2, 13 on 6/13, and 24 on 6/10). High outlyers were not noted for the untreated bathroom wall, all means fell close to the value ranges.

Since Super Therm reflects sound, a better application for acountical insulation would be to apply the ceramic to the exterior wall of the house so sound generated outside would be reflected away from the house, never penetrating the interior wall.

In an attempt to measure the ability of Super Therm to reflect and contain sound within a room, a third series of tests is presently underway, in which the sound monitors are set up on the outside wall of the house and sound from a stereo is generated within the bedroom and bathroom. Results from the first two preliminary tests run on this design are presented in Table 2: Comparison of acountical reflective ability between a Super Therm treated wall and untreated wall.

HOW SUPER THERM® REDUCES SOUND TRANSMISSION BY UP TO 68%

Conventional thinking about sound reduction (or dampening) is geared toward the absorption of sound waves into a mass of material having a very low density. Most materials designed and used for sound dampening require thickness, and their performance is similar to fiberglass insulation or foam rubber. When this material is new, clean, and dry, it performs well in laboratory tests.

In the real world it ages, gets soiled, and allows moisture (in the form of humidity) to be absorbed. These three factors result in increasing the density of the material. Higher density materials tend to vibrate and allow sound waves to be carried through them. In the same manner, fiberglass insulation absorbs heat and allows it to pass through, the use of traditional dampening materials allow sound waves to pass through.

Its time to shift the paradigm about sound dampening!

SUPER THERM® is a water-based coating that was originally designed to block heat waves from penetrating into a surface. Its performance is consistent in dealing with how heat and sound waves travel and is not affected by age, moisture, or surface dirt. The four light-weight ceramic compounds contained in SUPER THERM® are designed to form a crystalline structure. This crystalline structure has very little density and is reflective in nature, so it is resistant to absorb sound or heat.

Quite simply, SUPER THERM® dampens sound waves before they are allowed to travel to the more dense material coated. If sound waves cannot cause the substrate to vibrate, the sound cannot continue.

SUPER THERM® dampens sound waves. It blocks sound by interrupting the vibration continuance. The essence is to stop sound waves from loading into a substrate which cause vibration. By virtue of the lack of density, SUPER THERM® will stop up to 68% of sound transmission.

SOME TYPICAL STC RATINGS

2 × 4 on 16" or 24" centers, 3/8-5/8 inch wallboard, rock wool or fiberglass batting	STC 30 to 42
Same as above with plaster instead of wallboard	STC 40 to 54
Staggered stud 2 × 4's on 2 × 6 plate, 2 sheets of 5/8 inch plasterboard on each side, 2" fiberglass inside	STC 51

Caveats

The STC system is useful for comparing different ways of building a partition, but it is not a guarantee of a certain level of isolation. It tends to give too much credit to materials which absorb high frequencies, such as sheetrock, and too little to materials and forms of construction which absorb the lower frequencies.

In practice, the STC of the laboratory sample represents the optimum condition, and is rarely achieved in actual construction. The difference between the actual or Field STC (FSTC) and the laboratory STC is a result of leaks and flanking paths, in other words, sound entering a wall in a common assembly is also entering the floor, traveling through the floor and breaking out in the adjoining space, by-passing the wall. A similar effect is found if sound is allowed to enter air return plenum spaces above or below walls. The degree to which these flanking paths are disconnected will determine how closely the field test results approach the laboratory results.

STC -Lab	Field STC	Subjective description of effectiveness
26-30	20-22	Most sentences clearly understood
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62-65	55	Music heard faintly, bass notes "thump"; power woodworking equipment clearly audible
70	60	Music still heard very faintly if played loud.
75+	65+	Effectively blocks most air-borne noise sources

Table 1: Subjective interpretation of effects of STC as measured (assumes normal quiet background level - NC 35)

Note: The actual effect perceived effect of STC depends on the background noise levels, room volumes, surface areas, sound absorption values and spectral content of the sound source.

WHAT IS STC?

The actual behavior of two partitions with the same STC rating can be dramatically different, as the STC is weighted in favor of the part of the sound spectrum that represents the human voice. In practice, one of the most annoying transmitted sounds between dwelling units tends to be the bass in music, a part of the sound spectrum far removed from the voice range. So, an eight inch concrete block wall rated at STC 50, that can block 20 dB more sound in some bass frequencies would be a better choice than an STC 50 drywall partition for an application where music or mechanical noise will be a problem.

Changes in the National Building Code 1990, now require that partitions separating dwelling units meet an STC 50 requirement, and the building code provides sample ratings for several types of wall constructions. Unfortunately, test ratings of the same wall section vary from test to test, and in field situations, walls cannot be expected to perform as well as the test sample in laboratory conditions. This drop in performance can leave the builder liable for additional construction to bring up the performance of the wall if the tenants obtain field test results from the dwelling units that confirm a reduced STC.

For example, a wall section listed by the NBC 1990 as meeting the STC 50 requirement has staggered 2 x 4 wood studs on a 2 x 6 plate with batt insulation filling the cavity and a single layer of drywall either side. In laboratory tests, the STC rating of that particular wall section varies from STC 47 to STC 51. In field tests, the wall might get only about STC 46, even with caulking at the plates. Any cracks in the wall or holes for electrical or mechanical servicing will further reduce the actual field result, leaving the builder responsible for upgrades. Rigid connections between wall surfaces can also seriously degrade the wall performance. The higher the target STC, the more critical are the sealing and structural isolation requirements. The builder's best options for getting a satisfactory STC result are to specify partitions with a laboratory rating of STC 54 or better. If in doubt at an early stage in the construction, testing can be done to rate the construction and upgrades recommended before costly finishing is in place.

SUPER THERM – INSULATION / SOUND DEADENING

Subject: Fwd: SKODA/Portland Streetcars
Date: Mon, 17 Sep 2001 21:15:31 -0400 (EDT)
From: TRyan59789@aol.com
To: scorkpr@swbell.net

SKODA STREETCARS
100 YR old Company
Czech Republic
Memphis Trolly Cars
Mfg. in Portland, Or

David: When I replied to Mike's respond e mail to me I thought a cc of same would go along to you. It seems not, so I am doing the enclosed accordingly.

This as we had hoped, if Mike's response will be as I expect, will be very, very significant as per my earlier comments to you, in as much as Super Therm can replace costly belly pan, damping (spray coating of same) and useless wetable fiberglass/batt insulation, with significant fire, thermal, water proofing and acoustical treatment to boot.

Best to all,

Tom Ryan

Subject: RE: SKODA/Portland Streetcars
Date: Mon, 17 Sep 2001 11:21:56 -0400
From: "Collins, Mike" <MCollins@ltk.com>
To: "TRyan59789@aol.com" <TRyan59789@aol.com>

Mike Collins
LTK Engineer
Los Angeles

Tom,

The noise problems on the streetcar is a problems with pure tones. The tones are generated in the motors at the IGBT switching frequency. There is something in the motors that is resonating. Moving the switching frequency +/- about the center 2K frequency changes this noise.

NOISE CONTROL USING SUPER THERM

As for road noise coming through the flooring, there is a remarkable difference between the Skoda cars with the Super Therm and the Tri-Met Siemens cars with the traditional batting. The difference is most noticeable in the low floor center sections. The Skoda cars are much, much quieter that the Siemens cars.

Mike

-----Original Message-----
From: TRyan59789@aol.com [mailto:TRyan59789@aol.com]
Sent: Monday, September 10, 2001 11:43 AM
To: Collins, Mike
Cc: scorkpr@swbell.net
Subject: SKODA/Portland Streetcars

Mike. Hello. As to the subject cars and the application of our Super Therm to the bottom of the plywood flooring which was selected as a fire and thermal coating of which we had significant successful applications and related test data proving same accordingly.

During a related conversation a comment was made that

Subject: [Fwd: Pictures of flooring for Skoda cars]
Date: Fri, 10 Nov 2000 12:00:03 -0600
From: David Williams <scorkpr@swbell.net>
Organization: Superior Products USA
To: supertherm@aol.com

Friday, November 10, 2000

TO: J.E. Pritchett
FROM: David R. Williams

Dear J.E.:

We haven't obtained a release from LTK Engineering yet on these pictures so keep them as inside information at this time. I will keep you updated with further revelations concerning this precedent setting application in railcars.

Sincerely,

David.

Subject: Pictures of flooring for Skoda cars
Date: Wed, 25 Oct 2000 05:39:00 -0400
From: JOHN PROSPER <JPROSPER@ltk.com>
To: scorkpr@swbell.net

Dave,

Attached are pictures of floor panels that have been paintede, unfortunately these are the last set of floor panels that needed to be painted and are ready for installation into car # 5. Also attached is an interior view of the car prior to the flooring being installed which gives you and idea of the flooring framework. There is no metal bedpan attached to the underneath of the vechicle.

I hope this helps, if you have any questions please let me know.

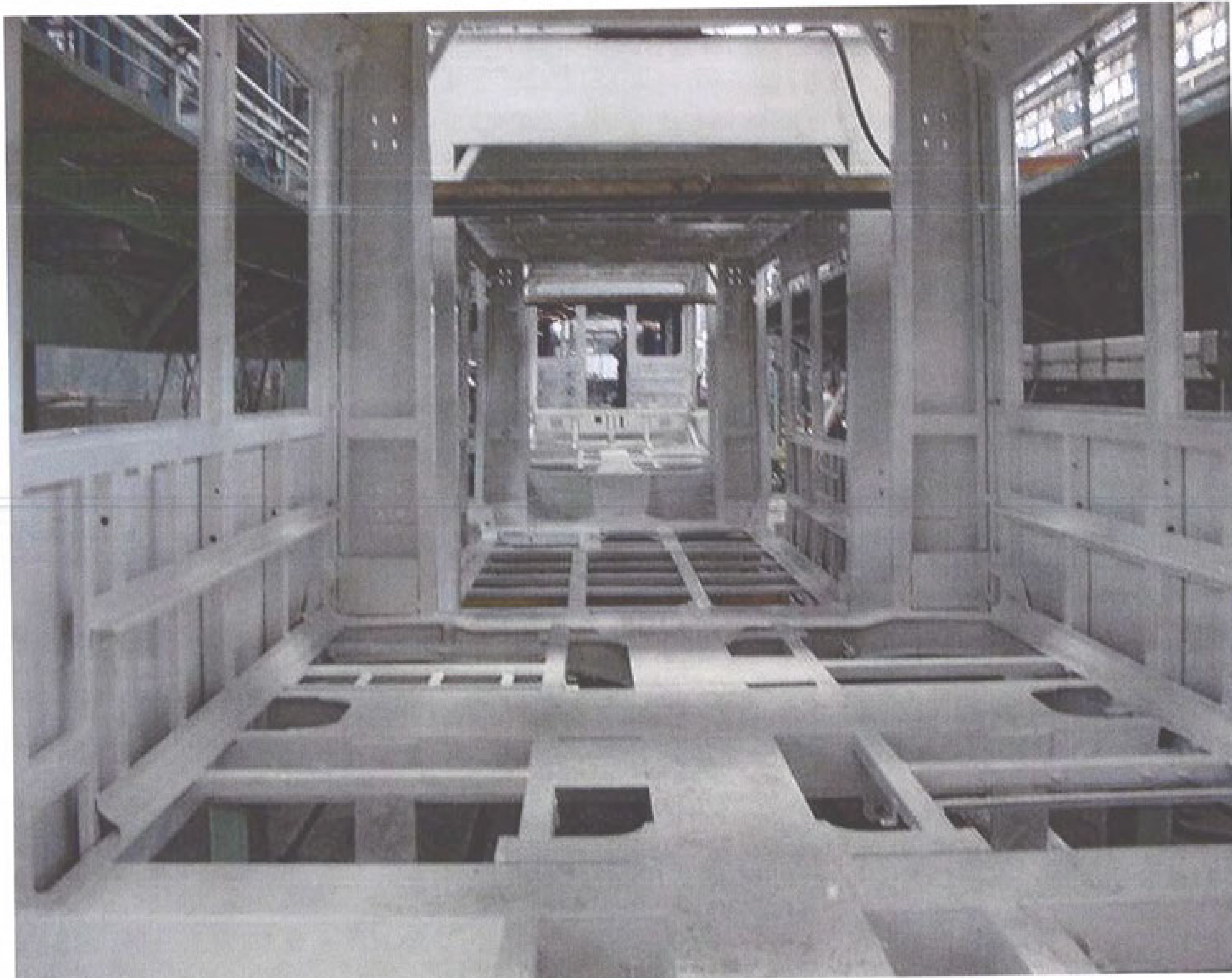
Thanks

John

Part 1.2.1.2	**Name:** Dsc00006.jpg **Type:** JPEG Image (image/jpeg) **Encoding:** base64

Part 1.2.1.3	**Name:** Dsc00004.jpg **Type:** JPEG Image (image/jpeg) **Encoding:** base64

John Prosper
LTK Engineer
Los Angeles
Took Pictures of cars
in Czech Republic



SOUND REDUCTION and STC performance of existing concrete block or poured concrete walls.

SUPER THERM and how it adds to sound reduction. Also how sound and heat waves are similar and carried in the same type of waves which gives SUPER THERM the ultimate advantage over all other materials trying to offer sound or offer heat blockage when SUPER THERM does both at the same time and outperforms these standard sound or heat conduction blockers.

In sound reduction, the air space in the concrete block walls was the key to trying to reduce sound transmission through walls in apartments, homes and commercial buildings. When this was originally tested by the sound labs the STC was based on this dead air space to try and reduce the sound wave transmission. Today, the building requirements are calling for more solid walls to strengthen buildings against wind and storm. This changing of the construction of walls changed the STC testing results, but of course, the new construction techniques have not been retested to see the greatly reduced STC results because the air space is no longer there.

The following comment from a Florida group underlines what is happening with sound transmission through these walls and the attached article backs up our understanding with how SUPER THERM will work to fix the problems of sound and therefore heat transmission.

"Now what I learned is much of what we are doing to strengthen structures in Florida to handle the winds etc we are undoing the standards for sound (STC)....as you will see the air space in concrete block and concrete is the key to STC...and while fiberglass helps to absorb (they say) .....but what we have done is required rebar in the cell and the cells to be

filled...when we do that the STC rating of the block because of the holes in the block are gone and the STC went with it...we are adding all kinds of clips and straps to the roofs and metal supports, and we are adding lot and lots of fasteners which are great sound transmission vehicles! So the Builder/Developer is making claims in his advertising of sound between units but it isn't there and the new owner is complaining. I believe they don't know why...As seen, deep in the report it begins to talk about a thin coat of the right stuff can "short circuit" or create a "sound break" and they liken it to a thermal break. SUPER THERM does just that and has got to be the low cost solution, particularly when coupled with other performance enhancements".

Ray

Concerning the attached report:

As you read the report, you will see that the dead air space is critical to reducing the sound transmission. Under figure 2, the paragraph talks about sound absorbing materials (like fiberglass) cannot add or help in any degree of sound blocking over the applied 75mm or 3 inches in thickness. **The fact is established that sound and heat travel the same way.** Given this fact, fiberglass is not effective in blocking sound and therefore heat when applied in a thickness over 75mm or 3 inches in thickness as the actual resulting effect is diminished with no benefit. This effectively states that any fiberglass over 75mm or 3 inches in thickness is worthless in blocking sound transmission and additionally any control of heat load.

Gypsum wall board when applied one sheet on each side of the stud and having the dead air space is only a STC of 40 while adding fiberglass or other sound materials only adds 8 points which is still under the 55 standard rating desired. One board on one side and two boards on the other side will give a 44 rating and with sound materials totals only a rating of 52. Finally when two boards are attached to both sides of the studs (four boards total) does it have a rating of 52 and with sound deadening materials reaches a 56 rating (one point over the desired rating for walls).

Taken from the report: "....drywall attached directly to both sides of the wood studs has an STC rating of about 33. The addition of sound absorbing material in this wall increases its rating by about only 3 points, because the sound energy is transmitted directly from one layer of wallboard to the other through the studs" THIS IS A VERY IMPORTANT POINT. SUPER THERM can be applied directly over the wallboard that will cover the studs and deaden the sound transmission. In Infrared video, studs heat up and transmit heat through very quickly after the heat source is applied. The studs are exposed without the benefit of any kind of insulation covering them. When taken as a full skeleton of a house, a commercial building or industrial complex, think of the support columns or studs without insulation covering allowing sound and heat to load and pass through instantly. SUPER THERM is coated directly over the studs or wall boards to prevent the loading of sound or heat and therefore blocking this huge leak in heat and sound transmission through the walls and roof structures.

The tests on the Super Therm coated walls were performed by the standard ASTM E 90 with STC values determined by ASTM E 413. The STC values were 38 for one coated surface (surface facing sound), 39 for two coated surfaces (both faces of wall) and 41 for four coated surfaces (both exterior faces and both surfaces inside wall cavity).

The reports have the one-third octave band sound levels for each test. As for parameters, sound is produced and measured on one side of the wall and at the same time measured on the other side of the wall. The wall construction is described in the reports. The receiving room absorption was measured and used in calculating the STC.

The acoustical engineer said for all practical purposes, that one coat of Super Therm (tested at 38) on the surface **performed like 3" of fiberglass** that would be placed into a wall cavity, and **the single coating of Super Therm would increase the wall efficiency by 50%**. Two coats, one each side (tested at 39) would increase the wall efficiency to 51%, and the 4 coat system (tested at 41) would increase efficiency of the wall by 60%.

Note: The results and increase efficiency values given above were from testing all three octave bands. The lower frequency band is extremely low in pitch and is more in the range of a foghorn. Super Therm, along with most other materials, does very little to block this range and this frequency testing skews the overall test results. Most common sounds we ordinarily hear is in the mid to high frequency range, which if tested in those areas alone, would bring the rating from 38 up to 51.

As a final note in concrete block wall construction where wallboard is attached to finish the walls , the furring strips used to attach to the concrete surface to accept the wallboard must be " 60 mm (2.4 inches) thickness to meet the 80Hz criterion previously noted". This amount of dead air space must be used as a minimum requirement. SUPER THERM can be applied directly to the wallboard without this required thickness of dead air space to block and control sound and heat transmission.

From our testing and field studies over the years, we know exactly how SUPER THERM compares to fiberglass and the basic points and concerns that the buying public should be concerned with as expressed by Mr. Bill Gleckman, as follows:

WILLIAM B. GLECKMAN ARCHITECT 310 EAST 69TH STREET NEW YORK NEW YORK 10021 TEL212/734-1500 FAX212/517-3516
EMAIL: wgleckman@nyc.rr.com

March 16, 2005

SUPERTHERM has been tested in laboratories and used in the field for over fifteen years. It can be categorically stated that SUPERTHEM is more effective than any other type of insulation product on the market in controlling the flow of heat.

The success of SUPERTHERM has prompted the fabricators and sales reps of other insulation products to discredit SUPERTHERM and to discourage the buying public from knowing the truth. Because these other products cannot control all three types of heat flow (conduction, convection and radiation) and prevent mold and mildew as does SUPERTHERM they make use of fictional concepts such as "R" values and publish "test results" extolling their supposed effectiveness. It must be stated here and now that these tests were only conducted at 23C to 25C, not the full range of temperatures to which buildings are exposed. Further they make no mention of moisture content (as anyone in the field knows wet fiberglass or mineral wool is useless). When batt type insulation is pressed into place the compression reduces by as much as 50% their stated insulation values. Another thing these test reports fail to mention is that the crevices in batt type insulation provide nesting places for mold and mildew which cause "sick building syndrome".

The scientific facts are: Written by PhD Inn Choi

Sound Energy Absorption

Incident sound energy which is not absorbed must be reflected, transmitted or dissipated. A material's sound absorbing properties can be described as a sound absorption coefficient in a particular frequency range. The coefficient can be viewed as a percentage of sound being absorbed, where 1.00 is complete absorption (100%) and 0.01 is minimal (1%).

Most good sound reflectors prevent sound transmission by forming a solid, impervious barrier. Conversely, most good sound absorbers readily transmit sound. Sound reflectors tend to be impervious and massive, while sound absorbers are generally porous, lightweight material.

There are three basic categories of sound absorbers: porous materials commonly formed of matted or spun fibers; panel (membrane) absorbers having an impervious surface mounted over an airspace; and resonators created by holes or slots connected to an enclosed volume of trapped air. The absorptivity of each type of sound absorber is dramatically influenced by the mounting method employed.

Porous absorbers

Common porous absorbers include carpet, draperies, aerated plaster, fibrous mineral wool and glass fiber, and porous ceiling tile. Generally, all of these materials allow air to flow into a cellular structure where sound energy is converted to heat. Porous absorbers are the most commonly used sound absorbing materials. Thickness plays an important role in sound absorption by porous materials. Fabric applied directly to a hard, massive substrate such as plaster or gypsum board does not make an efficient sound absorber due to the very thin layer of fiber. Thicker materials generally provide more bass sound absorption or damping.

Resonators

Resonators typically act to absorb sound in a narrow frequency range. Resonators include some perforated materials and materials that have openings (holes and slots). The resonant frequency is governed by the size of the opening, the length of the neck and the volume of air trapped in holes. Typically, perforated materials only absorb the mid-frequency range. Slots usually have a similar acoustic response. Long narrow slots can be used to absorb low frequencies..

Membrane Panels

Typically, membrane panels are non-rigid, non-porous materials which are placed over an airspace that vibrates in a flexural mode in response to sound pressure exerted by adjacent air molecules. Common membrane panels include thin wood paneling over framing, lightweight impervious ceilings and floors, glazing and other large surfaces capable of resonating in response to sound. Membrane panels are usually most efficient at absorbing low frequencies.

Sound is a wave like radiation, and has absorption coefficient as radiation. Sound is muted due to absorption or dissipation, not just absorption.

1. Porous material is a good sound absorber as sound is 'absorb' along the length of the material

2. Resonators 'absorb' sound along the length of holes/slots

3. Membrane Panels works because it 'vibrates' when sound wave strikes the surface

No. 1 & 2 above are absorbers. Sound energy is converted into heat. The thicker the material (No.1) or hole (No.2), the better for absorption.

No. 3 is actually a sound 'dissipater', not an 'absorber'. Sound energy is converted into kinetic energy via vibration. In this case, the membrane should have an air space behind to allow vibration.

In short, sound is either converted into heat energy through absorption or kinetic energy through dissipation. There are no other sound conversion mechanisms other than these two. Any future tests must be based on these two fundamental principles.

The sound Report file is as follows:

CBD-239. Factors Affecting Sound Transmission Loss

A.C.C. Warnock

Abstract

The sound transmission losses of single and double layer walls and floors are determined by the physical properties of the component materials and the methods of assembly. These factors are discussed.

Introduction

The sound transmission loss of a partition or a floor are determined by physical factors such as mass and stiffness. In a double layer assembly, such as gypsum wallboard on wood or metal framing, the depth of air spaces, the presence or absence of sound absorbing material, and the degree of mechanical coupling between layers critically affect sound transmission losses and therefore the sound transmission class (STC). (These terms were discussed in Canadian Building Digest 236.[1]) An understanding of these factors can lead to improved design and fewer errors. Small changes in the arrangement of materials can yield large changes in STC with little or no increase in cost.

Three interacting physical factors are important in determining whether an occupant of a multi-family dwelling is bothered by noise from neighbours. These are the sound transmission losses of party walls or floors, the level of noise generated in neighbouring homes, and the level of background sound in the occupant's own home. The last two factors can vary widely and one has to select a value of STC that will provide protection for most situations and accept those cases where annoyance is caused by an unusually noisy neighbour or unusually low background sound levels. If the level of background sound is high enough, intruding sounds will be masked and will not be detectable. On the other hand, if the background noise is excessively high, it can interfere with sleep, relaxation, and even conversation. Experience around the world has shown that for occupants of multi-family dwellings to enjoy a reasonable degree of acoustical privacy, the effective STC between dwelling units should be at least 55. Values in excess of STC 60 can be achieved with typical building materials without resorting to extreme designs, although care is needed during the design and construction processes.

Mass Law

The most important physical property controlling the airborne sound transmission loss through an assembly is the mass per unit area of its component layers. The "mass law" is a theoretical rule that applies to most materials in certain frequency ranges. It can be approximated as $TL = 20 \log_{10} (m_s f) - 48$ (1)where TL is the random incidence transmission loss of the layer; m_s is the mass per unit area, kg/m²; and f is the frequency of the sound wave, Hz. The mass per unit area, m_s, is the product of the material density and its thickness. Values of ms for 1 mm thicknesses of common materials are presented in Table 1.

The mass law equation predicts that each time the frequency of measurement or the mass per unit area of a single layer wall is doubled, the transmission loss increases by about 6 dB. To increase the sound transmission loss of a partition by 12 dB at all frequencies, therefore, the mass per unit area must be increased by a factor of 4; an increase of 18 dB requires an increase by a factor of 8 and so on. Mass per unit area can be increased by increasing thickness or by selecting a more dense material. A single layer of poured concrete 150 mm thick gives an STC of about 55. Layers of this weight are generally the practical limit in normal construction. If a higher STC value than this is necessary, and it often is in high quality construction, it is not economical to continually double the wall or floor thickness to achieve it. Double layer assemblies are a more practical way of getting high STC values without excessive weight.

Effects of Stiffness

Sound transmission losses of partitions and floors are also influenced by stiffness. Transmission loss graphs for stiff materials show dips in particular frequency ranges where the sound transmission losses are reduced below those expected from mass law. This is called the coincidence effect and often leads to a reduced STC rating. Materials with very low stiffness such as sheet lead effectively do not show coincidence dips. Coincidence frequencies for different materials occur in different parts of the acoustical spectrum, sometimes outside the normal range used in building acoustics. The coincidence or critical frequency, f_c, for a given material may be calculated from: $f_c = A/t$ (2) where A is a constant for each material under consideration and t is the material thickness, mm.

Table 1 gives values of A that permit the calculation of the coincidence frequency for different materials. For example steel has an A value of 12,700 Hz-mm and Equation 2 shows that a 5 mm sheet of steel has a coincidence frequency of 2540 Hz. Similarly, a layer of concrete 100 mm thick would have a coincidence dip at 187 Hz. Figure 1 shows idealized transmission loss curves, including coincidence dips, for some common materials. Materials A, B, and C all have the same mass per unit area but quite different STC ratings because of differing coincidence effects. Because the critical frequencies of concrete and plywood in the thicknesses commonly used fall in the frequency range that is important in building acoustics (100 to 4000 Hz), they are particularly vulnerable to STC reductions due to the effects of coincidence. For gypsum wallboard the coincidence frequency is quite high and the effect on the STC is usually less. The depth of the coincidence dip is determined by the energy losses in the material and at its edges where it is in contact with other materials in the supporting structure. The greater the energy losses, the shallower the coincidence dip and the less the effect on the STC.

Table 1. Surface Mass, m_s, for 1 mm Thickness and Constant, A, for Calculation of Critical

Frequency, f_c, of Some Common Building Materials

Material	m_s kg/m² per mm	A Hz-mm
Aluminium	2.7	12,900
Concrete, dense poured	2.3	18,700
Hollow concrete block (nominal thickness, 150 mm)	1.1	20,900
Fir timber	0.55	8,900
Glass	2.5	15,200
Lead	11.0	55,900
Plexiglas or Lucite	1.15	30,800
Steel	7.7	12,700
Gypsum board	0.82	39,000
Plywood	0.6	21,700

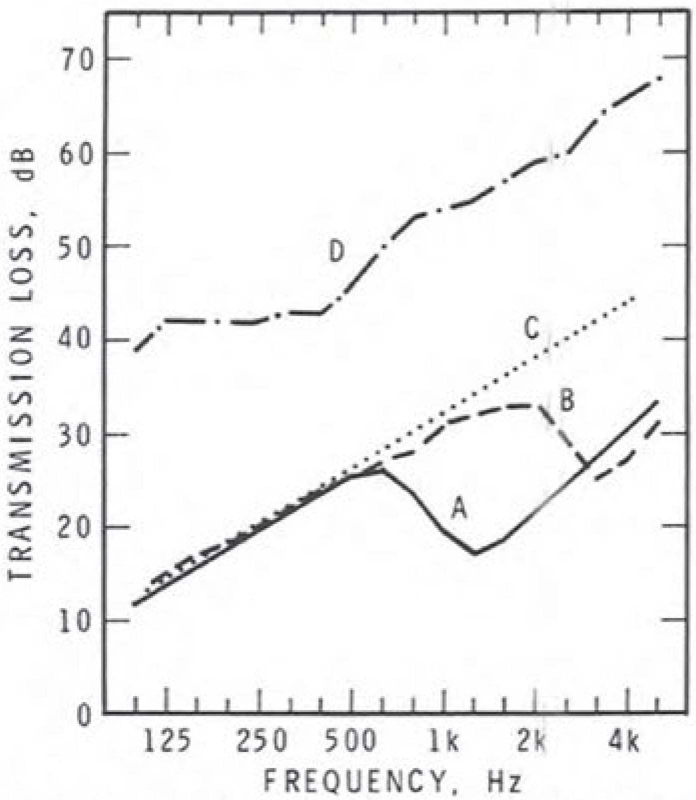


Figure 1. Transmission losses of typical single-leaf walls, A: 16 mm plywood, 10 kg/m², STC 21; B: 13 mm wallboard, 10 kg/m², STC 28; C: 1.3 mm steel, 10 kg/m², STC 30; D: 100 mm concrete, 235 kg/m², STC 52.

When two layers of material such as wallboard are glued firmly together, they behave like a single thick layer with an associated lowering of the coincidence frequency. If the layers are only held together loosely (with screws for example) so that they can slide over each other to some extent during bending motions, then the coincidence frequency does not move to lower frequencies and the friction between the layers can introduce some extra energy losses.

Double Layer Assemblies

When lightweight construction and high STC values are desired, double layer constructions must be used. These can be very effective but introduce additional effects that must be appreciated if double layer designs are to be successful. Important factors, in addition to the masses of the component layers, are the depth of the air space, the use of sound absorbing materials within the air spaces, and the rigidity of the mechanical coupling between the layers. The ideal double layer assembly has no rigid mechanical connection between its two surfaces.

In a double layer wall or floor the air trapped between the two layers acts as a spring and a resonance, called the mass-air-mass resonance, occurs at a frequency f_{mam} given by:

$$f_{\mathrm{mam}} = 1897 \sqrt{m_1 + m_2} / \sqrt{D m_1 m_2}$$

(3)

where m_1, m_2 are the surface masses of the layers, kg/m²; and D is the distance between the layers, mm. The larger the air space or the heavier the materials, the lower the frequency at which resonance occurs. At frequencies below the resonance frequency, the layers are coupled by the air in the cavity and the TL is that due to the sum of their masses. Close to the resonance frequency, however, the transmission losses are usually lower than this. Above the resonance frequency, the sound transmission loss increases much more rapidly than mass law predictions for the sum of the masses. Figure 2 gives an example of the benefits to be obtained by increasing the air space between the two layers of a wall. Generally, partitions should be designed so that the mass-air-mass resonance is below 80 Hz.

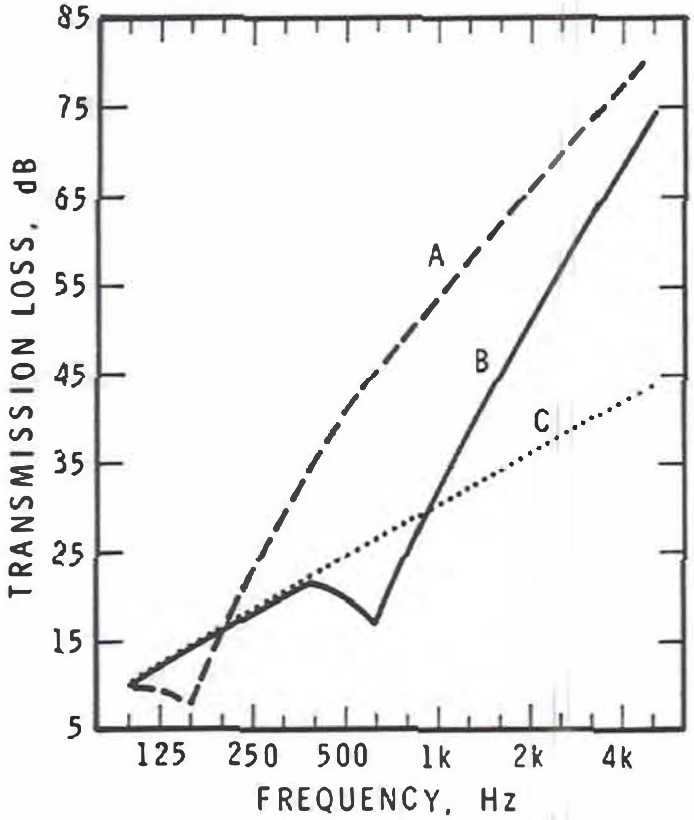


Figure 2. Effect of air space on ideal double walls with 0.5 mm steel on each face, sound absorbing material in the cavity and no rigid mechanical connections between the faces. A has an airspace of 100 mm, a resonance dip at 135 Hz, and an STC of 29; B has an airspace of 5 mm, a resonance dip at 630 Hz, and an STC of 24. Curve C represents mass law predictions for a single 1 mm steel sheet and has an STC of 28.

Standing wave resonances between the layers of a double layer wall or floor occur at relatively high frequencies and the sound transmission losses can be further reduced by them. The negative effects of most of these resonances can be reduced by the addition of sound absorbing material inside the cavities. For normal wall thicknesses (around 100 mm) the density and the thickness of the sound absorbing material is not a very important factor. Increasing the thickness beyond about 75 mm has little effect on the STC rating, although, for floors or walls that are significantly thicker than normal, it becomes more important to use thicker layers of glass fibre. The type of glass fibre or mineral wool insulation normally used for thermal purposes absorbs sound well and is quite adequate for use inside double layer walls as a sound absorbing material.

Gypsum Board Walls

The mechanical connection between the layers of wallboard can be reduced by the use of staggered wood studs, separate rows of wood studs, or a single row of wood studs with resilient metal furring strips to support the wallboard layers independently of each other. Non-load-bearing steel studs are usually resilient enough to provide adequate mechanical decoupling between the layers. Good results have also been obtained using 150 mm load-bearing steel studs in conjunction with resilient channels. Table 2 gives some representative STC values for typical constructions. The presence of the sound absorbing material increases the STC by about 8 points relative to the same wall without sound absorbing material. The thickness of the wallboard is not specified in the table since it is only a guide. Walls with 16 mm board would be better than those with 13 mm board by a few points. The table shows that STC values of 60 or more can be obtained if the air space is large enough and enough wallboard is used. Such values have been measured in buildings as well as in laboratories.

Table 2. STC Ratings for Walls Formed From Two Layers of Wallboard*

	Number of Layers of Wallboard on Each Wall Surface		
Wall construction	1+1	1+2	2+2
38 x 89 mm wood studs with resilient steel channels on one side	48 [40]	52 [44]	56 [52]
Staggered 38 x 89 mm wood studs	50 [41]	53 [47]	55 [52]
Double row of 38 x 89 mm wood studs with small gap between them	57 [46]	60 [52]	63 [57]
90 mm steel studs	45 [39]	49 [45]	56 [50]
150 mm load-bearing steel studs with resilient metal channels on one side	58	60	63

*Values not in brackets are for walls filled with sound absorbing material. Values in brackets are for walls without sound absorbing material.

In contrast to the values in the table, the common internal partition used in single family homes with drywall attached directly to both sides of the wood studs has an STC rating of about 33. The addition of sound absorbing material in this wall increases its rating by about only 3 points, because the sound energy is transmitted directly from one layer of wallboard to the other through the studs. The sound absorbing material in the cavity is of much less benefit than it would be if the layers were decoupled, in which case most of the sound would be transmitted through the air in the cavity. Rigid mechanical connections are the acoustical equivalent of an electrical short circuit or a thermal bridge in an insulated wall and should be avoided.

Concrete Block Walls

Concrete block walls commonly have wallboard applied to each face as a finishing material. Resilient connections and sound absorbing material in cavities are as important in block walls as they are in wood or steel frame construction. The mass-air-mass resonance is also important. If the air gap behind the wallboard is too small, the sound transmission losses can be reduced relative to the unfinished wall. For a single layer of wallboard attached to a concrete block wall, the air space should be greater than 60 mm to meet the 80 Hz criterion previously noted. For a double layer of wallboard, the space may be as small as 35 mm. These air spaces are larger than those typically used in concrete block walls where relatively thin wood furring strips are often used to attach the wallboard. Even using adhesive to attach wallboard directly to concrete can result in a thin film of air a few mm in thickness trapped behind the wallboard and a deleterious mass-air-mass resonance. Reduced sound transmission losses caused by the mass-air-mass resonance are often the cause of a low STC for a potentially good concrete block wall. An increase in the air gap of just a few centimetres can increase the STC considerably.

Some concrete blocks are slightly porous so that the effective thickness of the air layer behind the wallboard is greater than its physical dimensions and the mass-air-mass resonance is lower than expected. This characteristic can only be verified by acoustical testing, however. Sound transmission class ratings for some concrete block constructions can be found in references 2, 3 and 4. STC ratings of 60 or more can readily be achieved with a concrete block wall if it is correctly designed and constructed.

Flanking Transmission

In laboratory measurements of airborne sound transmission, the only significant sound transmission path between the test rooms is through the test partition or the test floor itself. In real buildings, however, sound travels between suites indirectly by way of the surrounding constructions as well as directly through the common wall or floor assembly. These less obvious paths for the sound are called flanking paths and, in a poor design, they can transmit more sound energy than the direct path through the common wall or floor. All of these paths comprise a system that must be considered as a whole so that assemblies built in the field can attain values close to those in laboratory tests. Floors are particularly prone to increased impact sound transmission because of flanking transmission through the supporting structure. Flanking transmission is beyond the scope of this Digest, however. If the physical factors that control the STC of partitions and floor assemblies are understood, the principles can be applied to all transmission paths. Further information can be found in reference 5.

References

1. Warnock. A.C.C. Fundamentals of building acoustics. Canadian Building Digest 236, 1985.*
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3. Northwood, T.D. and Monk, D.W. Sound transmission loss of masonry walls: Twelve-inch lightweight concrete blocks comparison of latex and plaster sealers. Building Research Note 93, September 1974.**
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5. ASTM E497-76. Standard recommended practice for installation of fixed partitions of light frame type for the purpose of conserving their sound insulation efficiency. American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA, 19103, U.S.A.

Available from Division of Building Research, National Research Council of Canada.

Photocopies available from CISTI.

Originally published July 1985.

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construction

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