Pacifica Companies
Attention: Mark O'Gorden
1785 Hancock Street, Suite 100
San Diego, California 92110

December 22, 2004

Job #A41130N1

SUBJECT: FIELD SOUND TRANSMISSION CLASS (FSTC) TEST RESULTS
SOUTHWOOD GARDEN TOWNHOMES CONDOMINIUM CONVERSION
54 QUAY COURT, SACRAMENTO, CALIFORNIA 95831

At your request, we have conducted 11 Field Sound Transmission Class (FSTC) tests between residential units located in the Southwood Garden Townhomes condominium conversion project on Quay Court in Sacramento, California. At the time of testing, remodeling had not begun in the tested units. The complex consists of 26 buildings with 98 residential units based upon two different floor plans. There are no common stacked multi-family floor/ceiling assemblies between the townhome units in this complex. The project location is shown on the Vicinity Map, Figure 1, following this report. The Southwood Garden Townhomes Complex Map and Floor Plan Drawings are included in Appendix A.

A total of 11 FSTC tests were conducted for this proposed condominium conversion project. The purpose of these tests was to determine the FSTC sound insulation ratings of the common wall assemblies between adjacent units. The result of each test is expressed as a single number, which approximates or best represents the sound reduction, in decibels (dB), from one side of the common wall (partition) to the other. The field tests were conducted in accordance with the 2001 American Society for Testing and Materials (ASTM) Standards E 336-97, E 413-87 (Re-approved 1999), and other related standards, as applicable. Please refer to Appendix B for copies of pertinent 2001 ASTM Standards.

Summary of Results

The FSTC tests were conducted throughout the complex between the common wall assemblies of six different adjacent unit pairs. The units tested were selected by the acoustical consultant as the most representative of the entire complex.

The FSTC tests conducted on the common wall assemblies resulted in a FSTC ratings ranging from 48 to 54. The minimum FSTC rating, according to the 2001 California Building Code (based on the 1997 Uniform Building Code), Appendix Chapter 12, Division II and IIA, Sections 1208 and 1208A, is 45. Please refer to Appendix C for a copy of the pertinent 2001 California Building Code Sections.

All of the 11 common wall assemblies tested passed the FSTC tests. The FSTC test values are summarized later within this report.

Introduction

The field sound insulation tests were conducted during the daytime hours of December 8, 2004.

To meet the room and partition size criteria of ASTM procedures, living rooms, dining rooms, and bedrooms were selected for the tests. Upon inspection at the time of testing, our engineers selected the rooms to be tested based on requirements in the applicable ASTM standards for room volume and panel size. This partition selection offers the testing of partitions with the greatest common surface area, which normally provides the most accurate test results.

The 2001 California Building Code allows for acceptance of building plans that reference laboratory-tested partitions with STC ratings exceeding the minimum required FSTC (installed) ratings by 5 rating points. It is generally understood that up to 5 rating points are lost during actual construction, which is not expected to achieve controlled laboratory conditions, as minor deficiencies in construction can reduce the overall desired sound insulation class value. For purposes of sound insulation within new multiple-family residential structures, it is important for construction to be conducted with a focus on acoustical construction details, or greater deficiencies could result.

Appendix Chapter 12, Sections 1208 and 1208A of the 2001 California Building Code requires common wall assemblies (partitions) in multiple-family residential structures to be built in order to attain a minimum field-tested (FSTC) rating of 45 or higher. The identification and use of a laboratory-tested assembly that is rated 50 or higher does not waive the requirement for the final, installed assembly to achieve a FSTC rating of at least 45 in the field.

Noise and Sound Level Descriptors

All noise level or sound level values presented herein, other than the STC values, are expressed in terms of decibels (dB). Time weighted averaged noise levels are expressed by the symbol L_{EQ}, for a specified time duration. These data unit metrics are used to express noise levels for both measurement and municipal regulations, and for land use guidelines and enforcement of noise ordinances. Some of the data may also be presented as octave-band filtered or ⅓-octave-band filtered sound levels. Sound Transmission Class (STC) is a single-number rating system used to express the octave-band noise attenuation performance of a partition as compared to a standardized reference curve. Further explanation can be provided upon request.

All sound level measurements conducted and presented in this report, in accordance with the regulations, were made with a sound level meter that conforms to the American National Standards Institute specifications for sound level meters ANSI SI.4-1983 (R2001). All instruments are maintained with National Bureau of Standards traceable calibration, per the manufacturer's standards.

Please refer to Appendix D for an explanation of FSTC testing methodology.

FSTC Test Results

The results of the FSTC testing are summarized in Table 1.

Table 1. Southwood Garden Townhomes - Summary of FSTC Tests and Results

Test Date	Test #	Source Unit	Source Room	Receiving Unit	Receiving Room	Assembly	Results
12/8/04	1	18	Living Room	19	Living Room	Common Wall	FSTC: 51 PASSED
12/8/04	2	18	Dining Room	19	Dining Room	Common Wall	FSTC: 53 PASSED
12/8/04	3	59	Bedroom	58	Bedroom	Common Wall	FSTC: 50 PASSED
12/8/04	4	36	Bedroom	35	Bedroom	Common Wall	FSTC: 53 PASSED
12/8/04	5	2	Living Room	1	Living Room	Common Wall	FSTC: 48 PASSED
12/8/04	6	2	Dining Room	1	Dining Room	Common Wall	FSTC: 50 PASSED
12/8/04	7	73	Dining Room	72	Dining Room	Common Wall	FSTC: 54 PASSED
12/8/04	8	73	Bedroom	72	Bedroom	Common Wall	FSTC: 52 PASSED
12/8/04	9	91	Living Room	92	Living Room	Common Wall	FSTC: 51 PASSED
12/8/04	10	91	Dining Room	92	Dining Room	Common Wall	FSTC: 52 PASSED
12/8/04	11	91	Bedroom	92	Bedroom	Common Wall	FSTC: 52 PASSED

For further details, please refer to Appendix E: FSTC Test Data and Results - Common Wall Tests.

Conclusions, Limitations, and Recommendations

All of the 11 field-tested common wall assemblies passed the minimum requirement for the 2001 California Building Code of a FSTC rating of 45, as tested by Eilar Associates and in accordance with the ASTM Standards and Procedures.

The test results herein do not apply to rooms that are significantly different from those tested, or that have different wall construction.

Certification

The tested partitions data and results documented within this acoustical analysis are true and factual and based on the information available. This report was prepared by Justin Smith, Jessica Rasmussen, John Gorr, Michael Burrill, and Douglas Eilar. Please call if you have any questions or require additional information.

EILAR ASSOCIATES

Justin Smith, Acoustical Engineer

Michael Burrill, Senior Acoustical Engineer

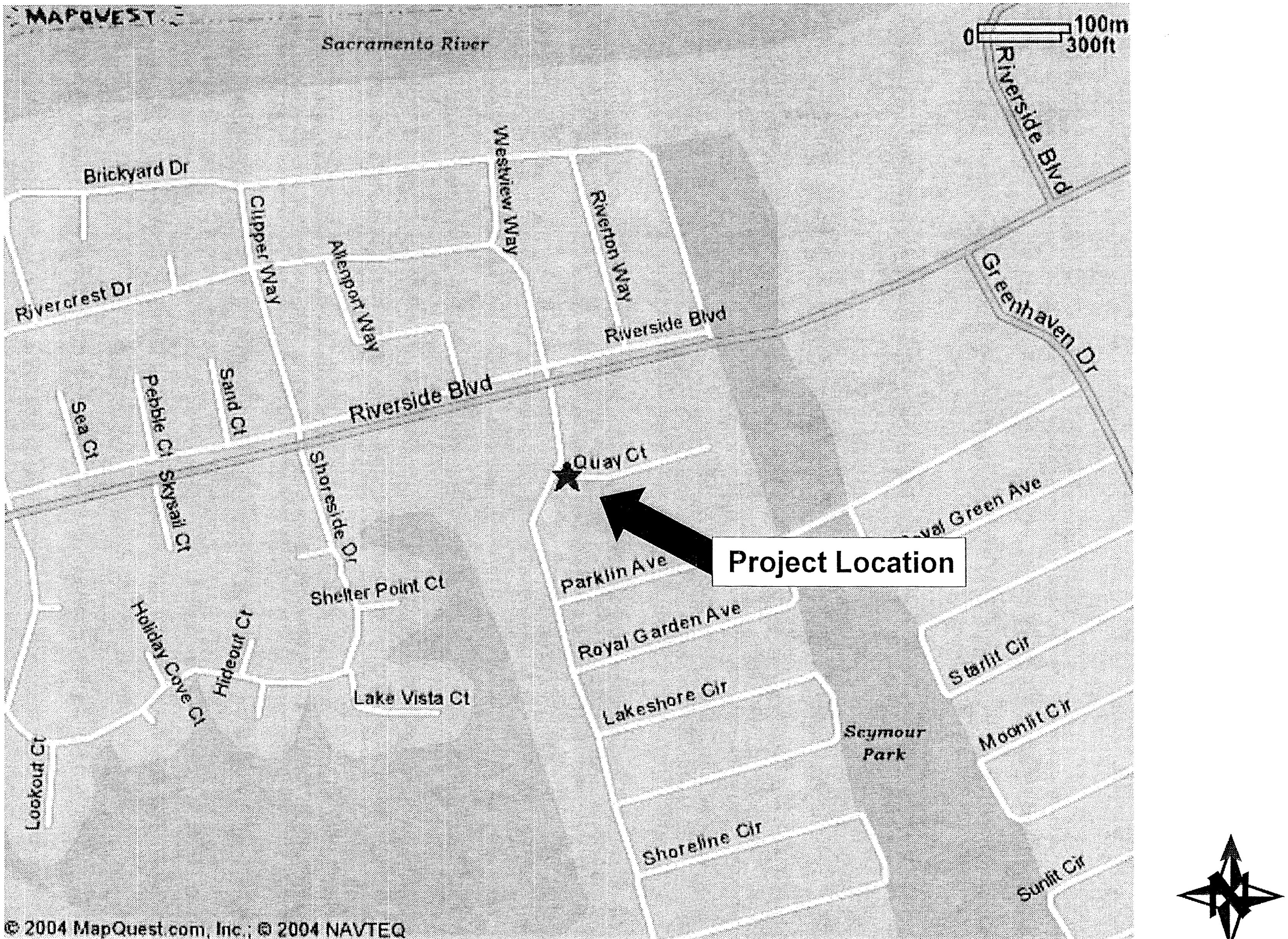
Figures

1. Vicinity Map

Appendices

A. Complex Map and Floor Plans
B. Applicable 2001 ASTM Standards
C. Applicable 2001 California Building Code Sections
D. FSTC Testing Methodology
E. FSTC Test Data and Results - Common Wall Tests

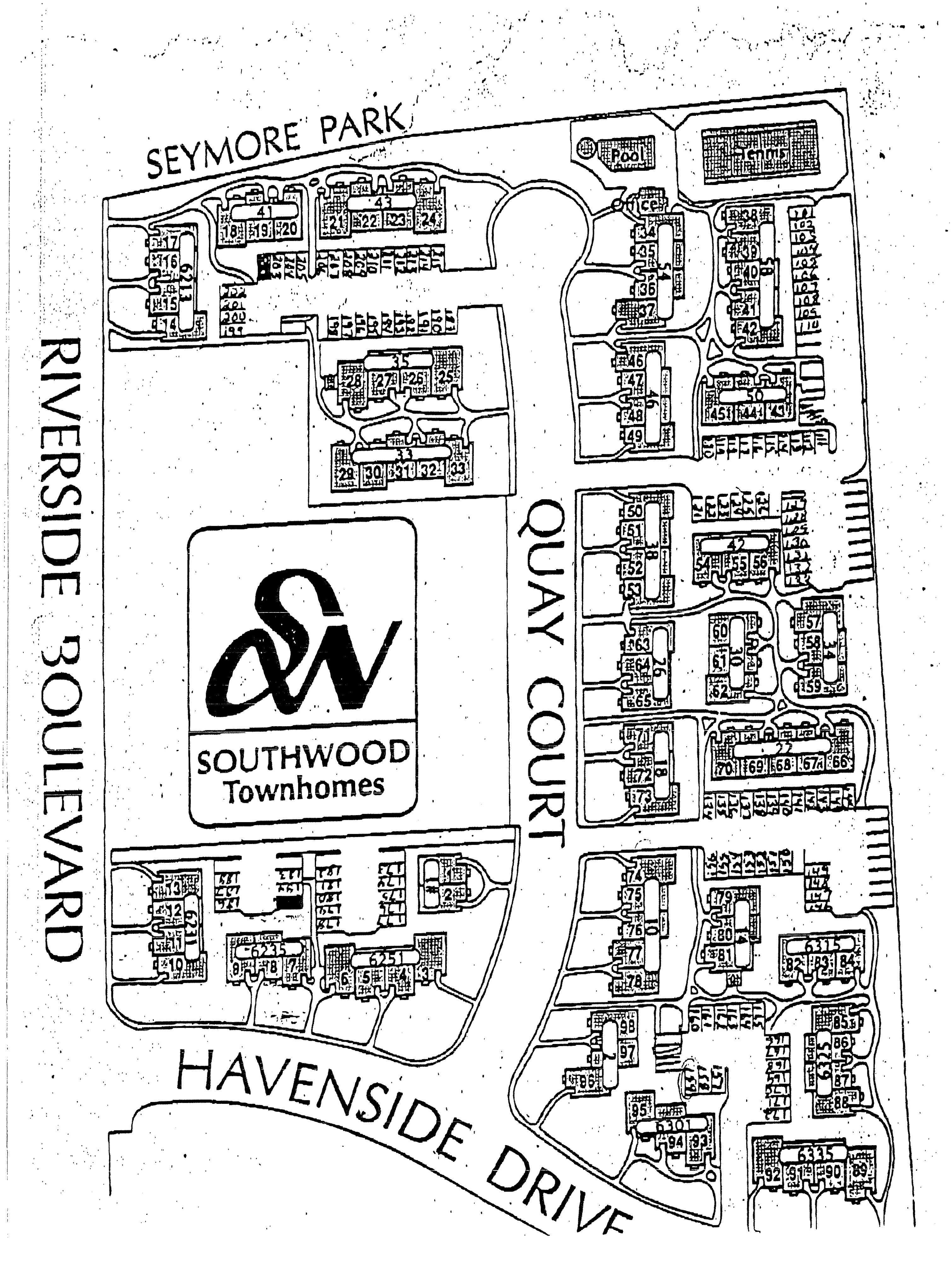
FIGURES



Eilar Associates 539 Encinitas Boulevard, Suite 206 Encinitas, California 92024 760-753-1865	Vicinity Map Project # A41130N1	Figure 1

APPENDIX A

Complex Map and Floor Plans

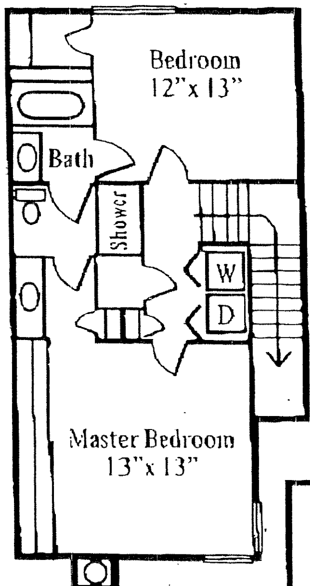

SEYMORE PARK
Pool
RIVERSIDE BOULEVARD
QUAY COURT
HAVENSIDE DRIV
SOUTHWOOD
Townhomes

Experience Townhome Living — A Great Place To Be

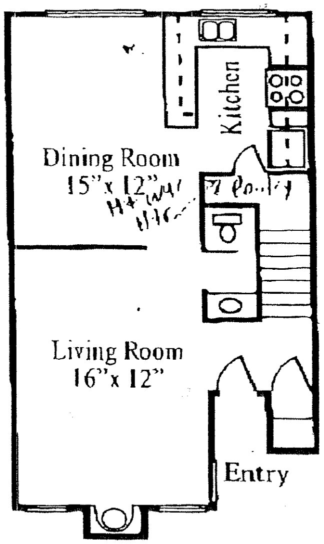
2 Bedroom Townhome 1230 Sq./Ft.

2/2.25 short toilet

Upstairs



Downstairs



You saw unit ______

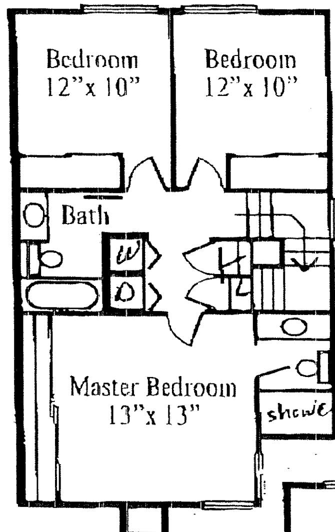
Rent ______

Deposit ______

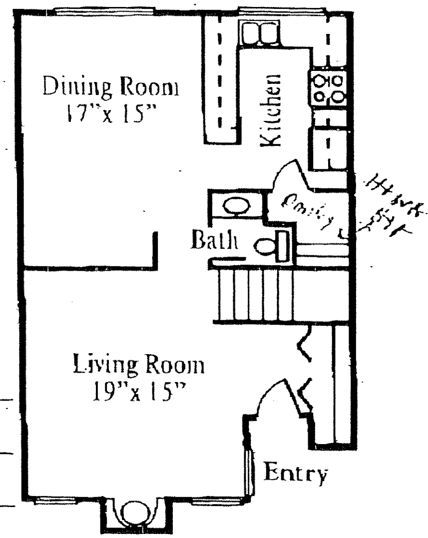
3 Bedroom Townhome 1441 Sq./Ft.

3/2.5

Upstairs



Downstairs



You saw unit ______

Rent ______

Deposit ______

Interior Amenities...

- Plush wall-to-wall carpet in neutral colors to complement any decor
- Large wood burning fireplaces for comfort and intimate ambiance
- Modern, energy-saving mini blinds
- Complete appliances including dishwashers garbage disposals, self-cleaning ovens, full size washers and dryers

Exterior Amenities...

- Pool, spa and lighted tennis courts for private use of Southwood residents
- Fenced patios
- Immediately adjacent to Seymour Park for children's play, sports and recreation

Construction Amenities...

- Townhome-style living
- Central heating and air conditioning
- Generous closet space and linen storage supplemented by outdoor storage units
- Kitchen pantries, snack bars, and ample kitchen cupboard space
- Covered parking space
- Energy efficient tile roofing and stucco exterior

SOUTHWOOD
TOWNHOMES

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APPENDIX B

Applicable 2001 ASTM Standards

Standard Test Method for Measurement of Airborne Sound Insulation in Buildings[1]

This standard is issued under the fixed designation E 336; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 NOTE—Equation 3 was editorially revised in August 2003.

INTRODUCTION

This test method is part of a set of standards for evaluating the sound-insulating properties of building elements. It is designed to measure the sound isolation between two rooms or the performance of a partition element installed as an interior part of a building. Others in the set cover the airborne sound transmission loss of an isolated partition element in a controlled laboratory environment (Test Method E 90), the laboratory measurement of impact sound transmission through floors (Test Method E 492), the measurement of impact sound transmission in buildings (Test Method E 1007), the measurement of sound transmission through building facades and facade elements (Guide E 966), the measurement of sound transmission through a common plenum between two rooms (Test Method E 1414), a quick method for the determination of airborne sound isolation in multiunit buildings (Practice E 597), and the measurement of sound transmission through door panels and systems (Test Method E 1408).

1. Scope

1.1 *Measures of Acoustical Insulation*—This test method covers procedures for determining the sound insulation between two rooms in a building. The evaluation may be made including all paths by which sound is transmitted or attention may be focused only on the dividing partition. The word "partition" in this test method includes all types of walls, floors, or any other boundaries separating two spaces. The boundaries may be permanent, operable, or movable.

1.2 *Application to Building Specifications*:

1.2.1 *Sound Transmission Class or Transmission Loss Specifications*—Building specifications may require that partitions have a certain minimum sound transmission class (STC) or transmission losses (TL). When it is required to demonstrate that a specific partition in a finished building complies with such specifications, a test satisfying the requirements of Annex A1 will be required.

1.2.1.1 Measurements may be made in accordance with the main body of this test method and with the requirements in Annex A1 without taking any steps to eliminate flanking transmission along paths other than that through the common partition. Transmission loss values can then be calculated as though the partition in question were the only transmission path. These apparent transmission loss values give a lower limit for the performance of the partition. Clearly when these values exceed the specifications, no further investigation is needed. If the partition is apparently not in compliance, then the procedures described in Annex A2 to reduce flanking transmission should be followed and the partition retested.

1.2.2 *Sound Isolation Specifications*—Where a building code specifies minimum values of noise isolation class (NIC) or normalized noise isolation class (NNIC), then only the procedures in the main body of the test method are necessary. Of the available single number ratings, NNIC relates best to occupant satisfaction in an occupied building.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 634 Terminology Relating to Environmental Acoustics[2]

E 90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions[2]

E 413 Classification for Rating Sound Insulation[2]

[1] This test method is under the jurisdiction of ASTM Committee E-33 on Environmental Acoustics and is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

Current edition approved March 10, 1997. Published August 1997. Originally published as E 336 – 71. Last previous edition E 336 – 96.

[2] *Annual Book of ASTM Standards*, Vol 04.06.

E 492 Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine[2]

E 597 Practice for Determining a Single-Number Rating of Airborne Sound Isolation for Use in Multiunit Building Specifications[2]

E 966 Guide for Field Measurement of Airborne Sound Insulation of Building Facades and Facade Elements[2]

E 1007 Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures[2]

E 1408 Test Method for Laboratory Measurement of the Sound Transmission Loss of Door Panels and Door Systems[2]

E 1414 Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum[2]

2.2 *ANSI Standards:*

S1.4 Specification for Sound Level Meters[3]

S1.10 Pressure Calibration of Laboratory Standard Pressure Microphones[3]

S1.11 Specification for Octave-Band and Fractional-Octave—Band Analog and Digital Filters[3]

S12.31 Precision Methods for the Determination of Sound Power Levels of Broad Band Noise Sources in Reverberation Rooms[3]

2.3 *IEC Standard:*

IEC 804 Specification for Integrating Sound Level Meters[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, see Terminology C 634.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *noise reduction, NR*—in sound transmission measurements, in a specified frequency band, the difference between the average sound pressure levels measured in two enclosed spaces or rooms due to one or more sound sources in one of them.

3.2.2 *normalized noise reduction, NNR*—the noise reduction between rooms that would exist if the reverberation time, *T*, in the receiving room were 0.5 s.

NOTE 1—The normalized noise reduction is approximately equal to the noise reduction that would exist between the rooms when ordinarily furnished.

3.2.3 *noise isolation class, NIC*—a single-number rating derived from measured values of noise reduction in accordance with Classification E 413.

NOTE 2—NIC provides a measure of the sound isolation between two enclosed spaces that are acoustically connected by one or more paths.

3.2.4 *normalized noise isolation class, NNIC*—a single-number rating, similar to noise isolation class, except that it is derived from measured values of normalized noise reduction.

3.2.5 *field transmission loss, FTL*—of a partition installed in a building, in a specified frequency band, 10 times the common logarithm of the ratio, of the airborne sound power incident on the partition to the sound power transmitted by the partition and radiated on the other side. The quantity so obtained is expressed in decibels. (See Eq 10.)

3.2.6 *field sound transmission class, FSTC*—the sound transmission class of a partition installed in a building derived from values of field transmission loss in accordance with Classification E 413.

3.2.7 *flanking transmission*—sound that travels between a source and a receiving room along paths other than through the partition dividing the two rooms.

4. Summary of Test Method

4.1 The noise reduction between two rooms in a building is obtained by measuring the difference between the average sound pressure levels in each room at specified frequencies in one-third octave bands when one room, the source room, contains a source of noise.

4.2 The rate of decay of sound in the receiving room is measured to enable calculation of room sound absorption or normalization factors.

4.3 The noise reduction may be normalized to a reference reverberation time of 0.5 s (see 3.2.2).

4.4 When room size and absorption requirements are satisfied so sound fields are sufficiently diffuse and when flanking is not significant, the field transmission loss may be calculated and reported (see the conditions in Annex A1 and Annex A2).

5. Significance and Use

5.1 *Measurement of Sound Isolation*—If the purpose of the test is to determine the existing degree of sound isolation between a certain pair of adjacent spaces (rooms), any peculiarities of the environment or of the partition common to the two rooms, including existing flanking transmission paths, must be considered as part of the whole structure to be tested. No preparation of the test specimen is either needed or permitted. Pertinent measures are the noise reduction (NR), noise isolation class (NIC), normalized noise reduction (NNR), and normalized noise isolation class (NNIC) and the procedures in Annex A1 and Annex A2 need not be followed.

5.1.1 The main text of this test method specifies procedures and requirements for measuring the noise reduction between two enclosed spaces or rooms. If these requirements are satisfied, noise reduction measurements can always be made. When all sound paths, including flanking transmission paths, are included in the measurements, noise reduction is a property of the two adjacent spaces, all connecting structures and the separating partition. Under such conditions, the noise reduction or normalized noise reduction provides a measure of the sound isolation between the spaces.

5.2 *Transmission Loss Measurement*—Tests may be made to demonstrate that the sound attenuation of a specific partition in a building complies with a specification. Or, test data, along with other test data on nominally identical test specimens, may be used to typify the field performance of a particular partition type. In such cases, care should be taken to see that all conditions are "typical," that the hazards of measurements are minimized, as specified in 6.2, and that all significant flanking is eliminated. Annex A2 describes procedures for checking that

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[4] Available from International Electrotechnical Commission (IEC), 3 rue de Varembé, P.O. Box 131, 1211 Geneva 20, Switzerland.

no substantial flanking is present. Pertinent measures are field sound transmission loss (FTL) and field sound transmission class (FSTC).

NOTE 3—It is sometimes possible to use Practice E 597 to determine if the acoustical isolation between two rooms is sufficient to meet building specifications.

5.2.1 The procedures and requirements described in Annex A1 and Annex A2 must be followed when the sound transmission loss properties of a partition are required. The problems of measuring the sound transmission loss properties of a partition in the field are much more difficult than those found in the laboratory or those associated with the field measurement of room-to-room sound isolation. In ordinary buildings, (1) a great variety of room shapes and sizes will be encountered; (2) the amount of energy exchange at the nominal boundaries of the test specimen will vary widely; and (3) there is almost always a problem of flanking transmission. Such variations influence the test results to a degree that is not generally predictable. Therefore, there may be substantial differences between sound transmission losses of similar partitions when measured in the laboratory and when measured in normal buildings, even though efforts are made to minimize leaks and flanking transmission **(1)**.[5] The procedures and requirements described in Annex A1 and Annex A2 are intended to minimize these differences. No effort shall be made to adjust field data to laboratory values under this test method.

5.2.2 It is possible that problems raised by flanking transmission or by an unusual field-test situation will make the measurement of field transmission loss so difficult or meaningless as to be impractical. If this is so, it is preferable to acknowledge the fact instead of attempting to apply an inappropriate measurement procedure.

6. Test Specimens

6.1 The special significance of this field test method is that measurements are made with partitions as found in the field in normally constructed buildings. Nevertheless, some judgment must be used to ensure that the field conditions, as found, are consistent with the purposes of the test.

6.2 *Test Location*—Find or install a test specimen of the desired type in surroundings most suitable for the test. The two spaces separated by the test specimen should be selected on the basis of (1) suitable size and shape, (2) freedom from structural irregularities near the test partition and freedom from offset conditions between the source and receiving room, and (3) (for field transmission loss measurements) freedom from flanking and satisfaction of the other requirements in Annex A1.

6.3 *Size and Mounting*—The minimum recommended lateral dimension and area of a test partition are 2.3 m (7.5 ft) and 5.5 m^2 (60 ft^2) respectively. The size and mounting conditions of the test specimen should be representative of the type of partition under study. Any unusual feature should be avoided unless this peculiarity is characteristic of the structure under investigation. Very small partitions sometimes yield different transmission loss values from similar large ones, and should not be used for test purposes unless the small size is characteristic of the construction being investigated, for example, a door. Any exceptional features shall be made clear in reporting the results.

6.4 Determine the radiating area of the test partition in the receiving room with careful attention to what elements constitute the test specimen. If the test partition presents different areas to the source and receiving rooms, use the area of the part common to both rooms. In this case, however, the test results may deviate considerably from the results for a partition with the same area exposed on both sides.

6.5 *Flanking Transmission*—In almost all installations in the field, sound can arrive in the receiving space by paths other than that directly through the partition nominally under test **(1,2)**. Flanking transmission includes structure-borne sound transmitted to the partition by the other surfaces (side walls, floor, ceiling) of the source room. Whether flanking transmission includes possible leaks around the edge of the partition depends on the type of partition and the purpose of the test. A decision must be made as to whether the leaks around the edge are a part of the partition. Any such decisions must be described in the test report.

6.6 *Drying and Curing Period*—Test specimens that incorporate materials for which there is a curing or drying process (for example, adhesives, plasters, concrete, mortar, and damping compound) shall age for a sufficient interval before testing. Aging periods for certain common materials are recommended in Test Method E 90 and summarized in Table 1 of this test method.

7. Test Signal

7.1 *Signal Spectrum*—The sound signals used for these tests shall be random noise containing an approximately continuous distribution of frequencies over each test band.

7.2 *Bandwidth*—The measurement bandwidth shall be one-third octave. Specifically, the overall frequency response of the electrical system, including the filter or filters in the source and microphone sections, shall for each test band conform to the specifications in ANSI S1.11 for a one-third octave band filter set, Order 3 or higher, Type 1 or better.

7.2.1 Filtering may be done either in the source or the measurement system or partly in both, provided that the required overall characteristic is achieved. Apart from defining

TABLE 1 Recommended Minimum Aging Periods Before Testing

Material	Recommended Minimum Aging Period
Masonry	28 days
Plaster:	
Thicker than 3 mm (⅛ in.)	28 days
Thinner than 3 mm (⅛ in.)	3 days
Wallboard Partitions:	
With water-base laminating adhesives	14 days
With non-water-base laminating adhesives	3 days
With typical joint and finishing compounds	12 h
Other	As appropriate for caulking and adhesive compounds involved

[5] The boldface numbers in parentheses refer to the list of references at the end of this test method.

the bandwidth of test signals, filters in the microphone system reduce extraneous noise lying outside the test bands, including possible distortion in the source system; a filter in the source system serves to concentrate the available sound power in the test band or bands.

NOTE 4—Paragraphs 7.2 and 7.2.1 are intended to describe the effective results, rather than specific instrumentation. Any system that achieves the specified results is acceptable.

7.3 *Standard Test Frequencies*—The minimum range of measurements shall be a series of contiguous one-third octave bands with mid-band frequencies from 125 to 4000 Hz. It is desirable that the range be extended to include at least the 100 and 5000-Hz bands.

7.4 *Sound Sources*:

7.4.1 The source(s) should radiate sound over a wide angle to avoid a strong direct field component. To satisfy this requirement over the frequency range of the measurements might require the use of loudspeaker systems with separate drivers for the high and low frequencies.

7.4.2 *Location of Sound Sources*—Sound sources should be far enough away from the test partition that the direct field reaching the latter is as small as possible compared to the reverberant field. (For testing walls, sources are usually placed in corners away from the specimen. When the test specimen is a floor the source usually must be placed in the lower room.) Pointing loudspeakers into corners reduces the direct field from the loudspeakers in the source room.

7.5 *Multiple Sound Source Positions*—Measured values of noise reduction especially at low frequencies, may change significantly when loudspeaker position in the source room is changed. Where this occurs, sound transmission loss can be measured for several loudspeaker positions and the values averaged to provide a less biased result. Sound sources can be used either in sequence or simultaneously. If they are used simultaneously, they must be driven by separate noise generators and amplifier channels so the outputs are uncorrelated. Multiple, uncorrelated sound sources also have been found to reduce the spatial variance of sound pressure level in reverberation rooms. If multiple sources are used, they should be well separated in the room.

7.5.1 *Sound Power of Sources*—The sound power of the source(s) must be sufficient to get the signal level in the receiving room far enough above background noise to meet the requirements of 10.5. The power required depends on the source room absorption, the nature of the test specimen, and the background noise in the receiving room.

8. Microphone Requirements

8.1 Microphones are used to measure average sound pressure levels in the rooms and sound decay rates in the receiving room.

8.2 *Microphone Electrical Requirements*—Use microphones that are stable and substantially omnidirectional in the frequency range of measurement. (A 13 mm (0.5 in.) random-incidence condenser microphone is recommended.) Specifically, microphones, amplifiers, and electronic circuitry to process microphone signals must satisfy the requirements of ANSI S1.4 for Type 1 sound level meters, except that A, B, and C weighting networks are not required since one-third octave filters are used.

8.3 *Microphone Calibration*—Calibrate microphone(s) periodically (annually, for example) throughout the test frequency range by a qualified laboratory technique (see ANSI S1.10).

9. Sensitivity Checks

9.1 Carefully check all instruments at the time of the tests. This is particularly important in field measurements where the hazards of transportation increase the likelihood that the equipment will be found out of adjustment at the test site.

9.2 When source room levels and receiving room levels are measured with the same instruments, perform sensitivity checks before beginning the measurements in each room and at intervals during the test, to ensure drift of not more than 0.5 dB.

9.3 When two sets of sound level measuring equipment are used for measurement of sound levels in the source and receiving rooms, check the sensitivity of both sets before field tests are begun and at intervals of not more than 30 min thereafter. Use the same calibration equipment for all calibrations. The microphones should all be of the same make and model.

9.4 Make the sensitivity check of the microphone(s) using an acoustic or electrostatic calibrator that is known to be stable. The sensitivity check will usually consist of impressing a known sound pressure upon the microphone system, keeping account of all variable gain settings in the equipment. This procedure establishes a relationship between electrical output and sound pressure level at the microphone. All subsequent electrical outputs can thus be converted to sound pressure levels at the microphone, taking into account the filter response and any changes of gain in the system.

9.4.1 A nominal sine wave having less than 10 % distortion and amplitude stability to within 0.2 dB is recommended as a calibration signal.

9.5 The sensitivity check need be made at only one frequency within the range from 200 to 1250 Hz.

9.6 Include the entire measuring setup (including the microphone, all cables, and instruments) in the check for sensitivity. Recheck the entire setup after any changes, adjustments, or substitutions of cables or equipment.

9.7 If equipment is sensitive to line voltage variations, use a line-voltage regulator.

10. Measurement of Average Sound Pressure Levels

10.1 The measurement procedure requires the determination of the average sound pressure levels $\bar{L}_1$ and $\bar{L}_2$ produced in the two rooms by the sound source in the source room. The measurement process must account for variations with microphone position, microphone sensitivity, and possible changes in the spectrum and level of the source, and it must be repeated for each test frequency band. Various spatial sampling arrangements are possible. A single microphone may be moved continuously or placed sequentially at several measurement positions or an array of stationary microphones may be used.

10.2 *Averaging Time*—The average sound pressure level in a given period of time is best obtained using an instrument that provides a direct reading of the required value. Such instruments include integrating sound level meters that meet the requirements of IEC 804 or real-time frequency analysers. Other methods may also be satisfactory.

10.2.1 *Fixed Microphones*—For each sampling position, the averaging time shall be sufficient to yield an accurate estimate of the time-averaged level. This requires longer averaging times at low frequencies than at high. For 95 % confidence limits of $\pm e$ dB in a one-third octave band with center frequency, f, the averaging time, T_a, may be estimated from:

$$T_a = \frac{310}{fe^2} \tag{1}$$

Thus at 125 Hz, the minimum averaging time for confidence limits of$\pm$ 0.5 dB should be 9.9 s. For more information see Ref **(7)**.

10.2.2 *Moving Microphones*—For mechanically or manually swept microphones, integration times should be long enough that repeat measurements are not significantly different. A typical time for a sweep of the room is 60 s.

10.3 *Fixed Microphones*:

10.3.1 *Number of Microphone Positions*—Use at least six microphone positions in each room.

10.3.2 *Microphone Positions*—Locate microphones to sample adequately the sound field in each room with the following restrictions:

10.3.2.1 Except as noted below, the shortest distance from any microphone position to any major extended surface shall be not less than 1 m (3.3 ft) if the requirements for microphone separation (see 10.3.2.4) and number of microphones (see 10.3.1) can be met with this distance. If these requirements cannot be met then the shortest distance from any microphone position to any major extended surface may be reduced but must never be less than 0.5 m (1.6 ft) **(3)**.

10.3.2.2 *Direct Field of Sound Source(s)*—The minimum distance from the source to the nearest measurement point should be such that there is minimal influence on the measurement of the average sound pressure level by the direct sound field. This distance will depend on the absorption of the room and other factors. For practical purposes it is sufficient to ensure that no microphone is within 1.5 m (5 ft) of the source.

10.3.2.3 In the receiving room, position the microphones so that the average sound pressure level is not substantially influenced by the direct field of the partition. Do not place a microphone in the receiving room within 1.0 m (3.3 ft) of the partition.

NOTE 5—In heavily furnished (absorptive) source or receiving rooms, it may not be possible to avoid the effects of the direct field of the source or the partition. In such cases, transmission loss measures would be invalid, but noise reduction measurements may still be reported.

NOTE 6—In certain field situations, the determination of what constitutes the receiving room and its volume may not be obvious. An example is when a living room is connected to a kitchen in the same unit through an opening in a dividing wall that does not extend to the ceiling, and both "rooms" adjoin a party wall under test. Some judgment may be required to define the volume of the "room." It is recommended that sound pressure level measurements be performed in all portions of the room under consideration. The ancillary volume can be disregarded in the calculations if the average sound pressure level is 6 or more decibels below the average level in the principal portion of the source or receiving room.

10.3.2.4 Ensure that fixed microphone positions are separated by at least 1 m (3.3 ft). This separation is deemed sufficient for the purposes of this test method. Do not use microphone arrangements that are obviously symmetrical, such as all in the same vertical or horizontal plane.

NOTE 7—To provide independent samples of the sound field, stationary microphones in an ideal diffuse sound field, should be spaced at least one-half wavelength apart **(3)**.

10.4 *Moving Microphones*—Moving microphones may be used in conjunction with sound level meters or the equivalent that give integrated levels in accordance with IEC 804. This combination has the advantage that it provides average sound pressure levels in the rooms automatically. The same system used to measure the average sound pressure level must be used to measure background noise so that any mechanical or human sounds are present in both cases.

10.4.1 *Mechanically Operated Microphones*—A single microphone continuously moving along a defined traverse such as a circular path may be used instead of stationary microphone positions, provided that the restrictions given in 10.3.2 are met at all points on the path. For the purposes of this test method, it is sufficient if the radius of a circular path is at least 1 m (3.3 ft).

NOTE 8—The number of equivalent fixed microphone positions for a straight line traverse of length L is $2L/\lambda$ and for a circular or closed traverse of length L is $2L/\lambda - 1$ where λ is the wavelength of interest **(4)**.

10.4.2 *Manually Swept Microphones*—The microphone should be held well away from the operator's body (a boom serves to increase the distance). The operator should slowly turn and move the microphone to sample as much of the central volume of the room as possible. The restrictions on microphone proximity to surfaces in 10.3.2 must still be met.

10.5 *Background Noise*—Make measurements of background noise levels routinely in each frequency band to ensure that the observations are not affected by extraneous sound, electrical noise in the receiving system, or electrical cross-talk between source and receiving systems. Make corrections at each measurement position when background level is less than 10 dB below the combined level due to signal and background. If the background level is between 5 and 10 dB below the combined level, the adjusted value of the signal level is calculated as follows:

$$L_s = 10 \log (10^{L_{sb}/10} - 10^{L_b/10}) \tag{2}$$

where:

L_b = background noise level in each band, dB,
L_{sb} = combined level of signal and background, dB, and
L_s = adjusted signal level, dB.

If the signal level cannot be adjusted so that the background level is at least 5 dB below the combined level, then subtract 2 dB from the combined level and use this as the adjusted signal level. In this case, the measurements can be used only to provide an estimate of the lower limit of the noise reduction. Identify such measurements in the test report.

NOTE 9—Since acoustical background noise levels can vary quickly with time, due to transportation, construction, or occupancy noises, it is desirable that the sound source can be operated remotely so that the background noise check is made immediately after each sound level measurement.

10.6 *Determination of Space-Average Levels*—Following the procedures of 10.3.1 and 10.4.1, obtain two sets of average sound pressure levels corresponding to the sampling in the two rooms. For fixed microphones, the space-average level for the room is calculated as follows:

$$\bar{L} = 10 \log_{10}\left[\frac{1}{n}\sum_{i=1}^{n} 10^{L_i/10}\right] \quad (3)$$

where L_i are the set of time-average levels taken at n locations in the room.

NOTE 10—Throughout this test method, log is taken to mean $\log_{10}$, unless otherwise indicated.

11. Determination of Receiving Room Absorption

11.1 Receiving room absorption, A_2, is determined by measuring the rate of decay of sound pressure level in the receiving room in the same one-third octave bandwidths and with the room in the same condition as for the measurement of $<L_1>$ and $<L_2>$. Determine the sound absorption of the receiving room, A_2, as follows.

11.2 Activate sound source(s) in the receiving room for a few seconds, then switch them off and record the curves giving the decay of sound pressure level in the room at each one-third octave band frequency. This may be done using a real-time analyzer or sound level meter with built-in algorithms or interfaced to a computer with appropriate software. With such instrumentation, decay rates or reverberation times can be obtained automatically.

11.2.1 Instrument decay rates in each frequency band should be at least 3 times the room decay rates so measurements of sound decay rates are not biased. The instrument decay rate can be measured by attaching a noise generator directly to the input, switching off the generator, and then measuring the decay.

11.3 *Measurement of Decay Rate from Decay Curves*—First select a point on the decay curve as close as practical to 0.1 s after the sound source has been switched off. Select a second point on the decay curve no more than 25 dB lower in sound pressure level than the first point. The second point must be at least 10 dB above the background noise level. Determine the straight line that best approximates the portion of the decay curve between these two points. The slope of the line, d, gives the rate of decay of sound pressure level in decibels per second. Fitting may be done to individual decay curves, or to the average of several.

11.4 *Number of Decay Rate Measurements*—Obtain the mean room decay rate by averaging the rates for at least three decays measured at each of at least three locations 1 m or more apart in the receiving room. For example, the mean decay rate could be obtained by measuring four decays at each of four locations in the receiving room and averaging a total of 16 decays. Microphones placed in room corners may be used. A moving microphone may also be used when measuring the decay rate, in which case spatial averaging will be automatic but an average of several decays is still necessary.

NOTE 11—Sound decay rates vary from one decay to the next because of the random nature of the sound excitation. They also vary with the position of the microphone in the room. Thus an average value should be found.

NOTE 12—Note that because the quantity entering into the transmission loss calculation is only 10 log A_2, highly precise measurements are not essential. Thus a 10 % uncertainty in measuring A_2 results in only a 0.4 dB uncertainty in the calculated transmission loss value.

11.5 A_2 is given by the Sabine equation:

$$A_2 = 0.921 \frac{Vd}{c} \quad (4)$$

where:
A_2 = sound absorption of the room, m^2,
c = speed of sound in air, m/s,
V = volume of room, m^3, and
d = rate of decay of sound pressure level in the room, dB/s.

(Note that $d = 60/T$ where T is reverberation time in seconds.)

When V and c are in cubic feet and feet per second respectively; A_2 is in sabins (square feet).

11.6 The speed of sound changes with temperature, and it shall be calculated for the conditions existing at the time of test from the equation:

$$c = 20.047\sqrt{273.15 + t}\ m/s \quad (5)$$

where:
t = receiving room temperature, °C.

12. Calculation

12.1 Calculate the noise reduction, the difference between the space-average sound pressure levels obtained in the source and receiving rooms, using:

$$NR = \bar{L}_1 - \bar{L}_2 \quad (6)$$

where:
$\bar{L}_1$ = average sound pressure level in the source room, dB, and
$\bar{L}_2$ = average sound pressure level in the receiving room, dB.

12.1.1 If required, normalized noise reduction values are calculated as follows:

$$NNR = \bar{L}_1 - \bar{L}_2 + 10 \log (T/0.5) \quad (7)$$

where:
T = reverberation time in the receiving room, s.

(Note that $T = 60/d$ where d is the rate of decay of sound pressure level, dB/s.)

12.1.2 When air temperature is approximately 20°C, room sound absorption is related to the reverberation time as follows:

$$T = 0.161\ V/A_2 \quad (8)$$

where:
A_2 = room absorption, m², and
V = room volume, m³ or

$$T = 0.049\ V/A_2 \tag{9}$$

where:
A_2 = room absorption, sabins, and
V = room volume, ft³.

12.2 Provided the requirements of Annex A1 have been met, the field sound transmission losses of the partition may be calculated from measurements in the two rooms as follows:

$$FTL = \bar{L}_1 - \bar{L}_2 + 10 \log (S/A_2) \tag{10}$$

where:
S = area of the test partition, m²(ft²), and
A_2 = sound absorption in the receiving room, m²(sabins).

(Note that A_2 is the absorption with the test partition in place; sound transmitted from the receiving room back into the source room through the test partition constitutes part of the sound absorbed from the receiving room.)

12.3 This test method specifies the use of one-third octave bands for measurement and calculation of noise reduction and all derived quantities. It does not allow measurement of octave band noise reductions because these are very sensitive to the shape of the spectrum in the source room and to the details of the transmission loss characteristics of the test panel. In applications where octave band values are required, they must be calculated using the expression:

$$NR_{oct,fc} = -10 \log\left[\frac{1}{3} \sum_{B=B_c-1}^{B_c+1} 10^{-NR_B/10}\right] \tag{11}$$

where f_c is a preferred octave band mid-band frequency as specified in ANSI S1.6. The summation is made over three one-third octave band NR values: one at the frequency f_c with band number B_c and the adjacent one-third octave bands, with band numbers $B_c + 1$ and $B_c - 1$. The octave band values calculated from this expression approximate what would be measured if the spectrum in the source room had the same sound pressure level in each one-third octave band. (Random noise with this spectrum is known as "Pink noise.")

13. Report

13.1 Report the following information:

13.1.1 *Statement of Conformance to Standard*—State that the tests were conducted in accordance with this test method. Note any deviations clearly.

13.1.2 *Description of Test Environment*:

13.1.2.1 A general description of the source and receiving spaces and their environs, including furnishings.

13.1.2.2 A sketch showing the layout, dimensions, and volumes of the test rooms.

13.1.2.3 The dimensions of the test partition.

13.1.3 *Description of Test Specimen*:

13.1.3.1 If the information is available and relevant to the purpose of this test method, give a complete description of the test partition, including all of the essential constructional elements, the size, thickness, and an estimate of the average weight per unit area of the specimen.

NOTE 13—If there are no access panels, outlet boxes, etc., that would permit a direct measurement of wall thickness, the specimen thickness can often be deduced by measurement between windows or doorways separated by the test specimen.

13.1.3.2 Any description of the test specimen should as far as practicable be based upon measurement and examination of the specimen itself, rather than upon the building plans or information received from the builder or others.

13.1.3.3 If the construction or installation of the test specimen is, for some reason, such that the results do not represent normal performance of the specimen, state this fact explicitly.

13.2 *Description of Test Procedure*:

13.2.1 The method used to measure room absorption.

13.2.2 The procedures, if used, to evaluate possible flanking transmission.

13.3 *Statement of Test Results*:

13.3.1 State clearly which kind of results are being presented (NR, NNR, or FTL). If flanking transmission has not been evaluated as specified in Annex A2, then field transmission loss values may be referred to as minimum field transmission loss values.

13.3.2 State the mean values of L_1, L_2, A_2 (or RT) for the measurements. As appropriate, state the mean value, rounded to the nearest 1 dB, of NR, NNR, or FTL of the test results at the specified frequencies. This must be done in tabular form and may also be done in graphical form. For measurements made in rooms smaller than the limits given by A1.3.1, mark the values of noise reduction or transmission loss at those frequencies below the limit to show that the measurements are not as reliable.

13.3.3 Where flanking tests have been performed as described in Annex A2, state the measured values of NR or FTL before and after the construction of the supplementary shields.

13.4 *Noise Isolation Class or Normalized Noise Isolation Class (NIC or NNIC)*—Where only sound pressure levels have been measured, state the NIC. Where decay rate measurements have also been made, state the NIC and the NNIC.

13.5 *Field Sound Transmission Class (FSTC)*—For test partitions whose field transmission loss has been measured in one-third octave bands in accordance with this test method including Annex A1 and for which, by applying the methods of Annex A2, either no significant flanking has been found or it has been eliminated, a field sound transmission class (FSTC) may be assigned in accordance with Classification E 413.

13.5.1 Where flanking has not been evaluated but the requirements of Annex A1 have been met, the measured data may be used to calculate transmission loss values that give a lower limit for the sound insulation of the specimen. These data may be used to calculate a value of FSTC that represents the minimum sound insulation the specimen is capable of. This minimum FSTC may be reported but its significance should be clearly stated.

14. Precision and Bias

14.1 *Precision*—The precision of this test method has not been established.

14.2 *Bias*—There is no known bias in this test method.

15. Keywords

15.1 airborne sound transmission loss; flanking transmission; noise isolation class; noise reduction; normalized noise isolation class; sound transmission coefficient; sound transmission loss; transmission loss

ANNEXES

(Mandatory Information)

A1. MEASUREMENT OF FIELD SOUND TRANSMISSION LOSS

A1.1 Field transmission loss is defined in 3.2.5. In the laboratory test procedure (Test Method E 90), transmission loss is determined by mounting the partition between two reverberation rooms, one of which (the source room) contains one or more sound sources. The rooms are arranged so the only significant sound transmission between them is through the test specimen and the sound fields in them are adequately diffuse. Under these conditions, the transmission loss is related, by Eq 10, to the space-time average sound pressure levels in the two rooms, the area of the test partition, and the absorption in the receiving room. When these quantities are measured in appropriate frequency bands, the transmission loss as a function of frequency can be calculated. When this situation is closely approximated in the field, the noise reduction measurements may be used to calculate field transmission loss values also using Eq 10.

A1.2 *Required Conditions*—To make acceptable measurements of sound transmission loss in the field the conditions following must be met.

A1.3 *Room Size:*

A1.3.1 *Minimum Volume*—The volume of each room should be not less than 60 m^3 (2100 ft^3) for measurements down to 100 Hz, 40 m^3 (1400 ft^3) for measurements down to 125 Hz, and 25 m^3 (880 ft^3) for measurements down to 160 Hz. Where these criteria are not satisfied, no attempt should be made to determine field transmission loss, though the noise reduction may always be measured and reported.

NOTE A1.1—The room volume requirement at 125 Hz is obtained by assuming that a minimum of ten room modes will provide a sufficiently good approximation to a diffuse sound field. At other frequencies, the minimum room volume can be calculated by requiring that the same average modal spacing as at 125 Hz is maintained. Thus larger rooms are needed at lower frequencies.

A1.3.2 In situations where either the source room or the receiving room is small compared to the wavelength of sound, the measured noise reduction becomes unduly influenced by the properties of the rooms and no longer characterizes the test specimen. Therefore "incident" or "radiated" sound power and transmission loss cannot be defined in the usual way. This situation will occur in any closed space if the frequency is low enough.

A1.4 *Room Shape*—In addition to the minimum volume requirement in A1.3.1, it is preferable to avoid extreme ratios of room dimensions. Therefore, the room height shall be 2.3 m (7.5 ft) or greater and no lateral receiving room dimension shall be less than 2.75 m (9 ft), the wavelength of the middle frequency of the 125 Hz one-third octave band.

A1.5 *Room Absorption*—At all frequencies, the room absorption, A, for each room shall be less than:

$$A = V^{2/3} \tag{A1.1}$$

where V is the room volume. If V is in cubic metres (cubic feet), then A is in square metres (sabins).

NOTE A1.2—The sound absorption in each of the rooms should be low to achieve the best possible simulation of the ideal diffuse field condition, and in order to keep the region dominated by the direct field (in both the source and receiving rooms) as small as possible.

A1.6 *Partition Area*—For transmission loss measurements, the dimensions of the part of the test partition common to both sources and receiving rooms shall be at least 2.3 by 2.4 m (7.5 by 8 ft), unless a door or window is being evaluated.

A1.7 Once the primary measurement of field transmission loss is complete, a supplementary test may be made to demonstrate that no significant flanking transmission is present. Details of suitable tests for flanking transmission are outlined in Annex A2.

A1.8 After evaluating or eliminating flanking transmission, the sound transmission loss of the test partition may then be calculated from measurements in the two rooms in accordance with Eq 11.

A1.9 If flanking transmission is found to be affecting the transmission loss when following the procedures outlined in Annex A2, the calculated FTL values may be referred to as minimum FTL values since they will be at least as great as when no flanking exists.

A2. CHECKS FOR FLANKING TRANSMISSION

A2.1 In measurements where the field transmission loss of the test panel is required, it may be necessary to reduce flanking transmission to a negligible amount so that the measured levels in the receiving room correspond only to that sound which is transmitted through the partition under test. The following test may be performed in accordance with Section 10 and Annex A1 for field transmission loss measurements to demonstrate the absence of significant flanking transmission.

A2.2 *Shielding*—After the initial measurement of apparent transmission loss has been made, cover one side of the test partition with an additional panel designed to reduce transmission through the test specimen by at least 10 dB. A suitable construction consists of a layer of plywood or gypsum board weighing at least 10 kg/m^2 (2 lb/ft^2), free-standing or lightly supported from the test facade and spaced at least 100 mm (4 in.) from it, with soft sound-absorbing material such as glass fiber batts in the space. The blocking panel must be sealed at joints and around the perimeter with tape, gaskets, or caulking compound, so as to form a complete auxiliary wall. It may be convenient to arrange the panels in a splayed, zig-zag configuration so that, when the edges are taped together to form a hinge, the array is free-standing, like a decorative screen.

A2.2.1 Take care that the area shielded comprises all, but not more than, the structural elements making up the specimen under test. For example, in the case of an operable or demountable partition, it is usually understood that the manufacturer has the responsibility of providing an adequate seal to the surrounding structure; this seal, therefore, is part of the specimen under test. In this case, tape the supplementary skin just outside the seal, so that the seal is covered (as part of the specimen) for the second measurement.

A2.2.2 The supplementary skin may be added on either side of the test partition, but if it is applied on the source side, there is no need to remeasure the absorption in the receiving space.

A2.2.3 The apparent TL of this modified partition is then measured and compared with the initial TL measurement. If, in each frequency band, the apparent TL of the modified partition is at least 10 dB higher than the initially measured TL, then the initial measurements may be deemed to represent the true TL of the test specimen. If the difference in apparent TL is less than 5 dB, then there is too much flanking sound transmission to permit a reliable determination of the true TL. If the difference is between 5 and 10 dB, an estimate of the true TL can be made by treating receiving room level measurements with the blocked-off test specimen as background noise, thus:

$$TL_a = -10 \log (10^{-TL_e/10} - 10^{-TL_b/10}) \quad \text{(A2.1)}$$

where:

TL_b = level with the test specimen blocked off, dB,
TL_e = level with test specimen exposed, dB, and
TL_a = adjusted level due to transmission through the test specimen alone, dB.

A2.3 *Comparison with Laboratory Data*—After the transmission loss calculations have been made, the resulting field data may be compared with laboratory transmission loss data for a similar type of partition. One should not necessarily expect close agreement, but widely divergent trends may indicate the existence of flanking paths, of leaks, or of deviations from the nominal construction of the test specimen.

A2.4 Other procedures may be used to estimate the importance of flanking transmission.

A2.4.1 *Listening Tests*—The simplest procedure is to try to detect obvious leaks where sound is entering the space by way of unintended paths. This can be accomplished by listening at the wall surfaces with either a stethoscope or with a microphone and amplifier driving a pair of ear phones.

A2.4.1.1 A word of caution is in order concerning the investigation of sound fields near interior room surfaces. As the leak test apparatus is moved into a corner, an increase in sound level due to pressure doubling near boundaries and corners is usually heard and measured; this effect should not be mistaken for a sound leak.

A2.5 *Vibration Measurements*—One may also investigate whether the surfaces of the receiving room other than the test partition are vibrating significantly at the test frequencies; an accelerometer may be used to compare the vibration of the test partition with that of the other surfaces. The average vibration level in each band of each of the other room surfaces should be at least 10 dB below that of the test partition.

A2.5.1 The accelerometer should be small and of low mass compared to the surface mass of the room surfaces. Other techniques using advanced instrumentation such as correlation analyzers and sound intensity meters may also be useful but their application is beyond the scope of this test method.

A2.6 Clearly identify in the report all data for which the flanking transmission is observed but cannot be effectively eliminated. It may be stated that the field transmission loss is at least as great as the test data indicate.

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Designation: E 413 – 87 (Reapproved 1999)

Classification for Rating Sound Insulation[1]

This standard is issued under the fixed designation E 413; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This classification provides methods of calculating single-number acoustical ratings for laboratory and field measurements of sound transmission obtained in one-third octave bands. The method may be applied to laboratory or field measurements of the sound transmission loss of a partition in which case the single-number ratings are called sound transmission class (STC) or field sound transmission class (FSTC), respectively. The method may also be applied to laboratory and field measurements of the sound isolation between two spaces, in which case the single-number ratings are called the noise isolation class (NIC) or normalized noise isolation class (NNIC).

2. Referenced Documents

2.1 *ASTM Standards:*

C 634 Terminology Relating to Environmental Acoustics[2]

E 90 Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions[2]

E 336 Test Method for Measurement of Airborne Sound Insulation in Buildings[2]

E 596 Test Method for Laboratory Measurement of the Noise Reduction of Sound-Isolating Enclosures[2]

2.2 *ISO Standard*

ISO717 Rating of Sound Insulation for Dwellings[3]

3. Terminology

3.1 For definitions of terms used in this classification, see Terminology C 634.

4. Significance and Use

4.1 The procedure may be applied to one-third octave band sound transmission losses of test specimens measured in accordance with Test Method E 90 to derive sound transmission class (STC). It can also be applied to (*1*) similar quantities measured in accordance with Test Method E 336, to derive field sound transmission class (FSTC), noise isolation class (NIC), and normalized noise isolation class (NNIC) and to (*2*) noise reductions measured in accordance with Method E 596 to derive noise isolation class.

4.2 These single-number ratings correlate in a general way with subjective impressions of sound transmission for speech, radio, television, and similar sources of noise in offices and buildings. This classification method is not appropriate for sound sources with spectra significantly different from those sources listed above. Such sources include machinery, industrial processes, bowling allies, power transformers, musical instruments, many music systems and transportation noises such as motor vehicles, aircraft and trains. For these sources, accurate assessment of sound transmission requires a detailed analysis in frequency bands.

4.3 The single-number ratings obtained can be used to compare the potential sound insulation of partitions or floors tested in laboratory conditions or the actual sound isolation between different suites in buildings. The rating for a partition built and tested in a building may be lower than that obtained for a partition tested in a laboratory because of flanking transmission or construction errors.

NOTE 1—A similar rating procedure, described in ISO 717, provides single figure sound insulation ratings with a frequency range that extends from 100 to 3150 Hz and with no maximum deficiency specified at individual frequencies.

5. Procedure

5.1 The reference contour is defined by the array of levels given in Table 1 and shown in Fig. 1.

TABLE 1 Reference Sound Insulation Contour for Calculation of Single-Number Ratings

NOTE 1—Reference sound insulation contour for calculation of single-number ratings. This contour has a rating of zero. Other contours may be derived by adding the same integer simultaneously to all values in the table.

Frequency, Hz	125	160	200	250	315	400	500	630
Level, dB	−16	−13	−10	−7	−4	−1	0	1
Frequency, Hz	800	1000	1250	1600	2000	2500	3150	4000
Level, dB	2	3	4	4	4	4	4	4

5.2 Round the data to which the contour is to be fitted to the

[1] This classification is under the jurisdiction of ASTM Committee E33 on Environmental Acousticsand is the direct responsibility of Subcommittee E33.03 on Sound Transmission.

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[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

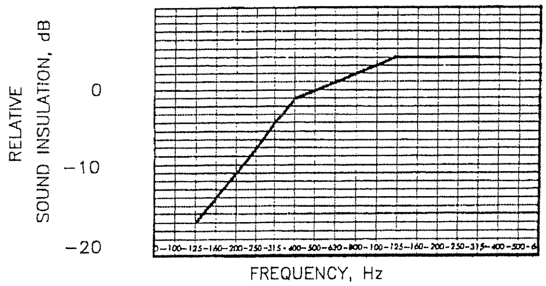

FIG. 1 Reference Contour for Calculating Sound Transmission Class and Other Ratings

nearest integer if this is not already specified in the measurement standard.

5.3 Fit the reference contour to the data by increasing simultaneously all the values in Table 1 in 1 dB increments until some of the measured data are less than the shifted reference contour.

5.4 At each frequency calculate the difference between the shifted reference value and the measured data. Only deficiencies, that is, where the measured data are less than the reference contour, are counted in the fitting procedure. Continue to increase the reference contour values until the most stringent of the following conditions is satisfied:

5.4.1 The sum of the deficiencies is less than or equal to 32 dB;

5.4.2 The maximum deficiency at any one frequency does not exceed 8 dB.

5.5 The STC, FSTC, NIC, or NNIC rating is given by the value of the shifted reference contour at 500 Hz.

NOTE 2—This fitting procedure can be done numerically or graphically. One graphical technique involves placing a transparent overlay of the reference contour over a graph of measured data to the same scale, adjusting initially by trial and error, then making finer adjustments until the criteria are satisfied.

6. Presentation of Results

6.1 It is recommended that the data be plotted to the scale sizes recommended in Note 3, along with the shifted reference contour (see Fig. 2). This type of presentation draws attention to the frequency regions of the measured data that limit the single-number rating.

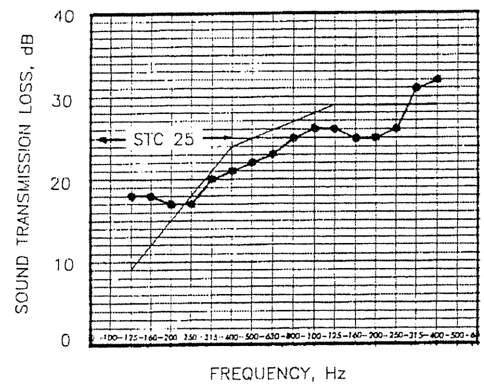

FIG. 2 Example of Reference Contour Fitted to Transmission Loss Data (STC 25)

NOTE 3—Recommended graph scale sizes are 2 mm/dB for the ordinate and 50 mm per 10 to 1 frequency ratio for the logarithmic abscissa. The ordinate scale should start at 0 dB. If larger or smaller scale sizes are unavoidable, the same aspect ratio of 25 dB per 10 to 1 frequency ratio should be retained.

7. Keywords

7.1 architectural acoustics; building design; field sound transmission class (FSTC); noise isolation class (NIC); normalized noise isolation class (NNIC); sound insulation rating; sound transmission class (STC); partitions (buildings)

APPENDIX

(Nonmandatory Information)

X1. METHODS OF CALCULATING STC

X1.1 *Calculating STC Using a Worksheet:*

NOTE X1.1—Although X1.1 and X1.2 describe calculation of sound transmission class from sound transmission loss data, the method is equally suitable for calculating the other single-number ratings mentioned in the standard.

X1.1.1 The STC may be calculated numerically using the worksheet at the end of this section. The procedure is as follows:

X1.1.2 Write the transmission loss for each one-third octave center frequency from 125 through 4000 Hz in the column labelled "TL" on the worksheet.

X1.1.3 For each frequency add the number in the "Adjustment" column algebraically to the TL and write the result in the "Adjusted TL" column.

X1.1.4 Draw a circle around the lowest adjusted TL. Add eight to the circled number to get the first trial STC. Write this trial STC at the top of the first column under "Trial STCs and deficiencies."

X1.1.5 For each frequency subtract the adjusted TL from the current trial STC. If this number is positive, write it under the trial STC opposite the frequency; otherwise leave a blank.

X1.1.6 Add the deficiencies for the trial STC. Write the sum at the bottom of the column.

X1.1.7 If the sum of the deficiencies is 32 or less, the trial STC is the true STC, and the calculation is complete.

X1.1.8 If the sum of the deficiencies is greater than 32, subtract one from the current trial STC to get a new trial STC. Write the new trial STC at the top of the next column. (This can be done after each subtraction in X1.1.5.)

X1.1.9 Repeat X1.1.5-X1.1.8 until the correct STC is found.

X1.2 *Calculating STC Using a Computer Program:*

X1.2.1 The BASIC program shown in Fig. X1.1 can be used as a subroutine in other programs and altered as necessary to calculate single-number ratings based on the reference contour.

NOTE X1.2—See Note X1.1.

```
00010 rem       Routine to calculate STC, FSTC, NIC or NNIC
00020 rem       The data values are in array TL.
00030 rem       Differences between data and reference contour
00040 rem       are in the array DIFFERENCE
00050 rem       The reference contour is read into STC_CONT.
00060 rem
00100 for BAND=21 to 36   ! Band numbers corresponding to 125 and 4000 Hz
00120   read STC_CONT(BAND)            ! GET REFERENCE STC 0 CONTOUR
00130 next BAND
00140 data -16,-13,-10,-7,-4,-1,0,1,2,3,4,4,4,4,4,4
00150 rem
00155 rem    To reduce computation time, first increase the estimated STC
00160 rem    so that at 125 hertz the reference contour is 8 dB above the
00165 rem    data at this frequency.  The trial STC value is a further
00170 rem    16 dB above this contour value.  The program then lowers the
00175 rem    reference contour until the criteria are satisfied.
00185 rem
00190 let STC=INT(TL(21)+.5+16+8) ! STC eventually becomes the correct value
00200 SUM=0  ! for sum of deficiencies
00210 for BAND=21 to 36
00240   let DIFFERENCE(BAND)=STC_CONT(BAND)+STC-INT(TL(BAND)+.5)
00250      rem 8 dB rule - no deficiency greater than 8 dB
00260   if DIFFERENCE(BAND)>8 then STC=STC-1:GO TO 200
00270      rem Count only deficiencies i.e. data below contour
00360   if DIFFERENCE(BAND)>0 then let SUM=SUM+DIFFERENCE(BAND)
00370      rem sum of deficiencies must not be greater than 32 dB
00380   if SUM>32 then STC=STC-1:GO TO 200
00480 next BAND
00490 rem
00500 rem       After exit from the routine, STC is the correct value of
00520 rem       STC, NIC, FSTC or NNIC as appropriate
```

FIG. X1.1 BASIC Computer Program to Calculate Single-Number Ratings

TABLE X1.1 Worksheet for Calculating STC and Similar Ratings

Frequency	TL	Adjustment	Adjusted TL	Trial STCs and Deficiencies				
				29	28	27	26	25
125	18	16	34	...	...	...	...	...
160	18	13	31	...	...	...	...	...
200	17	10	27	2	1	...	...	...
250	17	7	24	5	4	3	2	1
315	20	4	24	5	4	3	2	1
400	21	1	22	7	6	5	4	3
500	22	0	22	7	6	5	4	3
630	23	−1	22	7	6	5	4	3
800	25	−2	23		5	4	3	2
1000	26	−3	23			4	3	2
1250	26	−4	22			5	4	3
1600	25	−4	21				5	4
2000	25	−4	21				5	4
2500	26	−4	22					3
3150	30	−4	26					
4000	31	−4	27					
		Sum of deficiencies:		>32	>32	>32	>32	29

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

APPENDIX C

Applicable 2001 California Building Code Sections

2001 California Building Code

California Code of Regulations
Title 24, Part 2, Volume 1

California Building Standards Commission

Based on 1997 Uniform Building Code

EFFECTIVE
November 1, 2002

(For errata and supplements, see History Note Appendix)

149F01

2001 California Building Code
California Code of Regulations, Title 24, Part 2 (Volume 1)

Published by ICBO

International Conference of Building Officials
5360 WORKMAN MILL ROAD
WHITTIER, CA 90601-2298
(800) 423-6587

California Building Standards Commission
2525 NATOMAS PARK DRIVE, SUITE 130
SACRAMENTO, CALIFORNIA 95833-2936
(916) 263-0916

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Division II—SOUND TRANSMISSION CONTROL

SECTION 1208 — SOUND TRANSMISSION CONTROL

1208.1 General. In Group R Occupancies, wall and floor-ceiling assemblies separating dwelling units or guest rooms from each other and from public space such as interior corridors and service areas shall provide airborne sound insulation for walls, and both airborne and impact sound insulation for floor-ceiling assemblies.

The standards listed below are recognized standards (see Sections 3503 and 3504).

1. ASTM E 90 and E 413, Laboratory Determination of Airborne Sound Transmission Class (STC)
2. ASTM E 492, Impact Sound Insulation
3. ASTM E 336, Airborne Sound Insulation Field Test

1208.2 Airborne Sound Insulation. All such separating walls and floor-ceiling assemblies shall provide an airborne sound insulation equal to that required to meet a sound transmission class (STC) of 50 (45 if field tested).

Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings.

Entrance doors from interior corridors together with their perimeter seals shall have a laboratory-tested STC rating of not less than 26 and such perimeter seals shall be maintained in good operating condition.

1208.3 Impact Sound Insulation. All separating floor-ceiling assemblies between separate units or guest rooms shall provide impact sound insulation equal to that required to meet an impact insulation class (IIC) of 50 (45 if field tested). Floor coverings may be included in the assembly to obtain the required ratings and must be retained as a permanent part of the assembly and may be replaced only by other floor covering that provides the same sound insulation required above.

1208.4 Tested Assemblies. Field or laboratory tested wall or floor-ceiling designs having an STC or IIC of 50 or more may be used without additional field testing when, in the opinion of the building official, the tested design has not been compromised by flanking paths. Tests may be required by the building official when evidence of compromised separations is noted.

1208.5 Field Testing and Certification. Field testing, when required, shall be done under the supervision of a professional acoustician who shall be experienced in the field of acoustical testing and engineering and who shall forward certified test results to the building official that minimum sound insulation requirements stated above have been met.

1208.6 Airborne Sound Insulation Field Tests. When required, airborne sound insulation shall be determined according to the applicable Field Airborne Sound Transmission Loss Test procedures. All sound transmitted from the source room to the receiving room shall be considered to be transmitted through the test partition.

1208.7 Impact Sound Insulation Field Test. When required, impact sound insulation shall be determined.

SECTION 1209 — SOUND TRANSMISSION CONTROL SYSTEMS

Generic systems as listed in the *Fire Resistance Design Manual*, Fourteenth Edition, dated April 1994, as published by the Gypsum Association, may be accepted where a laboratory test indicates that the requirements of Section 1208 are met by the system.

Division IIA—SOUND TRANSMISSION CONTROL

SECTION 1208A — SOUND TRANSMISSION CONTROL

1208A.1 [For HCD 1] General.

1208A.1.1 [For HCD 1] Purpose and scope. The purpose of this section is to establish uniform minimum noise insulation performance standards to protect persons within new hotels, motels, dormitories, apartment houses and dwellings other than detached single-family dwellings from the effects of excessive noise, including, but not limited to, hearing loss or impairment and interference with speech and sleep. This section shall apply to all buildings for which applications for permits were made subsequent to August 22, 1974.

1208A.1.2 Definitions. The following special definitions shall apply to this section:

SOUND TRANSMISSION CLASS (STC) is a single-number rating used to compare walls, floor-ceiling assemblies and doors for their sound-insulating properties with respect to speech and small household appliance noise. The STC is derived from laboratory measurements of sound transmission loss across a series of 16 test bands.

Laboratory STC ratings should be used to the greatest extent possible in determining that the design complies with this section.

FIELD SOUND TRANSMISSION CLASS (FSTC) is a single-number rating similar to STC, except that the transmission loss values used to derive the FSTC are measured in the field. All sound transmitted from the source room to the receiving room is assumed to be through the separating wall or floor-ceiling assembly.

This section does not require determination of the FSTC, and field measured values of noise reduction should not be reported as transmission loss.

IMPACT INSULATION CLASS (IIC) is a single-number rating used to compare the effectiveness of floor-ceiling assemblies in providing reduction of impact-generated sounds such as footsteps. The IIC is derived from laboratory measurements of impact sound pressure level across a series of 16 test bands using a standardized tapping machine. Laboratory IIC ratings should be used to the greatest extent possible in determining that the design complies with this section.

FIELD IMPACT INSULATION CLASS (FIIC) is a single-number rating similar to the IIC, except that the impact sound pressure levels are measured in the field.

NOISE ISOLATION CLASS (NIC) is a single-number rating derived from measured values of noise reduction between two enclosed spaces that are connected by one or more paths. The NIC is not adjusted or normalized to a standard reverberation time.

NORMALIZED NOISE ISOLATION CLASS (NNIC) is a single-number rating similar to the NIC, except that the measured noise reduction values are normalized to a reverberation time of one-half second.

NORMALIZED A-WEIGHTED SOUND LEVEL DIFFERENCE (D_n) means, for a specified source room sound spectrum, D_n is the difference, in decibels, between the average sound levels produced in two rooms after adjustment to the expected acoustical conditions when the receiving room under test is normally furnished.

DAY-NIGHT AVERAGE SOUND LEVEL (L_{dn}) is the A-weighted equivalent continuous sound exposure level for a 24-hour period with a 10 db adjustment added to sound levels occurring during nighttime hours (10 p.m. to 7 a.m.).

COMMUNITY NOISE EQUIVALENT LEVEL (CNEL) is a metric similar to the L_{dn}, except that a 5 db adjustment is added to the equivalent continuous sound exposure level for evening hours (7 p.m. to 10 p.m.) in addition to the 10 db nighttime adjustment used in the L_{dn}.

1208A.1.3 [For HCD 1] Relevant standards. The current edition of the following standards is generally applicable for determining compliance with this section.

Copies may be obtained from the American Society for Testing and Materials (ASTM) at 1916 Race Street, Philadelphia, Pennsylvania 19103.

ASTM C 634, Standard Definitions of Terms Relating to Environmental Acoustics.

ASTM E 90, Standard Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions.

ASTM E 336, Standard Test Method for Measurement of Airborne Sound Insulation in Buildings.

ASTM E 413, Standard Classification for Determination of Sound Transmission Class.

ASTM E 492, Standard Method of Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine.

ASTM E 497, Standard Recommended Practice for Installation of Fixed Partitions of Light Frame Type for the Purpose of Conserving Their Sound Insulation Efficiency.

ASTM E 597, Recommended Practice for Determining A Single-Number Rating of Airborne Sound Isolation in Multiunit Building Specifications.

ASTM E 966, Standard Guide for Field Measurement of Airborne Sound Insulation of Building Facades and Facade Elements.

ASTM E 989, Standard Classification for Determination of Impact Insulation Class (IIC).

ASTM E 1007, Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures.

ASTM E 1014, Standard Guide for Measurement of Outdoor A-Weighted Sound Levels.

1208A.1.4 [For HCD 1] Complaints. Where a complaint as to noncompliance with this chapter requires a field test, the complainant shall post a bond or adequate funds in escrow for the cost of said testing. Such costs shall be chargeable to the complainant if the field tests show compliance with this chapter. If the tests show noncompliance, testing costs shall be borne by the owner or builder.

1208A.1.5 Local modification. The governing body of any city or city and county may, by ordinance, adopt changes or modifications to the requirements of this section as set forth in Section 17922.7 of the Health and Safety Code.

1208A.1.6 Interdwelling sound transmission control.

1208A.1.6.1 Wall and floor-ceiling assemblies. Wall and floor-ceiling assemblies separating dwelling units or guest rooms from each other and from public or service areas such as interior corridors, garages and mechanical spaces shall provide airborne sound insulation for walls, and both airborne and impact sound insulation for floor-ceiling assemblies.

EXCEPTION: Impact sound insulation is not required for floor-ceiling assemblies over nonhabitable rooms or spaces not de-

signed to be occupied, such as garages, mechanical rooms or storage areas.

1208A.2 Airborne Sound Insulation. All such acoustically rated separating wall and floor-ceiling assemblies shall provide airborne sound insulation equal to that required to meet a sound transmission class (STC) rating of 50 based on laboratory tests as defined in ASTM E 90 and E 413. Field-tested assemblies shall meet a noise isolation class (NIC) rating of 45 for occupied units and a normalized noise isolation class (NNIC) rating of 45 for unoccupied units as defined in ASTM Standards E 336 and E 413.

ASTM E 597 may be used as a simplified procedure for field tests of the airborne sound isolation between rooms in unoccupied buildings. In such tests, the minimum value of D_n is 45 db for compliance.

Entrance doors from interior corridors together with their perimeter seals shall have STC ratings not less than 26. Such tested doors shall operate normally with commercially available seals. Solid-core wood-slab doors $1^3/_8$ inches (35 mm) thick minimum or 18 gage insulated steel-slab doors with compression seals all around, including the threshold, may be considered adequate without other substantiating information.

Field tests of corridor walls should not include segments with doors. If such tests are impractical, however, the NIC or NNIC rating for the composite wall-door assembly shall not be less than 30.

Penetrations or openings in construction assemblies for piping, electrical devices, recessed cabinets, bathtubs, soffits or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required ratings.

1208A.3 Impact Sound Insulation. All acoustically rated separating floor-ceiling assemblies shall provide impact sound insulation equal to that required to meet an IIC rating of 50 based on laboratory tests as defined in ASTM E 492 and E 989. Field-tested assemblies shall meet a field impact insulation class (FIIC) rating of 45 for both occupied and unoccupied units as defined in ASTM E 1007 and E 989, with the exception that the measured impact sound pressure levels shall not be normalized to a standard amount of absorption in the receiving room.

Floor coverings may be included in the assembly to obtain the required ratings. These coverings must be retained as a permanent part of the assembly and may be replaced only by other floor coverings that provide the required impact sound insulation.

1208A.4 Tested Assemblies.

1208A.4.1 Laboratory-tested wall or floor-ceiling designs having STC or IIC ratings of 50 or more may be used by the building official to determine compliance with this section during the plan review phase. Field tests shall be required by the building official when evidence of sound leaks or flanking paths is noted, or when the separating assembly is not built according to the approved design.

1208A.4.2 Generic sound transmission control systems as listed in the Catalog of STC and IIC Ratings for Wall and Floor-Ceiling Assemblies, as published by the Office of Noise Control, California Department of Health Services, or the Fire Resistance Design Manual, as published by the Gypsum Association, may be used to evaluate construction assemblies for their sound transmission properties. Other tests from recognized laboratories may also be used. When ratings for essentially similar assemblies differ, and when ratings are below STC or IIC 50, field testing may be used to demonstrate that the building complies with this section.

1208A.4.3 For field testing, rooms should ideally be large and reverberant for reliable measurements to be made in all test bands. This is often not possible for bathrooms, kitchens, hallways or rooms with large amounts of sound-absorptive materials. Field test results should, however, report the measured values in all bands, noting those which do not meet relevant ASTM criteria for diffusion.

1208A.4.4 It should be noted that STC ratings do not adequately characterize the sound insulation of construction assemblies when the intruding noise is predominantly low pitched, as is often produced by amplified music or by large pieces of mechanical equipment.

It should also be noted that the transmission of impact sound from a standardized tapping machine may vary considerably for a given design due to differences in specimen size, flanking transmission through associated structure and the acoustical response of the room below. Laboratory IIC values should therefore be used with caution when estimating the performance of hard-surfaced floors in the field. Additionally, IIC ratings may not always be adequate to characterize the subjectively annoying creak or boom generated by footfalls on a lumber floor.

1208A.5 Certification. Field testing, when required, shall be done under the supervision of a person experienced in the field of acoustical testing and engineering and who shall forward test results to the building official showing that the sound isolation requirements stated above have been met. Documentation of field test results should generally follow the requirements outlined in relevant ASTM standards.

1208A.6 Not adopted by the State of California.

1208A.7 Not adopted by the State of California.

1208A.8 Exterior Sound Transmission Control.

1208A.8.1 Application consistent with local land-use standards, residential structures located in noise critical areas, such as proximity to highways, county roads, city streets, railroads, rapid transit lines, airports or industrial areas shall be designed to prevent the intrusion of exterior noises beyond prescribed levels. Proper design shall include, but shall not be limited to, orientation of the residential structure, setbacks, shielding and sound insulation of the building itself.

1208A.8.2 Allowable interior noise levels. Interior noise levels attributable to exterior sources shall not exceed 45 db in any habitable room. The noise metric shall be either the day-night average sound level (L_{dn}) or the community noise equivalent level (CNEL), consistent with the noise element of the local general plan.

NOTE: L_{dn} is the preferred metric for implementing these standards.

Worst-case noise levels, either existing or future, shall be used as the basis for determining compliance with this section. Future noise levels shall be predicted for a period of at least 10 years from the time of building permit application.

1208A.8.3 Airport noise sources. Residential structures to be located where the annual L_{dn} or CNEL (as defined in Title 21, Subchapter 6, California Code of Regulations) exceeds 60 db shall require an acoustical analysis showing that the proposed design will achieve prescribed allowable interior level. For public-use airports or heliports, the L_{dn} or CNEL shall be determined from the airport land-use plan prepared by the county wherein the airport is located. For military bases, the L_{dn} shall be determined from the facility Air Installation Compatible Use Zone (AICUZ) plan. For all other airports or heliports, or public-use airports or heliports for which a land-use plan has not been developed, the L_{dn} or CNEL shall be determined from the noise element of the general plan of the local jurisdiction.

When aircraft noise is not the only significant source, noise levels from all sources shall be added to determine the composite site noise level.

1208A.8.4 ***Other noise sources.*** *Residential structures to be located where the L_{dn} or CNEL exceeds 60 db shall require an acoustical analysis showing that the proposed design will limit exterior noise to the prescribed allowable interior level. The noise element of the local general plan shall be used to the greatest extent possible to identify sites with noise levels potentially greater than 60 db.*

1208A.8.5 ***Compliance.*** *Evidence of compliance shall consist of submittal of an acoustical analysis report, prepared under the supervision of a person experienced in the field of acoustical engineering, with the application for a building permit. The report shall show topographical relationships of noise sources and dwelling sites, identification of noise sources and their characteristics, predicted noise spectra and levels at the exterior of the proposed dwelling structure considering present and future land usage, basis for the prediction (measured or obtained from published data), noise attenuation measures to be applied, and an analysis of the noise insulation effectiveness of the proposed construction showing that the prescribed interior noise level requirements are met.*

If interior allowable noise levels are met by requiring that windows be unopenable or closed, the design for the structure must also specify a ventilation or air-conditioning system to provide a habitable interior environment. The ventilation system must not compromise the dwelling unit or guest room noise reduction.

1208A.8.6 ***Field testing.*** *When inspection indicates that the construction is not in accordance with the approved design, or that the noise reduction is compromised due to sound leaks or flanking paths, field testing may be required. A test report showing compliance or noncompliance with prescribed interior allowable levels shall be submitted to the building official.*

Measurements of outdoor sound levels shall generally follow the guidelines in ASTM E 1014.

Field measurements of the A-weighted airborne sound insulation of buildings from exterior sources shall generally follow the guidelines in ASTM E 966.

For the purpose of this standard, sound level differences measured in unoccupied units shall be normalized to a receiving room reverberation time of one-half second. Sound level differences measured in occupied units shall not be normalized to a standard reverberation time.

APPENDIX D

FSTC Testing Methodology

Field Sound Transmission Class (FSTC) Methodology

Testing

FSTC testing is conducted by generating a steady-state, wide-band sound source, using an Ivie IE-20B Noise Generator to produce a pink noise signal. The acoustic signal is directly patched into a Fender Passport P-150 Portable Sound System. The amplified signal is manually adjusted for each test in order to account for variable room volume and absorption differences. This signal adjustment allows the engineer to achieve the overall desired acoustic output spectrum, peaking at approximately 100 decibels. The amplifier/noise generator system is placed in the source room at least one meter from all walls, and is located as far as possible away from the wall or floor/ceiling assembly being tested. This is done to ensure complete source room signal saturation.

The space-time average ⅓-octave-band sound pressure level in the source and receiving rooms is measured with a Larson Davis PRM 902 microphone connected to a Larson Davis System 824 Real Time Analyzer. The sound level meter is field-calibrated before and after each test, to ensure accuracy.

The microphone is manually swept through the central volume of the room, sampling as much space as possible. The integration time during the noise measurement is long enough to ensure that repeat measurements are not significantly different. The microphone is held well away from the operator's body and turned slowly.

Analysis

The filtered ⅓-octave-band data recorded for the source room and receiving room, as described in ASTM E413-87 (Re-approved 1999), the average of the seven RT_{60} sound decay measurements, and the room dimensions, are used in calculating the FSTC rating. The amount of absorption A (in Sabins) in the receiving room is calculated using the room volume (V_{ROOM}) and the RT_{60} values, applying the formula $A_2=0.049*V_{ROOM}/RT_{60}$. The difference in the ⅓-octave band sound pressure level measurement between the two rooms is normalized by adding $10 \log(S/A_2)$, where "S" equals the area of the tested assembly.

This normalized value is compared to the reference value for a specified FSTC class. If the maximum deviation below the reference value at a single frequency does not exceed 8, and the sum of these deviations does not exceed 32, then the assembly meets the requirements for that class. The class is incremented unitarily until the assembly fails at least one of the aforementioned requirements. The FSTC value is recorded as the highest integer value that does not fail. If this value is equal to or greater than 45, then the assembly passes the FSTC test.

Reverberation Time Methodology

Testing

Reverberation time is defined as the time required for the sound pressure level in a room to decay 60 dB after the sound source has stopped. Reverberation times (RT_{60}) are measured by a Larson Davis PRM 902 microphone connected to a Larson Davis System 824 Real Time Analyzer. Room reverberation testing is conducted by generating a steady-state, wide-band, pink noise signal, using an Ivie IE-20B noise generator. The pink noise signal is directly patched into a Fender Passport P-150 Portable Sound System. The sound source is activated for a few seconds, then switched off, allowing for the measurement of the sound decay rate. The Larson Davis 824 Real Time Analyzer filters the sound decay into ⅓-octave-bands centered on 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, and 5000 hertz (Hz). At each frequency, a minimum of seven reverberation time measurements are taken, in order to calculate and apply individual arithmetic mean values per ⅓-octave-band.

Analysis

Analysis of the measured reverberation time data is accomplished using Larson Davis DNA 4.0 acoustics software. In the case of the Larson Davis System 824 in conjunction with DNA 4.0, the RT_{60} is extrapolated from the time measured for a 20 dB decay at each ⅓-octave-band

APPENDIX E

FSTC Test Data and Results - Common Wall Tests

EILAR ASSOCIATES
ACOUSTICAL CONSULTING

Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 1

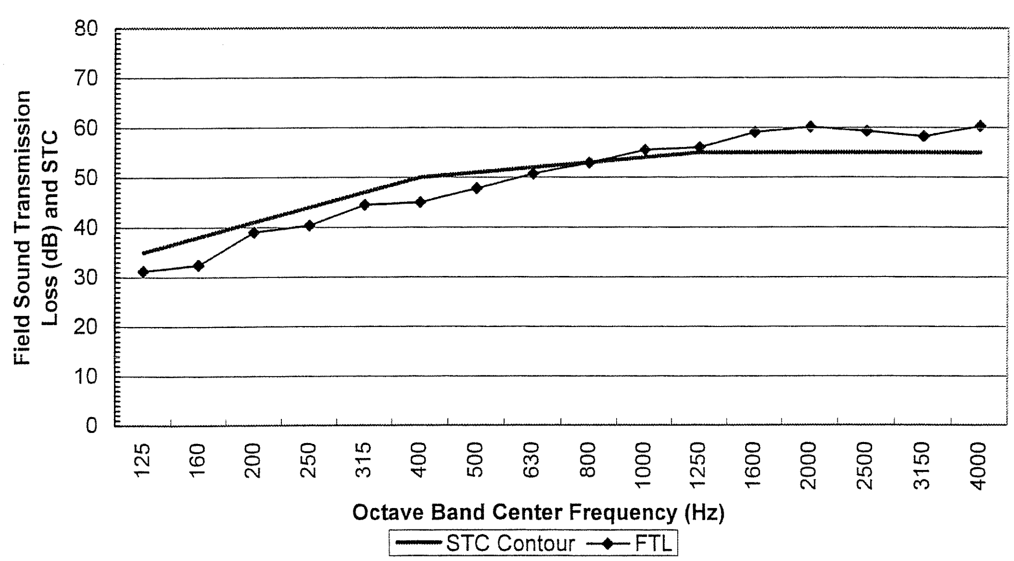
FSTC: 51
TEST PASSED

Source Unit/Room:	Unit 18 Living Room	
Source Panel Height:	7.92	feet
Source Panel Width:	16.67	feet
Source Panel Area:	132.03	feet^2

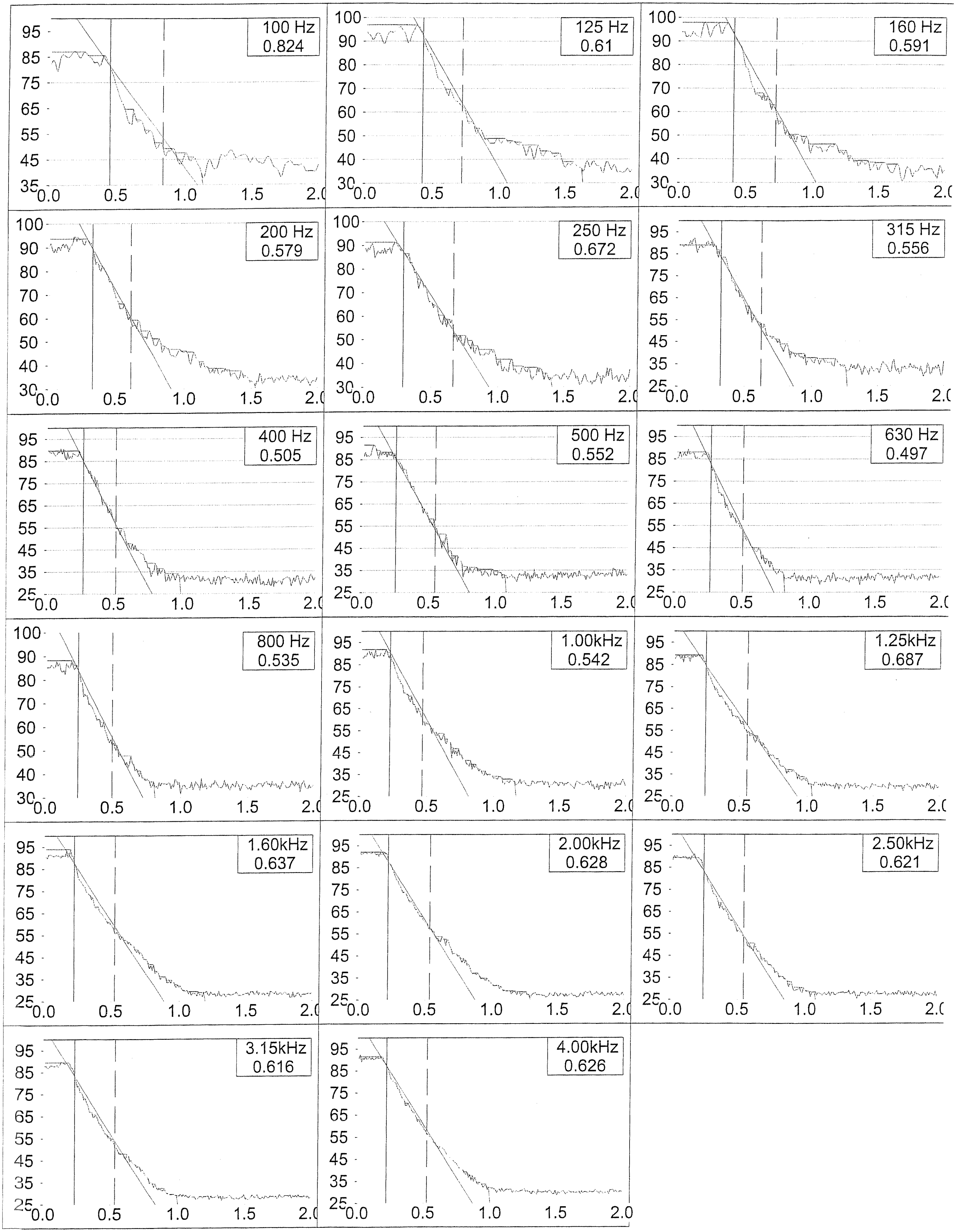
Receiver Unit/Room:	Unit 19 Living Room	
Receiver Room Length:	16.75	feet
Receiver Room Width:	12.17	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	1614.47	feet^3
Adjacent Open Volume Fraction:	25	%
Effective Volume:	2018.09	feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	92.8	60.7	0.610	162.1	-0.9	31.2	35	**3.8**
160	95.3	61.8	0.591	167.3	-1.0	32.5	38	**5.5**
200	89.6	49.5	0.579	170.8	-1.1	39.0	41	**2.0**
250	87.4	46.6	0.672	147.2	-0.5	40.3	44	**3.7**
315	89.7	43.9	0.556	177.9	-1.3	44.5	47	**2.5**
400	89.3	42.6	0.505	195.8	-1.7	45.0	50	**5.0**
500	87.9	38.8	0.552	179.1	-1.3	47.8	51	**3.2**
630	85.6	33.1	0.497	199.0	-1.8	50.7	52	**1.3**
800	85.8	31.4	0.535	184.8	-1.5	52.9	53	*
1000	88.8	31.9	0.542	182.4	-1.4	55.5	54	*
1250	86.8	30.4	0.687	143.9	-0.4	56.0	55	*
1600	89.6	29.8	0.637	155.2	-0.7	59.1	55	*
2000	90.3	29.4	0.628	157.5	-0.8	60.1	55	*
2500	88.3	28.2	0.621	159.2	-0.8	59.3	55	*
3150	86.8	27.7	0.616	160.5	-0.8	58.3	55	*
4000	89.3	28.2	0.626	158.0	-0.8	60.3	55	*

Overall Deficiency: **27.0**
Maximum Deficiency: **5.5**



Field Sound Transmission Loss and STC Contour


100 Hz 0.824
125 Hz 0.61
160 Hz 0.591
200 Hz 0.579
250 Hz 0.672
315 Hz 0.556
400 Hz 0.505
500 Hz 0.552
630 Hz 0.497
800 Hz 0.535
1.00kHz 0.542
1.25kHz 0.687
1.60kHz 0.637
2.00kHz 0.628
2.50kHz 0.621
3.15kHz 0.616
4.00kHz 0.626

EILAR ASSOCIATES
ACOUSTICAL CONSULTING

Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 2

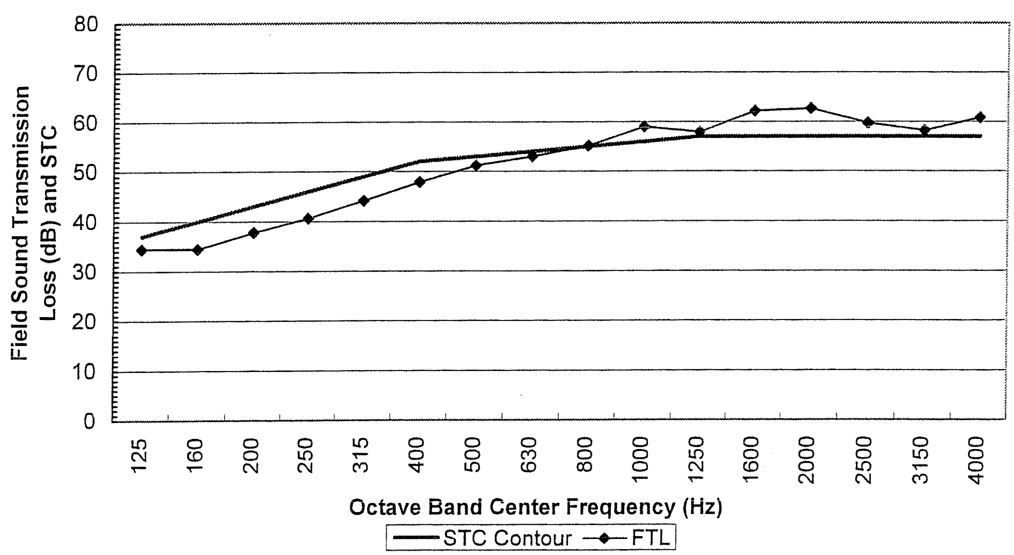
FSTC: 53
TEST PASSED

Source Unit/Room: Unit 18 Dining Room
Source Panel Height: 7.92 feet
Source Panel Width: 15.42 feet
Source Panel Area: 122.13 feet^2

Receiver Unit/Room: Unit 19 Dining Room
Receiver Room Length: 15.08 feet
Receiver Room Width: 11.83 feet
Height of Receiver Room: 7.92 feet
Receiver Room Volume: 1412.90 feet^3
Adjacent Open Volume Fraction: 33 %
Effective Volume: 1879.16 feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	92.4	56.1	0.497	185.3	-1.8	34.5	37	**2.5**
160	93.0	55.4	0.366	251.6	-3.1	34.5	40	**5.5**
200	91.4	51.4	0.452	203.7	-2.2	37.8	43	**5.2**
250	89.2	47.1	0.532	173.1	-1.5	40.6	46	**5.4**
315	90.4	44.3	0.480	191.8	-2.0	44.1	49	**4.9**
400	90.0	40.4	0.504	182.7	-1.7	47.9	52	**4.1**
500	88.6	35.7	0.509	180.9	-1.7	51.2	53	**1.8**
630	85.8	31.1	0.506	182.0	-1.7	53.0	54	**1.0**
800	86.4	28.9	0.434	212.2	-2.4	55.1	55	*
1000	88.7	28.7	0.601	153.2	-1.0	59.0	56	*
1250	87.2	28.2	0.590	156.1	-1.1	57.9	57	*
1600	90.1	27.3	0.656	140.4	-0.6	62.2	57	*
2000	90.6	27.0	0.613	150.2	-0.9	62.7	57	*
2500	88.4	27.3	0.546	168.6	-1.4	59.7	57	*
3150	87.6	27.4	0.479	192.2	-2.0	58.2	57	*
4000	90.0	27.8	0.551	167.1	-1.4	60.8	57	*

Overall Deficiency: **30.5**
Maximum Deficiency: **5.5**



Field Sound Transmission Loss and STC Contour

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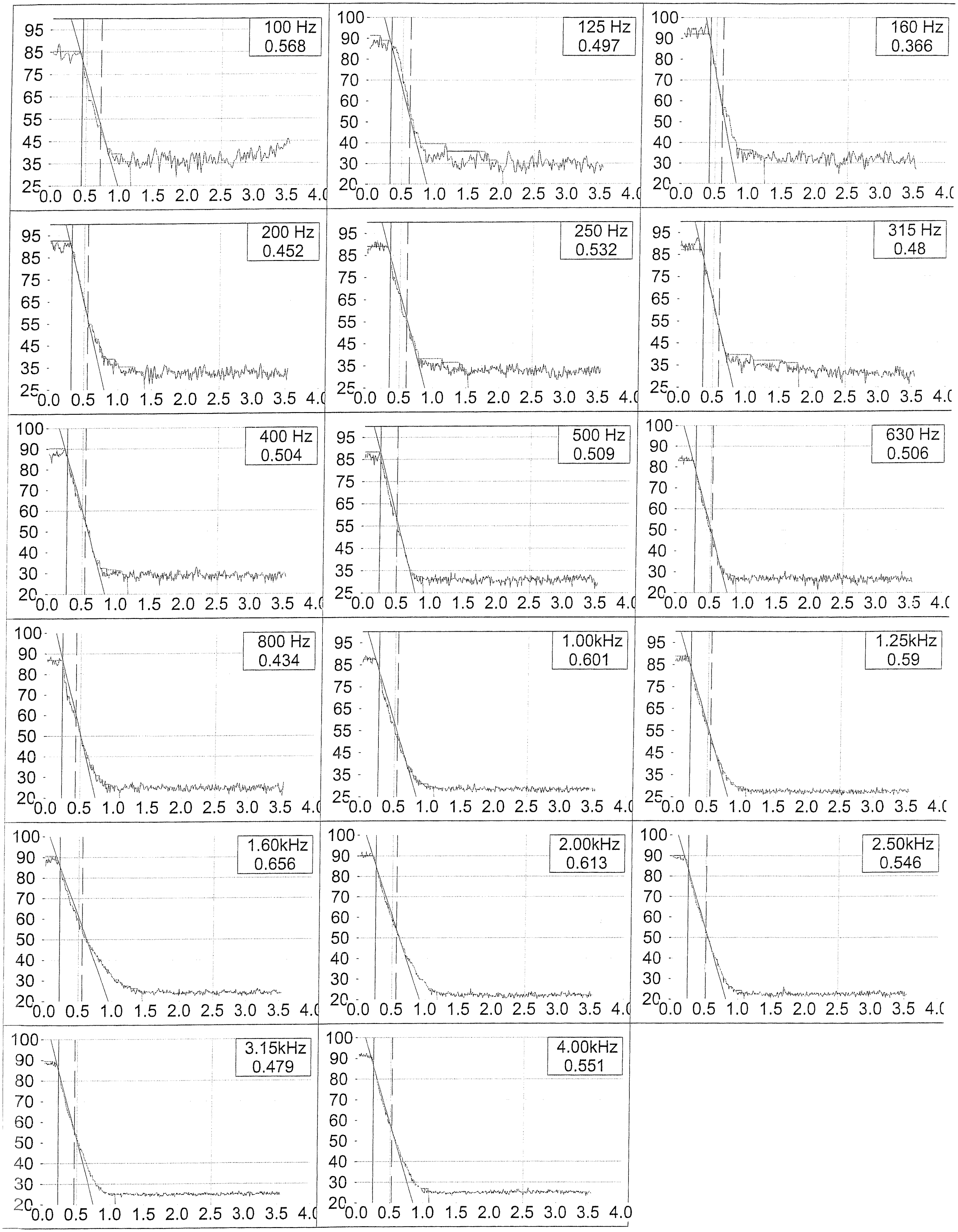
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125 Hz
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160 Hz
0.366
200 Hz
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250 Hz
0.532
315 Hz
0.48
400 Hz
0.504
500 Hz
0.509
630 Hz
0.506
800 Hz
0.434
1.00kHz
0.601
1.25kHz
0.59
1.60kHz
0.656
2.00kHz
0.613
2.50kHz
0.546
3.15kHz
0.479
4.00kHz
0.551

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 3

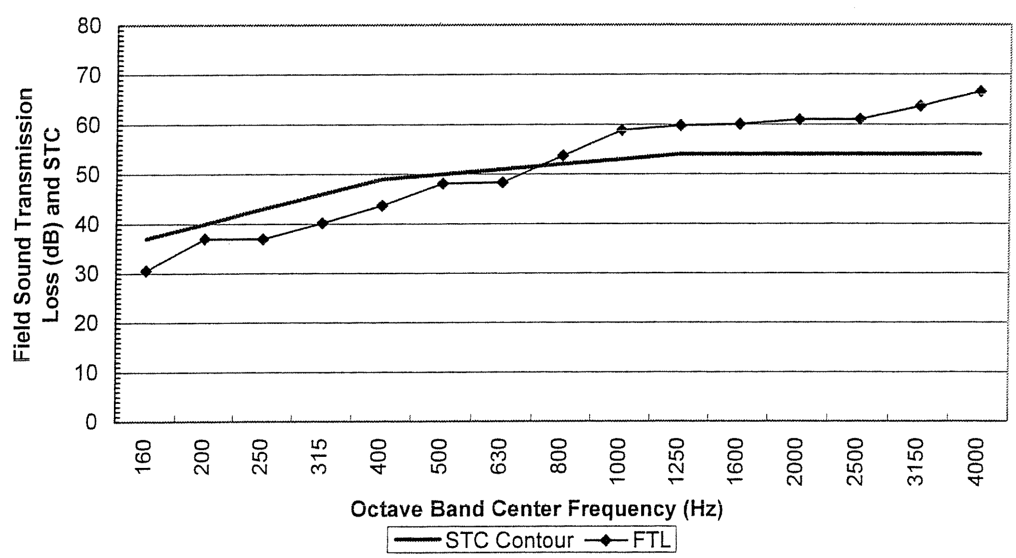
FSTC: 50
TEST PASSED

Source Unit/Room: Unit 59 Bedroom
Source Panel Height: 7.92 feet
Source Panel Width: 9.67 feet
Source Panel Area: 76.59 feet^2

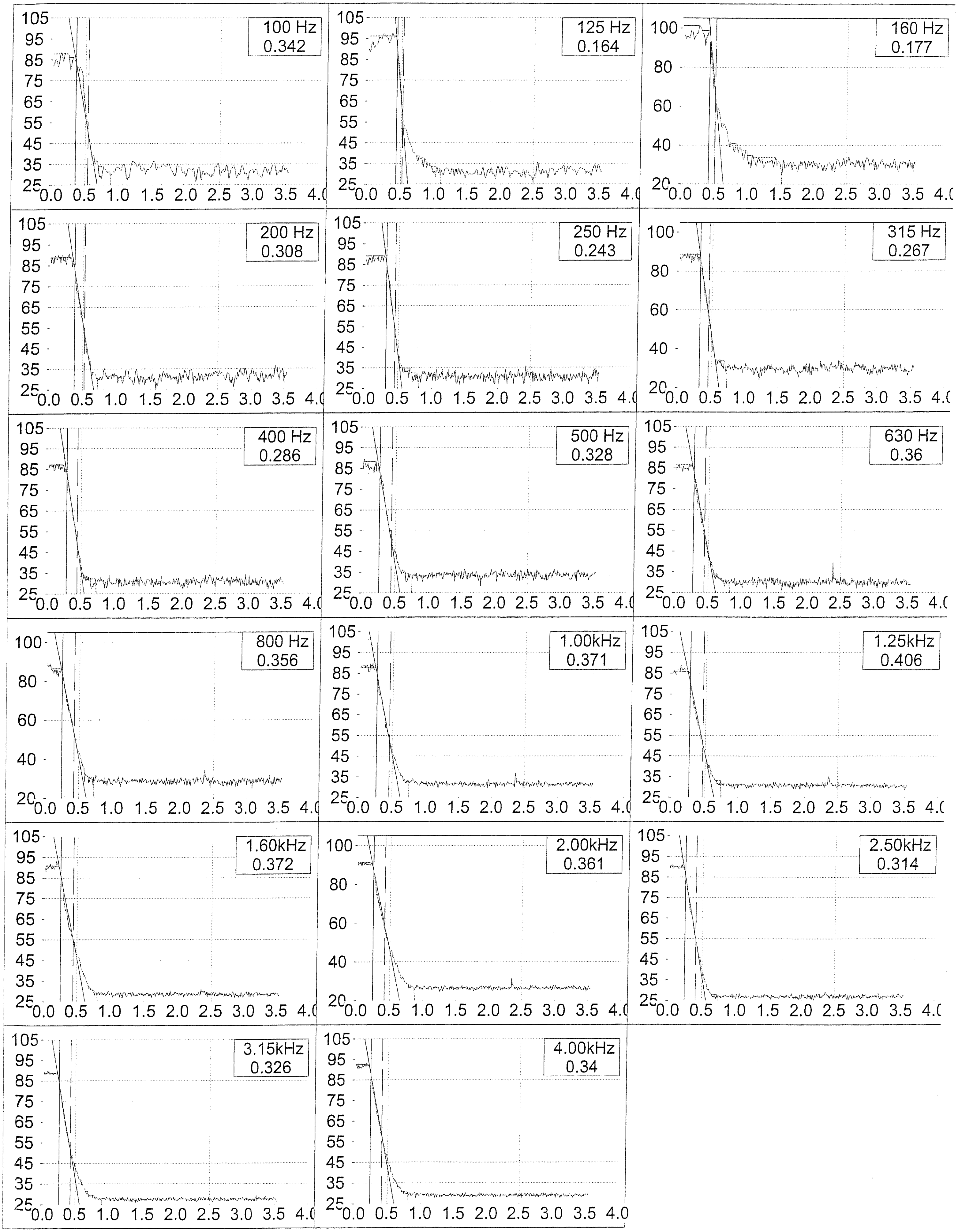
Receiver Unit/Room: Unit 58 Bedroom
Receiver Room Length: 10.50 feet
Receiver Room Width: 9.67 feet
Height of Receiver Room: 7.92 feet
Receiver Room Volume: 804.16 feet^3
Adjacent Open Volume Fraction: 10 %
Effective Volume: 884.57 feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
160	93.4	57.8	0.177	244.9	-5.0	30.6	37	**6.4**
200	87.3	47.7	0.308	140.7	-2.6	37.0	40	**3.0**
250	87.3	46.7	0.243	178.4	-3.7	36.9	43	**6.1**
315	89.1	45.7	0.267	162.3	-3.3	40.1	46	**5.9**
400	86.6	40.0	0.286	151.6	-3.0	43.6	49	**5.4**
500	85.3	34.8	0.328	132.1	-2.4	48.1	50	**1.9**
630	82.5	32.2	0.360	120.4	-2.0	48.3	51	**2.7**
800	83.8	28.1	0.356	121.8	-2.0	53.7	52	*
1000	87.0	26.3	0.371	116.8	-1.8	58.9	53	*
1250	85.9	24.7	0.406	106.8	-1.4	59.8	54	*
1600	89.1	27.2	0.372	116.5	-1.8	60.1	54	*
2000	89.9	27.0	0.361	120.1	-2.0	60.9	54	*
2500	88.6	25.0	0.314	138.0	-2.6	61.0	54	*
3150	88.6	22.5	0.326	133.0	-2.4	63.7	54	*
4000	90.9	22.1	0.340	127.5	-2.2	66.6	54	*

Overall Deficiency: **31.3**
Maximum Deficiency: **6.4**



Field Sound Transmission Loss and STC Contour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125 Hz
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160 Hz
0.177
200 Hz
0.308
250 Hz
0.243
315 Hz
0.267
400 Hz
0.286
500 Hz
0.328
630 Hz
0.36
800 Hz
0.356
1.00kHz
0.371
1.25kHz
0.406
1.60kHz
0.372
2.00kHz
0.361
2.50kHz
0.314
3.15kHz
0.326
4.00kHz
0.34

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Normalized Field Sound Transmission Class (FSTC) Test and Results — ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 4

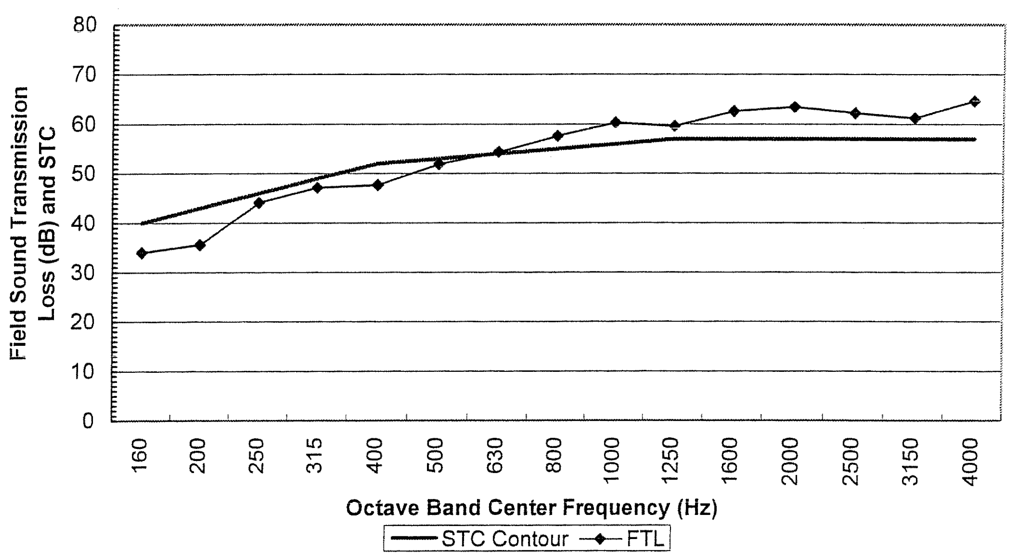
FSTC: 53
TEST PASSED

Source Unit/Room: Unit 36 Bedroom
Source Panel Height: 7.92 feet
Source Panel Width: 10.33 feet
Source Panel Area: 81.81 $feet^2$

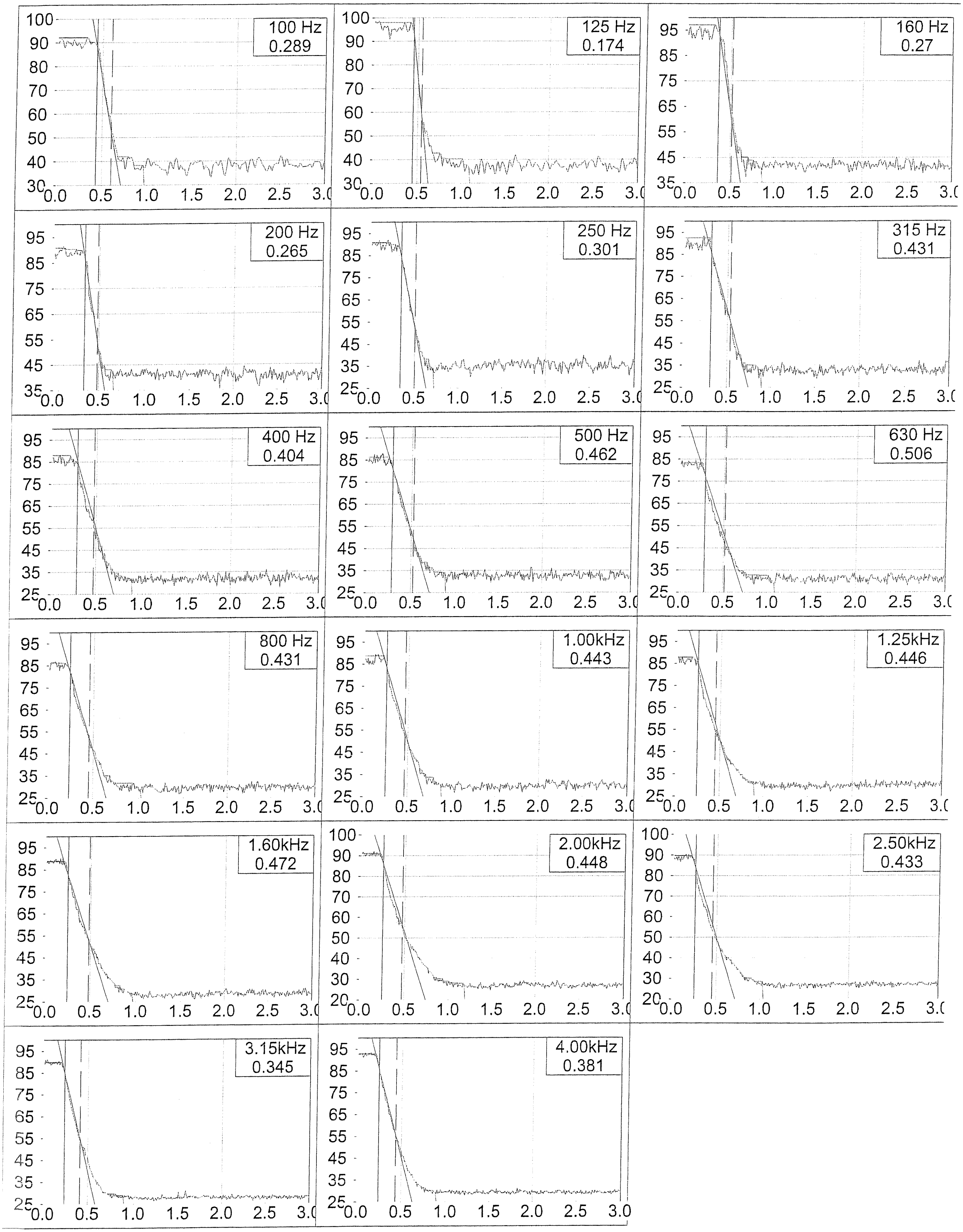
Receiver Unit/Room: Unit 35 Bedroom
Receiver Room Length: 13.75 feet
Receiver Room Width: 10.33 feet
Height of Receiver Room: 7.92 feet
Receiver Room Volume: 1124.94 $feet^3$
Adjacent Open Volume Fraction: 0 %
Effective Volume: 1124.94 $feet^3$

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
160	93.4	55.4	0.270	204.2	-4.0	34.0	40	**6.0**
200	87.2	47.6	0.265	208.0	-4.1	35.5	43	**7.5**
250	88.2	40.6	0.301	183.1	-3.5	44.1	46	**1.9**
315	87.4	38.3	0.431	127.9	-1.9	47.2	49	**1.8**
400	88.3	38.4	0.404	136.4	-2.2	47.7	52	**4.3**
500	85.2	31.7	0.462	119.3	-1.6	51.9	53	**1.1**
630	83.5	27.9	0.506	108.9	-1.2	54.4	54	*
800	85.1	25.6	0.431	127.9	-1.9	57.6	55	*
1000	88.1	26.0	0.443	124.4	-1.8	60.3	56	*
1250	86.6	25.2	0.446	123.6	-1.8	59.6	57	*
1600	89.5	25.4	0.472	116.8	-1.5	62.6	57	*
2000	91.0	25.8	0.448	123.0	-1.8	63.4	57	*
2500	89.2	25.1	0.433	127.3	-1.9	62.2	57	*
3150	89.0	24.9	0.345	159.8	-2.9	61.2	57	*
4000	91.5	24.4	0.381	144.7	-2.5	64.6	57	*

Overall Deficiency: **22.6**
Maximum Deficiency: **7.5**



Field Sound Transmission Loss and STC Contour



100 Hz
0.289
125 Hz
0.174
160 Hz
0.27
200 Hz
0.265
250 Hz
0.301
315 Hz
0.431
400 Hz
0.404
500 Hz
0.462
630 Hz
0.506
800 Hz
0.431
1.00kHz
0.443
1.25kHz
0.446
1.60kHz
0.472
2.00kHz
0.448
2.50kHz
0.433
3.15kHz
0.345
4.00kHz
0.381

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 5

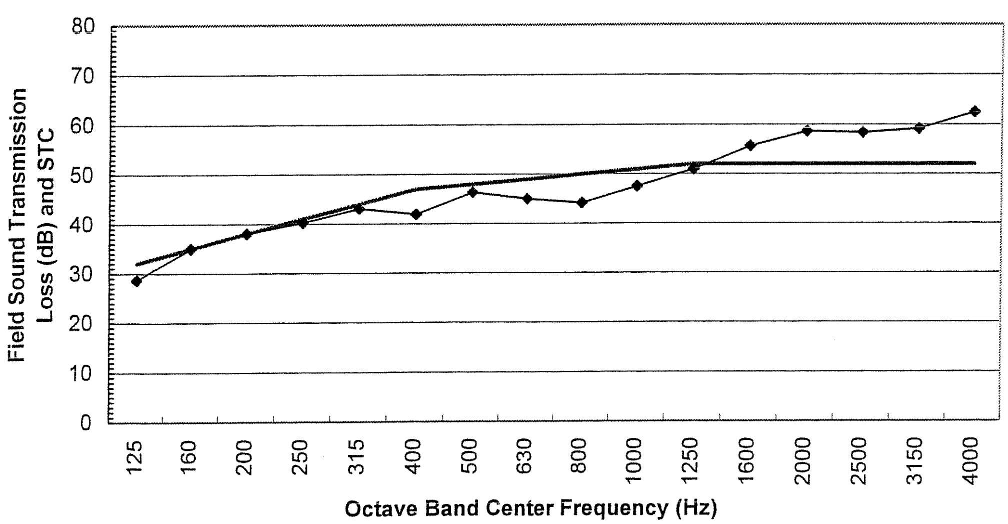
FSTC: 48
TEST PASSED

Source Unit/Room:	Unit 2 Living Room	
Source Panel Height:	7.92	feet
Source Panel Width:	16.58	feet
Source Panel Area:	131.31	feet^2

Receiver Unit/Room:	Unit 1 Living Room	
Receiver Room Length:	16.58	feet
Receiver Room Width:	12.25	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	1608.59	feet^3
Adjacent Open Volume Fraction:	25	%
Effective Volume:	2010.74	feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	89.0	56.1	0.281	350.6	-4.3	28.6	32	**3.4**
160	93.1	54.4	0.318	309.8	-3.7	35.0	35	*
200	88.1	46.6	0.335	294.1	-3.5	38.0	38	*
250	86.5	42.3	0.301	327.3	-4.0	40.2	41	**0.8**
315	86.7	40.8	0.390	252.6	-2.8	43.1	44	**0.9**
400	84.9	39.9	0.369	267.0	-3.1	41.9	47	**5.1**
500	84.6	35.2	0.372	264.9	-3.0	46.4	48	**1.6**
630	81.7	33.4	0.352	279.9	-3.3	45.0	49	**4.0**
800	82.9	35.5	0.359	274.4	-3.2	44.2	50	**5.8**
1000	86.0	35.2	0.355	277.5	-3.3	47.5	51	**3.5**
1250	84.2	30.4	0.391	252.0	-2.8	51.0	52	**1.0**
1600	87.9	29.1	0.363	271.4	-3.2	55.6	52	*
2000	88.8	27.0	0.361	272.9	-3.2	58.6	52	*
2500	87.3	25.7	0.357	276.0	-3.2	58.4	52	*
3150	86.9	24.3	0.336	293.2	-3.5	59.1	52	*
4000	89.3	23.3	0.33	298.6	-3.6	62.4	52	*

Overall Deficiency: **26.1**
Maximum Deficiency: **5.8**



Field Sound Transmission Loss and STC Contour

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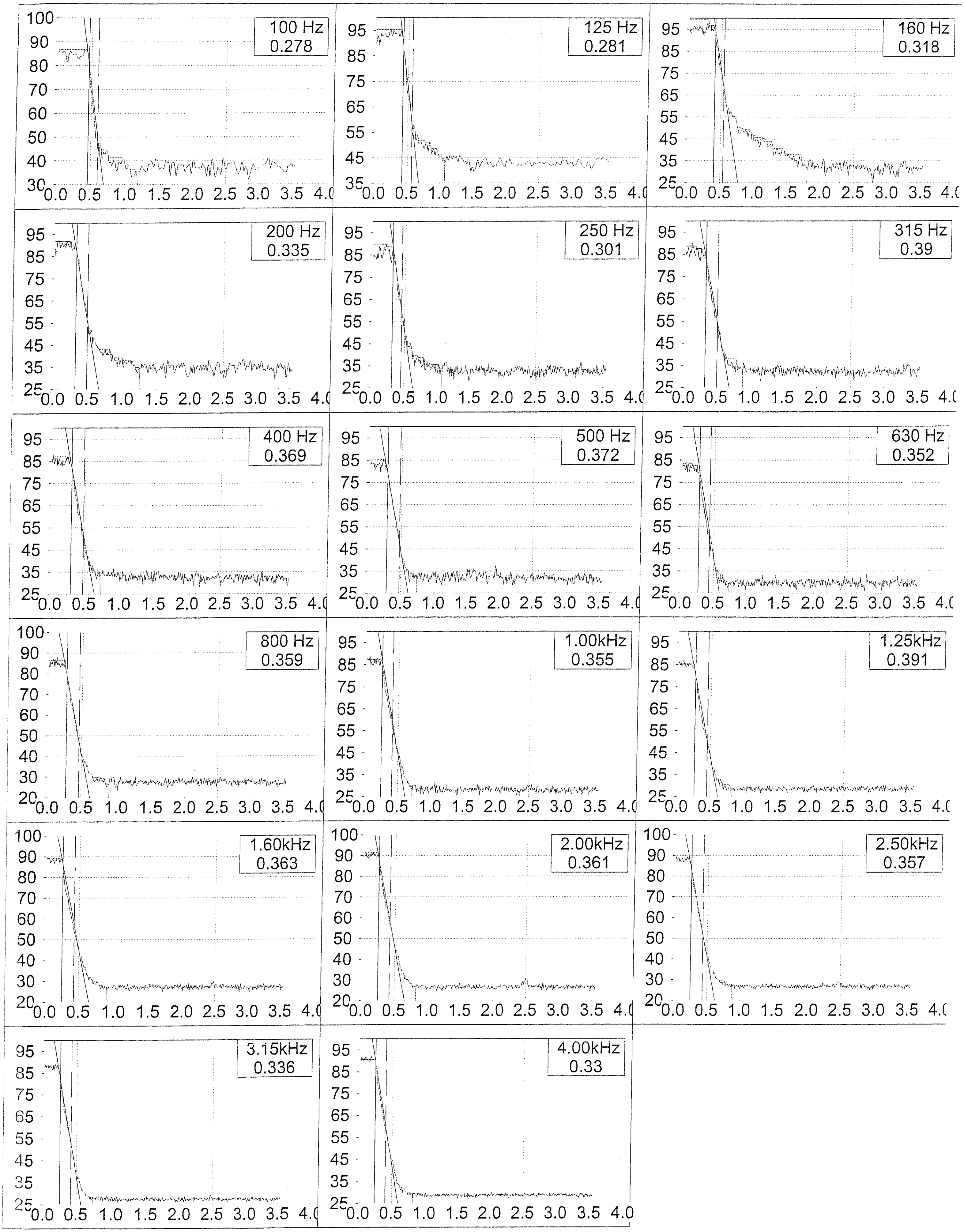
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125 Hz 0.281
160 Hz 0.318
200 Hz 0.335
250 Hz 0.301
315 Hz 0.39
400 Hz 0.369
500 Hz 0.372
630 Hz 0.352
800 Hz 0.359
1.00kHz 0.355
1.25kHz 0.391
1.60kHz 0.363
2.00kHz 0.361
2.50kHz 0.357
3.15kHz 0.336
4.00kHz 0.33

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 6

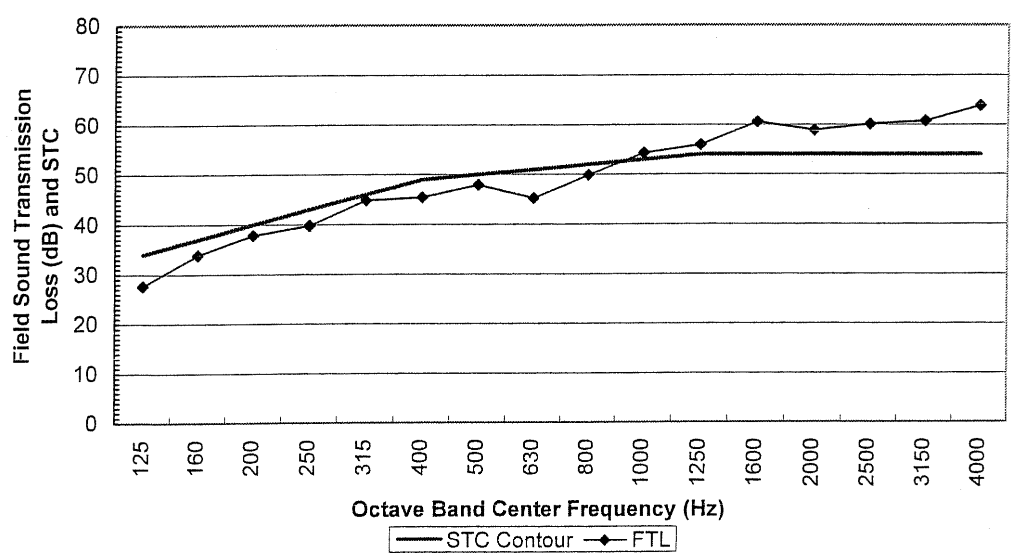
FSTC: 50
TEST PASSED

Source Unit/Room:	Unit 2 Dining Room	
Source Panel Height:	7.92	feet
Source Panel Width:	15.42	feet
Source Panel Area:	122.13	$feet^2$

Receiver Unit/Room:	Unit 1 Dining Room	
Receiver Room Length:	15.42	feet
Receiver Room Width:	12.00	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	1465.52	$feet^3$
Adjacent Open Volume Fraction:	33	%
Effective Volume:	1949.14	$feet^3$

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	91.3	59.6	0.310	308.1	-4.0	27.7	34	**6.3**
160	92.9	54.0	0.245	389.8	-5.0	33.9	37	**3.1**
200	89.1	46.7	0.274	348.6	-4.6	37.8	40	**2.2**
250	85.9	42.1	0.310	308.1	-4.0	39.8	43	**3.2**
315	87.6	39.3	0.350	272.9	-3.5	44.8	46	**1.2**
400	87.2	38.7	0.381	250.7	-3.1	45.4	49	**3.6**
500	86.3	35.3	0.387	246.8	-3.1	47.9	50	**2.1**
630	83.2	34.3	0.337	283.4	-3.7	45.2	51	**5.8**
800	83.9	30.6	0.354	269.8	-3.4	49.9	52	**2.1**
1000	86.2	28.9	0.389	245.5	-3.0	54.3	53	*
1250	85.2	26.1	0.383	249.4	-3.1	56.0	54	*
1600	88.4	25.0	0.408	234.1	-2.8	60.6	54	*
2000	89.0	27.1	0.390	244.9	-3.0	58.9	54	*
2500	87.6	24.3	0.378	252.7	-3.2	60.1	54	*
3150	87.8	23.3	0.333	286.8	-3.7	60.8	54	*
4000	90.1	22.8	0.355	269.0	-3.4	63.9	54	*

Overall Deficiency: **29.6**
Maximum Deficiency: **6.3**



Field Sound Transmission Loss and STC Contour

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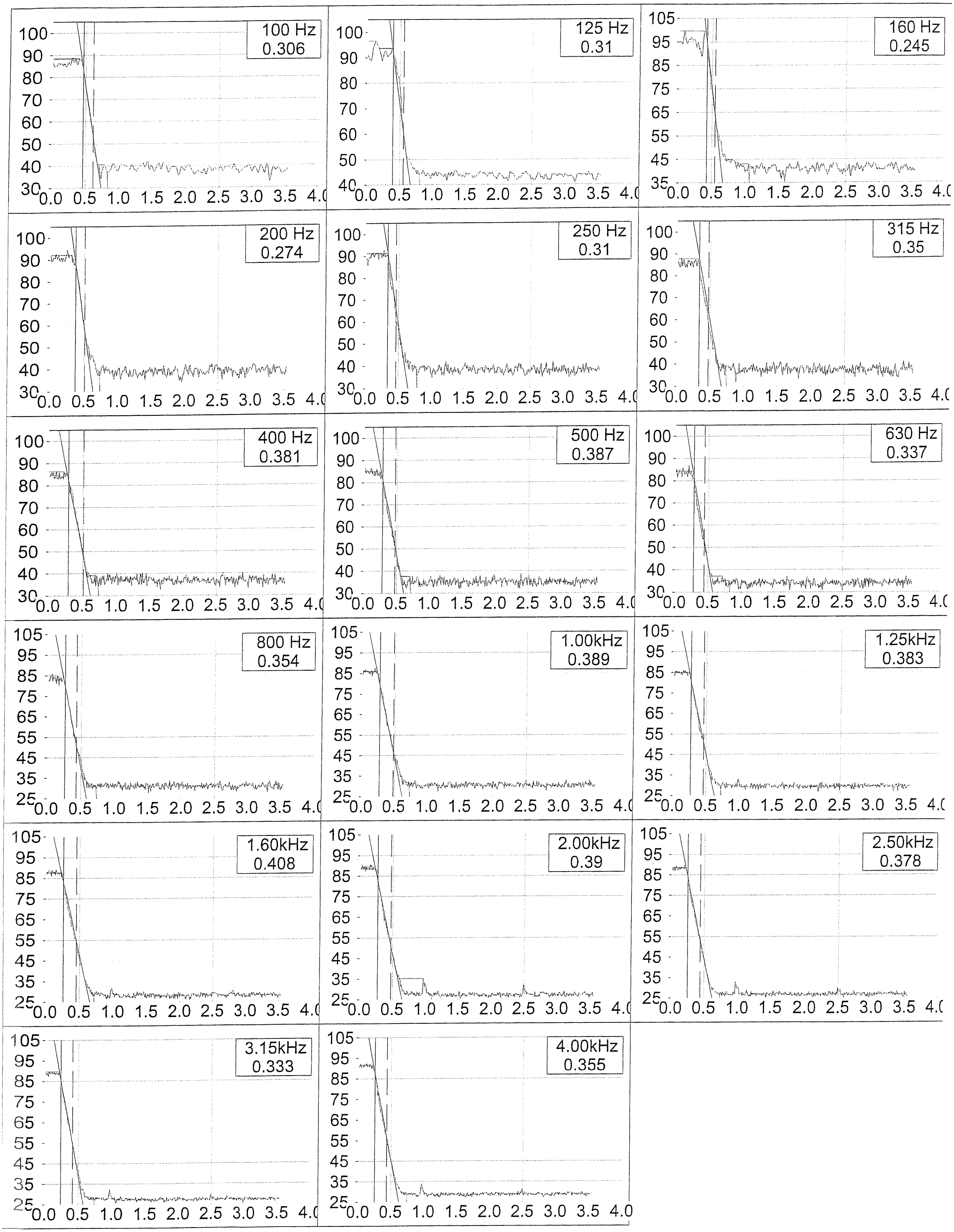
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125 Hz
0.31
160 Hz
0.245
200 Hz
0.274
250 Hz
0.31
315 Hz
0.35
400 Hz
0.381
500 Hz
0.387
630 Hz
0.337
800 Hz
0.354
1.00kHz
0.389
1.25kHz
0.383
1.60kHz
0.408
2.00kHz
0.39
2.50kHz
0.378
3.15kHz
0.333
4.00kHz
0.355

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 7

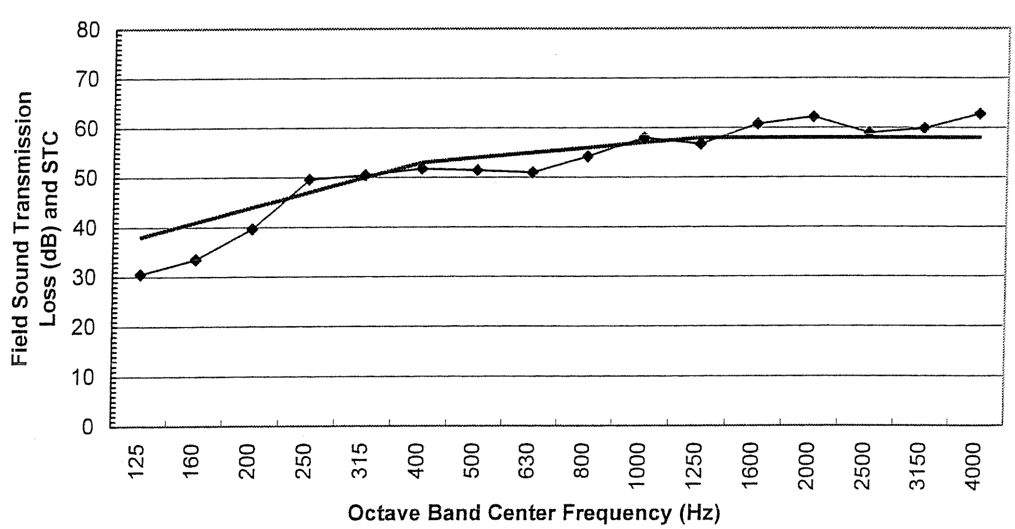
FSTC: 54
TEST PASSED

Source Unit/Room:	Unit 73 Dining Room	
Source Panel Height:	7.92	feet
Source Panel Width:	17.33	feet
Source Panel Area:	137.25	$feet^2$

Receiver Unit/Room:	Unit 72 Dining Room	
Receiver Room Length:	15.42	feet
Receiver Room Width:	12.00	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	1465.52	$feet^3$
Adjacent Open Volume Fraction:	33	%
Effective Volume:	1949.14	$feet^3$

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	93.7	59.3	0.284	336.3	-3.9	30.5	38	**7.5**
160	95.7	59.2	0.349	273.7	-3.0	33.5	41	**7.5**
200	90.6	48.5	0.396	241.2	-2.4	39.7	44	**4.3**
250	88.8	36.5	0.377	253.3	-2.7	49.6	47	*
315	88.6	35.3	0.364	262.4	-2.8	50.5	50	*
400	86.8	32.7	0.405	235.8	-2.4	51.7	53	**1.3**
500	84.6	30.5	0.377	253.3	-2.7	51.4	54	**2.6**
630	82.0	28.5	0.387	246.8	-2.5	51.0	55	**4.0**
800	82.6	26.0	0.403	237.0	-2.4	54.2	56	**1.8**
1000	85.0	25.0	0.435	219.6	-2.0	58.0	57	*
1250	83.5	24.8	0.437	218.6	-2.0	56.7	58	**1.3**
1600	87.1	24.0	0.408	234.1	-2.3	60.8	58	*
2000	87.9	23.3	0.402	237.6	-2.4	62.2	58	*
2500	86.5	24.7	0.363	263.1	-2.8	59.0	58	*
3150	86.2	23.5	0.362	263.8	-2.8	59.9	58	*
4000	88.3	22.9	0.380	251.3	-2.6	62.8	58	*

Overall Deficiency: **30.3**
Maximum Deficiency: **7.5**



Field Sound Transmission Loss and STC Contour

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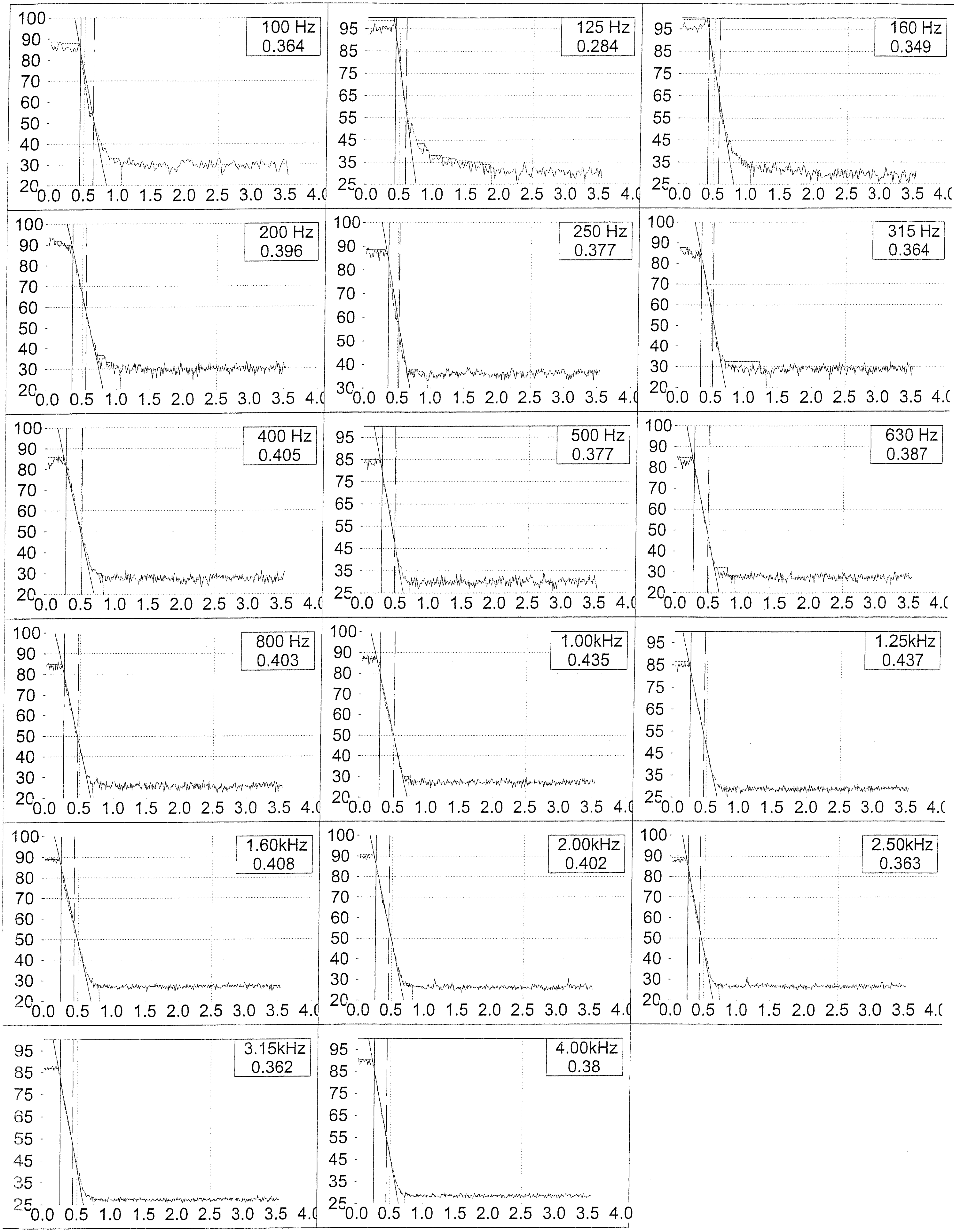

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125 Hz 0.284
160 Hz 0.349
200 Hz 0.396
250 Hz 0.377
315 Hz 0.364
400 Hz 0.405
500 Hz 0.377
630 Hz 0.387
800 Hz 0.403
1.00kHz 0.435
1.25kHz 0.437
1.60kHz 0.408
2.00kHz 0.402
2.50kHz 0.363
3.15kHz 0.362
4.00kHz 0.38

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 8

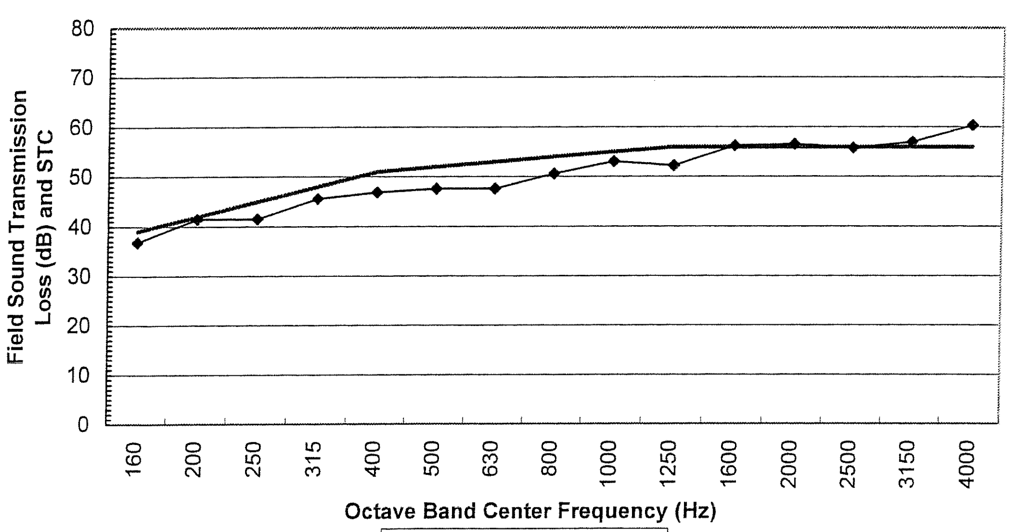
FSTC: 52
TEST PASSED

Source Unit/Room:	Unit 73 Bedroom	
Source Panel Height:	7.92	feet
Source Panel Width:	9.67	feet
Source Panel Area:	76.59	$feet^2$

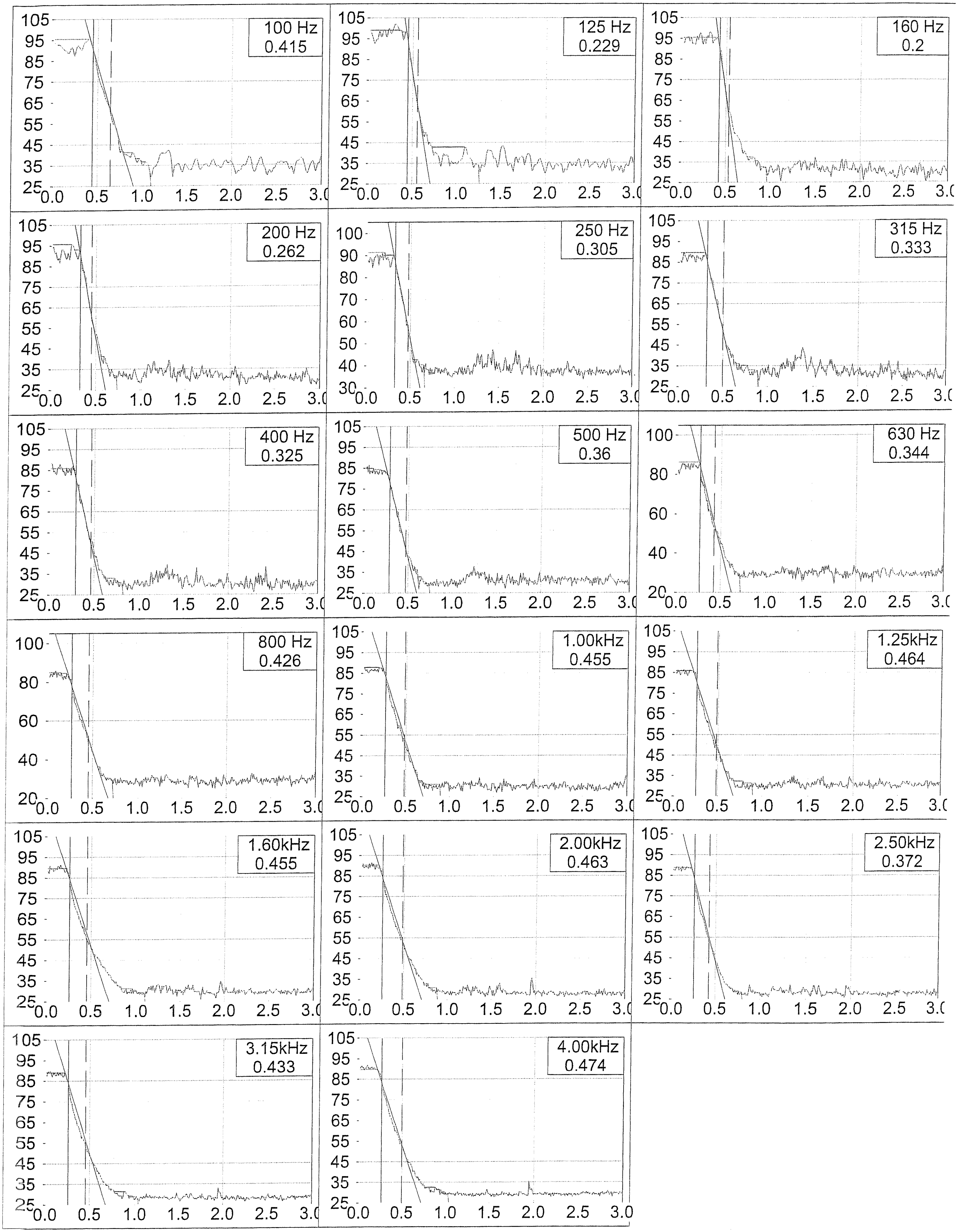
Receiver Unit/Room:	Unit 72 Bedroom	
Receiver Room Length:	10.50	feet
Receiver Room Width:	9.67	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	804.16	$feet^3$
Adjacent Open Volume Fraction:	10	%
Effective Volume:	884.57	$feet^3$

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
160	93.8	52.5	0.200	216.7	-4.5	36.8	39	**2.2**
200	90.5	45.7	0.262	165.4	-3.3	41.5	42	**0.5**
250	87.0	42.8	0.305	142.1	-2.7	41.5	45	**3.5**
315	85.1	37.2	0.333	130.2	-2.3	45.6	48	**2.4**
400	84.1	34.8	0.325	133.4	-2.4	46.9	51	**4.1**
500	82.2	32.6	0.360	120.4	-2.0	47.6	52	**4.4**
630	80.9	31.1	0.344	126.0	-2.2	47.6	53	**5.4**
800	82.6	30.8	0.426	101.7	-1.2	50.6	54	**3.4**
1000	83.9	29.9	0.455	95.3	-0.9	53.1	55	**1.9**
1250	82.5	29.4	0.464	93.4	-0.9	52.2	56	**3.8**
1600	86.3	29.1	0.455	95.3	-0.9	56.3	56	*
2000	86.9	29.5	0.463	93.6	-0.9	56.5	56	*
2500	85.5	27.9	0.372	116.5	-1.8	55.8	56	**0.2**
3150	85.4	27.3	0.433	100.1	-1.2	56.9	56	*
4000	87.1	26.0	0.474	91.4	-0.8	60.3	56	*

Overall Deficiency: **31.9**
Maximum Deficiency: **5.4**



Field Sound Transmission Loss and STC Contour


100 Hz
0.415
125 Hz
0.229
160 Hz
0.2
200 Hz
0.262
250 Hz
0.305
315 Hz
0.333
400 Hz
0.325
500 Hz
0.36
630 Hz
0.344
800 Hz
0.426
1.00kHz
0.455
1.25kHz
0.464
1.60kHz
0.455
2.00kHz
0.463
2.50kHz
0.372
3.15kHz
0.433
4.00kHz
0.474

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

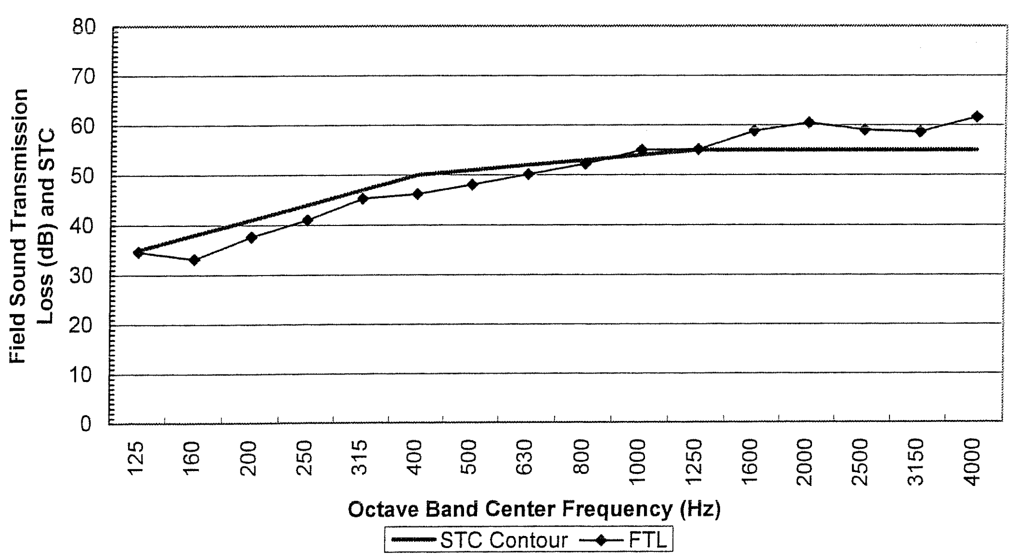
Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 9

FSTC: 51
TEST PASSED

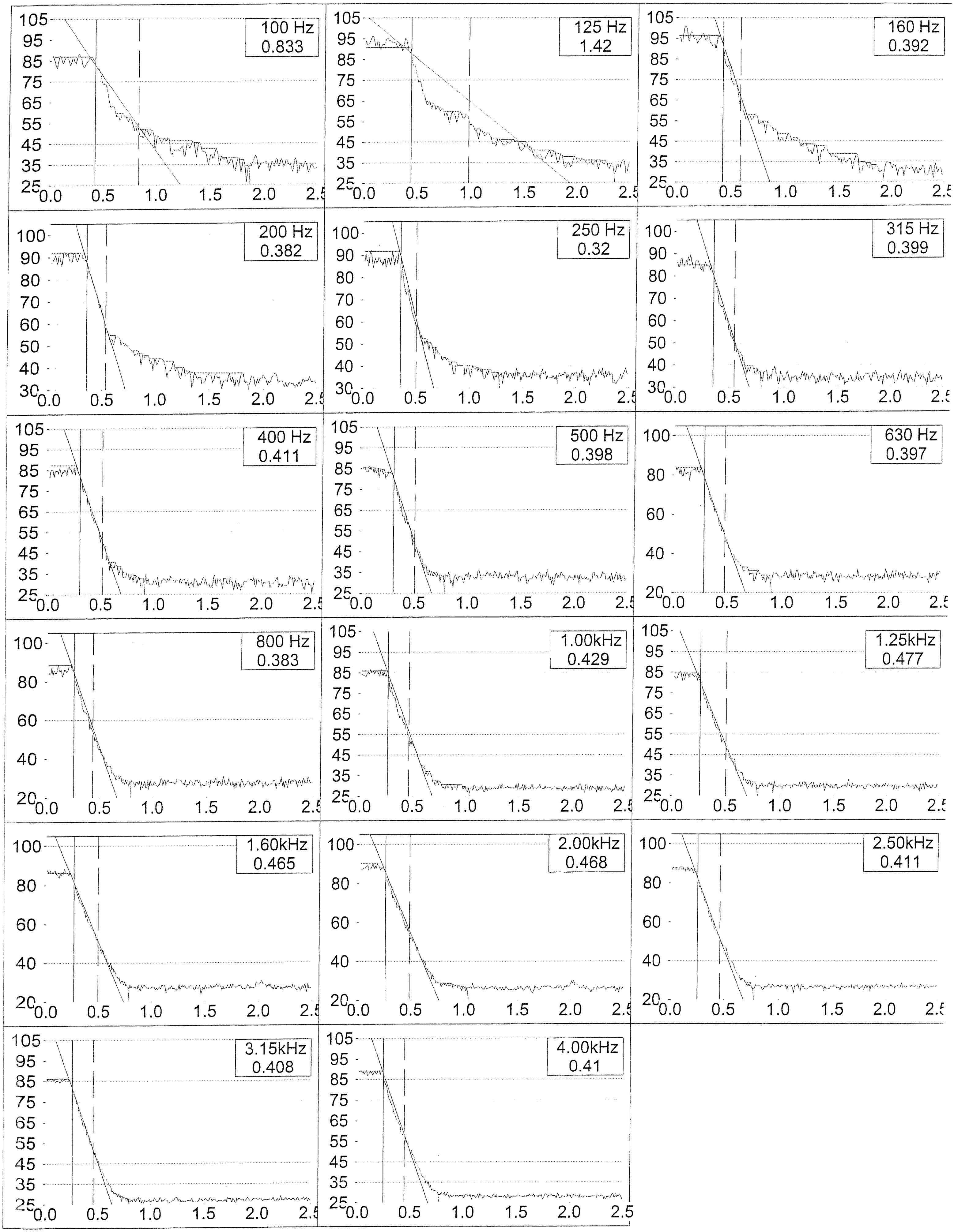
Source Unit/Room:	Unit 91 Living Room		Receiver Unit/Room:	Unit 92 Living Room	
Source Panel Height:	7.92	feet	Receiver Room Length:	15.67	feet
Source Panel Width:	12.42	feet	Receiver Room Width:	15.50	feet
Source Panel Area:	98.37	feet^2	Height of Receiver Room:	7.92	feet
			Receiver Room Volume:	1923.65	feet^3
			Adjacent Open Volume Fraction:	33	%
			Effective Volume:	2558.45	feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	93.9	59.7	1.420	88.3	0.5	34.7	35	**0.3**
160	98.0	59.7	0.392	319.8	-5.1	33.2	38	**4.8**
200	90.9	48.0	0.382	328.2	-5.2	37.7	41	**3.3**
250	87.9	40.9	0.320	391.8	-6.0	41.0	44	**3.0**
315	87.9	37.6	0.399	314.2	-5.0	45.3	47	**1.7**
400	86.0	34.9	0.411	305.0	-4.9	46.2	50	**3.8**
500	83.0	29.9	0.398	315.0	-5.1	48.0	51	**3.0**
630	81.9	26.7	0.397	315.8	-5.1	50.1	52	**1.9**
800	83.4	26.0	0.383	327.3	-5.2	52.2	53	**0.8**
1000	85.8	26.1	0.429	292.2	-4.7	55.0	54	*
1250	84.6	25.2	0.477	262.8	-4.3	55.1	55	*
1600	88.2	25.0	0.465	269.6	-4.4	58.8	55	*
2000	89.3	24.5	0.468	267.9	-4.4	60.4	55	*
2500	87.8	23.9	0.411	305.0	-4.9	59.0	55	*
3150	87.8	24.2	0.408	307.3	-4.9	58.7	55	*
4000	90.2	23.7	0.41	305.8	-4.9	61.6	55	*

Overall Deficiency: **22.7**
Maximum Deficiency: **4.8**



Field Sound Transmission Loss and STC Contour



100 Hz
0.833
125 Hz
1.42
160 Hz
0.392
200 Hz
0.382
250 Hz
0.32
315 Hz
0.399
400 Hz
0.411
500 Hz
0.398
630 Hz
0.397
800 Hz
0.383
1.00kHz
0.429
1.25kHz
0.477
1.60kHz
0.465
2.00kHz
0.468
2.50kHz
0.411
3.15kHz
0.408
4.00kHz
0.41

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 10

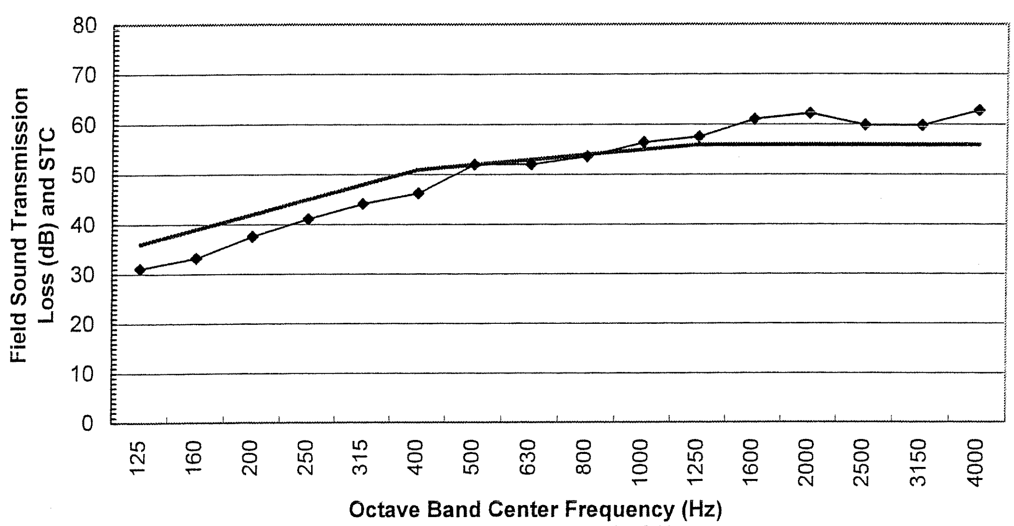
FSTC: 52
TEST PASSED

Source Unit/Room:	Unit 91 Dining Room	
Source Panel Height:	7.92	feet
Source Panel Width:	12.75	feet
Source Panel Area:	100.98	$feet^2$

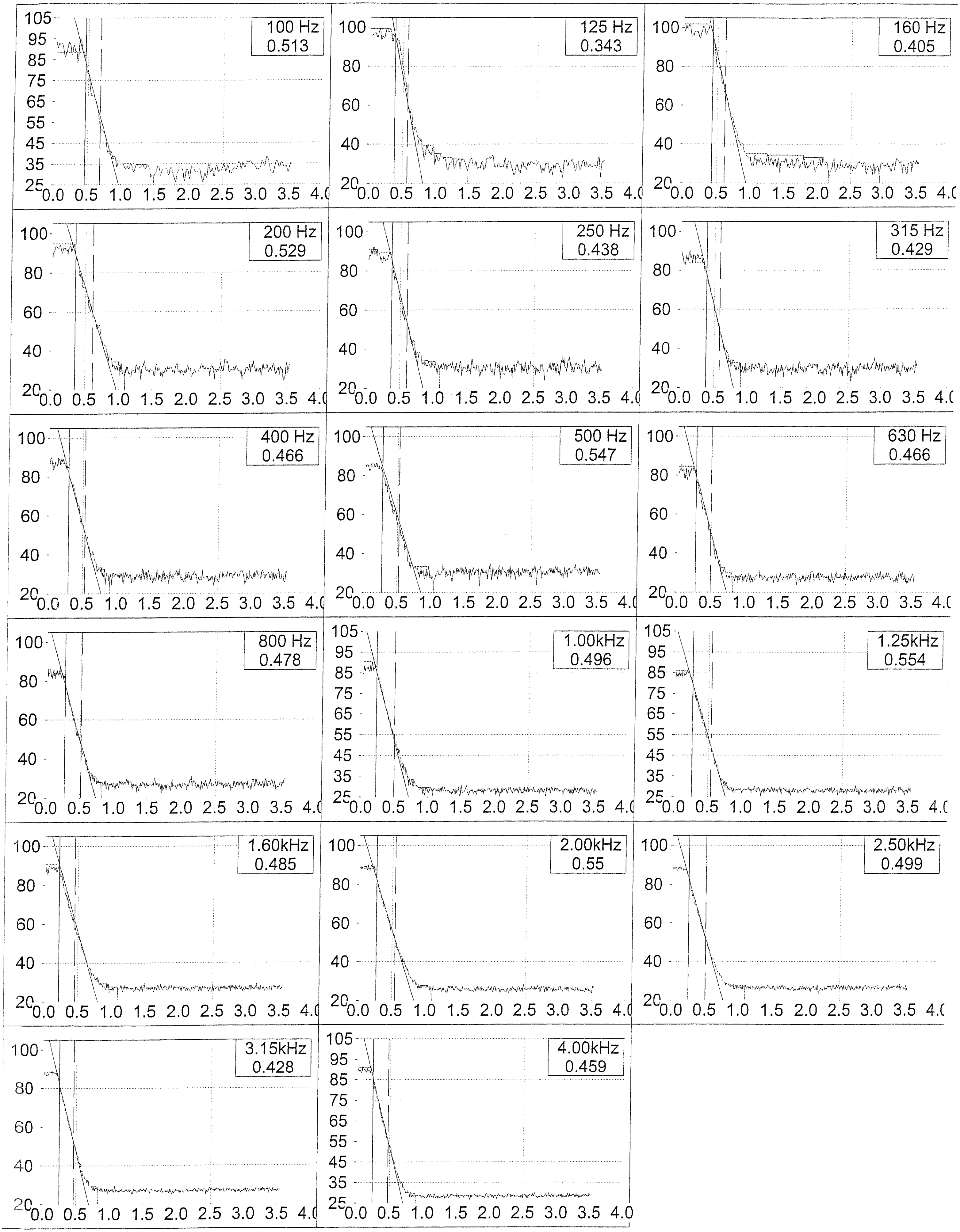
Receiver Unit/Room:	Unit 92 Dining Room	
Receiver Room Length:	17.33	feet
Receiver Room Width:	11.92	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	1636.06	$feet^3$
Adjacent Open Volume Fraction:	33	%
Effective Volume:	2175.96	$feet^3$

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
125	95.6	59.6	0.343	310.9	-4.9	31.1	36	**4.9**
160	97.0	59.6	0.405	263.3	-4.2	33.2	39	**5.8**
200	90.0	49.4	0.529	201.6	-3.0	37.6	42	**4.4**
250	87.4	42.5	0.438	243.4	-3.8	41.1	45	**3.9**
315	87.6	39.6	0.429	248.5	-3.9	44.1	48	**3.9**
400	85.4	35.6	0.466	228.8	-3.6	46.2	51	**4.8**
500	84.7	29.8	0.547	194.9	-2.9	52.0	52	*
630	82.6	27.0	0.466	228.8	-3.6	52.0	53	**1.0**
800	83.6	26.5	0.478	223.1	-3.4	53.7	54	**0.3**
1000	85.9	26.2	0.496	215.0	-3.3	56.4	55	*
1250	84.7	24.4	0.554	192.5	-2.8	57.5	56	*
1600	87.9	23.5	0.485	219.8	-3.4	61.0	56	*
2000	89.1	24.1	0.550	193.9	-2.8	62.2	56	*
2500	87.5	24.4	0.499	213.7	-3.3	59.8	56	*
3150	87.5	23.8	0.428	249.1	-3.9	59.8	56	*
4000	89.8	23.4	0.459	232.3	-3.6	62.8	56	*

Overall Deficiency: **28.9**
Maximum Deficiency: **5.8**



Field Sound Transmission Loss and STC Contour



100 Hz
0.513
125 Hz
0.343
160 Hz
0.405
200 Hz
0.529
250 Hz
0.438
315 Hz
0.429
400 Hz
0.466
500 Hz
0.547
630 Hz
0.466
800 Hz
0.478
1.00kHz
0.496
1.25kHz
0.554
1.60kHz
0.485
2.00kHz
0.55
2.50kHz
0.499
3.15kHz
0.428
4.00kHz
0.459

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Normalized Field Sound Transmission Class (FSTC) Test and Results ***Common Wall Test***

Test Date: 12/8/04
Project # A41130N1
Project Name: Southwood Garden
Test # 11

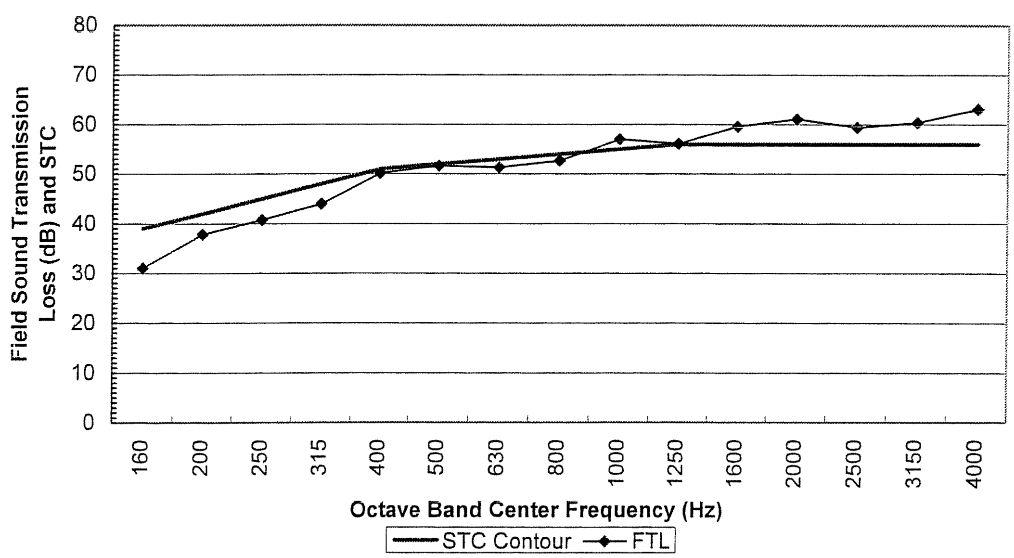
FSTC: 52
TEST PASSED

Source Unit/Room:	Unit 91 Bedroom	
Source Panel Height:	7.92	feet
Source Panel Width:	5.17	feet
Source Panel Area:	40.95	feet^2

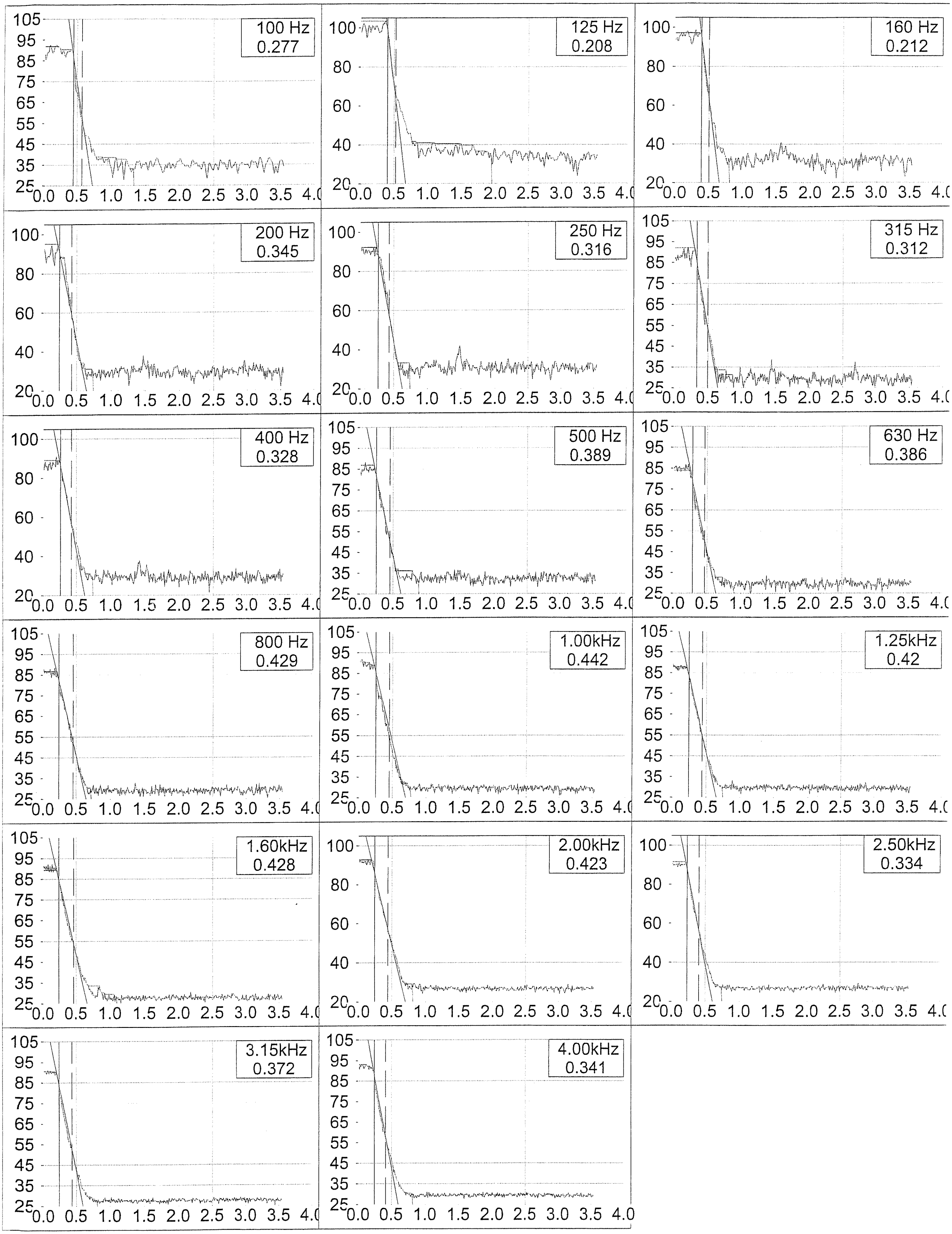
Receiver Unit/Room:	Unit 92 Bedroom	
Receiver Room Length:	10.50	feet
Receiver Room Width:	9.67	feet
Height of Receiver Room:	7.92	feet
Receiver Room Volume:	804.16	feet^3
Adjacent Open Volume Fraction:	10	%
Effective Volume:	884.57	feet^3

1/3 Octave Band (Hz)	Source Sound Level L_1 (dB)	Receiver Sound Level L_2 (dB)	RT_{60} Mean (Sec)	Absorption A_2 (Sabins)	10 log (S/A_2)	Field Sound Trans. Loss FTL (dB)	Reference Value	Deficiency
160	98.6	60.6	0.212	204.5	-7.0	31.0	39	**8.0**
200	90.8	48.1	0.345	125.6	-4.9	37.8	42	**4.2**
250	90.7	44.7	0.316	137.2	-5.3	40.7	45	**4.3**
315	90.1	40.8	0.312	138.9	-5.3	44.0	48	**4.0**
400	87.7	32.5	0.328	132.1	-5.1	50.1	51	**0.9**
500	86.3	30.3	0.389	111.4	-4.3	51.7	52	**0.3**
630	84.9	29.2	0.386	112.3	-4.4	51.3	53	**1.7**
800	86.1	29.5	0.429	101.0	-3.9	52.7	54	**1.3**
1000	88.8	28.0	0.442	98.1	-3.8	57.0	55	*
1250	87.9	27.8	0.420	103.2	-4.0	56.1	56	*
1600	91.0	27.5	0.428	101.3	-3.9	59.6	56	*
2000	92.0	26.9	0.423	102.5	-4.0	61.1	56	*
2500	90.3	25.9	0.334	129.8	-5.0	59.4	56	*
3150	89.8	24.9	0.372	116.5	-4.5	60.4	56	*
4000	92.2	24.2	0.341	127.1	-4.9	63.1	56	*

Overall Deficiency: **24.6**
Maximum Deficiency: **8.0**



Field Sound Transmission Loss and STC Contour


100 Hz 0.277
125 Hz 0.208
160 Hz 0.212
200 Hz 0.345
250 Hz 0.316
315 Hz 0.312
400 Hz 0.328
500 Hz 0.389
630 Hz 0.386
800 Hz 0.429
1.00kHz 0.442
1.25kHz 0.42
1.60kHz 0.428
2.00kHz 0.423
2.50kHz 0.334
3.15kHz 0.372
4.00kHz 0.341