Laboratory Measurements of the Sound Insulation of Building Façade Elements

J.S. Bradley and J.A. Birta

IRC Internal Report, IRC IR-818

October 2000

Summary

This report provides the results of over 100 laboratory measurements of the sound transmission loss of building façade components. These included various wall and roof constructions along with some windows and a number of tests to evaluate the effects of vents on sound insulation.

The current work is a major component of the IBANA project (Insulating Buildings Against Noise from Aircraft). The complete IBANA project includes both laboratory and field measurements of building façade sound insulation as well as the creation of computer software to permit the convenient use of this data to design the exterior sound insulation of buildings against aircraft noise.

Tests were performed according to the ASTM E90 procedure that involves building the test partition in an opening between two reverberation chambers. The results give measures of the sound insulation of each façade component for randomly incident sound energy. The OITC (Outdoor-Indoor Transmission Class) was used to give a single-number rating of the sound insulation of each construction against aircraft noise.

Many of the tests were carried out as a number of mini-series in which a particular component was varied but other details of the construction were not varied. For example the effects of different exterior wall cladding were investigated on the same basic wall construction.

Walls

- Tests of various wood stud walls had OITC ratings from a low of 25 to a high of 44. Increasing the stud spacing, adding resilient channels, or using a staggered stud configuration all significantly increased the rating of the wall. Combining one of these improvements with additional surface layers to increase their mass produced further improvements in the overall sound insulation.
- The sound insulation of walls with the conventional 406 mm stud spacing and directly attached surface layers is usually limited by a dip in the sound transmission loss at about 125 Hz. The sound insulation rating of these walls can be improved by using a larger stud spacing, by attaching the gypsum board with resilient channels or by using a staggered stud configuration.

Windows

- Manufactured contemporary windows can have sound insulation that is either inferior to or superior to that of the double glazing units that they include. Sliding windows tended to be limited by air leaks. Several better casement windows had sound transmission loss values better than those of the double glazing units.
- All of the double glazing units and complete windows had lower sound transmission loss values than reported in an earlier laboratory study of the same combination of glass and air space.
- Adding a storm window with a sufficiently large air space significantly improved the overall sound insulation of the window.

Roofs

- Wood-joist and wood-truss flat roof constructions tended to have sound insulation ratings similar to the better walls. This is because the shingles provided a heavier surface layer and also because these roofs had a greater cavity depth than the walls.
- Sloping roof constructions tended to have better OITC ratings than the flat roofs. However, when the shingles and OSB of these roofs were replaced with steel sheeting the overall sound insulation was reduced.
- Adding vents to the roofs reduced the OITC ratings by up to 3 points. The effect of vents was less when there was more insulation in the roof cavity and when the gypsum board was directly attached.
- The sound insulation of light-weight steel deck roof systems varied with the amount of pebbles on the roof and the presence of a T-bar ceiling.

Table of Contents

Acknowledgements

Primary financial support for the IBANA project was provided by Transport Canada, the Department of National Defence and the National Research Council. To date additional funding has been received from Vancouver International Airport Authority. In kind support from Ottawa Airport, Thermo-Cell Industries and from Chantecler Windows is also gratefully acknowledged.

Disclaimer

The contents of this report are the results of tests and analyses carried out in the acoustics laboratory of the Institute for Research in Construction at the National Research Council of Canada. While they are thought to be the best interpretation of the available data, other interpretations are possible and these results may not reflect the policies of either Transport Canada or the Department of National Defence.

1. Introduction

This report presents the results of an extensive series of laboratory measurements of the sound insulation of building façade elements. These results include measurements of the sound transmission loss of various wall and roof constructions along with some tests of windows and the effects of various vents. This work is a major component of the IBANA project (Insulating Buildings Against Noise from Aircraft). The complete IBANA project includes both laboratory and field measurements of building façade sound insulation as well as the creation of computer software to permit the convenient use of these data to design the exterior sound insulation of buildings against aircraft noise.

The IBANA project is a result of an earlier comprehensive review of the NEF aircraft noise measure and various aspects of predicting aircraft noise and its effects in Canada [1-3]. One of the conclusions of the review was that improved building sound insulation was a key remedial measure for minimising the impact of aircraft noise. It was further concluded that, in Canada, available technical information and guidelines [4] for achieving improved sound insulation were very much out of date and inadequate. A more specific investigation of current knowledge of building façade sound insulation issues was also completed [5]. This study found that although the basic principles were generally well understood there was almost no available data representative of the sound insulation of modern Canadian building constructions. Further there was only a rough understanding of the relationship between laboratory and field sound insulation data, and existing Canadian guidelines were based on aircraft noise spectra that are not representative of modern aircraft types.

The IBANA project includes the following key components:

- Laboratory measurements of the sound insulation of various building façade components including various wall and roof constructions as well as windows and the effects of vents.
- Field measurements of the sound insulation of various configurations of a simple wood frame test house at Ottawa Airport.
- Development of a procedure for conversion between laboratory and field measurements of sound insulation.
- Development of software to enable the more accurate and convenient design of the required sound insulation for buildings exposed to aircraft noise.
- Field validation of the new design procedure.

The IBANA project is a 3-year project, but the bulk of the work is to be completed in the first two years. This report represents the results of the work described in the first bullet above. It also provides the database of sound insulation data to be used in the new software.

The main body of the report discusses the trends shown by the various series of measurements. It is hoped that this will help readers to more conveniently understand the major trends and to make it possible for them to estimate the likely effects of other similar constructions.

Appendix III tabulates all of the measured sound insulation data. The data for each reported construction fills one single page. This provides a convenient reference for laboratory measurements of the sound insulation of various building façade components representative of modern Canadian constructions. Of course, all constructions currently in use could not be included, but a wide range of common and acoustically relevant constructions were tested. The choice of constructions was helped by comments from the advisory panel listed in Appendix I. The choice was also influenced by a desire to illustrate trends so that the likely effects of other constructions could be estimated.

2. Testing Procedure

2.1 Sound transmission loss measurements

The sound transmission loss measurements given in this report were obtained in laboratory measurements following the standard ASTM E90 procedure [6]. This procedure involves building the wall or roof to be tested in a special test opening between two reverberant test chambers. High levels of a test noise are produced in the source chamber and the levels of the sound in both the source and receiving reverberation chambers are measured. The acoustical characteristics of the receiving room are obtained from reverberation time measurements. The sound transmission loss values calculated from these measurements indicate the amount of sound energy transmitted though the test partition as a function of frequency. The test chambers are designed to provide a diffuse sound field in which sound will be incident on the test partition more or less equally from all directions. This is, of course, not the same as for real buildings exposed to the noise from passing aircraft, which will be incident on the building at various specific angles of incidence.

The actual test procedure exceeded the requirements of the ASTM E90 standard in several ways. Although the standard requires measurements to be made in the 1/3 octave bands from 125 to 4k Hz, in this work measurements are reported for the 1/3 octave bands from 50 to 5k Hz. The additional lower frequency measurements are particularly important because typical outdoor sound sources such as aircraft noise contain significant low frequency sound energy. In the laboratory measurements, sound levels were measured at 9 independent locations in the source and the receiving reverberation chambers. Similarly, reverberation times were measured from the ensemble average of 10 decays at the same 9 independent microphone positions in the receiving chamber. The tests were repeated for both directions of propagation through the test partitions. That is, in one test one reverberation chamber was the source chamber and in the second the other chamber was the source chamber. The results quoted in this report are always the average of the two tests. In addition to descriptions of each construction, all test results are referred to by their Test ID (e.g. TLA-99-029a) to provide a unique identifier for each result. This also permits the reader to refer to the complete test result details in Appendix III and index.

2.2 Construction details

The details of each construction are described by a series of letters and numbers describing the components of the wall or roof in order from one side to the other. For example the base wall with vinyl siding attached is described as follows:

VIN1_OSB11_WS140(406)_GFB152_G13.

This indicates that starting from the outside there is 1 mm thick vinyl siding (VIN) attached to 11 mm thick OSB sheathing. The wood studs (WS) are 140 mm studs spaced at 406 mm with 152 mm thick glass fibre batt insulation (GFB) in the cavity. The inner surface is a single layer of 13 mm thick gypsum board (G). Descriptions of all of the symbols used are included in Appendix II. The numerical part of the code indicates the thickness or spacing in mm. For the wall and window tests the components are listed in order from the small chamber side to the large chamber side. For the roof tests, components are listed from the upper chamber to the lower chamber side of the roof. This corresponds to going from the outer surface to the inner surface of the roof.

Some materials were not varied throughout these tests and these common properties are, for brevity, not always repeated in the following discussions. OSB sheathing was always 11 mm thick and only 13 mm thick regular gypsum board was used. All walls and roofs included a polyethylene vapour barrier immediately under the interior gypsum board layers.

2.3 Single number ratings

The E90 procedure provides measured sound transmission loss values in decibels versus 1/3 octave band frequency. Various single number ratings can be calculated from the complete data to give a convenient rank ordering of various constructions. Most commonly, the Sound Transmission Class (STC) is calculated. It is a single number rating obtained by fitting a standard reference contour to the measured transmission loss values according to the rules specified in ASTM E413 [7]. Although the STC rating is widely used, it is only intended for use with typical indoor noises such as speech and typical office sounds. It is not appropriate for rating exterior façade elements to typical outdoor noises that usually contain high levels of low frequency sound.

The ASTM Outdoor-Indoor Transmission Class (OITC) [8] has been developed as a single number rating for exterior façades and typical transportation type noise sources. In this report both STC and OITC are included in Appendix III. However, because STC is not an appropriate single number rating to rank order exterior façade elements, only OITC values are included in the discussions in the text of the following sections. The OITC rating gives the A-weighted reduction of the test partition to a standard outdoor noise spectrum and includes frequencies from 80 to 4k Hz. It is intended that this standard spectrum be representative of all types of outdoor noises and not necessarily just aircraft noise. Previous comparisons [5] with aircraft noise spectra suggested that the OITC source spectrum has higher levels at both high and low frequency extremes than do typical modern commercial jet aircraft noise spectra. Although these spectral differences might lead to small differences in ranking of various constructions, the OITC rating is used for convenience in the discussions of this report. The new sound insulation design software being developed as part of this project will calculate the A-weighted level reduction for a selected aircraft noise spectrum as well as the standard OITC value.

2.4 The reverberation chamber test facilities

Two different pairs of reverberation chambers were used to perform the sound transmission loss tests. The transmission loss of windows and all wall constructions were performed in the wall test facility in building M27 at the Montreal Road NRC campus in Ottawa. The floor transmission loss facility in building M59 was used to test the roof constructions. Both facilities have computer-controlled robots to position the microphone in each room.

The wall test facility consists of two reverberation chambers side by side with movable test frames that can be rolled into position between the two reverberation chambers as illustrated by the sketch in Figure 1. Both chambers are mounted on springs to vibrationally isolate them from each other, from the test frame, and from other parts of the building. The larger of the two chambers is 250 m^3 and the smaller is 135 m^3. The test frame allows the construction of test walls that are 8 ft. high (2.44 m) by 12 ft. long (3.66 m). The test frames roll into place on heavy steel tracks and are sealed into place between the two chambers with pneumatic seals as well as with foam seals and metal adhesive tape. Both chambers contain diffusing panels to increase the randomisation of sound reflections.

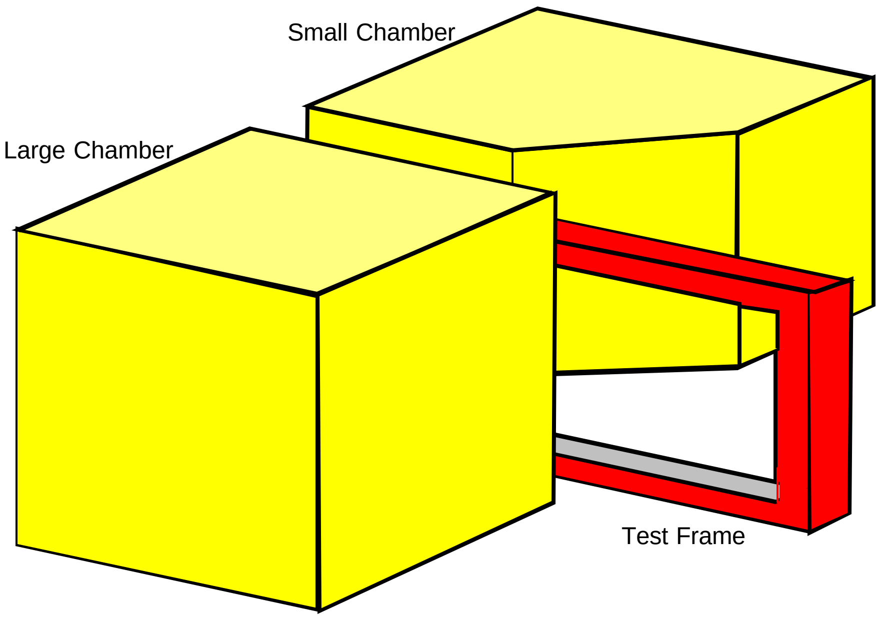


Figure 1. Sketch showing the two reverberation chambers of the wall test facility located in building M27.

The two reverberation chambers of the floor test facility are 173 m^3 and 170 m^3 in volume. One is positioned above the other but they are separately vibrationally isolated. Test frames in which the test floor or roof are constructed roll into place between the two chambers and are sealed in place with pneumatic seals in the same manner as in the wall test facility. The test frame allows the construction of floors (or roofs) that are 12.4 ft (3.785 m) by 15.4 ft (4.700 m) in size. The purpose of the moving test frames is to allow the more efficient construction of test structures outside of the test chambers while other structures are being tested. However, for the sound transmission loss measurements of sloping roof structures included in this report it was necessary to build the roof structure in place inside the reverberation chambers.

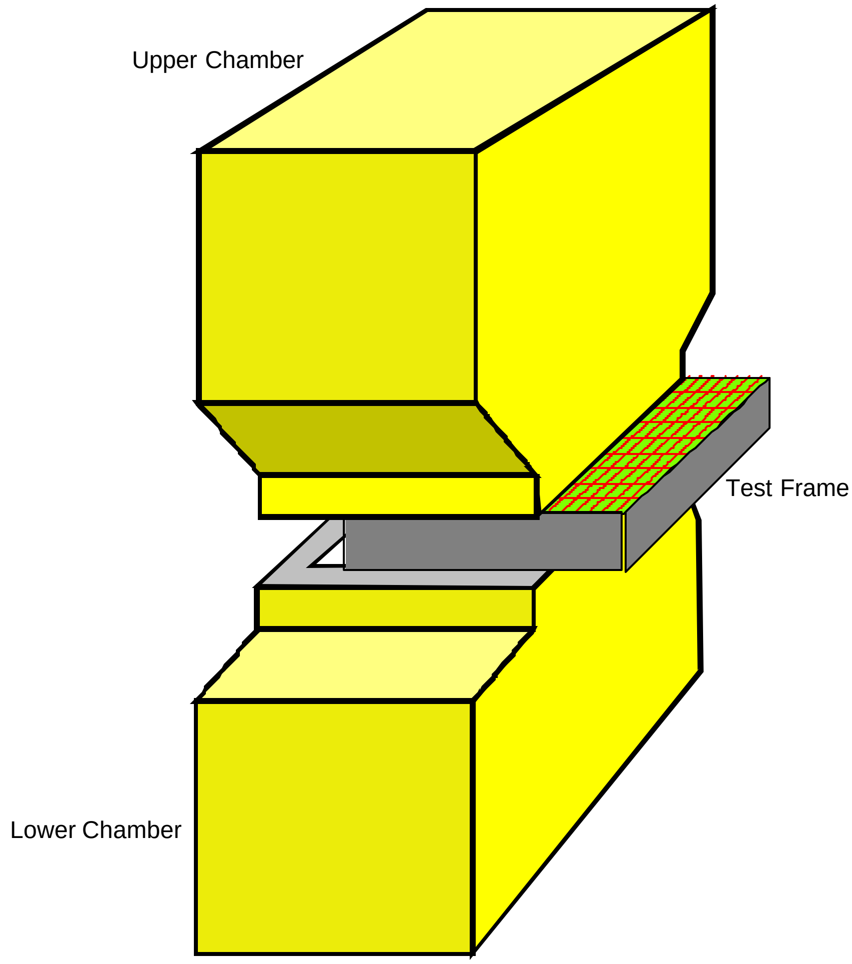


Figure 2. Sketch showing the two reverberation chambers of the floor test facility located in building M59.

2.5 Validation tests

The wall test facility underwent a major renovation immediately prior to the tests reported here. Because of this, a number of extra tests were carried out to verify the acceptable performance of the renovated test facility. Previous experience had shown that exposed portions of the test frame that holds the test walls could create flanking sound transmission paths. Although the test frame was a massive structure made of concrete filled steel sections, the inside surface of the test opening was lined with wood connected to the steel frame by a layer of thin rubber. The test walls were typically about half as thick as the test frame. This left a portion of the wood test frame liner exposed and a potential source of sound radiation of the vibrational energy transmitted through the test wall. This created a potential extra (or flanking) sound transmission path. The importance of this flanking path would be expected to vary with frequency and with the magnitude of the sound transmission loss of the test wall. This flanking path was eliminated by the addition of masking strips that covered the exposed parts of the test frame liner. The masking strips consisted of layers of gypsum board over a layer of glass fibre duct liner material. All of the edges and joints were carefully taped with adhesive metal tape.

The effect of the masking strips is illustrated in Figure 3. This shows the increase (improvement) in transmission loss with the addition of masking strips consisting of one or two layers of gypsum board over glass fibre duct liner. The test wall was the standard base wall consisting of 11 mm OSB on 140 mm studs with a 406 mm spacing, glass fibre thermal insulation in the cavity and 13 mm gypsum board as the other surface layer. These results show that adding masking strips consisting of a single layer of gypsum board improved the wall transmission loss at higher frequencies by up to about 2 dB. The addition of a second layer of gypsum board produced only a very small further improvement. All wall transmission loss tests in this report were performed with masking strips in place consisting of a double layer of gypsum board. This was assumed to practically eliminate any significant flanking path.

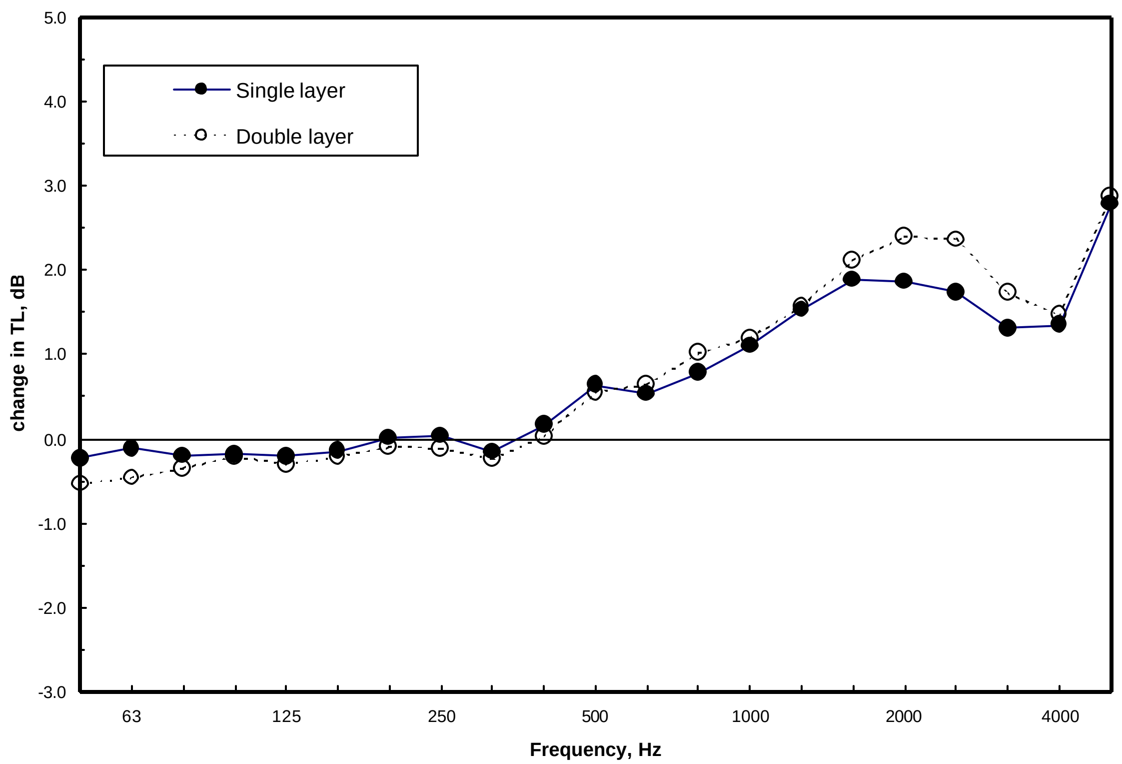


Figure 3. Measured increases in the transmission loss of the base wall with the addition masking strips consisting of either single or double 13 mm layers of gypsum board mounted over glass fibre duct liner material.

Preliminary evaluations also investigated the two types of repeatability of the sound transmission loss measurements. Retest-repeatability indicates the variations that occur when the same test wall construction is re-tested. Rebuild-repeatability measures the variations on completely rebuilding a test wall with the same or new materials and then re-testing that particular wall construction.

Figure 4 illustrates the repeat-repeatability of measurements of the base wall. (11 mm OSB on 140 mm studs with a 406 mm spacing, glass fibre thermal insulation in the cavity and 13 mm gypsum board as the other surface layer). The same wall structure was re-tested in the North test frame 4 times. In the South test frame, a nominally identical wall was re-tested two times. In between each test, the test frame was removed from between the test chambers and returned and the flanking strips remounted. Figure 4 shows the maximum deviations from the average transmission loss values for each test frame. These maximum differences are very small and mostly less than 0.2 dB. Thus repeated tests of the same wall structure can very precisely repeat the same transmission loss values.

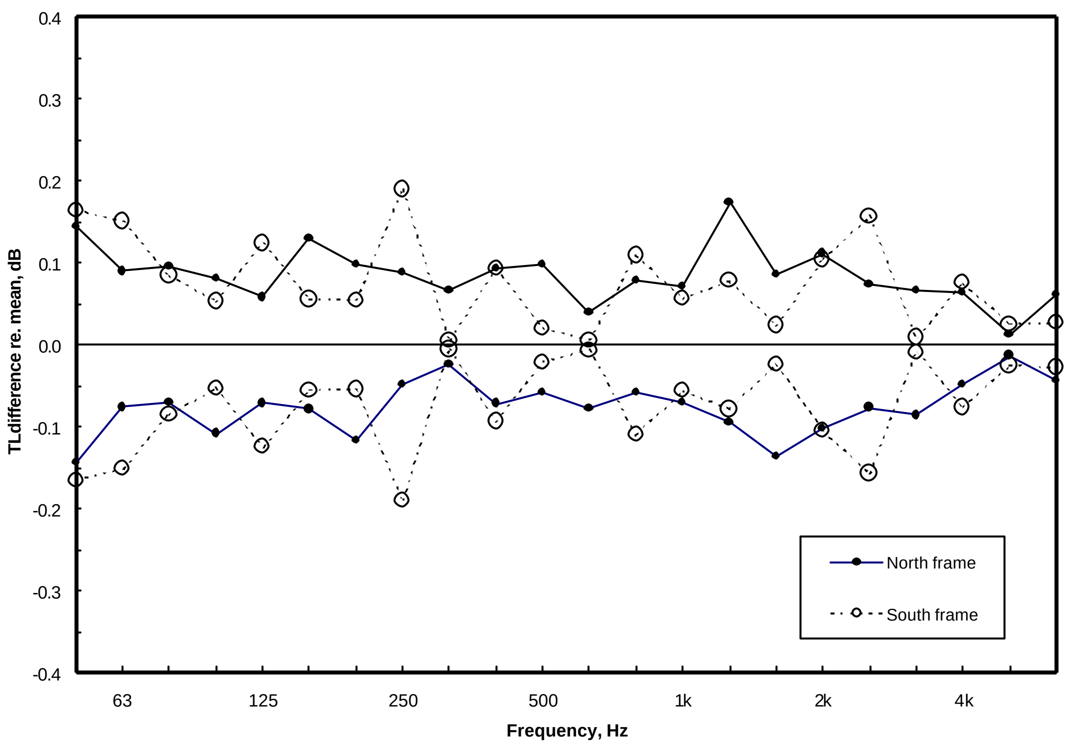


Figure 4. Maximum differences in measured sound transmission loss on repeated measurements of the same base wall constructions relative to the mean values. Tests in the North frame included 4 repeats and in the South frame 2 repeats.

Completely rebuilding a wall and re-testing it is expected to lead to larger differences. It is difficult to fasten components together in exactly the same manner each time even in the laboratory. Where different new materials are used, there will be further changes due to small differences in the material properties. If the same materials are used to re-construct a wall, they may have been permanently changed by use in the first construction. In the M27 wall facility there are two nominally identical test frames that may have small differences that might also influence the measured transmission loss values.

Two different tests of the rebuild-repeatability were carried out and the results are illustrated in Figure 5. In the South test frame the base wall was reconstructed from the same materials but shifted over 40 mm in the test frame. A nominally identical base wall was constructed in the North test frame but using different, new materials. Thus one curve in Figure 5 shows the differences on rebuilding with the same materials, but at a slightly different position, and the other shows the differences when rebuilding in a different test frame with new materials. Thus, in the latter both the materials and the test frame were changed and hence this is expected to lead to the largest differences. When the same materials were reused in the same test frame the differences indicated in Figure 5 were mostly less than 1 dB. When both the test frame and the materials were changed differences of up to 2 dB at higher frequencies are indicated in Figure 5.

However, it is usually possible to investigate smaller effects by making only small adjustments to a wall structure rather than completely rebuilding it. For example the effect of an additional layer of gypsum board can be determined more precisely than indicated by the rebuild-repeatability errors indicated in Figure 5 because the basic structure has not changed. Many of the results in this report consist of small series of tests where a particular construction is incrementally modified. The resulting trends in the measured sound transmission loss values generally confirm that such incremental effects can be illustrated more precisely than the rebuild-repeatability errors shown in Figure 5.

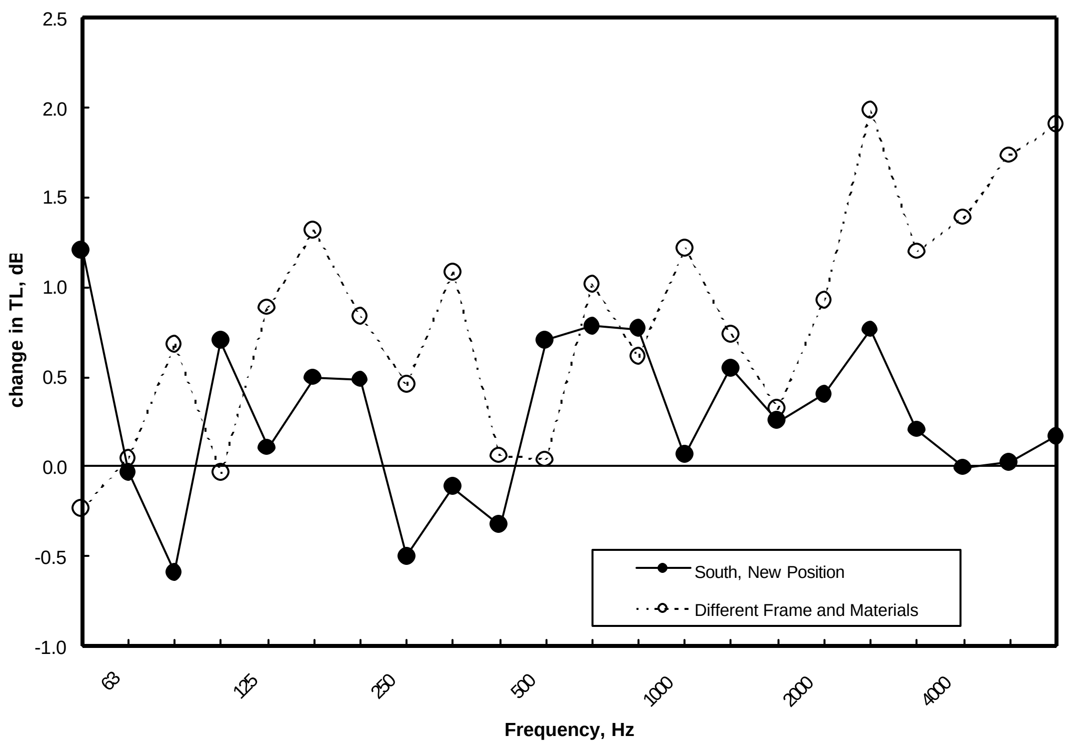


Figure 5. Differences in measured sound transmission loss of the base wall construction on completely rebuilding the walls.

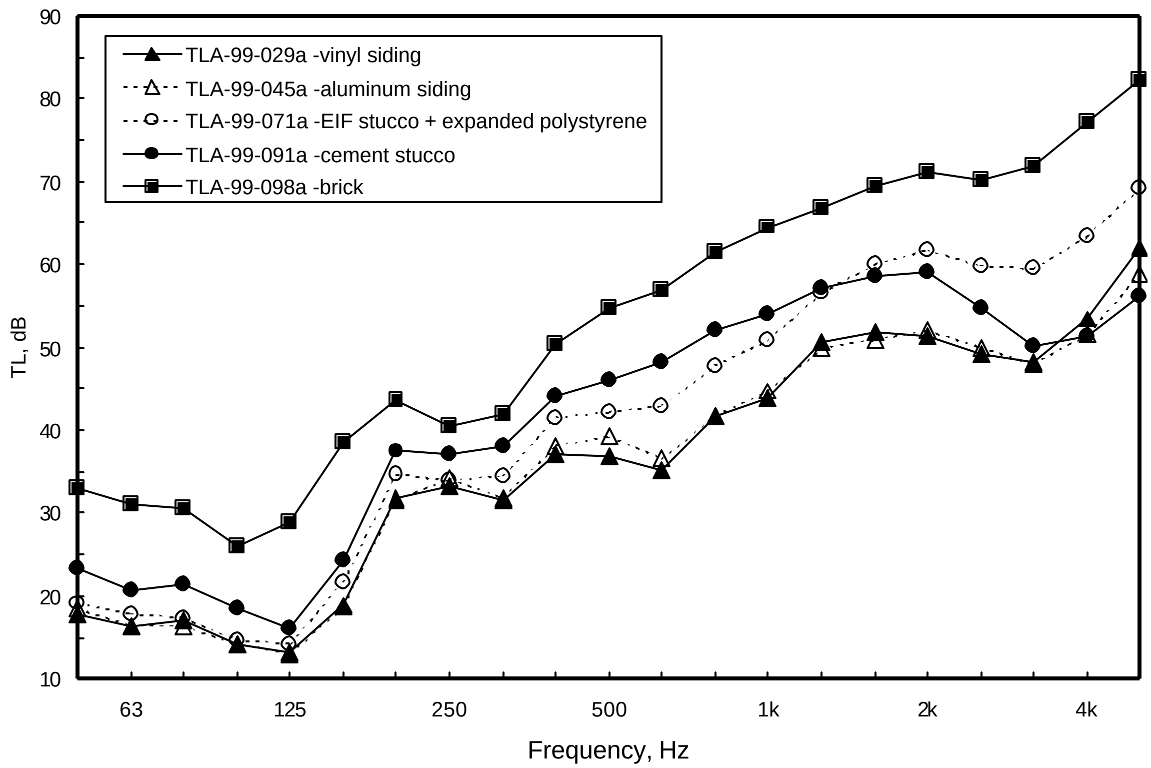
3. Walls

The various wall sound transmission loss measurements are discussed in this section. Each subsection considers the effect of a different component of the wall construction. The subsections are arranged by wall component in order from the outside surface (exterior cladding) to the inside surface. Many of the tested walls were variations from a base case wall that consisted of 11 mm OSB on 140 mm studs with a 406 mm spacing, 152 mm glass fibre thermal insulation in the cavity and 13 mm gypsum board as the other surface layer (OSB11_WS140(406)_GFB152_G13, see Appendix II for symbol descriptions). Many of the constructions consisted of variations of one of these basic components. Where other components were not varied, those components would correspond to this base wall case. For example, variations of the exterior cladding were all carried out on the base wall construction. Thus these tests only varied the exterior cladding on the same stud system, internal insulation and interior surface. However, other walls were constructed on completely different stud systems. Only walls based on wood stud constructions were included. Each test result is identified by its Test ID. Further information on the tested construction can be found in Appendix III under this same Test ID.

3.1 Varied exterior cladding.

The first component of the exterior walls that was varied was the exterior cladding. Five different types of exterior cladding were tested: vinyl siding, aluminum siding, acrylic stucco (exterior insulation and finish system EIF), cement stucco and brick. All five types of cladding were added to the base wall construction. (OSB11_WS140(406)_GFB152_G13). Figure 6 compares the measured sound transmission loss values. The vinyl and aluminum siding cases are very similar because both materials are very light in weight and do not significantly increase the mass of the wall surfaces. The acrylic stucco tends to produce lower sound transmission loss than the heavier cement stucco material. However, the exterior brick cladding provides the highest transmission loss values because of its much greater mass.

The OITC ratings of these walls vary from 25 to 40 dB. These will be seen to represent the range of OITC values found for most of the wall constructions. Only a few walls have OITC values outside of this range. Thus in comparing other results in this report an OITC of 25 represents a low value for a wall and a value of 40 represents a high OITC value for a wall.



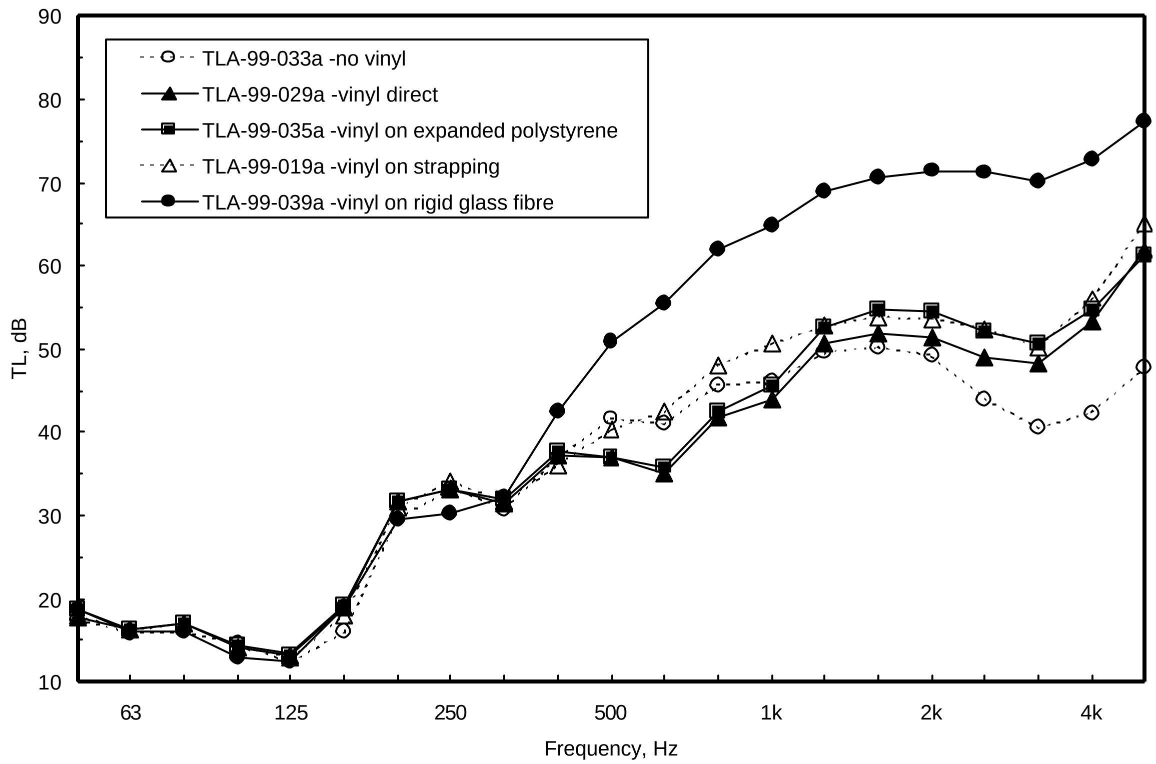
Test ID	Description	OITC
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-045a	ALM0.6_OSB11_WS140(406)_GFB152_G13	25
TLA-99-071a	G13_WS140(406)_GFB152_OSB11_BPAP0.7_EPS25_EIF6	27
TLA-99-091a	G13_WS140(406)_GFB152_OSB11_BPAP0.7_STUC9.5	29
TLA-99-098a	G13_WS140(406)_GFB152_OSB11_AIR16_BRI89	40

Figure 6. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for varied exterior cladding installed on the base wall (OSB11_WS140(406)_GFB152_G13).

3.2 Varied attachment of exterior cladding.

The second feature of walls that was varied was the method of attaching the exterior cladding to the wall system. In these tests vinyl siding was attached to the base wall by various methods. These included having the vinyl siding: directly attached to the OSB; including 19 mm wood strapping between the vinyl siding and the OSB; including a 25 mm layer of expanded polystyrene insulation between the vinyl siding and the OSB, and including a 25 mm layer of rigid glass fibre insulation between the vinyl siding and the OSB. The resulting sound transmission loss values are compared in Figure 7. For comparison the measured transmission loss of the base wall without any vinyl siding is also included in this figure.

All of the results in Figure 7 are essentially identical for frequencies up to and including the 315 Hz 1/3 octave band. Adding the vinyl siding to the base wall has a noticeable increase in the sound transmission loss at high frequencies. Adding the vinyl siding either directly to the OSB or by using strapping leads to a small decrease in the measured transmission loss in the 630 Hz band. However attaching the vinyl siding over a 25 mm layer of rigid glass fibre insulation has the most effect and increases the measured sound transmission loss quite significantly above 400 Hz. In spite of the various differences at mid and higher frequencies, the results in Figure 7 all have essentially the same OITC value. Thus for these walls it is the lower frequency performance of the walls that limits the rating of the walls against typical outdoor noises and the differences at mid and higher frequencies do not affect the overall rating of the sound insulation of the wall against aircraft noise.



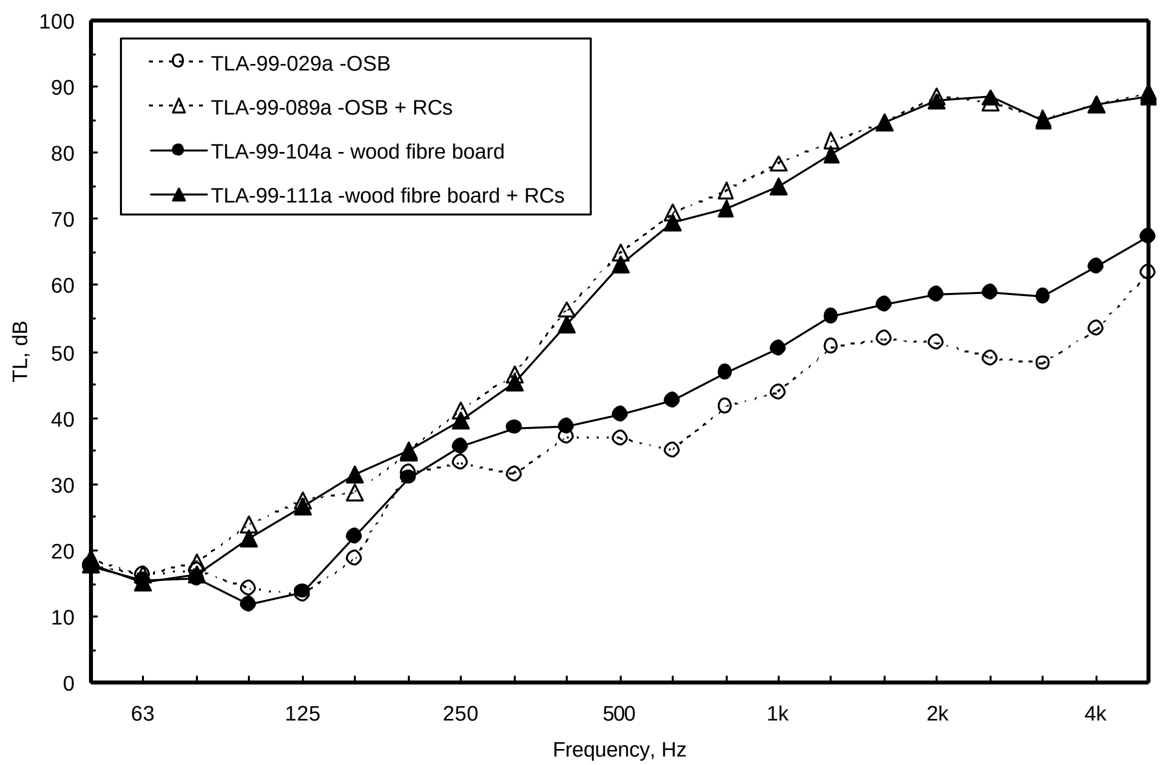
Test ID	Description	OITC
TLA-99-033a	OSB11_WS140(406)_GFB152_G13	25
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-035a	VIN1_EPS25_OSB11_WS140(406)_GFB152_G13	26
TLA-99-019a	VIN1_WFUR19(406)_OSB11_WS140(406)_GFB152_G13	25
TLA-99-039a	VIN1_GFR25_OSB11_WS140(406)_GFB152_G13	25

Figure 7. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for varied method of attaching vinyl siding to the base wall (OSB11_WS140(406)_GFB152_G13).

3.3 Varied exterior sheathing.

While OSB (Oriented Strand Board) is commonly used for the exterior sheathing of wood frame construction, various wood fibre board products are also used. The acoustical effects of these two types of materials were compared for two different wall constructions. In the first comparison the measurements of a base wall construction with vinyl siding directly attached to the OSB were compared to measurements of a similar wall construction with the OSB replaced with wood fibre board exterior sheathing. The comparison of the measured sound transmission loss values in Figure 8 illustrates that the wall with wood fibre board exterior sheathing has a little increased sound transmission loss at mid and high frequencies. These improvements are probably due to the slightly resilient connection between the vinyl siding and the stud system when wood fibre board is used. However, these differences do not influence the OITC rating and hence the walls are expected to provide equivalent sound insulation against aircraft noise.

The two types of exterior sheathing were also compared on the same stud system but with an interior surface consisting of two layers of gypsum board mounted on resilient channels. (The effects of resilient channels are discussed in section 3.6 below). Figure 8 shows that adding two layers of gypsum board on resilient channels leads to large increases in the measured sound transmission loss values relative to the two walls with only a single layer of gypsum board and



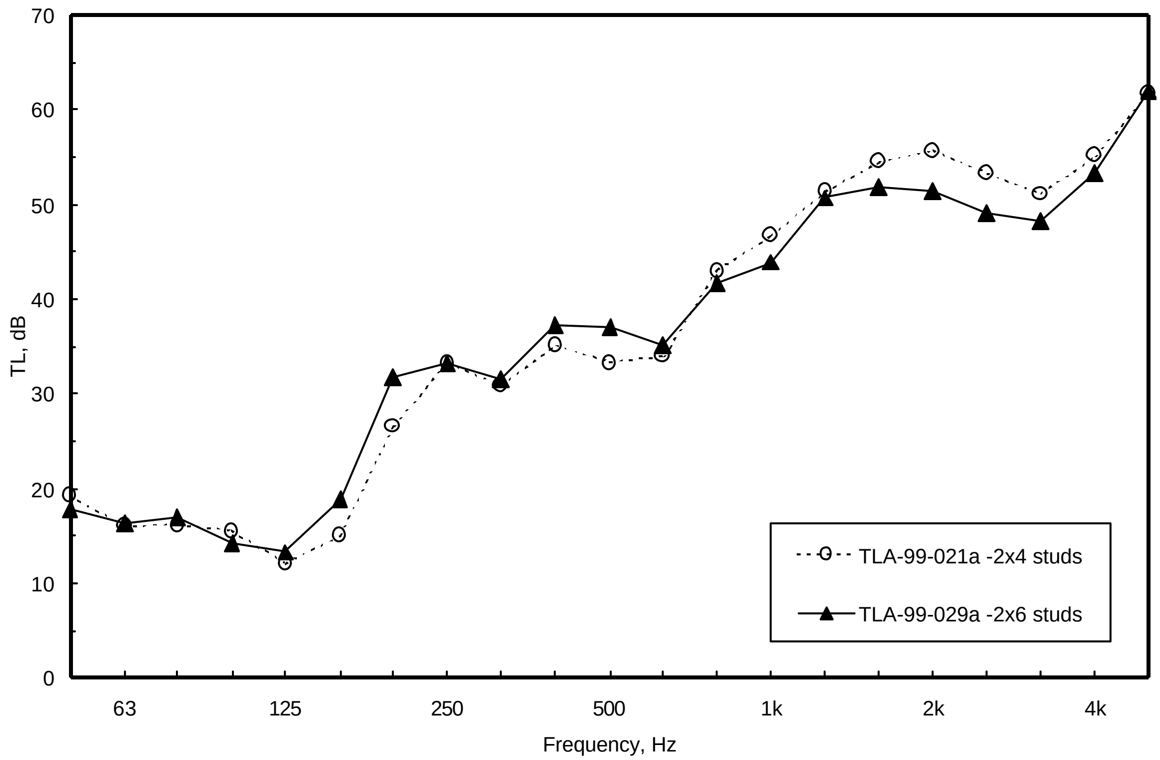
Test ID	Description	OITC
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-089a	VIN1_GFR25_OSB11_WS140(406)_GFB152_RC13(610)_2G13	35
TLA-99-104a	VIN1_WFB13_WS140(406)_GFB152_G13	25
TLA-99-111a	VIN1_GFR25_WFB13_WS140(406)_GFB152_RC13(610)_2G13	33

Figure 8. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls including 13 mm wood fibre board or 11 mm OSB exterior sheathing. The lower two curves are for varied exterior sheathing on the base wall construction. For the upper two curves the walls also included interior surfaces consisting of two layers of 13 mm gypsum board mounted on resilient channels.

no resilient channels. However, for these two improved walls there is very little difference between the wall with OSB and the other with wood fibre board. The OSB sheathing is heavier (6.9 kg/m^2 vs 3.5 kg/m^2) and would be expected to lead to a little greater sound transmission loss values. The OITC values in Figure 8 suggest that there is a 2 dB improvement in the OITC rating for the wall with OSB exterior sheathing. This is partly because the OITC standard requires that the OITC values be rounded off to integer values. In this case one value was rounded down and the other rounded up so that the actual difference was really closer to 1 dB and this is really a very minor improvement.

3.4 Varied stud system (stud size, stud spacing, and staggered studs).

Walls were constructed with varied wood stud systems. Both the stud size and the stud spacing were varied. Walls were also constructed with staggered studs where the two different wall surfaces are attached to different sets of studs constructed on the same plate.

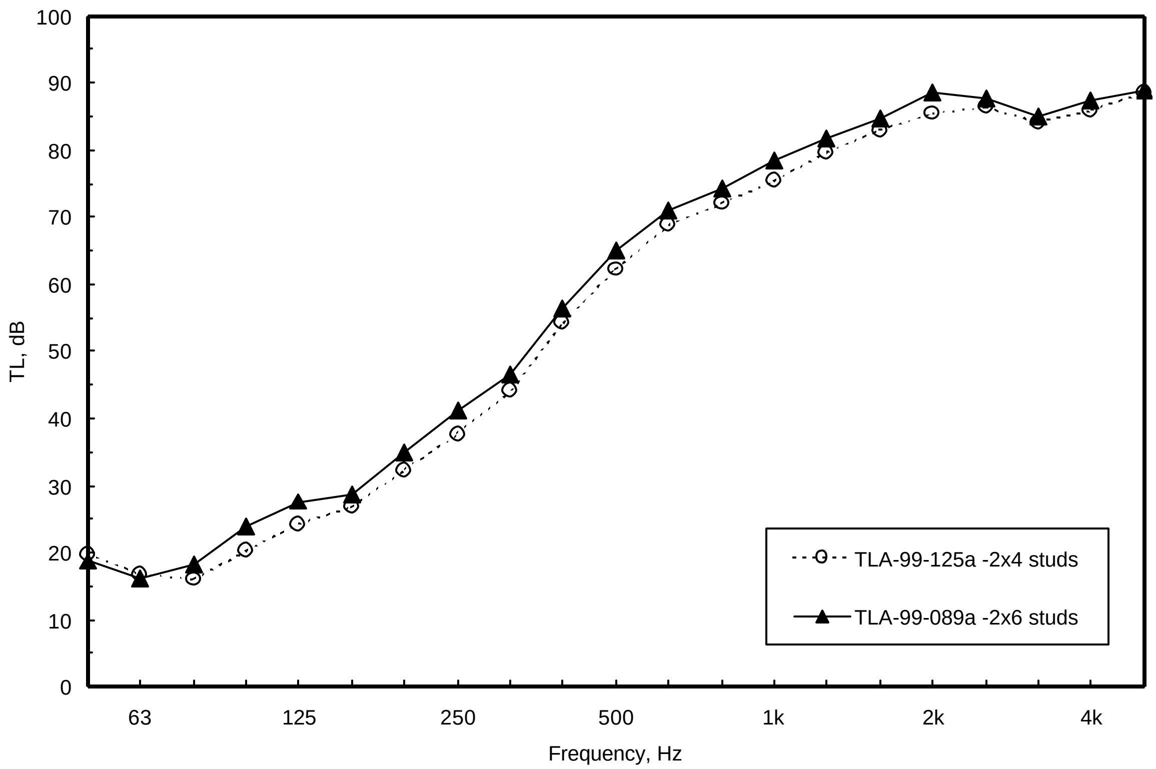


Test ID	Description	OITC
TLA-00-021a	VIN1_OSB11_WS89(406)_GFB89_G13	24
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25

Figure 9. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with either 89 mm or 140 mm wood studs both spaced at 406 mm. Both walls had vinyl siding mounted on 11 mm OSB sheathing with glass fibre in the cavity and a single layer of 13 mm gypsum board on the interior surface.

The effect of stud size was examined for variations of the base wall construction with either 89 mm (2” by 4”) or 140 mm (2” by 6”) wood studs with a 406 mm stud spacing. Figure 9 compares the sound transmission loss of these two walls both having vinyl siding as the exterior cladding. Figure 9 shows that the effect of stud size is quite small and the OITC ratings of the two walls are almost identical. The small differences that do occur vary with frequency. From 160 to 500 Hz the wall with the 140 mm studs has slightly higher sound transmission loss, but between 1 and 4 kHz the wall with the 89 mm studs has the higher sound transmission loss.

The effect of stud size was also examined for two other walls with higher overall sound transmission loss. These consisted of vinyl siding mounted over 25 mm rigid glass fibre insulation onto the OSB exterior sheathing. They both had glass fibre in the cavity and two layers of gypsum board mounted on resilient channels as the interior surface. The measurements of these walls are compared in Figure 10. For these constructions the wall with the 140 mm (2” by 6”) stud was consistently a little better in almost all 1/3 octave bands and had a little higher OITC rating. This is because the greater stud depth lowers the mass-air-mass resonance

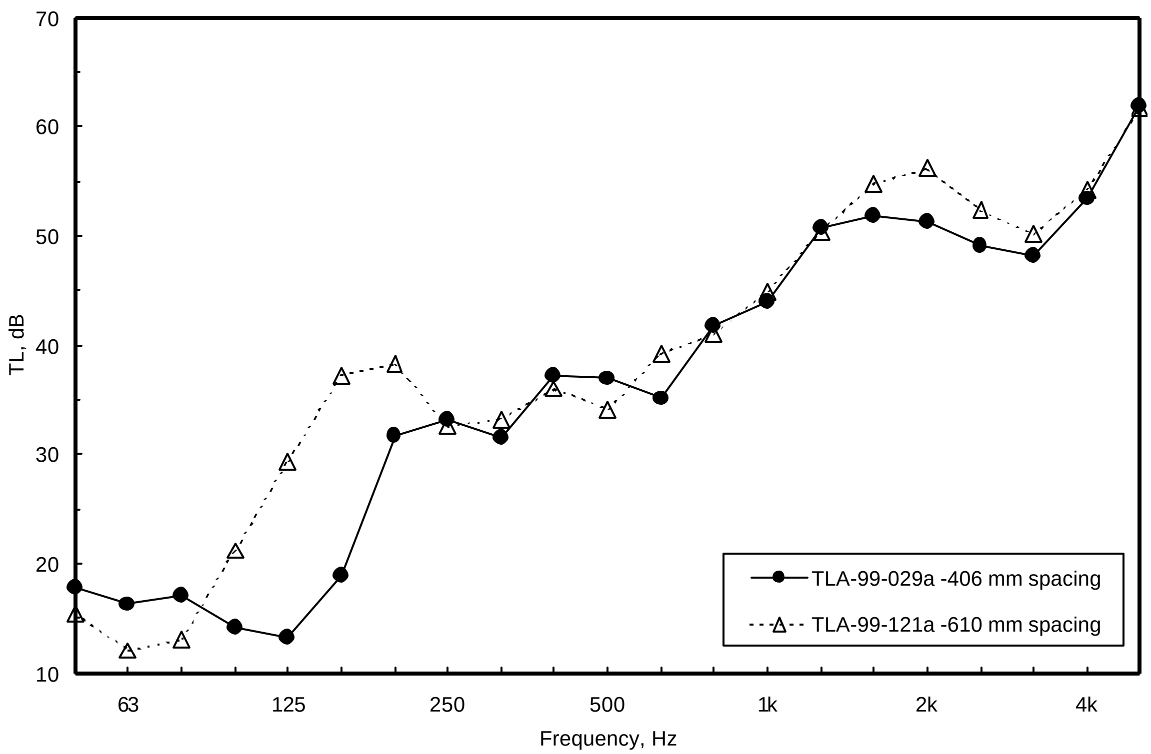


Test ID	Description	OITC
TLA-99-125a	VIN1_GFR25_OSB11_WS89(406)_GFB89_RC13(610)_2G13	48
TLA-99-089a	VIN1_GFR25_OSB11_WS140(406)_GFB152_RC13(610)_2G13	35

Figure 10. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with either 89 mm or 140 mm wood studs both spaced at 406 mm. Both walls had vinyl siding mounted over 25 mm rigid glass fibre insulation on 11 mm OSB sheathing with glass fibre in the cavity and a double layer of 13 mm gypsum board on resilient channels as the interior surface.

frequency a little. Thus for these constructions with structurally isolated surface layers, there is a small advantage for the larger studs.

While the effect of stud size was seen to be quite small, stud spacing is a more important determinant of the overall performance of exterior walls. The effect of stud spacing was investigated for both 89 mm and 140 mm wood stud walls. The wall constructions were similar to the base case having vinyl siding on OSB sheathing with glass fibre in the cavity and a single layer of gypsum board as the interior surface. Figure 11 compares two walls with 140 mm wood studs having either 406 mm or 610 mm stud spacing. Figure 12 compares the measurements of three walls having 89 mm wood studs and with stud spacings of 305, 406, and 610 mm. In both graphs the largest changes are at lower frequencies. In all of the walls measured in this study, having exterior sheathing and interior gypsum board directly attached to studs with a 406 mm stud spacing, there is a dip in the sound transmission loss at 125 Hz. Increasing the stud spacing shifts this dip to lower frequencies and improves the overall performance of the wall. Thus in Figure 11 increasing the stud spacing from 406 to 610 mm increases the OITC rating from 25 to 31. Similarly in Figure 12, increasing the stud spacing from 305 to 610 mm, increases the OITC

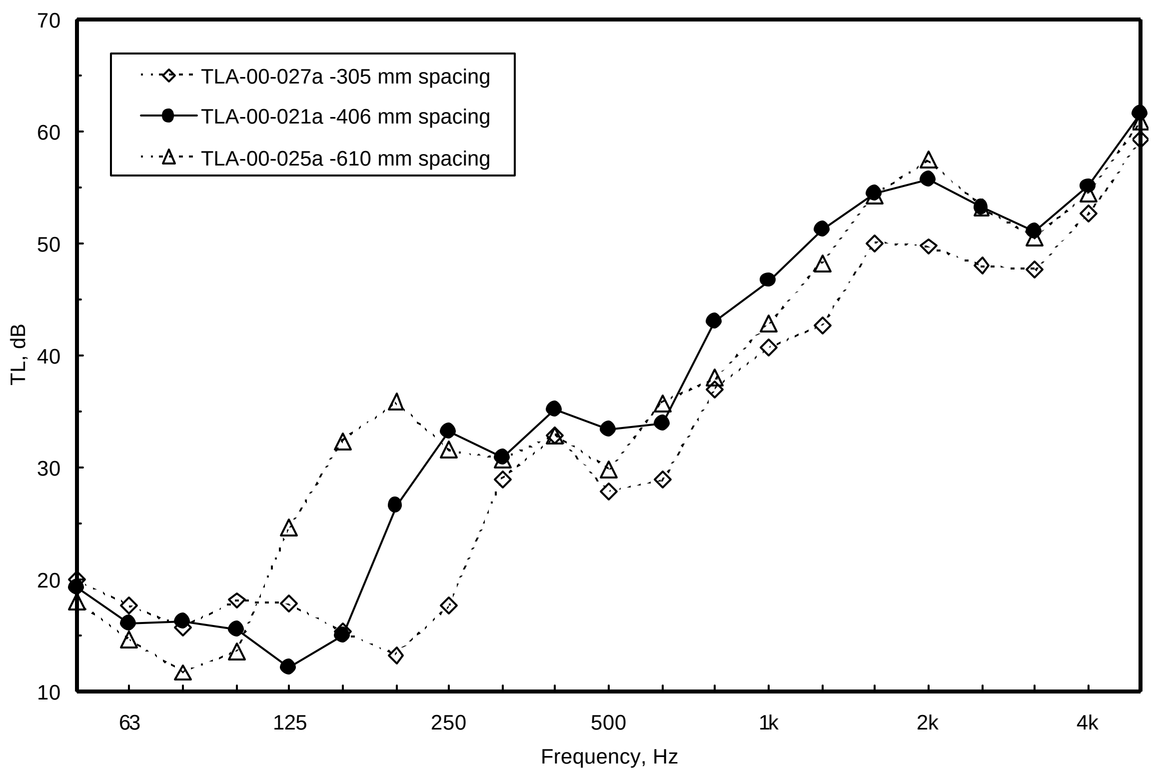


Test ID	Description	OITC
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-121a	VIN1_OSB11_WS140(610)_GFB152_G13	31

Figure 11. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with 140 mm wood studs spaced at either 406 or 610 mm. Both walls had vinyl siding mounted on 11 mm OSB sheathing with glass fibre in the cavity and a single 13 mm layer of gypsum board as the interior surface.

rating from 23 to 27. That is, in both cases using less material (larger stud spacing) leads to better performance.

The importance of stud spacing does not seem to be generally recognized. This may be because standard tests often only measure down to 125 Hz and hence do not show the low frequency performance of walls. However, the low frequency sound transmission loss often limits the overall performance of the wall and is particularly important when aircraft sounds are the noise source. The cause of the sound transmission loss dip that occurs at 125 Hz for a 406 mm stud spacing has been explained by the work of Lin and Garrelick [15] as the first structural resonance of the framed panel system made up of the surface layers and studs. As illustrated in Figures 11 and 12, the frequency of this resonance can be adjusted by varying the stud spacing. When the stud spacing is large, it may be confused with the mass-air-mass resonance of the wall. (The simple mass-air-mass resonance is caused by the combination of the masses of the two surface layers and the stiffness of the air cavity [equation 4.82, reference 16]. For example, with a 140

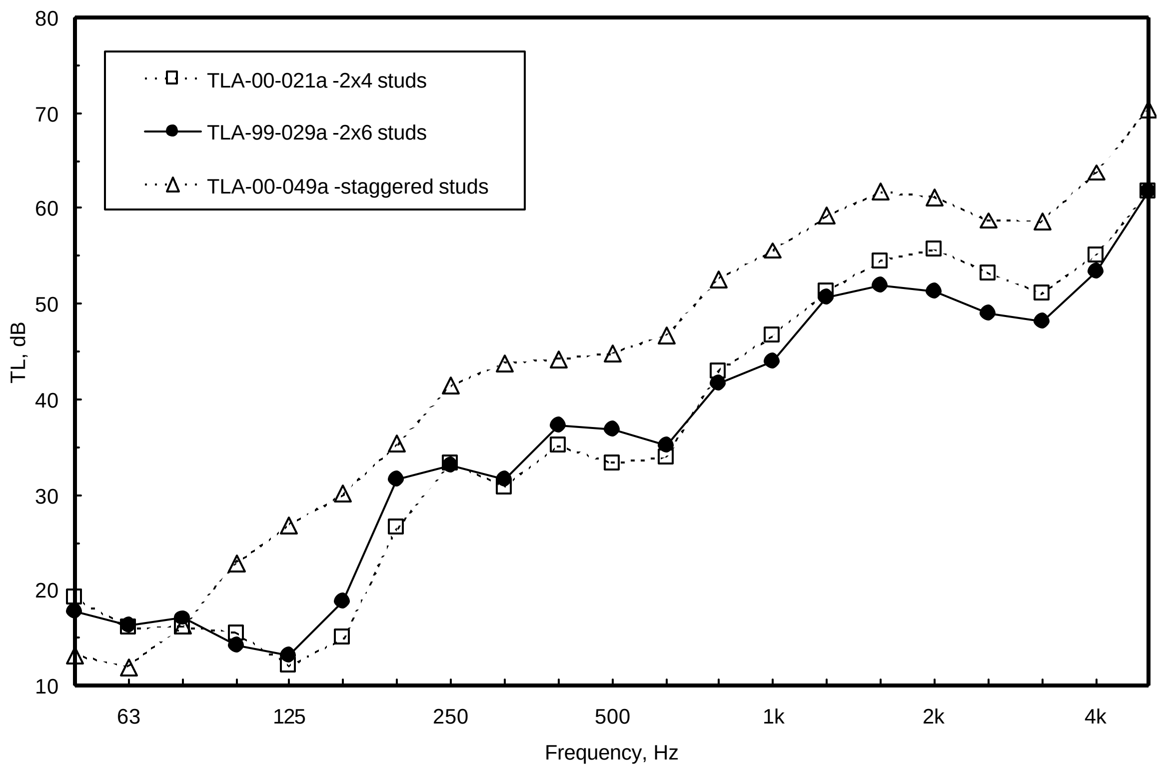


Test ID	Description	OITC
TLA-00-027a	VIN1_OSB11_WS89(305)_GFB89_G13	23
TLA-00-021a	VIN1_OSB11_WS89(406)_GFB89_G13	24
TLA-00-025a	VIN1_OSB11_WS89(610)_GFB89_G13	27

Figure 12. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with 89 mm wood studs spaced at 305, 406, or 610 mm. All three walls had vinyl siding mounted on 11 mm OSB sheathing with glass fibre in the cavity and a single 13 mm layer of gypsum board as the interior surface.

mm cavity filled with absorbing material and with 11 mm OSB and gypsum board surface layers, the mass-air-mass resonance should occur at about 60 Hz). However, Lin and Garrelick's work shows that the simple mass-air-mass resonance only occurs when the two surface layers are structurally separated such as in staggered stud walls (Figure 13) or when resilient channels are used (Section 3.6).

The low frequency structural resonance dips in the sound transmission loss plots of Figures 11 and 12 are eliminated if the interior gypsum board is attached using resilient channels (See section 3.6 for effects of resilient channels). That is, when one of the surface layers is resiliently attached and hence structurally separated, the framed panel system is changed and the primary structural resonance is eliminated. An alternative approach to reducing the mechanical connection between the two surfaces of the wall is to use a staggered stud system. In this case two sets of 89 mm (2" by 4") studs were used on a 140 mm plate (2" by 6"). The outer surface layers are attached to one set of studs and the inner surface layers to the other set of studs. The sound transmission loss of staggered stud walls are compared to other walls with the same stud



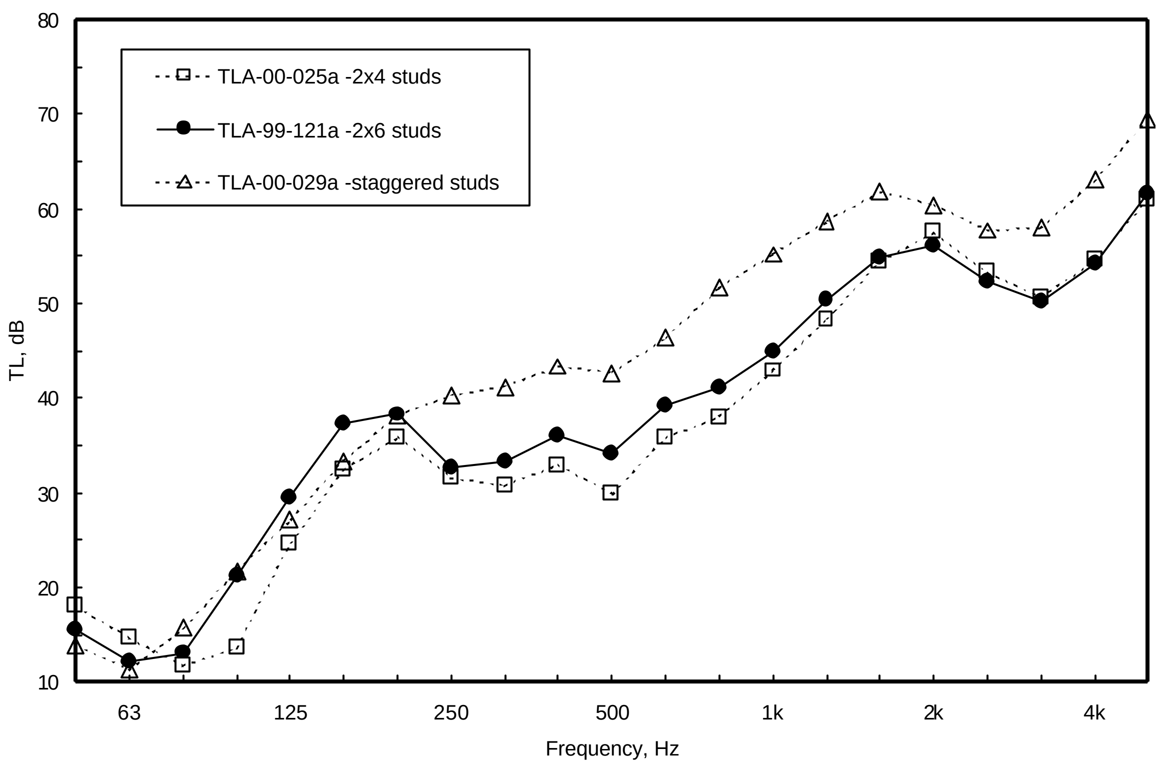
Test ID	Description	OITC
TLA-00-021a	VIN1_OSB11_WS89(406)_GFB89_G13	24
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-00-049a	VIN1_OSB11_SWS140(406)_2GFB65_G13	33

Figure 13. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with a 406 mm stud spacing. All three walls had vinyl siding mounted on 11 mm OSB sheathing with glass fibre in the cavity and a single 13 mm layer of gypsum board as the interior surface.

spacing in Figures 13 and 14. For the staggered stud walls, the simple mass-air-mass resonance that occurs at approximately 60 Hz limits the low frequency performance. All walls were constructed using vinyl siding directly attached to 11 mm OSB sheathing, glass fibre insulation in the cavity and a single 13 mm layer of directly attached gypsum board as the interior surface.

Figure 13 compares three walls with 406 mm stud spacing. Although the standard 89 mm and 140 mm wood constructions lead to quite similar results, the staggered stud wall is clearly superior. The transmission loss at 125 Hz is particularly improved and the overall performance of the staggered stud wall is superior to the other two walls. The OITC rating of the staggered stud wall is 33 while the other two walls have almost the same OITC ratings (24 and 25).

Figure 14 also indicates the superiority of the staggered stud construction. However, for these walls with a larger stud spacing (610 mm) the improvements are not as large. The overall OITC rating of the staggered stud wall is 33 compared to the 31 for the 140 mm stud wall system and 27 for the 89 mm stud wall. The improvements in going to staggered studs are less because the



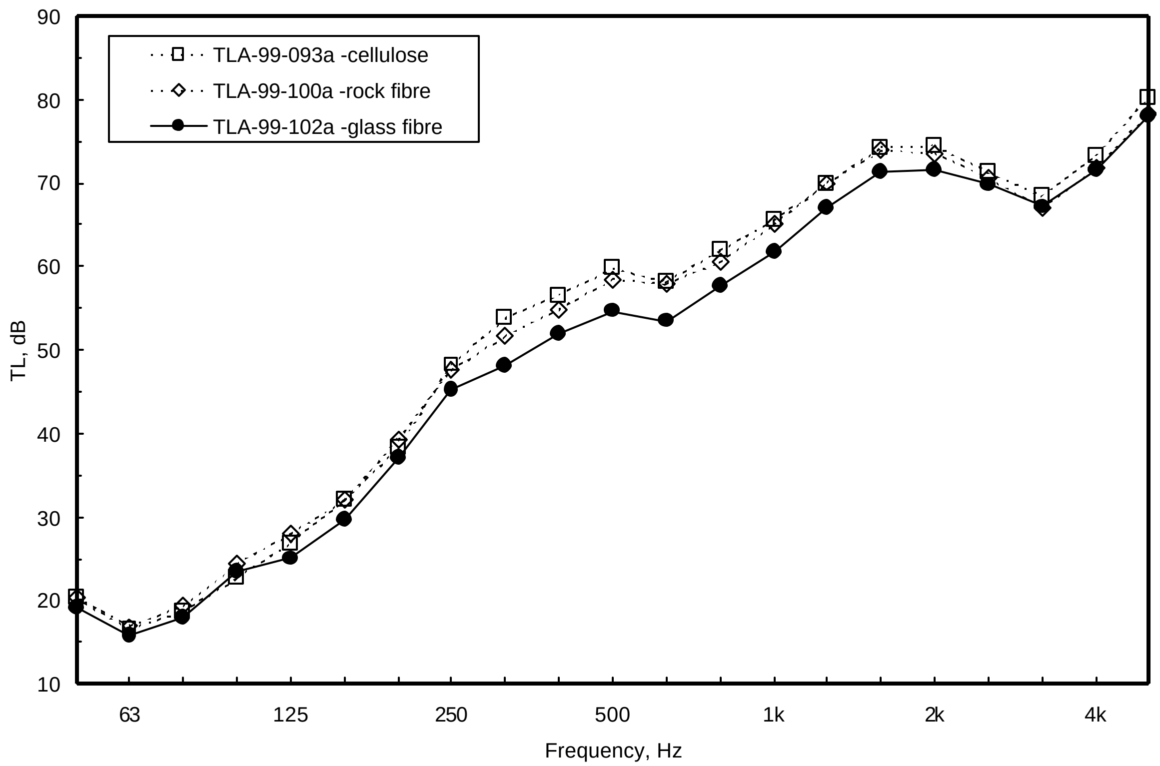
Test ID	Description	OITC
TLA-00-025a	VIN1_OSB11_WS89(610)_GFB89_G13	27
TLA-99-121a	VIN1_OSB11_WS140(610)_GFB152_G13	31
TLA-00-029a	VIN1_OSB11_SWS140(610)_2GFB65_G13	33

Figure 14. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with a 610 mm stud spacing. All three walls had vinyl siding mounted on 11 mm OSB sheathing with glass fibre in the cavity and a single 13 mm layer of gypsum board as the interior surface.

structural resonance that is eliminated is replaced by a mass-air-mass resonance at about the same frequency.

3.5 Varied internal insulation.

The effect on measured sound transmission loss of three different types of thermal insulation in the wall cavity were evaluated. It was assumed that thermal and practical requirements for the insulation would normally require the cavity to be completely filled and so only completely filled wall cavities were tested. All of the walls in this study included a thin 0.2 mm polyethylene vapour barrier under the gypsum board to correctly reproduce typical field conditions. Figure 15 compares the measured sound transmission loss values for three different types of cavity insulation. These were glass fibre, rock fibre and dry blown-in cellulose fibre. These were tested in walls that included resilient channels because these were thought most likely to show



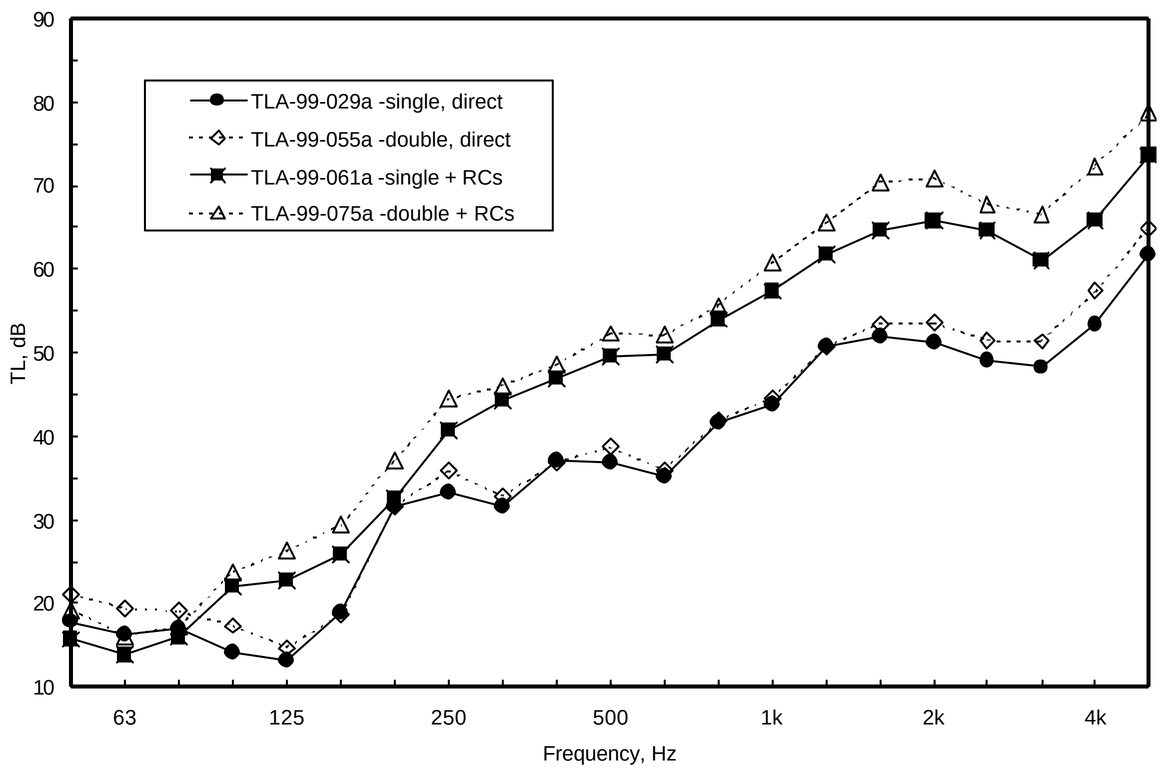
Test ID	Description	OITC
TLA-99-093a	VIN1_OSB11_WS140(406)_CFL140_RC13(610)_2G13	35
TLA-99-100a	VIN1_OSB11_WS140(406)_RFB140_RC13(610)_2G13	36
TLA-99-102a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34

Figure 15. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with a 3 types of cavity insulation. All three walls had vinyl siding directly attached to 11 mm OSB on 140 mm wood studs spaced at 406 mm and with a single 13 mm layer of gypsum board attached via resilient channels as the interior surface.

the expected small effects of different types of cavity insulation. Thus the walls were constructed of vinyl siding directly attached to 11 mm OSB sheathing attached to 140 mm wood studs and with a single layer of gypsum board attached via resilient channels. The results in Figure 15 indicate some small differences for different cavity insulation. The glass fibre material used in these tests led to slightly lower sound transmission loss at most frequencies and this wall had a lower OITC rating. The glass fibre material was also of lower density (9.7 kg/m^3) than either the rock fibre (40 kg/m^3) or the cellulose fibre (57 kg.m^3).

3.6 Effect of resilient channels and interior surface layers.

Increasing the number of layers of gypsum board increases the mass of the interior wall surface and will generally increase the sound transmission loss of the wall. Attaching the gypsum board



Test ID	Description	OITC
TLA-99-029a	VIN1_OSB11_WS140(406)_GFB152_G13	25
TLA-99-055a	VIN1_OSB11_WS140(406)_GFB152_2G13	27
TLA-99-061a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_G13	32
TLA-99-075a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34

Figure 16. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed with combinations of one or two layers of 13 mm gypsum board with and without resilient channels. All four walls had vinyl siding directly attached to 11 mm OSB on 140 mm wood studs spaced at 406 mm and with glass fibre insulation in the cavity.

using resilient channels creates a vibration break between the interior and exterior surfaces of the wall and will substantially increase the sound transmission loss of the wall. Walls were tested with both one and two layers of gypsum board with and without resilient channels. In all four cases the wall was constructed with vinyl siding directly mounted on 11 mm OSB sheathing on 140 mm wood studs spaced at 406 mm and with glass fibre insulation in the cavity. The resulting sound transmission loss values are compared in Figure 16.

The two walls with resilient channels are clearly much superior to the two walls without resilient channels. The walls with resilient channels have OITC ratings of 32 and 34 compared to the 25 and 27 of the two walls without resilient channels. Adding resilient channels leads to increased sound transmission loss values at the critical 125 Hz dip as well as at all higher frequencies. The 125 Hz improvement was explained earlier (Section 3.4). Adding resilient channels eliminates the primary structural resonance [15] but adds a much lower frequency mass-air-mass resonance. The addition of a second layer has a smaller but important effect. This is most marked for the case including resilient channels. This is partly because without resilient channels there may be a significant transmission of energy through the rigid connection to the wood studs which can limit the potential benefits of the added mass.

Resilient channels provide a spring-like connection between the gypsum board and the rest of the wall system. There are different designs of resilient channels that might effect their ability to function as a resilient connection. Three different designs of resilient channels were tested on the same wall construction. The three designs are illustrated in Figure 17. The GP and BM channels had different hole patterns and seemed to feel a little different when flexed. The GP Special channels were the same cross section as the regular GP channels but were specially constructed without holes or extra bends. It was expected that these Special channels might be

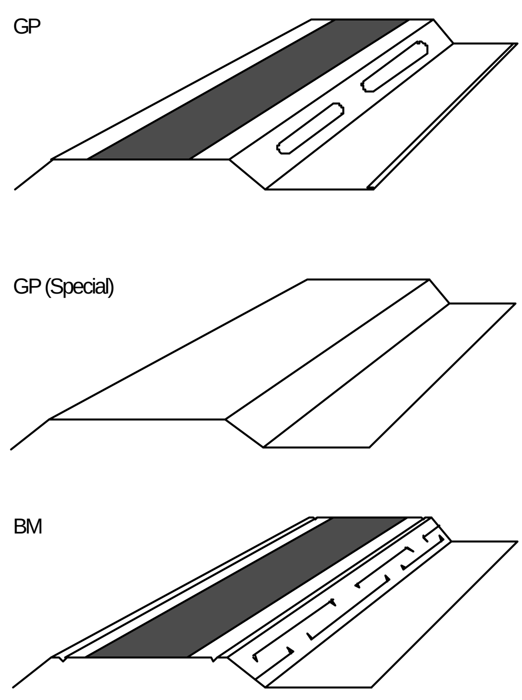
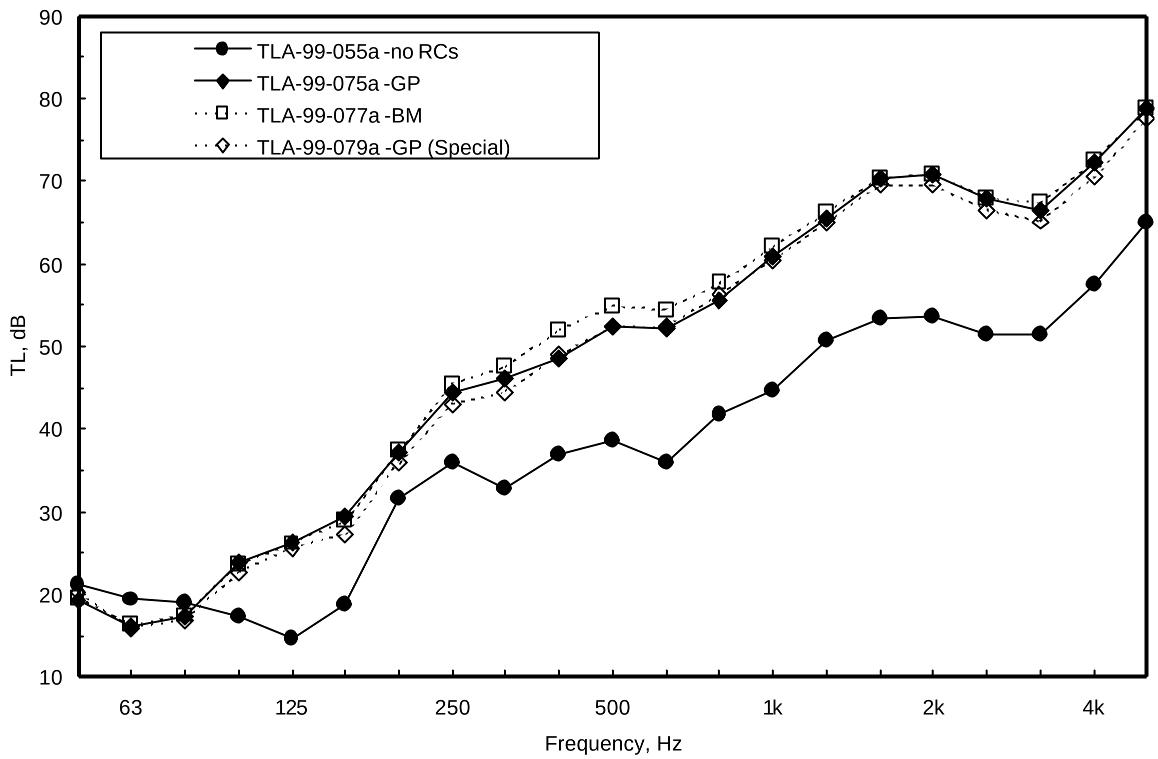


Figure 17. Sketch of the three types of resilient channels.

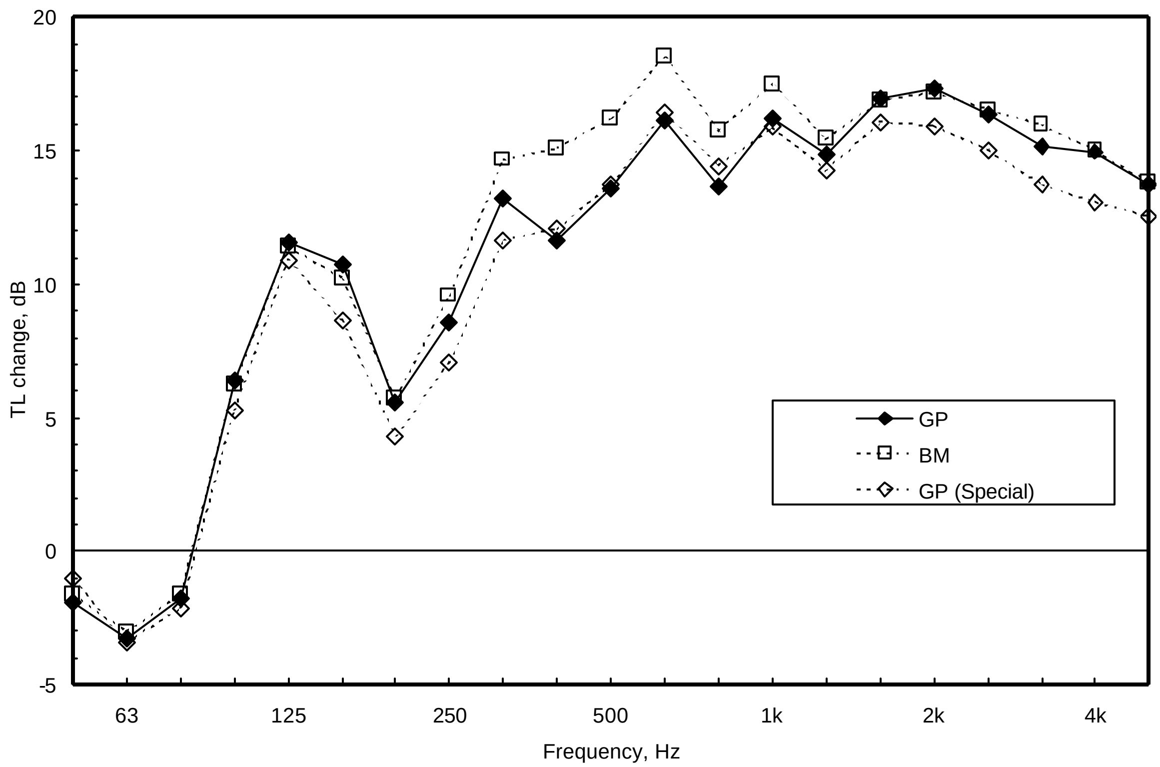
inferior and demonstrate the importance of various holes and extra bends in the design of the resilient channels. The measured sound transmission loss values for walls constructed with these three types of channels are compared to a similar wall without resilient channels in Figure 18. The walls with channels are clearly much superior but the differences among the three types of channels are very small. All walls consisted of vinyl siding directly attached to 140 mm wood studs spaced at 406 mm and with two layers of 13 mm gypsum board attached using the resilient channels.

To better examine the differences among the results for the three types of channels, the results are re-plotted in Figure 19 as the differences in sound transmission loss relative to the case without channels. Figure 19 shows that at many frequencies adding resilient channels leads to improvements of 10 to 15 dB or more. They are particularly helpful at 125 Hz where the



Test ID	Description	OITC
TLA-99-055a	VIN1_OSB11_WS140(406)_GFB152_2G13	27
TLA-99-075a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34
TLA-99-077a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34
TLA-99-079a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	33

Figure 18. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for walls constructed using three types of resilient channels with a wall constructed without resilient channels. All four walls had vinyl siding directly attached to 11 mm OSB on 140 mm wood studs spaced at 406 mm, with glass fibre insulation in the cavity and with two layers of gypsum board.



Test IDs	Description
TLA-99-075a - TLA-99-055a	GP
TLA-99-077a - TLA-99-055a	BM
TLA-99-079a - TLA-99-055a	GP (Special)

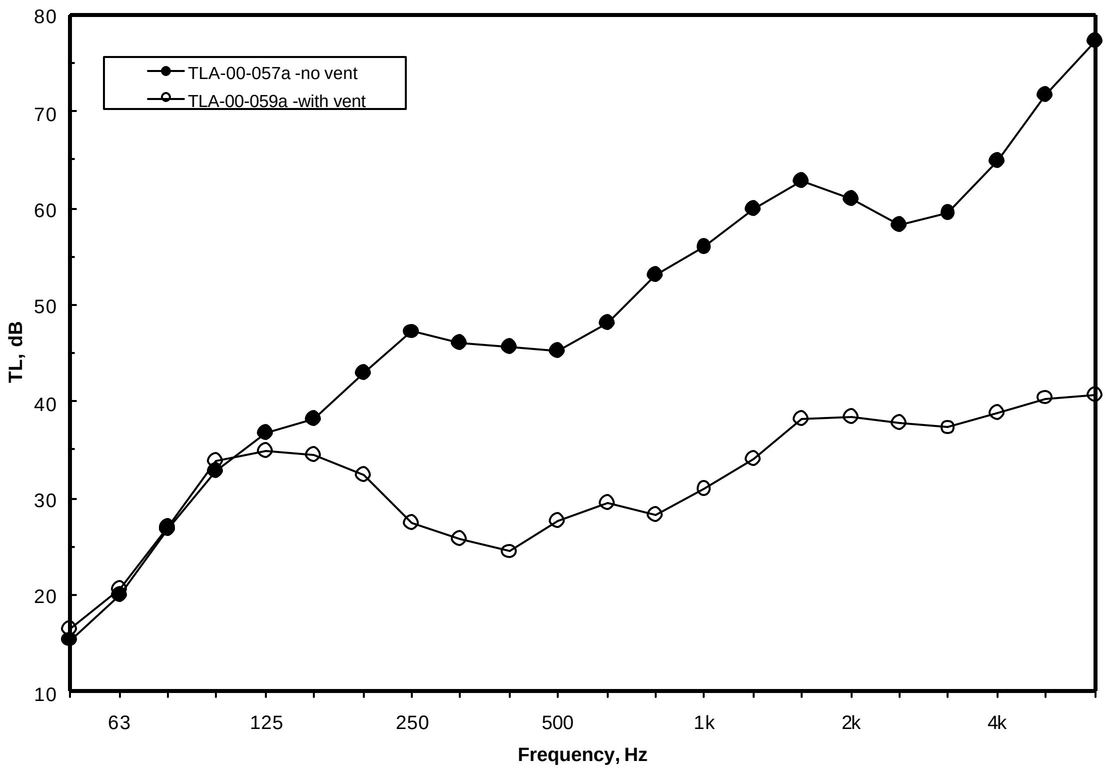
Figure 19. Incremental effect of three types of resilient channels relative to a similar wall without resilient channels.

performance of walls without channels and with a 406 mm stud spacing is usually most limited. At extremely low frequency (63 Hz) there is actually a small degradation in the transmission loss when channels are added. For the walls with resilient channels, the mass-air-mass resonance of the wall occurs in this band and leads to increased sound transmission in the band.

3.7 Vents.

The effect of a typical domestic exhaust fan was tested to determine its effect on the sound insulation of an exterior wall. The unit was a range hood type fan that would normally be located over a stove. The fan exhausted directly through the wall. That is there was no extra duct work. There were two spring-loaded flaps intended to stop air flow back into the house and that would also act to minimise the transmission of sound through the duct. The effect of the added kitchen exhaust fan was tested in a superior wall consisting of a staggered stud construction that without the vent had an OITC rating of 43. Adding the kitchen exhaust fan decreased the OITC rating to 30. Figure 20 shows that the sound transmission loss at the lowest frequencies was not affected, but at most frequencies the addition of the exhaust fan significantly reduced the effective sound insulation.

This test demonstrates that superior sound insulation cannot be achieved for walls with this type of vent. It would be necessary to add additional duct work with sound absorbing linings or a duct silencer to minimize sound propagation through the exhaust vent.

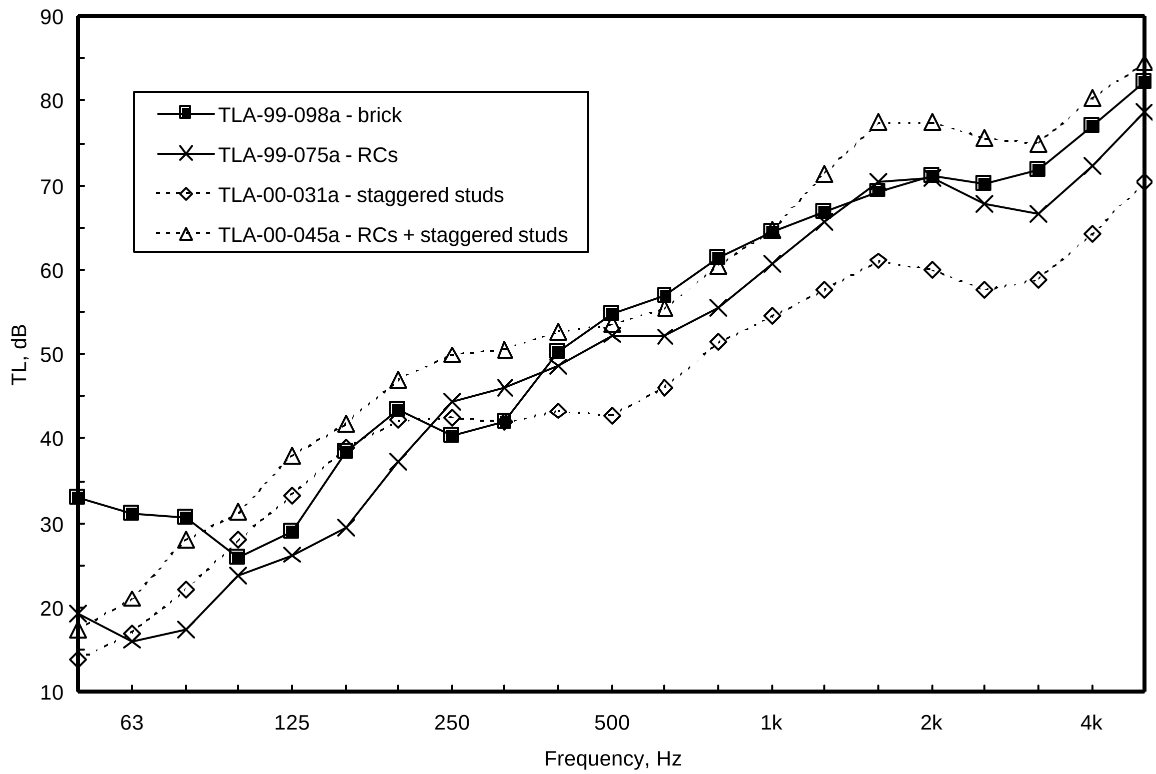


Test ID	Description	OITC
TLA-00-057a	VIN1_2OSB11_WS140(406)_2GFB65 _2G13	43
TLA-00-059a	VIN1_2OSB11_WS140(406)_2GFB65 _2G13 + Kitchen exhaust vent	30

Figure 20. Effect of kitchen exhaust fan mounted in a superior wall.

3.8 Superior wall constructions

This subsection compares the performance of several walls that are among the highest overall sound insulation ratings obtained in this study. Brick walls are often thought of as a performance standard desirable in other walls. Figure 21 compares the measured sound transmission loss of three other walls with a wall having exterior brick cladding. The brick wall result (repeated from Figure 6) has an OITC rating of 40. A wall consisting of two layers of gypsum board attached to the base wall via resilient channels and with vinyl siding had an OITC rating of 34. However, the staggered stud wall with single layers of OSB and gypsum board had an OITC rating of 39 and with double layers of both OSB and gypsum board the wall had an OITC rating of 43. Thus it is possible to build walls of comparable or even superior performance to a brick wall.

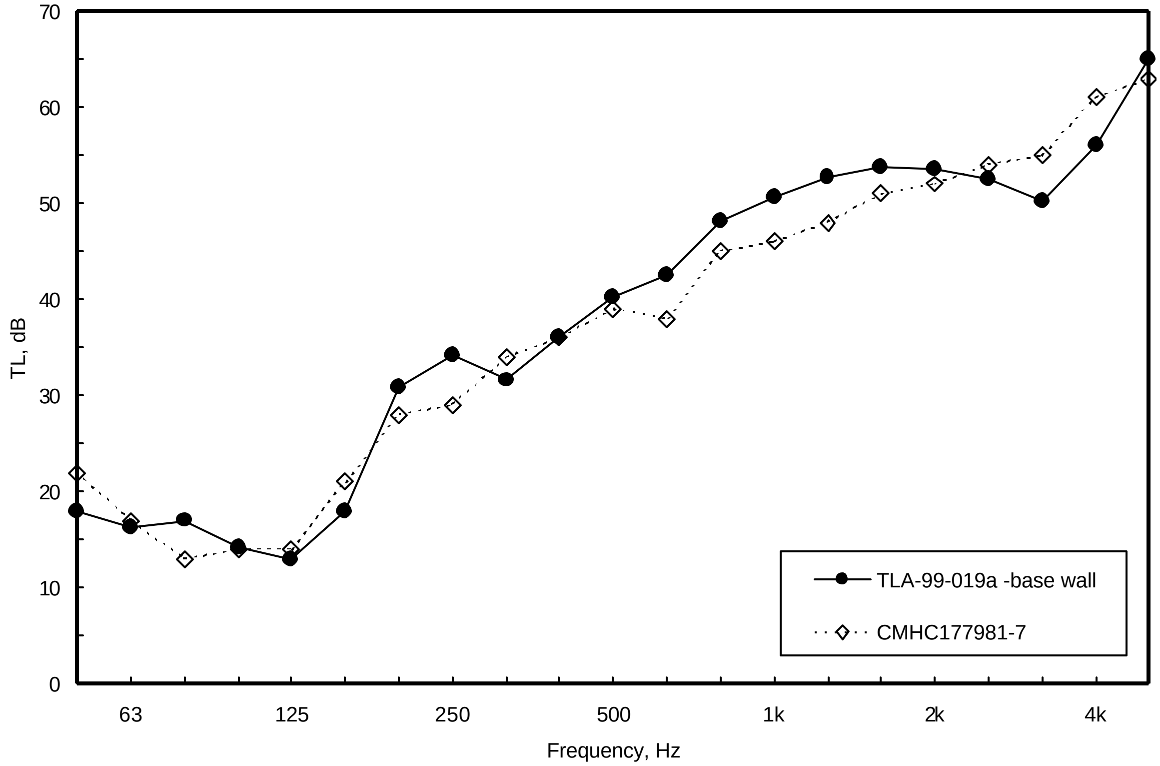


Test ID	Description	OITC
TLA-99-098a	G13_WS140(406)_GFB152_OSB11_AIR16_BRI89	40
TLA-99-075a	VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13	34
TLA-00-031a	VIN1_OSB11_SWS140(610)_2GFB65_2G13	39
TLA-00-045a	VIN1_2OSB11_SWS140(610)_2GFB65_RC13(610)_2G13	44

Figure 21. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for four different wall constructions having superior sound transmission loss.

3.9 Comparisons with other studies.

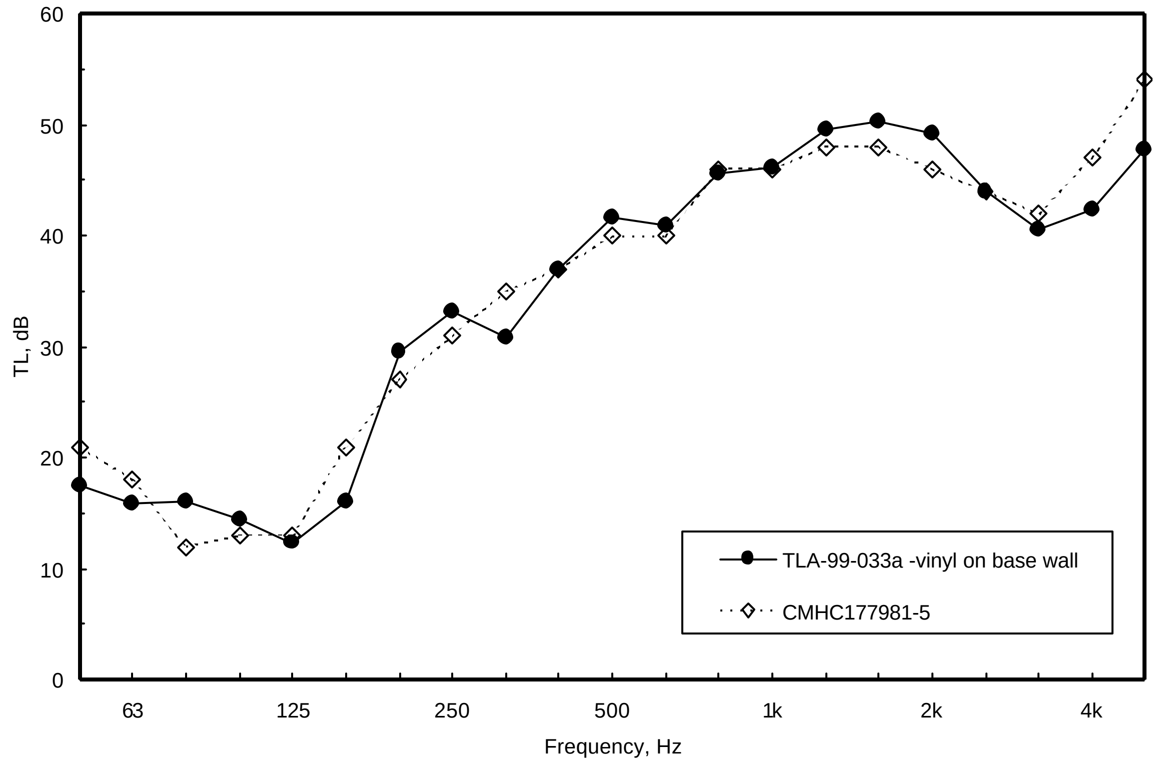
One recent Canadian study tested the sound transmission loss of several wood frame exterior wall constructions [9]. One of these was the same construction as the base wall used in the current study. Figure 22 compares measured sound transmission loss values from both studies for the base wall consisting of 11 mm OSB on 140 mm wood studs spaced at 406 mm with glass fibre in the cavity and 13 gypsum board as the interior surface. Although there are a few larger differences at very low and very high frequencies, the RMS (root mean squared) difference between the two test results is only 2.9 dB and the average difference is 0.4 dB. Some larger differences are to be expected because this comparison includes different construction techniques, materials and different laboratories with possibly small differences in test procedures.



Test ID	Description	OITC
TLA-99-019a	VIN1_WFUR19(406)_OSB11_WS140(406)_GFB152_G13	25
CMHC177981-7	VIN1_WF25_OSB11_WS140(400)_GFB140_G13	25

Figure 22. Comparison with results from measured sound transmission loss values versus 1/3 octave band frequency from the CHMC study [9] for the base wall construction.

The two studies also both tested one complete wall of the same nominal construction. Figure 23 compares the results for the two tests of these walls that consisted of vinyl siding attached on 19 mm wood furring to 11 mm OSB on 140 mm wood studs spaced at 406 mm with glass fibre insulation in the cavity and a single 13 mm layer of gypsum board as the interior surface. This comparison again shows that the two studies produced quite similar results and the overall RMS difference was only 3.3 dB with an average difference of 0.0 dB.



Test ID	Description	OITC
TLA-99-033a	OSB11_WS140(406)_GFB152_G13	25
CMHC177981-5	OSB11_WS140(400)_GFB140_G13	25

Figure 23. Comparison of measured sound transmission loss values versus 1/3 octave band frequency with results from the CHMC study [9] for the base wall construction with vinyl siding attached via 19 mm wood strapping.

4. Windows

Windows are usually a critical weak component of the sound insulation of the building façade. Typically windows have lower sound transmission loss than walls and other major façade components. However, extensive work to develop windows with improved sound insulation was beyond the scope of this project. The window sound insulation tests were intended to answer a few specific questions and to provide data for windows typically used in modern Canadian buildings.

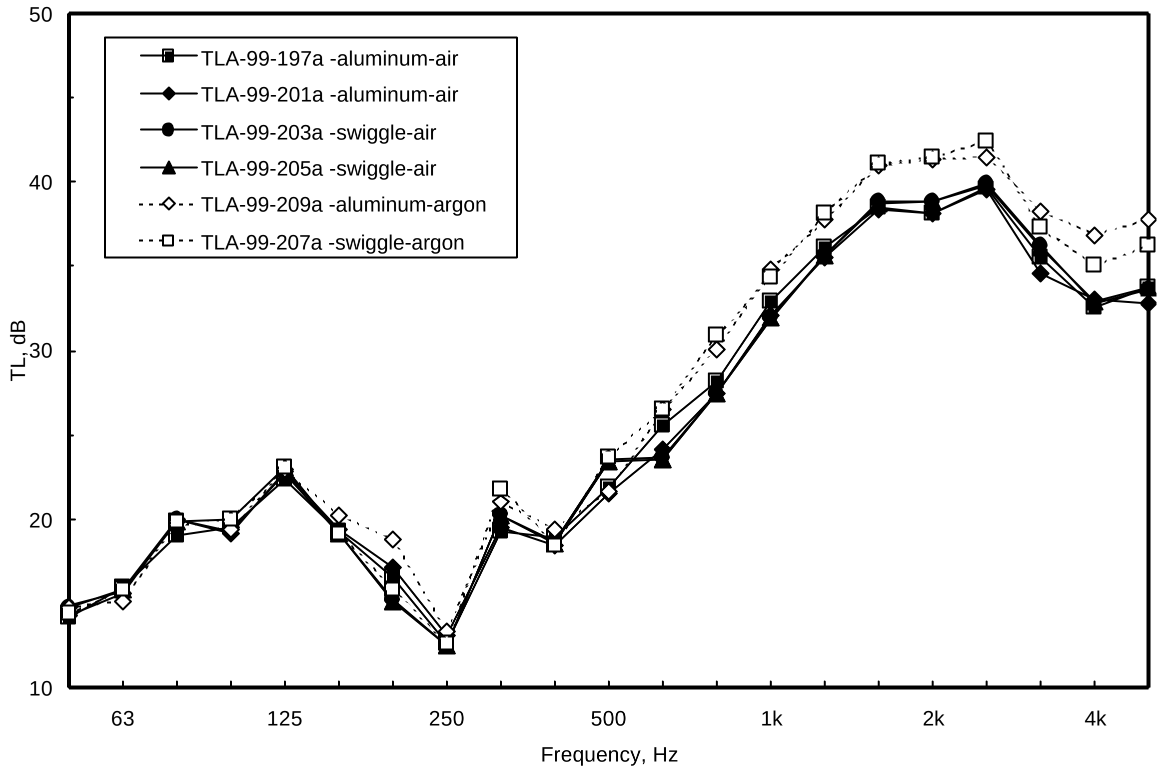
Previous research work [10] had established the fundamental importance of the thickness of each layer of glass and the depth of the separating air space. However, the results of one recent study [11] suggested that the sound insulation of contemporary manufactured window units were lower than the results of the older research studies. Most of the earlier work was carried out on laboratory constructions rather than on commercially manufactured window units because the purpose of the earlier work was to develop an understanding of the basic principles influencing the sound insulation of windows. Thus in addition to characterising typical modern Canadian windows, the current tests were intended to determine if there are systematic differences according to the materials and construction of the window frames as well as with the details of the seals of operable windows.

Six different operable windows were tested. Each was approximately 1.2 m by 1.2 m in size. Five of the six windows were made by the same manufacturer but included different window types and frame constructions. To better understand the effects of the window frames of each type of window, separate tests of the sound insulation of the double glazing units used in the windows were first carried out. All of the sound transmission loss tests of windows and glazing units were conducted with the units installed in a double wall designed to meet the requirements of ISO 140 [12]. This wall was tested to have sound transmission loss more than 10 dB greater than the transmission loss of the window units in each 1/3 octave frequency band.

4.1 Comparison of double glazing units.

The sound transmission loss of six different double glazing units was measured. Each unit was constructed of two layers of 3 mm thick glass with a 13 mm airspace. The double glazing units were 0.451 m by 1.045 m in size. They consisted of combinations of either aluminum or swiggle spacers and either air or argon filled cavities.

The measured sound transmission loss values of the 6 double glazing units are given in Figure 24. They are all seen to have very similar properties with small differences for different types of gas in the cavity. All of the double glazing units have a pronounced dip at 250 Hz, which is thought to be due to the mass-air-mass resonance for this thickness of glass and contained air space. There was no clear effect of the different types of spacers. The units with argon in the cavity have slightly higher transmission loss values at higher frequencies. The argon gas would be expected to shift the mass-air mass resonance of the glazing units but this is not evident from results in Figure 24. However, these differences do not have a significant effect on the OITC ratings and all of the units have essentially the same rating.



Test ID	Description	OITC
TLA-99-197a	aluminum-air	22
TLA-99-201a	aluminum-air	22
TLA-99-203a	swiggle-air	22
TLA-99-205a	swiggle-air	22
TLA-99-209a	aluminum-argon	23
TLA-99-207a	swiggle-argon	22

Figure 24. Comparison of measured sound transmission loss values versus 1/3 octave band frequency for 6 double glazing units.

4.2 Varied window type.

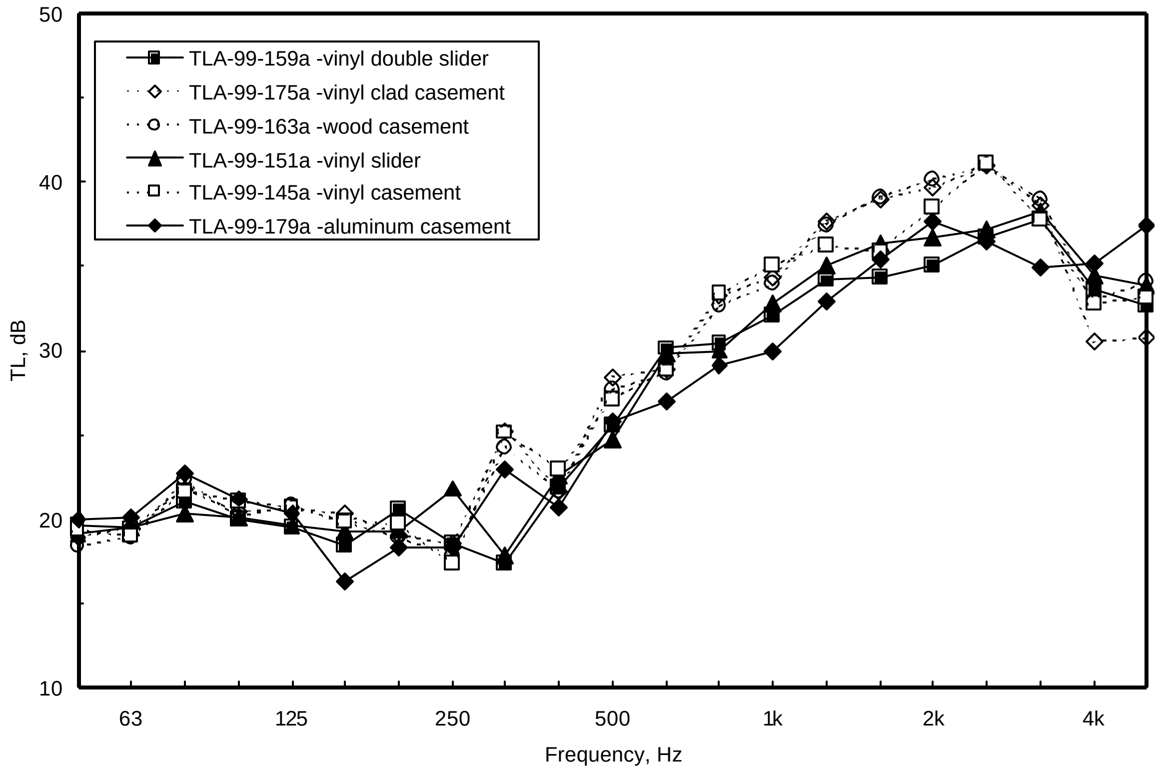
The six window units were installed in the ISO filler wall and were each tested twice. The first test evaluated the normally closed condition of the operable window and the second condition evaluated the window with any possible air leaks sealed with tape. The six windows are described in Table 2 below and all contained double glazing units with two layers of 3 mm glass separated by a 13 mm air space. All of the windows, except the aluminum casement window, were made by the same manufacturer as the six double glazing units described in the section above.

The measured sound transmission loss values of the 6 windows are given in Figures 25 and 26 and the OITC ratings for all cases are compared in Table 1. Figure 25 shows the results with all seals taped and Figure 26 shows the results for the normally closed (and not taped) condition of the windows. There are more variations among the results in Figure 26 because of the additional effects of less than perfect window seals. The results for the 6 different windows in Figure 25 are quite similar and have OITC ratings of from 24 to 26. The range in OITC values is inflated slightly due to rounding off of the OITC values to the nearest integer. The windows are actually all close to an OITC of 25 except for two that are slightly inferior (the vinyl double slider and the aluminum casement windows). The overall OITC ratings are all limited by the poor low frequency performance of the windows with this combination of glass and air space.

Type	**Construction**	**Taped**		**Not Taped**	
		Test ID	**OITC**	**Test ID**	**OITC**
Double slider	Vinyl	TLA-99-159a	24	TLA-99-157a	23
Casement	Vinyl clad wood	TLA-99-175a	26	TLA-99-173a	25
Casement	Wood	TLA-99-163a	25	TLA-99-161a	25
Slider	Vinyl	TLA-99-151a	25	TLA-99-149a	25
Casement	Vinyl	TLA-99-145a	25	TLA-99-143a	25
Casement	Aluminum	TLA-99-179a	24	TLA-99-177a	23

Table 1. Summary of the 6 window units that were tested for seals taped or not taped.

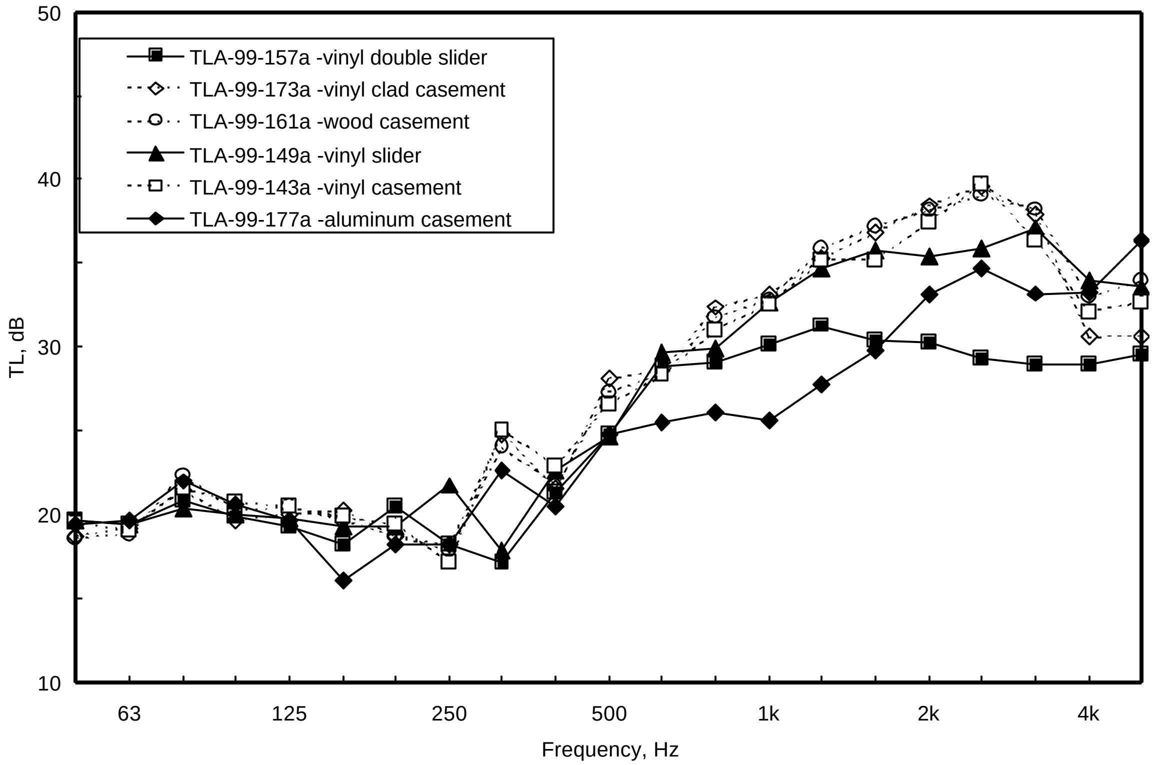
There are some detailed differences among the six results in Figure 25. There is a dip at 250 Hz for 4 of the 6 windows as observed for the double glazing units in Figure 24. However, for the results of the two sliding windows this dip appears to be one band higher at 315 Hz. There are larger differences at higher frequencies. Above 500 Hz the aluminum casement window and the two sliding windows tend to have inferior performance. However, the wood casement window, the vinyl casement window and the vinyl clad wood casement window had quite similar higher frequency performance that was superior to the other windows.



Test ID	Description	OITC
TLA-99-159a	vinyl double slider	24
TLA-99-175a	vinyl clad casement	26
TLA-99-163a	wood casement	25
TLA-99-151a	vinyl slider	25
TLA-99-145a	vinyl casement	25
TLA-99-179a	aluminum casement	24

Figure 25. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for 6 operable windows with all seals taped.

The comparisons shown in Figure 26 indicate that two of the windows seemed to have inferior window seals. Tests of the vinyl double slider showed it to be quite inconsistent. Pushing on the window prior to a test could significantly change the results. The aluminum casement window also had obviously decreased performance when the seals were not taped. In spite of their considerably degraded higher frequency performance the overall OITC ratings only decreased by 1 OITC point. Thus, window seals can degrade the overall performance, but even the windows with better seals are poor barriers to aircraft noise because the combination of glass and air space does not allow for improved low frequency sound insulation.



Test ID	Description	OITC
TLA-99-157a	vinyl double slider	23
TLA-99-173a	vinyl clad casement	25
TLA-99-161a	wood casement	25
TLA-99-149a	vinyl slider	25
TLA-99-143a	vinyl casement	25
TLA-99-177a	aluminum casement	23

Figure 26. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for 6 operable windows with all seals not taped.

4.3 Benefits of storm windows.

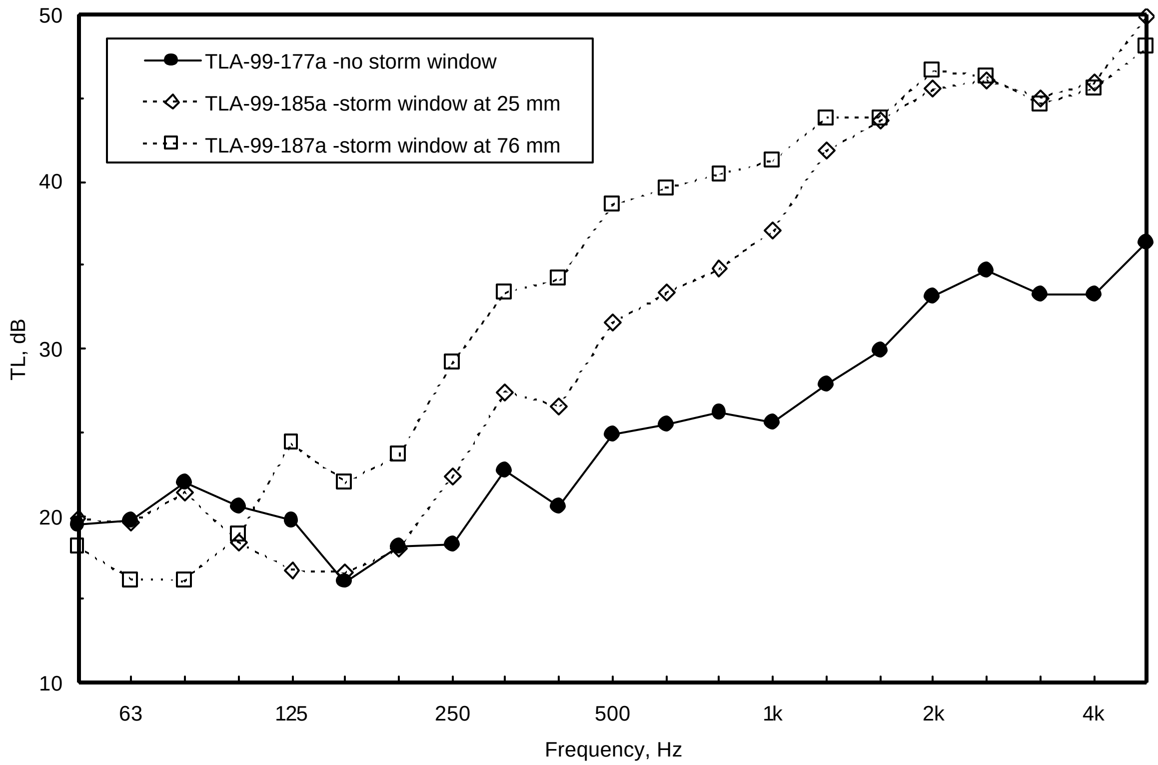
Although improved windows can be designed having thicker layers of glass and larger air spaces between the two layers of glass, this can be an expensive option where otherwise satisfactory windows already exist. The incremental effect of adding a conventional aluminum storm widow was tested to evaluate this less expensive renovation technique for improved sound insulation. The aluminum storm window unit was added to three of the windows. In each case there was no attempt to tape any of the window seals.

Table 2 below gives the resulting OITC ratings for the windows with and without an additional storm window. In most cases the storm window unit was simply added to the outside of the window frame creating a 25 mm air space between the glass of the storm window and that of the main window. For the aluminum casement window the frame was also built out to create a 76 mm air space between the glass of the storm window and that of the main window. The results in Table 2 show that adding the storm window with a 25 mm air space increased the overall OITC rating by 1 to 4 OITC points. Adding the storm window with a 76 mm air space increased the OITC rating of the aluminum casement window from 23 to 30.

Window	Window Not Taped	Window + Storm, 25 mm air space	Window + storm, 76 mm air space
Aluminum casement	23	25	30
Vinyl slider	25	26	
Double slider	23	27	

Table 2. OITC ratings of the windows with and without added storm windows.

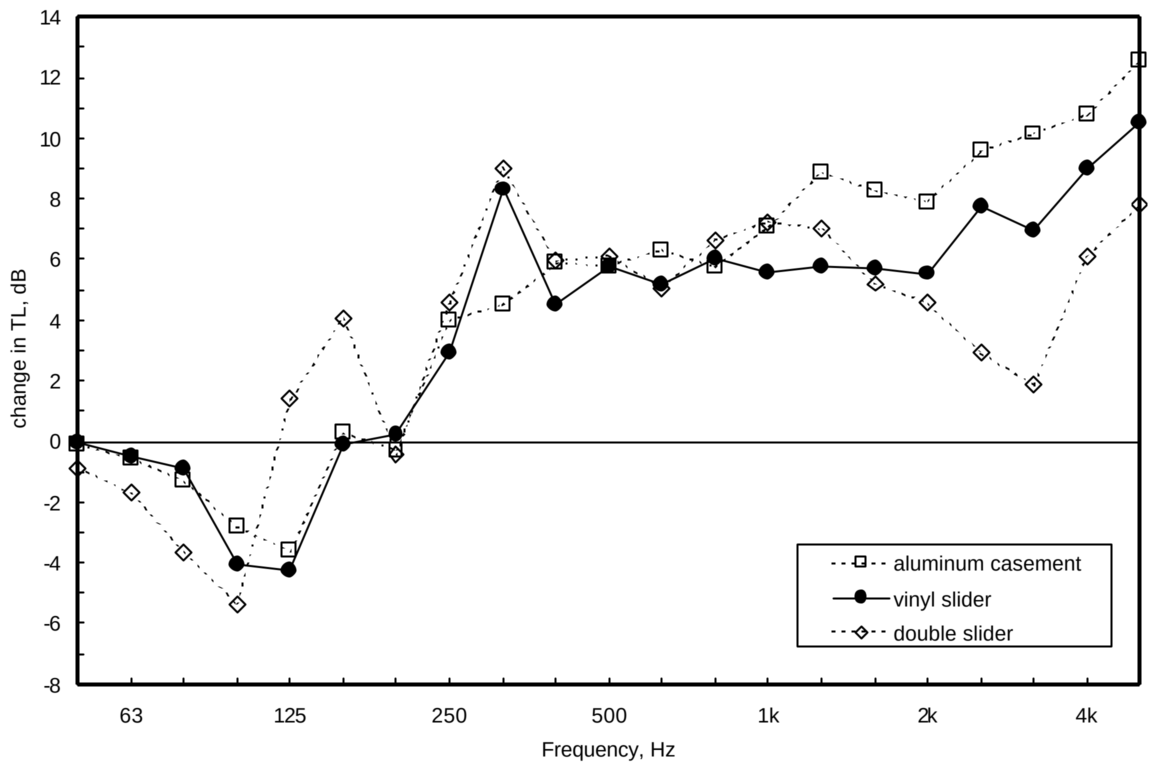
The measured values of sound transmission loss versus frequency for the aluminum casement window with and without an added storm window are given in Figure 27. Adding a storm window with a 25 mm air space leads to a useful improvement in the mid- and high-frequency sound transmission loss. Adding the storm window with a 76 mm air space causes this improvement to extend to lower frequencies. If one calculates the expected mass-air-mass resonance frequency for 13, 25 and 76 mm air spaces, the resonance frequency decreases from approximately 270 to 200 and to 110 Hz with the increasing air space. Clearly an even larger air space would lead to further improvements.



Test ID	Description	OITC
TLA-99-177a	no storm window	23
TLA-99-185a	storm window at 25 mm	25
TLA-99-187a	storm window at 76 mm	30

Figure 27. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for the aluminum casement window with and without an added storm window.

Adding the storm window with only a 25 mm air space leads to small improvements in the overall OITC rating because the low frequency performance of the window is not greatly improved. That is, there is little improvement in the low frequency region where the sound transmission loss of the original window is least satisfactory to begin with. The effect of the storm window with a 25 mm air space is explored further in Figure 28. This figure shows the difference in measured sound transmission loss values when the storm window was added with a 25 mm air space to three different windows. For all three windows the incremental effects are quite similar with modest improvements at higher frequencies and some small negative improvements at lower frequencies. That is at around 125 Hz the added storm window degrades the performance of the original window for this case of a 25 mm air space. Adding a storm window can be an economical technique for improving the overall sound insulation of a window. However, to provide significantly improved sound transmission loss the air space between the original window and the added storm window should be 76 mm or more.



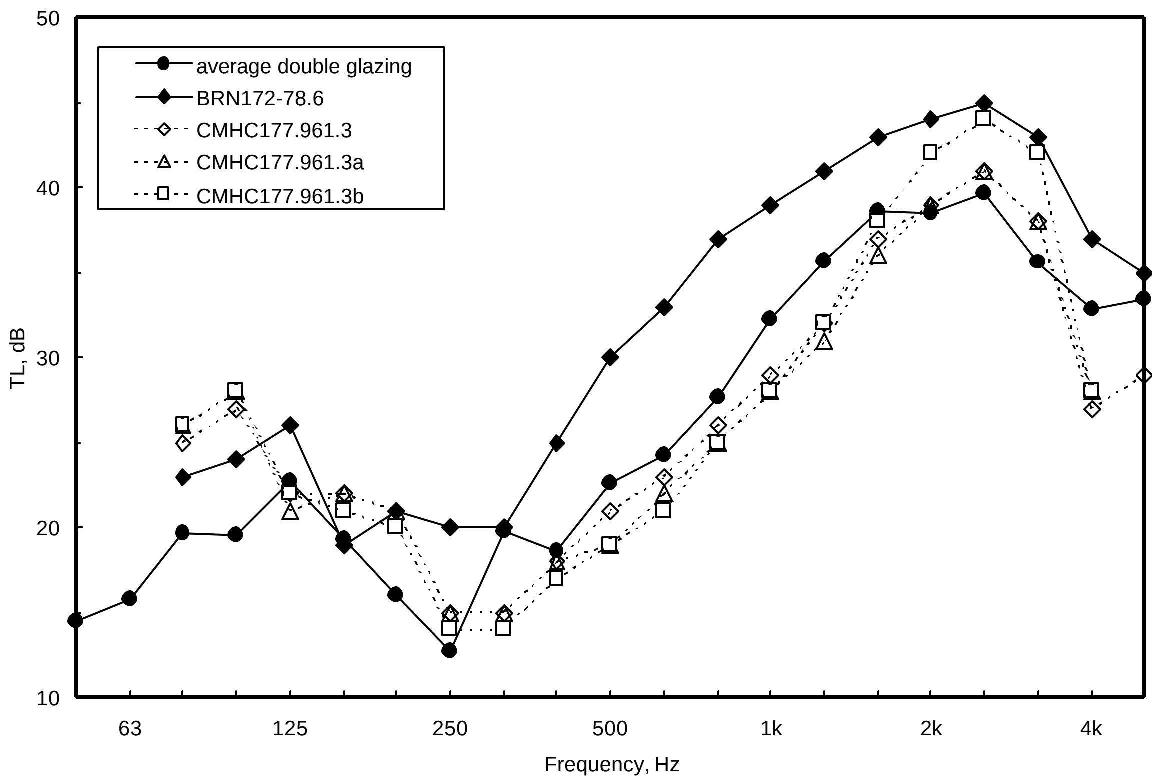
Test IDs	Description
TLA-99-185a – TLA-99-179a	aluminum casement
TLA-99-153a – TLA-99-151a	vinyl slider
TLA-99-165a – TLA-99-159a	double slider

Figure 28. Comparisons of incremental sound transmission loss values versus 1/3 octave band frequency when a conventional aluminum storm window is added with a 25 mm air space.

4.4 Comparisons with other studies.

Several comparisons with previously published measurements of the sound transmission loss of windows have been made. A recent Canadian study [11] included measurements of the sound insulation of both complete windows and several double glazing units. The measurements of one of those windows and three of the double glazing units should be comparable to the present results because they all consisted of two layers of 3 mm glass separated by a 13 mm air space.

Figure 29 compares measured sound transmission loss values of double glazing units. The average of the measurements of the 4 double glazing units with air shown in Figure 24 is compared with three measurements of thermopane units from the CMHC study [11]. The three thermopane units consisted of two layers of 3 mm glass with a 13 mm air space but with various types of spacers. Overall the double glazing units from the two studies produced quite similar results. There are some larger differences at the very low frequencies and around 4 kHz in the coincidence dip region. Also shown on this graph is a result from a large laboratory study of various combinations of glass and air spaces [10]. This test was for a unit consisting of the same double layer of 3 mm glass separated by a 13 mm air space, but produced higher sound transmission loss values at most frequencies above 250 Hz than the factory sealed double glazing units. The sizes of the glass in each study were different. However, the small panes from the present study (0.451 m by 1.045 m) produced quite similar results to the 1.6 by 1.2 m panes from the CMHC study. The earlier NRC result was for glass that was 1.8 by 0.625 m in size. There seems to be no consistent effect of pane size. The double glazing units from the current study and those from the CHMC tests were all factory sealed double glazing where the glass is glued to the spacers to form a strong air tight connection. The unit in

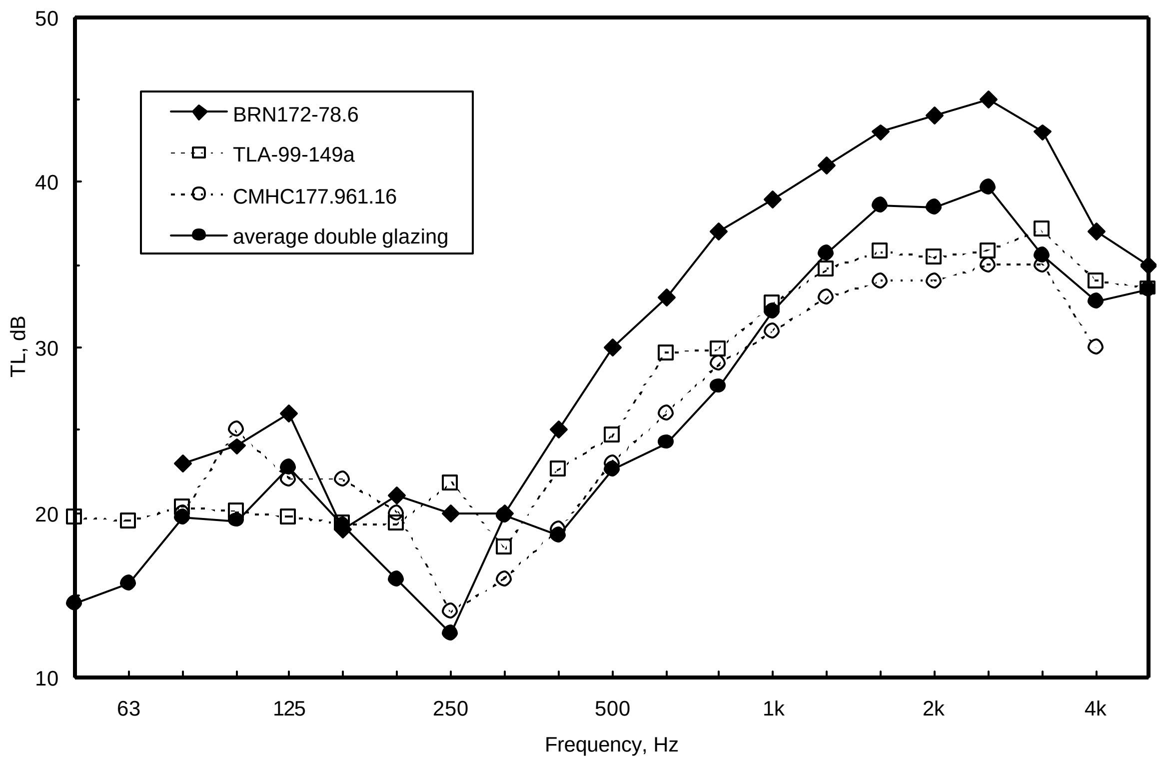


Description	OITC
average of double gazing units (TLA-99-197a, TLA-99-201a, TLA-99-203a, TLA-99-205a)	22
BRN172-78.6	27
CMHC177.961.3	22
CMHC177.961.3a	22
CMHC177.961.3b	21

Figure 29. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for glazing consisting of two layers of 3 mm glass separated by a 13 mm air space.

the earlier NRC study consisted of two layers of glass caulked in place as constructed in the laboratory. It is assumed that the manner in which the two layers of glass were connected led to the differences shown in Figure 29. Previous studies have shown that the manner in which the edge of the glass is constrained can significantly affect the measured sound transmission loss [5,13].

Figure 30 compares tests of complete sliding windows with those for the double glazing units and the results from the earlier NRC study. The results for the vinyl-clad wood-frame sliding window from the CMHC study are very similar to the results from the vinyl-frame sliding window in the current study. The average result of the 4 double glazing units produced slightly higher sound transmission loss around 2 kHz suggesting that leaks or transmission through the window frame may limit the performance of the

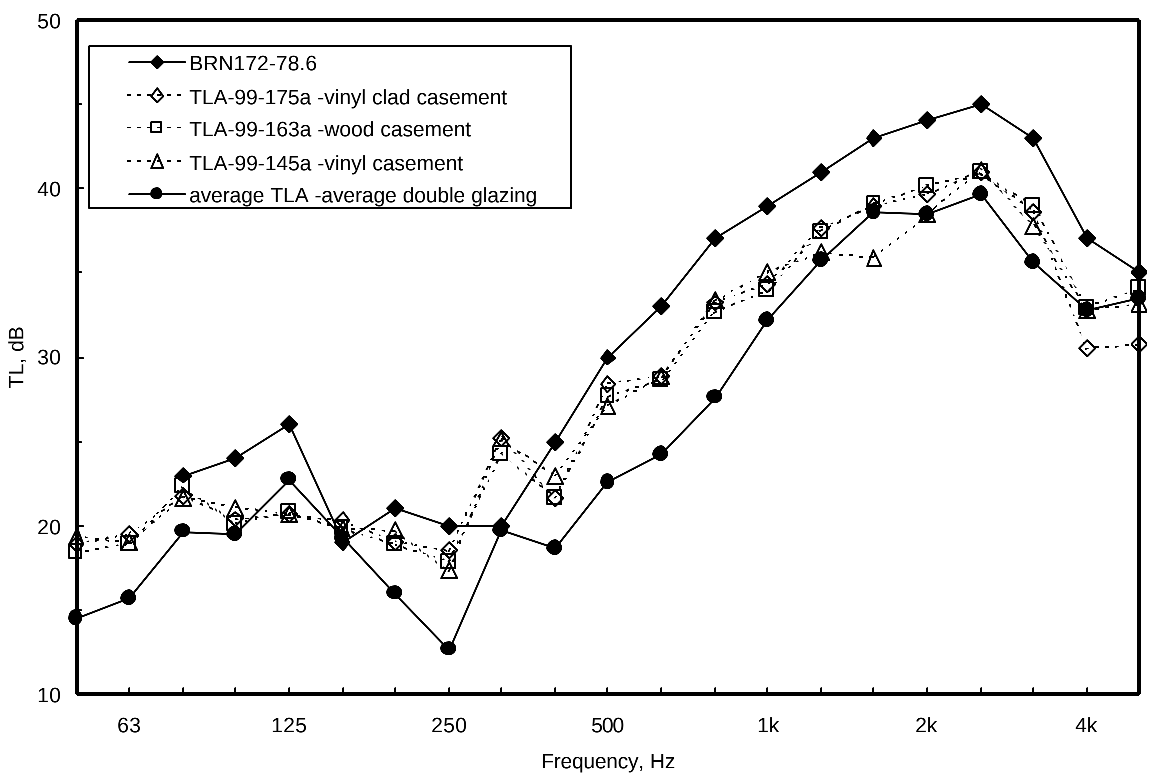


Description	OITC
BRN172-78.6	27
TLA-99-149a	25
CMHC177.961.16	22
average of double glazing units (TLA-99-197a, TLA-99-201a, TLA-99-203a, TLA-99-205a)	22

Figure 30. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for two sliding windows with the average of the 4 double glazing units and with the earlier NRC results.

sliding windows. Comparison of the results in Figures 25 and 26 suggests that air leaks limit the performance of these windows. Figure 30 also shows that the earlier NRC result for the same glass thickness and air space produced considerably higher sound transmission loss values in the mid- to high-frequency region.

Figure 31 compares the measured sound transmission loss of three casement windows from the current study with the same average of the 4 double glazing units and also with the earlier NRC results. The three casement windows (vinyl-frame, wood-frame, and vinyl-clad wood-frame) produced very similar sound transmission loss values. The average of the 4 double glazing units tended to produce slightly lower sound insulation at many frequencies and exhibited a pronounced dip at 250 Hz that was assumed to be the mass-air-mass resonance of these units. However, the sound transmission loss values from the earlier NRC study [10] were greater at all frequencies above 400 Hz.



Test ID	Description	OITC
BRN172-78.6		27
TLA-99-175a	vinyl clad casement	26
TLA-99-163a	wood casement	25
TLA-99-145a	vinyl casement	25
average double glazing unit (TLA-99-197a, TLA-99-201a, TLA-99-203a, TLA-99-205a)	double glazing units	22

Figure 31. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for three casement windows with the average of the 4 double glazing units and with the earlier NRC results.

The comparisons of Figures 30 indicate that the current tests agree well with other tests of modern Canadian windows. The results of Figure 31 show that the better casement windows can have higher sound transmission loss than the double glazing units from which they are constructed. The frames constituted up to 25% of the area of the complete windows. If the frame had higher transmission loss than the glazing units at mid-frequencies some increase in transmission loss would be expected. However this would be much smaller than indicated at mid-frequencies in Figure 31. The differences are more likely due to the different mounting and edge constraints of the glass in the two cases. A recent study [14] has shown, that at frequencies above 1k Hz, more sound energy was transmitted through the window frame than through the glass. This may be another factor contributing to the relatively lower sound transmission loss at higher frequencies (above 1k Hz) of the three better casement windows in Figure 31. On the other hand, even these better casement windows did not produce the high sound transmission loss values obtained in earlier laboratory studies [10]. This may again indicate that changes to the method of mounting the glass in the window frames of the factory built windows could lead to improved sound insulation similar to the results from the earlier laboratory study. These earlier results should not be used to represent modern manufactured Canadian windows. The combination of the influences of the mounting of the glass and of sound transmission through the window frame are significant problems that need to be better understood in order to develop improved sound insulating windows.

5. Roofs

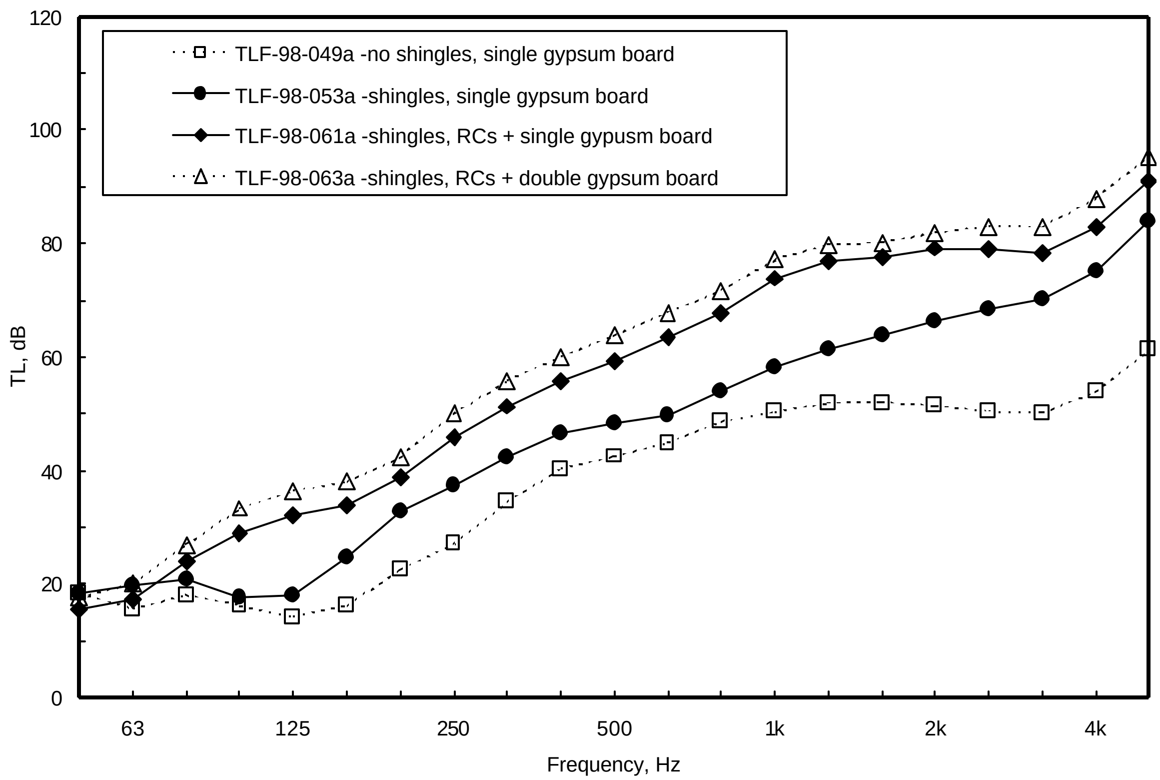
Sound transmission loss measurements were made of variations of 4 different types of roof structures. There were three different types of flat roof constructions: wood-joist, wood-truss and steel deck. The wood-joist and wood-truss constructions are also representative of a domestic ‘cathedral ceiling’ type construction where the interior and exterior surfaces are parallel. Several sloping roof constructions with an attic space were also tested. These were based on a raised heel wood-truss system that permits the attic insulation to extend to over the exterior wall. Raised heel wood-truss roofs were tested with both shingles on OSB as well as steel sheeting as the outside surface.

Contemporary Canadian roof constructions normally include a vapour barrier immediately behind the interior gypsum board, thermal insulation in the roof cavity and vents between the roof cavity and the outside to minimize moisture build-up in the roof cavity. All of the roofs tested in this study included a thin polyethylene vapour barrier immediately behind the gypsum board. Roofs were tested with various amounts of thermal insulation in the roof cavity. Tests were also conducted with and without various combinations of roof vents to investigate the reduction of the sound transmission loss caused by various combinations of vents and the details of the roof constructions, All of the roof sound transmission loss tests were carried out in the floor sound transmission loss facility.

5.1 Wood-joist flat/cathedral ceiling roofs.

The 235 mm wood-joist roofs could be representative of a simple flat roof or of a domestic ‘cathedral ceiling’ type construction where the outer and inner surfaces are parallel. The outer surface consisted of asphalt shingles over building paper on 11 mm OSB sheathing. The OSB sheathing was attached to the wood-joists via 38 mm wood purlins required by the National Building Code to allow air movement in the roof cavity. The cavity was filled with glass fibre thermal insulation and four different combinations of outer surface layers were tested. An initial test excluded the shingles but included the 11 mm OSB sheathing and a single layer of directly attached 13 mm gypsum board. The complete roof system was tested with one layer of 13 mm gypsum board directly attached and both one and two layers of 13 mm gypsum board attached via resilient channels.

The results of these four tests are given in Figure 32. As expected, the results for the roof without shingles produced the lowest sound transmission loss values. These results are quite similar to those for the base wall construction with the same 406 mm spacing of the joists/studs. For example the results for the base wall construction shown in Figure 7, (TLA-99-033a) with an OITC rating of 25 exhibit very similar sound transmission loss versus frequency characteristics. In both cases there is a minimum at 125 Hz that was shown to be related to the spacing of the wall studs. Adding the asphalt shingles adds considerable additional mass to the outer surface and increases the OITC rating from 26 to 30. When resilient channels are included, much larger increases in the overall sound insulation of the wood-joist roof are obtained. The OITC ratings then increased to 40 and 43 with one and two layers of gypsum board respectively.



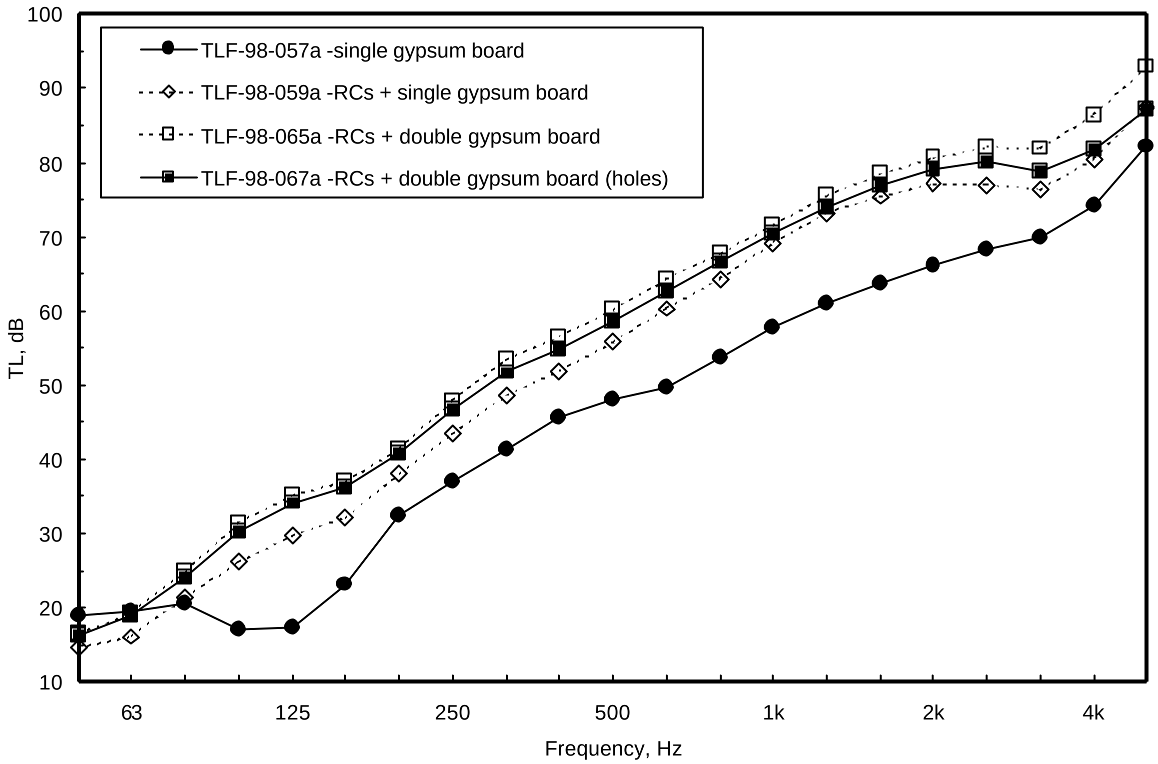
Test ID	Description	OITC
TLF-98-049a	OSB13_WS38(406)_WJ235(406)_GFB203_G13	26
TLF-98-053a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_G13	30
TLF-98-061a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_RC13(610)_G13	40
TLF-98-063a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_RC13(610)_2G13	43

Figure 32. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for 235 mm wood-truss roof systems with varied surface layers.

Several variations of the wood-joist roofs were tested with the addition of roof vents. In most cases 6 conventional plastic roof vents were added. Each was mounted on a hole with an area of 0.053 m^2. The total number of roof vents was approximately double that normally required for adequate ventilation of the roof cavity and so these results represent a worst case scenario. Results in section 5.4 below confirm that smaller effects of adding roof vents occur when a smaller number of vents are used. Figure 33 shows measured sound transmission loss values for different combination of gypsum board and resilient channels for wood-joist roofs including roof vents. The summary results in Table 3 indicate that the overall OITC ratings are decreased by small amounts when roof vents are added. The largest differences occur for the roof system that included a single layer of gypsum board attached using resilient channels.

Layers of gypsum board	Resilient channels	OITC No vents	OITC With vents
1	No	30	29
1	Yes	40	37
2	Yes	43	42

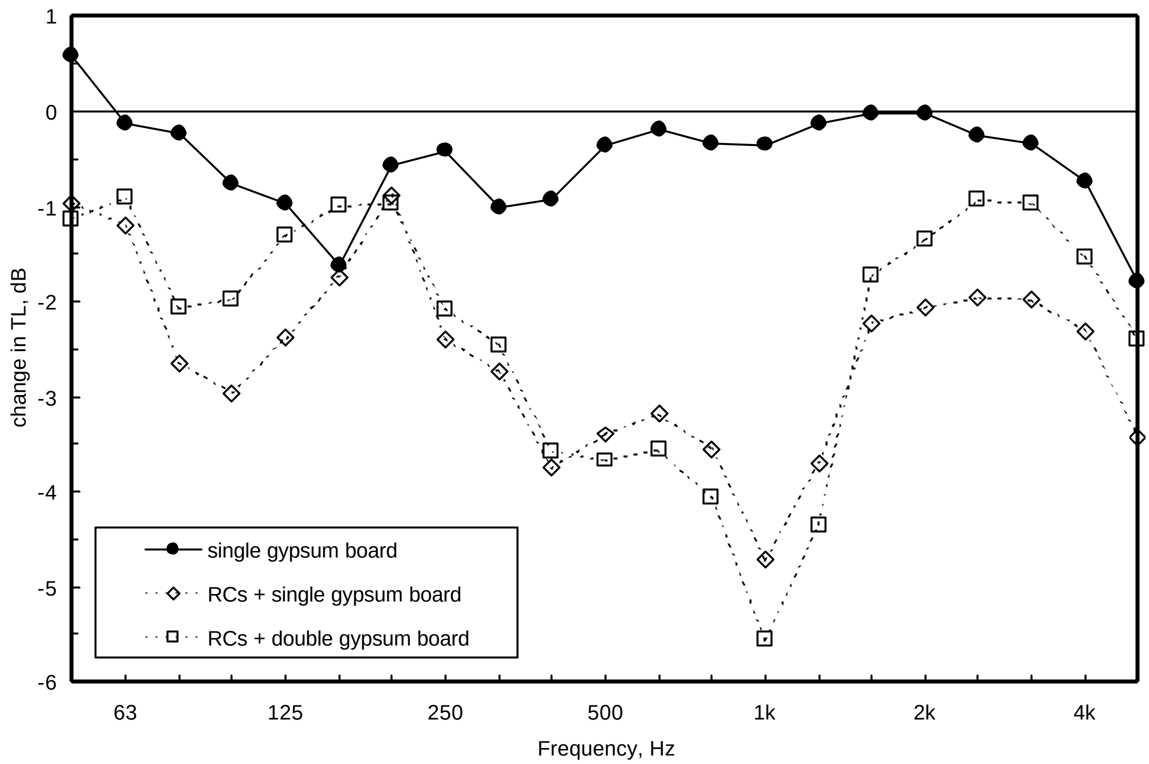
Table 3. OITC ratings for 235 mm wood-joist roofs with and without 6 roof vents.



Test ID	Description	OITC
TLF-98-057a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_G13	29
TLF-98-059a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_RC13(610)_G13	37
TLF-98-065a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_RC13(610)_2G13	42
TLF-98-067a	SHN3_BPAP0.7_OSB13_WS38(406)_WJ235(406)_GFB203_RC13(610)_2G13	41

Figure 33. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for various 235 mm wood-joist roof systems with 6 roof vents.

The effects of adding roof vents to wood-joist roofs are explored in more detail in Figure 34. This graph plots the differences that occurred when roof vents were added as a function of frequency for three different wood-joist roofs. The roof with a single layer of gypsum board directly attached changed the least when the roof vents were added. There is a small dip at 160 Hz but at most other frequencies the changes are less than 1 dB. The roofs with one or two layers of gypsum board attached using resilient channels, changed much more when the roof vents were added. For both of these roofs the changes illustrated in Figure 34 were largest at 1 kHz. However the changes in the low frequency (80 to 160 Hz) region have a greater influence on the OITC rating because the sound transmission loss of the roof is lower at these frequencies.

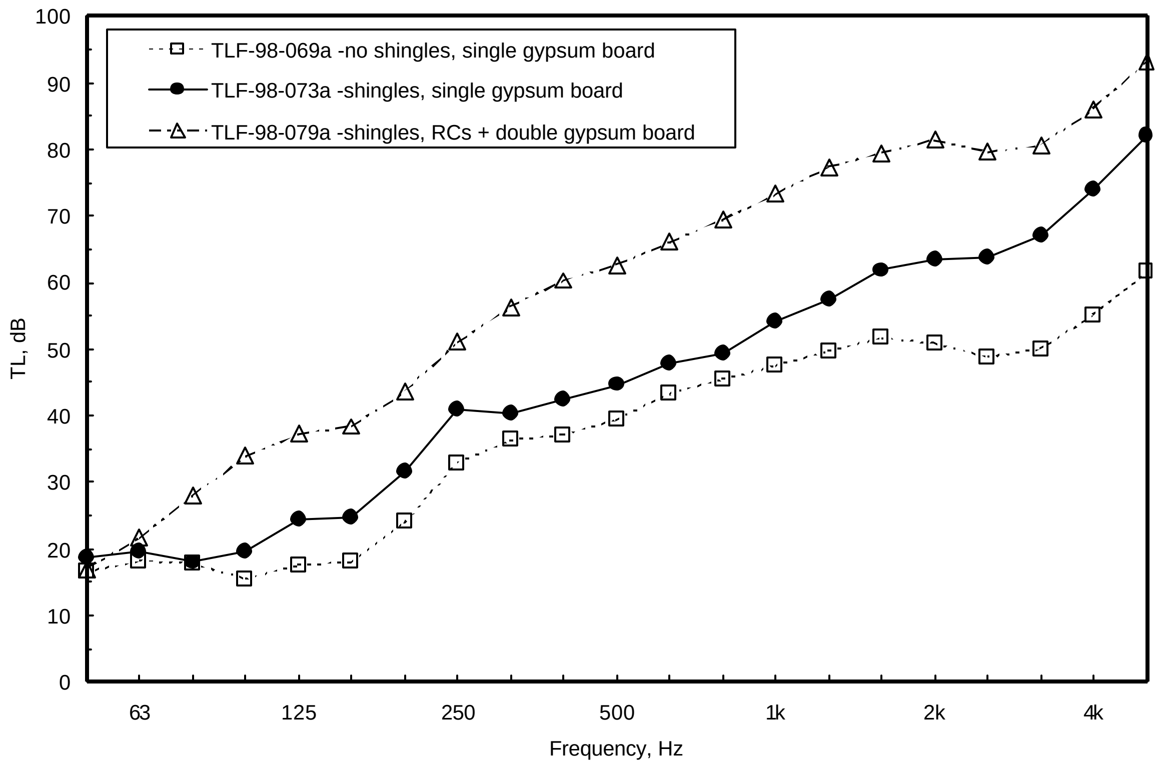


Test IDs	Description
TLF-98-057a – TLF-98-053a	single gypsum board
TLF-98-059a - TLF-98-061a	RCs + single gypsum board
TLF-98-065a - TLF-98-063a	RCs + double gypsum board

Figure 34. Incremental effects of adding roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for 3 wood-joist roofs.

5.2 Wood-truss flat/cathedral ceiling roofs.

The 356 mm wood-truss roof systems could also be representative of either flat roofs or of domestic ‘cathedral ceiling’ type roofs. Figure 35 shows measured sound transmission loss values for tests of 3 roofs constructed with 356 mm wood-trusses. The first test was of a partial construction before the shingles were added. This included a single layer of gypsum board as the interior surface and glass fibre thermal insulation in the cavity. This partial construction had a slightly higher rating (OITC 27) than the partial construction of the wood-joist roof in Figure 32 (OITC 26). The other two results in Figure 35 correspond to complete wood-truss roof constructions with one layer of 13 mm gypsum board directly attached and two layers attached via resilient channels. Both included 264 mm of glass fibre thermal insulation. Comparison of these results with the corresponding wood-joist roof results in Figure 32 again shows small increases in the overall sound insulation rating. (OITC ratings increased by 1 or 2 points). When the wood-joist and wood-truss results are compared in detail, it is seen that the lower-frequency performance of the wood-truss roofs is better but the mid-frequency performance is slightly inferior.



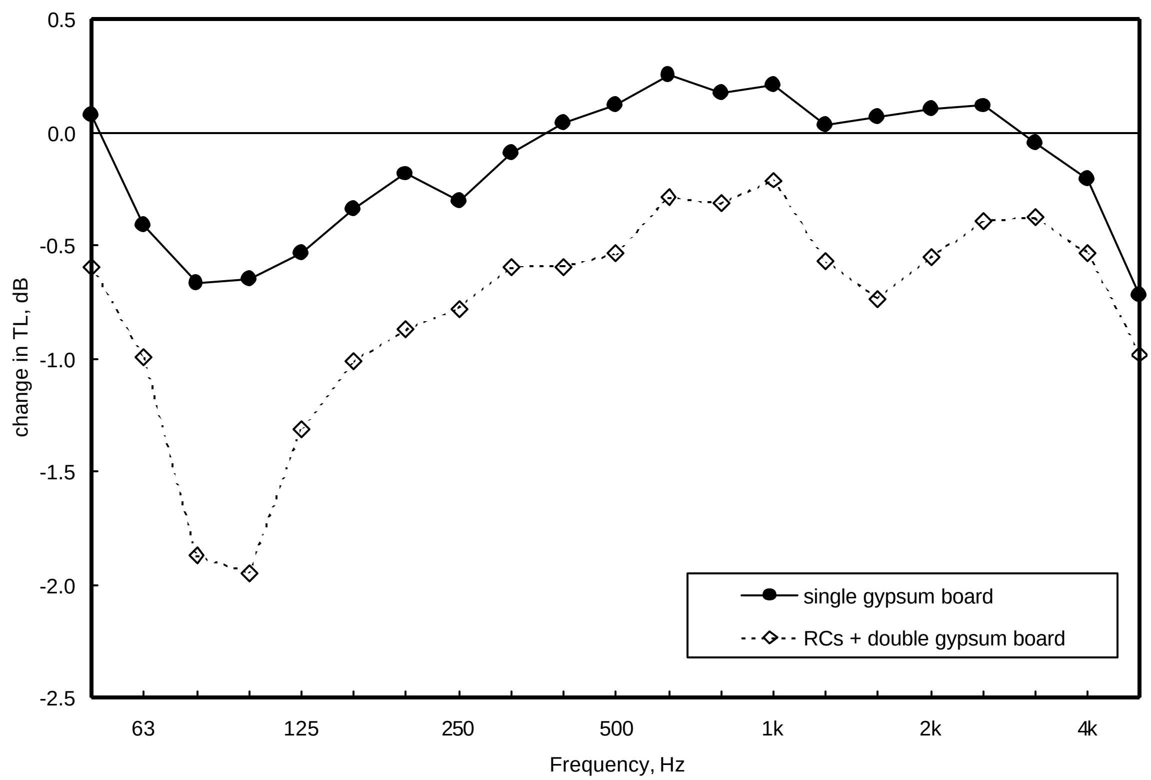
Test ID	Description	OITC
TLF-98-069a	OSB13_WT356(406)_GFB264_G13	27
TLF-98-073a	SHN3_BPAP0.7_OSB13_WT356(406)_GFB264_G13	32
TLF-98-079a	SHN3_BPAP0.7_OSB13_WT356(406)_GFB264_RC13(610)_2G13	44

Figure 35. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for various 356 mm wood-truss roof systems.

Two wood-truss roofs were tested with the addition of the same 6 roof vents added to the wood-joist roofs in section 5.1 above. Table 4 shows that the addition of the roof vents reduced the OITC ratings by only 1 point. When the roof vents were added, the rating of the wood-truss roof with a single layer of directly attached gypsum board reduced from an OITC of 32 to 31. The rating of the wood-truss roof with a double layer of gypsum board reduced from an OITC of 44 to 43 when the roof vents were added. The differences are plotted as a function of frequency in Figure 36. For both roofs the differences were largest at lower frequencies around 80 and 100 Hz. However, for the roof with a single layer of directly attached gypsum board, the changes were always less than 1 dB. Thus for the wood-truss roof system, adding vents only has a small effect and mostly at low frequencies.

Shingles	Layers of gypsum board	Resilient channels	OITC No vents	OITC With vents
No	1	No	27	26
Yes	1	No	32	30
Yes	2	Yes	44	43

Table 4. OITC ratings for wood 356 mm wood-truss roofs with and without roof vents.



Test IDs	Description
TLF-98-075a – TLF-98-073a	single gypsum board
TLF-98-077a - TLF-98-079a	RCs + double gypsum board

Figure 36. Incremental effects of adding roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for 2 wood-truss roofs.

5.3 Raised heel wood-truss roof with shingles.

Figure 37 illustrates the construction of the raised heel wood-truss roofs. These roof systems contained a significant attic space and hence the tests included variations of the amount of thermal insulation as well as varied surface layers and roof vents.

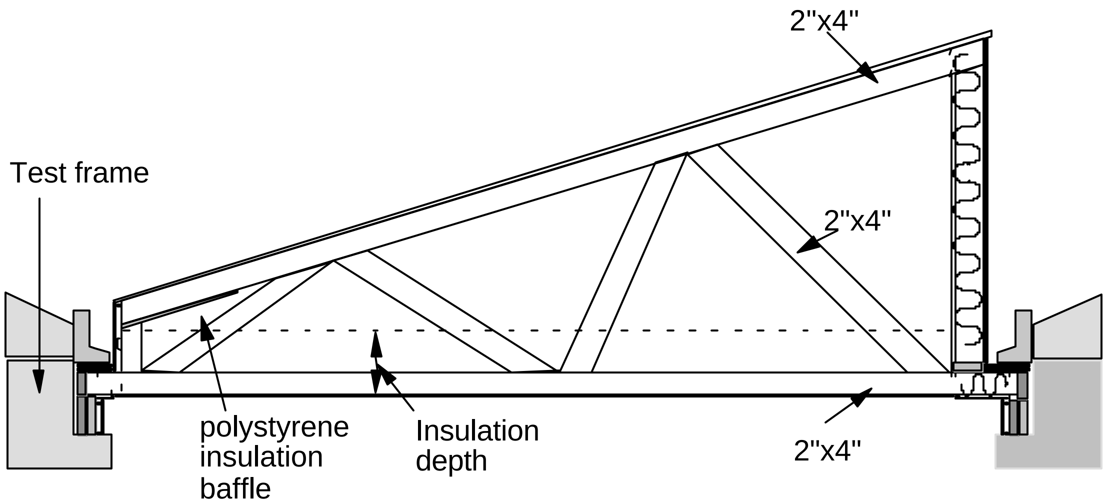
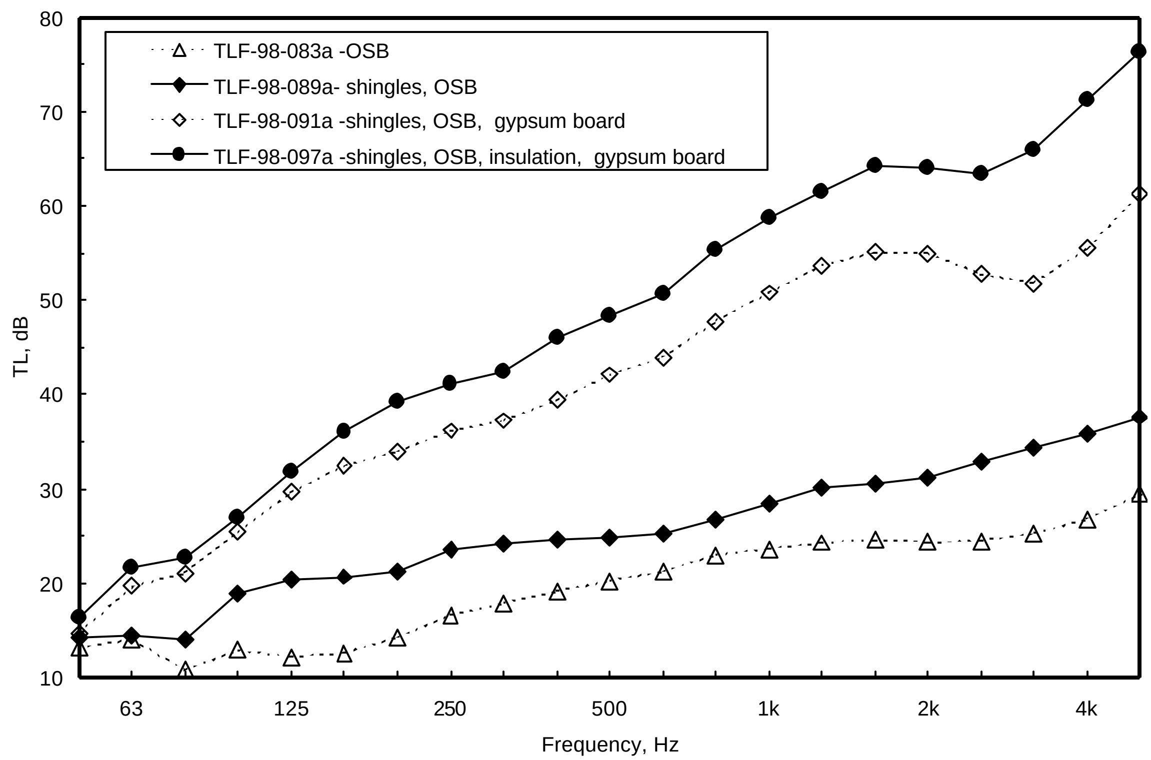


Figure 37. Sketch of section of the raised heel wood-truss roof construction in the test frame intended to represent half of a typical roof structure. The trusses were constructed of 2” by 4” lumber (38 mm by 89 mm) and with a 4 in 12 slope.

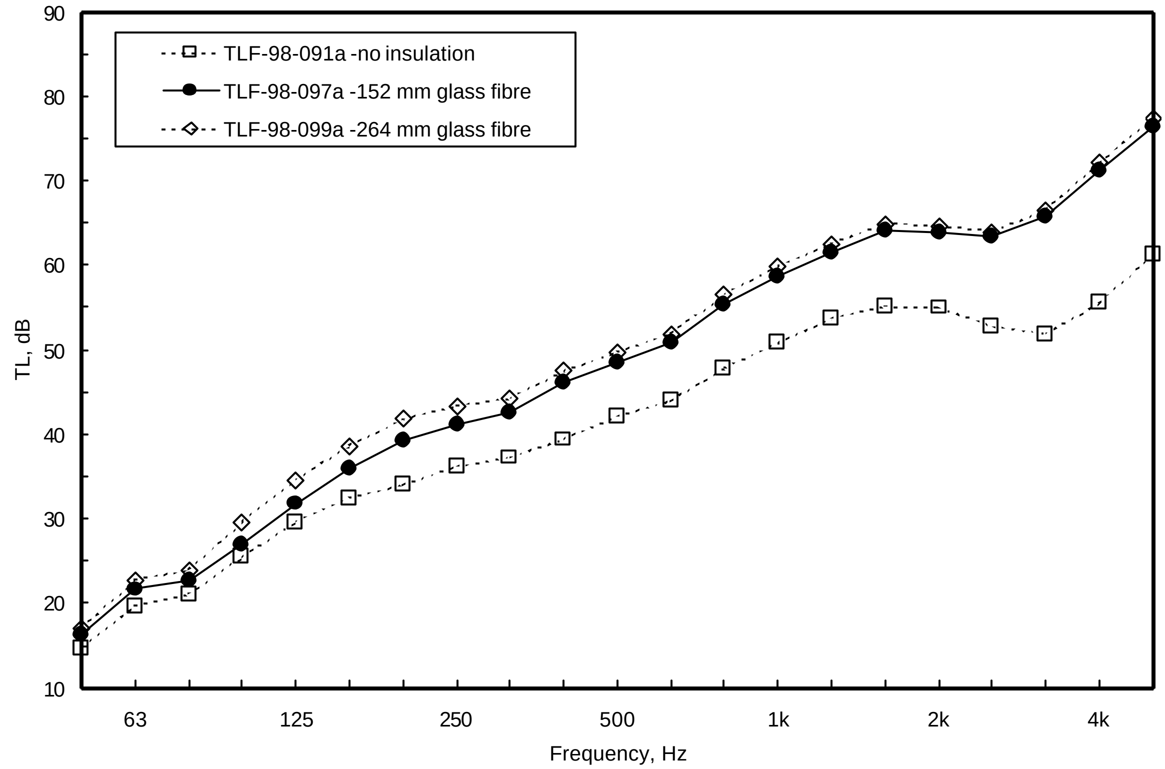
The measured sound transmission loss results in Figure 38 illustrate the gradual improvements to the sound insulation as particular components were added to the roof system. The first of these partial tests included only the wood-trusses and the 11 mm OSB sheathing. For the second test the shingles were added to the OSB sheathing. The third test added a single layer of directly attached gypsum board and the fourth test added R20 (152 mm thick) glass fibre batt insulation in the attic space. As shown in Figure 38 the corresponding OITC ratings increased from 19 to 39 with the increments to the roof construction significantly improving the OITC rating. The results in Figure 38 also show that the improvements in measured sound transmission loss occur at all frequencies. But are generally greater at higher frequencies.



Test ID	Description	OITC
TLF-98-083a	OSB11_RHWT1626	19
TLF-98-089a	SHN3_BPAP0.7_OSB11_RHWT1626	25
TLF-98-091a	SHN3_BPAP0.7_OSB11_RHWT1626_G13	36
TLF-98-097a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	39

Figure 38. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency showing the improvements as various components were added to the raised heel wood-truss roof system.

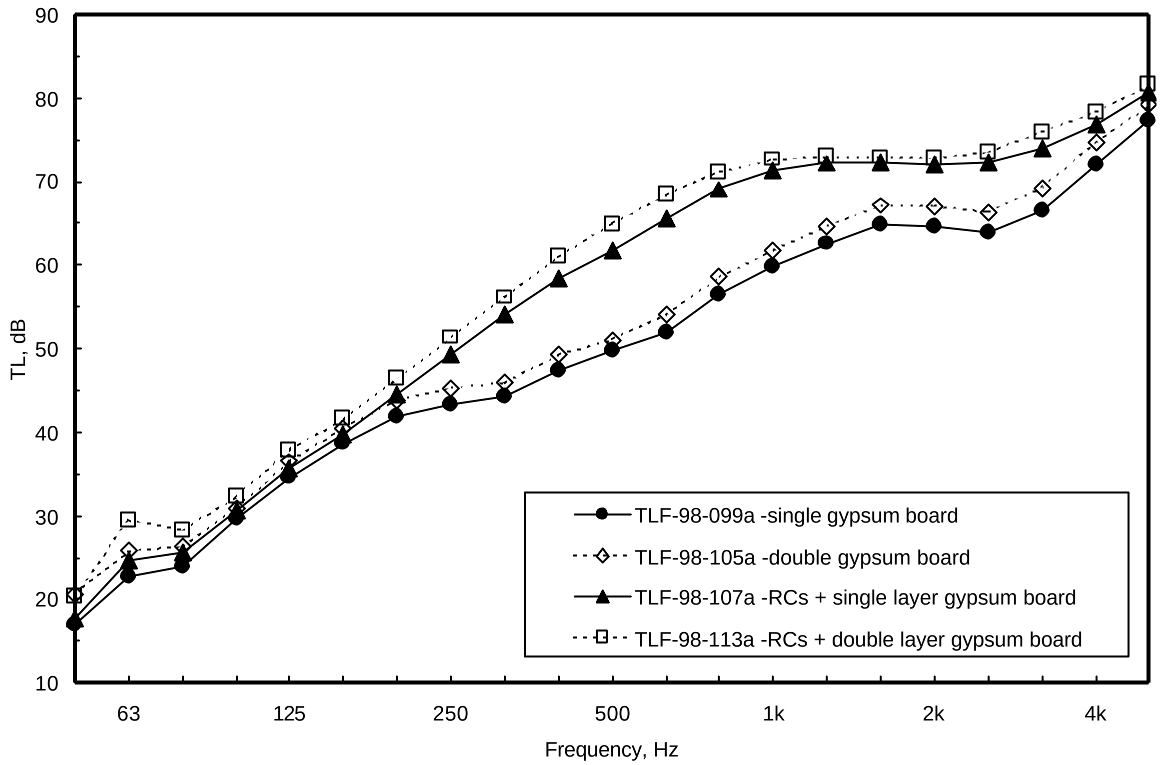
The effects of varied thermal insulation in the attic space are shown for the complete raised heel wood-truss roof system with shingles in Figure 39. The three results correspond to: no insulation, R20 glass fibre insulation (152 mm thick), and R40 glass fibre insulation (264 mm thick). Adding R20 insulation significantly increases the sound transmission loss mostly at higher frequencies and causes the OITC rating to increase from 36 to 39. Increasing the insulation further to R40 produces further small increases in the measured sound transmission loss values of the roof that are greatest in the 100 to 250 Hz region and lead to an OITC rating of 41.



Test ID	Description	OITC
TLF-98-091a	SHN3_BPAP0.7_OSB11_RHWT1626_G13	36
TLF-98-097a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	39
TLF-98-099a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13	41

Figure 39. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency showing the effects of varied thermal insulation in the attic space of the raised heel wood-truss roof system.

The raised heel wood-truss roof system was also tested with varied interior surface layers. The four combinations of one and two layers of 13 mm gypsum board with and without resilient channels were all measured for roofs with R40 glass fibre thermal insulation in the attic space. As illustrated by the results in Figure 40, adding resilient channels produces much larger increases in sound transmission loss than doubling the number of layers of gypsum board. Because the outer surface, consisting of asphalt shingles and OSB, is relatively heavy, adding a second layer of 13 mm gypsum board is a proportionally smaller increase in the total mass and hence leads to smaller increases in the sound transmission loss of the roof. However, at the more critical lower frequencies, it is as effective as adding resilient channels. That is, adding resilient channels increases the OITC rating from 41 to 42 for the case of a single layer of gypsum board but adding a second layer of gypsum board increases the OITC rating from 41 to 43. For two layers of gypsum board on resilient channels the OITC rating is increased to 44.



Test ID	Description	OITC
TLF-98-099a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13	41
TLF-98-105a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13	43
TLF-98-107a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13	42
TLF-98-113a	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13	44

Figure 40. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency showing the effects of varied interior surface layers on the raised heel wood-truss roof system.

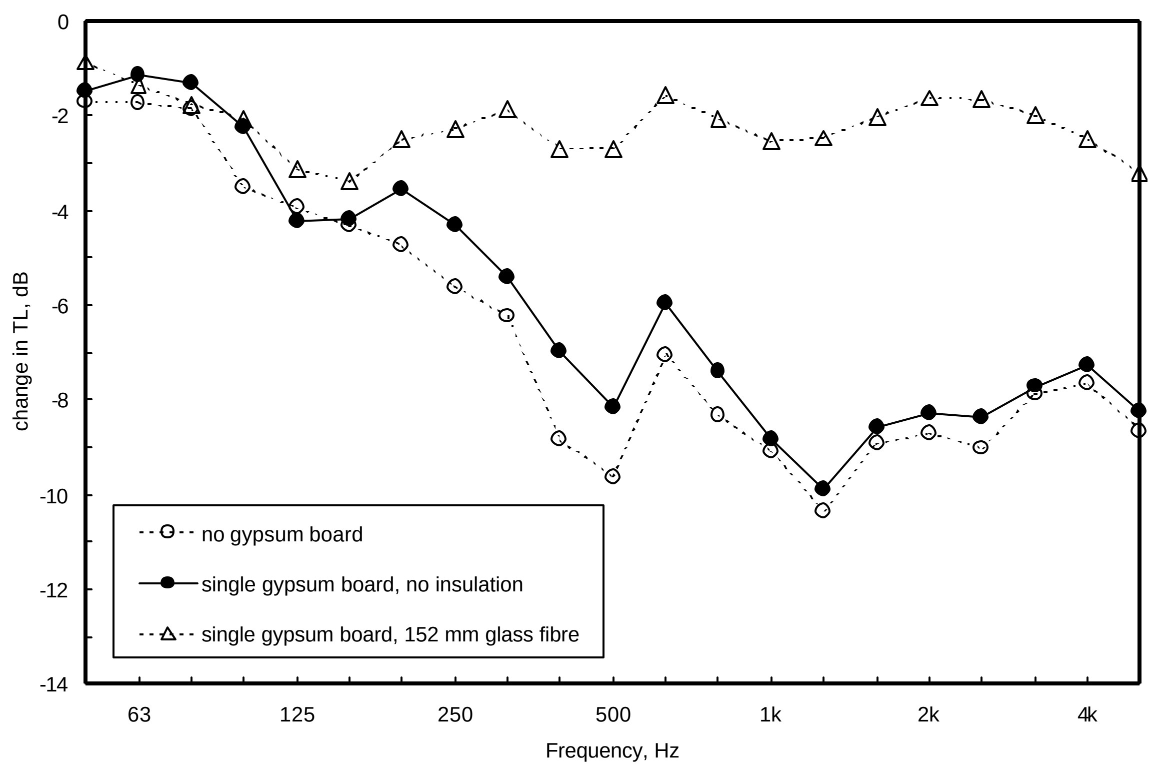
The effect of adding roof vents depends on the amount of attic insulation and the particular combination of surface layers and resilient channels. Table 5 below shows the influence of roof vents on OITC ratings obtained from the measured sound transmission loss values of the raised heel wood-truss roofs.

The first three rows of Table 5 show the effect of roof vents for varied attic insulation and roofs having a single layer of directly attached gypsum board. The addition of roof vents decreases the OITC ratings by 2 or 3 points and the effect is less with more attic insulation. The last four rows of Table 5 show the effect of roof vents for varied layers of gypsum board with and without resilient channels. Again there are only small reductions in the OITC ratings with the addition of the roof vents and adding roof vents to the roof with two layers of gypsum board on resilient channels had the smallest effect. However, with roof vents present, the roof with one layer of gypsum board on resilient channels was only slightly less effective than the roof with two layers directly attached.

Attic insulation	Layers of gypsum board	Resilient channels	OITC No vents	OITC With vents
None	1	None	36	33
R20	1	None	39	36
R40	1	None	41	39
R40	2	None	43	41
R40	1	Yes	42	40
R40	2	Yes	44	43

Table 5. OITC ratings with and without the effect of roof vents for roof constructions based on raised heel wood-truss constructions.

The detailed changes due to the addition of roof vents are illustrated in Figure 41 for various combinations of roof components. This plot shows the changes in measured sound transmission loss values as a function of frequency when roof vents were added.

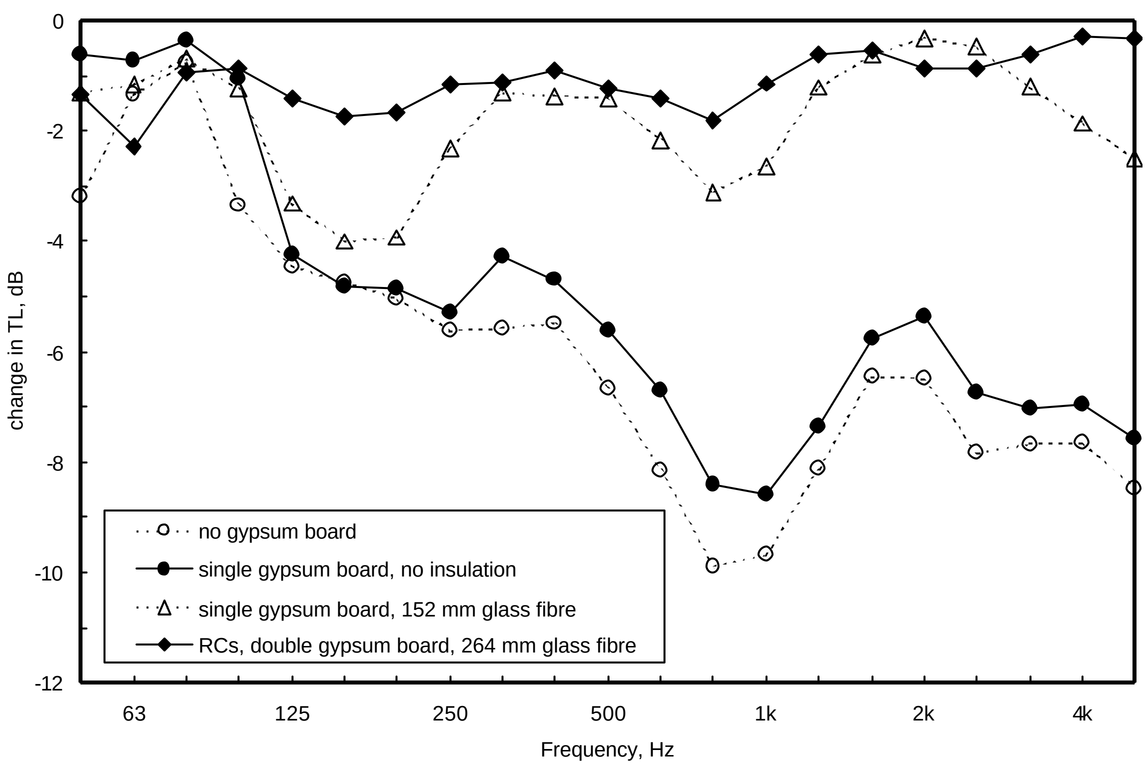


Test IDs	Description
TLF-98-087 - TLF-98-089	no gypsum board
TLF-98-093 - TLF-98-091	single gypsum board, no insulation
TLF-98-095 - TLF-98-097	single gypsum board, 152 mm glass fibre

Figure 41. Incremental effects of adding roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for raised heel wood-truss roof systems.

For the partial construction of the roof without a gypsum board ceiling and for the case with a ceiling but no insulation in the attic space, quite large changes are seen at higher frequencies. When R20 thermal insulation is added to the attic space, the effect of adding roof vents is much decreased.

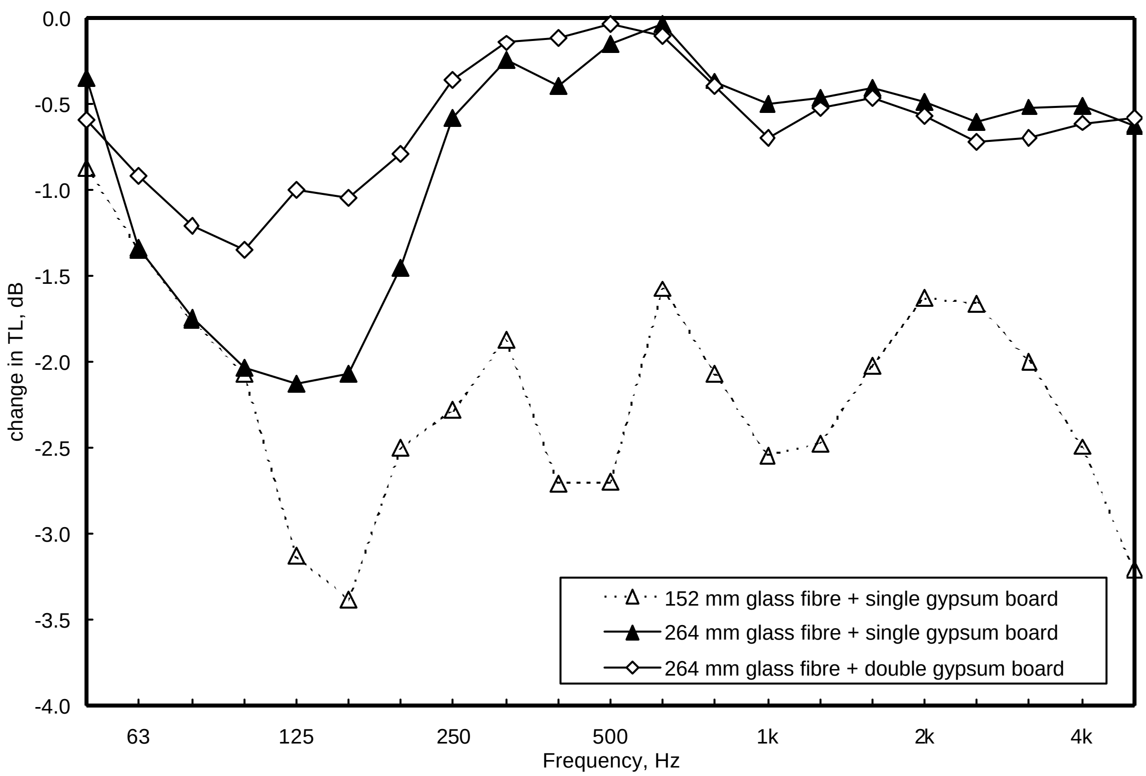
Figure 42 shows the incremental effects of ridge vents for similar combinations of roof components. These differences are similar to those in Figure 41. For roofs with no ceiling or a ceiling but no insulation, there are again quite large changes when a ridge vent is added. When there is a least R20 insulation in the attic space, the larger changes at mid to higher frequencies are much less. With R40 insulation in the attic the effect of adding a ridge vent is very small. This case can also be compared with the effects when roof vents are added for R40 insulation in the attic in Figures 43 and 44.



Test IDs	Description
TLF-98-117a - TLF-98-119a	no gypsum board
TLF-98-123a - TLF-98-121a	single gypsum board, no insulation
TLF-98-125a - TLF-98-097a	single gypsum board, 152 mm glass fibre
TLF-98-115a - TLF-98-113a	RCs, double gypsum board, 264 mm glass fibre

Figure 42. Incremental effects of adding a ridge vent in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for raised heel wood-truss roof systems.

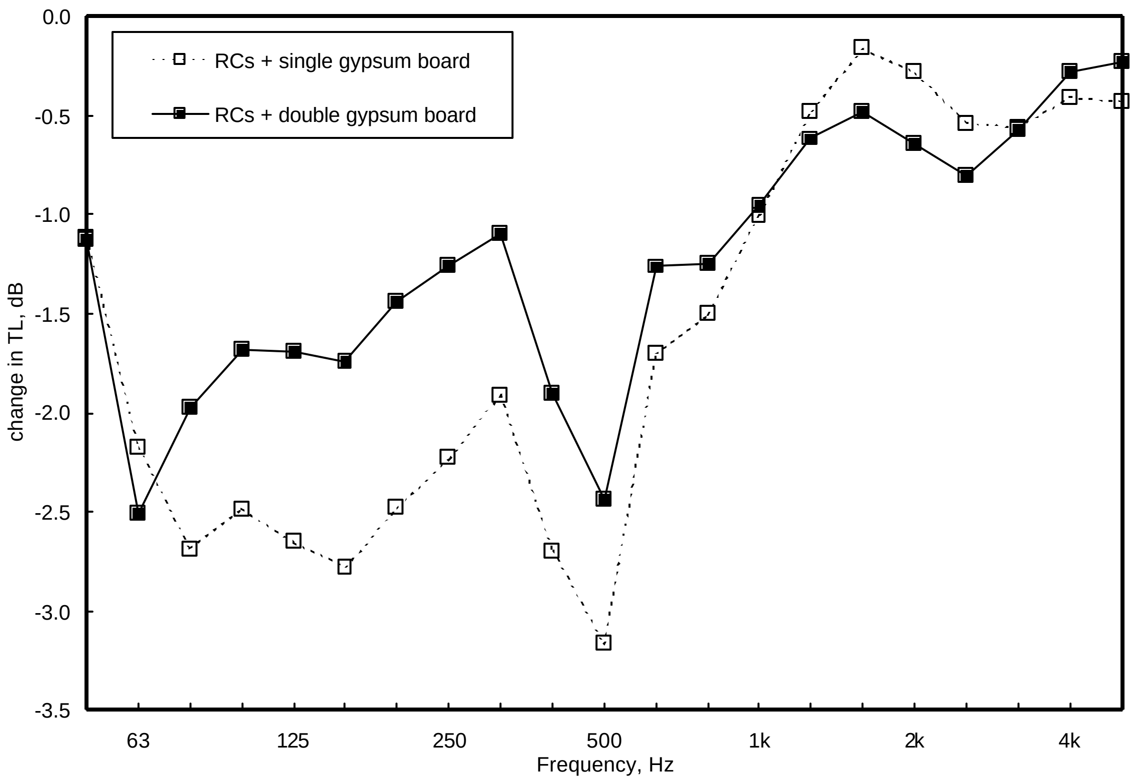
Figure 43 shows the incremental effects of adding roof vents to roofs with varied thermal insulation and varied layers of directly attached gypsum board. The largest changes occur for the case of the least amount of gypsum board and thermal insulation. This case for R20 insulation and a single layer of directly attached gypsum board was also included in Figure 41. Adding more thermal insulation to a thickness of 264 mm of glass fibre (R40) reduces the effects of roof vents at mid- and high-frequencies to changes of less than 1 dB. Increasing the gypsum board from one to two layers of 13 mm gypsum board reduces the effect of the roof vents at low frequencies. For the combination of 2 layers of gypsum board and R40 insulation the addition of roof vents has only a very small effect.



Test IDs	Description
TLF-98-095a - TLF-98-097a	152 mm glass fibre + single gypsum board
TLF-98-101a - TLF-98-099a	264 mm glass fibre + single gypsum board
TLF-98-103a - TLF-98-105a	264 mm glass fibre + double gypsum board

Figure 43. Incremental effects of adding roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for raised heel wood-truss roof systems and varied layers of gypsum board and thermal insulation.

The effects of adding roof vents to roofs where the gypsum board was attached with resilient channels is illustrated in Figure 44. As expected the incremental effect of adding roof vents is less for the roof with two layers of gypsum board than for a roof with a single layer of gypsum board. However, comparing Figures 43 and 44 shows that the roof vents have larger effects for roofs where the gypsum board is resiliently attached than for similar roofs with directly attached gypsum board.

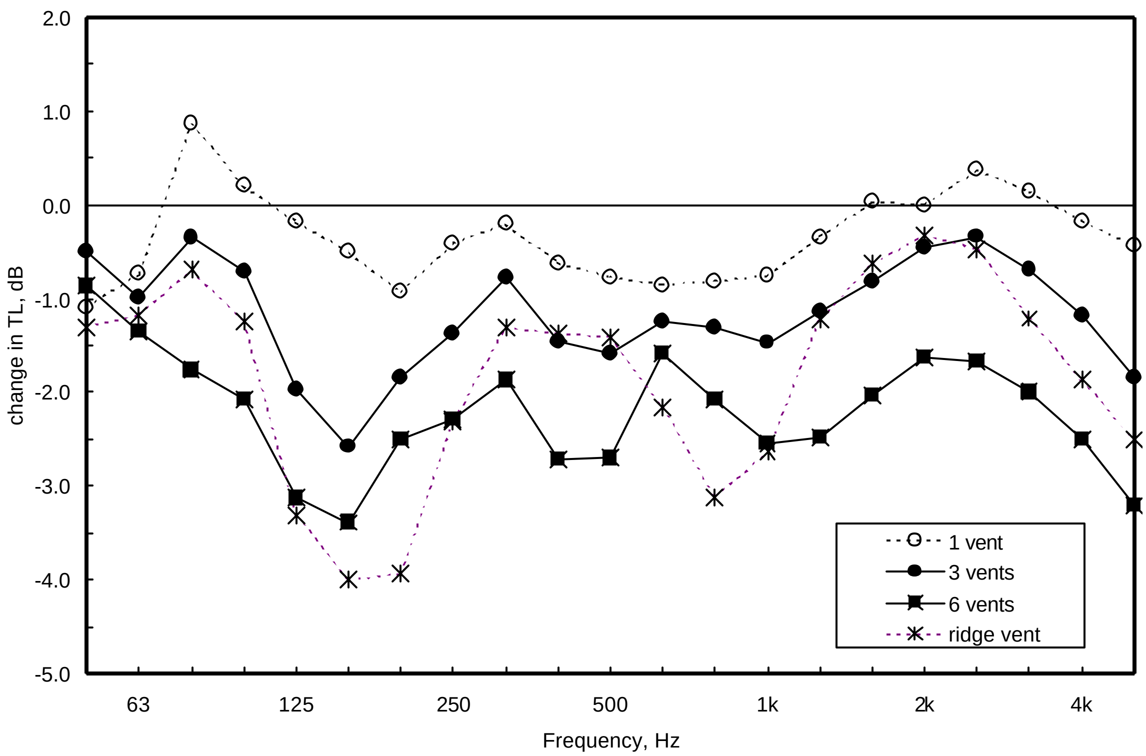


Test IDs	Description
TLF-98-109a - TLF-98-107a	RCs + single gypsum board
TLF-98-111a - TLF-98-113a	RCs + double gypsum board

Figure 44. Incremental effects of adding roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for raised heel wood-truss roof systems with the gypsum board attached via resilient channels.

All of the measurements of the effects of roof vents were obtained by adding 6 roof vents. Further tests were carried out to determine the influence of smaller numbers of roof vents. These were tested on a roof with single layer of directly attached gypsum board and R20 glass fibre insulation in the attic space. The incremental effects of adding all 6 roof vents were shown in Figures 43 and 44. The result for adding 6 roof vents to a roof with a single layer of directly attached gypsum board and R20 glass fibre insulation from Figure 43 is repeated in Figure 45. Figure 45 also shows the effect of adding 3 roof vents and also only one roof vent. The variations of the changes with frequency in Figure 45 for 1, 3 or 6 roof vents are similar but the changes to the roof sound transmission loss decrease when fewer vents are present. Three vents in the test roof is probably more representative of typical roofs and thus the various results for adding 6 roof vents presented in Figures 41 to 44 exaggerate the likely effects in real roofs.

Figure 45 also includes the incremental effect of a ridge vent in the same roof construction. This vent was installed along the complete length of the peak of the roof. The addition of a ridge vent is seen to be roughly comparable to the addition of 3 or 6 individual roof vents. The changes to the OITC ratings due to the addition of vents are included in Table 6 and the effects of ridge vents are discussed further in the following section.



Test IDs	Description
TLF-98-129a - TLF-98-097a	1 vent
TLF-98-127a - TLF-98-097a	3 vents
TLF-98-095a - TLF-98-097a	6 vents
TLF-98-125a - TLF-98-097a	ridge vent

Figure 45. Incremental effects of adding a ridge vent or one, three or six roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for a raised heel wood-truss roof.

5.4 Raised heel wood-truss roof with steel sheeting.

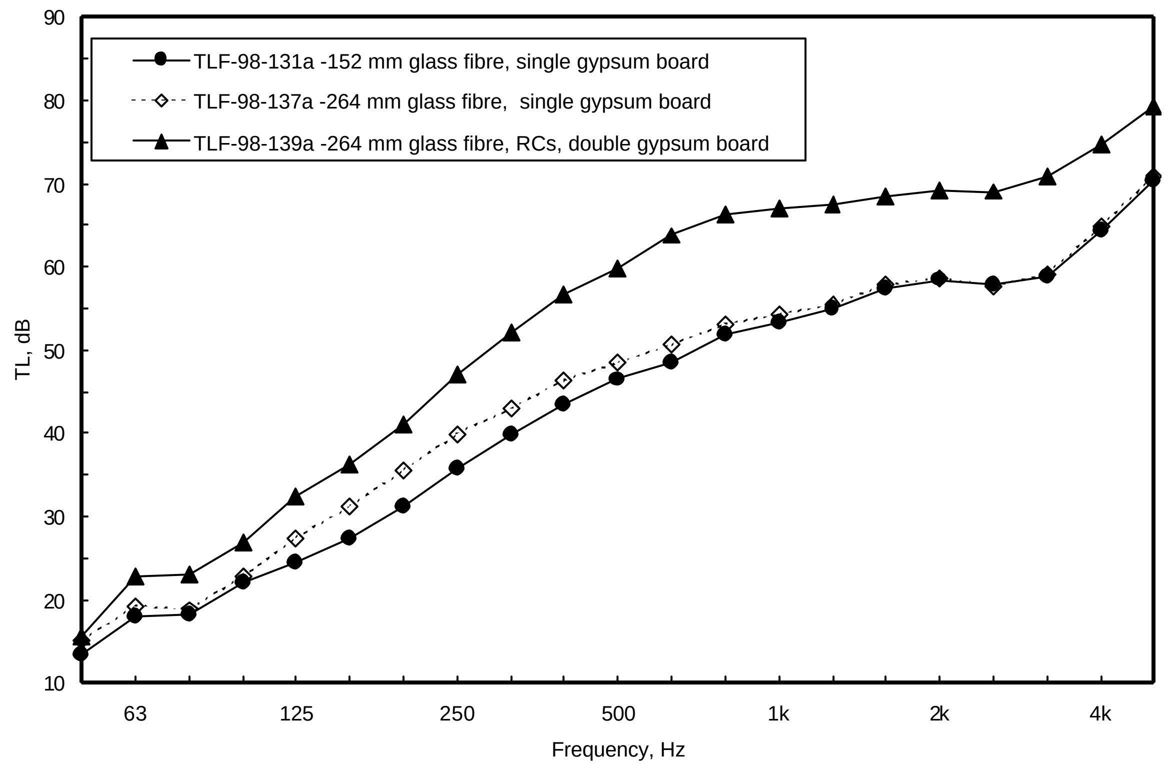
The sound transmission loss of the raised heel wood-truss roof was also tested with the shingles and OSB sheathing replaced with steel roofing. Three different combinations of thermal insulation and gypsum board layers were tested both with and without the ridge vent supplied with the steel roofing. The OITC ratings of the various steel roofs that were tested are summarised in Table 6. For comparison Table 6 repeats the OITC ratings for the corresponding roofs with asphalt shingles and OSB sheathing.

Exterior layer and Vent	**Attic insulation**	**Layers of gypsum board**	**Resilient channels**	**OITC No vents**	**OITC With vents**
Steel –ridge vent	R20	1	None	33	33
Steel –ridge vent	R40	1	None	35	34
Steel - ridge vent	R40	2	Yes	39	39
Shingles -6 roof vents	R20	1	None	39	36
Shingles -6 roof vents	R40	1	None	41	39
Shingles -6 roof vents	R40	2	Yes	44	43
Shingles –ridge vent	R20	1	None	39	37
Shingles -ridge vent	R40	2	Yes	44	43

Table 6. OITC ratings for the steel roofs both with and without a ridge vent and the corresponding results for similar roofs with shingles and OSB sheathing.

Without a ridge vent, the steel roofs have OITC ratings that are 5 or 6 points lower than the corresponding roof with shingles on OSB sheathing and without any roof vents. However, the differences are less when both types of roofs are vented.

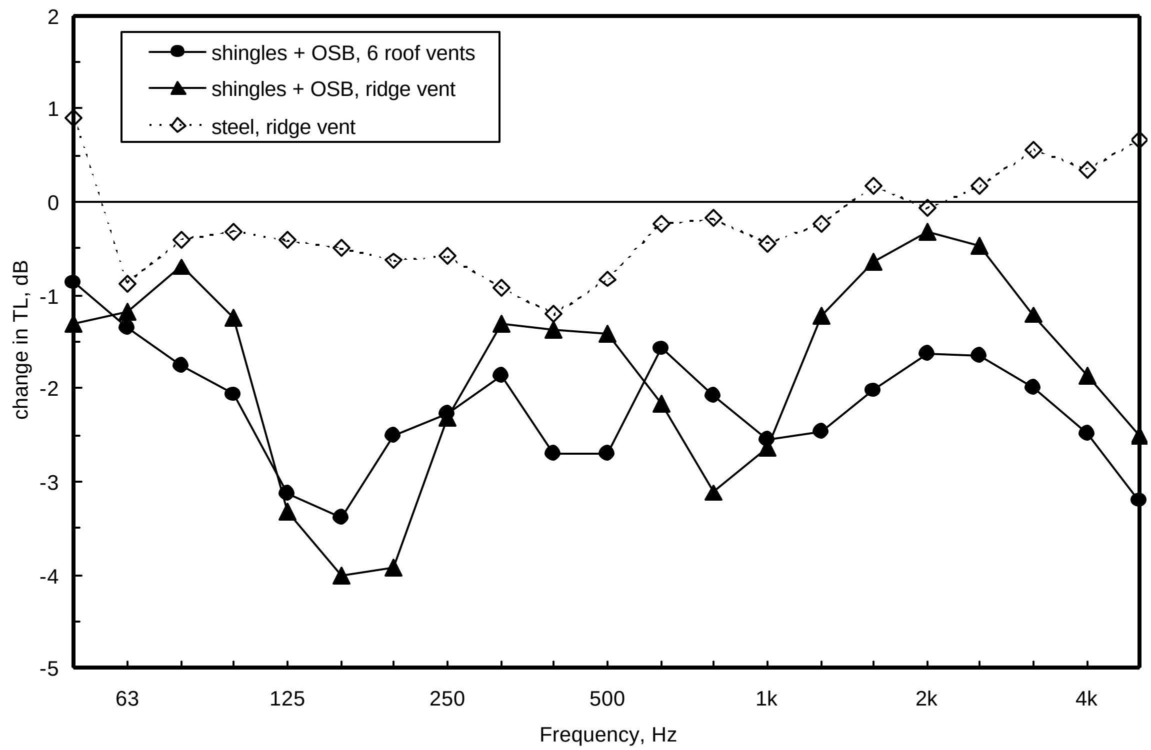
Figure 46 shows the measured sound transmission loss versus frequency values for the three steel roofs with a ridge vent. Increasing the thermal insulation in the attic space from R20 to R40 produced only small increases in the measured sound transmission loss. However, the combination of R40 insulation with two layers of gypsum board mounted on resilient channels produced a quite large increase in sound transmission loss at mid and high frequencies.



Test ID	Description	OITC
TLF-98-131a	STE0.3_WFUR19(406)_RHWT1626_GFB152_G13	33
TLF-98-137a	STE0.3_WFUR19(406)_RHWT1626_GFB264_G13	35
TLF-98-139a	STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13	39

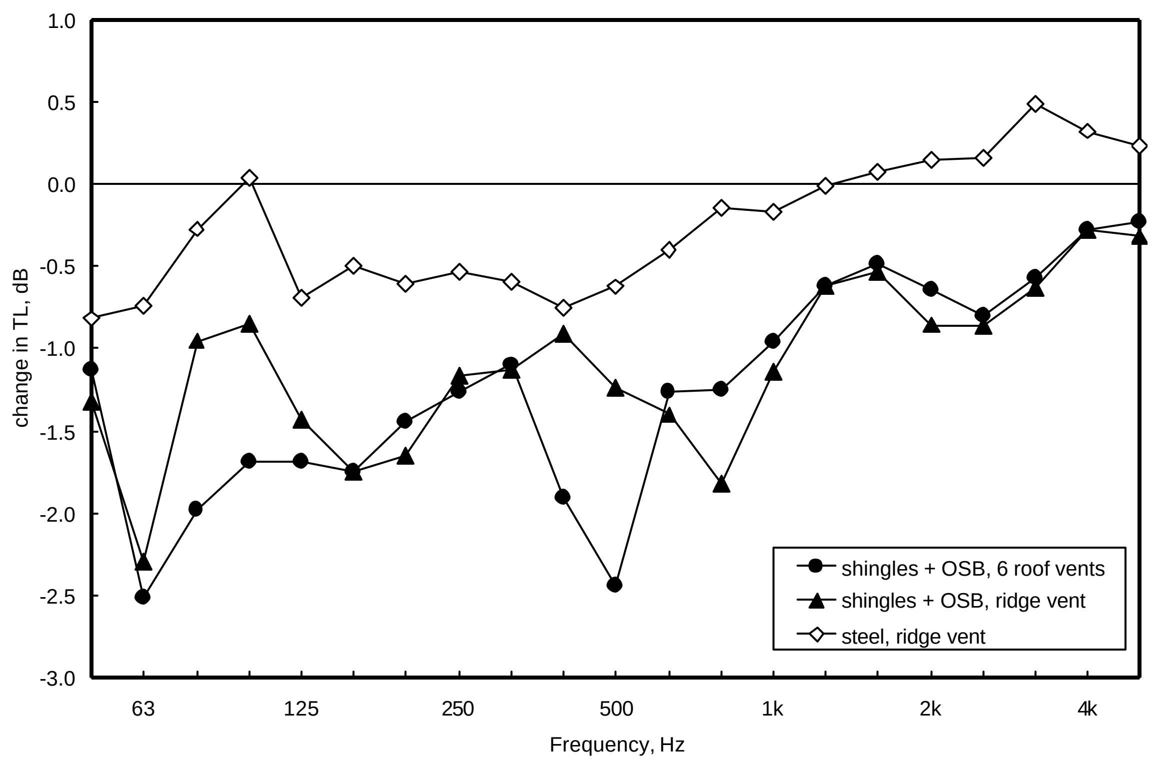
Figure 46. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for steel roofs on a raised heel wood-truss roof system.

Figures 47 and 48 compare the incremental effects of adding either 6 roof vents or a ridge vent to steel roofs and roofs with shingles on OSB sheathing. The comparisons in Figure 47 are for roofs with R20 thermal insulation and a single layer of directly attached gypsum board. Roofs with R40 attic insulation and two layers of gypsum board attached with resilient channels are compared in Figure 48. In both plots the changes in sound transmission loss are least for the steel roofs and rarely exceed 1 dB in any 1/3 octave frequency band for that type of roof. The magnitude of the effects of adding a ridge vent to roofs with shingles on OSB sheathing are similar to the effects of adding 6 roof vents but the detailed variations with frequency are not the same. The changes to the OITC ratings given in Table 6 also indicate that adding a ridge vent has a similar overall effect to adding 6 roof vents.



Test IDs	Description
TLF-98-095a - TLF-98-097a	shingles + OSB, 6 roof vents
TLF-98-125a - TLF-98-097a	shingles + OSB, ridge vent
TLF-98-133a - TLF-98-131a	steel, ridge vent

Figure 47. Incremental effects of adding a ridge vent or six roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for a raised heel wood-truss roof with R20 insulation and a single layer of directly attached 13 mm gypsum board.



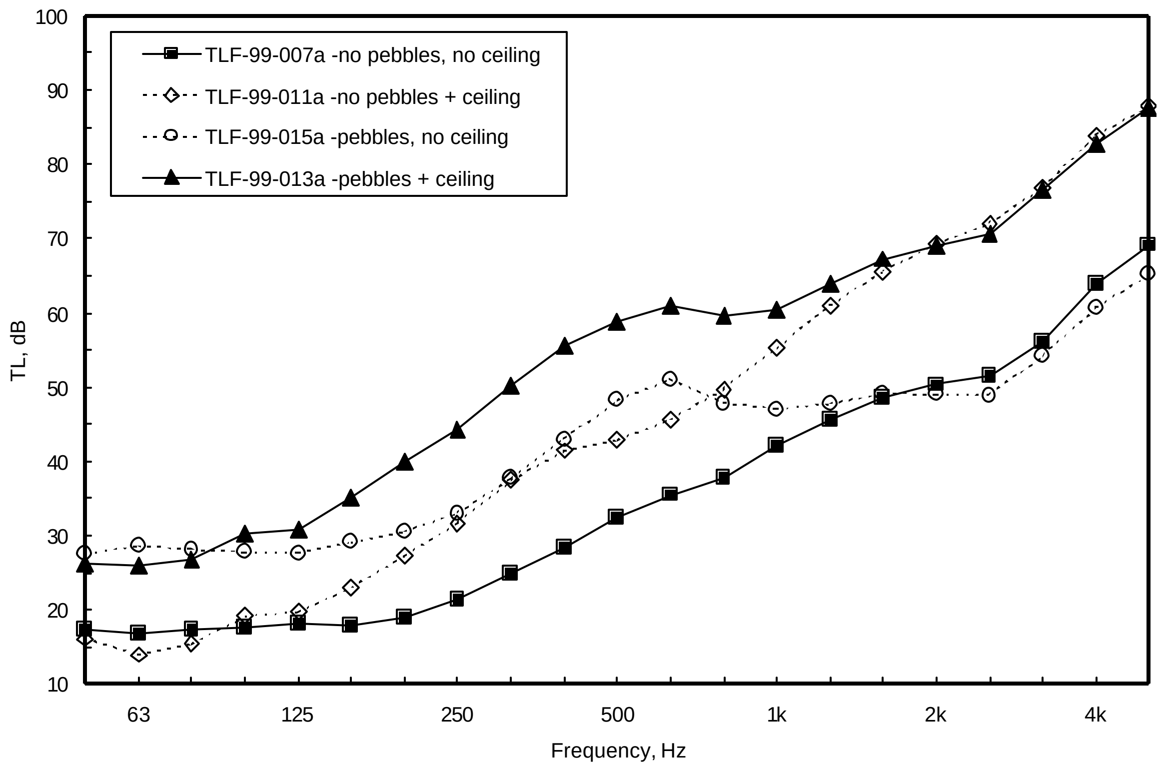
Test IDs	Description
TLF-98-111a - TLF-98-113a	shingles + OSB, 6 roof vents
TLF-98-115a - TLF-98-113a	shingles + OSB, ridge vent
TLF-98-141a - TLF-98-139a	steel, ridge vent

Figure 48. Incremental effects of adding a ridge vent or six roof vents in terms of changes to measured sound transmission loss versus 1/3 octave band frequency for a raised heel wood-truss roof with R40 insulation and a double layer of 13 mm gypsum board attached using resilient channels.

5.5 Steel deck flat roof.

The final type of roof that was tested consisted of variations of a light-weight steel deck roof system commonly used in many commercial buildings. The base roof consisted of a complete steel deck roof with thermal insulation and an exterior roofing membrane. The variations of this type of roof that were tested included combinations of adding pebbles on the roof and a T-bar ceiling below the roof. The added pebbles were a 25 mm layer of 9 mm (3/8”) pebbles. The added ceiling consisted of 16 mm (5/8”) thick mineral fibre ceiling tiles supported in a conventional T-bar system with the top of the ceiling tiles 352 mm below the lowest corrugation of the steel deck. The measured sound transmission loss versus frequency for the four different variations of the roof are compared in Figure 49.

The roof without either added pebbles or a ceiling had an OITC rating of 26. Adding pebbles tended to improve the low- and mid-frequency sound transmission loss. Adding the suspended ceiling tended to improve the mid- and high-frequency sound transmission loss. Figure 49 shows that the combination of adding pebbles and a T-bar ceiling increased the OITC rating to 41.



Test ID	Description	OITC
TLF-99-007a	GMEM4_PSMEM0.2_WFB13_INSUL70_PAP0.3_STE0.8_SJ254(1610)	26
TLF-99-011a	GMEM4_PSMEM0.2_WFB13_INSUL70_PAP0.3_STE0.8_SJ254(1610)_ AIR352_CTILE16	29
TLF-99-015a	PEB25_GMEM4_PSMEM0.2_WFB13_INSUL70_PAP0.3_STE0.8_ SJ254(1610)	37
TLF-99-013a	PEB25_GMEM4_PSMEM0.2_WFB13_INSUL70_PAP0.3_STE0.8_ SJ254(1610)_AIR352_CTILE16	41

Figure 49. Comparisons of measured sound transmission loss values versus 1/3 octave band frequency for steel deck roofs.

6. Conclusions

The sound transmission loss of over 100 constructions representing building façade components have been measured in standard laboratory tests involving pairs of reverberation chambers. The results are representative of the expected sound insulation of each construction when exposed to randomly incident sound. The constructions have included various types of roofs and walls as well as a number of windows. The effects of vents on sound insulation were also evaluated.

Walls

Only wood stud walls were tested and they had OITC ratings from about 25 for the base wall to 40 for a brick wall. Some superior constructions had OITC ratings as high as 44. Therefore, for simple comparisons an OITC of 25 can be considered as a low sound insulation and an OITC of 40 as a high sound insulation rating.

Increasing the stud spacing to 610 mm, adding resilient channels, or using a staggered stud configuration increased the OITC rating from 25 for the base wall to values in the low 30s. Combining one of these three improvements with additional layers to the interior or exterior surfaces (and hence increasing their mass) produced walls with OITC ratings as high as 44.

The performance of walls built with the exterior sheathing and interior gypsum on studs with the conventional 406 mm spacing is limited by a dip in the transmission loss at about 125 Hz. The performance of these walls can be improved by using a larger stud spacing, attaching the gypsum board with resilient channels, or by using a staggered stud configuration.

Windows

Double glazing units made of two layers of 3 mm glass with a 13 mm air space have an OITC rating of about 22. Manufactured windows including these double glazing units have OITC ratings of 23 to 26. The sliding windows tested here seemed to be more prone to air leakage than the casement windows and this limited the higher frequency sound transmission loss but had little effect on the OITC rating of the sliding windows. Some better casement windows had a little higher sound transmission loss than the double glazing units that they included.

Comparisons with previous laboratory studies suggested that they found higher sound transmission loss values than measured for the contemporary manufactured windows with the same glass and air space.

Adding a storm window with a sufficiently large air space (≥76 mm) can significantly improve the sound insulation of the window to an OITC rating of 30 or more.

Roofs

Each roof system was tested with variations to the interior surface layers as well as both with and without roof vents. Where possible, the amount of attic insulation was also varied.

Wood-joist roofs had OITC ratings of from 30 to 43. These ratings were reduced by 1 to 3 OITC points when roof vents were added.

The wood-truss roofs had OITC ratings of from 32 to 44 and these were reduced by 1 point when roof vents were added.

The sloping raised heel wood-truss roofs with shingles and OSB sheathing had OITC ratings from 39 to 44. These ratings were reduced by 2 or 3 OITC points when roof vents were added. The raised heel wood-truss roofs, with steel sheeting in place of the shingles and OSB, had OITC ratings of 33 to 39. Adding a ridge vent to these steel covered roofs reduced the OITC by up to 1 point.

Adding vents to the raised heel wood-truss roofs tended to have less effect when there was more insulation (R40) in the attic space and also when the gypsum board was directly attached. Adding a ridge vent had generally similar effects to adding several roof vents.

Tests of light weight steel deck roofs gave OITC ratings between 26 and 41 depending on whether pebbles were added on the roof and whether there was a T-bar ceiling in place.

References

[1] Bradley, J.S., “NEF Validation Study: (1) Issues Related to the Calculation of Airport Noise Contours”, IRC Contract Report A-1505.3, 1996

[2] Bradley, J.S., “NEF Validation Study: (2) Review of Aircraft Noise and its Effects”, IRC Contract Report A-1505.5, 1996

[3] Bradley, J.S., “NEF Validation Study: (3) Final Report”, IRC Contract Report A-1505.3, 1996

[4] Anon, “New Housing and Airport Noise”, Canada Mortgage and Housing (1981).

[5] J.S. Bradley , “Insulating Buildings Against Aircraft Noise: A Review”, IRC Internal Report, IRC IR-760, March 1998

[6] Anon, ASTM E90 – 97, “Standard Test Method for Laboratory Measurement of Airborne Sound Transmission loss of Building Partitions and Elements”, Am. Soc. for Testing and Materials, Philadelphia.

[7] Anon, ASTM E413, “Classification for Rating Sound Insulation”, Am. Soc. for Testing and Materials, Philadelphia.

[8] Anon, ASTM 1332, “Standard Classification for Determination of Outdoor-Indoor Transmission Class”, Am. Soc. for Testing and Materials, Philadelphia.

[9] Morin, M.,“Research Project on the Noise Isolation Provided by Exterior Walls in Wood Constructions”, CMHC Report 177.981, October, 1998.

[10] Quirt, J.D., “Measurements of the Sound Transmission Loss of Windows”, Building Research Note, BRN 172, Division of Building Research, National Research Council of Canada, Ottawa, (April 1981).

[11] Morin, M., “Noise Isolation Provided by Windows in Residential Projects”, CMHC Report, 177.961,March 1997.

[12] Anon, ISO 140/III, “Laboratory Measurement of Airborne Sound Insulation of Building Elements – Part III: Laboratory Measurements of Airborne Sound Insulation of Building Elements”.

[13] Utley, W.A. and Fletcher, B.L., “The Effects of Edge Conditions on the Sound Insulation of Double Windows"” J. Sound and Vibration, Vol. 26, No. 1, 63-72, (1973).

[14] Cervera, F. Uris, A., Gálvez, F., and Martinez-Sala, R., “Comparison of the Sound Reduction Index of a Window Using Pressure and Intensity Techniques”, Proc. Inter Noise ’98, paper #472, Auckland N.Z., November, (1998).

[15] Lin G-F., and Garrelick, J.M., “Sound Transmission Through Periodically Framed Parallel Plates”, J. Acoust. Soc. Am., Vol. 61, No. 4. pp. 1014-1018, (1961).

[16] Fahy, F., “Sound and Structural Vibration –Radiation, Transmission and Response”, Academic Press, New York (1985).

Appendix I Advisory Panel

Several aspects of the IBANA project have benefited from input from practitioners in the field. For example, the decisions concerning which constructions to include benefited from both an appreciation of the technical issues and some familiarity with current construction practice in various regions of Canada. It was also valuable to get feedback on the success of the new IBANA-Calc software while it was still under development. To ensure that the best choices were made, input was obtained from three acoustical consulting companies and a local architect. They were:

> Dr. Al. Lightstone, Valcoustics Canada Ltd., Richmond Hill, Ontario.
>
> Dr. Mohan Barman, Aercoustics Engineering Ltd., Rexdale, Ontario.
>
> Mr. Mike Noble and Mr. Doug Whicker, Barron Kennedy Lyzun, (BKL) Ltd., North Vancouver, BC.
>
> Mr. Gary Schafer, Griffiths Rankin Cook Architects, Ottawa.

Their input was most helpful to the project.

Appendix II Explanation of symbols used to describe constructions

AIR	air space
ALM	aluminum siding
BPAP	building paper
BRI	brick
CFL	dry, blown-in cellulose insulation
CTILE	ceiling tile
EIF	exterior insulation and finish system
EPS	expanded polystyrene
G13	12.7mm (1/2”) regular gypsum board
GFB	glass fibre batt insulation
GFR	rigid glass fibre insulation
GL	glass
GMEM	granular membrane
INSUL	insulation
OSB	oriented strand board
PAP	kraft paper
PEB	riverwashed pebbles
PLST	vapour barrier
PSMEM	peel and stick membrane
RC	resilient channels
RFB	rock fibre batt insulation
RHWT	raised heel wood-trusses
SJ	steel joists
SHN	roofing shingles
STE	corrugated steel roof
STUC	cement based stucco
VIN	vinyl siding
WFB	wood fibre board
WFUR(xxx)	wood furring strips xxx mm on center
WJ	wood-joists
WS(xxx)	wood studs spaced xxx mm on center
WT	wood-trusses

Table II-1. Symbols used to describe the details of the constructions in this report.

Throughout this report, the details of each construction are described by a series of letters and numbers listing the components of the wall or roof in order from one surface to the other. For example, the base wall with vinyl siding attached is described as follows:

VIN1_OSB11_WS140(406)_GFB152_G13.

This indicates that starting from the outside there is 1 mm thick vinyl siding (VIN) attached to 11 mm thick OSB sheathing. The wood studs (WS) are 140 mm studs spaced at 406 mm with 152 mm thick glass fibre batt insulation (GFB) in the cavity.

The inner surface is a single layer of 13 mm thick gypsum board (G). Descriptions of all of the symbols used are included in the table. The numerical part of the code indicates thickness or spacing in mm. For the wall and window tests the components are listed in order from the small chamber side to the large chamber side. For the roof tests, components are listed from the upper chamber to the lower chamber side of the roof. This corresponds to going from the outer surface to the inner surface of the roof.

Some materials were not varied throughout these tests and these common properties are, for brevity, not always repeated in the discussions. OSB sheathing was always 11 mm thick and only 13 mm thick regular gypsum board was used. All walls and roofs included a 0.2 mm thick polyethylene vapour barrier immediately under the interior gypsum board layers and a breather type sheathing membrane between the exterior cladding and the exterior sheathing.

Appendix III Data

This appendix contains the detailed results of the sound transmission loss tests of 108 different constructions. Each page describes one construction and includes a sketch of the cross-section of the construction as well as the details of materials and the sound transmission loss measurement results.

Each test has a unique Test ID number shown at the upper right hand corner of each page. For example, the first sample TEST ID is "TLA-00-027a". These allow the reader to relate results discussed in the body of this report to the details of a particular test result. Below the Test ID on each page the construction is described using the symbols used throughout this report and explained in Appendix II. These are simply a convenient compact description of the construction.

The various layers of the construction are listed at the upper left of each page and the details of the materials of each layer are given in the table in the middle of each page.

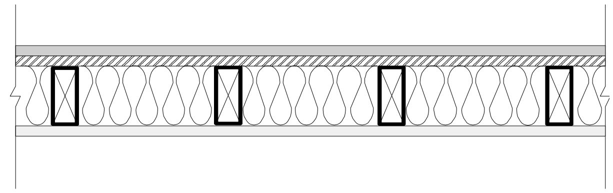
At the bottom of each page the graph shows measured sound transmission loss values versus 1/3 octave band frequency along with the corresponding STC contour. The table to the left of the graph also includes the same sound transmission loss vales as well as the STC and OITC single number ratings.

The results in this appendix are first grouped by major construction type: (a) walls, (b) windows, and (c) roofs. Within each major construction type, the results are arranged in order of increasing dimensions of the basic stud or joist system. The table below provides a table of contents of the data according to major construction types and sub-headings. The indexes at the end of the report allow the reader to find the results corresponding to a particular TEST ID or with a particular OITC rating.

National Research Council Canada

TLA-00-027a
VIN1_OSB11_WS89(305)_GFB89_G13
Construction Type: wall

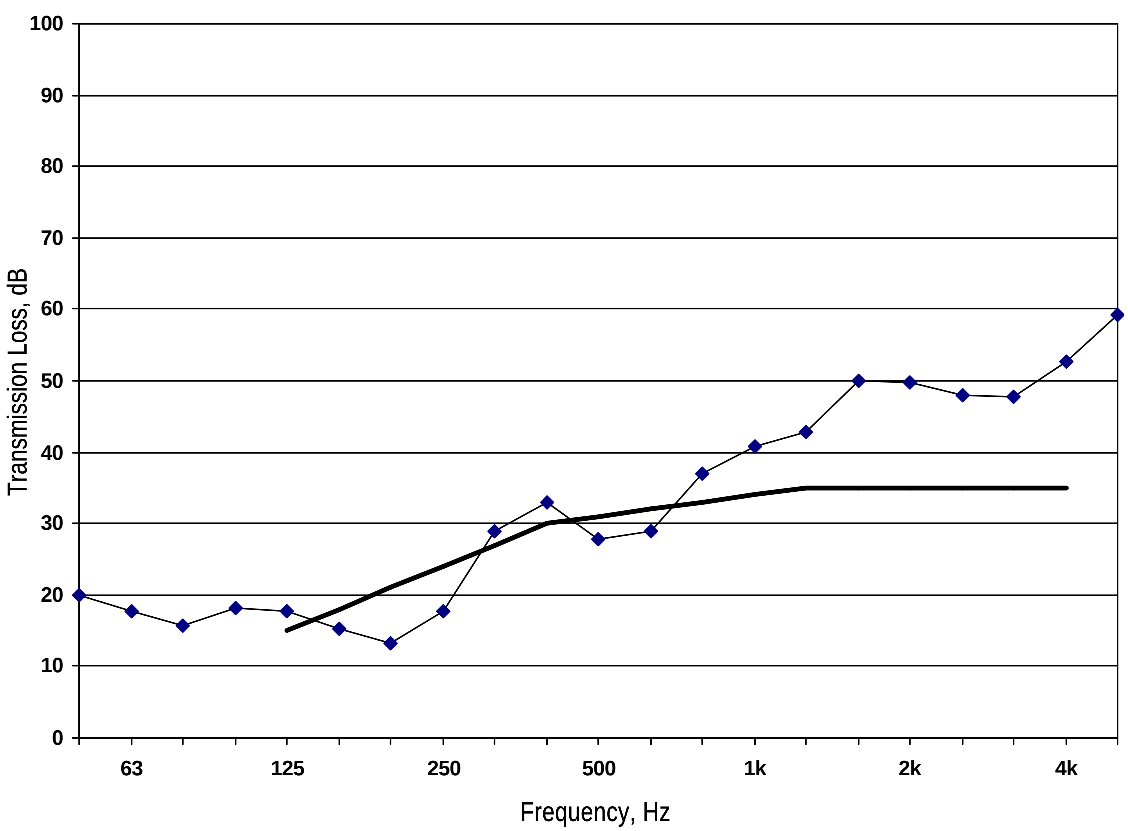
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	89 mm deep wood stud at 305 mm on centre
4	89 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	regular
thickness (mm)	1	11	89	89	13
spacing (mm)	*	*	305	*	*
total mass (kg)	19	60	60	8.9	71
linear density (kg/m)	0.4	*	1.4	*	*
surface density (kg/m^2)	*	6.7	*	0.8	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	305
fastener spacing #2 (mm)	*	305 field	*	*	*

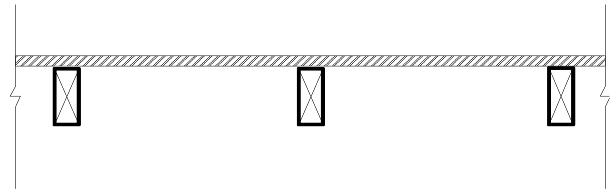
* indicates not applicable

Freq, Hz	TL, dB
50	20
63	18
80	16
100	18
125	18
160	15
200	13
250	18
315	29
400	33
500	28
630	29
800	37
1000	41
1250	43
1600	50
2000	50
2500	48
3150	48
4000	53
5000	59
STC	31
OITC	23



TLA-00-023a
OSB11_WS89(406)
Construction Type: wall

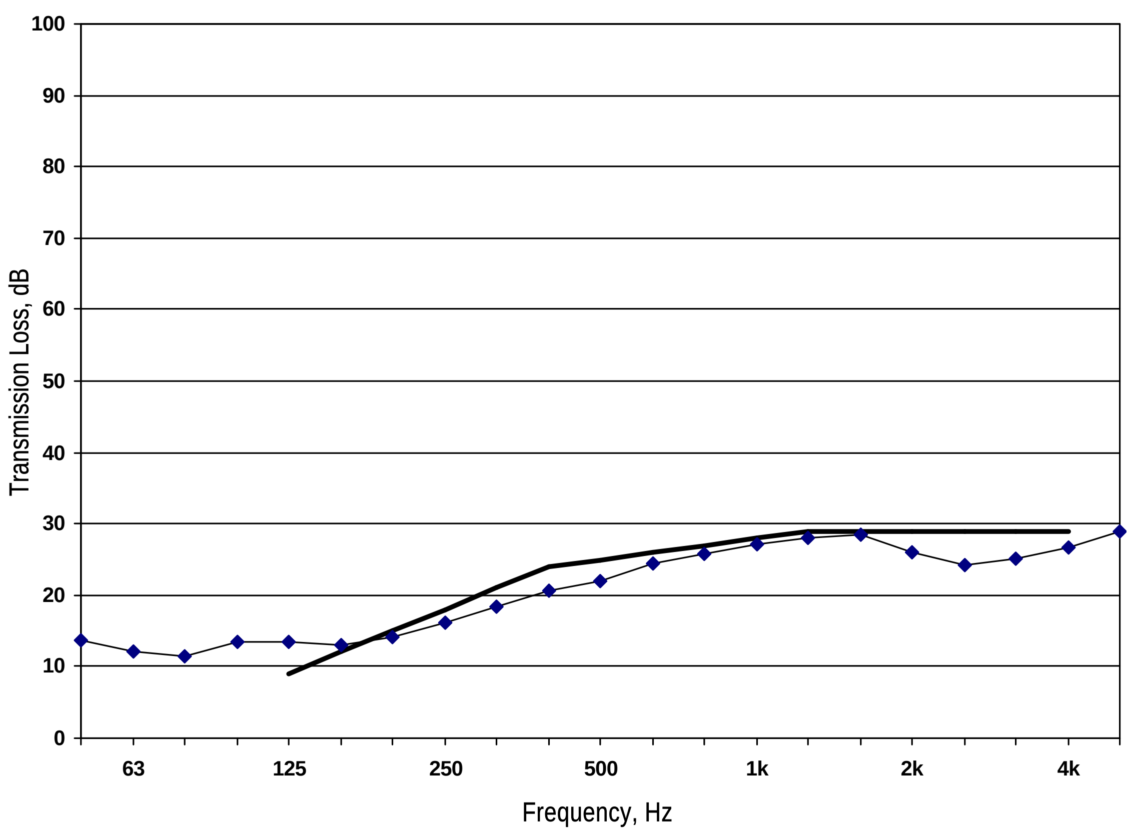
Element	Description
1	11 mm thick oriented strand board
2	89 mm deep wood stud at 406 mm on centre



	element 1	element 2
type	sheathing	studs
material	OSB	wood
thickness (mm)	11	89
spacing (mm)	*	406
total mass (kg)	60	52
linear density (kg/m)	*	1.5
surface density (kg/m^2)	6.7	*
fastener spacing #1 (mm)	152 edges	*
fastener spacing #2 (mm)	305 field	*

* indicates not applicable

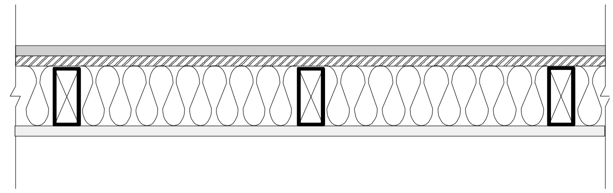
Freq, Hz	TL, dB
50	14
63	12
80	11
100	13
125	14
160	13
200	14
250	16
315	18
400	21
500	22
630	24
800	26
1000	27
1250	28
1600	28
2000	26
2500	24
3150	25
4000	27
5000	29
STC	25
OITC	20



NRC-CNRC National Research Council Canada

TLA-00-021a
VIN1_OSB11_WS89(406)_GFB89_G13
Construction Type: wall

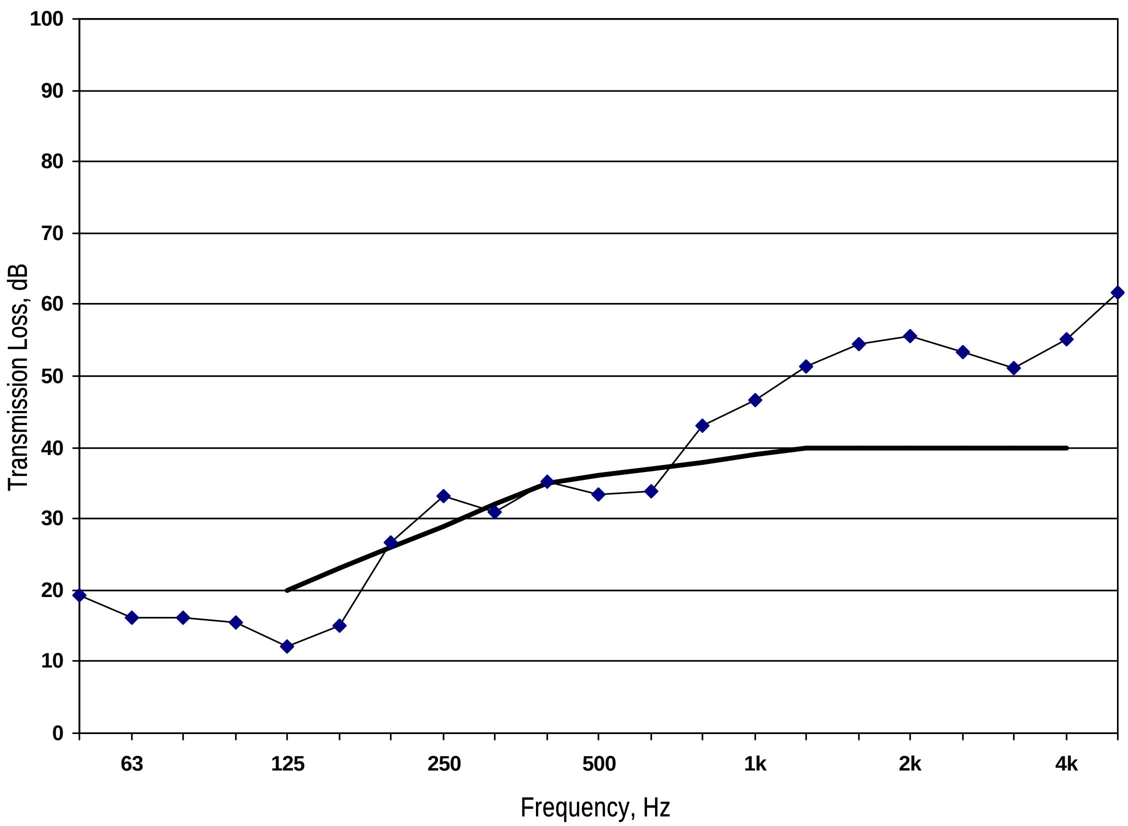
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	89 mm deep wood stud at 406 mm on centre
4	89 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	regular
thickness (mm)	1	11	89	89	13
spacing (mm)	*	*	406	*	*
total mass (kg)	19	60	52	8.2	70
linear density (kg/m)	0.4	*	1.5	*	*
surface density (kg/m^2)	*	6.7	*	1.0	7.8
fastener spacing #1 (mm)	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	305 field	*	*	*

* indicates not applicable

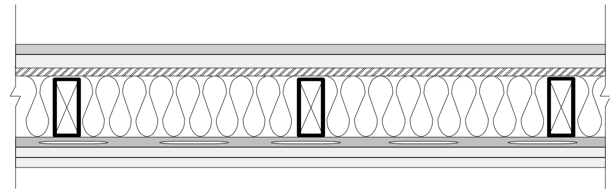
Freq, Hz	TL, dB
50	19
63	16
80	16
100	16
125	12
160	15
200	27
250	33
315	31
400	35
500	33
630	34
800	43
1000	47
1250	51
1600	54
2000	56
2500	53
3150	51
4000	55
5000	62
STC	36
OITC	24



NRC-CNRC National Research Council Canada

TLA-99-125a
VIN1_GFR25_OSB11_WS89(406)_GFB89_RC13(610)_2G13
Construction Type: wall

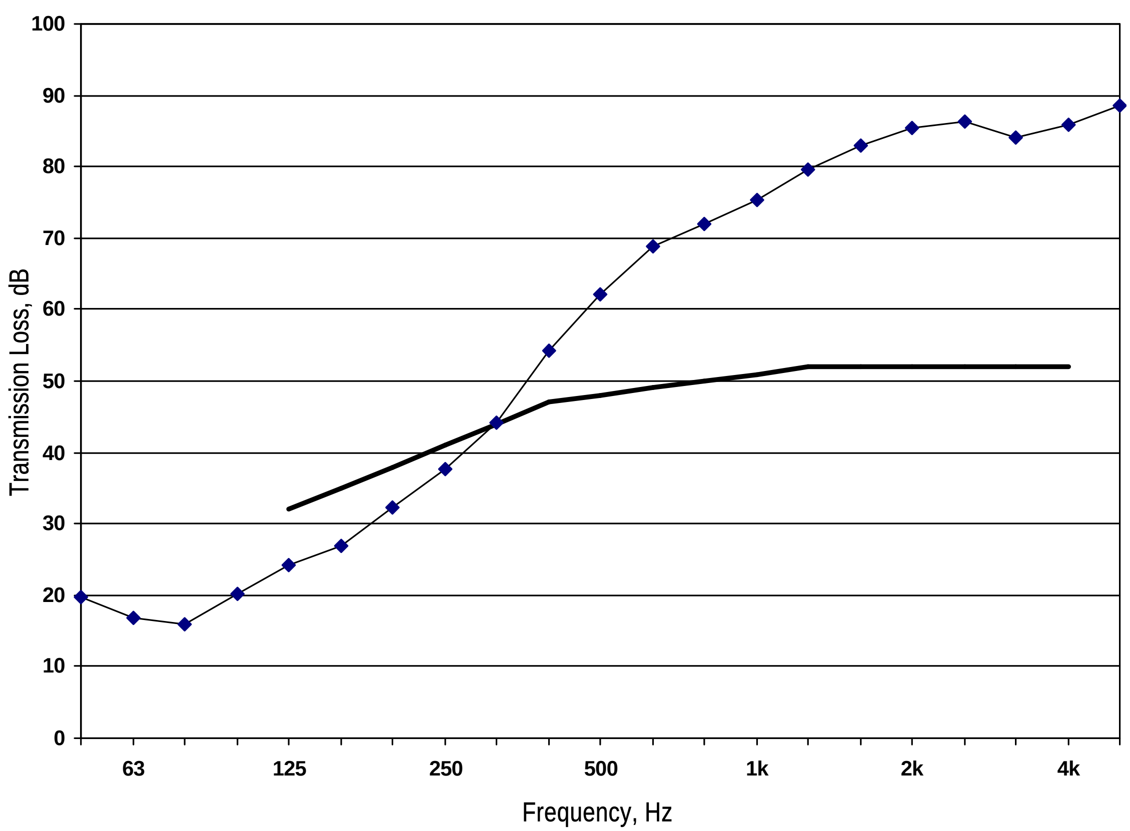
Element	Description
1	1 mm thick vinyl siding
2	25 mm thick rigid glass fibre insulation
3	11 mm thick oriented strand board
4	89 mm deep wood stud at 406 mm on centre
5	89 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	rigid insulation	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	glass fibre	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	1	25	11	89	89	13	13	13
spacing (mm)	*	*	*	406	*	610	*	*
total mass (kg)	20	12	67	58	7.8	4.4	71	71
linear density (kg/m)	*	*	*	1.7	*	0.2	*	*
surface density (kg/m^2)	0.4	1.3	7.5	*	0.9	*	7.9	7.9
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*	610 field	*

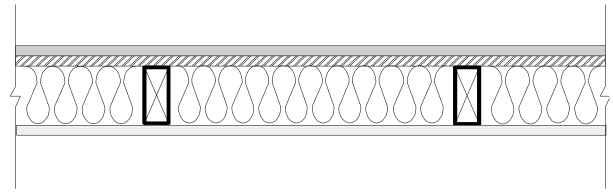
* indicates not applicable

Freq, Hz	TL, dB
50	20
63	17
80	16
100	20
125	24
160	27
200	32
250	38
315	44
400	54
500	62
630	69
800	72
1000	75
1250	80
1600	83
2000	85
2500	86
3150	84
4000	86
5000	89
STC	48
OITC	32



TLA-00-025a
VIN1_OSB11_WS89(610)_GFB89_G13
Construction Type: wall

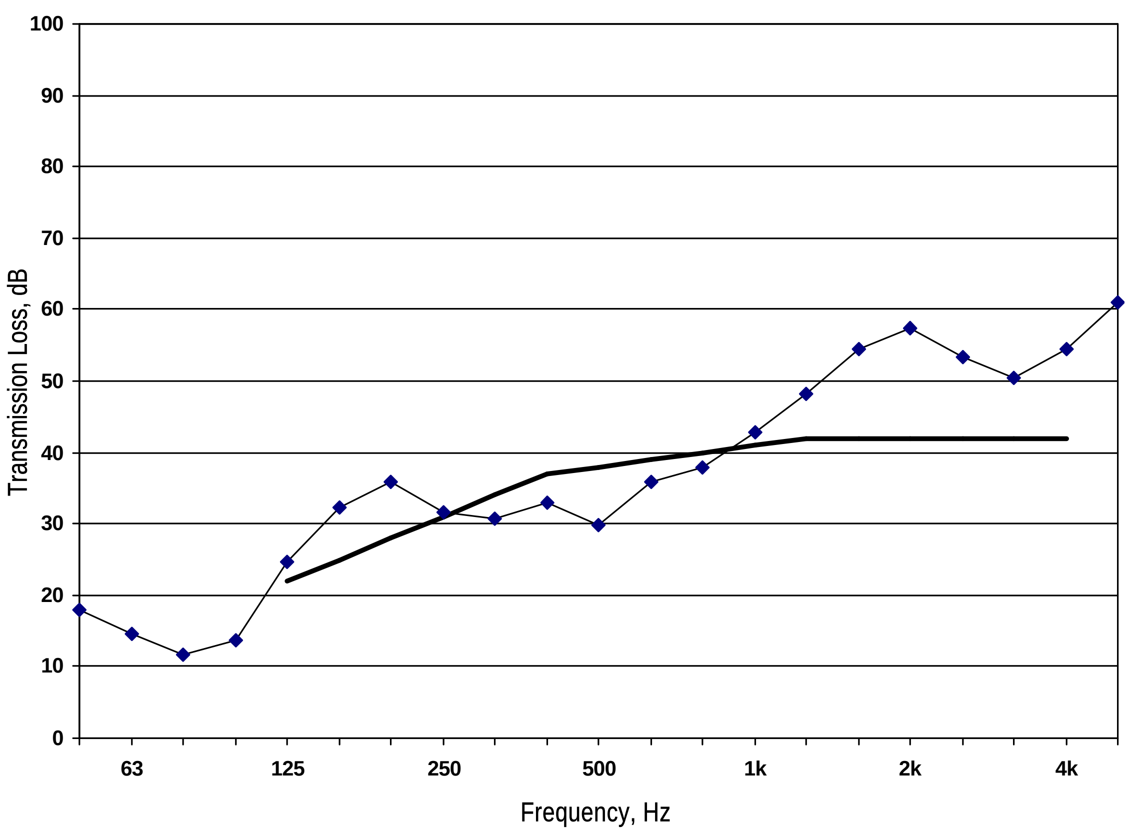
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	89 mm deep wood stud at 610 mm on centre
4	89 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	regular
thickness (mm)	1	11	89	89	13
spacing (mm)	*	*	610	*	*
total mass (kg)	19	60	43	8.9	71
linear density (kg/m)	0.4	*	1.5	*	*
surface density (kg/m^2)	*	6.7	*	0.8	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	305
fastener spacing #2 (mm)	*	305 field	*	*	*

* indicates not applicable

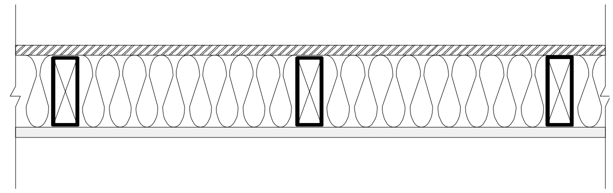
Freq, Hz	TL, dB
50	18
63	15
80	12
100	14
125	25
160	32
200	36
250	32
315	31
400	33
500	30
630	36
800	38
1000	43
1250	48
1600	54
2000	58
2500	53
3150	51
4000	55
5000	61
STC	38
OITC	27



National Research
Council Canada

TLA-99-033a
OSB11_WS140(406)_GFB152_G13
Construction Type: wall

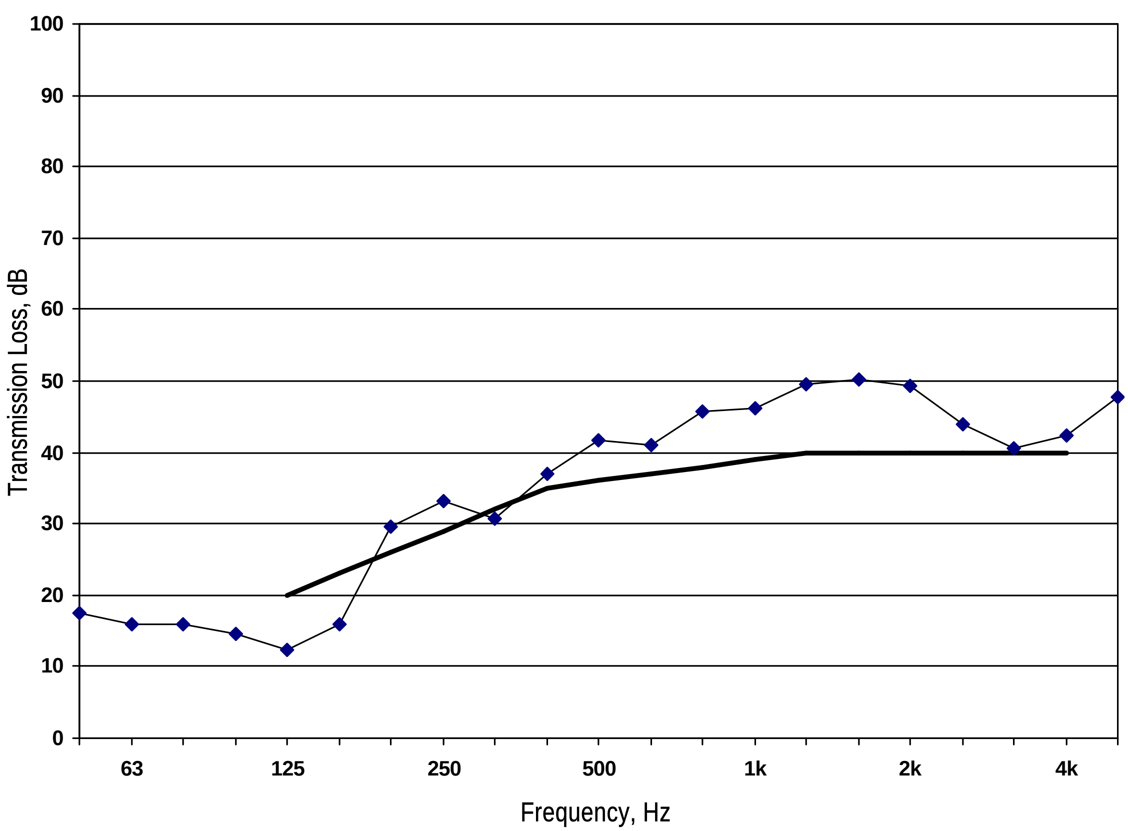
Element	Description
1	11 mm thick oriented strand board
2	140 mm deep wood stud at 406 mm on centre
3	152 mm thick glass fibre insulation in cavity
4	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4
type	sheathing	studs	insulation	gypsum board
material	OSB	wood	glass fibre	regular
thickness (mm)	11	140	152	13
spacing (mm)	*	406	*	*
total mass (kg)	59	88	13	72
linear density (kg/m)	*	2.6	*	*
surface density (kg/m^2)	6.6	*	1.4	8.1
fastener spacing #1 (mm)	152 edges	*	*	406
fastener spacing #2 (mm)	305 field	*	*	*

* indicates not applicable

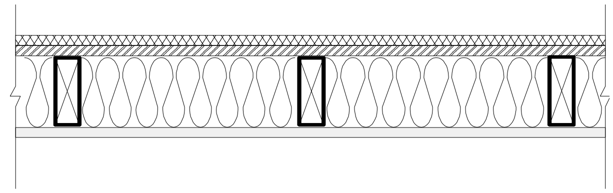
Freq, Hz	TL, dB
50	17
63	16
80	16
100	15
125	12
160	16
200	30
250	33
315	31
400	37
500	42
630	41
800	46
1000	46
1250	50
1600	50
2000	49
2500	44
3150	40
4000	42
5000	48
STC	36
OITC	25



NRC-CNRC National Research Council Canada

TLA-99-045a
ALM0.6_OSB11_WS140(406)_GFB152_G13
Construction Type: wall

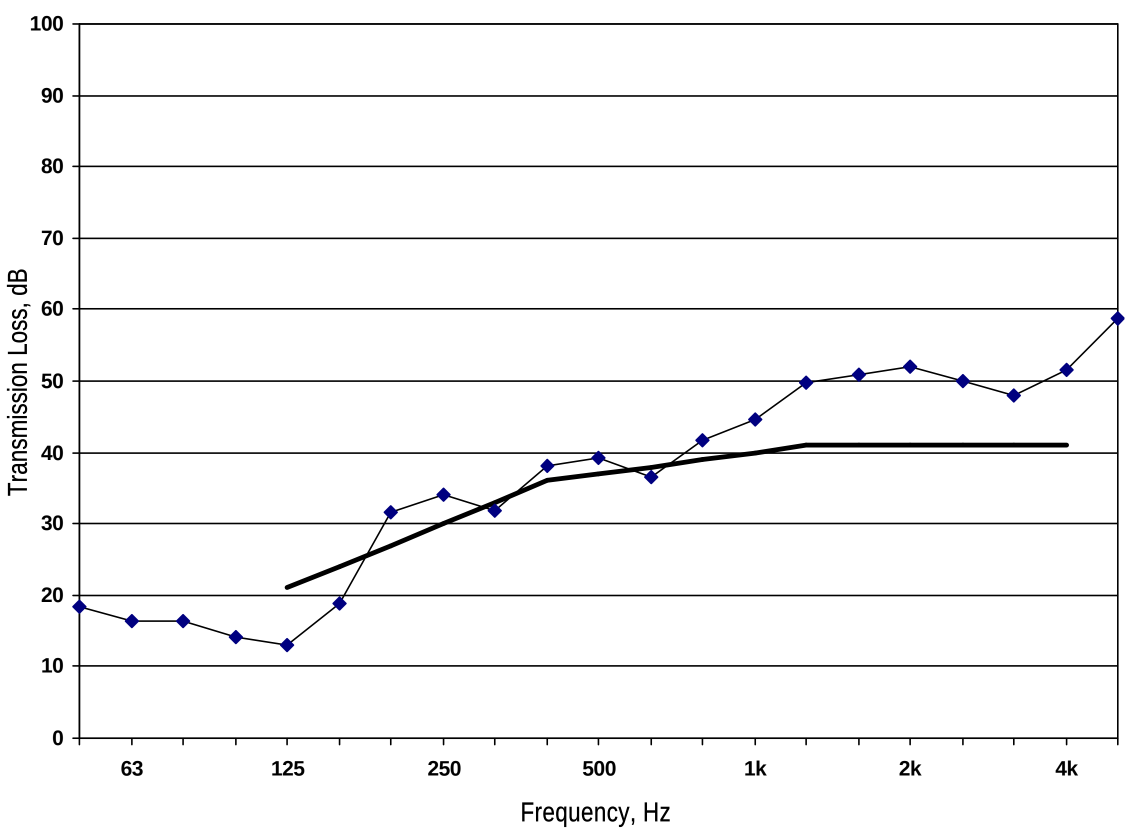
Element	Description
1	0.6 mm thick aluminum
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	aluminum	OSB	wood	glass fibre	regular
thickness (mm)	0.6	11	140	152	13
spacing (mm)	*	*	406	*	*
total mass (kg)	17	59	88	13	72
linear density (kg/m)	*	*	2.6	*	*
surface density (kg/m^2)	0.4	6.6	*	1.4	8.1
fastener spacing #1 (mm)	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	305 field	*	*	*

* indicates not applicable

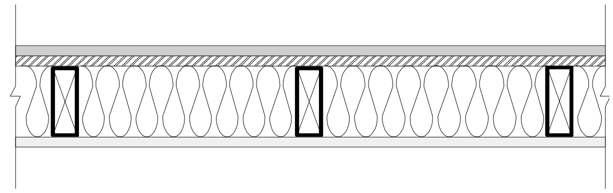
Freq, Hz	TL, dB
50	18
63	16
80	16
100	14
125	13
160	19
200	32
250	34
315	32
400	38
500	39
630	37
800	42
1000	45
1250	50
1600	51
2000	52
2500	50
3150	48
4000	52
5000	59
STC	37
OITC	25



National Research
Council Canada

TLA-99-029a
VIN1_OSB11_WS140(406)_GFB152_G13
Construction Type: wall

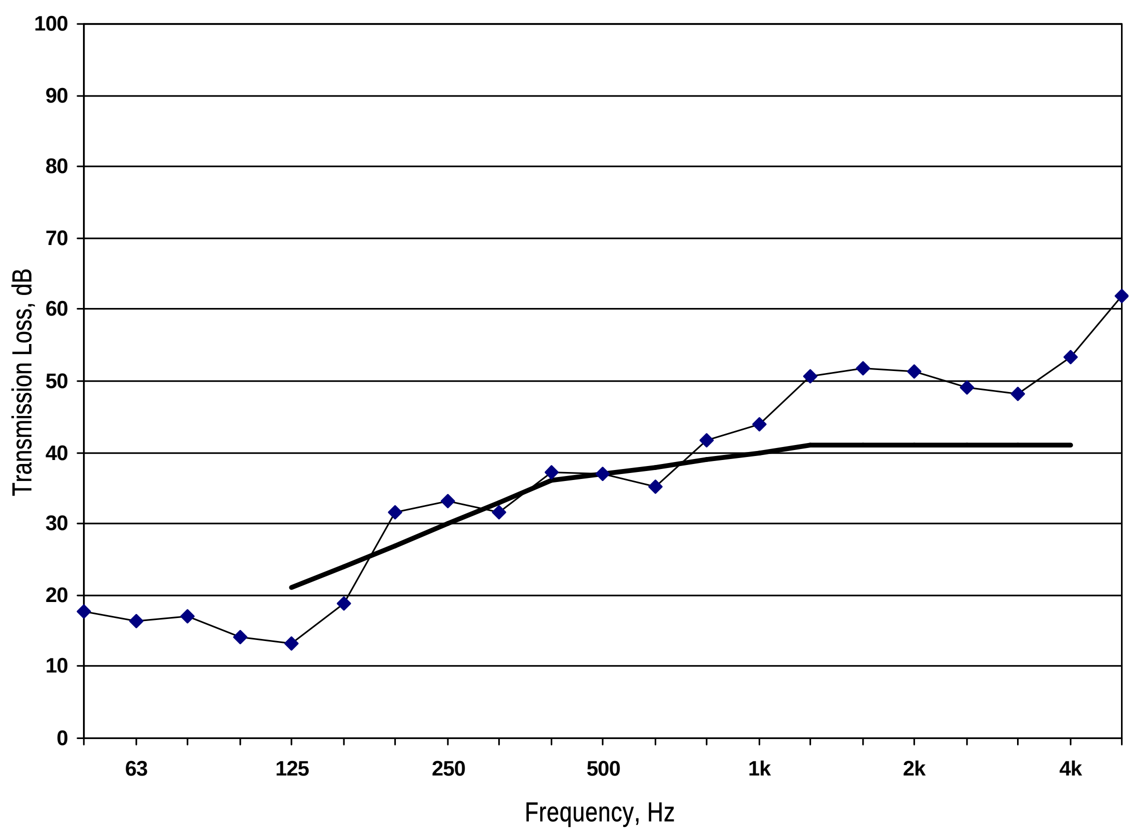
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	regular
thickness (mm)	1	11	140	152	13
spacing (mm)	*	*	406	*	*
total mass (kg)	20	62	111	12	72
linear density (kg/m)	*	*	3.2	*	*
surface density (kg/m^2)	0.4	6.9	*	1.4	8.1
fastener spacing #1 (mm)	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	305 field	*	*	*

* indicates not applicable

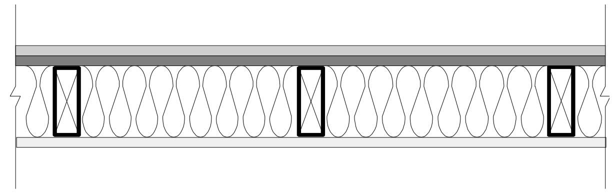
Freq, Hz	TL, dB
50	18
63	16
80	17
100	14
125	13
160	19
200	32
250	33
315	32
400	37
500	37
630	35
800	42
1000	44
1250	51
1600	52
2000	51
2500	49
3150	48
4000	53
5000	62
STC	37
OITC	25



NRC-CNRC National Research Council Canada

TLA-99-104a
VIN1_WFB13_WS140(406)_GFB152_G13
Construction Type: wall

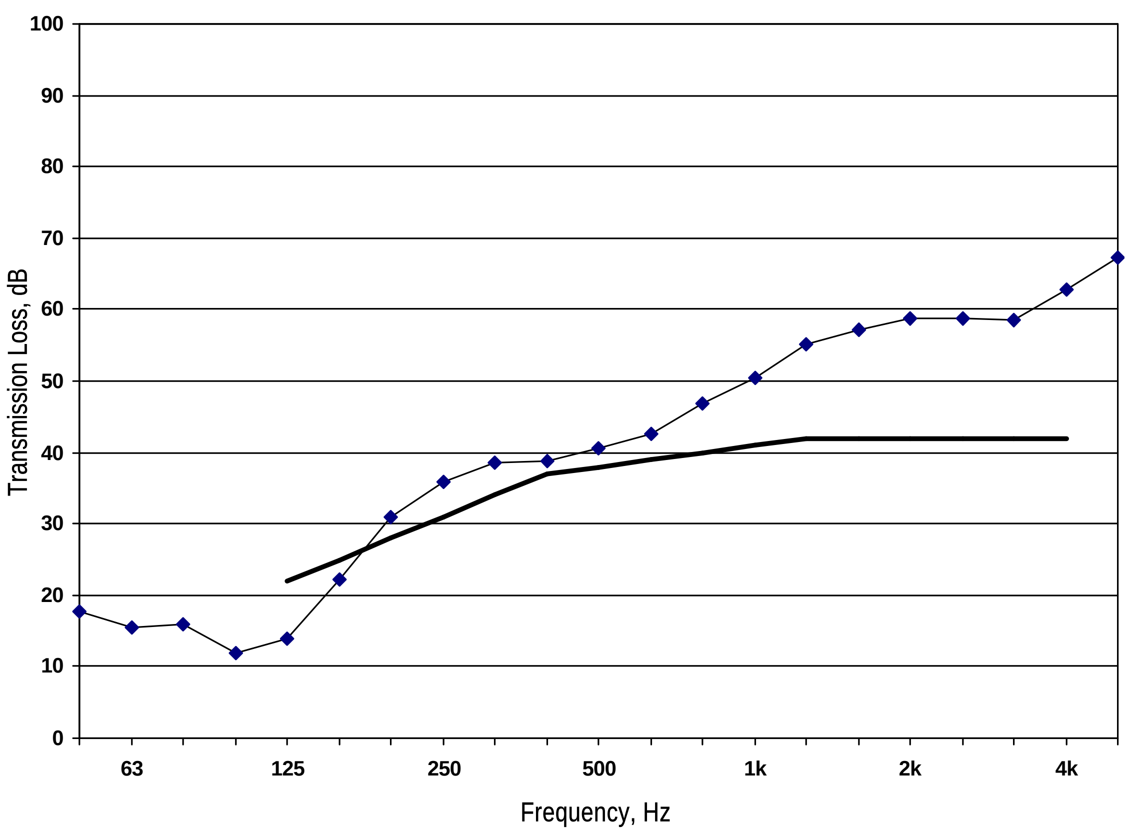
Element	Description
1	1 mm thick vinyl siding
2	13 mm thick wood fibre board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	fibre board	wood	glass fibre	regular
thickness (mm)	1	13	140	152	13
spacing (mm)	*	*	406	*	*
total mass (kg)	20	31	100	12	71
linear density (kg/m)	*	*	2.9	*	*
surface density (kg/m^2)	0.4	3.5	*	1.4	8.0
fastener spacing #1 (mm)	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	305 field	*	*	*

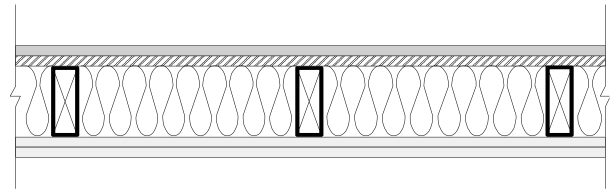
* indicates not applicable

Freq, Hz	TL, dB
50	18
63	16
80	16
100	12
125	14
160	22
200	31
250	36
315	39
400	39
500	41
630	43
800	47
1000	50
1250	55
1600	57
2000	59
2500	59
3150	58
4000	63
5000	67
STC	38
OITC	25



TLA-99-055a
VIN1_OSB11_WS140(406)_GFB152_2G13
Construction Type: wall

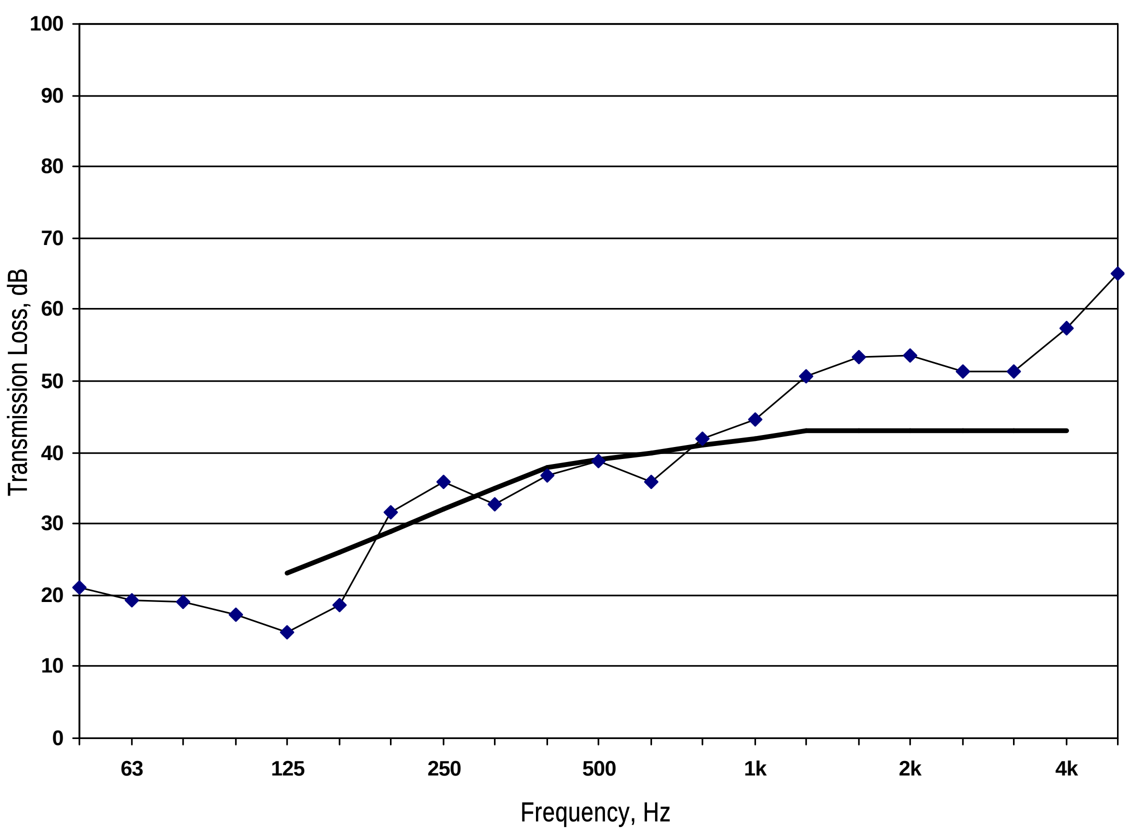
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	sheathing	studs	insulation	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	regular	regular
thickness (mm)	1	11	140	152	13	13
spacing (mm)	*	*	406	*	*	*
total mass (kg)	20	63	106	12	72	72
linear density (kg/m)	*	*	3.0	*	*	*
surface density (kg/m^2)	0.4	7.1	*	1.4	8.1	8.1
fastener spacing #1 (mm)	406	152 edges	*	*	610	406
fastener spacing #2 (mm)	*	305 field	*	*	*	*

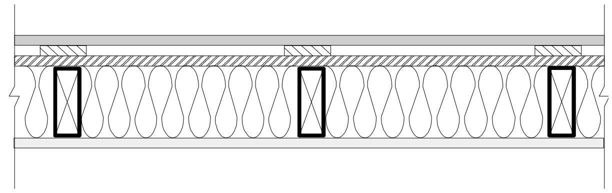
* indicates not applicable

Freq, Hz	TL, dB
50	21
63	19
80	19
100	17
125	15
160	19
200	32
250	36
315	33
400	37
500	39
630	36
800	42
1000	45
1250	51
1600	53
2000	54
2500	51
3150	51
4000	57
5000	65
STC	39
OITC	27



TLA-99-019a
VIN1_WFUR19(406)_OSB11_WS140(406)_GFB152_G13
Construction Type: wall

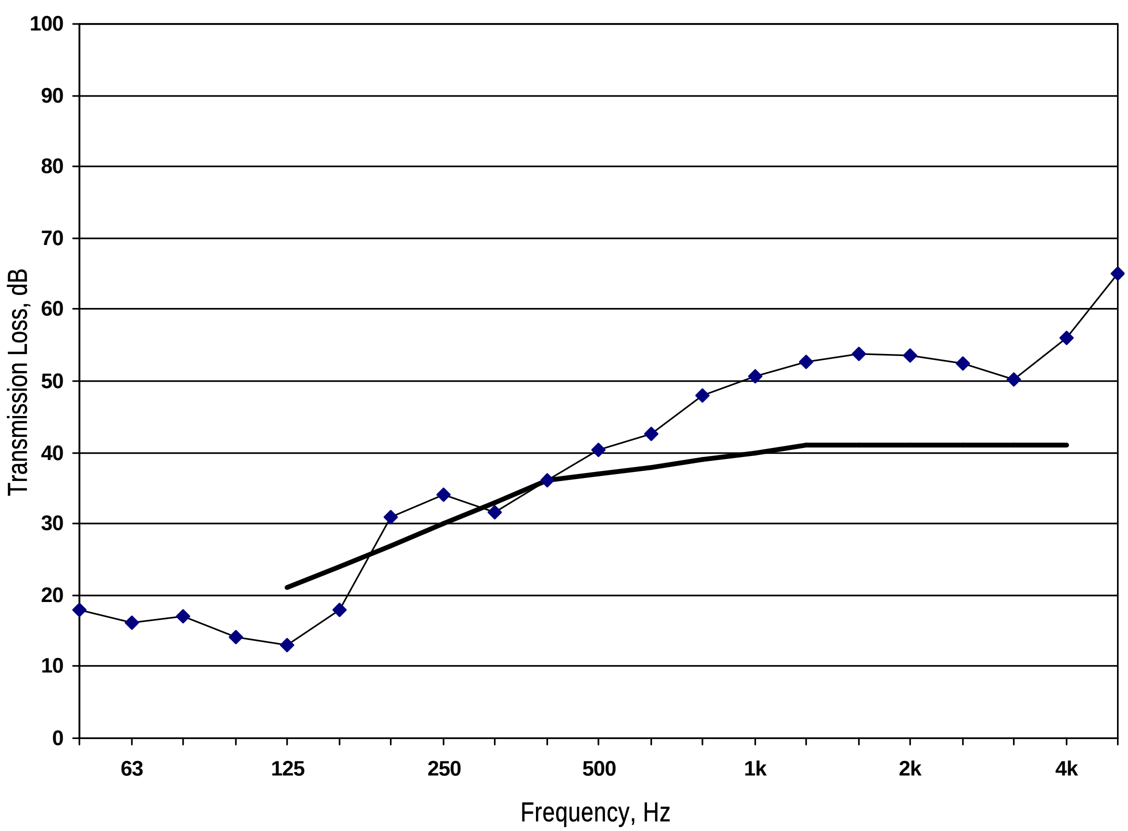
Element	Description
1	1 mm thick vinyl siding
2	19 mm thick wood furring at 406 mm on centre
3	11 mm thick oriented strand board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	strapping	sheathing	studs	insulation	gypsum board
material	vinyl	wood	OSB	wood	glass fibre	regular
thickness (mm)	1	19	11	140	152	13
spacing (mm)	*	406	*	406	*	*
total mass (kg)	20	16	62	111	12	72
linear density (kg/m)	*	0.51	*	3.2	*	*
surface density (kg/m^2)	0.4	*	6.9	*	1.4	8.1
fastener spacing #1 (mm)	406	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

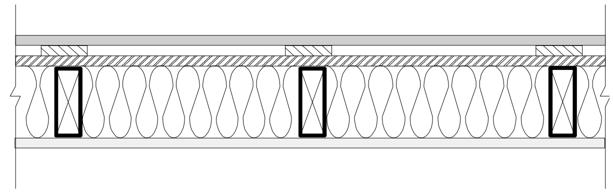
Freq, Hz	TL, dB
50	18
63	16
80	17
100	14
125	13
160	18
200	31
250	34
315	32
400	36
500	40
630	43
800	48
1000	51
1250	53
1600	54
2000	54
2500	52
3150	50
4000	56
5000	65
STC	37
OITC	25



NRC-CNRC National Research Council Canada

TLA-99-106a
VIN1_WFUR19(406)_WFB13_WS140(406)_GFB152_G13
Construction Type: wall

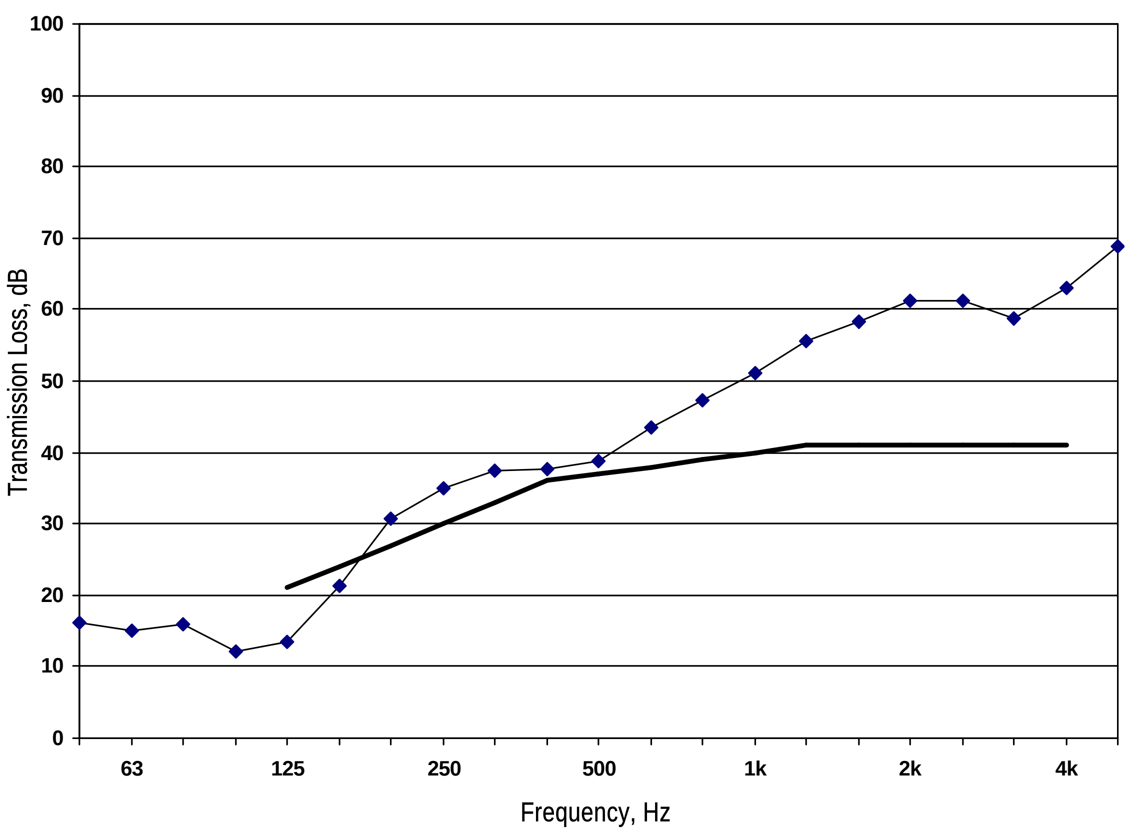
Element	Description
1	1 mm thick vinyl siding
2	19 mm thick wood furring at 406 mm on centre
3	13 mm thick wood fibre board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	strapping	sheathing	studs	insulation	gypsum board
material	vinyl	wood	fibre board	wood	glass fibre	regular
thickness (mm)	1	19	13	140	152	13
spacing (mm)	*	406	*	406	*	*
total mass (kg)	20	16	31	100	12	71
linear density (kg/m)	*	0.51	*	2.9	*	*
surface density (kg/m^2)	0.4	*	3.5	*	1.4	8.0
fastener spacing #1 (mm)	406	406	152 edges	*	*	406
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

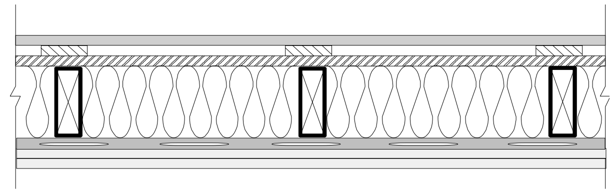
Freq, Hz	TL, dB
50	16
63	15
80	16
100	12
125	13
160	21
200	31
250	35
315	37
400	38
500	39
630	44
800	47
1000	51
1250	56
1600	58
2000	61
2500	61
3150	59
4000	63
5000	69
STC	37
OITC	25



National Research Council Canada

TLA-99-081a
VIN1_WFUR19(406)_OSB11_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

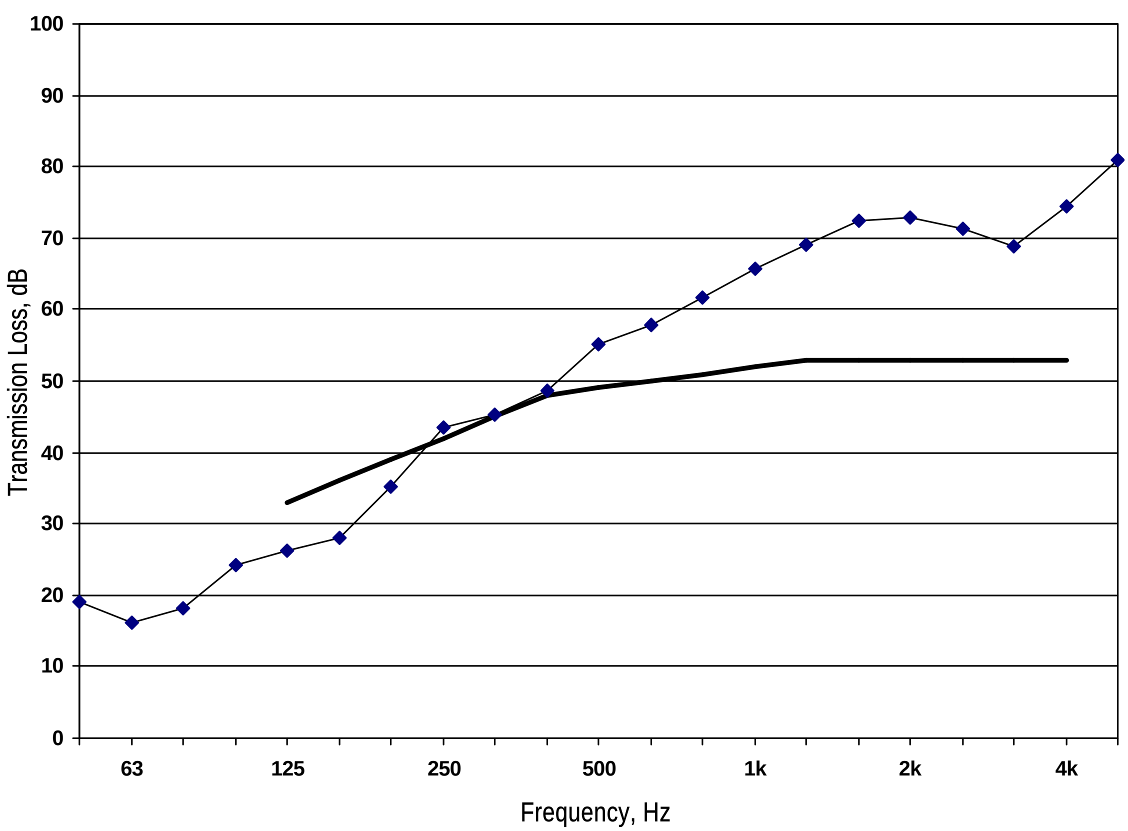
Element	Description
1	1 mm thick vinyl siding
2	19 mm thick wood furring at 406 mm on centre
3	11 mm thick oriented strand board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	strapping	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	wood	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	1	19	11	140	152	13	13	13
spacing (mm)	*	406	*	406	*	610	*	*
total mass (kg)	20	16	61	101	12	4.4	72	71
linear density (kg/m)	*	0.51	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	*	6.9	*	1.4	*	8.0	7.9
fastener spacing #1 (mm)	406	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	610 field	*

* indicates not applicable

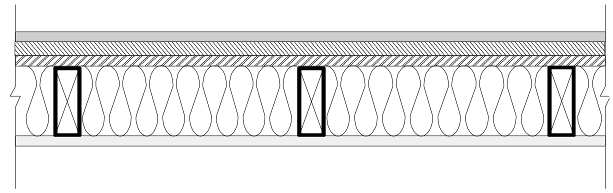
Freq, Hz	TL, dB
50	19
63	16
80	18
100	24
125	26
160	28
200	35
250	44
315	45
400	49
500	55
630	58
800	62
1000	66
1250	69
1600	72
2000	73
2500	71
3150	69
4000	74
5000	81
STC	49
OITC	34



National Research Council Canada

TLA-99-035a
VIN1_EPS25_OSB11_WS140(406)_GFB152_G13
Construction Type: wall

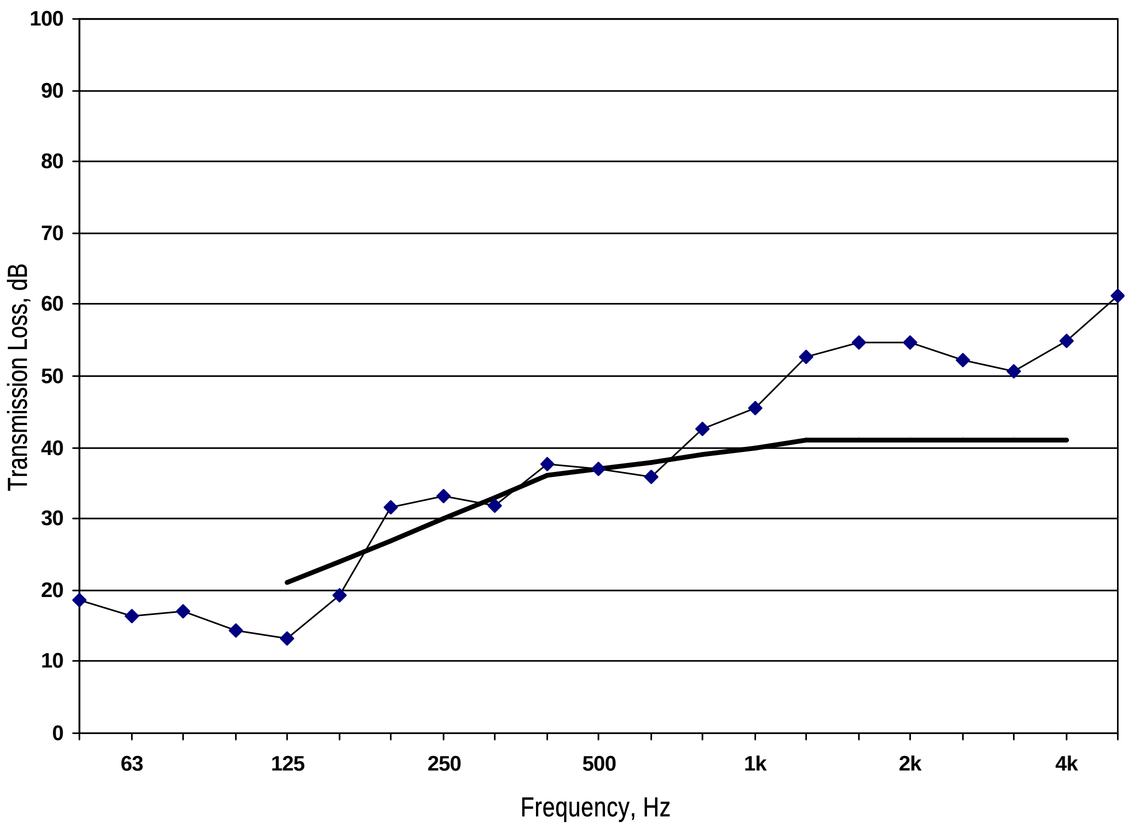
Element	Description
1	1 mm thick vinyl siding
2	25 mm thick expanded polystyrene
3	11 mm thick oriented strand board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	insulation	sheathing	studs	insulation	gypsum board
material	vinyl	polystyrene	OSB	wood	glass fibre	regular
thickness (mm)	1	25	11	140	152	13
spacing (mm)	*	*	*	406	*	*
total mass (kg)	20	5.4	62	111	12	72
linear density (kg/m)	*	*	*	3.2	*	*
surface density (kg/m^2)	0.4	0.6	6.9	*	1.4	8.1
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	406
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*

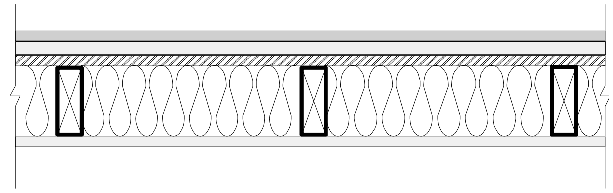
* indicates not applicable

Freq, Hz	TL, dB
50	19
63	16
80	17
100	14
125	13
160	19
200	32
250	33
315	32
400	38
500	37
630	36
800	43
1000	46
1250	53
1600	55
2000	55
2500	52
3150	51
4000	55
5000	61
STC	37
OITC	26



TLA-99-039a
VIN1_GFR25_OSB11_WS140(406)_GFB152_G13
Construction Type: wall

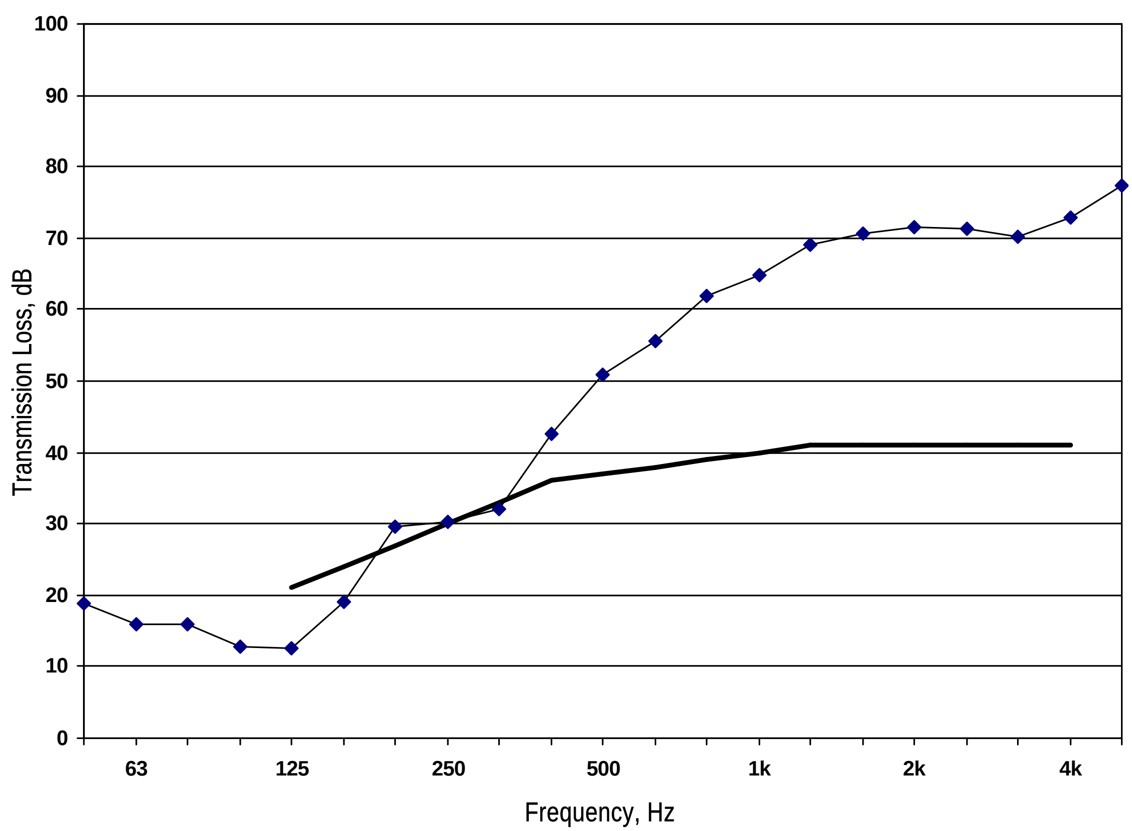
Element	Description
1	1 mm thick vinyl siding
2	25 mm thick rigid glass fibre insulation
3	11 mm thick oriented strand board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	rigid insulation	sheathing	studs	insulation	gypsum board
material	vinyl	glass fibre	OSB	wood	glass fibre	regular
thickness (mm)	1	25	11	140	152	13
spacing (mm)	*	*	*	406	*	*
total mass (kg)	20	12	62	111	12	72
linear density (kg/m)	*	*	*	3.2	*	*
surface density (kg/m^2)	0.4	1.3	6.9	*	1.4	8.1
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	406
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*

* indicates not applicable

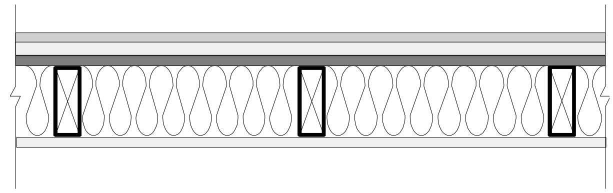
Freq, Hz	TL, dB
50	19
63	16
80	16
100	13
125	13
160	19
200	30
250	30
315	32
400	43
500	51
630	56
800	62
1000	65
1250	69
1600	71
2000	71
2500	71
3150	70
4000	73
5000	77
STC	37
OITC	25



National Research
Council Canada

TLA-99-108a
VIN1_GFR25_WFB13_WS140(406)_GFB152_G13
Construction Type: wall

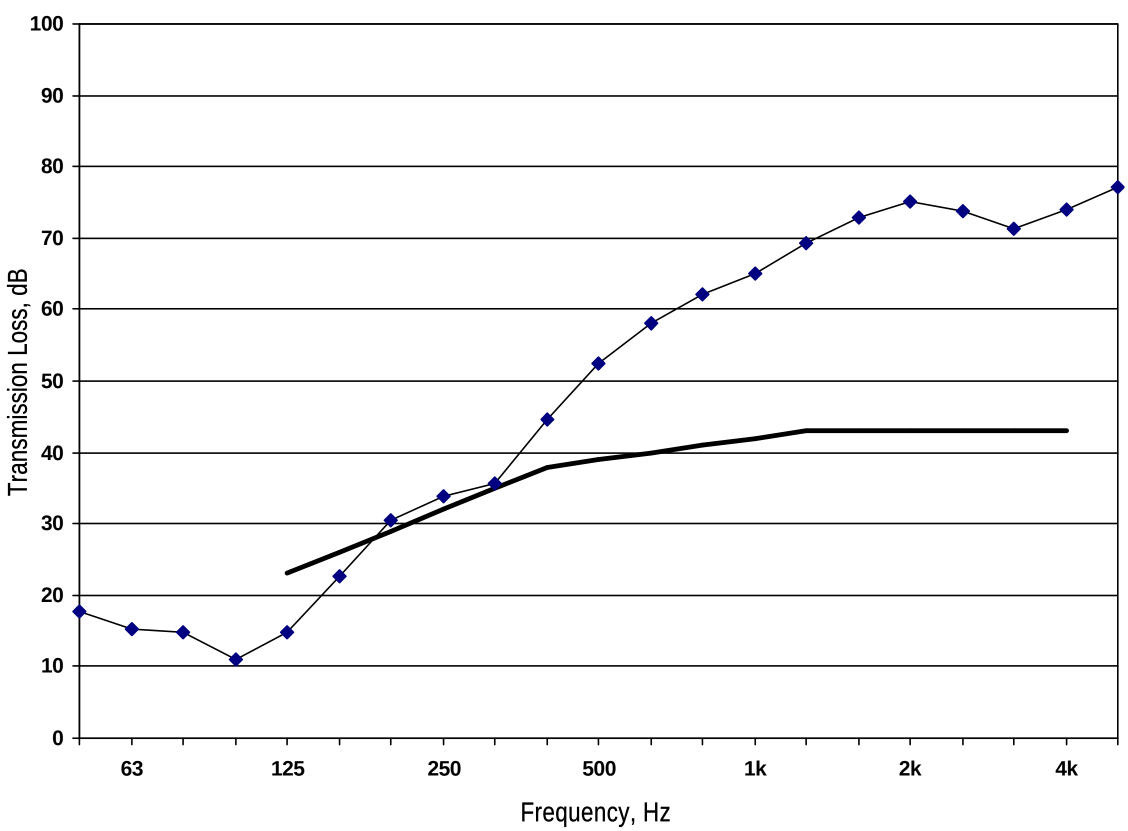
Element	Description
1	1 mm thick vinyl siding
2	25 mm thick rigid glass fibre insulation
3	13 mm thick wood fibre board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	insulation	sheathing	studs	insulation	gypsum board
material	vinyl	rigid glass fibre	fibre board	wood	glass fibre	regular
thickness (mm)	1	25	13	140	152	13
spacing (mm)	*	*	*	406	*	*
total mass (kg)	20	12	31	100	12	71
linear density (kg/m)	*	*	*	2.9	*	*
surface density (kg/m^2)	0.4	1.3	3.5	*	1.4	8.0
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	406
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*

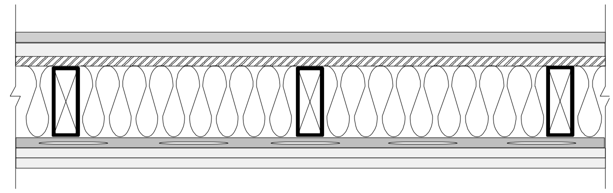
* indicates not applicable

Freq, Hz	TL, dB
50	18
63	15
80	15
100	11
125	15
160	23
200	30
250	34
315	36
400	45
500	53
630	58
800	62
1000	65
1250	69
1600	73
2000	75
2500	74
3150	71
4000	74
5000	77
STC	39
OITC	25



TLA-99-089a
VIN1_GFR25_OSB11_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

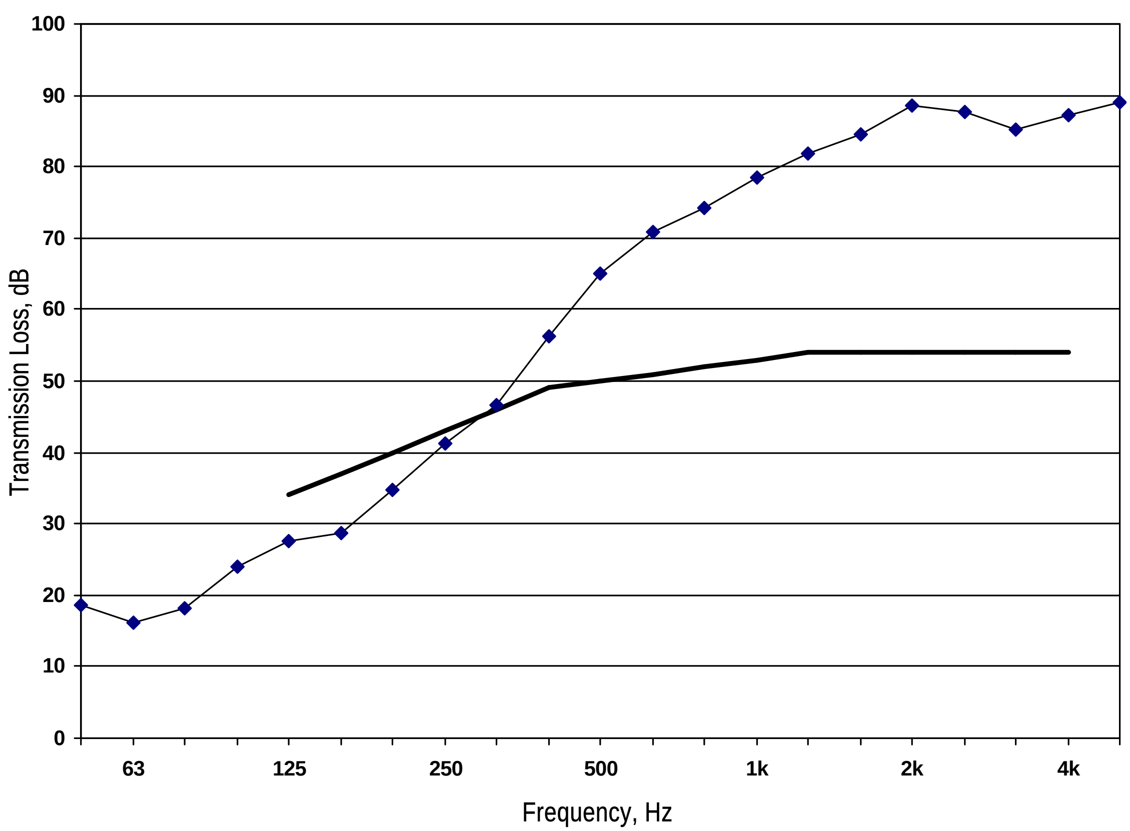
Element	Description
1	1 mm thick vinyl siding
2	25 mm thick rigid glass fibre insulation
3	11 mm thick oriented strand board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



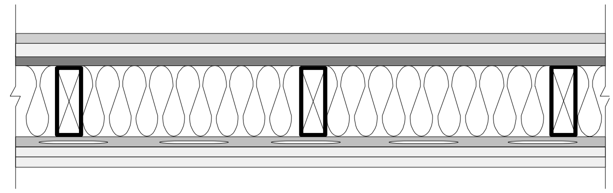
	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	rigid insulation	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	glass fibre	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	1	25	11	140	152	13	13	13
spacing (mm)	*	*	*	406	*	610	*	*
total mass (kg)	20	12	61	101	12	4.4	72	71
linear density (kg/m)	*	*	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	1.3	6.9	*	1.4	*	8.0	7.9
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*	610 field	*

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	16
80	18
100	24
125	28
160	29
200	35
250	41
315	47
400	56
500	65
630	71
800	74
1000	78
1250	82
1600	85
2000	89
2500	88
3150	85
4000	87
5000	89
STC	50
OITC	35



TLA-99-112a
VIN1_GFR25_WFB13_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

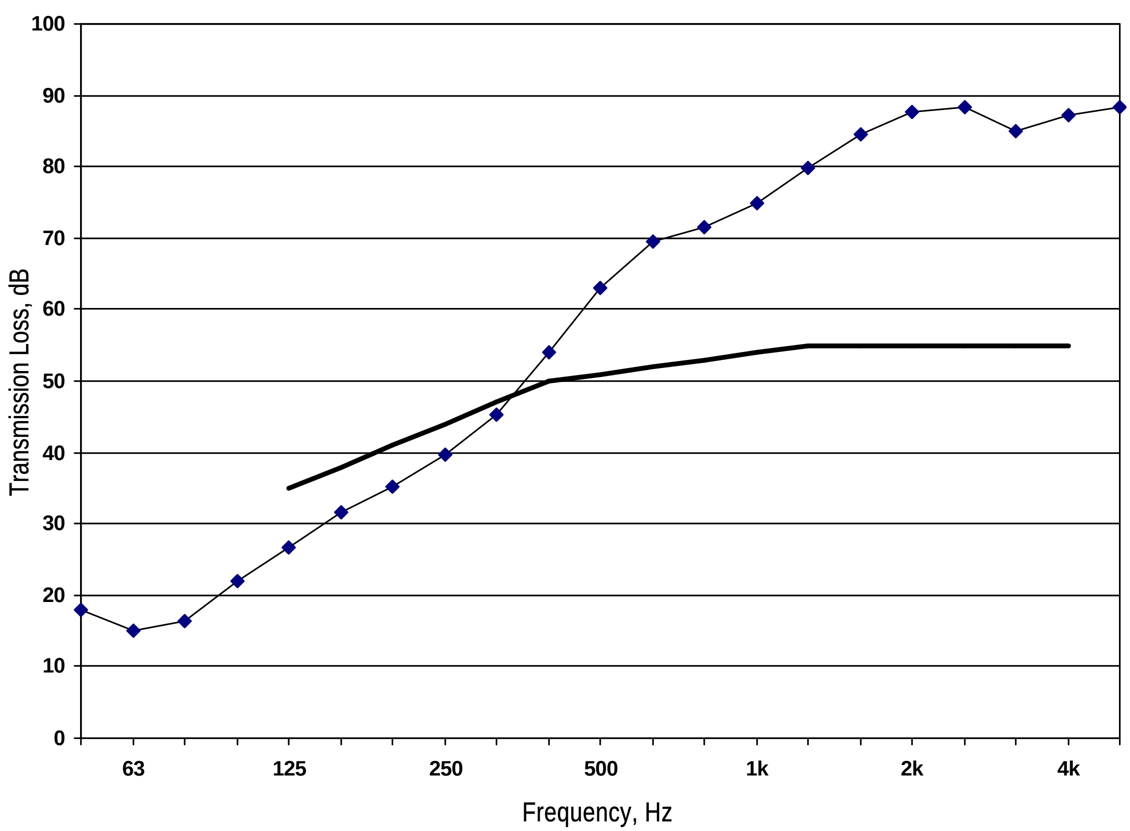


Element	Description
1	1 mm thick vinyl siding
2	25 mm thick rigid glass fibre insulation
3	13 mm thick wood fibre board
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	insulation	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	rigid glass fibre	fibre board	wood	glass fibre	GP	regular	regular
thickness (mm)	1	25	13	140	152	13	13	13
spacing (mm)	*	*	*	406	*	610	*	*
total mass (kg)	20	12	31	100	12	4.4	71	70
linear density (kg/m)	*	*	*	2.9	*	0.2	*	*
surface density (kg/m^2)	0.4	1.3	3.5	*	1.4	*	7.9	7.9
fastener spacing #1 (mm)	406	305 edges	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	457 field	305 field	*	*	*	610 field	*

* indicates not applicable

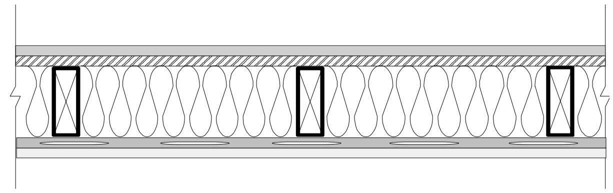
Freq, Hz	TL, dB
50	18
63	15
80	16
100	22
125	27
160	32
200	35
250	40
315	45
400	54
500	63
630	70
800	72
1000	75
1250	80
1600	85
2000	88
2500	88
3150	85
4000	87
5000	88
STC	51
OITC	33



National Research Council Canada

TLA-99-061a
VIN1_OSB11_WS140(406)_GFB152_RC13(610)_G13
Construction Type: wall

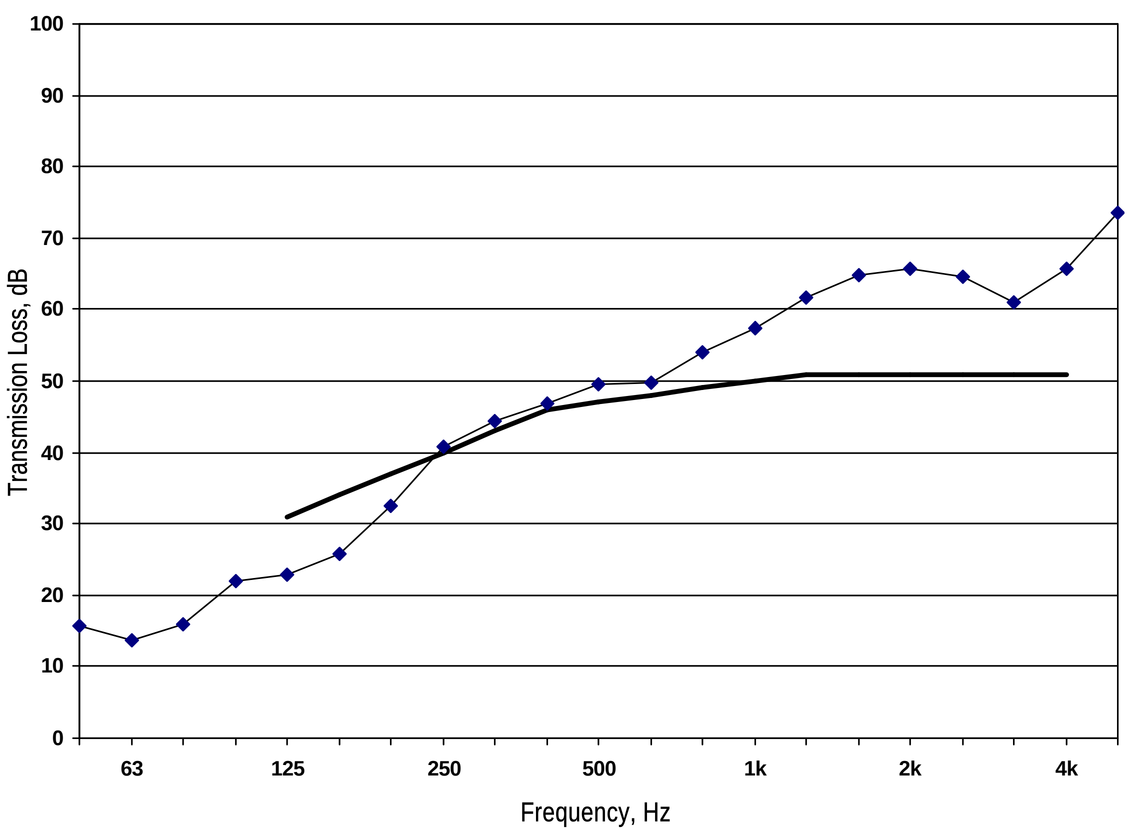
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board
material	vinyl	OSB	wood	glass fibre	GP	regular
thickness (mm)	1	11	140	152	13	13
spacing (mm)	*	*	406	*	610	*
total mass (kg)	20	63	106	12	4.3	72
linear density (kg/m)	*	*	3.0	*	0.2	*
surface density (kg/m^2)	0.4	7.1	*	1.4	*	8.0
fastener spacing #1 (mm)	406	152 edges	*	*	*	305
fastener spacing #2 (mm)	*	305 field	*	*	*	*

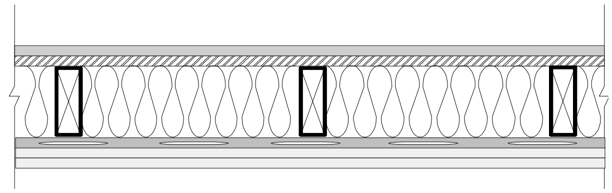
* indicates not applicable

Freq, Hz	TL, dB
50	16
63	14
80	16
100	22
125	23
160	26
200	33
250	41
315	44
400	47
500	50
630	50
800	54
1000	57
1250	62
1600	65
2000	66
2500	65
3150	61
4000	66
5000	74
STC	47
OITC	32



TLA-99-075a
VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

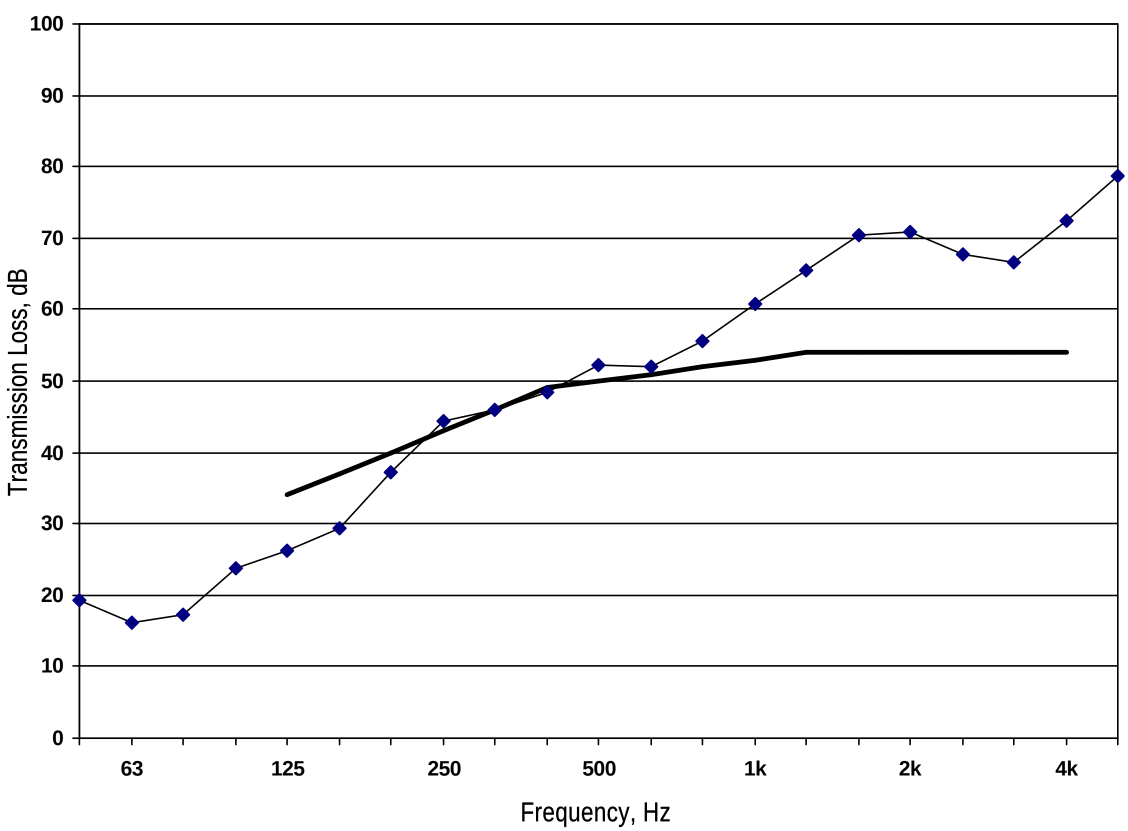
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	1	11	140	152	13	13	13
spacing (mm)	*	*	406	*	610	*	*
total mass (kg)	20	61	101	12	4.4	72	71
linear density (kg/m)	*	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	6.9	*	1.4	*	8.1	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	305 field	*	*	*	610 field	*

* indicates not applicable

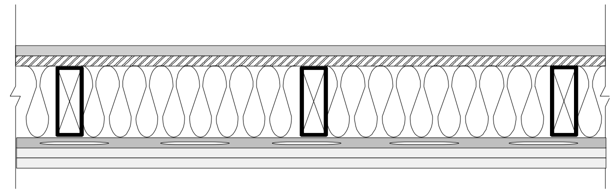
Freq, Hz	TL, dB
50	19
63	16
80	17
100	24
125	26
160	29
200	37
250	44
315	46
400	49
500	52
630	52
800	56
1000	61
1250	66
1600	70
2000	71
2500	68
3150	67
4000	72
5000	79
STC	50
OITC	34



NRC-CNRC National Research Council Canada

TLA-99-077a
VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

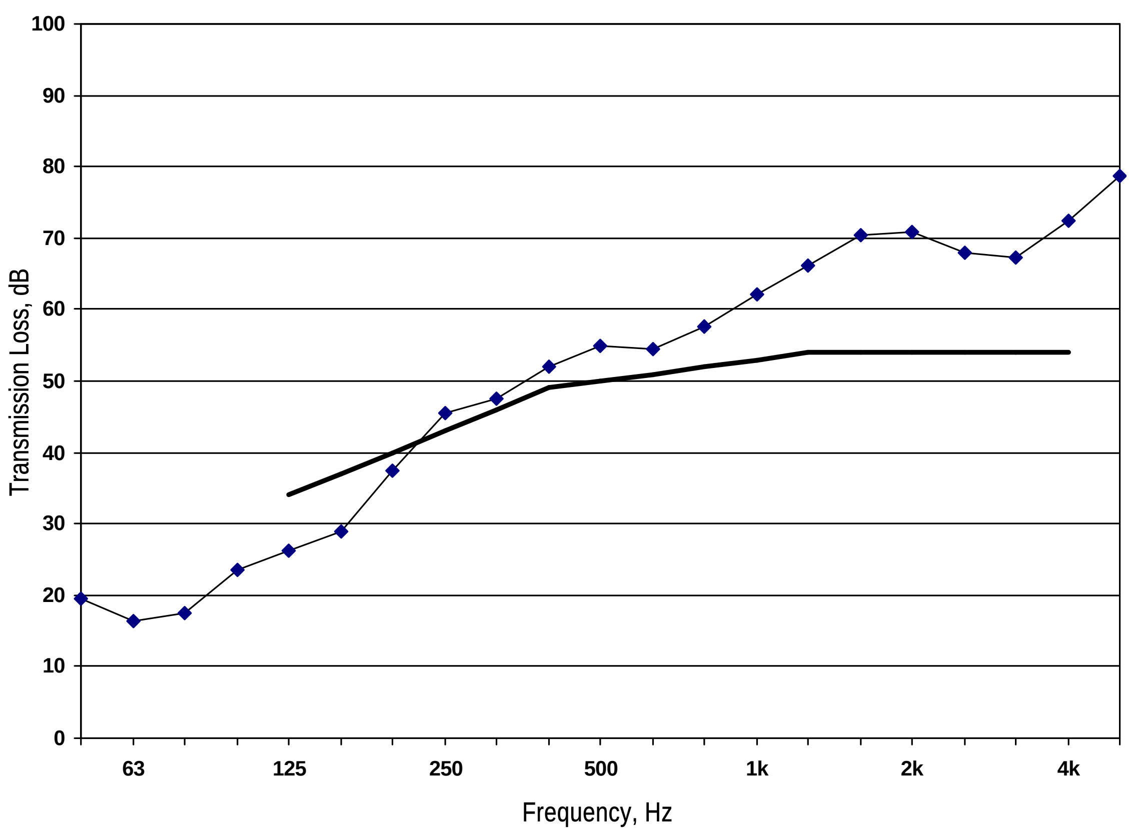
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	BM	regular	regular
thickness (mm)	1	11	140	152	13	13	13
spacing (mm)	*	*	406	*	610	*	*
total mass (kg)	20	61	101	12	4.4	72	71
linear density (kg/m)	*	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	6.9	*	1.4	*	8.1	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	305 field	*	*	*	610 field	*

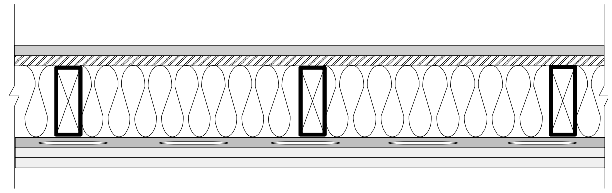
* indicates not applicable

Freq, Hz	TL, dB
50	20
63	16
80	17
100	24
125	26
160	29
200	37
250	45
315	48
400	52
500	55
630	54
800	58
1000	62
1250	66
1600	70
2000	71
2500	68
3150	67
4000	72
5000	79
STC	50
OITC	34



NRC-CNRC National Research Council Canada

TLA-99-079a
VIN1_OSB11_WS140(406)_GFB152_RC13(610)_2G13
Construction Type: wall

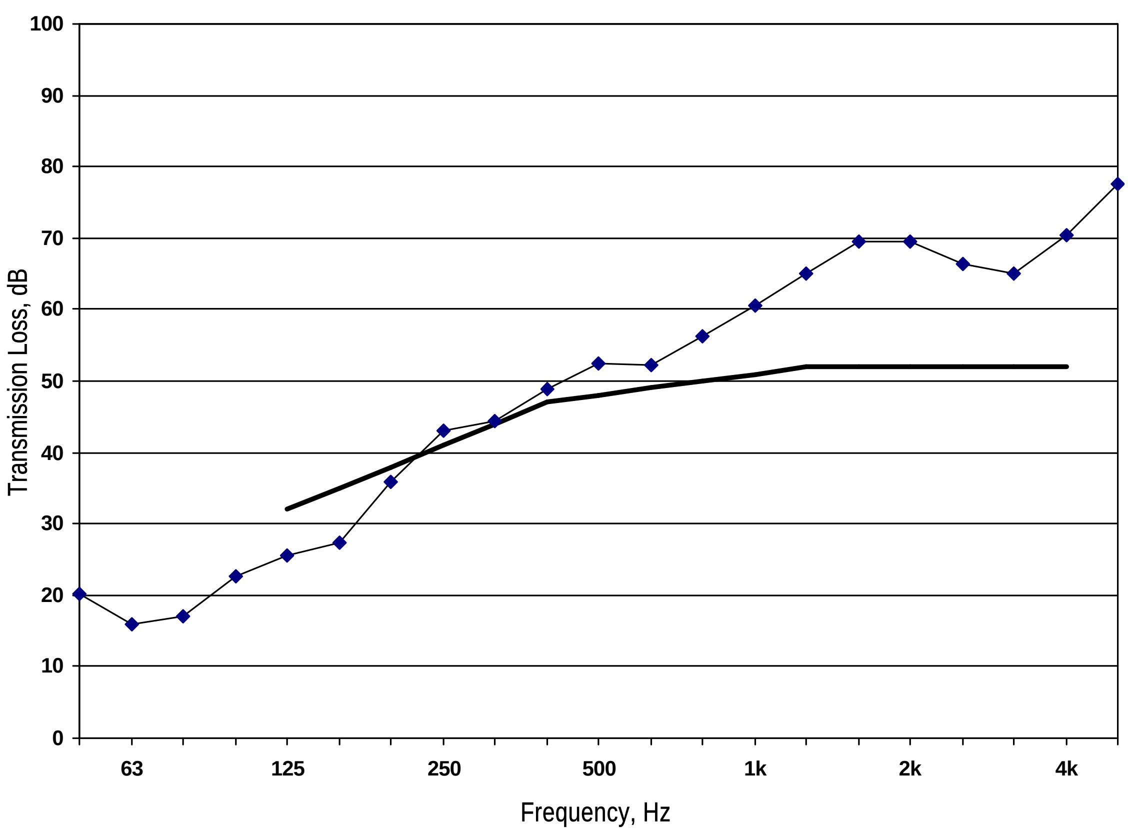


Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	GP (Special)	regular	regular
thickness (mm)	1	11	140	152	13	13	13
spacing (mm)	*	*	406	*	610	*	*
total mass (kg)	20	61	101	12	4.9	72	71
linear density (kg/m)	*	*	3.0	*	0.3	*	*
surface density (kg/m^2)	0.4	6.9	*	1.4	*	8.1	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	305 field	*	*	*	610 field	*

* indicates not applicable

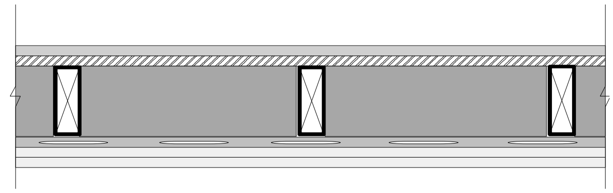
Freq, Hz	TL, dB
50	20
63	16
80	17
100	23
125	26
160	27
200	36
250	43
315	44
400	49
500	52
630	52
800	56
1000	60
1250	65
1600	70
2000	70
2500	66
3150	65
4000	70
5000	77
STC	48
OITC	33



NRC-CNRC National Research Council Canada

TLA-99-093a
VIN1_OSB11_WS140(406)_CFL140_RC13(610)_2G13
Construction Type: wall

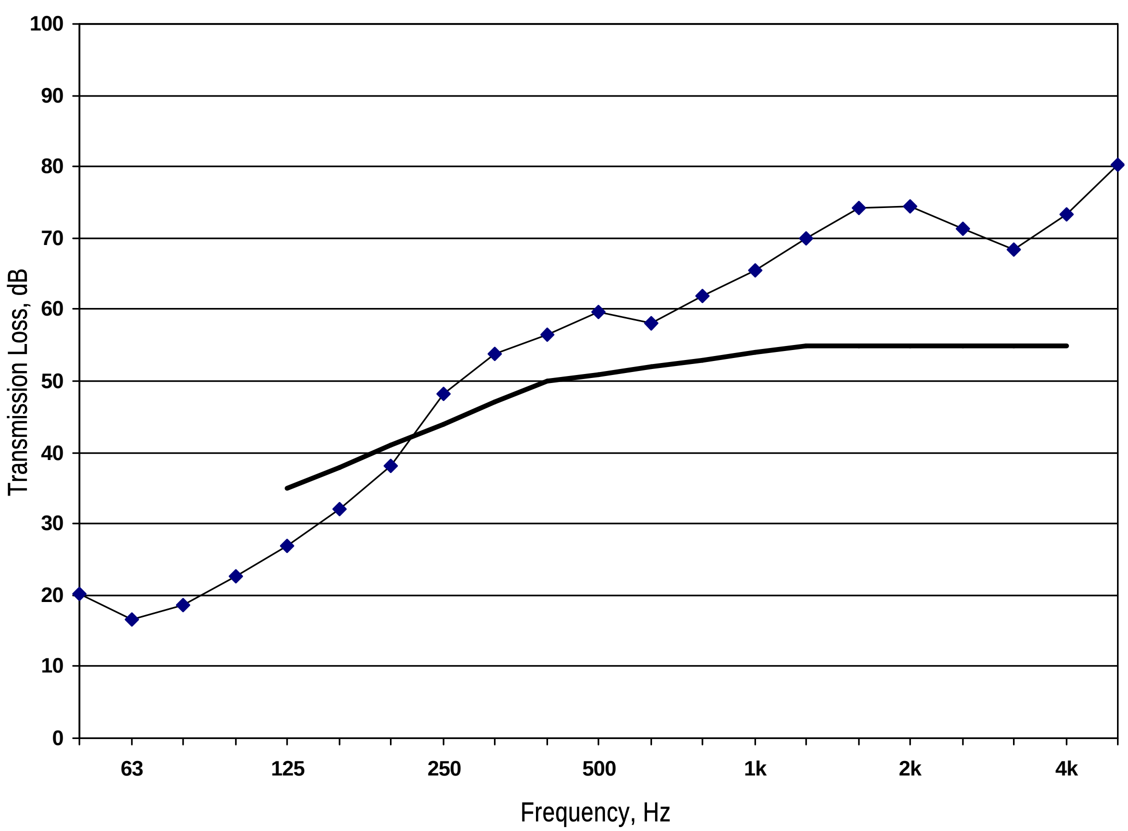
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	140 mm thick dry, blown cellulose insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	wood	cellulose	GP	regular	regular
thickness (mm)	1	11	140	140	13	13	13
spacing (mm)	*	*	406	*	610	*	*
total mass (kg)	20	61	101	61	4.3	69	72
linear density (kg/m)	*	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	6.9	*	8.0	*	7.7	8.0
fastener spacing #1 (mm)	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	305 field	*	*	*	610 field	*

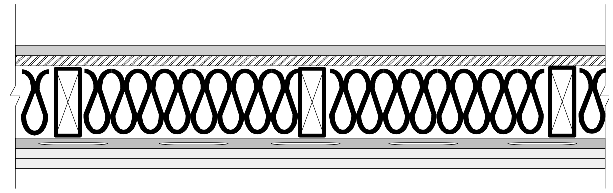
* indicates not applicable

Freq, Hz	TL, dB
50	20
63	17
80	19
100	23
125	27
160	32
200	38
250	48
315	54
400	57
500	60
630	58
800	62
1000	65
1250	70
1600	74
2000	74
2500	71
3150	68
4000	73
5000	80
STC	51
OITC	35



TLA-99-100a
VIN1_OSB11_WS140(406)_RFB140_RC13(610)_2G13
Construction Type: wall

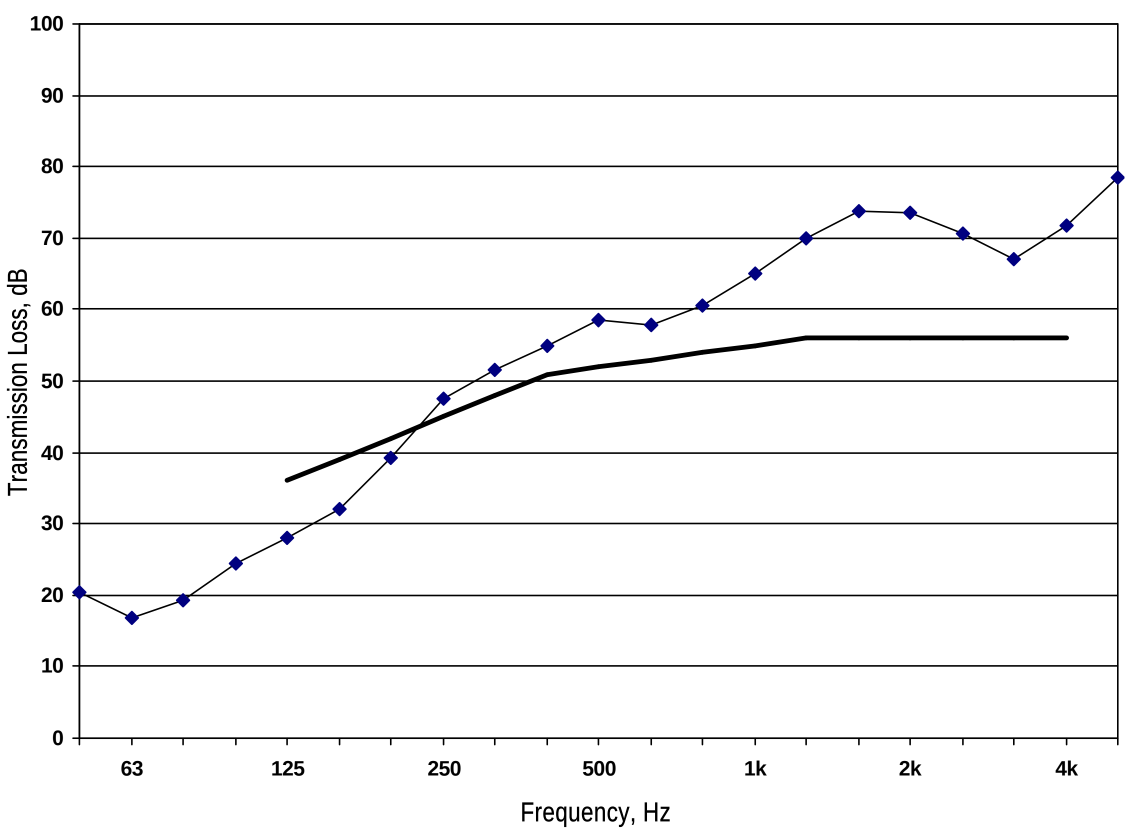
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 406 mm on centre
4	140 mm thick rock fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	wood	rock fibre	GP	regular	regular
thickness (mm)	1	11	140	140	13	13	13
spacing (mm)	*	*	406	*	610	*	*
total mass (kg)	20	61	101	47	4.3	69	72
linear density (kg/m)	*	*	3.0	*	0.2	*	*
surface density (kg/m^2)	0.4	6.9	*	5.6	*	7.7	8.0
fastener spacing #1 (mm)	406	152 edges	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	305 field	*	*	*	610 field	*

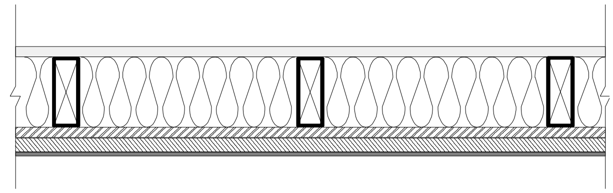
* indicates not applicable

Freq, Hz	TL, dB
50	20
63	17
80	19
100	24
125	28
160	32
200	39
250	48
315	52
400	55
500	58
630	58
800	61
1000	65
1250	70
1600	74
2000	74
2500	71
3150	67
4000	72
5000	78
STC	52
OITC	36



NRC-CNRC National Research Council Canada

TLA-99-071a
G13_WS140(406)_GFB152_OSB11_BPAP0.7_EPS25_EIF6
Construction Type: wall

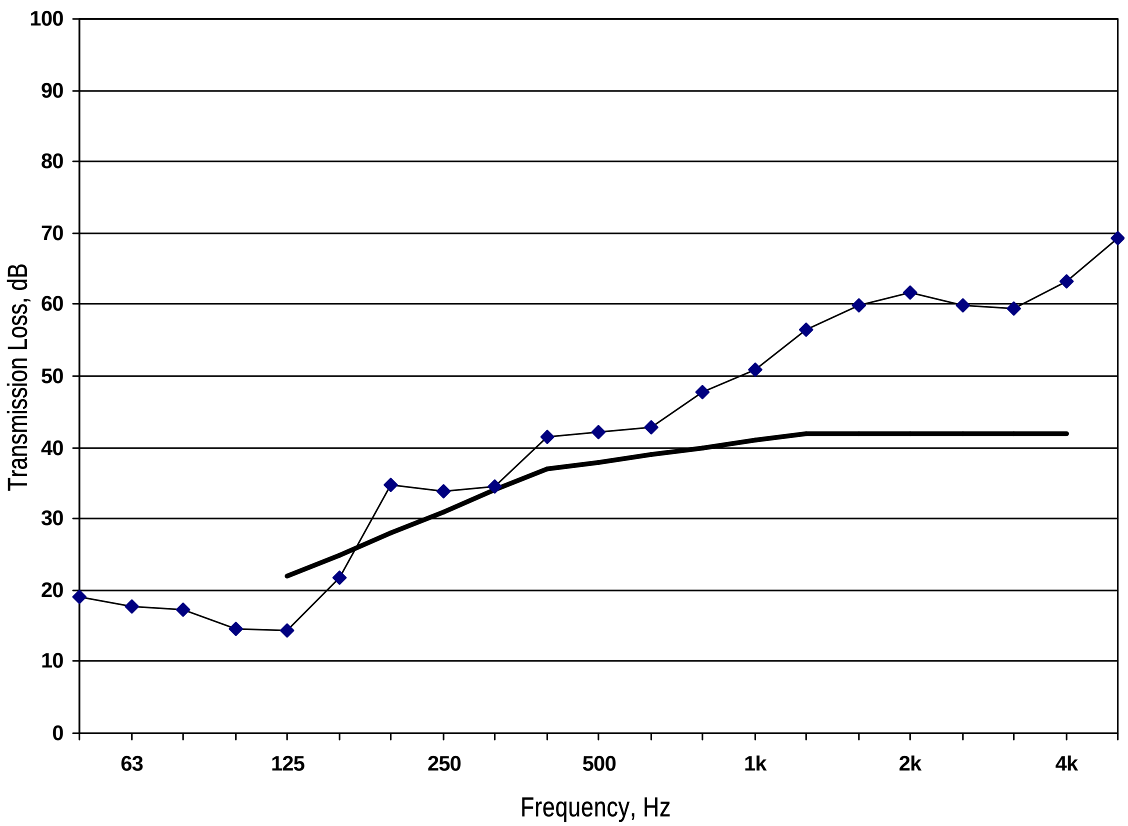


Element	Description
1	13 mm thick regular gypsum board
2	140 mm deep wood stud at 406 mm on centre
3	152 mm thick glass fibre insulation in cavity
4	11 mm thick oriented strand board
5	0.7 mm thick building paper
6	25 mm thick expanded polystyrene
7	6 mm thick exterior insulation and finish system (EIF)

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	gypsum board	studs	insulation	sheathing	paper	insulation	stucco
material	regular	wood	glass fibre	OSB	building paper	polystyrene	EIF
thickness (mm)	13	140	152	11	0.7	25	6
spacing (mm)	*	406	*	*	*	*	*
total mass (kg)	72	95	13	58	5.2	5.4	91
linear density (kg/m)	*	2.8	*	*	*	*	*
surface density (kg/m^2)	8.0	*	1.4	6.5	0.6	0.6	10
fastener spacing #1 (mm)	406	*	*	152 edges	*	305 edges	*
fastener spacing #2 (mm)	*	*	*	305 field	*	457 field	*

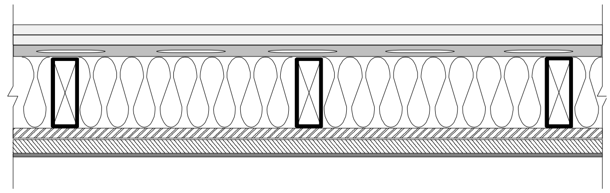
* indicates not applicable

Freq, Hz	TL, dB
50	19
63	18
80	17
100	15
125	14
160	22
200	35
250	34
315	34
400	41
500	42
630	43
800	48
1000	51
1250	57
1600	60
2000	62
2500	60
3150	59
4000	63
5000	69
STC	38
OITC	27



TLA-99-073a
2G13_RC13(610)_WS140(406)_GFB152_OSB11_BPAP0.7_EPS25_EIF6
Construction Type: wall

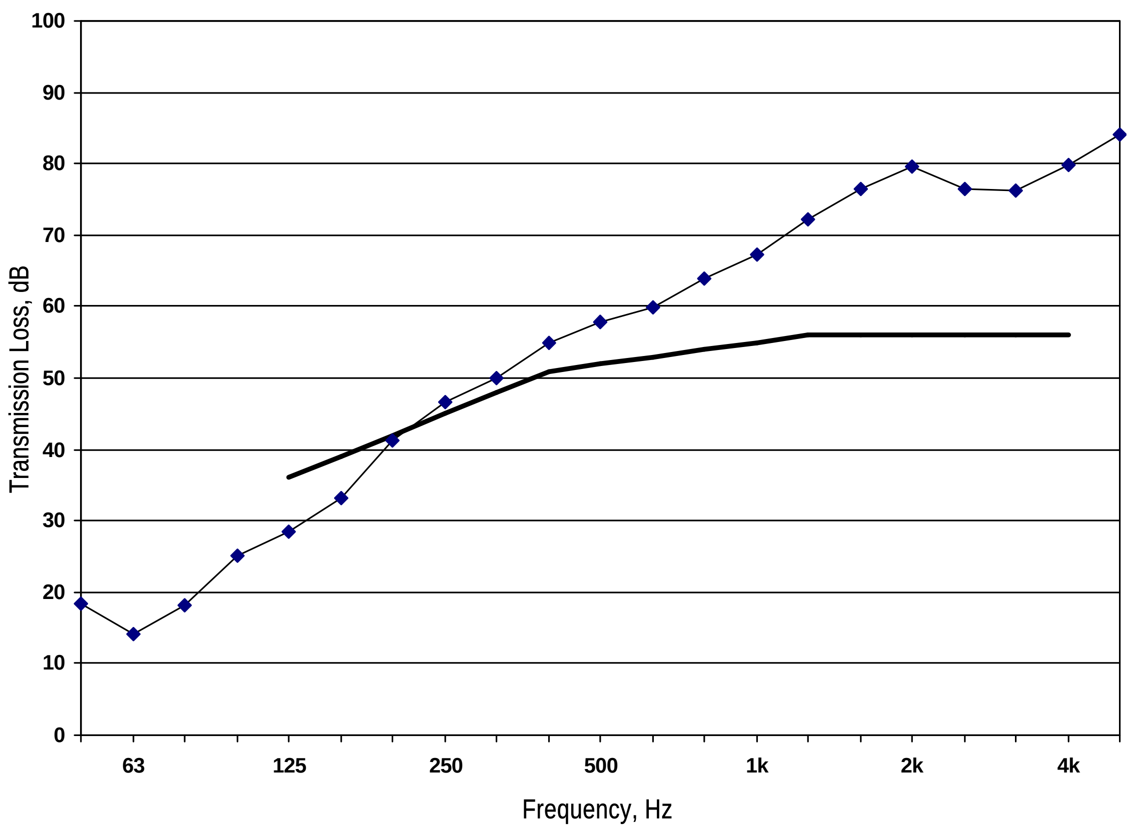
Element	Description
1	13 mm thick regular gypsum board
2	13 mm thick regular gypsum board
3	13 mm resilient channel at 610 mm on centre
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	11 mm thick oriented strand board
7	0.7 mm thick building paper
8	25 mm thick expanded polystyrene
9	6 mm thick exterior insulation and finish system (EIF)



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	gypsum board	gypsum board	resilient chan.	studs	insulation	sheathing	paper	insulation	stucco
material	regular	regular	GP	wood	glass fibre	OSB	building paper	polystyrene	EIF
thickness (mm)	13	13	13	140	152	11	0.7	25	6
spacing (mm)	*	*	610	406	*	*	*	*	*
total mass (kg)	72	71	4.3	95	13	58	5.2	5.4	91
linear density (kg/m)	*	*	0.2	2.8	*	*	*	*	*
surface density (kg/m^2)	8.0	8.1	*	*	1.4	6.5	0.6	0.6	10
fastener spacing #1 (mm)	305	305 edges	*	*	*	152 edges	*	305 edges	*
fastener spacing #2 (mm)	*	610 field	*	*	*	305 field	*	457 field	*

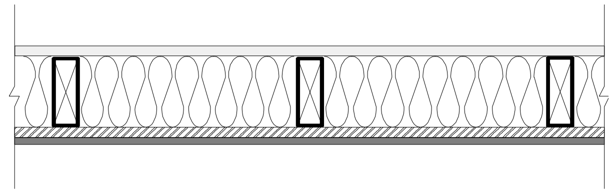
* indicates not applicable

Freq, Hz	TL, dB
50	18
63	14
80	18
100	25
125	28
160	33
200	41
250	47
315	50
400	55
500	58
630	60
800	64
1000	67
1250	72
1600	77
2000	80
2500	77
3150	76
4000	80
5000	84
STC	52
OITC	35



TLA-99-091a
G13_WS140(406)_GFB152_OSB11_BPAP0.7_STUC9.5
Construction Type: wall

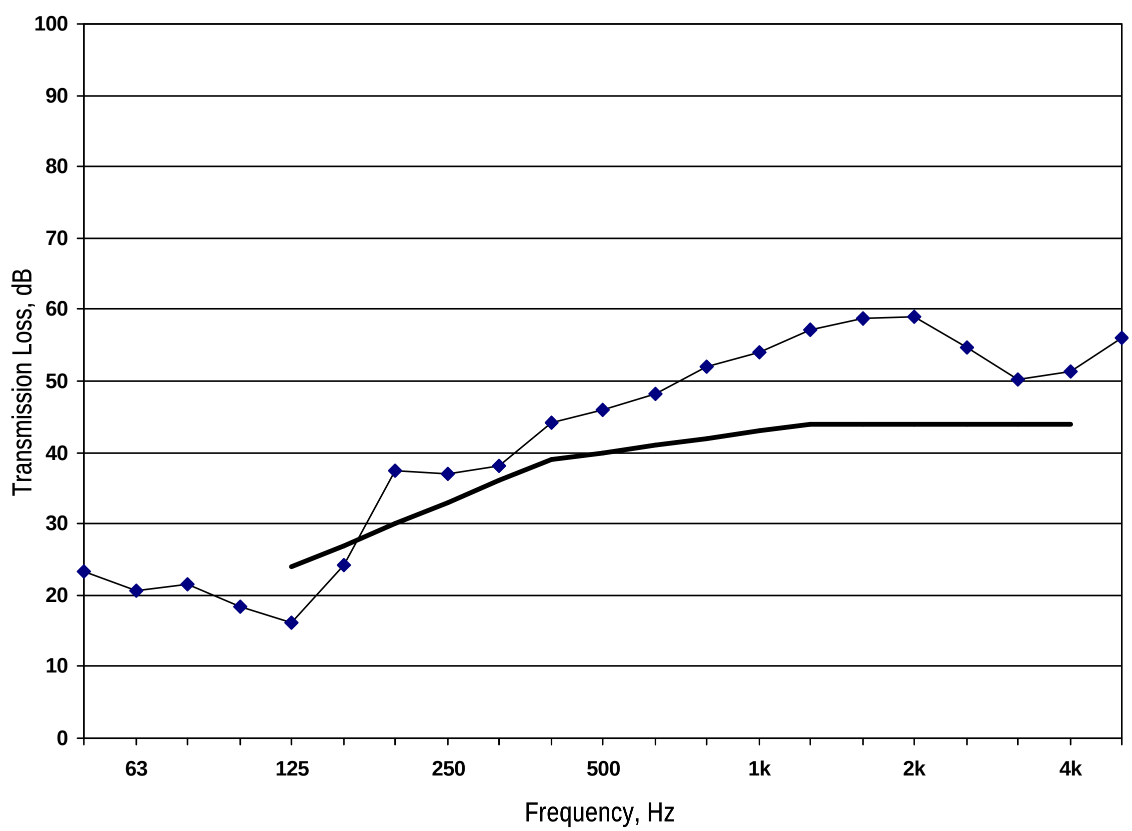
Element	Description
1	13 mm thick regular gypsum board
2	140 mm deep wood stud at 406 mm on centre
3	152 mm thick glass fibre insulation in cavity
4	11 mm thick oriented strand board
5	0.7 mm thick building paper
6	9.5 mm of cement stucco



	element 1	element 2	element 3	element 4	element 5	element 6
type	gypsum board	studs	insulation	sheathing	paper	stucco
material	regular	wood	glass fibre	OSB	building paper	cement
thickness (mm)	13	140	152	11	0.7	9.5
spacing (mm)	*	406	*	*	*	*
total mass (kg)	71	95	13	58	5.2	139
linear density (kg/m)	*	2.8	*	*	*	*
surface density (kg/m^2)	7.9	*	1.4	6.5	0.6	16
fastener spacing #1 (mm)	406	*	*	152 edges	*	*
fastener spacing #2 (mm)	*	*	*	305 field	*	*

* indicates not applicable

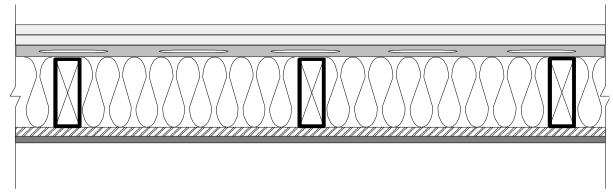
Freq, Hz	TL, dB
50	23
63	21
80	21
100	18
125	16
160	24
200	37
250	37
315	38
400	44
500	46
630	48
800	52
1000	54
1250	57
1600	59
2000	59
2500	55
3150	50
4000	51
5000	56
STC	40
OITC	29



NRC-CNRC National Research Council Canada

TLA-99-083a
2G13_RC13(610)_WS140(406)_GFB152_OSB11_BPAP0.7_STUC9.5
Construction Type: wall

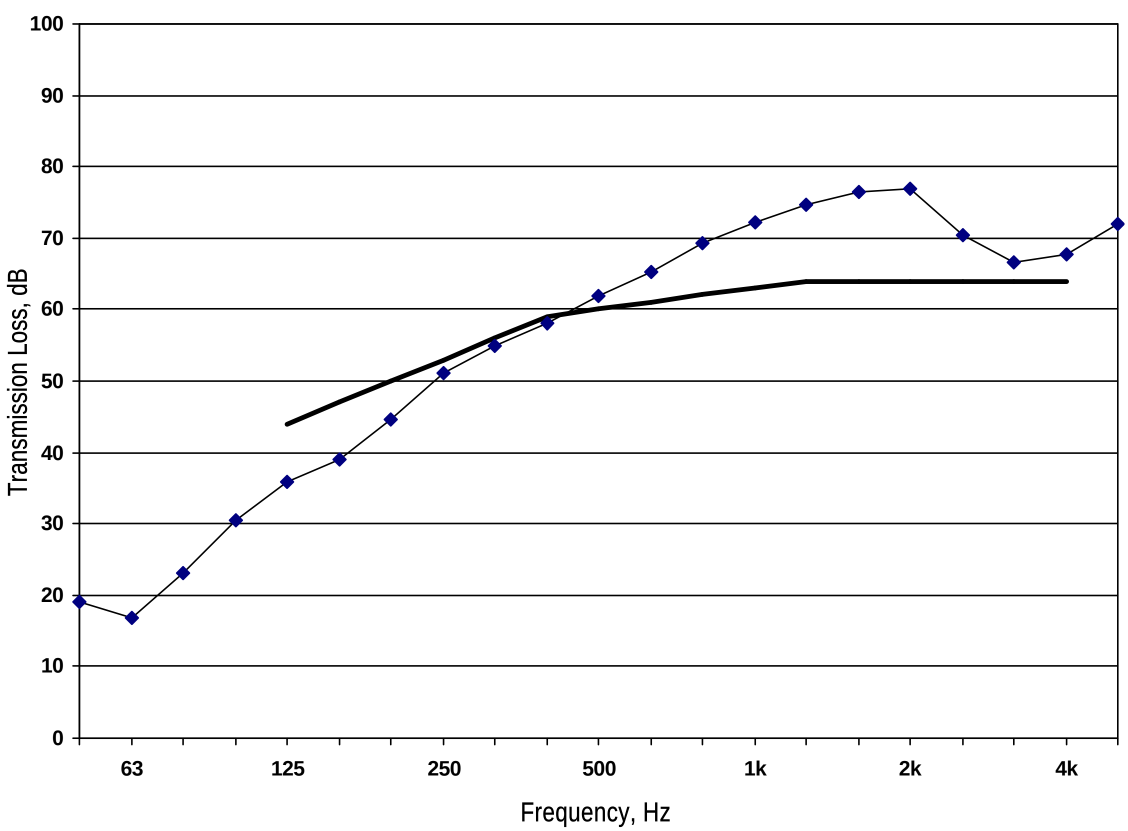
Element	Description
1	13 mm thick regular gypsum board
2	13 mm thick regular gypsum board
3	13 mm resilient channel at 610 mm on centre
4	140 mm deep wood stud at 406 mm on centre
5	152 mm thick glass fibre insulation in cavity
6	11 mm thick oriented strand board
7	0.7 mm thick building paper
8	9.5 mm of cement stucco



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	gypsum board	gypsum board	resilient chan.	studs	insulation	sheathing	paper	stucco
material	regular	regular	GP	wood	glass fibre	OSB	building paper	cement
thickness (mm)	13	13	13	140	152	11	0.7	9.5
spacing (mm)	*	*	610	406	*	*	*	*
total mass (kg)	72	71	4.3	95	13	58	5.2	139
linear density (kg/m)	*	*	0.2	2.8	*	*	*	*
surface density (kg/m^2)	8.0	8.0	*	*	1.4	6.5	0.6	16
fastener spacing #1 (mm)	305	305 edges	*	*	*	152 edges	*	*
fastener spacing #2 (mm)	*	610 field	*	*	*	305 field	*	*

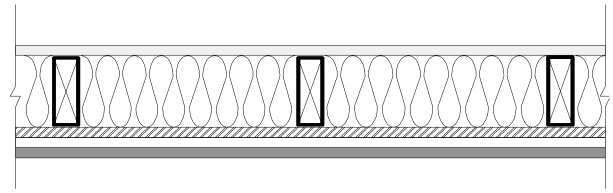
* indicates not applicable

Freq, Hz	TL, dB
50	19
63	17
80	23
100	30
125	36
160	39
200	45
250	51
315	55
400	58
500	62
630	65
800	69
1000	72
1250	75
1600	76
2000	77
2500	70
3150	67
4000	68
5000	72
STC	60
OITC	41



TLA-99-098a
G13_WS140(406)_GFB152_OSB11_AIR16_BRI89
Construction Type: wall

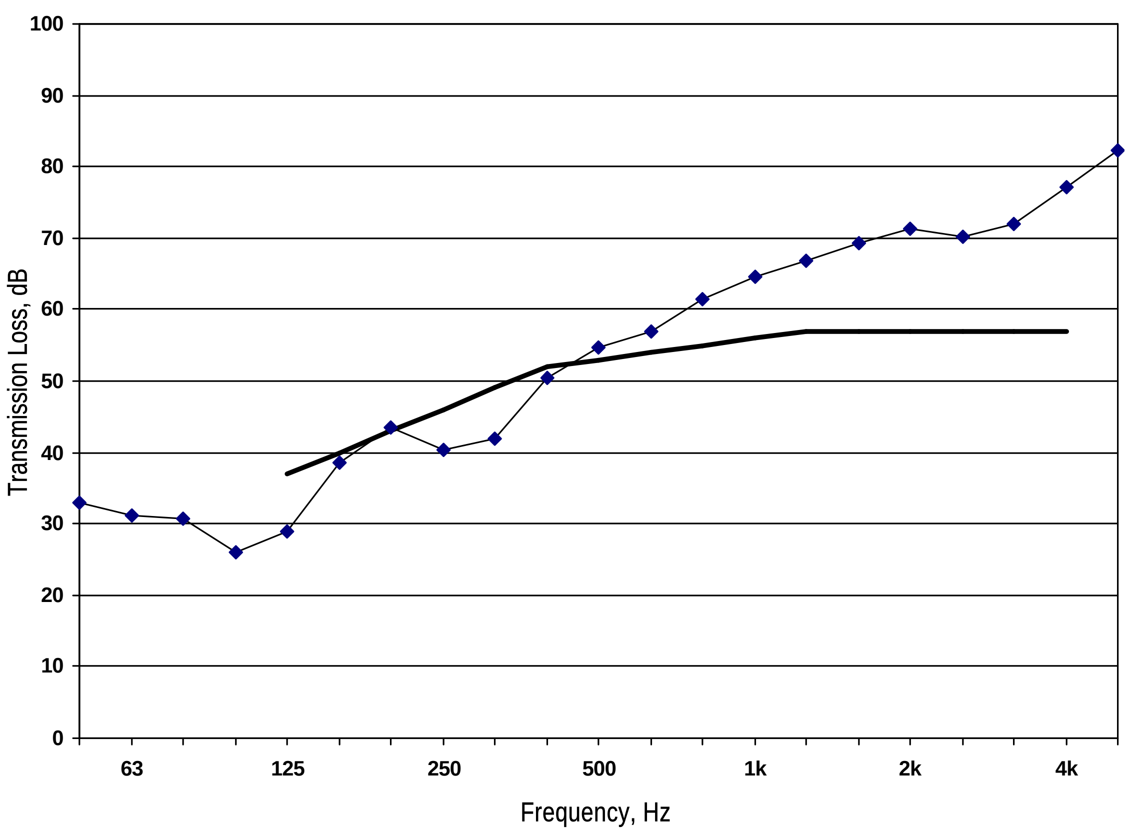
Element	Description
1	13 mm thick regular gypsum board
2	140 mm deep wood stud at 406 mm on centre
3	152 mm thick glass fibre insulation in cavity
4	11 mm thick oriented strand board
5	16 mm airspace
6	89 mm thick brick



	element 1	element 2	element 3	element 4	element 5	element 6
type	gypsum board	studs	insulation	sheathing	air	brick
material	regular	wood	glass fibre	OSB	*	*
thickness (mm)	13	140	152	11	16	89
spacing (mm)	*	406	*	*	*	*
total mass (kg)	71	95	13	62	*	1197
linear density (kg/m)	*	2.8	*	*	*	*
surface density (kg/m^2)	7.9	*	1.4	6.9	*	132
fastener spacing #1 (mm)	406	*	*	152 edges	*	*
fastener spacing #2 (mm)	*	*	*	305 field	*	*

* indicates not applicable

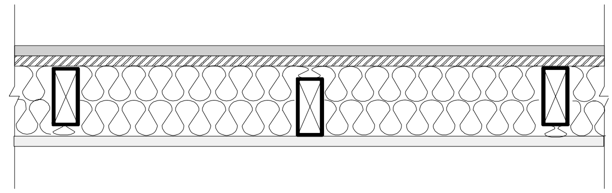
Freq, Hz	TL, dB
50	33
63	31
80	31
100	26
125	29
160	38
200	44
250	40
315	42
400	50
500	55
630	57
800	61
1000	64
1250	67
1600	69
2000	71
2500	70
3150	72
4000	77
5000	82
STC	53
OITC	40



National Research Council Canada

TLA-00-049a
VIN1_OSB11_SWS140(406)_2GFB65_G13
Construction Type: wall

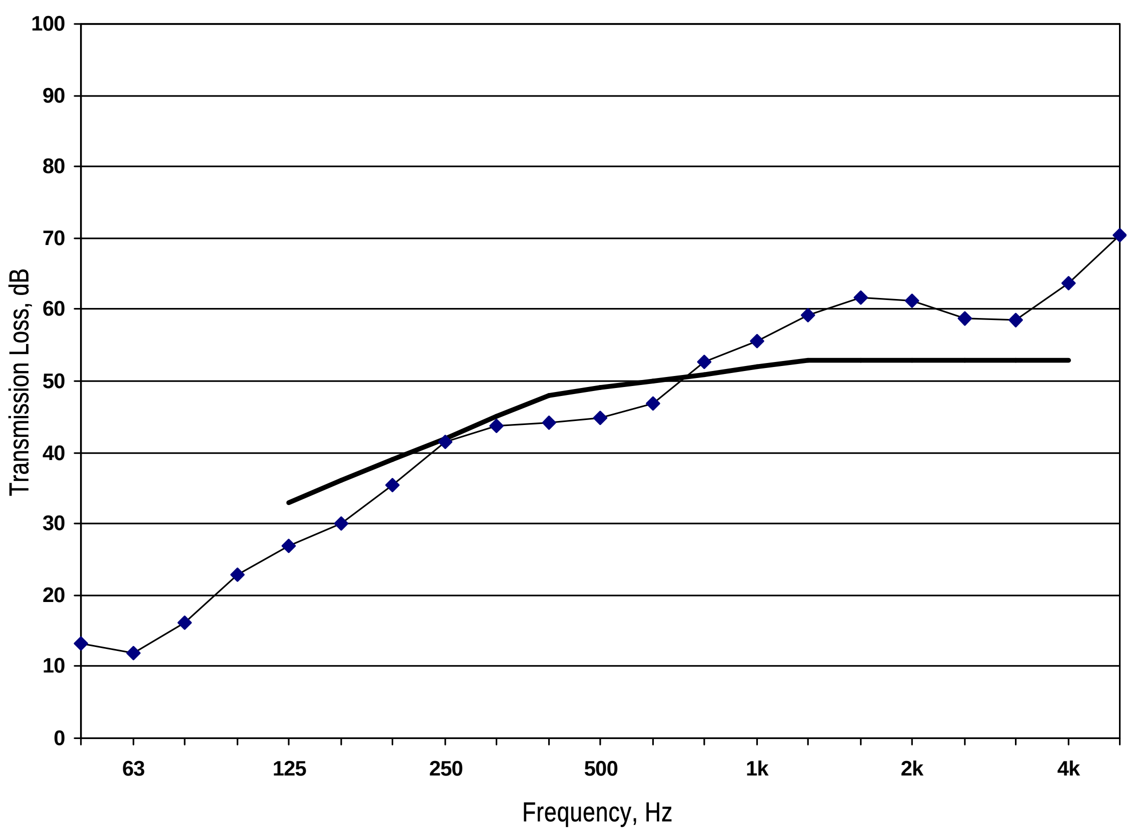
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm staggered wood studs at 406 mm on centre
4	65 mm thick glass fibre insulation in cavity
5	65 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	sheathing	studs	insulation	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	glass fibre	regular
thickness (mm)	1	11	140	65	65	13
spacing (mm)	*	*	406	*	*	*
total mass (kg)	19	60	59	6.3	6.3	70
linear density (kg/m)	0.4	*	1.9	*	*	*
surface density (kg/m^2)	*	6.8	*	0.7	0.7	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	*	406
fastener spacing #2 (mm)	*	305 field	*	*	*	*

* indicates not applicable

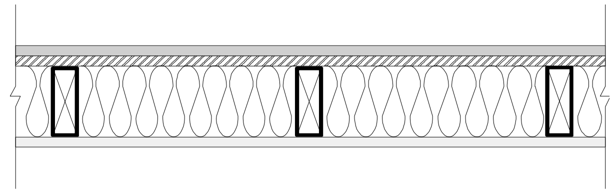
Freq, Hz	TL, dB
50	13
63	12
80	16
100	23
125	27
160	30
200	35
250	41
315	44
400	44
500	45
630	47
800	53
1000	56
1250	59
1600	62
2000	61
2500	59
3150	59
4000	64
5000	70
STC	49
OITC	33



NRC-CNRC National Research Council Canada

TLA-99-121a
VIN1_OSB11_WS140(610)_GFB152_G13
Construction Type: wall

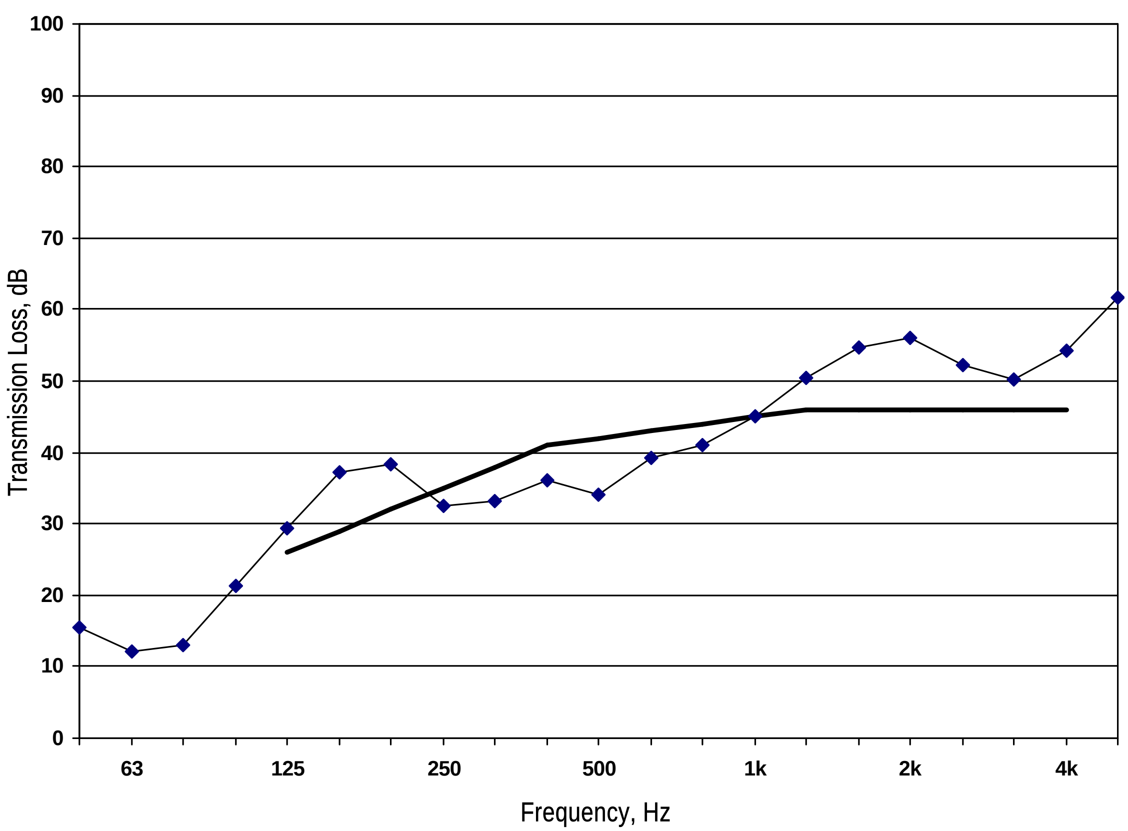
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm deep wood stud at 610 mm on centre
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5
type	siding	sheathing	studs	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	regular
thickness (mm)	1	11	140	152	13
spacing (mm)	*	*	610	*	*
total mass (kg)	20	67	79	14	70
linear density (kg/m)	*	*	2.9	*	*
surface density (kg/m^2)	0.4	7.5	*	1.6	7.9
fastener spacing #1 (mm)	406	152 edges	*	*	305
fastener spacing #2 (mm)	*	305 field	*	*	*

* indicates not applicable

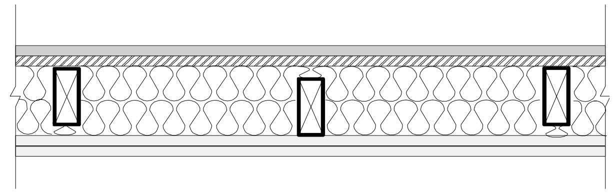
Freq, Hz	TL, dB
50	15
63	12
80	13
100	21
125	29
160	37
200	38
250	33
315	33
400	36
500	34
630	39
800	41
1000	45
1250	50
1600	55
2000	56
2500	52
3150	50
4000	54
5000	62
STC	42
OITC	31



NRC-CNRC National Research Council Canada

TLA-00-053a
VIN1_OSB11_SWS140(406)_2GFB65_2G13
Construction Type: wall

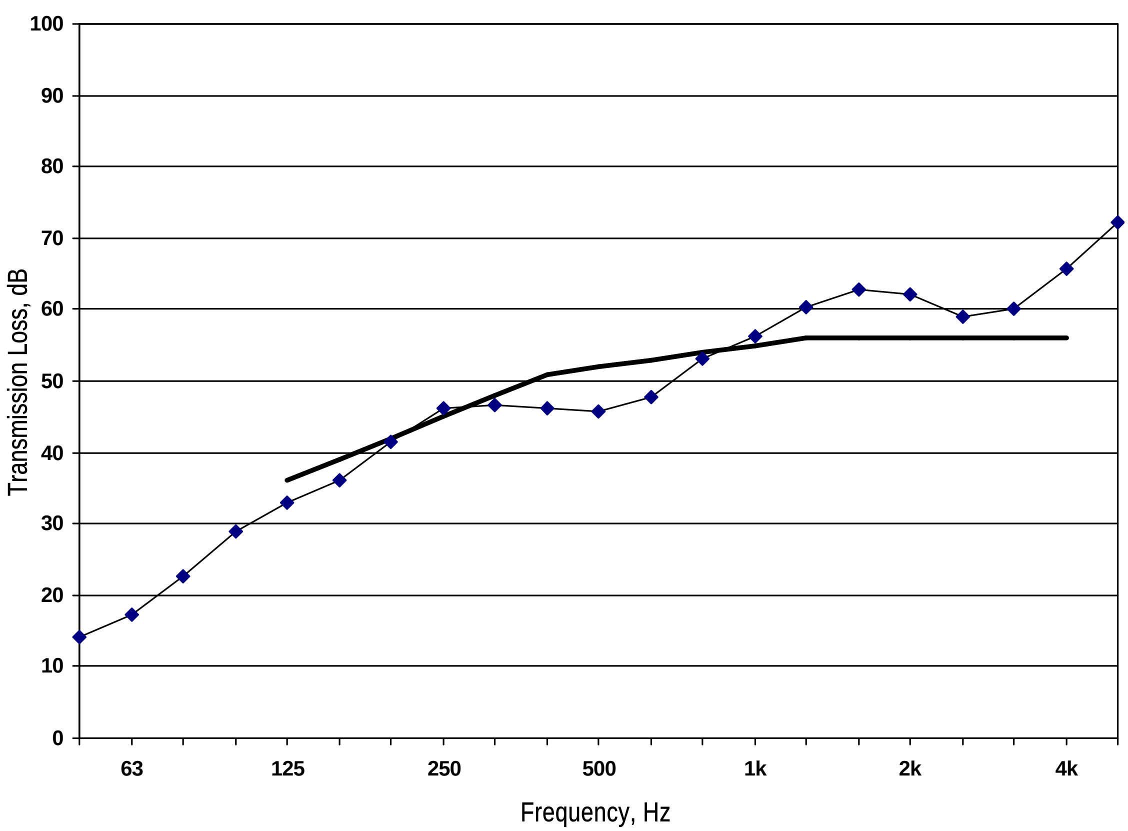
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm staggered wood studs at 406 mm on centre
4	65 mm thick glass fibre insulation in cavity
5	65 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	insulation	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	glass fibre	regular	regular
thickness (mm)	1	11	140	65	65	13	13
spacing (mm)	*	*	406	*	*	*	*
total mass (kg)	19	60	59	6.3	6.3	70	71
linear density (kg/m)	0.4	*	1.9	*	*	*	*
surface density (kg/m^2)	*	6.8	*	0.7	0.7	7.9	7.9
fastener spacing #1 (mm)	406	152	*	*	*	610	406
fastener spacing #2 (mm)	*	*	*	*	*	*	*

* indicates not applicable

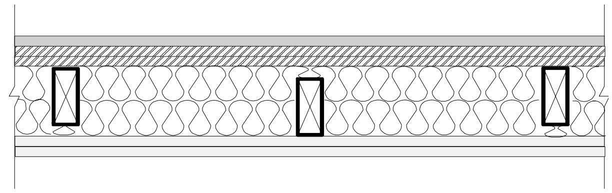
Freq, Hz	TL, dB
50	14
63	17
80	23
100	29
125	33
160	36
200	41
250	46
315	47
400	46
500	46
630	48
800	53
1000	56
1250	60
1600	63
2000	62
2500	59
3150	60
4000	66
5000	72
STC	52
OITC	39



NRC-CNRC National Research Council Canada

TLA-00-057a
VIN1_2OSB11_SWS140(406)_2GFB65_2G13
Construction Type: wall

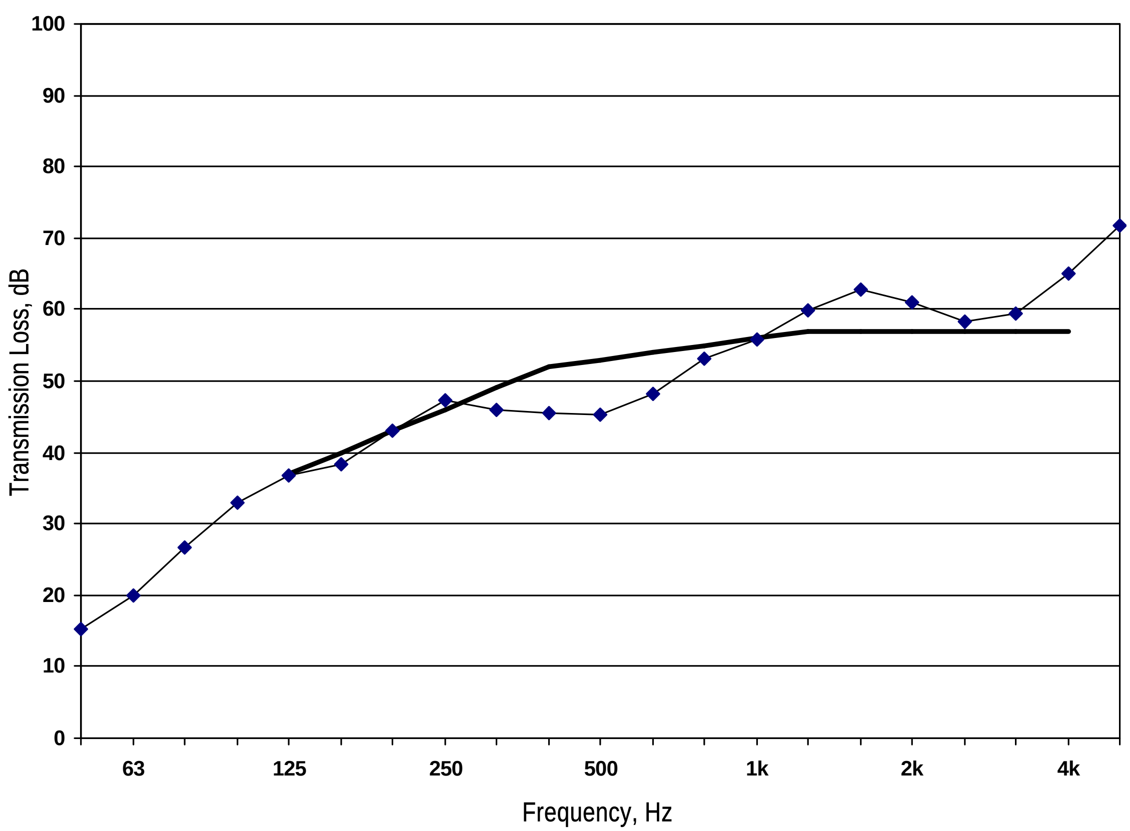
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 406 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	sheathing	sheathing	studs	insulation	insulation	gypsum board	gypsum board
material	vinyl	OSB	OSB	wood	glass fibre	glass fibre	regular	regular
thickness (mm)	1	11	11	140	65	65	13	13
spacing (mm)	*	*	*	406	*	*	*	*
total mass (kg)	19	59	60	59	6.3	6.3	70	71
linear density (kg/m)	0.4	*	*	1.9	*	*	*	*
surface density (kg/m^2)	*	6.6	6.8	*	0.7	0.7	7.9	7.9
fastener spacing #1 (mm)	406	152	305	*	*	*	610	406
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*

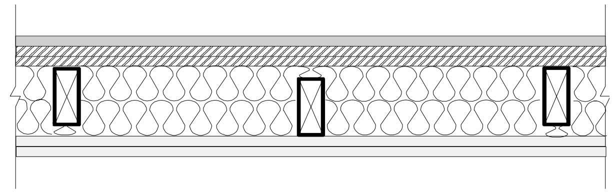
* indicates not applicable

Freq, Hz	TL, dB
50	15
63	20
80	27
100	33
125	37
160	38
200	43
250	47
315	46
400	46
500	45
630	48
800	53
1000	56
1250	60
1600	63
2000	61
2500	58
3150	59
4000	65
5000	72
STC	53
OITC	43



TLA-00-059a
VIN1_2OSB11_SWS140(406)_2GFB65_2G13
Construction Type: wall

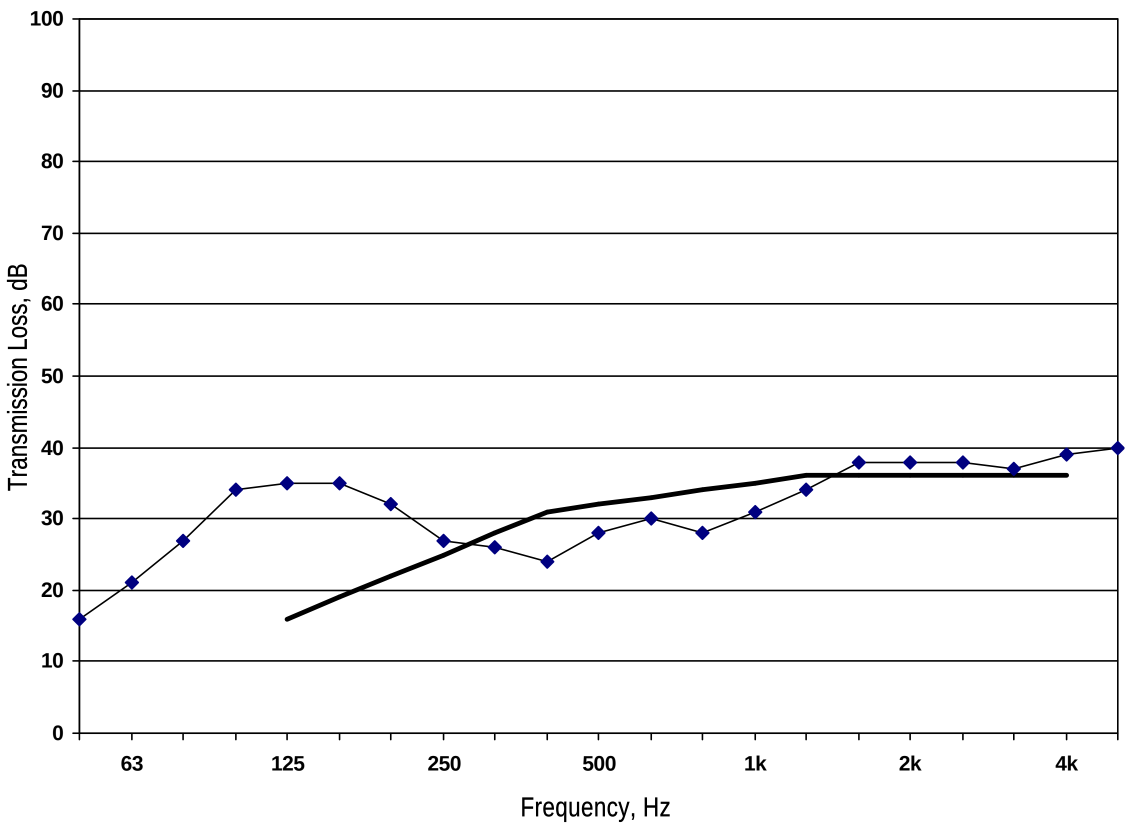
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 406 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	sheathing	gypsum board	gypsum board	sheathing	studs	insulation	insulation
material	vinyl	OSB	regular	regular	OSB	wood	glass fibre	glass fibre
thickness (mm)	1	11	13	13	11	140	65	65
spacing (mm)	*	*	*	*	*	406	*	*
total mass (kg)	19	59	70	71	60	59	6.3	6.3
linear density (kg/m)	0.4	*	*	*	*	1.9	*	*
surface density (kg/m^2)	*	6.6	7.9	7.9	6.8	*	0.7	0.7
fastener spacing #1 (mm)	406	152	610	406	305	*	*	*
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*

* indicates not applicable

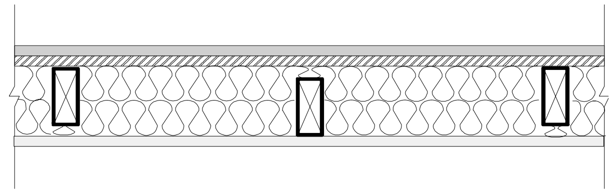
Freq, Hz	TL, dB
50	16
63	21
80	27
100	34
125	35
160	35
200	32
250	27
315	26
400	24
500	28
630	30
800	28
1000	31
1250	34
1600	38
2000	38
2500	38
3150	37
4000	39
5000	40
STC	32
OITC	30



National Research
Council Canada

TLA-00-029a
VIN1_OSB11_SWS140(610)_2GFB65_G13
Construction Type: wall

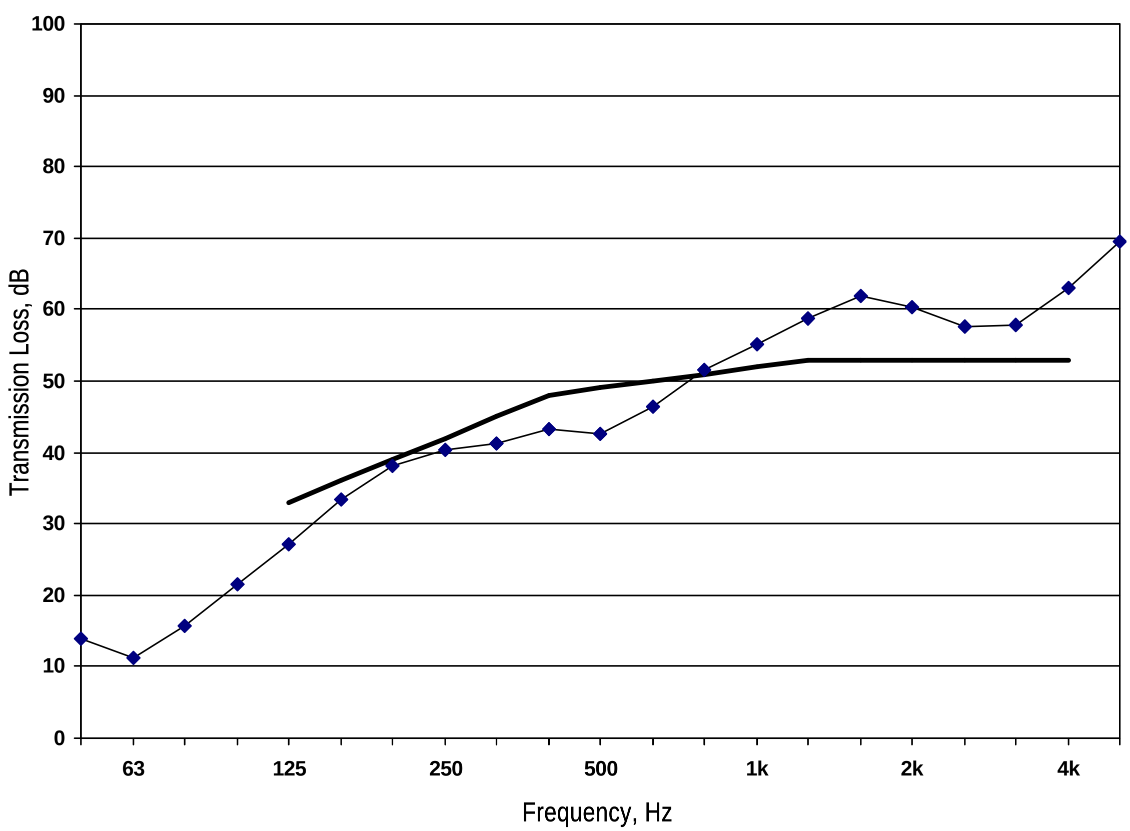
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm staggered wood studs at 610 mm on centre
4	65 mm thick glass fibre insulation in cavity
5	65 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6
type	siding	sheathing	studs	insulation	insulation	gypsum board
material	vinyl	OSB	wood	glass fibre	glass fibre	regular
thickness (mm)	1	11	140	65	65	13
spacing (mm)	*	*	610	*	*	*
total mass (kg)	19	60	49	5.9	5.9	70
linear density (kg/m)	0.4	*	2.0	*	*	*
surface density (kg/m^2)	*	6.7	*	0.7	0.7	7.8
fastener spacing #1 (mm)	406	152	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*	*

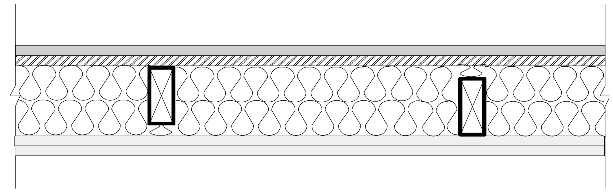
* indicates not applicable

Freq, Hz	TL, dB
50	14
63	11
80	16
100	22
125	27
160	33
200	38
250	40
315	41
400	43
500	43
630	46
800	52
1000	55
1250	59
1600	62
2000	60
2500	58
3150	58
4000	63
5000	70
STC	49
OITC	33



TLA-00-031a
VIN1_OSB11_SWS140(610)_2GFB65_2G13
Construction Type: wall

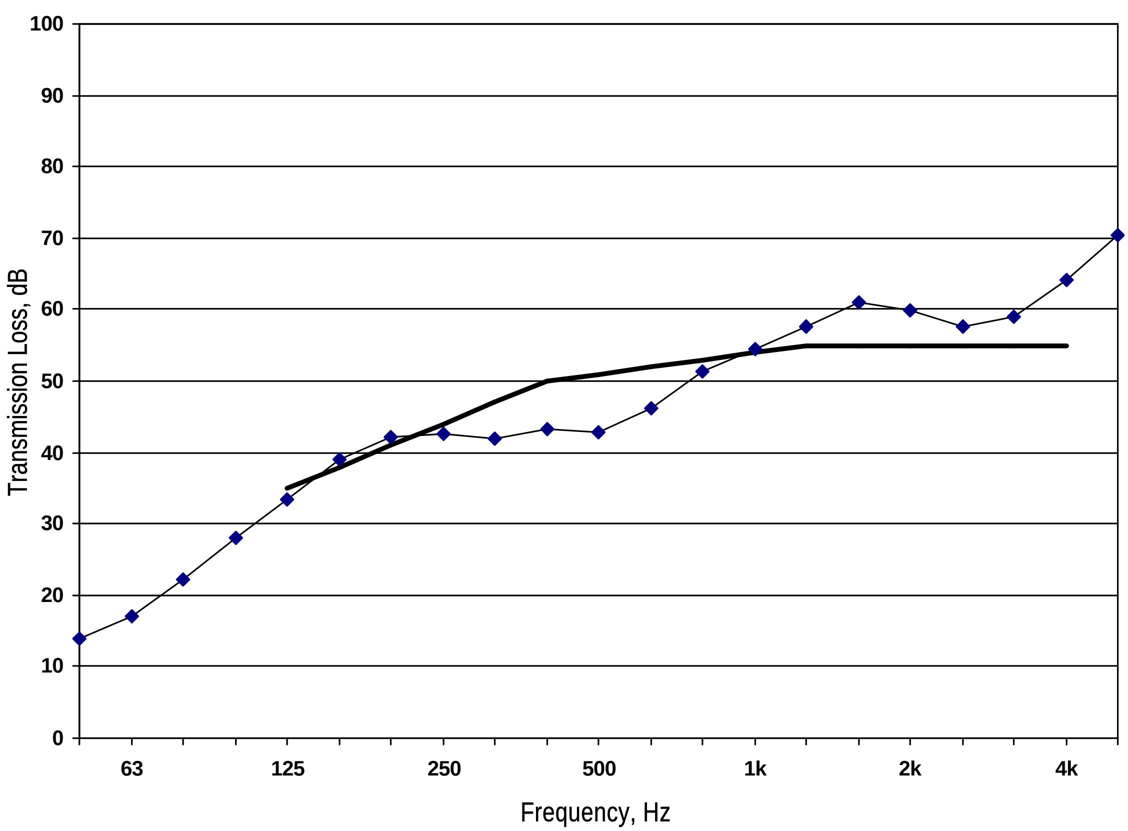
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	140 mm staggered wood studs at 610 mm on centre
4	65 mm thick glass fibre insulation in cavity
5	65 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	studs	insulation	insulation	gypsum board	gypsum board
material	vinyl	OSB	wood	glass fibre	glass fibre	regular	regular
thickness (mm)	1	11	140	65	65	13	13
spacing (mm)	*	*	610	*	*	*	*
total mass (kg)	19	60	49	5.9	5.9	70	70
linear density (kg/m)	0.4	*	2.0	*	*	*	*
surface density (kg/m^2)	*	6.7	*	0.7	0.7	7.8	7.9
fastener spacing #1 (mm)	406	152	*	*	*	610	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*

* indicates not applicable

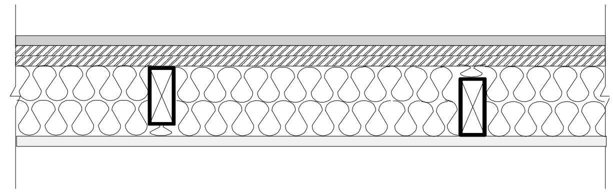
Freq, Hz	TL, dB
50	14
63	17
80	22
100	28
125	33
160	39
200	42
250	43
315	42
400	43
500	43
630	46
800	51
1000	54
1250	58
1600	61
2000	60
2500	58
3150	59
4000	64
5000	70
STC	51
OITC	39



NRC-CNRC National Research Council Canada

TLA-00-037a
VIN1_2OSB11_SWS140(610)_2GFB65_G13
Construction Type: wall

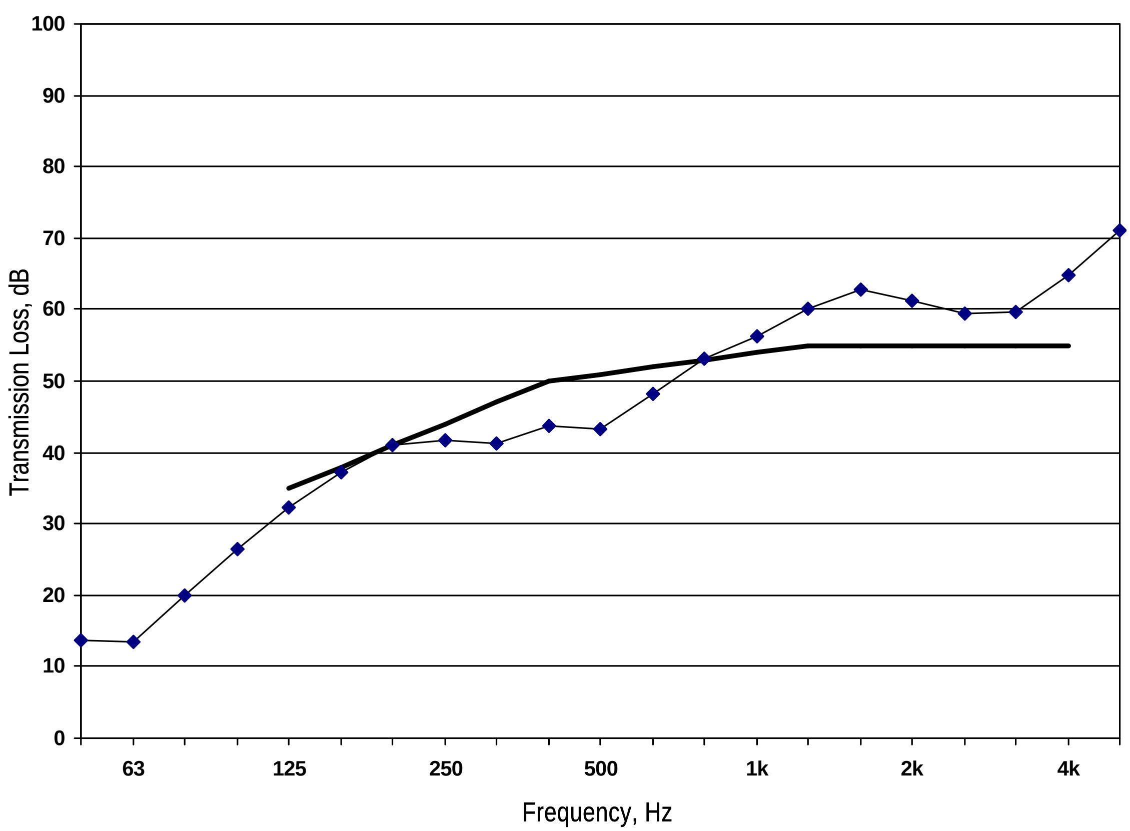
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 610 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	siding	sheathing	sheathing	studs	insulation	insulation	gypsum board
material	vinyl	OSB	OSB	wood	glass fibre	glass fibre	regular
thickness (mm)	1	11	11	140	65	65	13
spacing (mm)	*	*	*	610	*	*	*
total mass (kg)	19	60	59	49	5.9	5.9	70
linear density (kg/m)	0.4	*	*	2.0	*	*	*
surface density (kg/m^2)	*	6.7	6.6	*	0.7	0.7	7.8
fastener spacing #1 (mm)	406	305	152	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*

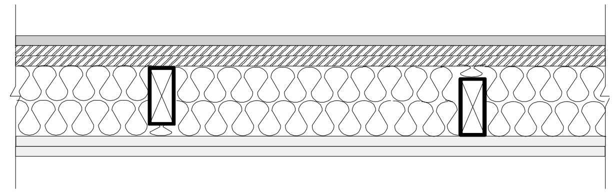
* indicates not applicable

Freq, Hz	TL, dB
50	14
63	14
80	20
100	26
125	32
160	37
200	41
250	42
315	41
400	44
500	43
630	48
800	53
1000	56
1250	60
1600	63
2000	61
2500	59
3150	60
4000	65
5000	71
STC	51
OITC	37



TLA-00-033a
VIN1_2OSB11_SWS140(610)_2GFB65_2G13
Construction Type: wall

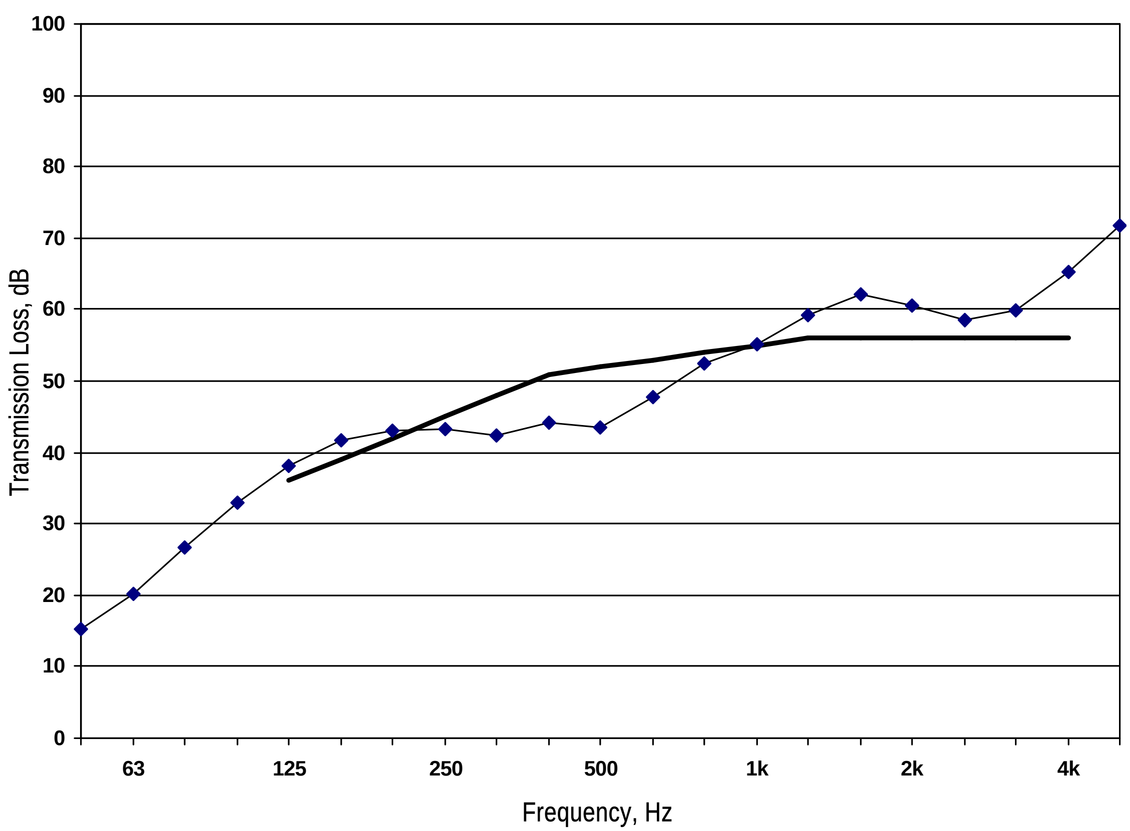
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 610 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	sheathing	sheathing	studs	insulation	insulation	gypsum board	gypsum board
material	vinyl	OSB	OSB	wood	glass fibre	glass fibre	regular	regular
thickness (mm)	1	11	11	140	65	65	13	13
spacing (mm)	*	*	*	610	*	*	*	*
total mass (kg)	19	58	60	49	5.9	5.9	70	70
linear density (kg/m)	0.4	*	*	2.0	*	*	*	*
surface density (kg/m^2)	*	6.5	6.7	*	0.7	0.7	7.8	7.9
fastener spacing #1 (mm)	406	152	305	*	*	*	610	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*

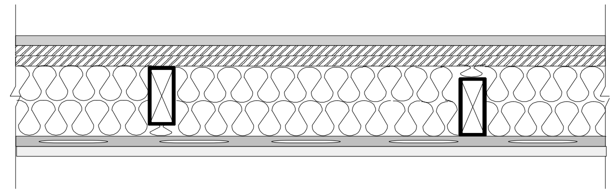
* indicates not applicable

Freq, Hz	TL, dB
50	15
63	20
80	27
100	33
125	38
160	42
200	43
250	43
315	42
400	44
500	44
630	48
800	53
1000	55
1250	59
1600	62
2000	61
2500	59
3150	60
4000	65
5000	72
STC	52
OITC	43



TLA-00-041a
VIN1_2OSB11_SWS140(610)_2GFB65_RC13(610)_G13
Construction Type: wall

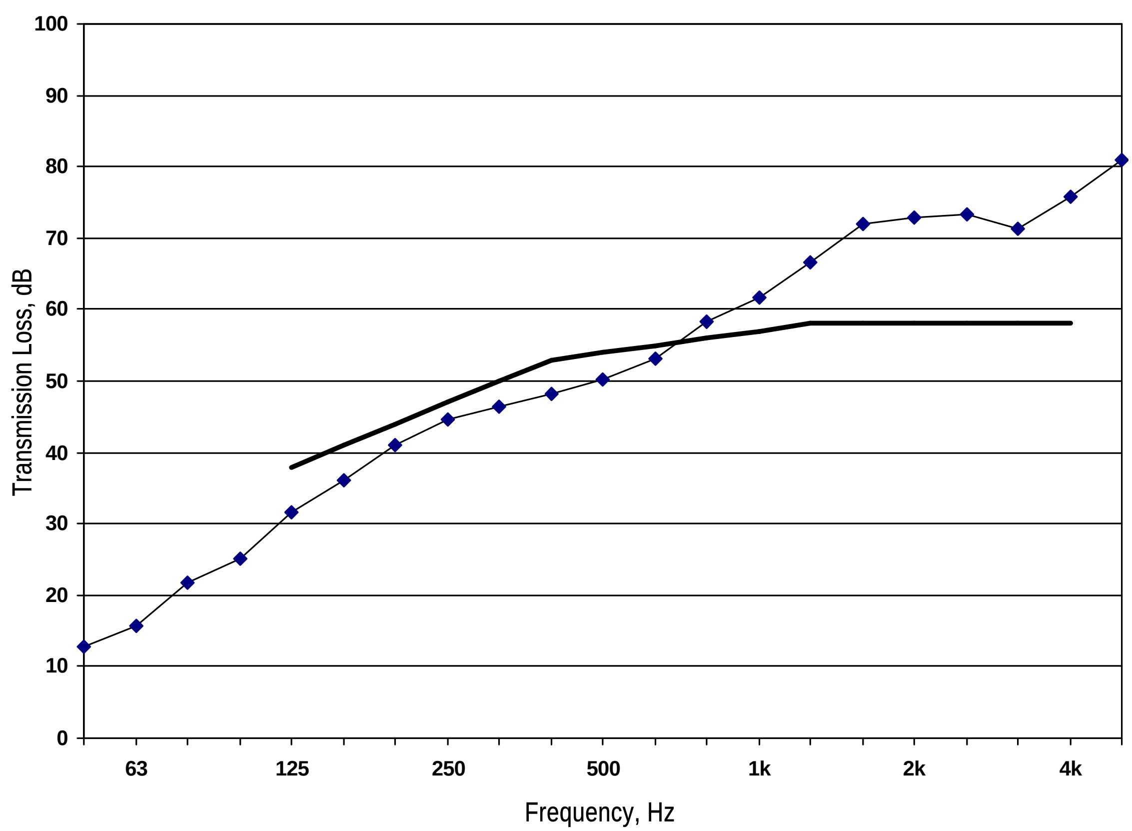
Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 610 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board



	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	siding	sheathing	sheathing	studs	insulation	insulation	resilient chan.	gypsum board
material	vinyl	OSB	OSB	wood	glass fibre	glass fibre	GP	regular
thickness (mm)	1	11	11	140	65	65	13	13
spacing (mm)	*	*	*	610	*	*	610	*
total mass (kg)	19	58	60	49	5.9	5.9	4.5	69
linear density (kg/m)	0.4	*	*	2.0	*	*	0.2	*
surface density (kg/m^2)	*	6.5	6.7	*	0.7	0.7	*	7.7
fastener spacing #1 (mm)	406	152	305	*	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*

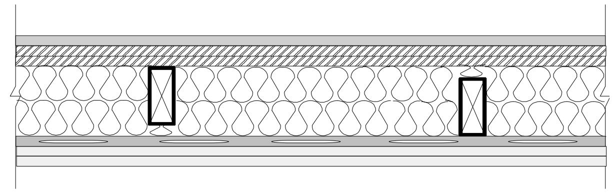
* indicates not applicable

Freq, Hz	TL, dB
50	13
63	16
80	22
100	25
125	32
160	36
200	41
250	45
315	46
400	48
500	50
630	53
800	58
1000	62
1250	67
1600	72
2000	73
2500	73
3150	71
4000	76
5000	81
STC	54
OITC	38



NRC-CNRC National Research Council Canada

TLA-00-045a
VIN1_2OSB11_SWS140(610)_2GFB65_RC13(610)_2G13
Construction Type: wall

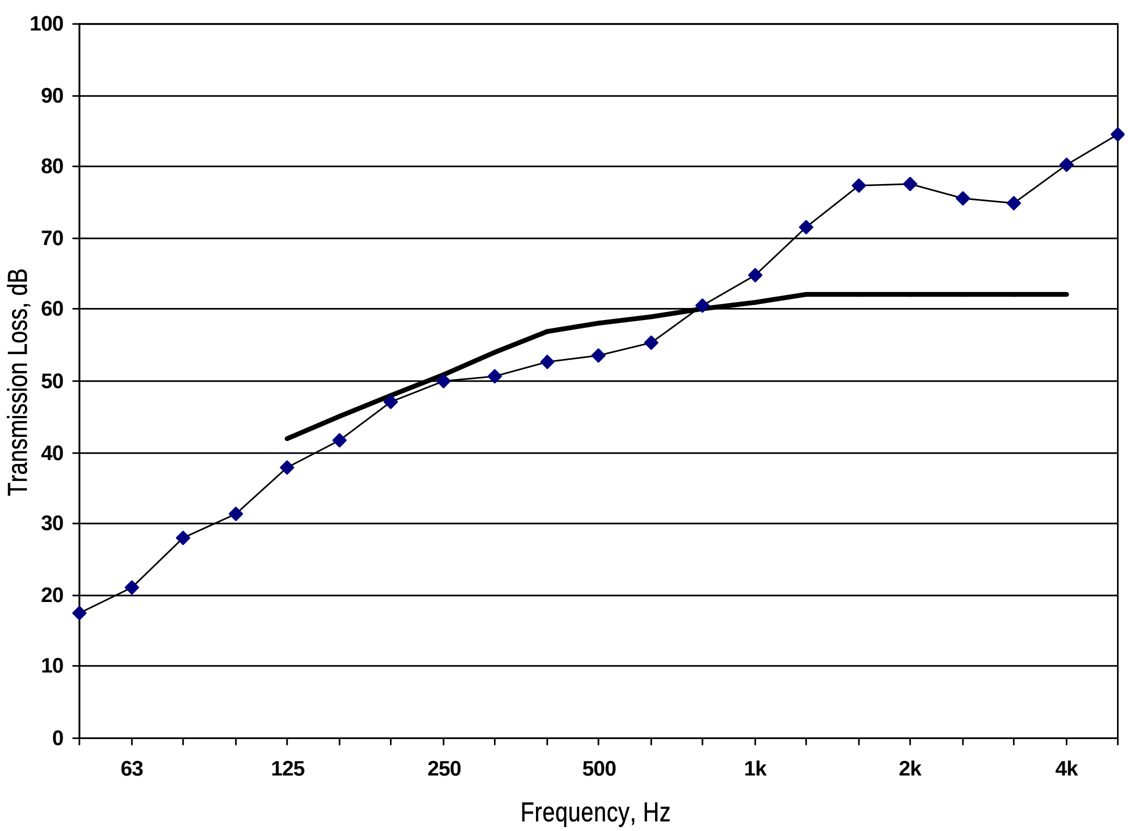


Element	Description
1	1 mm thick vinyl siding
2	11 mm thick oriented strand board
3	11 mm thick oriented strand board
4	140 mm staggered wood studs at 610 mm on centre
5	65 mm thick glass fibre insulation in cavity
6	65 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board
9	13 mm thick regular gypsum board

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	siding	sheathing	sheathing	studs	insulation	insulation	resilient chan.	gypsum board	gypsum board
material	vinyl	OSB	OSB	wood	glass fibre	glass fibre	GP	regular	regular
thickness (mm)	1	11	11	140	65	65	13	13	13
spacing (mm)	*	*	*	610	*	*	610	*	*
total mass (kg)	19	58	60	49	5.9	5.9	4.5	69	71
linear density (kg/m)	0.4	*	*	2.0	*	*	0.2	*	*
surface density (kg/m^2)	*	6.5	6.7	*	0.7	0.7	*	7.7	7.9
fastener spacing #1 (mm)	406	152	305	*	*	*	*	305 edges	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*	610 field	*

* indicates not applicable

Freq, Hz	TL, dB
50	17
63	21
80	28
100	31
125	38
160	42
200	47
250	50
315	51
400	53
500	53
630	55
800	60
1000	65
1250	71
1600	77
2000	77
2500	76
3150	75
4000	80
5000	84
STC	58
OITC	44



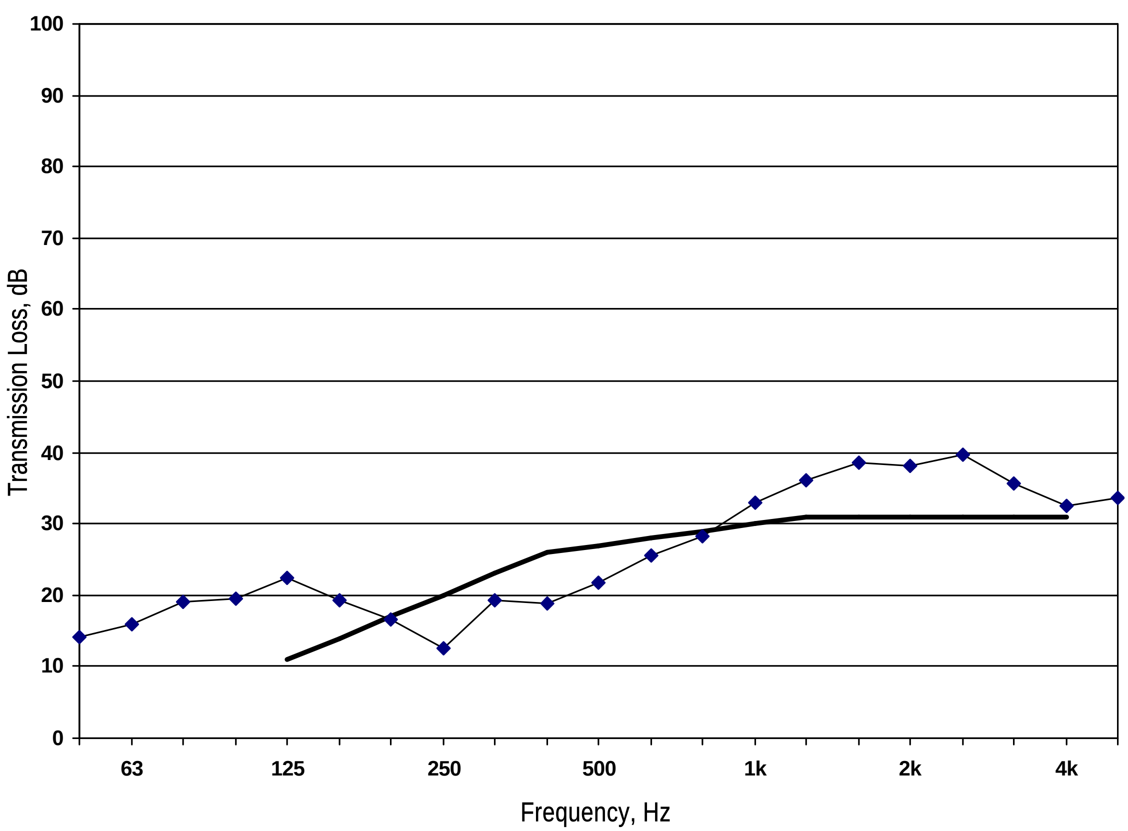
NRC-CNRC National Research Council Canada

TLA-99-197a
aluminum spacer with air
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	14
63	16
80	19
100	20
125	22
160	19
200	17
250	13
315	19
400	19
500	22
630	26
800	28
1000	33
1250	36
1600	38
2000	38
2500	40
3150	36
4000	33
5000	34
STC	27
OITC	22

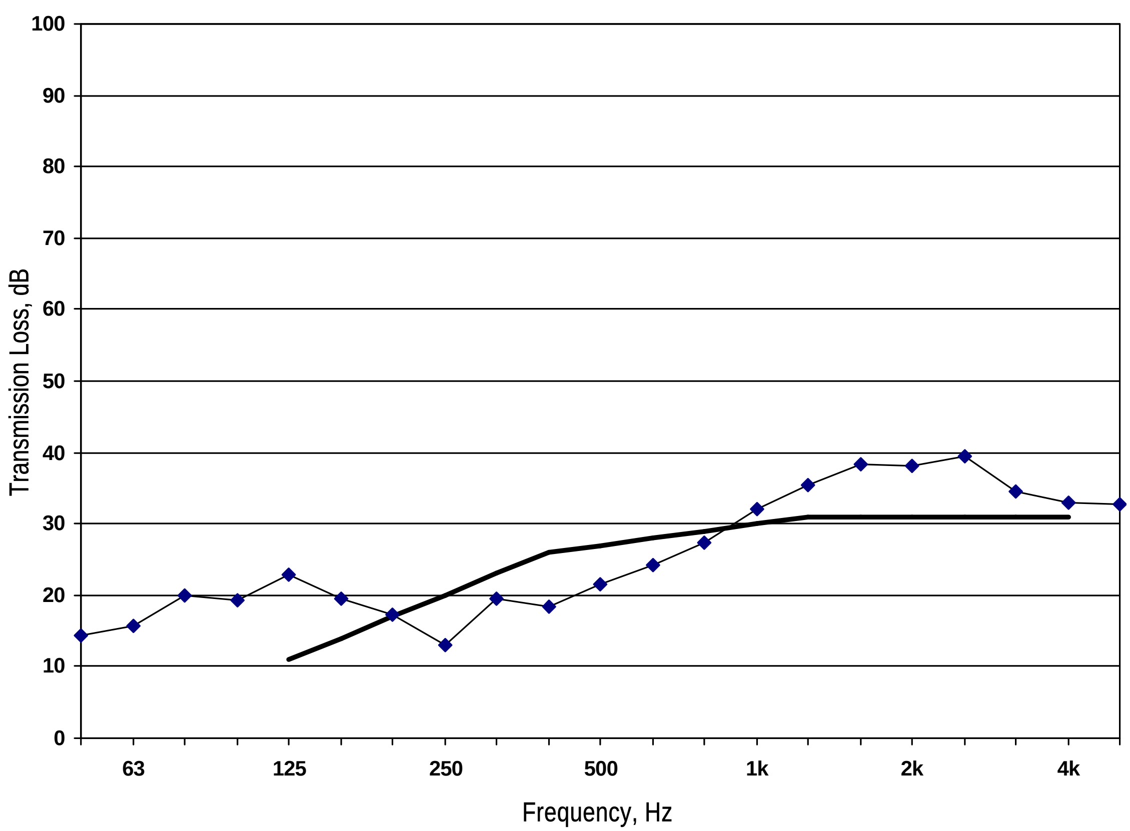


TLA-99-201a
aluminum spacer with air
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	14
63	16
80	20
100	19
125	23
160	19
200	17
250	13
315	20
400	18
500	22
630	24
800	27
1000	32
1250	35
1600	38
2000	38
2500	39
3150	35
4000	33
5000	33
STC	27
OITC	22

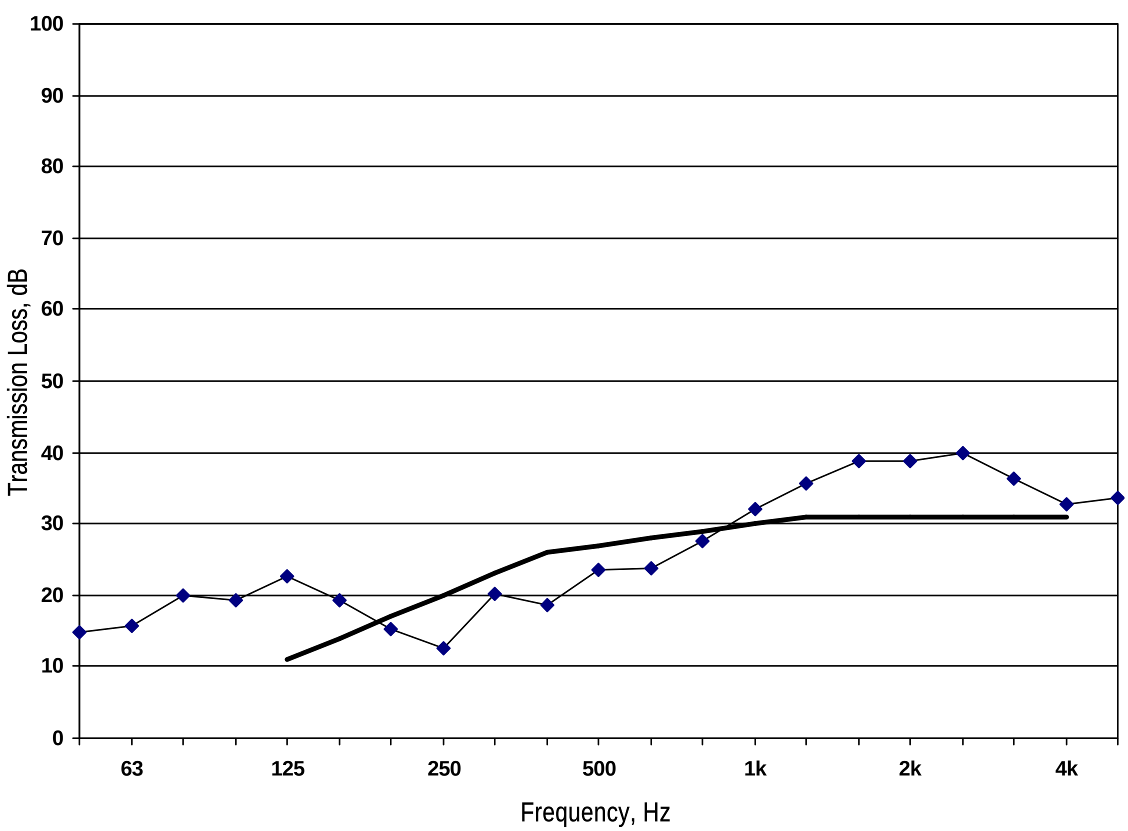


TLA-99-203a
swiggle spacer with air
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	swiggle
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	15
63	16
80	20
100	19
125	23
160	19
200	15
250	13
315	20
400	19
500	24
630	24
800	28
1000	32
1250	36
1600	39
2000	39
2500	40
3150	36
4000	33
5000	34
STC	27
OITC	22



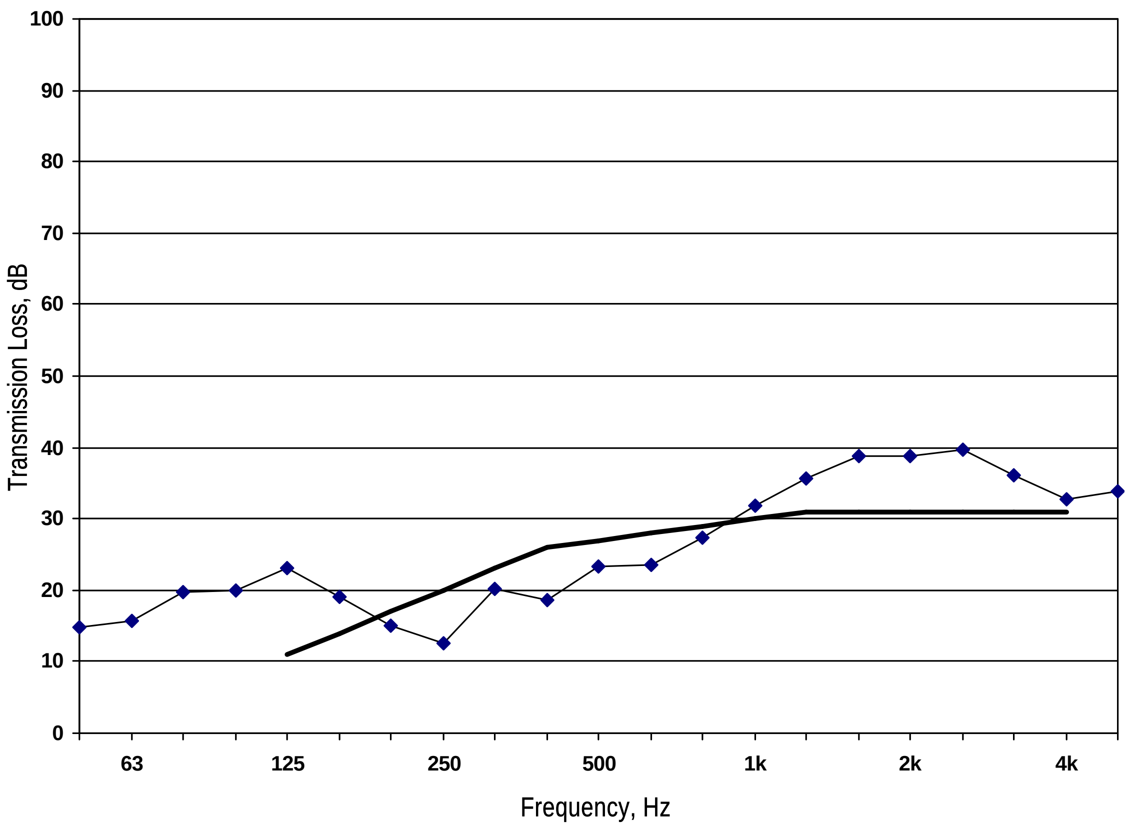
NRC-CNRC National Research Council Canada

TLA-99-205a
swiggle spacer with air
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	swiggle
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	15
63	16
80	20
100	20
125	23
160	19
200	15
250	12
315	20
400	19
500	23
630	24
800	27
1000	32
1250	36
1600	39
2000	39
2500	40
3150	36
4000	33
5000	34
STC	27
OITC	22

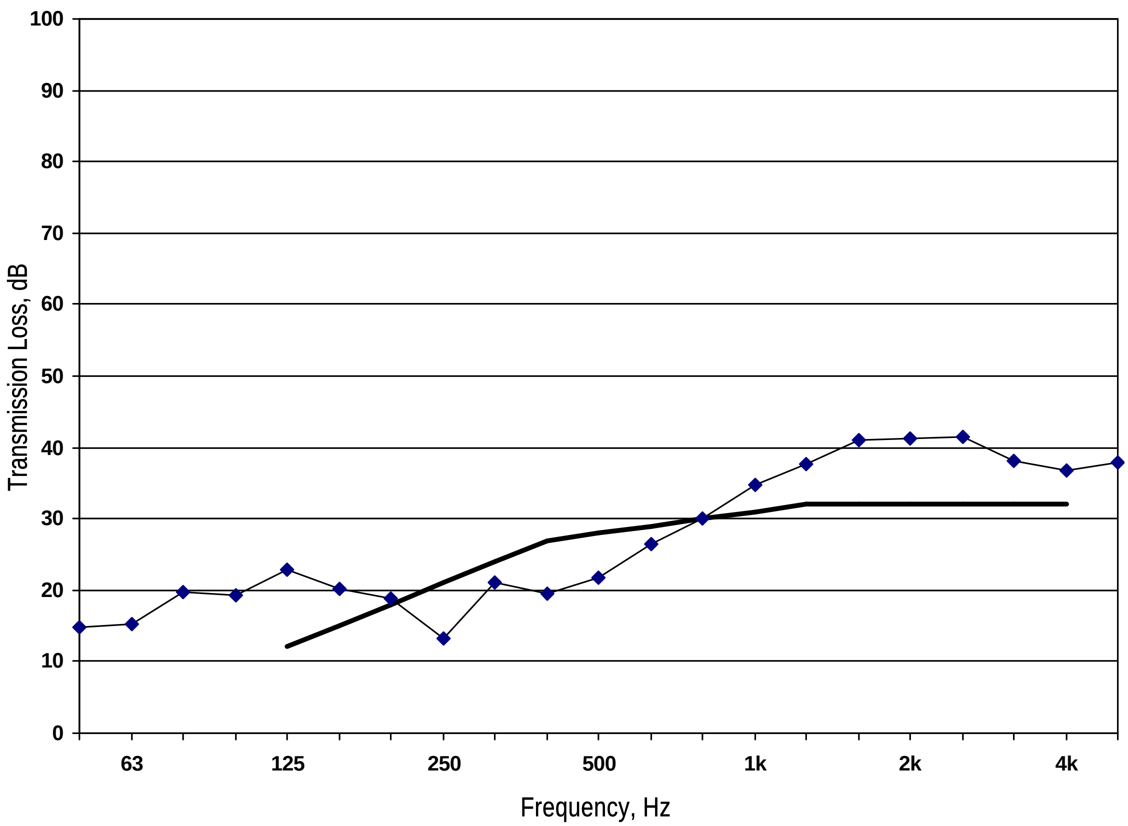


TLA-99-209a
aluminum spacer with argon
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	argon
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	15
63	15
80	20
100	19
125	23
160	20
200	19
250	13
315	21
400	19
500	22
630	26
800	30
1000	35
1250	38
1600	41
2000	41
2500	41
3150	38
4000	37
5000	38
STC	28
OITC	23

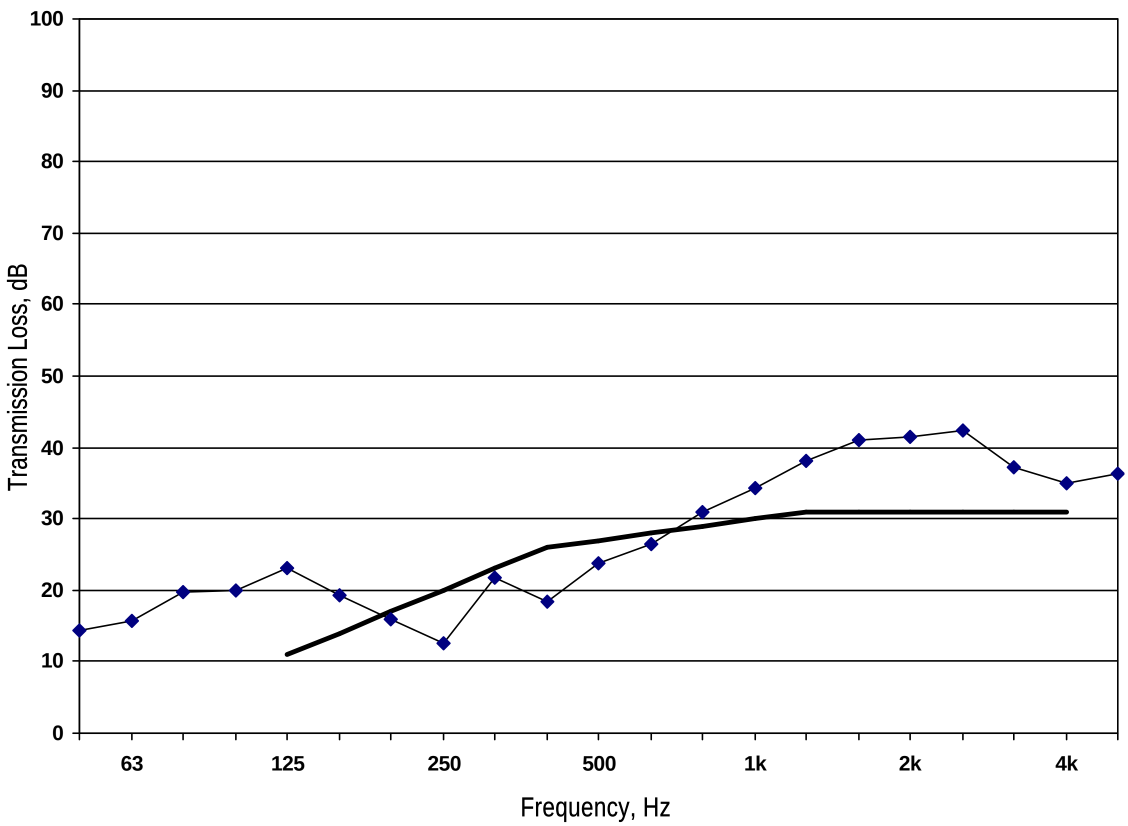


TLA-99-207a
swiggle spacer with argon
Construction Type: double glazing unit

window type	double glazing unit
frame material	*
glass 1 thickness (mm)	3
spacer type	swiggle
spacer thickness (mm)	13
gas in cavity	argon
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	14
63	16
80	20
100	20
125	23
160	19
200	16
250	13
315	22
400	18
500	24
630	27
800	31
1000	34
1250	38
1600	41
2000	41
2500	42
3150	37
4000	35
5000	36
STC	27
OITC	22



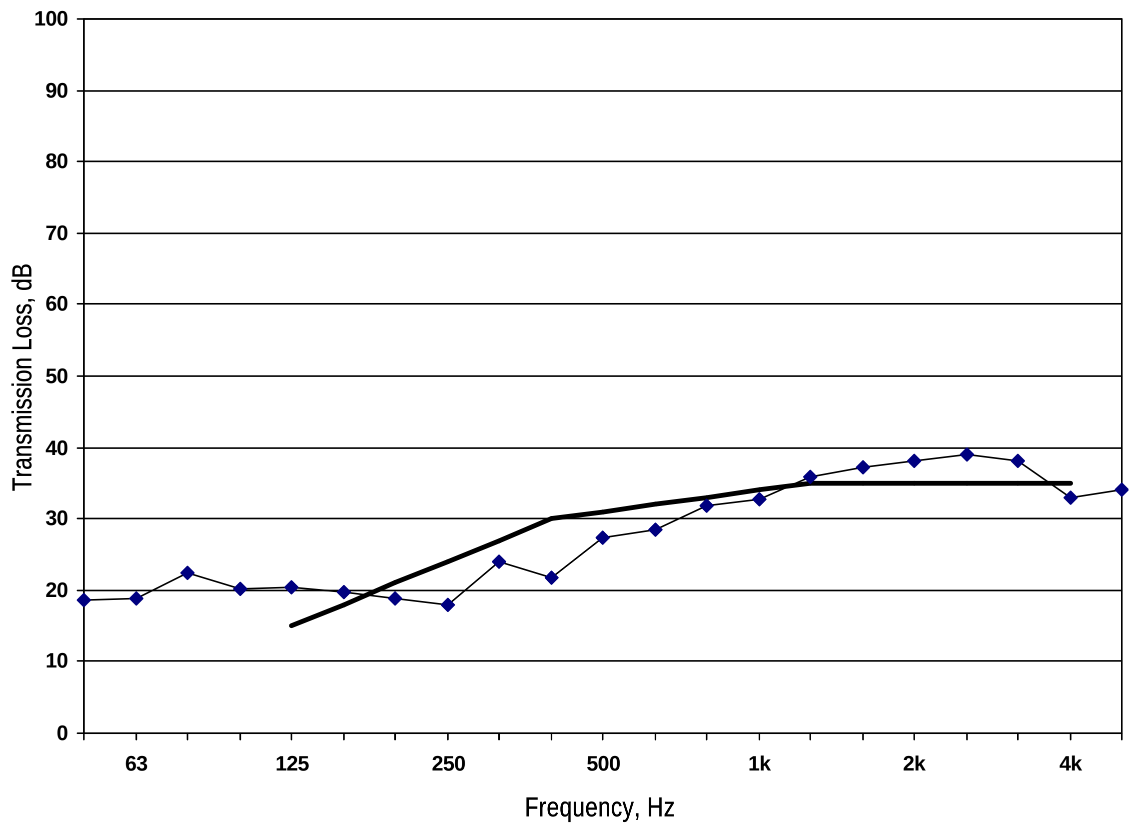
TLA-99-161a
wood casement
Construction Type: window

seals not taped

window type	casement
frame material	wood
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	19
80	22
100	20
125	20
160	20
200	19
250	18
315	24
400	22
500	27
630	28
800	32
1000	33
1250	36
1600	37
2000	38
2500	39
3150	38
4000	33
5000	34
STC	31
OITC	25



National Research
Council Canada

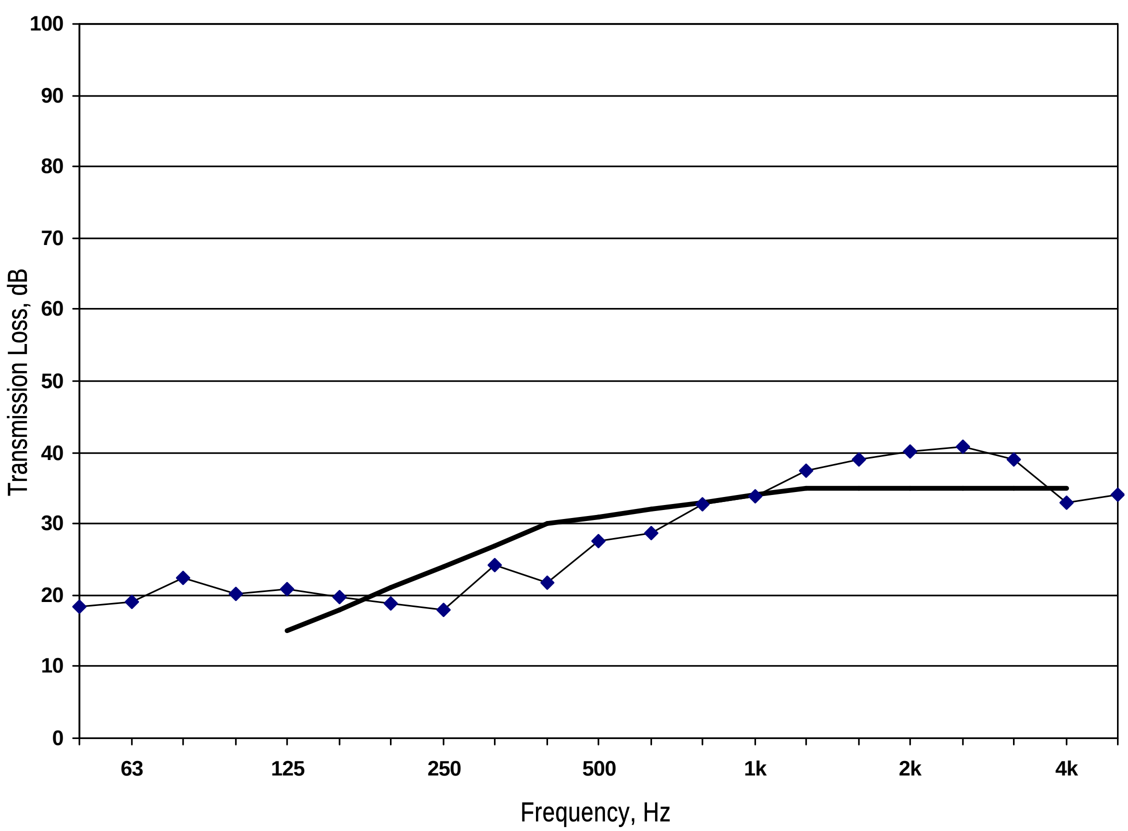
TLA-99-163a
wood casement
Construction Type: window

seals taped

window type	casement
frame material	wood
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	18
63	19
80	22
100	20
125	21
160	20
200	19
250	18
315	24
400	22
500	28
630	29
800	33
1000	34
1250	37
1600	39
2000	40
2500	41
3150	39
4000	33
5000	34
STC	31
OITC	25



National Research
Council Canada

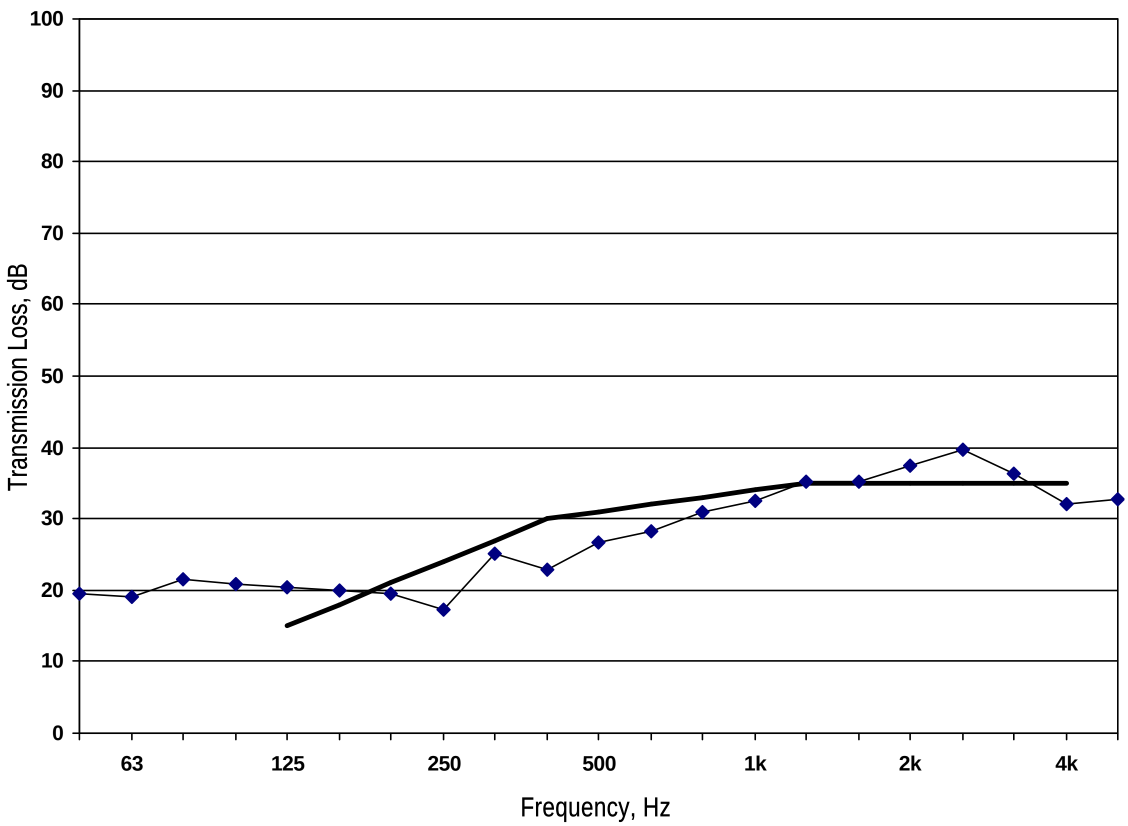
TLA-99-143a
vinyl casement
Construction Type: window

seals not taped

window type	casement
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	19
80	22
100	21
125	21
160	20
200	19
250	17
315	25
400	23
500	27
630	28
800	31
1000	33
1250	35
1600	35
2000	37
2500	40
3150	36
4000	32
5000	33
STC	31
OITC	25



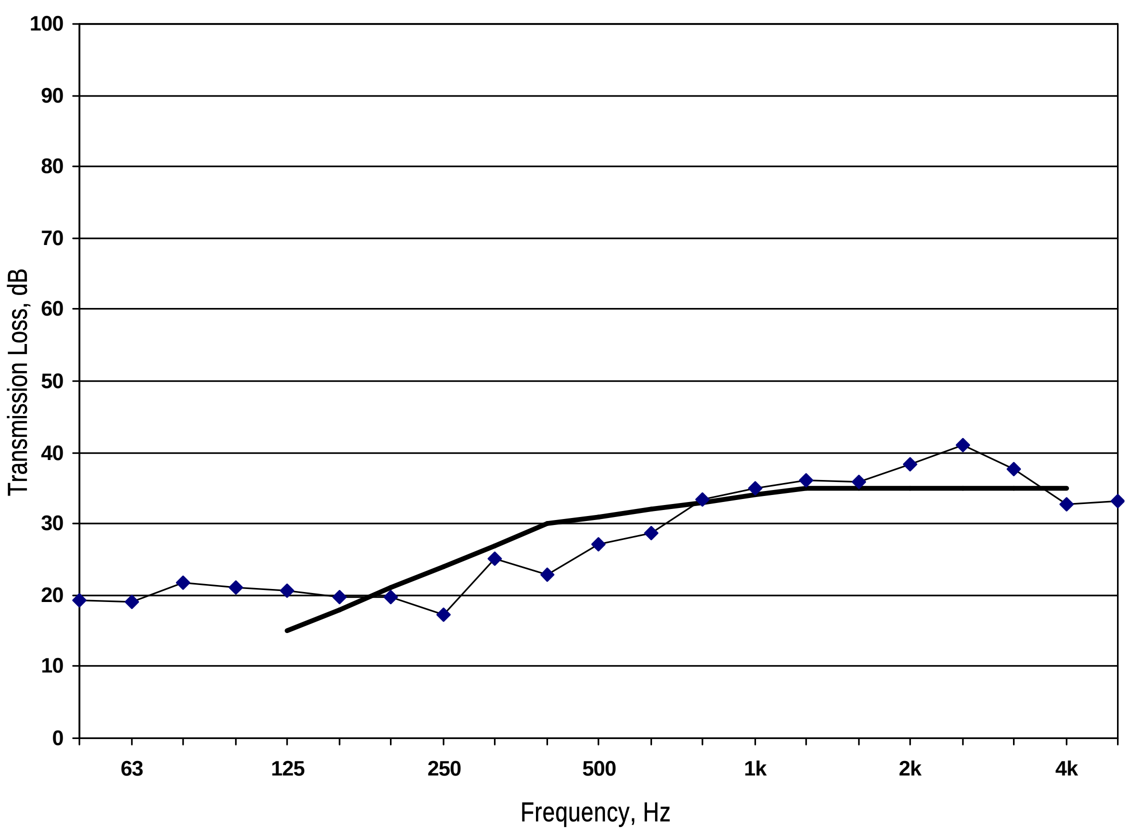
TLA-99-145a
vinyl casement
Construction Type: window

seals taped

window type	casement
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	19
80	22
100	21
125	21
160	20
200	20
250	17
315	25
400	23
500	27
630	29
800	33
1000	35
1250	36
1600	36
2000	38
2500	41
3150	38
4000	33
5000	33
STC	31
OITC	25



NRC-CNRC National Research Council Canada

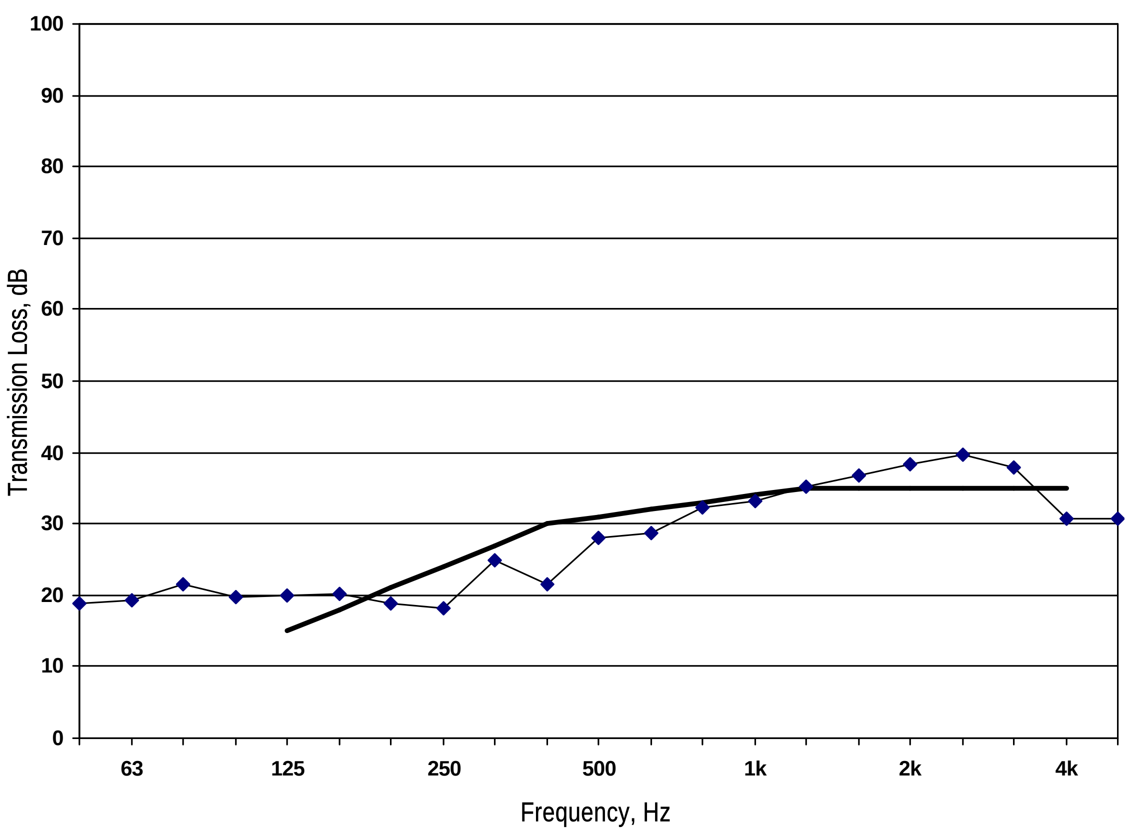
TLA-99-173a
vinyl clad casement
Construction Type: window

seals not taped

window type	casement
frame material	vinyl clad
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	19
80	21
100	20
125	20
160	20
200	19
250	18
315	25
400	22
500	28
630	29
800	32
1000	33
1250	35
1600	37
2000	38
2500	40
3150	38
4000	31
5000	31
STC	31
OITC	25



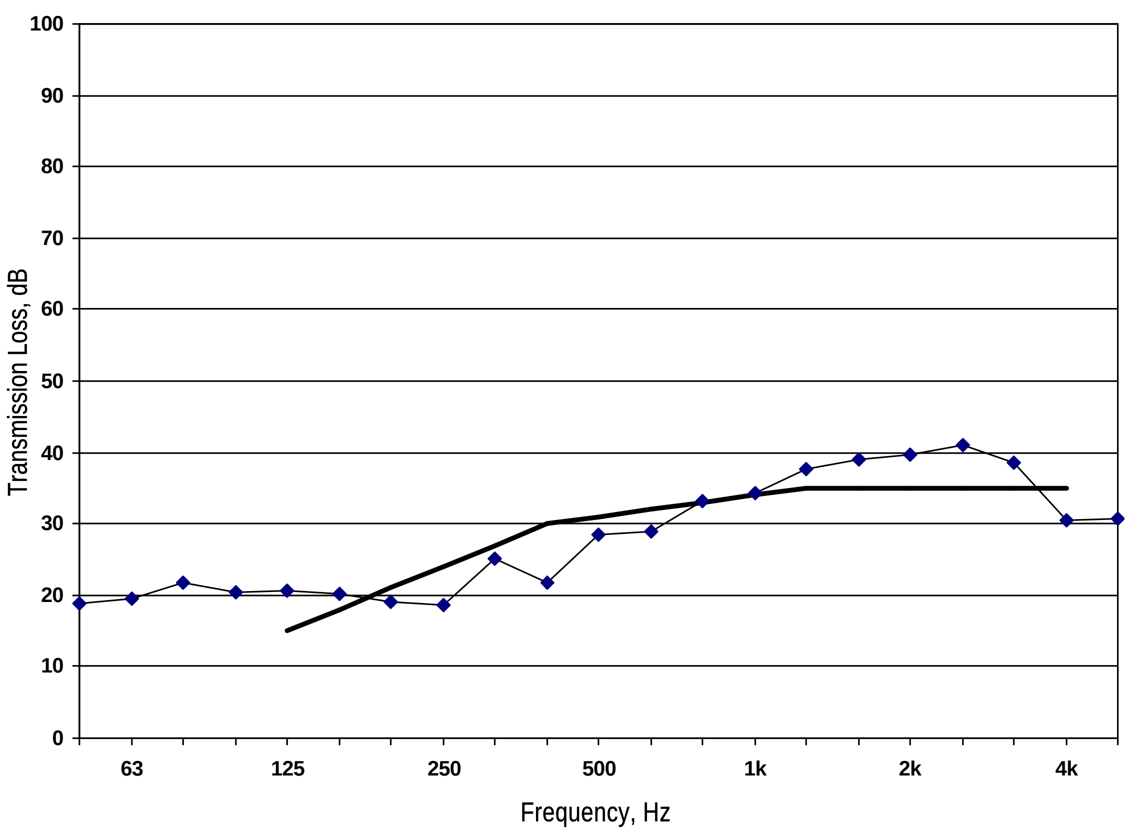
TLA-99-175a
vinyl clad casement
Construction Type: window

seals taped

window type	casement
frame material	vinyl clad
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	20
80	22
100	20
125	21
160	20
200	19
250	19
315	25
400	22
500	28
630	29
800	33
1000	34
1250	38
1600	39
2000	40
2500	41
3150	39
4000	31
5000	31
STC	31
OITC	26



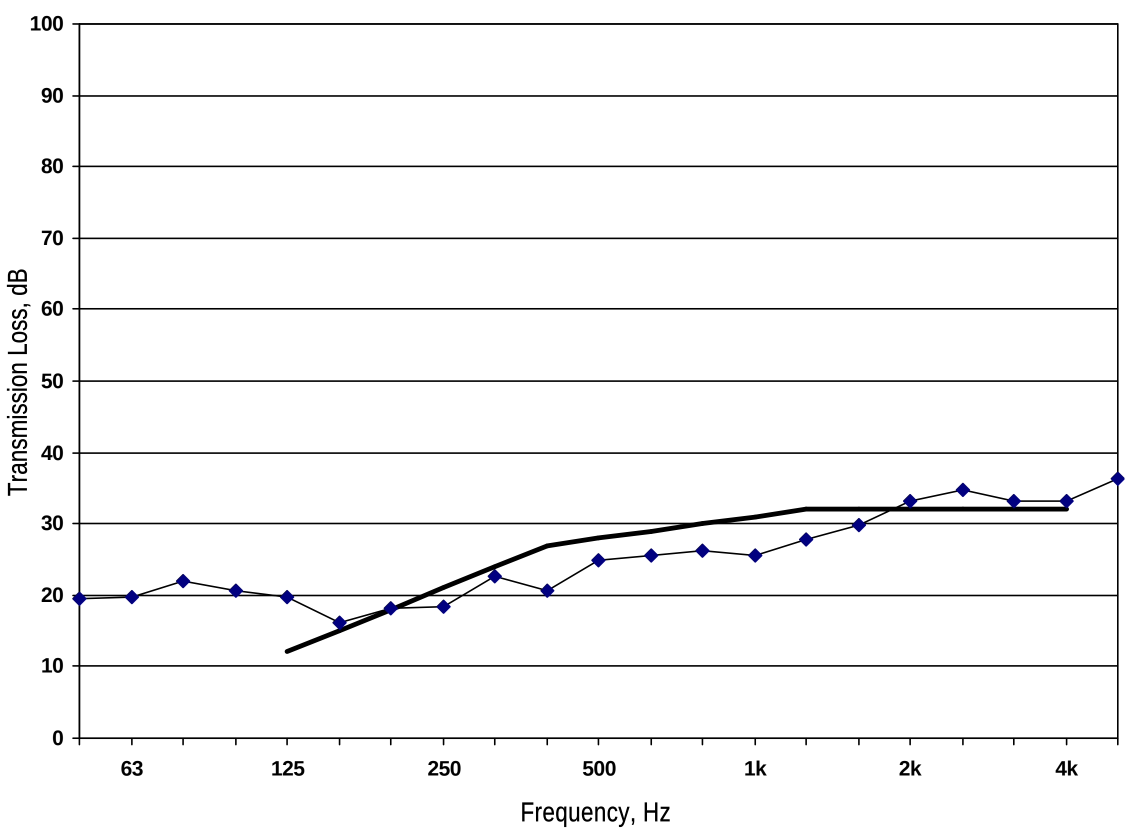
TLA-99-177a
aluminum casement
Construction Type: window

seals not taped

window type	casement
frame material	aluminum
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	20
80	22
100	21
125	20
160	16
200	18
250	18
315	23
400	21
500	25
630	25
800	26
1000	26
1250	28
1600	30
2000	33
2500	35
3150	33
4000	33
5000	36
STC	28
OITC	23



National Research
Council Canada

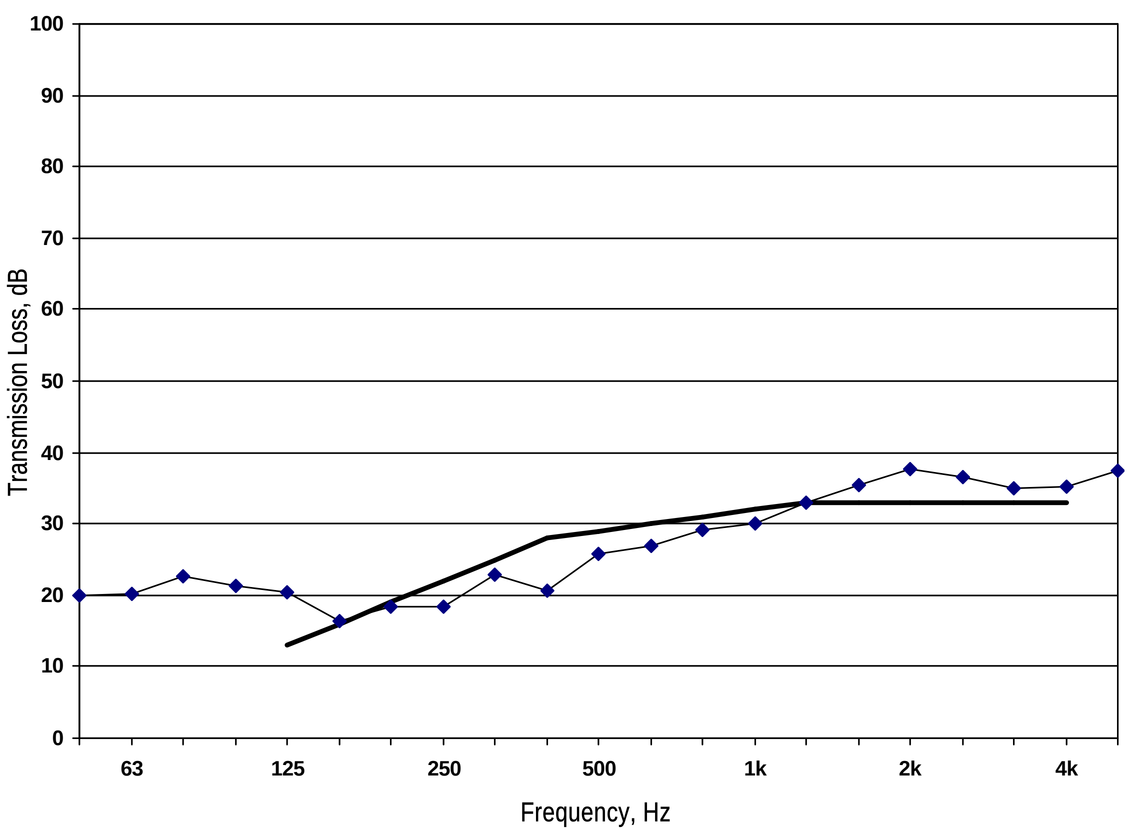
TLA-99-179a
aluminum casement
Construction Type: window

seals taped

window type	casement
frame material	aluminum
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	20
80	23
100	21
125	20
160	16
200	18
250	18
315	23
400	21
500	26
630	27
800	29
1000	30
1250	33
1600	35
2000	38
2500	37
3150	35
4000	35
5000	37
STC	29
OITC	24



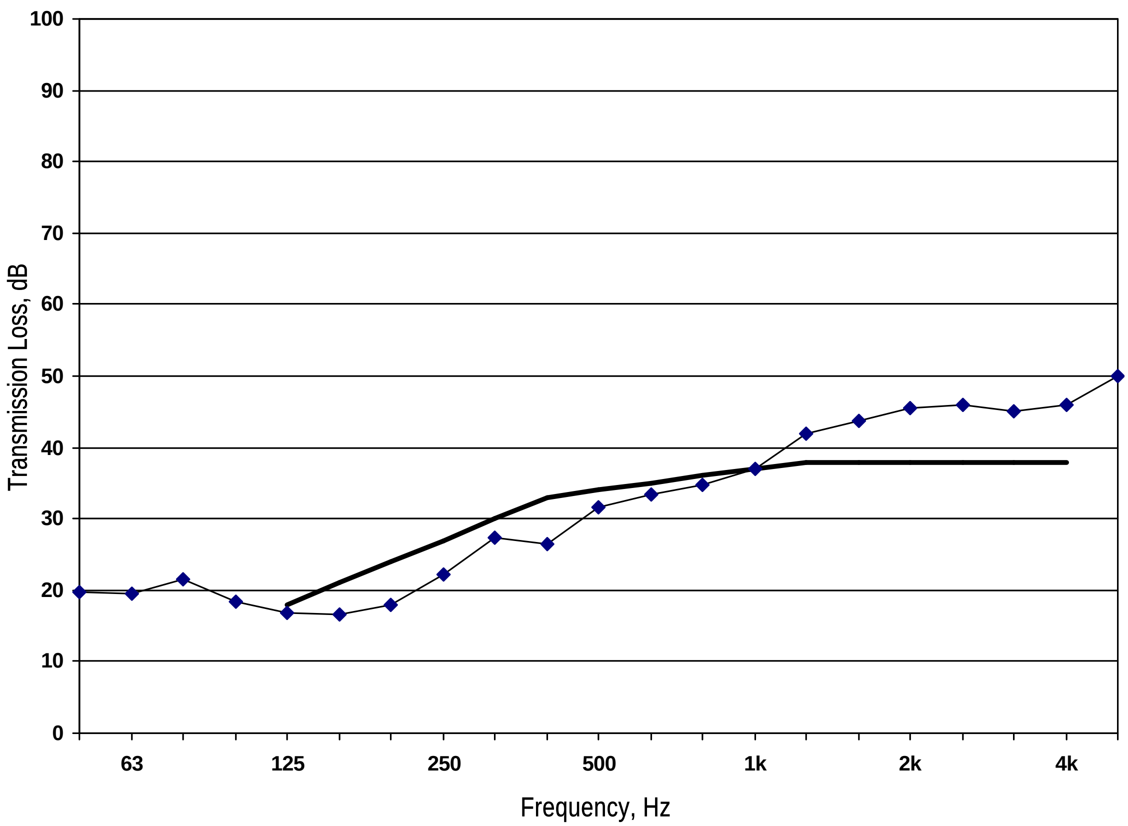
TLA-99-185a
aluminum casement
Construction Type: window

storm window installed (25 mm airspace)

window type	casement
frame material	aluminum
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	20
80	21
100	18
125	17
160	17
200	18
250	22
315	27
400	27
500	32
630	33
800	35
1000	37
1250	42
1600	44
2000	46
2500	46
3150	45
4000	46
5000	50
STC	34
OITC	25



NRC-CNRC National Research Council Canada

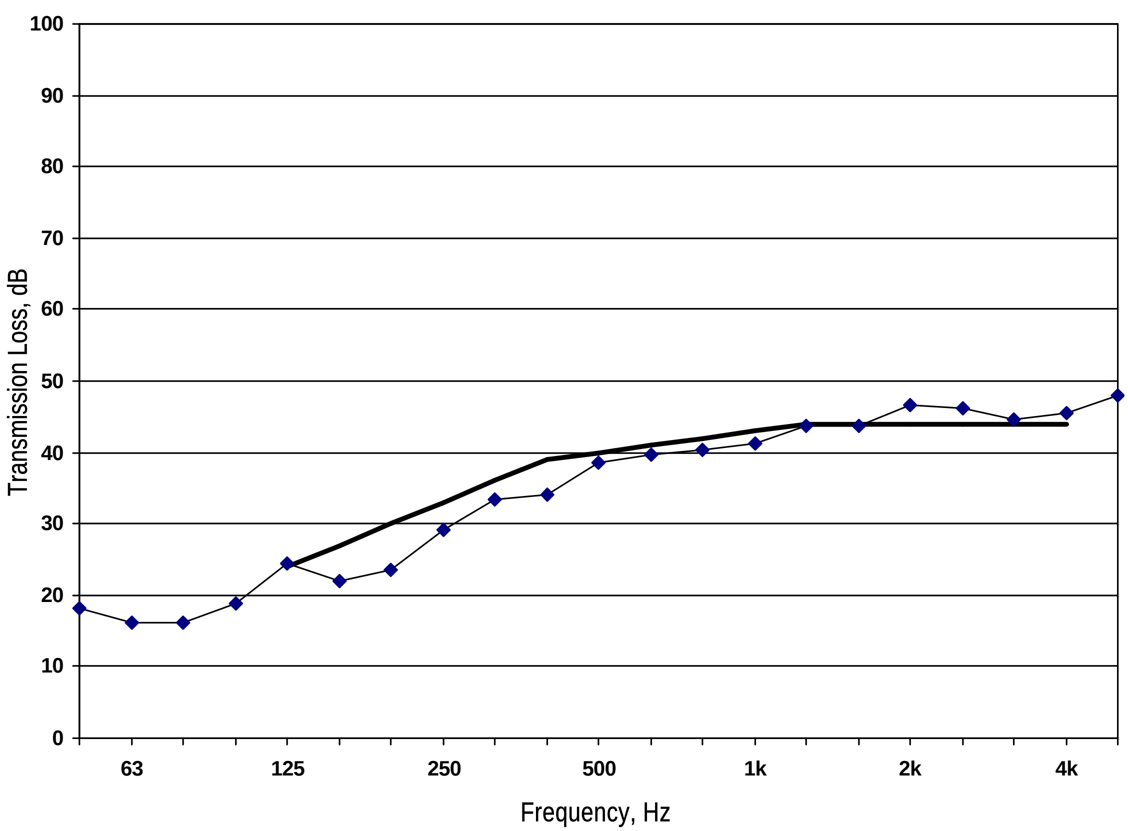
TLA-99-187a
aluminum casement
Construction Type: window

storm window installed (76 mm airspace)

window type	casement
frame material	aluminum
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	18
63	16
80	16
100	19
125	24
160	22
200	24
250	29
315	33
400	34
500	39
630	40
800	40
1000	41
1250	44
1600	44
2000	47
2500	46
3150	45
4000	46
5000	48
STC	40
OITC	30



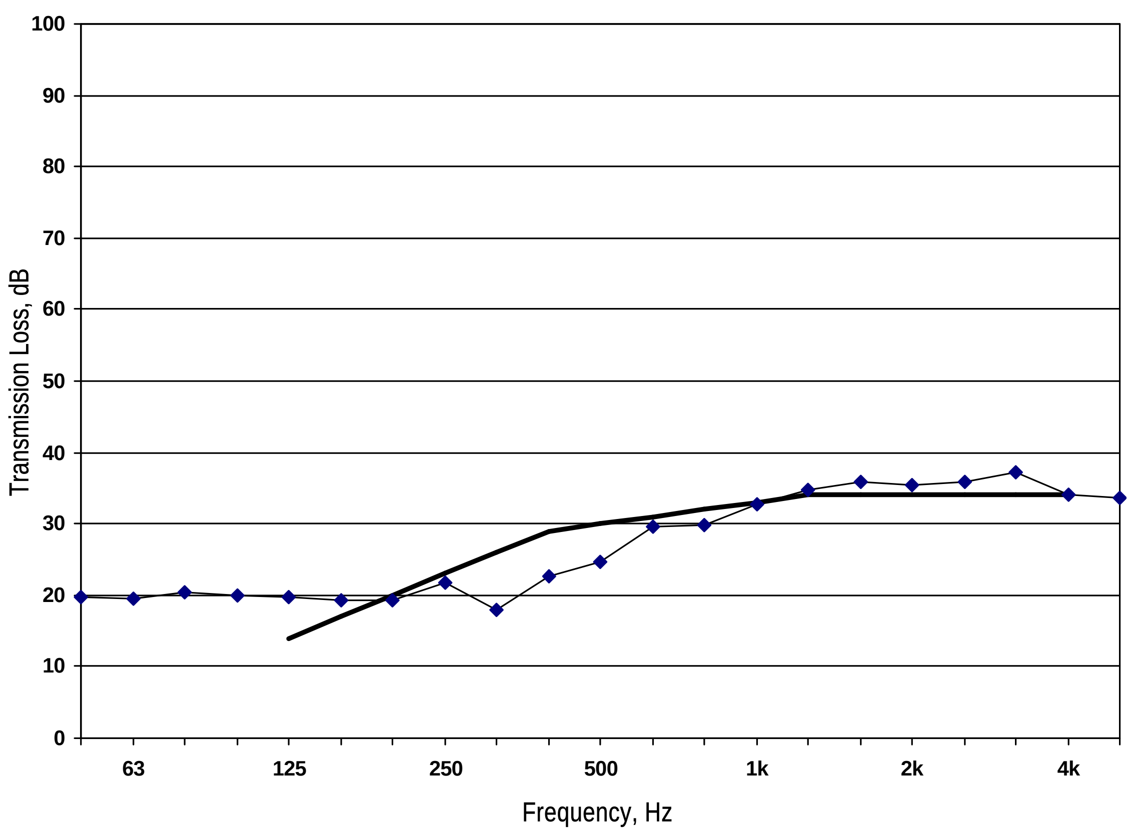
TLA-99-149a
vinyl slider
Construction Type: window

seals not taped

window type	slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	19
80	20
100	20
125	20
160	19
200	19
250	22
315	18
400	23
500	25
630	30
800	30
1000	33
1250	35
1600	36
2000	35
2500	36
3150	37
4000	34
5000	34
STC	30
OITC	25



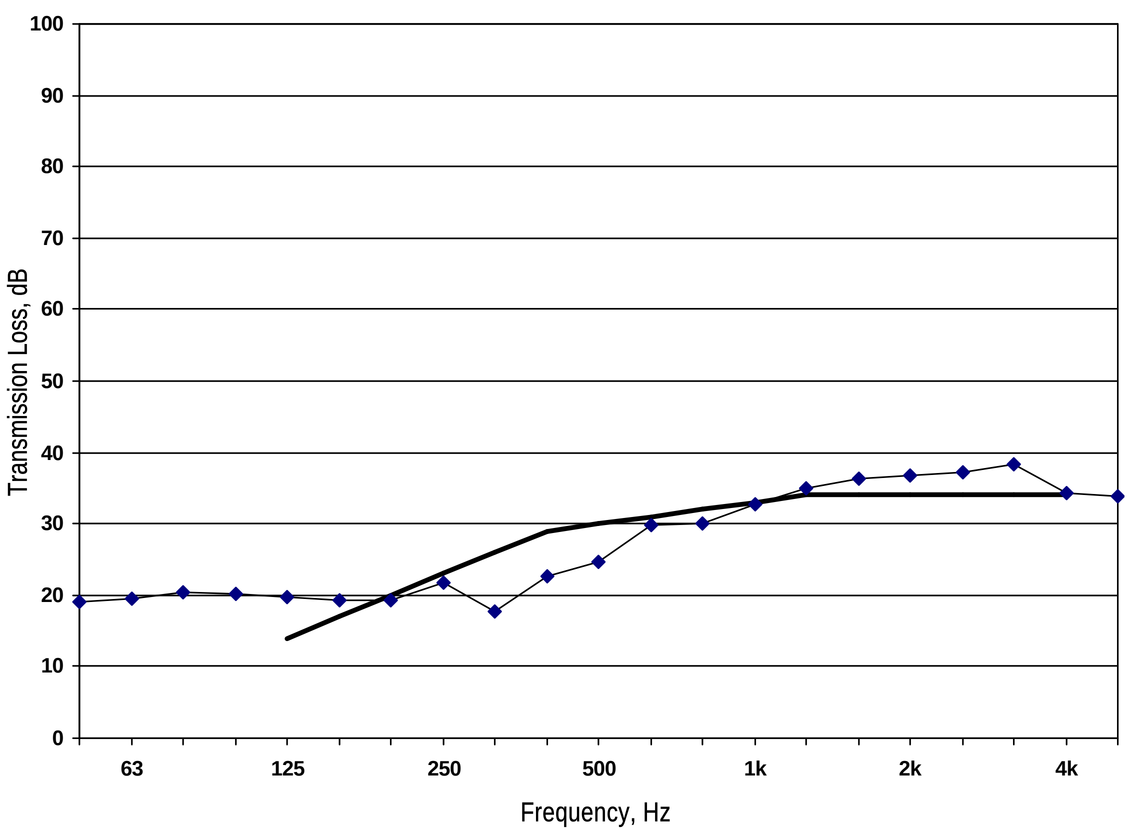
TLA-99-151a
vinyl slider
Construction Type: window

seals taped

window type	slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	20
80	20
100	20
125	20
160	19
200	19
250	22
315	18
400	23
500	25
630	30
800	30
1000	33
1250	35
1600	36
2000	37
2500	37
3150	38
4000	34
5000	34
STC	30
OITC	25



NRC-CNRC National Research Council Canada

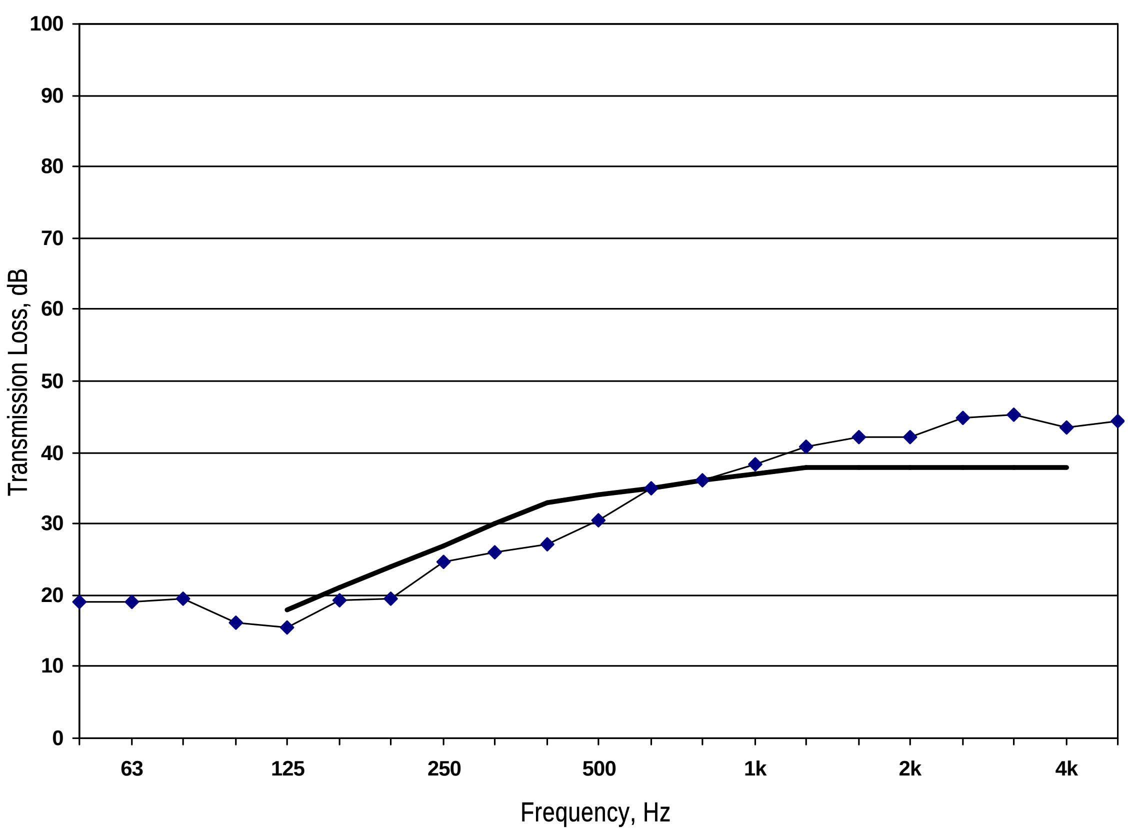
TLA-99-153a
vinyl slider
Construction Type: window

storm window installed (25 mm airspace)

window type	slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	19
63	19
80	19
100	16
125	15
160	19
200	20
250	25
315	26
400	27
500	30
630	35
800	36
1000	38
1250	41
1600	42
2000	42
2500	45
3150	45
4000	43
5000	44
STC	34
OITC	26



NRC-CNRC National Research Council Canada

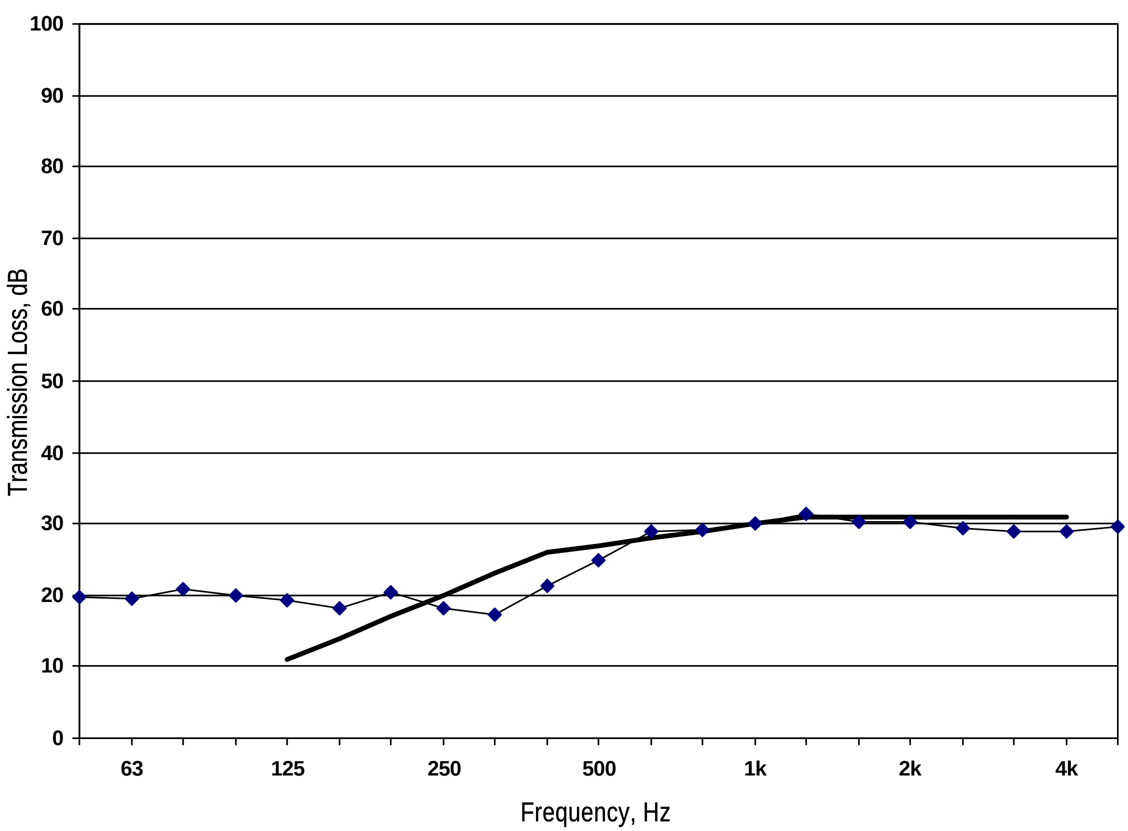
TLA-99-157a
vinyl double slider
Construction Type: window

seals not taped

window type	double slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	19
80	21
100	20
125	19
160	18
200	20
250	18
315	17
400	21
500	25
630	29
800	29
1000	30
1250	31
1600	30
2000	30
2500	29
3150	29
4000	29
5000	30
STC	27
OITC	23



National Research
Council Canada

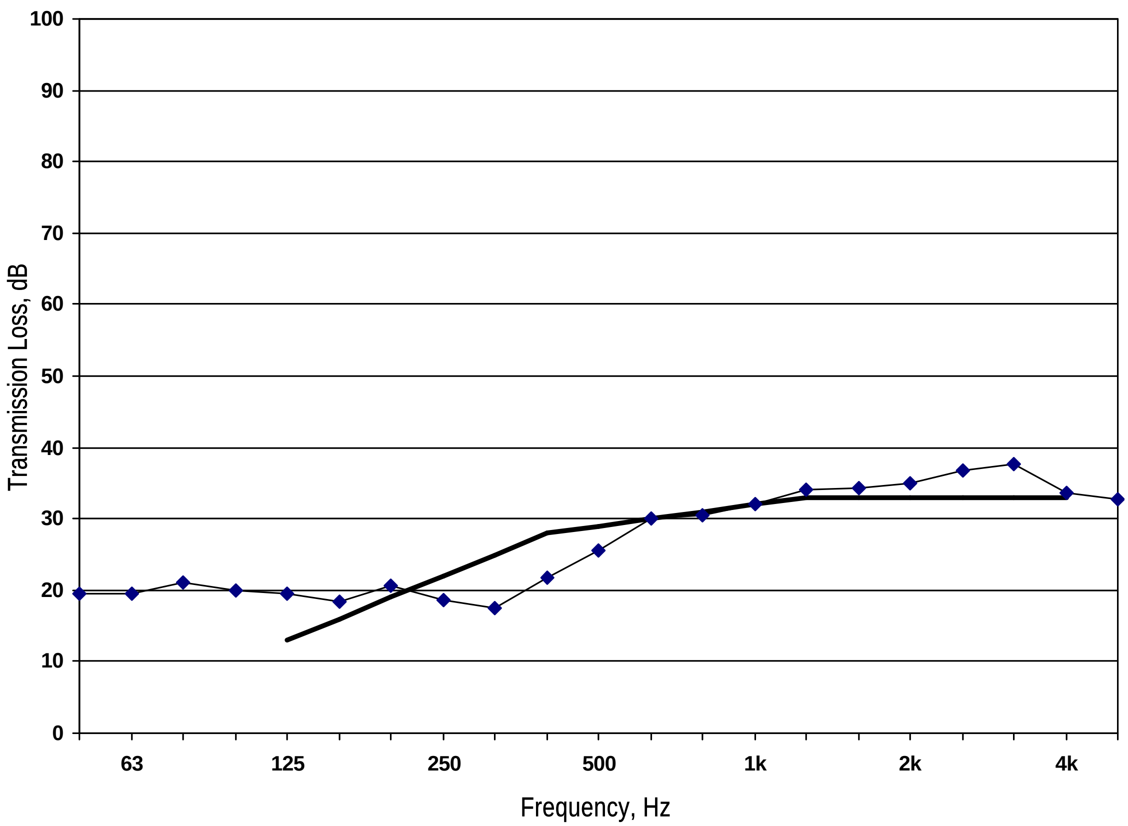
TLA-99-159a
vinyl double slider
Construction Type: window

seals taped

window type	double slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

* indicates not applicable

Freq, Hz	TL, dB
50	20
63	19
80	21
100	20
125	19
160	18
200	21
250	19
315	17
400	22
500	26
630	30
800	30
1000	32
1250	34
1600	34
2000	35
2500	37
3150	38
4000	34
5000	33
STC	29
OITC	24



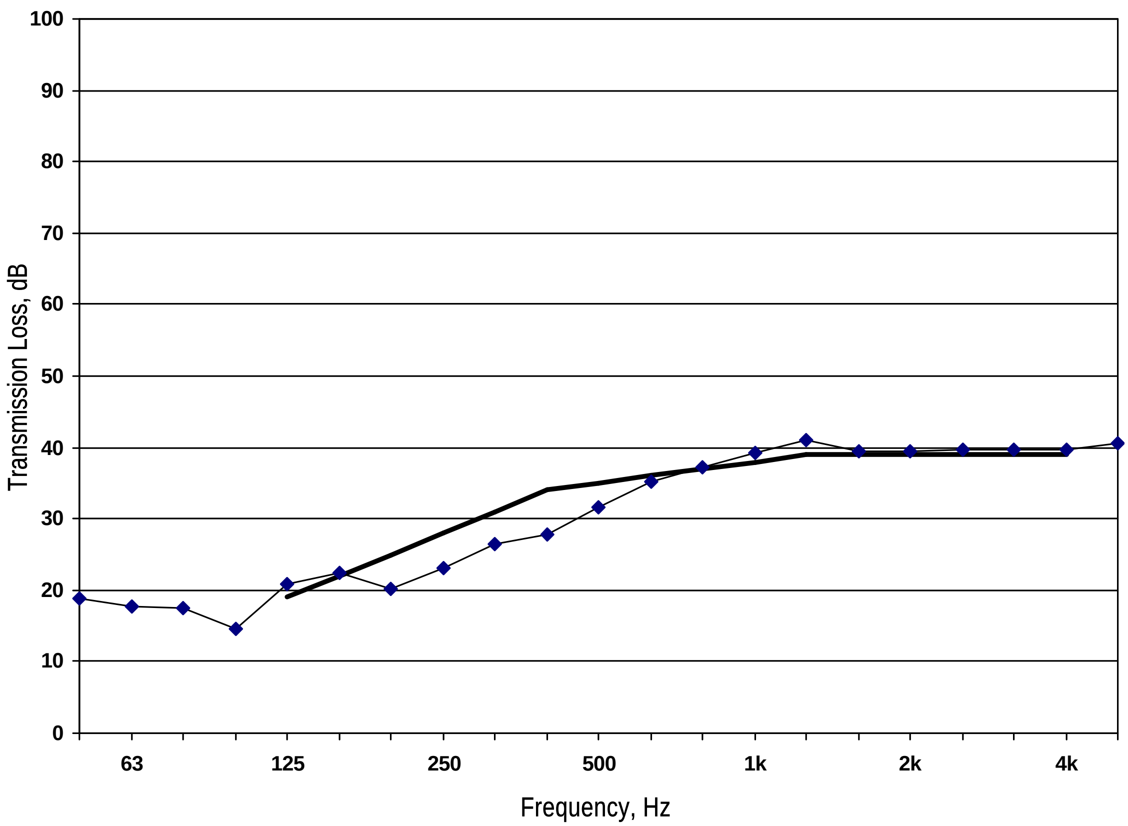
TLA-99-165a
vinyl double slider
Construction Type: window

storm window installed (25 mm airspace)

window type	double slider
frame material	vinyl
glass 1 thickness (mm)	3
spacer type	aluminum
spacer thickness (mm)	13
gas in cavity	air
glass 2 thickness (mm)	3

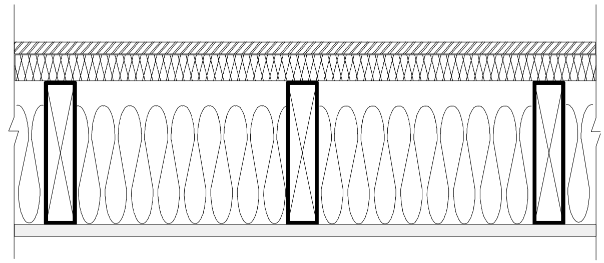
* indicates not applicable

Freq, Hz	TL, dB
50	19
63	18
80	17
100	15
125	21
160	22
200	20
250	23
315	26
400	28
500	32
630	35
800	37
1000	39
1250	41
1600	39
2000	40
2500	40
3150	40
4000	40
5000	41
STC	35
OITC	27



TLF-98-049a
OSB11_PL38(406)_WJ235(406)_GFB203_G13
Construction Type: roof

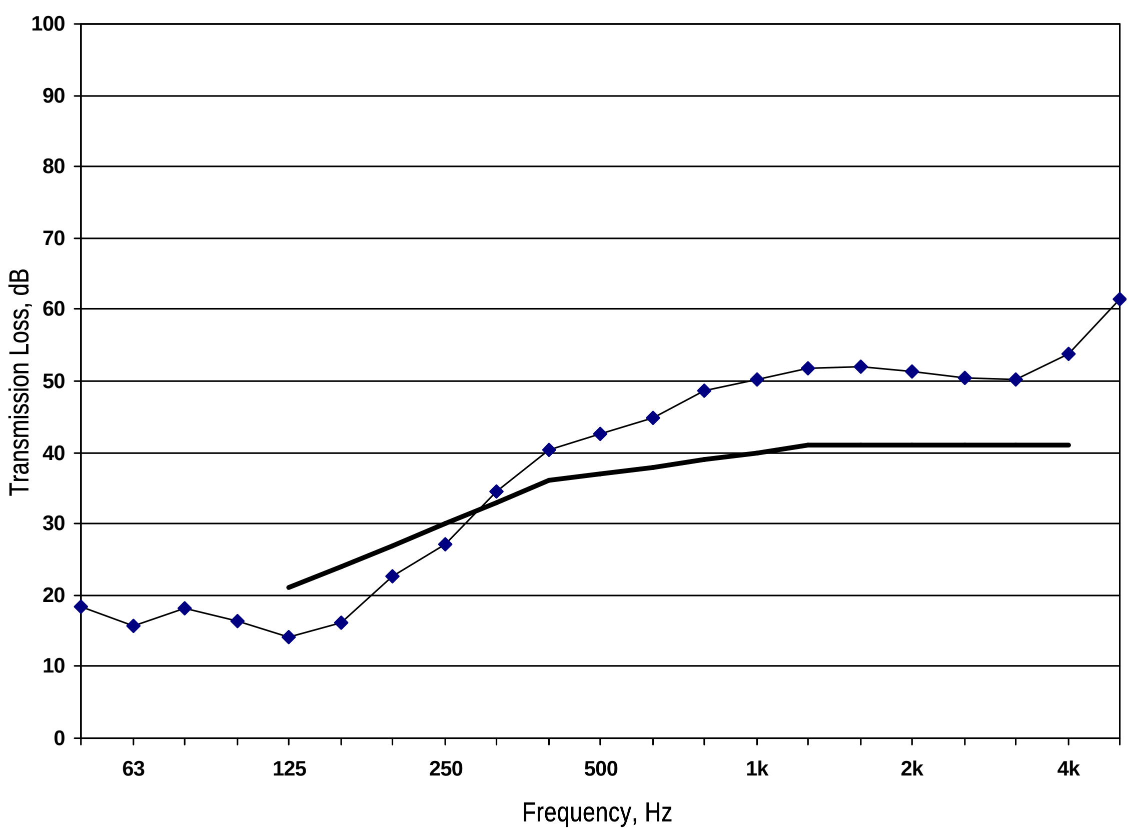
Element	Description
1	11 mm thick oriented strand board
2	38 mm deep wood purlin 406 mm on centre
3	235 mm deep wood joist at 406 mm on centre
4	203 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



Vents: not installed	element 1	element 2	element 3	element 4	element 5
type	subfloor	perlin	joists	insulation	gypsum board
material	OSB	wood	solid wood	glass fibre	regular
thickness (mm)	11	38	235	203	13
spacing (mm)	*	406	406	*	*
total mass (kg)	145	29	235	47	150
linear density (kg/m)	*	0.53	4.1	*	*
surface density (kg/m^2)	7.3	*	*	2.4	8.5
fastener spacing #1 (mm)	152 edges	*	*	*	305
fastener spacing #2 (mm)	305 field	*	*	*	*

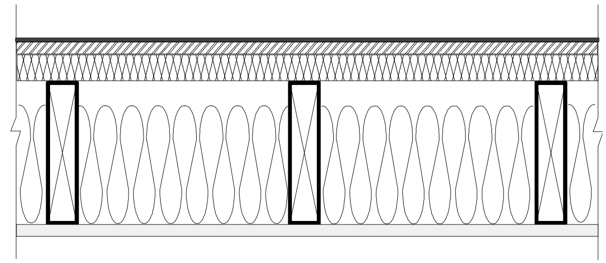
* indicates not applicable

Freq, Hz	TL, dB
50	18
63	16
80	18
100	16
125	14
160	16
200	23
250	27
315	34
400	40
500	43
630	45
800	49
1000	50
1250	52
1600	52
2000	51
2500	50
3150	50
4000	54
5000	61
STC	37
OITC	26



TLF-98-053a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13
Construction Type: roof

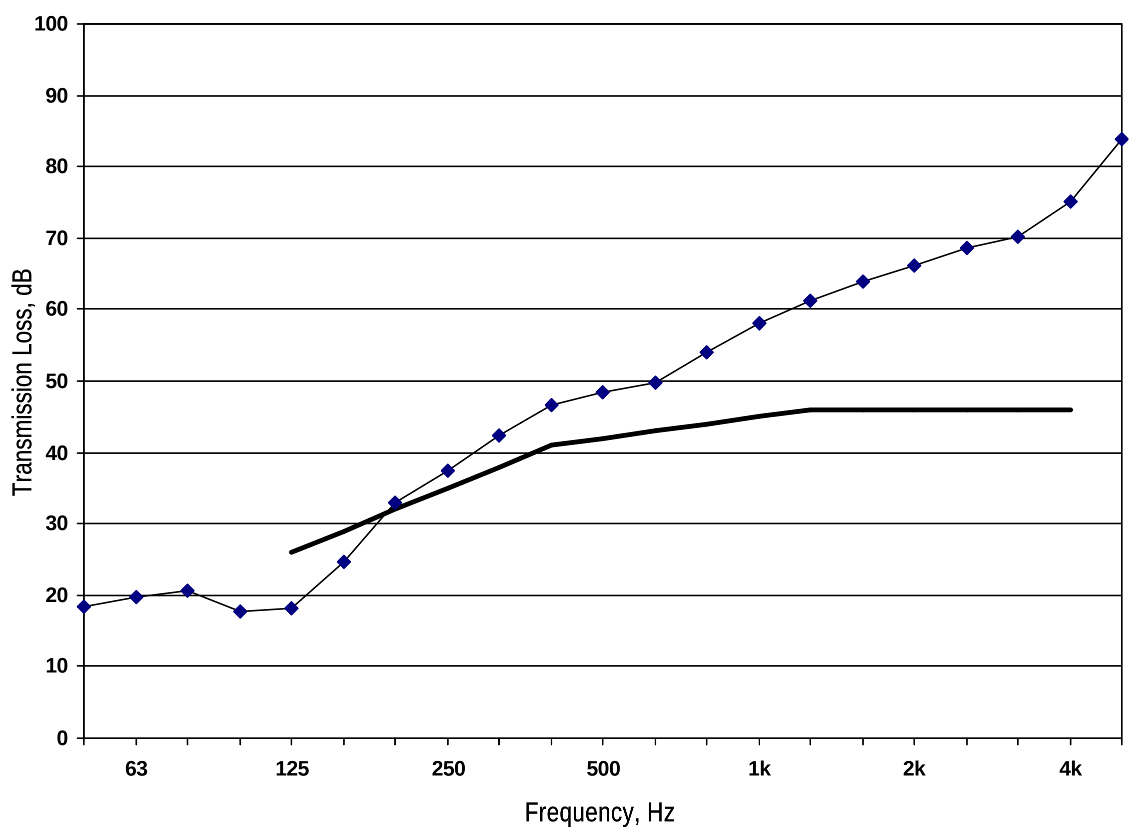
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	perlin	joists	insulation	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	regular
thickness (mm)	3	0.7	11	38	235	203	13
spacing (mm)	*	*	*	406	406	*	*
total mass (kg)	226	9.4	145	29	235	47	150
linear density (kg/m)	*	*	*	0.53	4.1	*	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

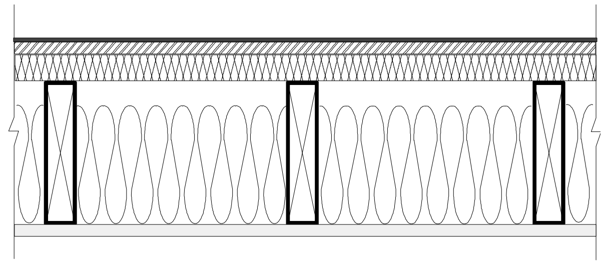
Freq, Hz	TL, dB
50	18
63	20
80	21
100	18
125	18
160	25
200	33
250	38
315	42
400	47
500	48
630	50
800	54
1000	58
1250	61
1600	64
2000	66
2500	69
3150	70
4000	75
5000	84
STC	42
OITC	30



NRC-CNRC National Research Council Canada

TLF-98-057a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13
Construction Type: roof

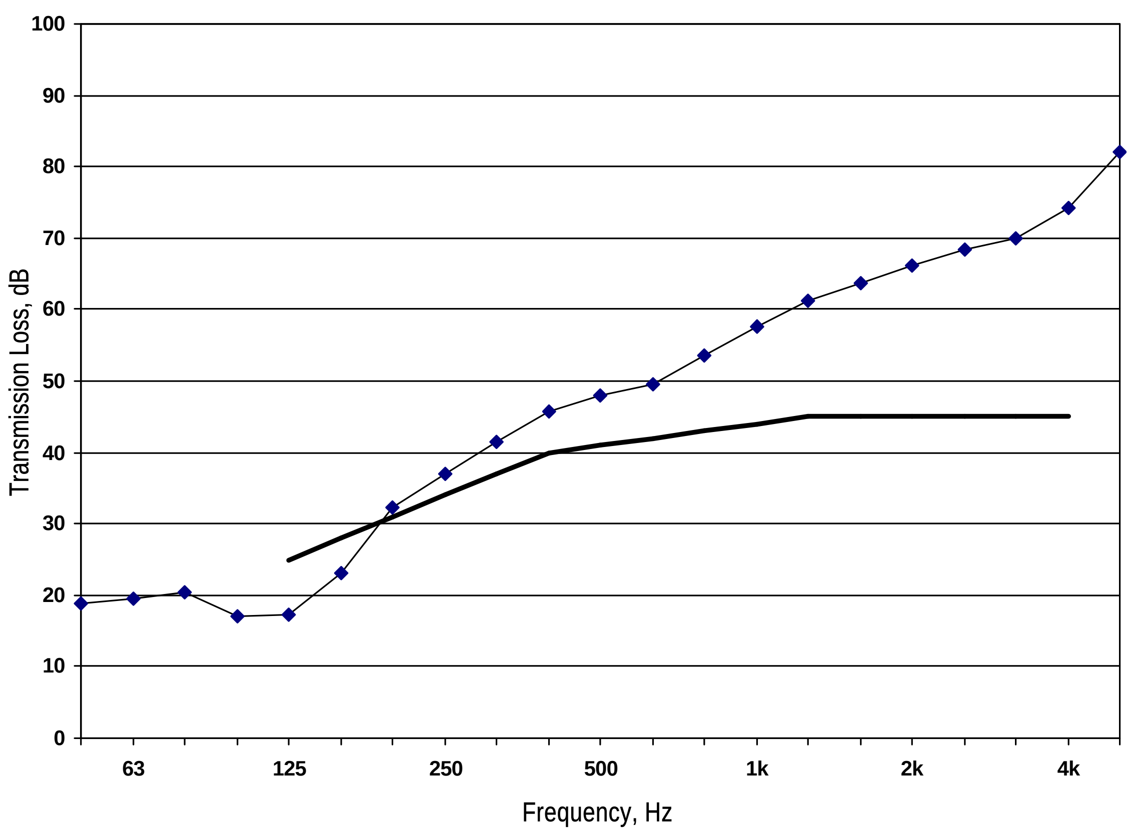
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	perlin	joists	insulation	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	regular
thickness (mm)	3	0.7	11	38	235	203	13
spacing (mm)	*	*	*	406	406	*	*
total mass (kg)	226	9.4	145	29	235	47	150
linear density (kg/m)	*	*	*	0.53	4.1	*	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

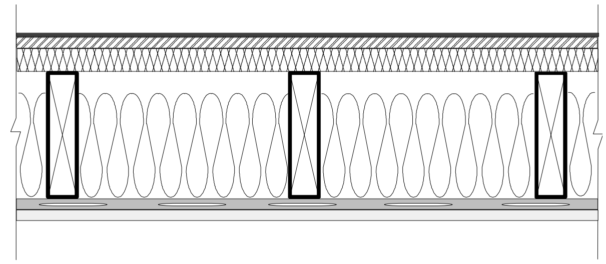
Freq, Hz	TL, dB
50	19
63	20
80	20
100	17
125	17
160	23
200	32
250	37
315	41
400	46
500	48
630	50
800	54
1000	58
1250	61
1600	64
2000	66
2500	68
3150	70
4000	74
5000	82
STC	41
OITC	29



NRC-CNRC National Research Council Canada

TLF-98-061a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board

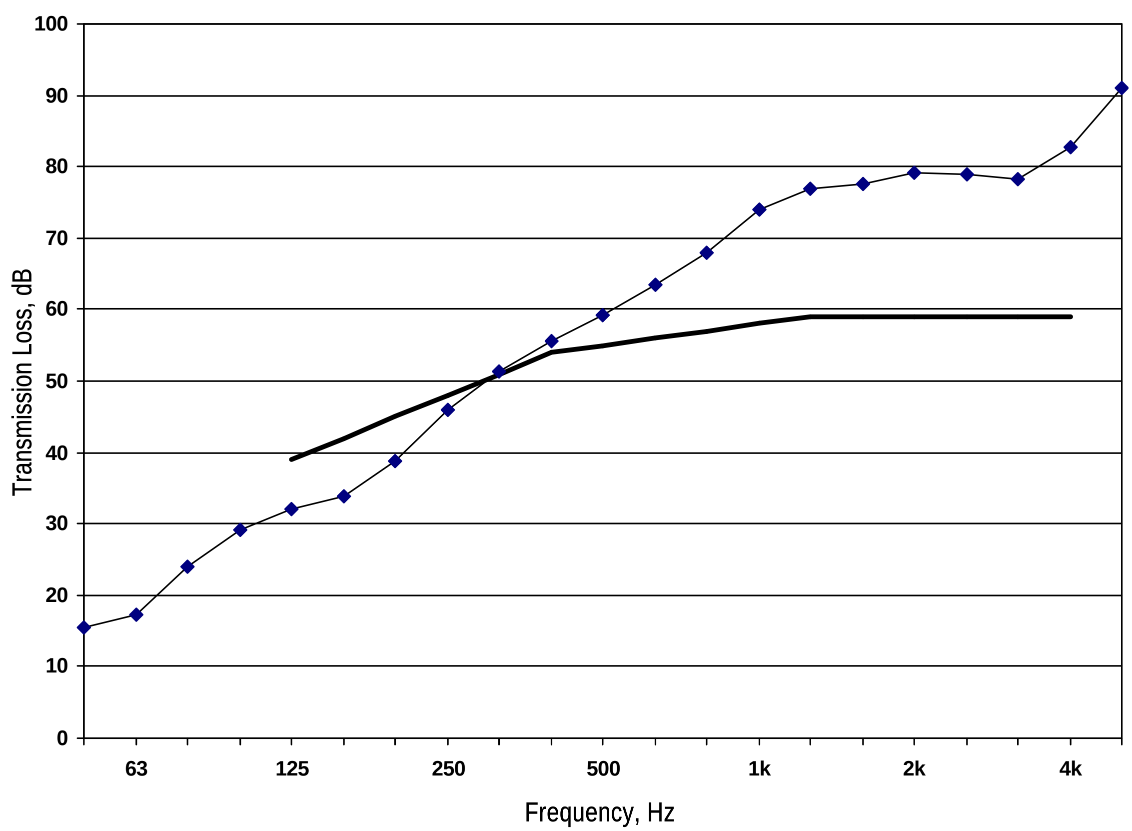


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	perlin	joists	insulation	resilient chan.	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	GP	regular
thickness (mm)	3	0.7	11	38	235	203	13	13
spacing (mm)	*	*	*	406	406	*	610	*
total mass (kg)	226	9.4	145	29	235	47	8.1	151
linear density (kg/m)	*	*	*	0.53	4.1	*	0.2	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	*	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

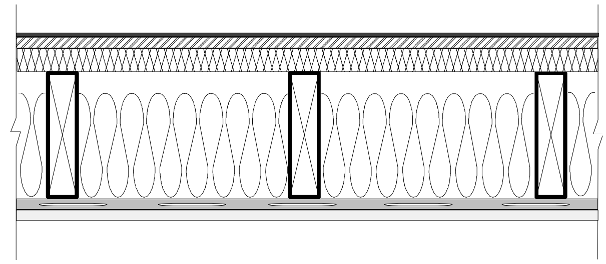
Freq, Hz	TL, dB
50	16
63	17
80	24
100	29
125	32
160	34
200	39
250	46
315	51
400	56
500	59
630	64
800	68
1000	74
1250	77
1600	78
2000	79
2500	79
3150	78
4000	83
5000	91
STC	55
OITC	40



NRC-CNRC National Research Council Canada

TLF-98-059a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13
Construction Type: roof

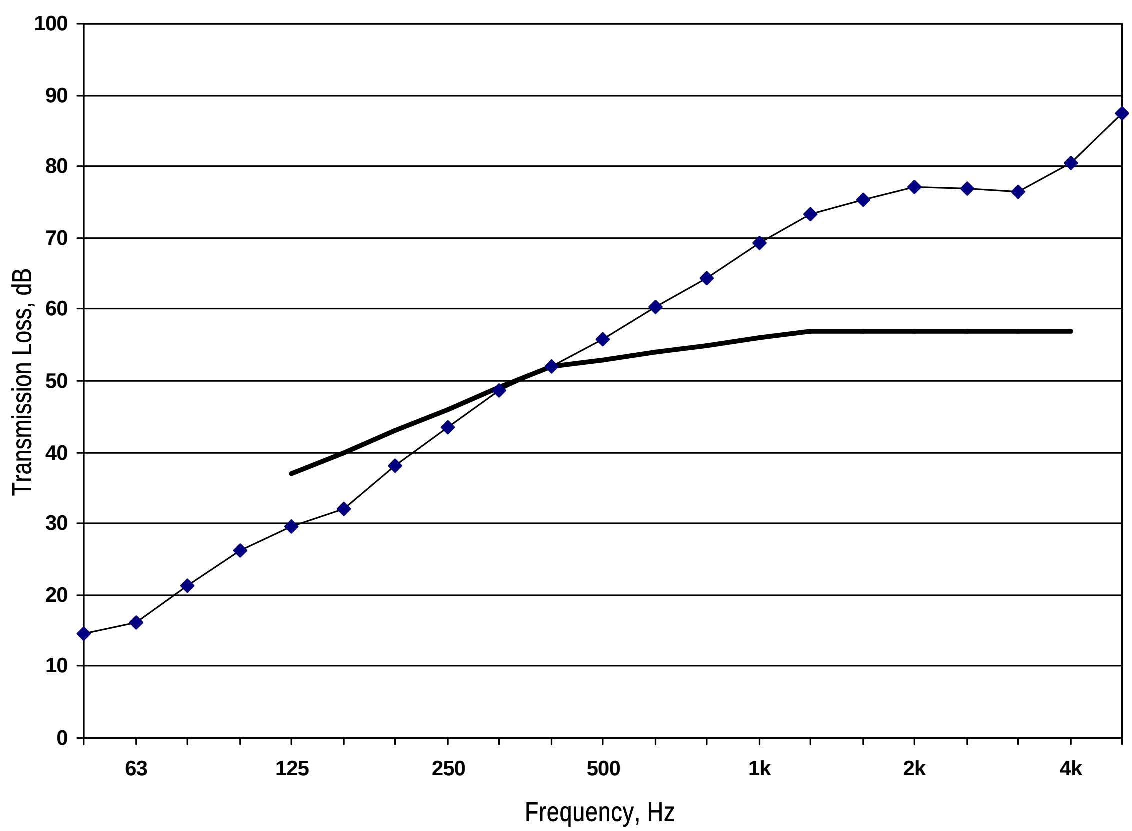
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	perlin	joists	insulation	resilient chan.	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	GP	regular
thickness (mm)	3	0.7	11	38	235	203	13	13
spacing (mm)	*	*	*	406	406	*	610	*
total mass (kg)	226	9.4	145	29	235	47	8.1	151
linear density (kg/m)	*	*	*	0.53	4.1	*	0.2	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	*	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

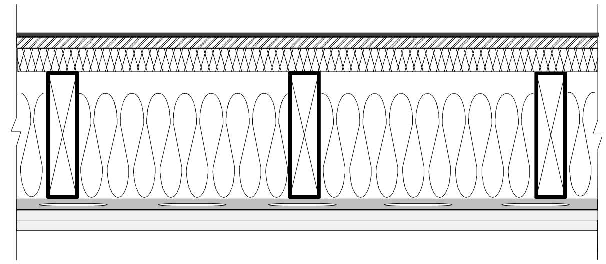
Freq, Hz	TL, dB
50	15
63	16
80	21
100	26
125	30
160	32
200	38
250	43
315	49
400	52
500	56
630	60
800	64
1000	69
1250	73
1600	75
2000	77
2500	77
3150	76
4000	81
5000	88
STC	53
OITC	37



NRC-CNRC National Research Council Canada

TLF-98-063a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board
9	13 mm thick regular gypsum board

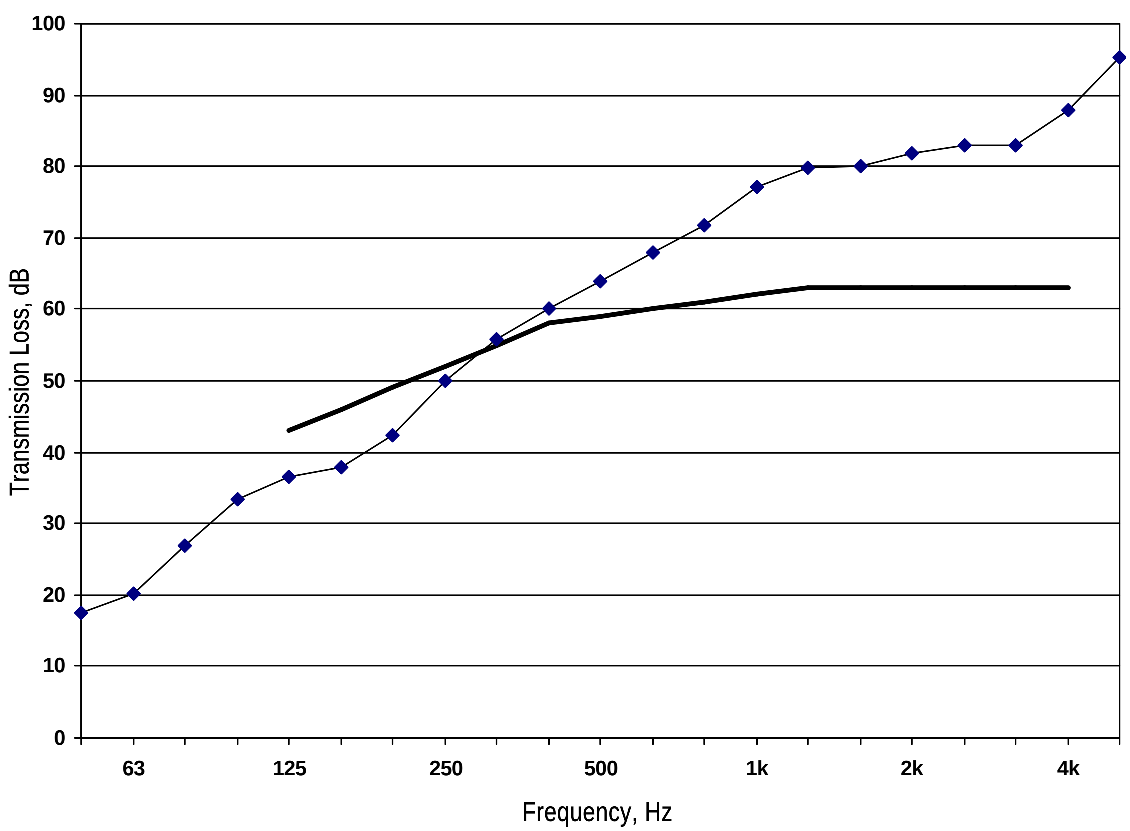


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	shingles	building paper	subfloor	perlin	joists	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	38	235	203	13	13	13
spacing (mm)	*	*	*	406	406	*	610	*	*
total mass (kg)	226	9.4	145	29	235	47	8.1	151	150
linear density (kg/m)	*	*	*	0.53	4.1	*	0.2	*	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	*	8.5	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*	*

* indicates not applicable

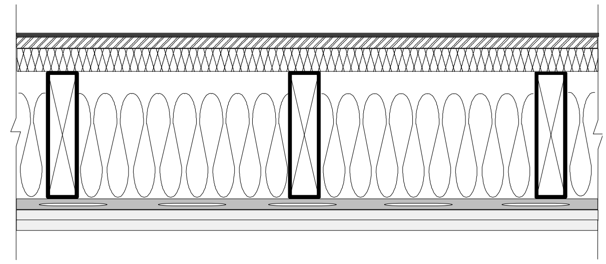
Freq, Hz	TL, dB
50	18
63	20
80	27
100	33
125	36
160	38
200	42
250	50
315	56
400	60
500	64
630	68
800	72
1000	77
1250	80
1600	80
2000	82
2500	83
3150	83
4000	88
5000	95
STC	59
OITC	43



NRC-CNRC National Research Council Canada

TLF-98-065a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13
Construction Type: roof

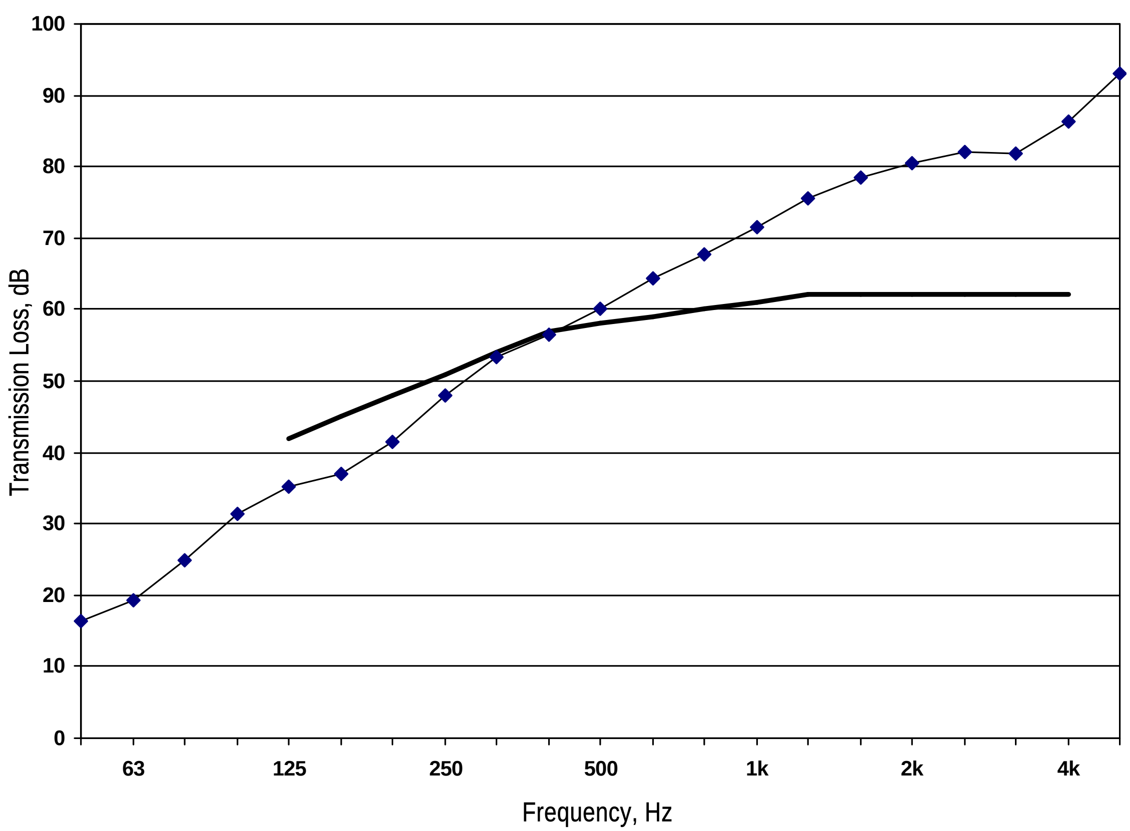
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board
9	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	shingles	building paper	subfloor	perlin	joists	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	38	235	203	13	13	13
spacing (mm)	*	*	*	406	406	*	610	*	*
total mass (kg)	226	9.4	145	29	235	47	8.1	151	150
linear density (kg/m)	*	*	*	0.53	4.1	*	0.2	*	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	*	8.5	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*	*

* indicates not applicable

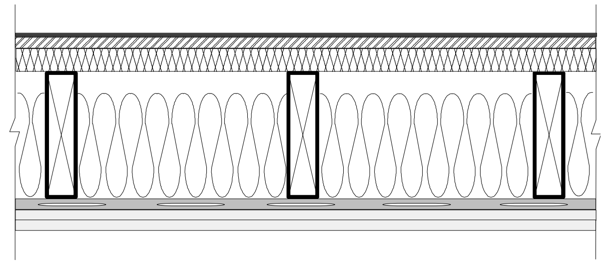
Freq, Hz	TL, dB
50	16
63	19
80	25
100	31
125	35
160	37
200	41
250	48
315	53
400	56
500	60
630	64
800	68
1000	72
1250	75
1600	78
2000	81
2500	82
3150	82
4000	86
5000	93
STC	58
OITC	42



National Research Council Canada

TLF-98-067a
SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13
Construction Type: roof

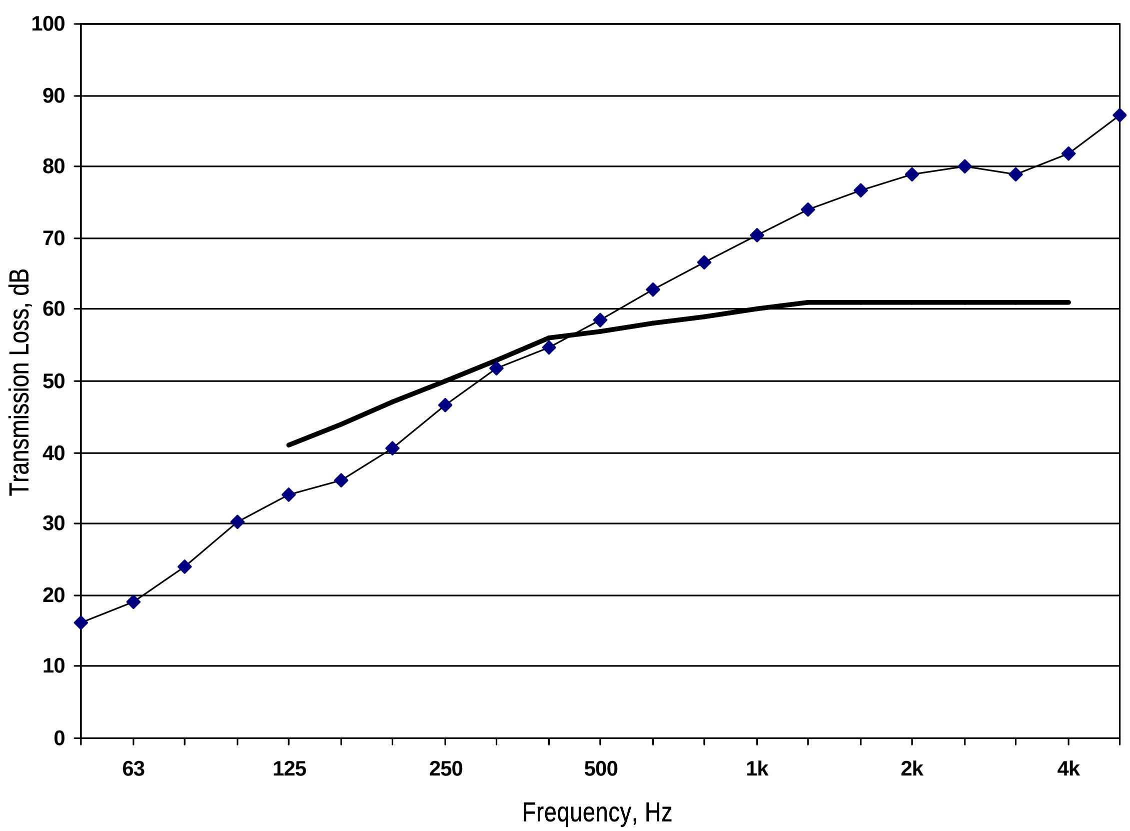
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	38 mm deep wood purlin 406 mm on centre
5	235 mm deep wood joist at 406 mm on centre
6	203 mm thick glass fibre insulation in cavity
7	13 mm resilient channel at 610 mm on centre
8	13 mm thick regular gypsum board
9	13 mm thick regular gypsum board



Vents: holes (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	shingles	building paper	subfloor	perlin	joists	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	solid wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	38	235	203	13	13	13
spacing (mm)	*	*	*	406	406	*	610	*	*
total mass (kg)	226	9.4	145	29	235	47	8.1	151	150
linear density (kg/m)	*	*	*	0.53	4.1	*	0.2	*	*
surface density (kg/m^2)	12	0.4	7.3	*	*	2.4	*	8.5	8.5
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*	*

* indicates not applicable

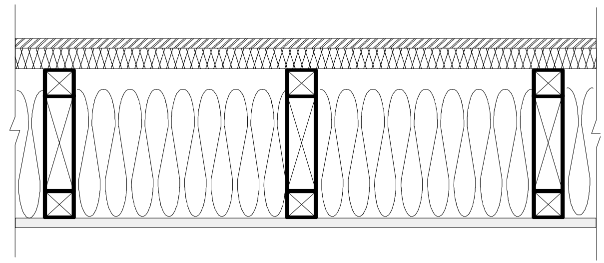
Freq, Hz	TL, dB
50	16
63	19
80	24
100	30
125	34
160	36
200	41
250	47
315	52
400	55
500	59
630	63
800	67
1000	70
1250	74
1600	77
2000	79
2500	80
3150	79
4000	82
5000	87
STC	57
OITC	41



NRC-CNRC National Research Council Canada

TLF-98-069a
OSB11_WT356(406)_GFB264_G13
Construction Type: roof

Element	Description
1	11 mm thick oriented strand board
2	356 mm deep wood truss at 406 mm on centre
3	264 mm thick glass fibre insulation in cavity
4	13 mm thick regular gypsum board

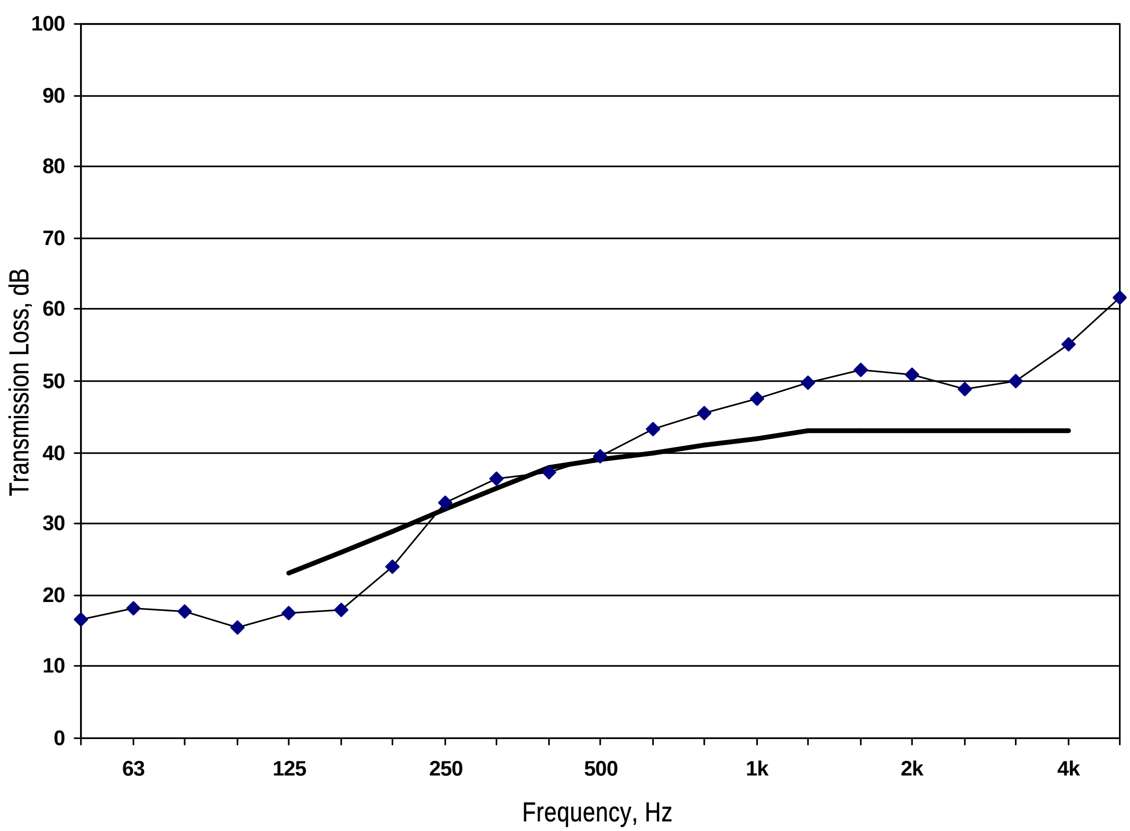


Vents: not installed

	element 1	element 2	element 3	element 4
type	subfloor	trusses	insulation	gypsum board
material	OSB	wood	glass fibre	regular
thickness (mm)	11	356	264	13
spacing (mm)	*	406	*	*
total mass (kg)	133	305	86	140
linear density (kg/m)	*	4.3	*	*
surface density (kg/m^2)	6.6	*	4.5	7.8
fastener spacing #1 (mm)	152 edges	*	*	305
fastener spacing #2 (mm)	305 field	*	*	*

* indicates not applicable

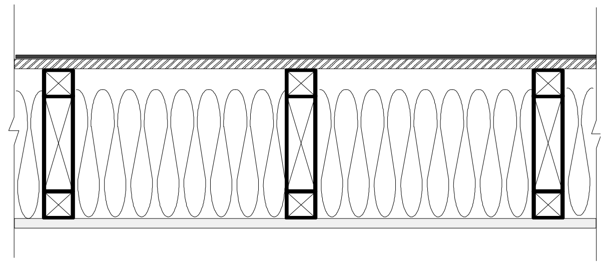
Freq, Hz	TL, dB
50	17
63	18
80	18
100	16
125	18
160	18
200	24
250	33
315	36
400	37
500	39
630	43
800	45
1000	48
1250	50
1600	52
2000	51
2500	49
3150	50
4000	55
5000	62
STC	39
OITC	27



NRC-CNRC National Research Council Canada

TLF-98-073a
SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13
Construction Type: roof

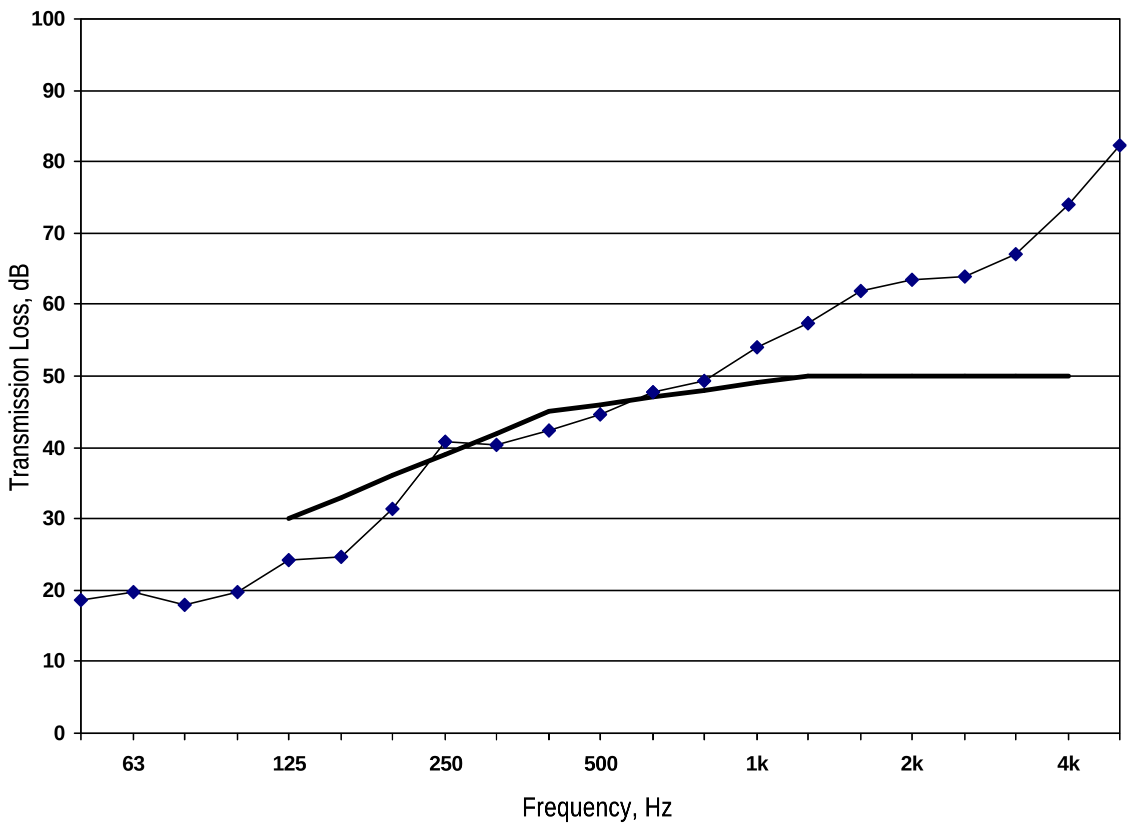
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	356 mm deep wood truss at 406 mm on centre
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	trusses	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	356	264	13
spacing (mm)	*	*	*	406	*	*
total mass (kg)	224	6.9	133	305	86	140
linear density (kg/m)	*	*	*	4.3	*	*
surface density (kg/m^2)	11	0.3	6.6	*	4.5	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

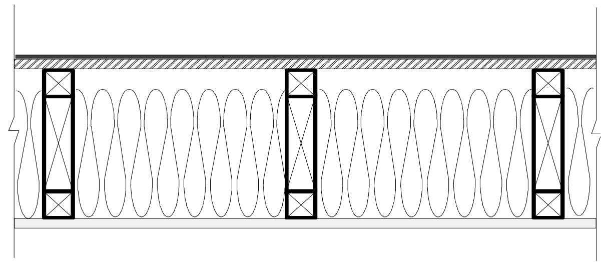
Freq, Hz	TL, dB
50	19
63	20
80	18
100	20
125	24
160	25
200	31
250	41
315	40
400	42
500	45
630	48
800	49
1000	54
1250	58
1600	62
2000	63
2500	64
3150	67
4000	74
5000	82
STC	46
OITC	32



National Research Council Canada

TLF-98-075a
SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	356 mm deep wood truss at 406 mm on centre
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board

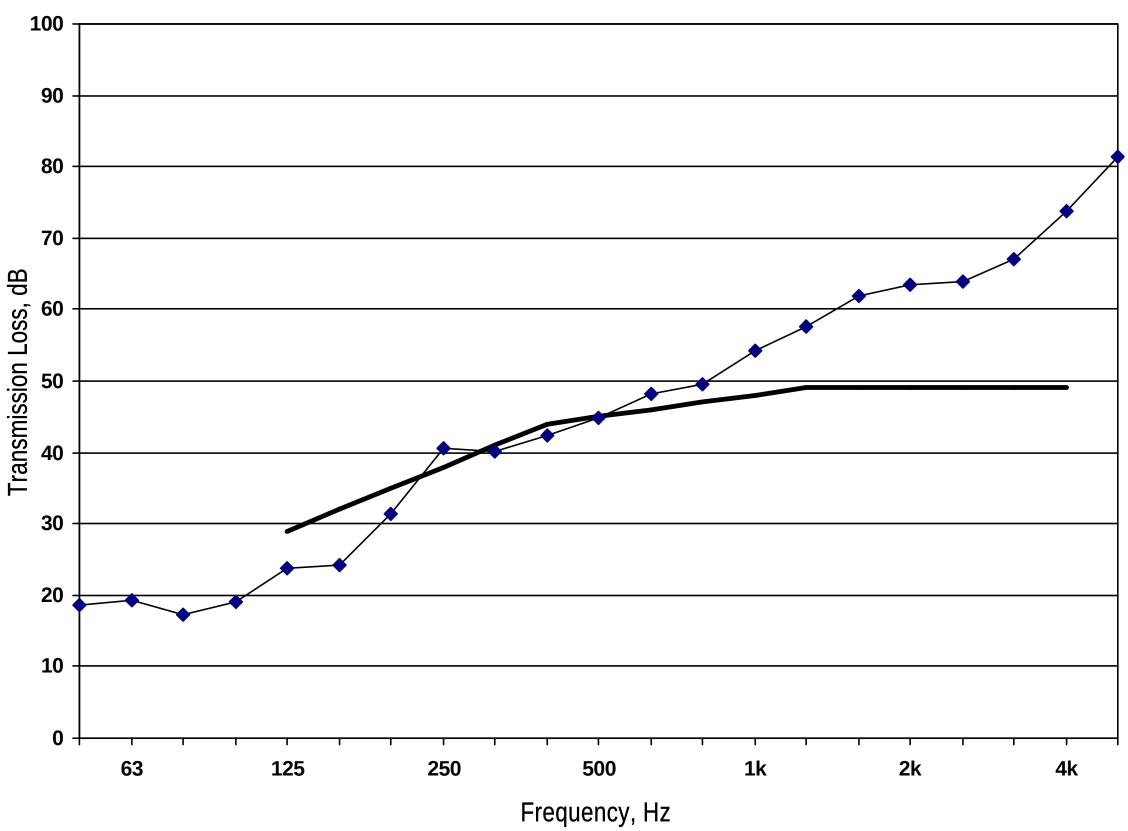


Vents: roof (6)

	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	trusses	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	356	264	13
spacing (mm)	*	*	*	406	*	*
total mass (kg)	224	6.9	133	305	86	140
linear density (kg/m)	*	*	*	4.3	*	*
surface density (kg/m^2)	11	0.3	6.6	*	4.5	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

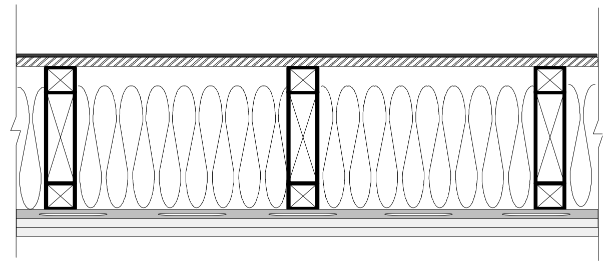
Freq, Hz	TL, dB
50	19
63	19
80	17
100	19
125	24
160	24
200	31
250	41
315	40
400	42
500	45
630	48
800	50
1000	54
1250	58
1600	62
2000	64
2500	64
3150	67
4000	74
5000	81
STC	45
OITC	31



National Research
Council Canada

TLF-98-079a
SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13
Construction Type: roof

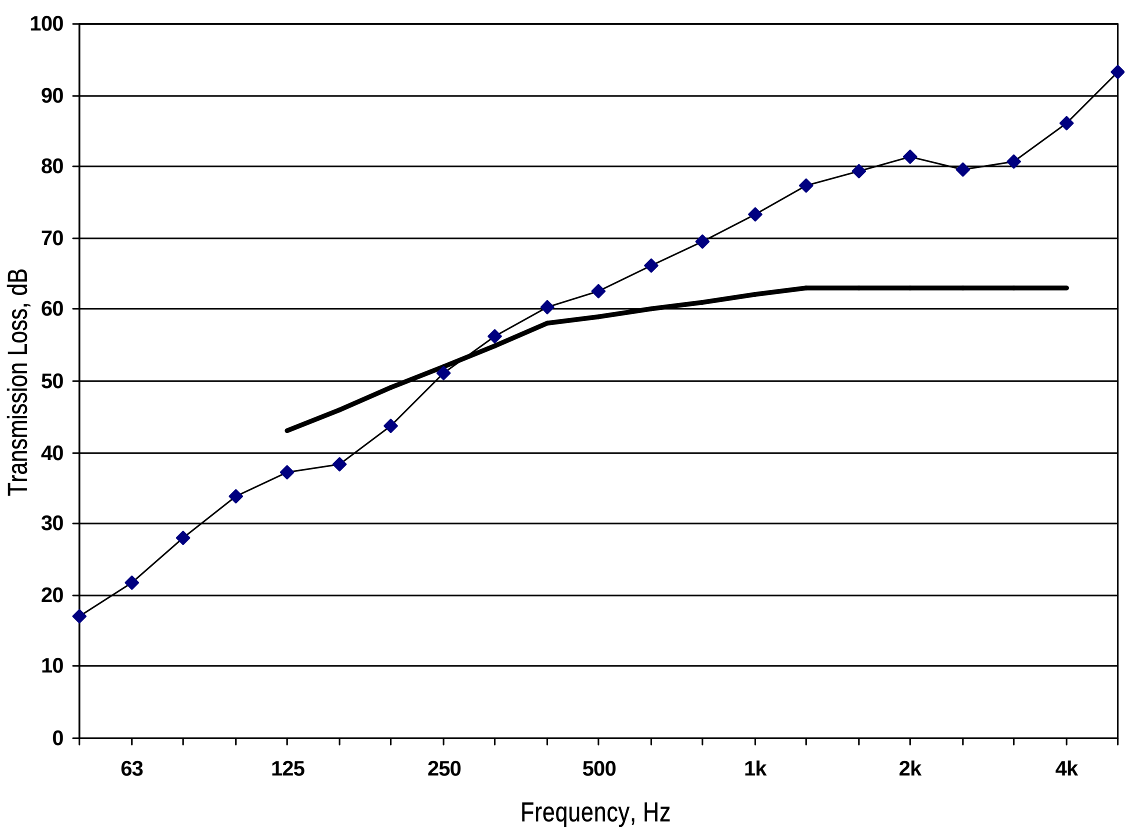
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	356 mm deep wood truss at 406 mm on centre
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	trusses	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	356	264	13	13	13
spacing (mm)	*	*	*	406	*	610	*	*
total mass (kg)	224	6.9	133	305	86	8.1	140	140
linear density (kg/m)	*	*	*	4.3	*	0.2	*	*
surface density (kg/m^2)	11	0.3	6.6	*	4.5	*	7.8	7.9
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

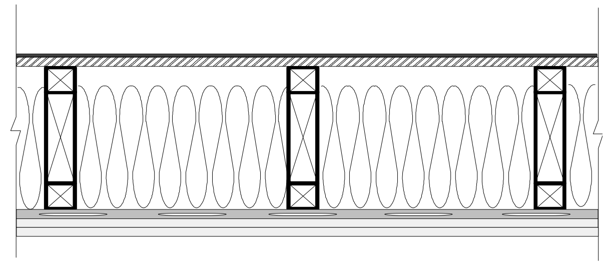
Freq, Hz	TL, dB
50	17
63	22
80	28
100	34
125	37
160	38
200	44
250	51
315	56
400	60
500	63
630	66
800	69
1000	73
1250	77
1600	79
2000	81
2500	80
3150	81
4000	86
5000	93
STC	59
OITC	44



NRC-CNRC National Research Council Canada

TLF-98-077a
SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	356 mm deep wood truss at 406 mm on centre
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board

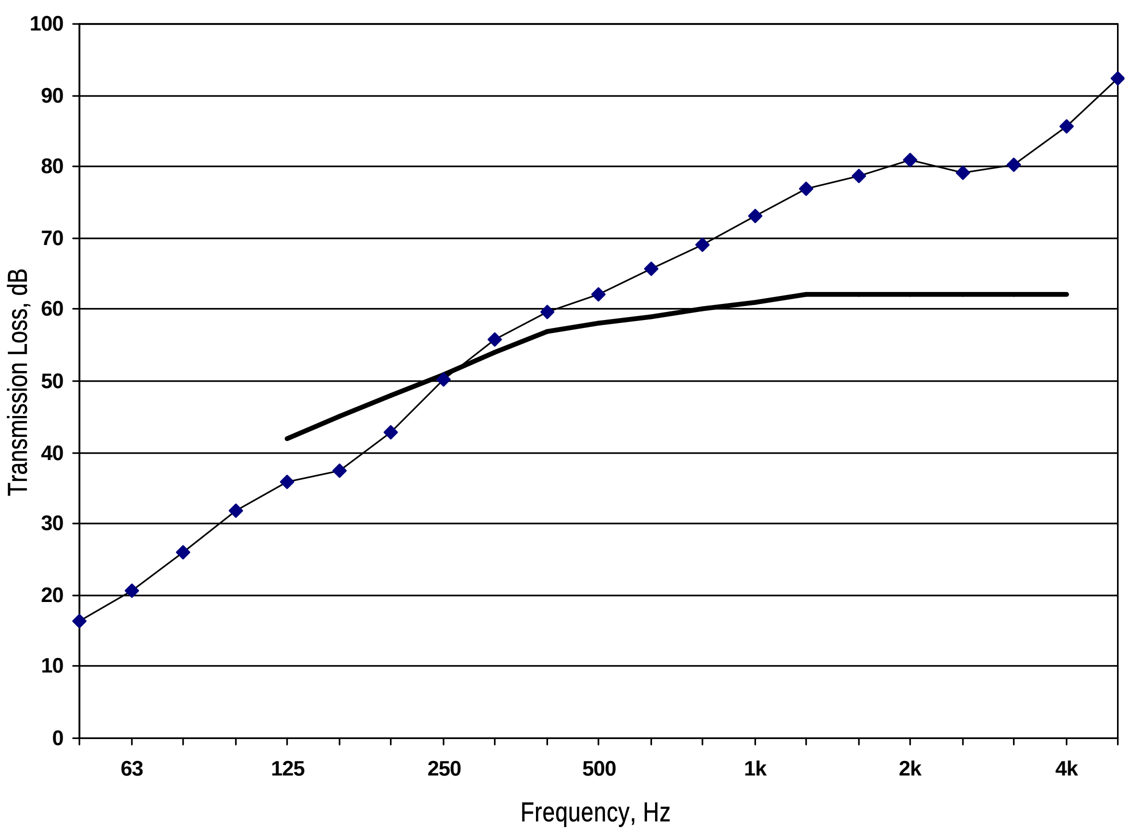


Vents: roof (6)

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	trusses	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	356	264	13	13	13
spacing (mm)	*	*	*	406	*	610	*	*
total mass (kg)	224	6.9	133	305	86	8.1	140	140
linear density (kg/m)	*	*	*	4.3	*	0.2	*	*
surface density (kg/m^2)	11	0.3	6.6	*	4.5	*	7.8	7.9
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

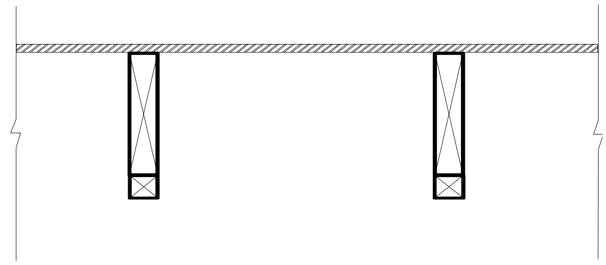
Freq, Hz	TL, dB
50	16
63	21
80	26
100	32
125	36
160	37
200	43
250	50
315	56
400	60
500	62
630	66
800	69
1000	73
1250	77
1600	79
2000	81
2500	79
3150	80
4000	86
5000	92
STC	58
OITC	43



National Research Council Canada

TLF-98-083a
OSB11_RHWT1626
Construction Type: roof

Element	Description
1	11 mm thick oriented strand board
2	1626 mm deep raised heel wood truss

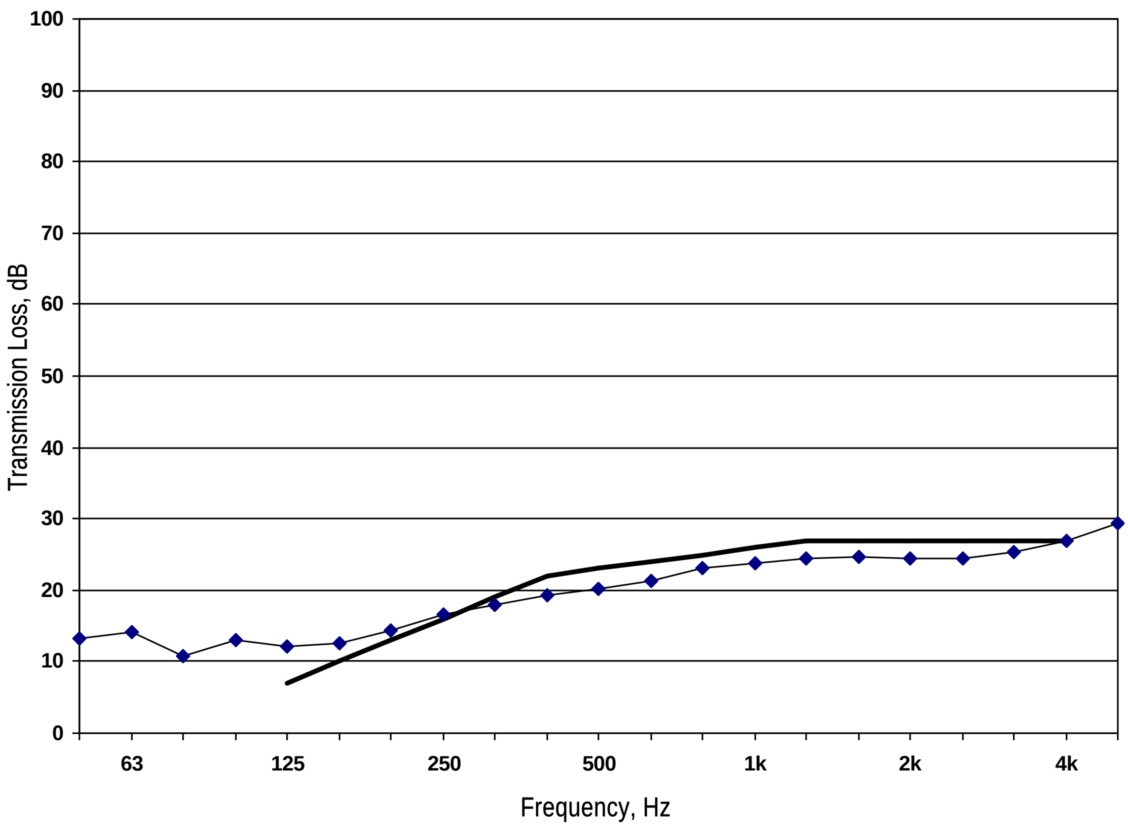


Vents: not installed

	element 1	element 2
type	subfloor	RH truss
material	OSB	wood
thickness (mm)	11	1626
spacing (mm)	*	610
total mass (kg)	109	284
linear density (kg/m)	*	6.2
surface density (kg/m^2)	6.8	*
fastener spacing #1 (mm)	152 edges	*
fastener spacing #2 (mm)	305 field	*

* indicates not applicable

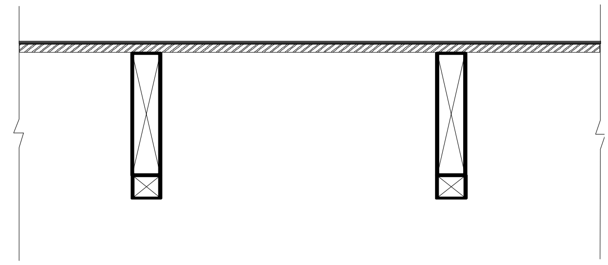
Freq, Hz	TL, dB
50	13
63	14
80	11
100	13
125	12
160	13
200	14
250	17
315	18
400	19
500	20
630	21
800	23
1000	24
1250	24
1600	25
2000	24
2500	25
3150	25
4000	27
5000	29
STC	23
OITC	19



NRC-CNRC National Research Council Canada

TLF-98-119a
SHN3_BPAP0.7_OSB11_RHWT1626
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss

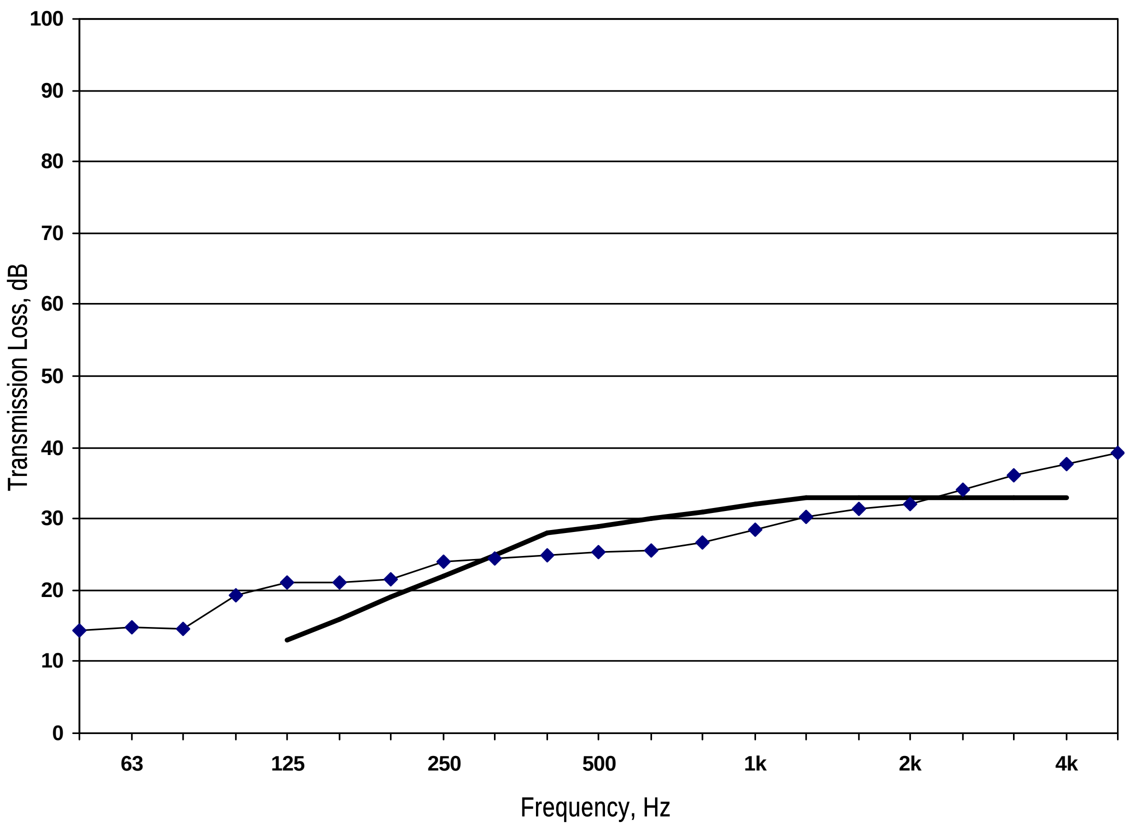


Vents: not installed

	element 1	element 2	element 3	element 4
type	shingles	building paper	subfloor	RH truss
material	asphalt	*	OSB	wood
thickness (mm)	3	0.7	11	1626
spacing (mm)	*	*	*	610
total mass (kg)	201	4.9	109	284
linear density (kg/m)	*	*	*	6.2
surface density (kg/m^2)	12	0.2	6.8	*
fastener spacing #1 (mm)	*	*	152 edges	*
fastener spacing #2 (mm)	*	*	305 field	*

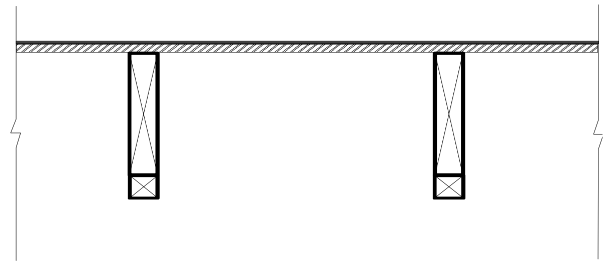
* indicates not applicable

Freq, Hz	TL, dB
50	14
63	15
80	15
100	19
125	21
160	21
200	22
250	24
315	24
400	25
500	25
630	26
800	27
1000	29
1250	30
1600	31
2000	32
2500	34
3150	36
4000	38
5000	39
STC	29
OITC	25



TLF-98-087a
SHN3_BPAP0.7_OSB11_RHWT1626
Construction Type: roof

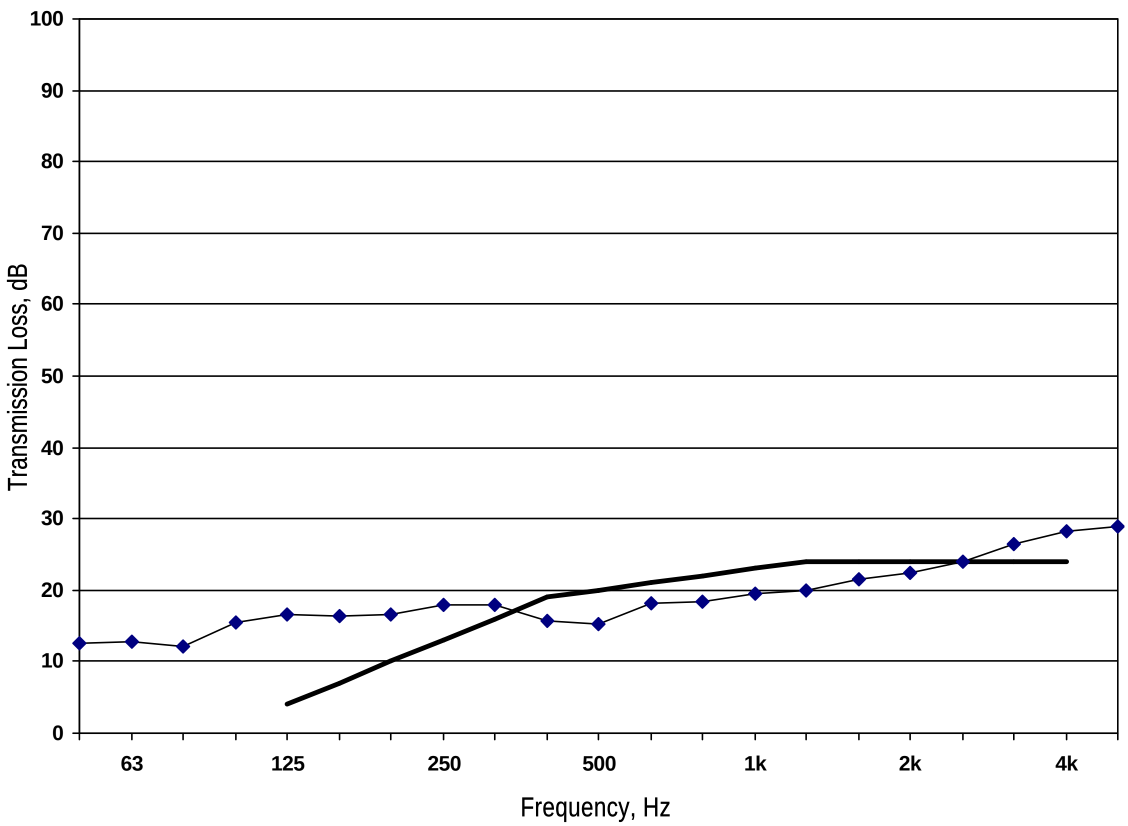
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss



Vents: roof (6)	element 1	element 2	element 3	element 4
type	shingles	building paper	subfloor	RH truss
material	asphalt	*	OSB	wood
thickness (mm)	3	0.7	11	1626
spacing (mm)	*	*	*	610
total mass (kg)	201	4.9	109	284
linear density (kg/m)	*	*	*	6.2
surface density (kg/m^2)	12	0.2	6.8	*
fastener spacing #1 (mm)	*	*	152 edges	*
fastener spacing #2 (mm)	*	*	305 field	*

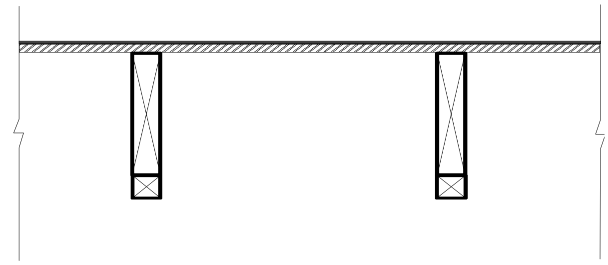
* indicates not applicable

Freq, Hz	TL, dB
50	13
63	13
80	12
100	15
125	17
160	16
200	17
250	18
315	18
400	16
500	15
630	18
800	18
1000	19
1250	20
1600	22
2000	23
2500	24
3150	27
4000	28
5000	29
STC	20
OITC	18



TLF-98-117a
SHN3_BPAP0.7_OSB11_RHWT1626
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss

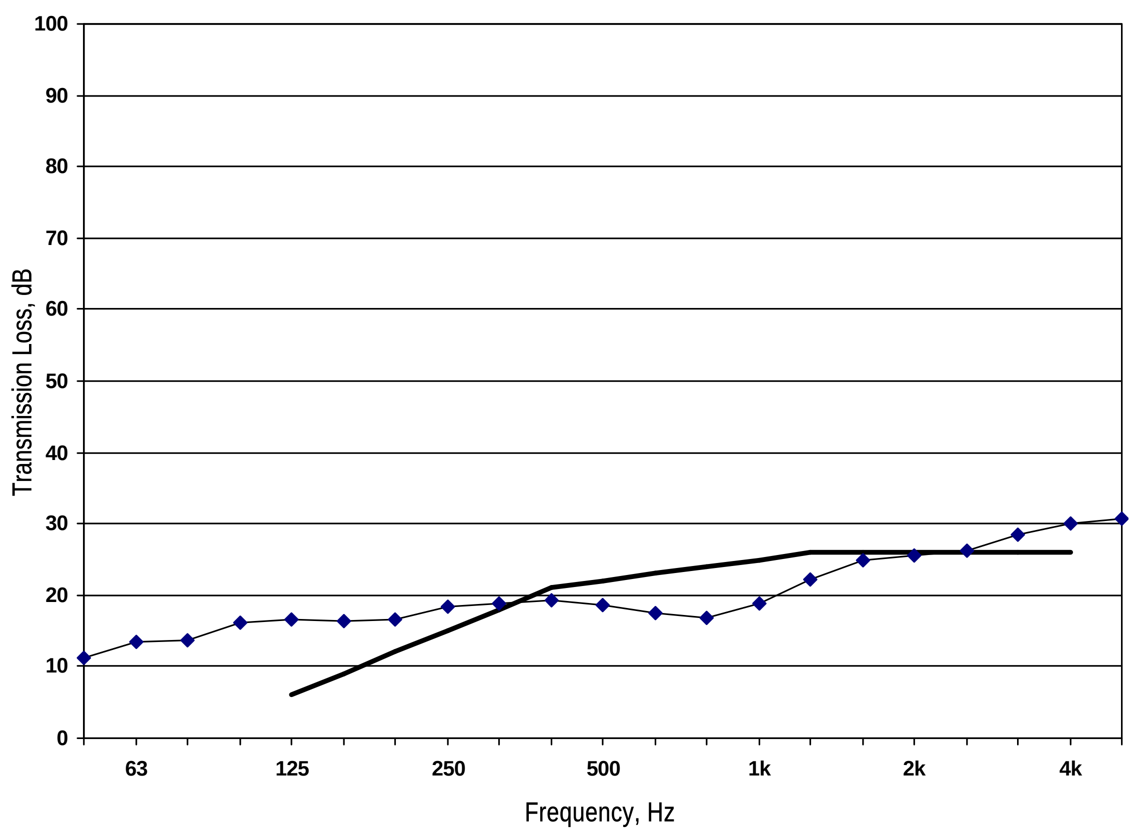


Vents: ridge

	element 1	element 2	element 3	element 4
type	shingles	building paper	subfloor	RH truss
material	asphalt	*	OSB	wood
thickness (mm)	3	0.7	11	1626
spacing (mm)	*	*	*	610
total mass (kg)	201	4.9	109	284
linear density (kg/m)	*	*	*	6.2
surface density (kg/m²)	12	0.2	6.8	*
fastener spacing #1 (mm)	*	*	152 edges	*
fastener spacing #2 (mm)	*	*	305 field	*

* indicates not applicable

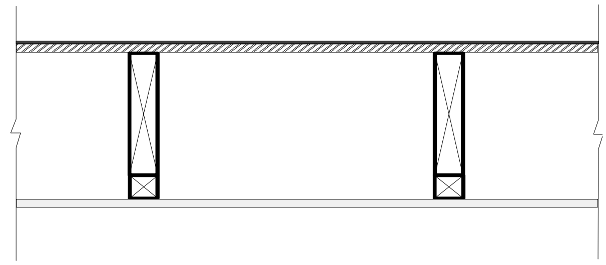
Freq, Hz	TL, dB
50	11
63	14
80	14
100	16
125	17
160	16
200	17
250	18
315	19
400	19
500	19
630	18
800	17
1000	19
1250	22
1600	25
2000	26
2500	26
3150	28
4000	30
5000	31
STC	22
OITC	19



NRC-CNRC National Research Council Canada

TLF-98-121a
SHN3_BPAP0.7_OSB11_RHWT1626_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	13 mm thick regular gypsum board

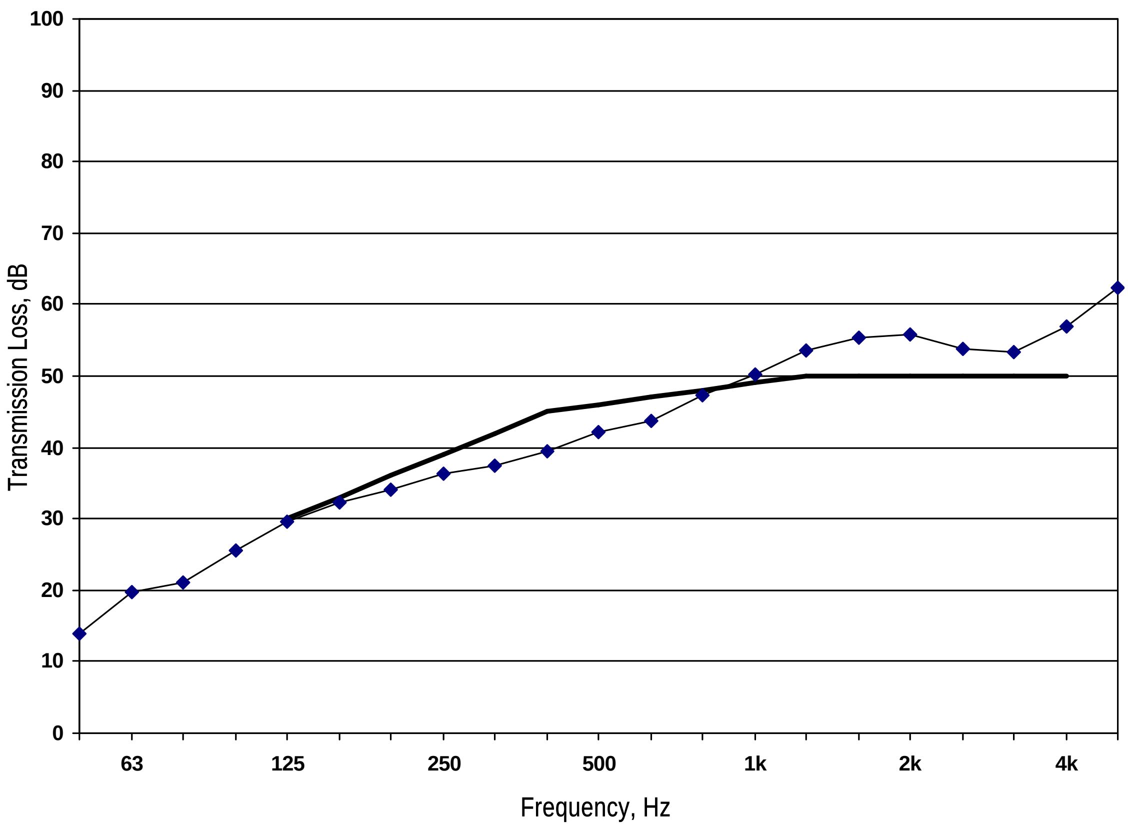


Vents: not installed

	element 1	element 2	element 3	element 4	element 5
type	shingles	building paper	subfloor	RH truss	gypsum board
material	asphalt	*	OSB	wood	regular
thickness (mm)	3	0.7	11	1626	13
spacing (mm)	*	*	*	610	*
total mass (kg)	201	4.9	109	284	116
linear density (kg/m)	*	*	*	6.2	*
surface density (kg/m^2)	12	0.2	6.8	*	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*

* indicates not applicable

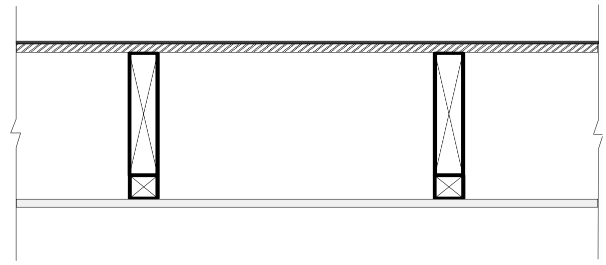
Freq, Hz	TL, dB
50	14
63	20
80	21
100	26
125	30
160	32
200	34
250	36
315	37
400	39
500	42
630	44
800	47
1000	50
1250	54
1600	55
2000	56
2500	54
3150	53
4000	57
5000	62
STC	46
OITC	36



NRC-CNRC National Research Council Canada

TLF-98-093a
SHN3_BPAP0.7_OSB11_RHWT1626_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	13 mm thick regular gypsum board

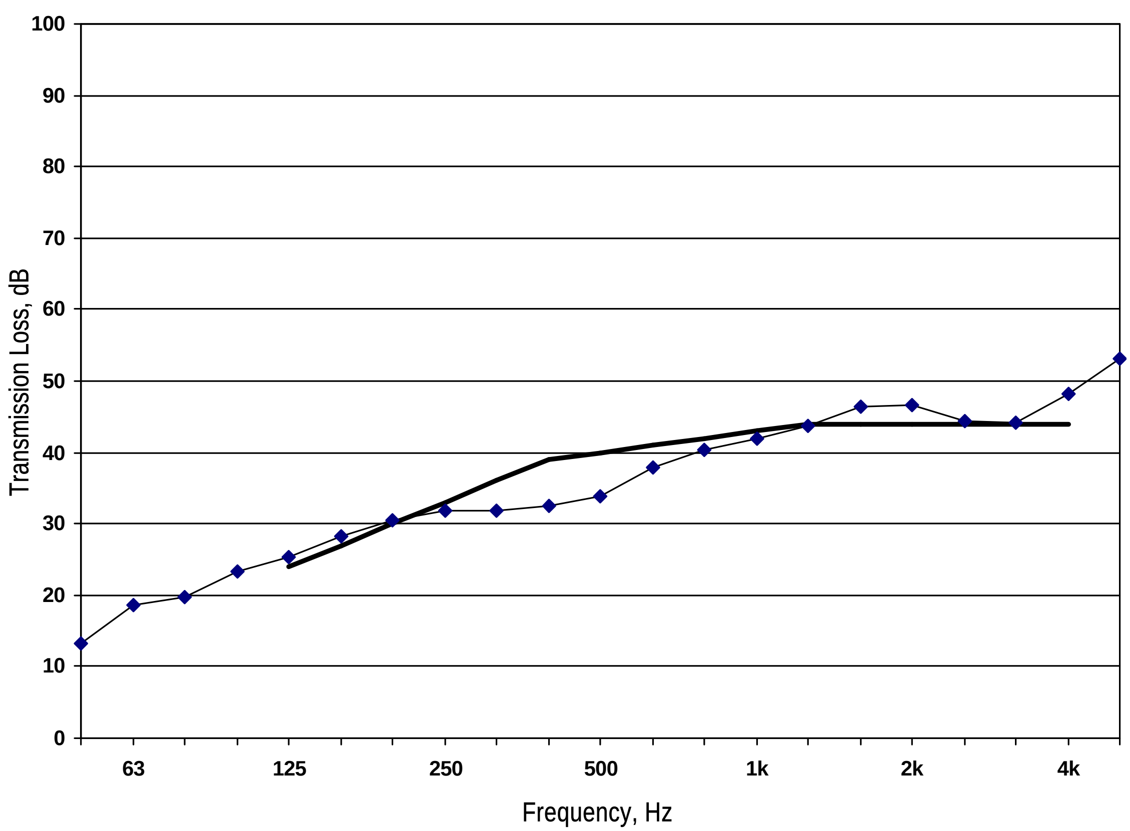


Vents: roof (6)

	element 1	element 2	element 3	element 4	element 5
type	shingles	building paper	subfloor	RH truss	gypsum board
material	asphalt	*	OSB	wood	regular
thickness (mm)	3	0.7	11	1626	13
spacing (mm)	*	*	*	610	*
total mass (kg)	201	4.9	109	284	120
linear density (kg/m)	*	*	*	6.2	*
surface density (kg/m^2)	12	0.2	6.8	*	8.0
fastener spacing #1 (mm)	*	*	152 edges	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*

* indicates not applicable

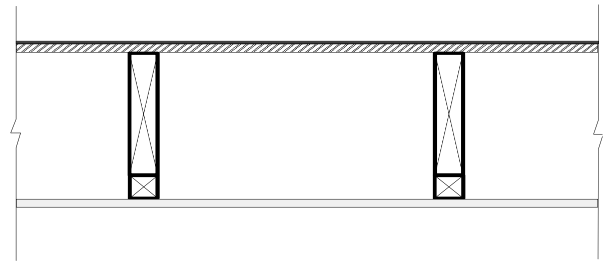
Freq, Hz	TL, dB
50	13
63	19
80	20
100	23
125	25
160	28
200	30
250	32
315	32
400	32
500	34
630	38
800	40
1000	42
1250	44
1600	47
2000	47
2500	44
3150	44
4000	48
5000	53
STC	40
OITC	33



NRC-CNRC National Research Council Canada

TLF-98-123a
SHN3_BPAP0.7_OSB11_RHWT1626_G13
Construction Type: roof

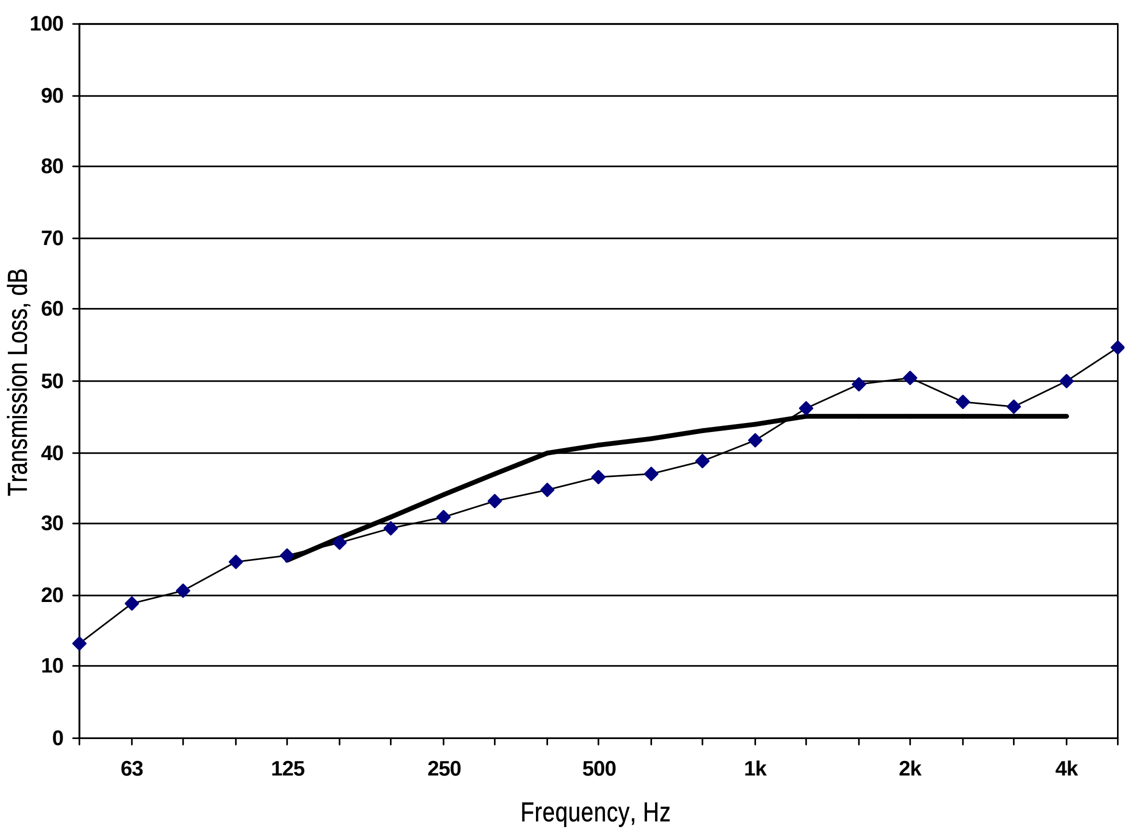
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	13 mm thick regular gypsum board



Vents: ridge	element 1	element 2	element 3	element 4	element 5
type	shingles	building paper	subfloor	RH truss	gypsum board
material	asphalt	*	OSB	wood	regular
thickness (mm)	3	0.7	11	1626	13
spacing (mm)	*	*	*	610	*
total mass (kg)	201	4.9	109	284	116
linear density (kg/m)	*	*	*	6.2	*
surface density (kg/m^2)	12	0.2	6.8	*	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*

* indicates not applicable

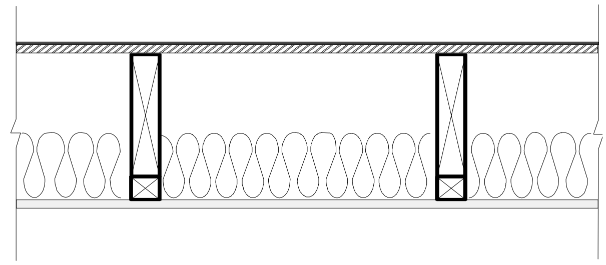
Freq, Hz	TL, dB
50	13
63	19
80	21
100	25
125	25
160	27
200	29
250	31
315	33
400	35
500	37
630	37
800	39
1000	42
1250	46
1600	50
2000	50
2500	47
3150	46
4000	50
5000	55
STC	41
OITC	33



National Research
Council Canada

TLF-98-097a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13
Construction Type: roof

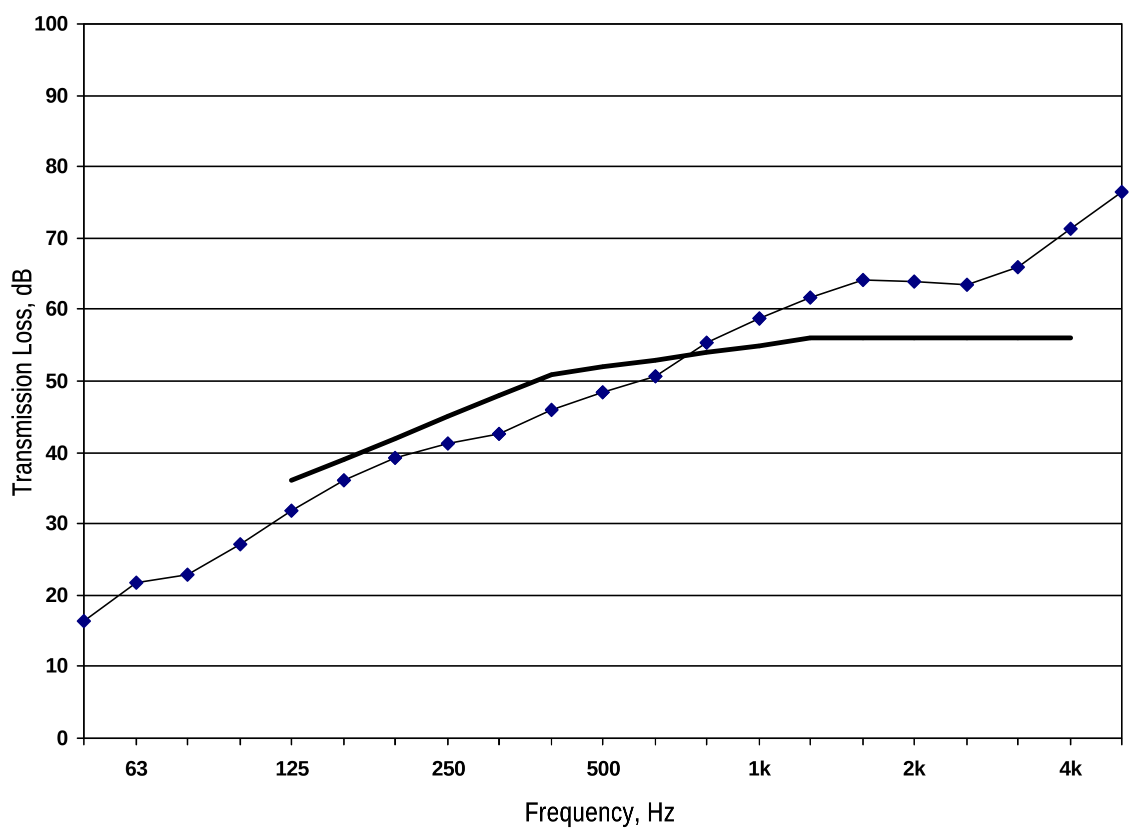
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	152	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	22	120
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	1.5	8.0
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

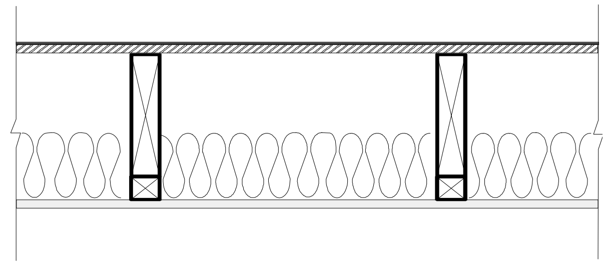
Freq, Hz	TL, dB
50	16
63	22
80	23
100	27
125	32
160	36
200	39
250	41
315	42
400	46
500	48
630	51
800	55
1000	59
1250	62
1600	64
2000	64
2500	63
3150	66
4000	71
5000	76
STC	52
OITC	39



NRC-CNRC National Research Council Canada

TLF-98-095a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board

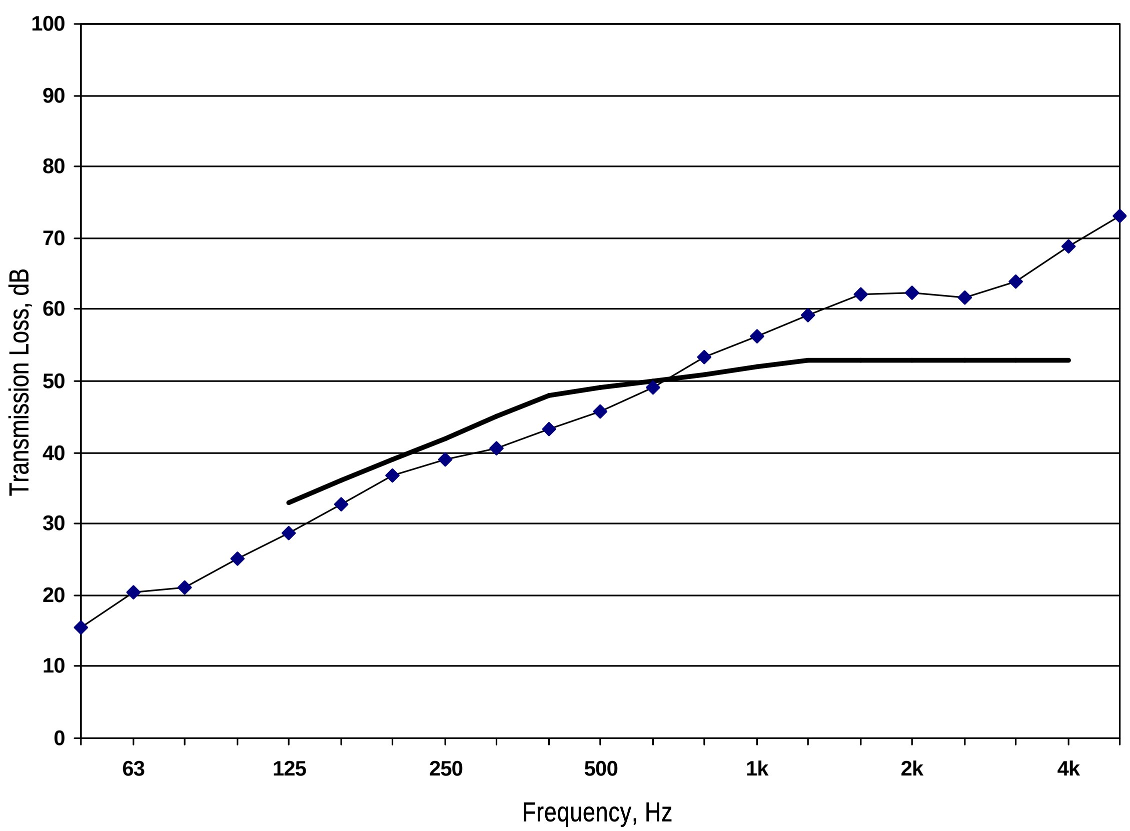


Vents: roof (6)

	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	152	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	22	120
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	1.5	8.0
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

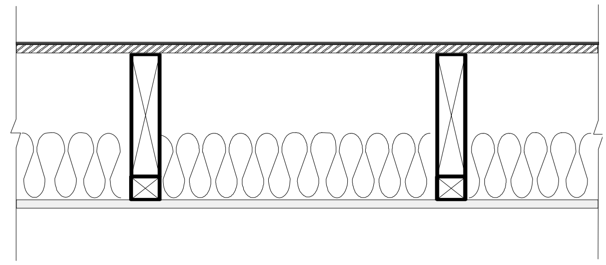
Freq, Hz	TL, dB
50	15
63	20
80	21
100	25
125	29
160	33
200	37
250	39
315	41
400	43
500	46
630	49
800	53
1000	56
1250	59
1600	62
2000	62
2500	62
3150	64
4000	69
5000	73
STC	49
OITC	36



NRC-CNRC National Research Council Canada

TLF-98-127a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13
Construction Type: roof

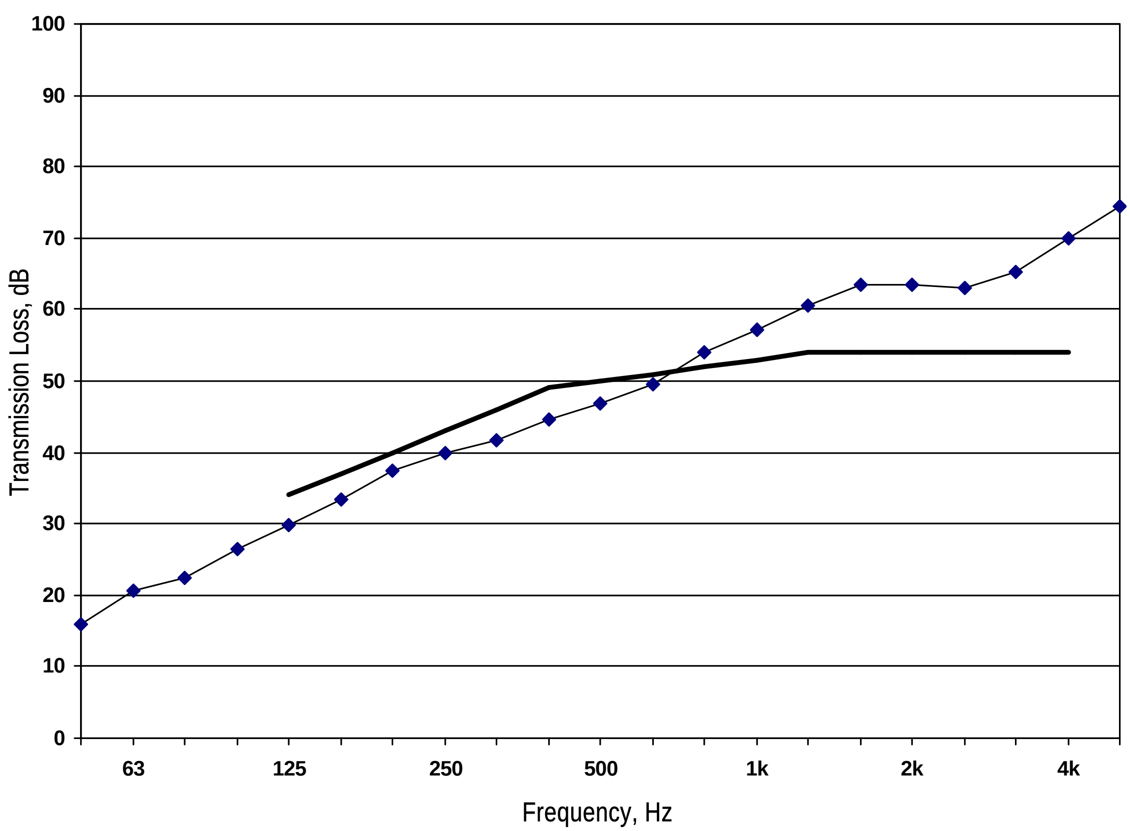
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



Vents: roof (3)	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	152	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	22	116
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	1.5	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

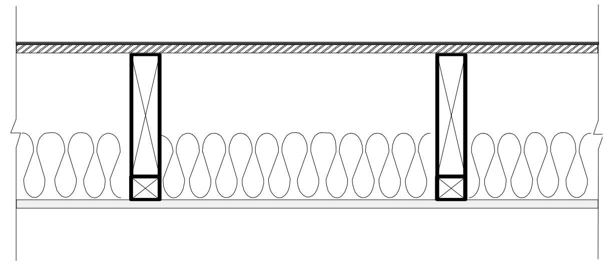
Freq, Hz	TL, dB
50	16
63	21
80	22
100	26
125	30
160	33
200	38
250	40
315	42
400	45
500	47
630	50
800	54
1000	57
1250	60
1600	63
2000	64
2500	63
3150	65
4000	70
5000	75
STC	50
OITC	38



NRC-CNRC National Research Council Canada

TLF-98-129a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13
Construction Type: roof

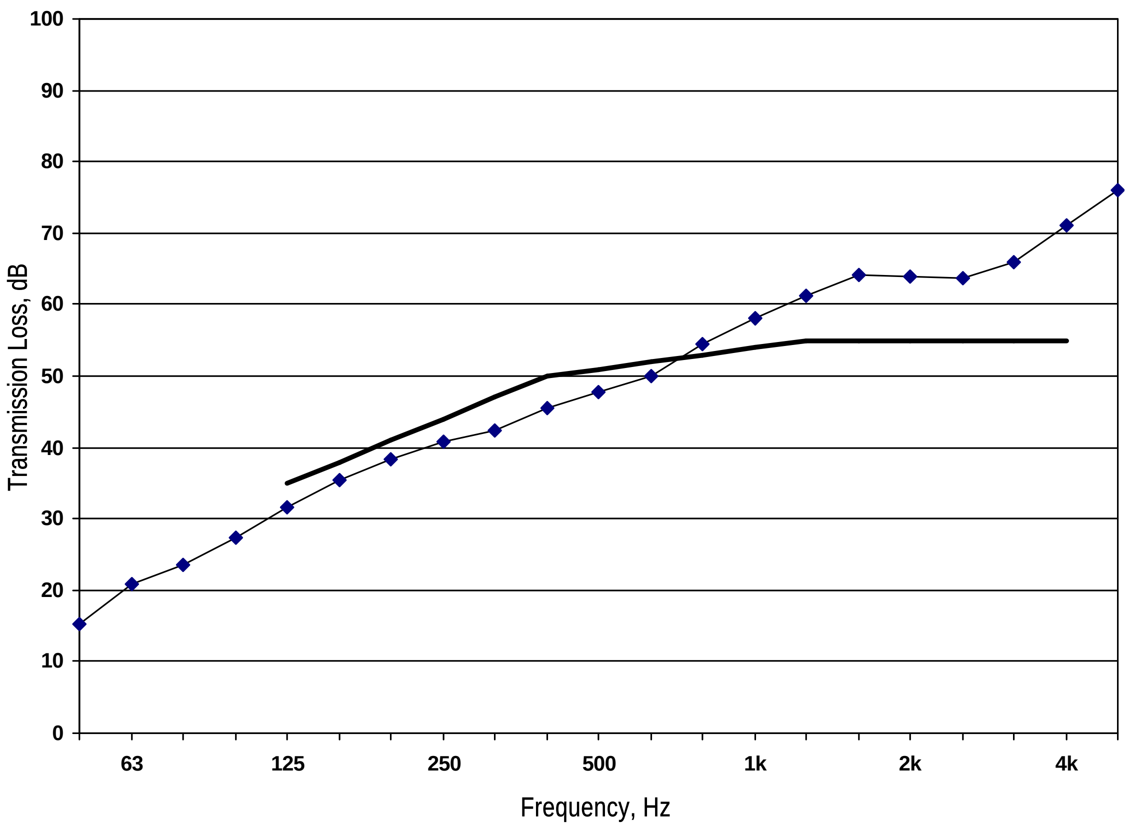
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



Vents: roof (1)	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	152	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	22	116
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	1.5	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

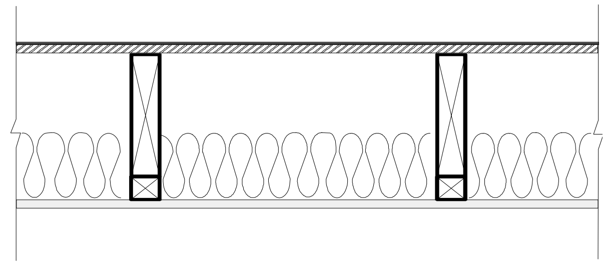
Freq, Hz	TL, dB
50	15
63	21
80	24
100	27
125	32
160	36
200	38
250	41
315	42
400	45
500	48
630	50
800	55
1000	58
1250	61
1600	64
2000	64
2500	64
3150	66
4000	71
5000	76
STC	51
OITC	39



National Research
Council Canada

TLF-98-125a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	152 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board

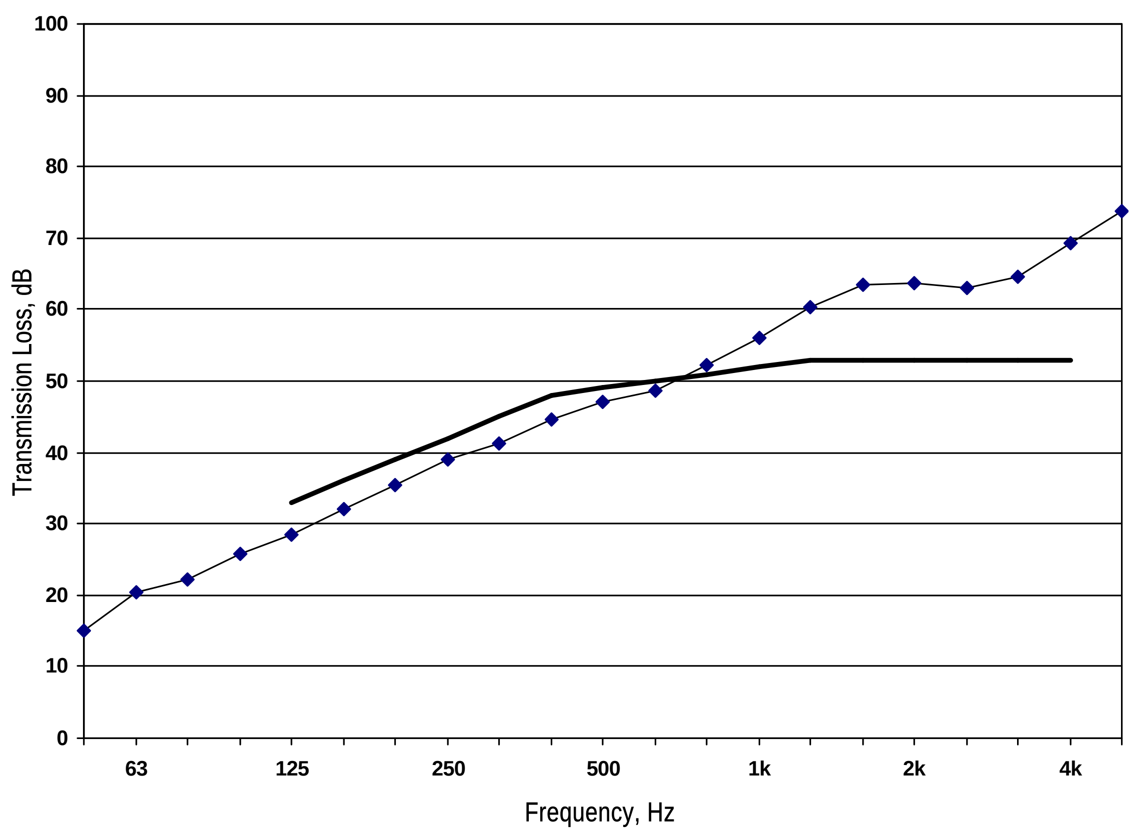


Vents: ridge

	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	152	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	22	116
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	1.5	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

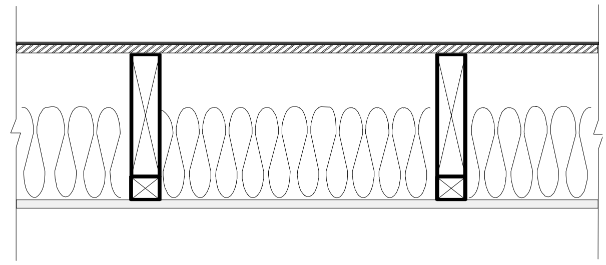
* indicates not applicable

Freq, Hz	TL, dB
50	15
63	20
80	22
100	26
125	29
160	32
200	35
250	39
315	41
400	45
500	47
630	49
800	52
1000	56
1250	60
1600	64
2000	64
2500	63
3150	65
4000	69
5000	74
STC	49
OITC	37



TLF-98-099a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board

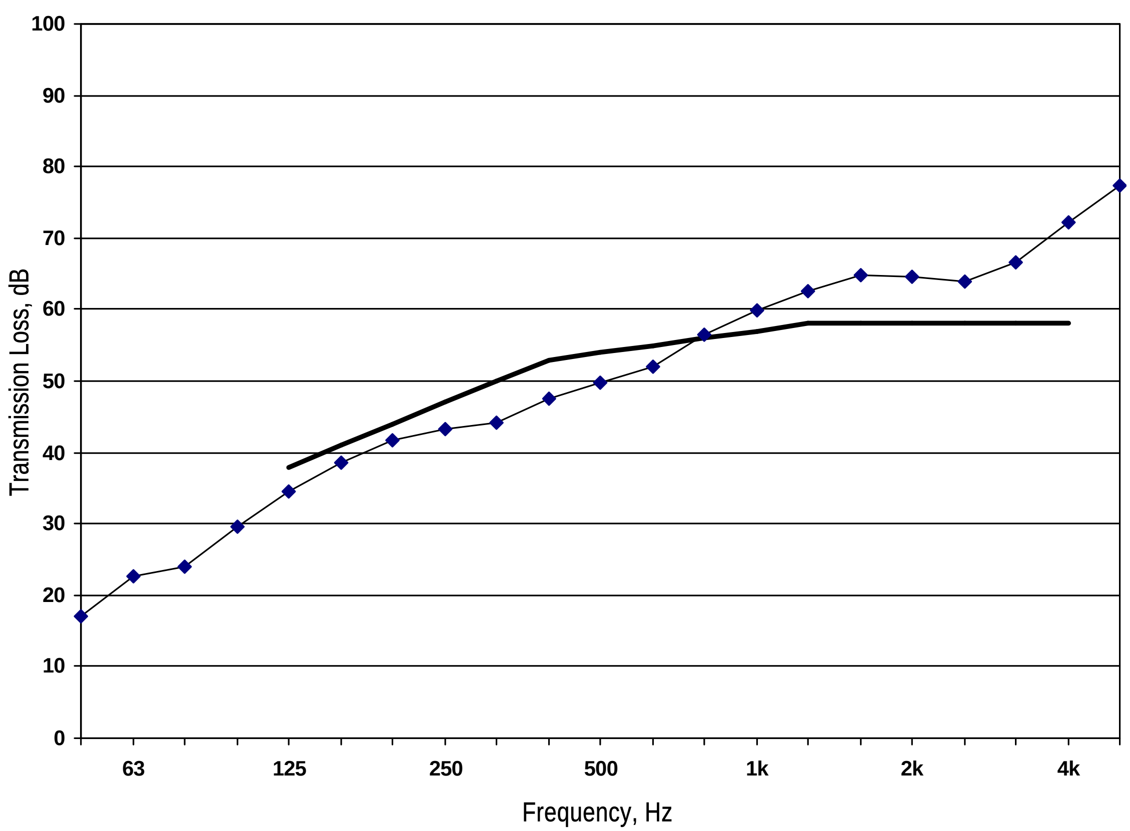


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	264	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	62	120
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	8.0
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

* indicates not applicable

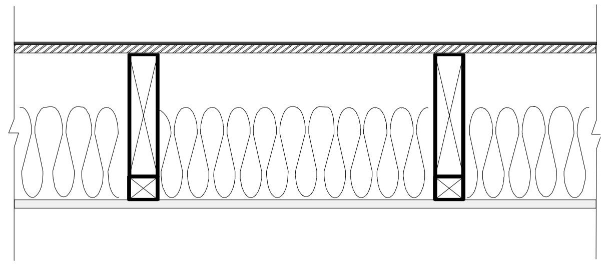
Freq, Hz	TL, dB
50	17
63	23
80	24
100	30
125	35
160	39
200	42
250	43
315	44
400	47
500	50
630	52
800	57
1000	60
1250	63
1600	65
2000	65
2500	64
3150	67
4000	72
5000	77
STC	54
OITC	41



NRC-CNRC National Research Council Canada

TLF-98-101a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13
Construction Type: roof

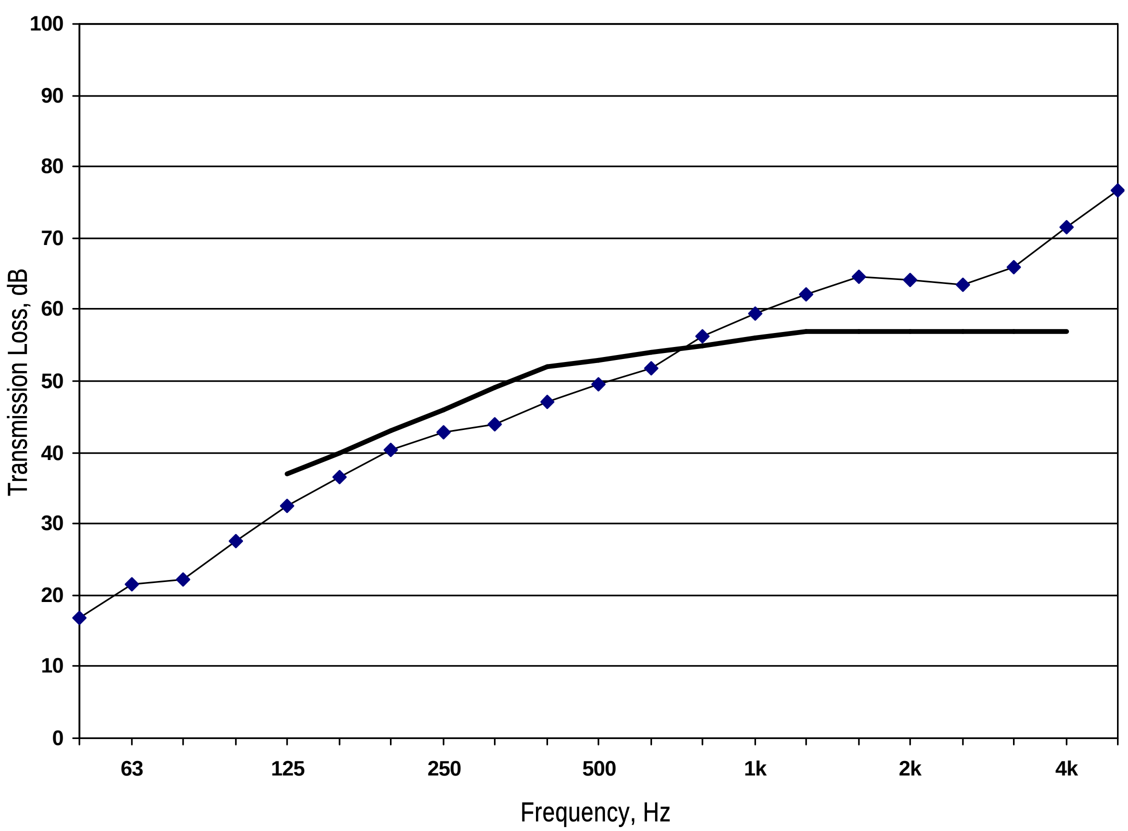
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular
thickness (mm)	3	0.7	11	1626	264	13
spacing (mm)	*	*	*	610	*	*
total mass (kg)	201	4.9	109	284	62	120
linear density (kg/m)	*	*	*	6.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	8.0
fastener spacing #1 (mm)	*	*	152 edges	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*

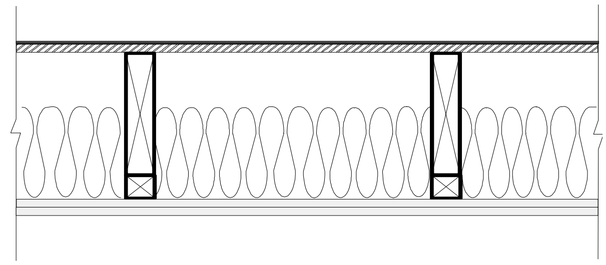
* indicates not applicable

Freq, Hz	TL, dB
50	17
63	21
80	22
100	28
125	32
160	37
200	40
250	43
315	44
400	47
500	50
630	52
800	56
1000	59
1250	62
1600	64
2000	64
2500	63
3150	66
4000	72
5000	77
STC	53
OITC	39



TLF-98-105a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board

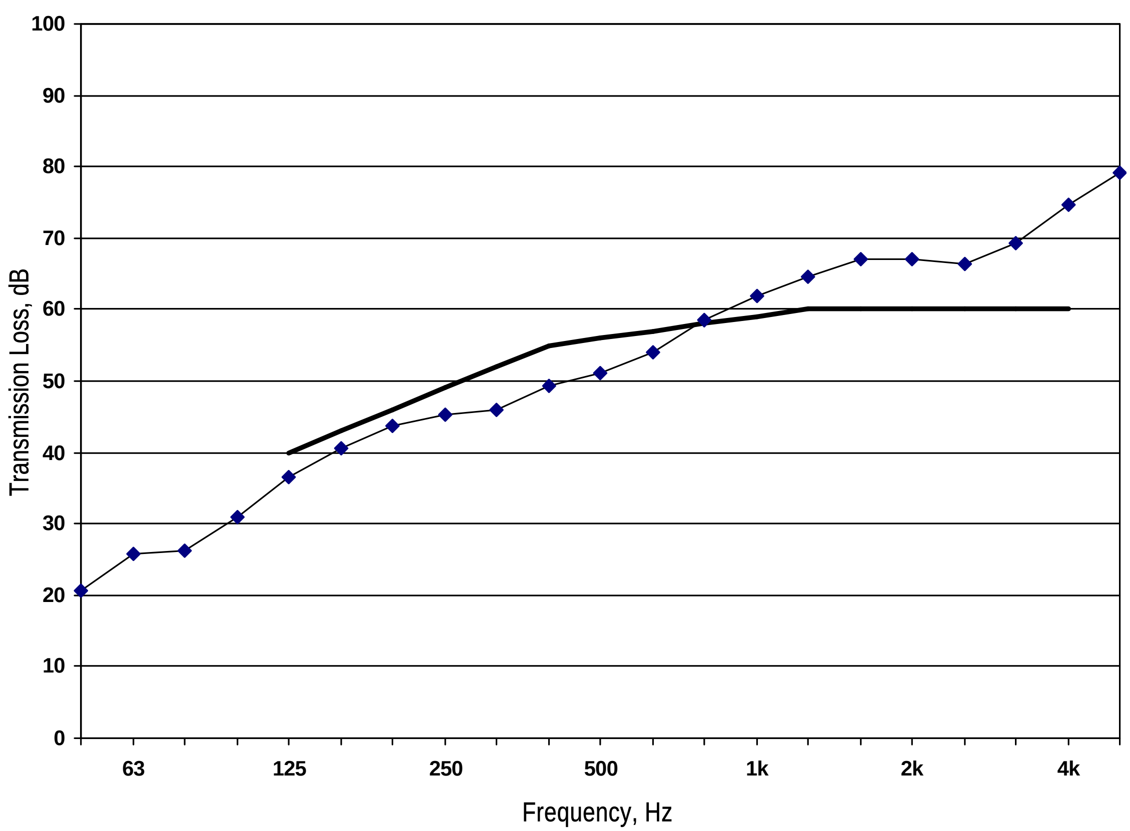


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular	regular
thickness (mm)	3	0.7	11	1626	264	13	13
spacing (mm)	*	*	*	610	*	*	*
total mass (kg)	201	4.9	109	284	62	120	117
linear density (kg/m)	*	*	*	6.2	*	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	8.0	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

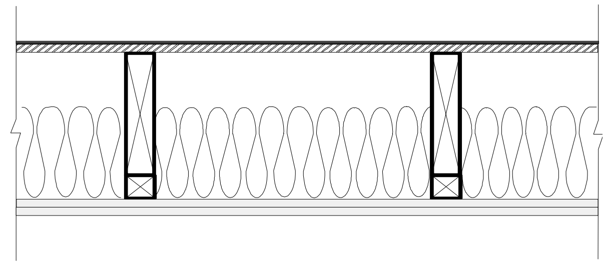
Freq, Hz	TL, dB
50	21
63	26
80	26
100	31
125	37
160	41
200	44
250	45
315	46
400	49
500	51
630	54
800	59
1000	62
1250	65
1600	67
2000	67
2500	66
3150	69
4000	75
5000	79
STC	56
OITC	43



NRC-CNRC National Research Council Canada

TLF-98-103a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board

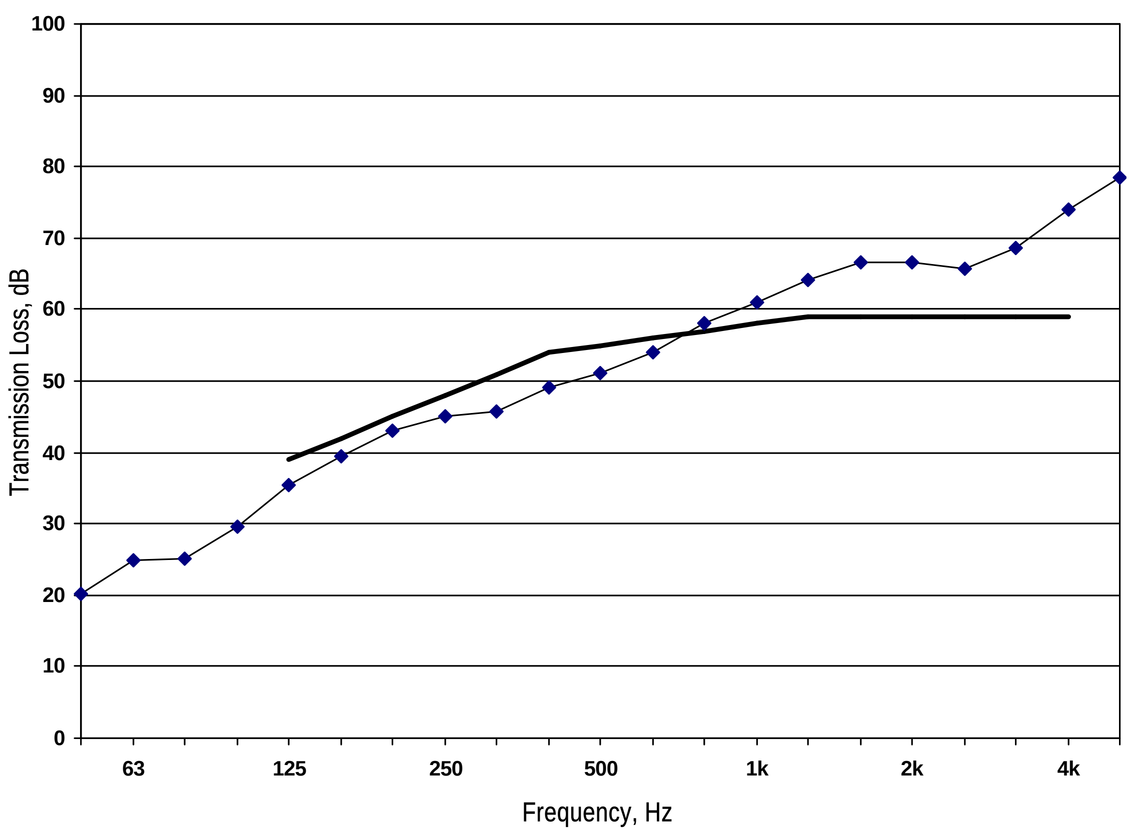


Vents: roof (6)

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	RH truss	insulation	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	regular	regular
thickness (mm)	3	0.7	11	1626	264	13	13
spacing (mm)	*	*	*	610	*	*	*
total mass (kg)	201	4.9	109	284	62	120	117
linear density (kg/m)	*	*	*	6.2	*	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	8.0	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

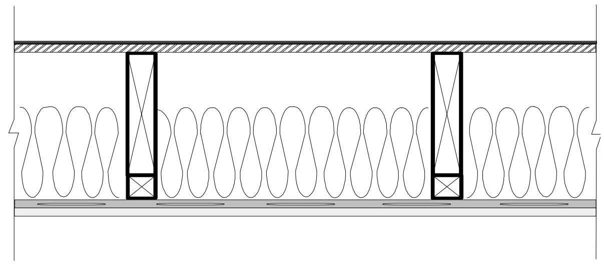
Freq, Hz	TL, dB
50	20
63	25
80	25
100	30
125	36
160	39
200	43
250	45
315	46
400	49
500	51
630	54
800	58
1000	61
1250	64
1600	67
2000	67
2500	66
3150	69
4000	74
5000	79
STC	55
OITC	41



NRC-CNRC National Research Council Canada

TLF-98-107a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board

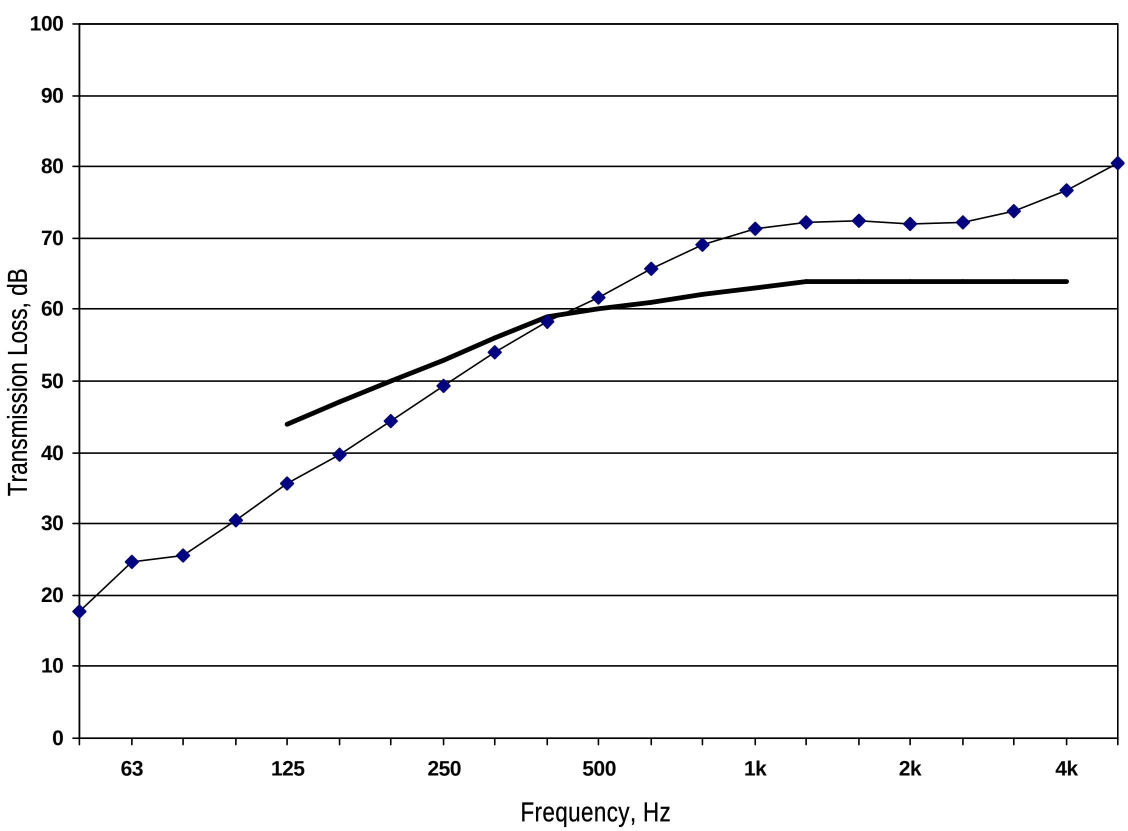


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	RH truss	insulation	resilient chan.	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular
thickness (mm)	3	0.7	11	1626	264	13	13
spacing (mm)	*	*	*	610	*	610	*
total mass (kg)	201	4.9	109	284	62	6.8	116
linear density (kg/m)	*	*	*	6.2	*	0.2	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	*	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

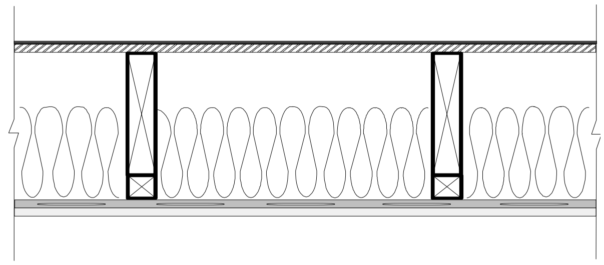
Freq, Hz	TL, dB
50	18
63	25
80	26
100	31
125	36
160	40
200	44
250	49
315	54
400	58
500	62
630	66
800	69
1000	71
1250	72
1600	72
2000	72
2500	72
3150	74
4000	77
5000	81
STC	60
OITC	42



NRC-CNRC National Research Council Canada

TLF-98-109a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13
Construction Type: roof

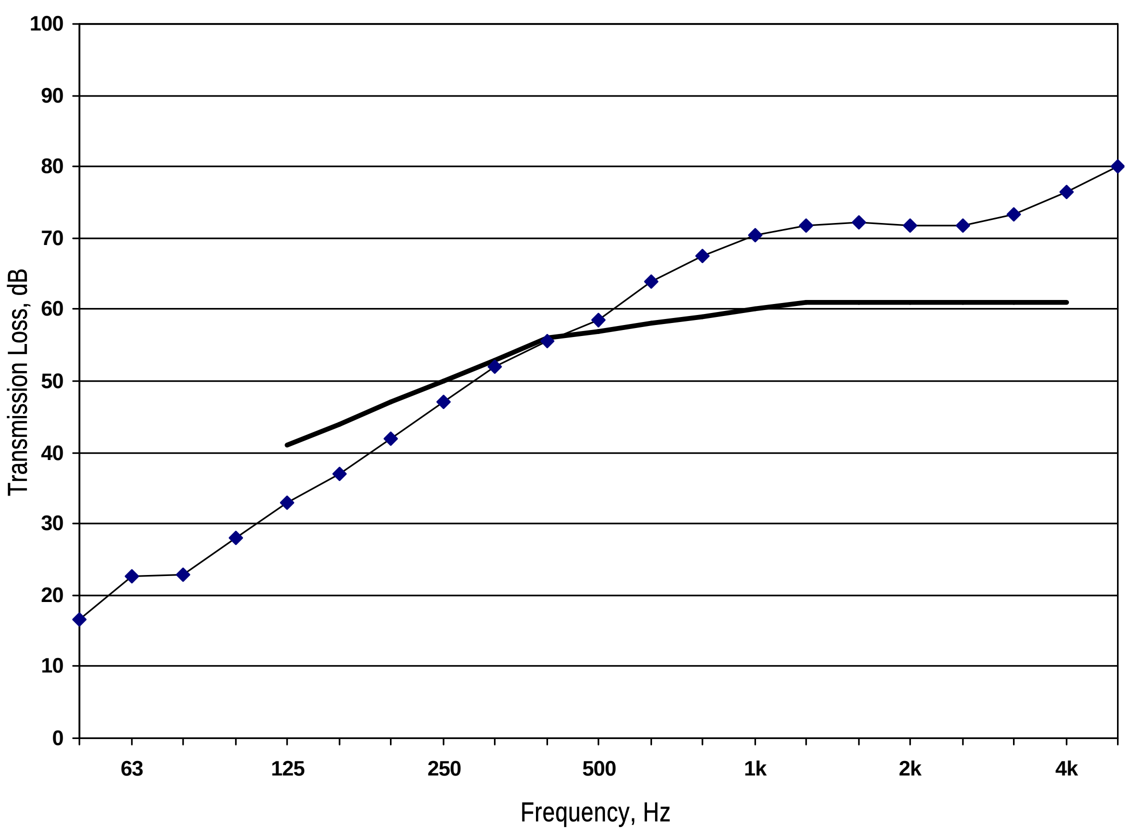
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	shingles	building paper	subfloor	RH truss	insulation	resilient chan.	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular
thickness (mm)	3	0.7	11	1626	264	13	13
spacing (mm)	*	*	*	610	*	610	*
total mass (kg)	201	4.9	109	284	62	6.8	116
linear density (kg/m)	*	*	*	6.2	*	0.2	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	*	7.8
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*

* indicates not applicable

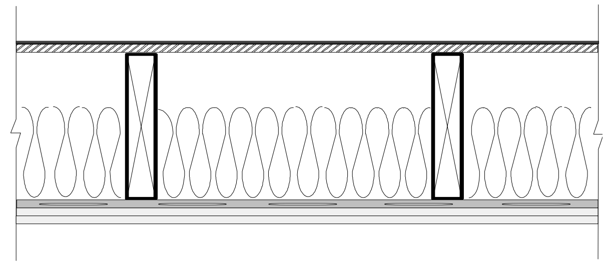
Freq, Hz	TL, dB
50	17
63	23
80	23
100	28
125	33
160	37
200	42
250	47
315	52
400	56
500	59
630	64
800	68
1000	70
1250	72
1600	72
2000	72
2500	72
3150	73
4000	76
5000	80
STC	57
OITC	40



National Research Council Canada

TLF-98-113a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13
Construction Type: roof

Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board

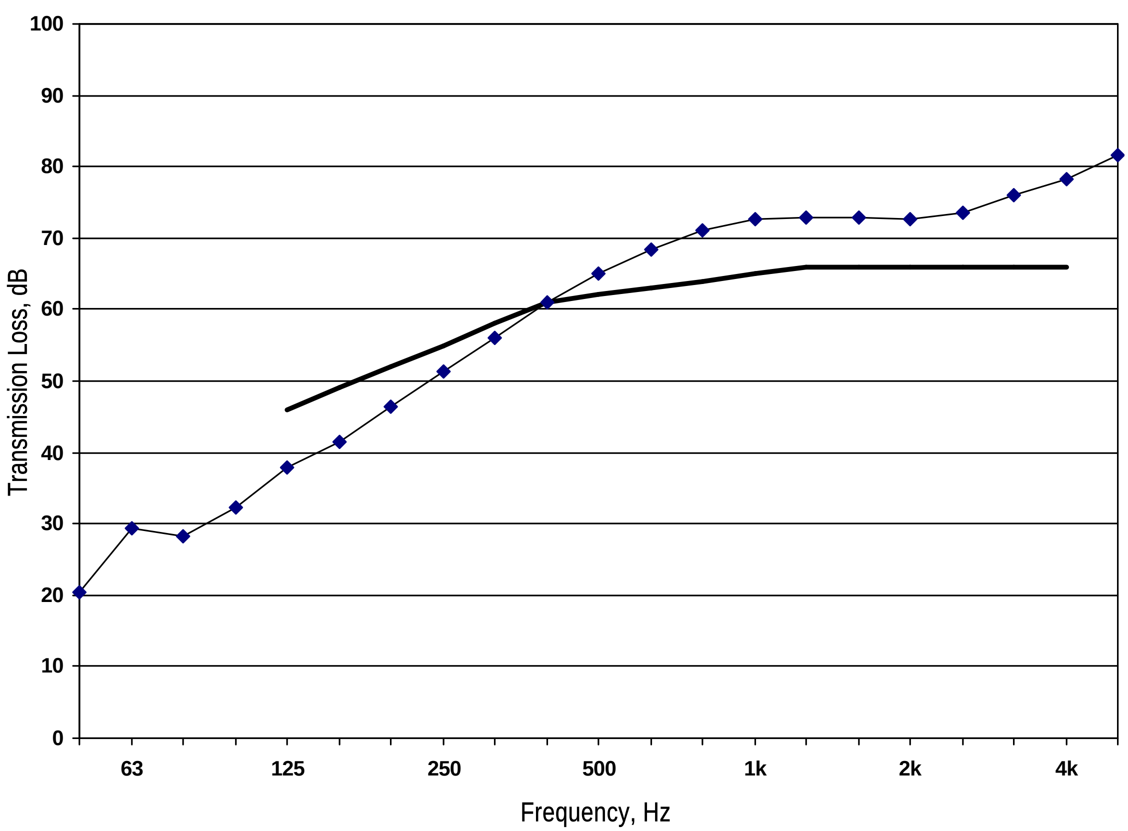


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	RH truss	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	1626	264	13	13	13
spacing (mm)	*	*	*	610	*	610	*	*
total mass (kg)	201	4.9	109	284	62	6.8	116	116
linear density (kg/m)	*	*	*	6.2	*	0.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	*	7.8	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

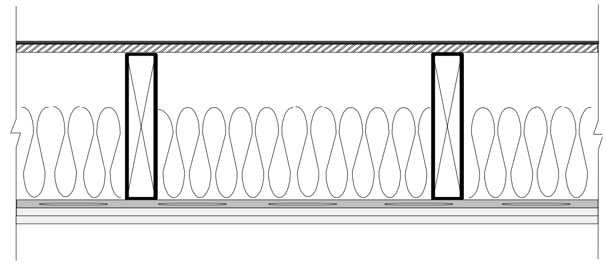
Freq, Hz	TL, dB
50	20
63	29
80	28
100	32
125	38
160	42
200	46
250	51
315	56
400	61
500	65
630	68
800	71
1000	73
1250	73
1600	73
2000	73
2500	73
3150	76
4000	78
5000	82
STC	62
OITC	44



NRC-CNRC National Research Council Canada

TLF-98-111a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13
Construction Type: roof

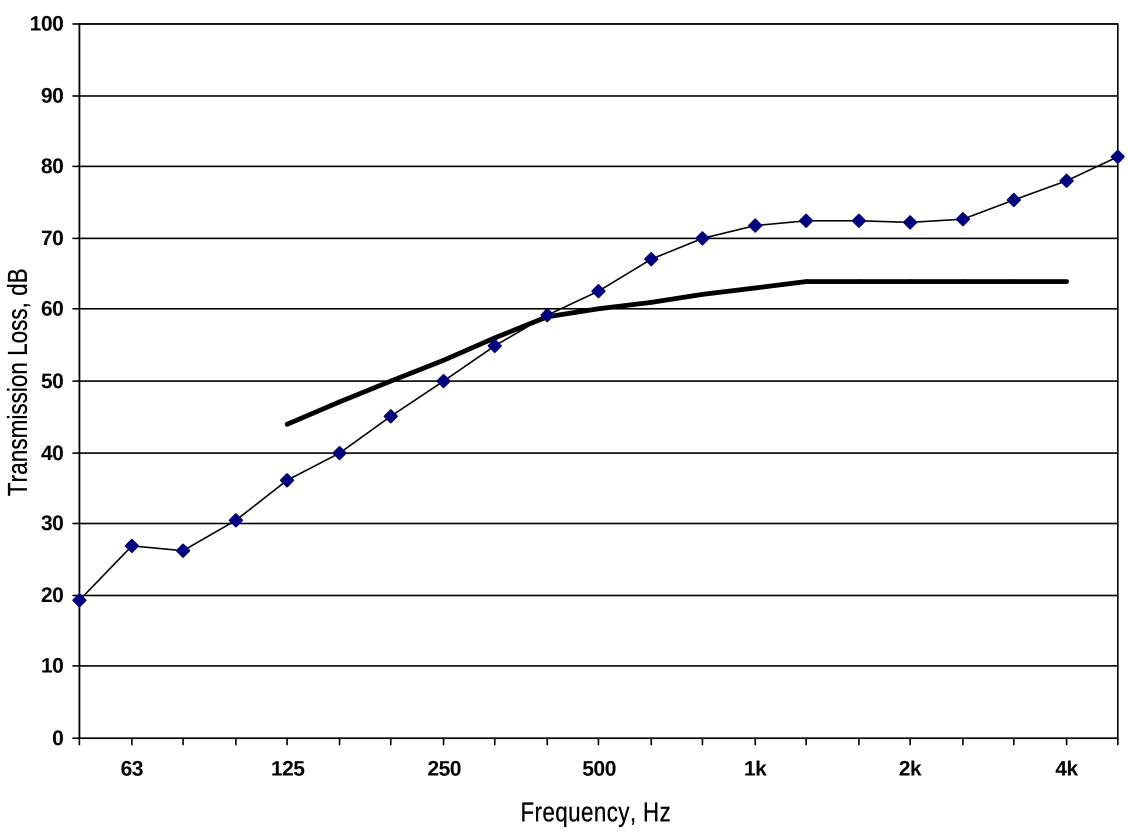
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



Vents: roof (6)	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	RH truss	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	1626	264	13	13	13
spacing (mm)	*	*	*	610	*	610	*	*
total mass (kg)	201	4.9	109	284	62	6.8	116	116
linear density (kg/m)	*	*	*	6.2	*	0.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	*	7.8	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

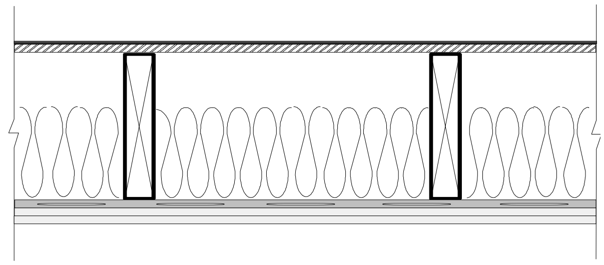
* indicates not applicable

Freq, Hz	TL, dB
50	19
63	27
80	26
100	31
125	36
160	40
200	45
250	50
315	55
400	59
500	63
630	67
800	70
1000	72
1250	72
1600	72
2000	72
2500	73
3150	75
4000	78
5000	81
STC	60
OITC	43



TLF-98-115a
SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13
Construction Type: roof

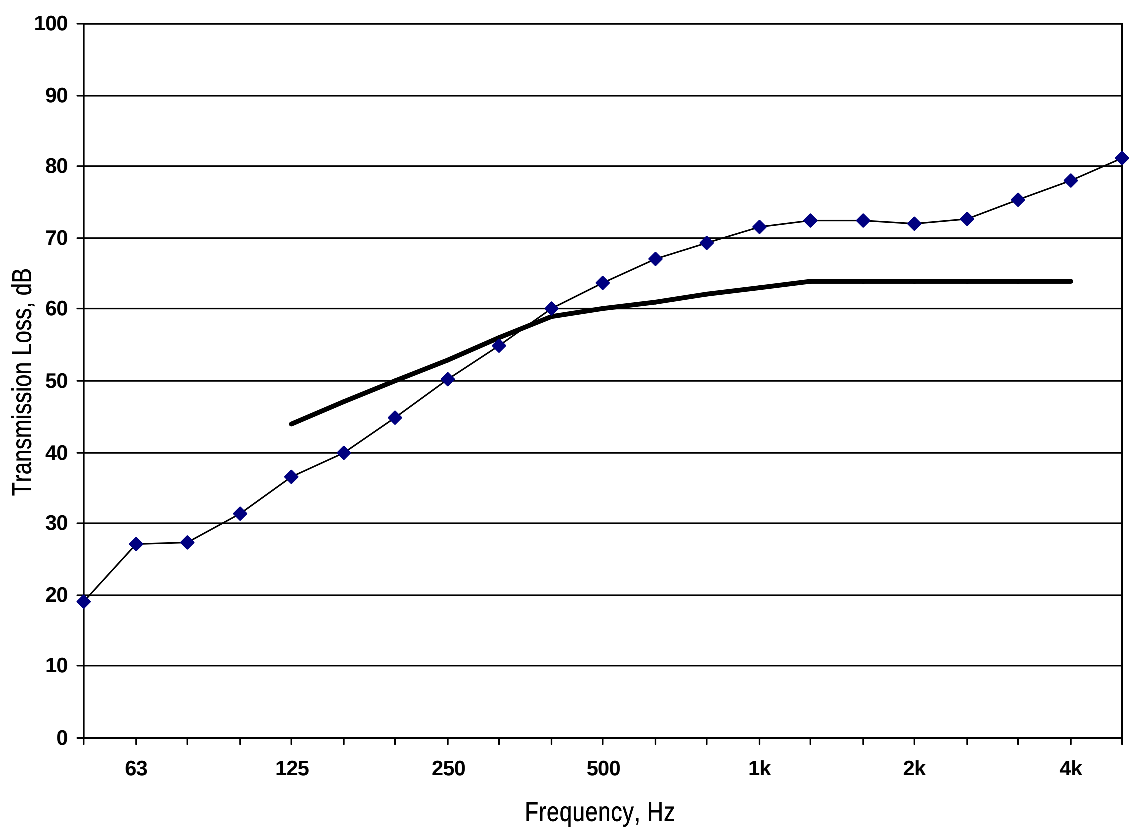
Element	Description
1	3 mm thick asphalt shingles
2	0.7 mm thick building paper
3	11 mm thick oriented strand board
4	1626 mm deep raised heel wood truss
5	264 mm thick glass fibre insulation in cavity
6	13 mm resilient channel at 610 mm on centre
7	13 mm thick regular gypsum board
8	13 mm thick regular gypsum board



Vents: ridge	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	shingles	building paper	subfloor	RH truss	insulation	resilient chan.	gypsum board	gypsum board
material	asphalt	*	OSB	wood	glass fibre	GP	regular	regular
thickness (mm)	3	0.7	11	1626	264	13	13	13
spacing (mm)	*	*	*	610	*	610	*	*
total mass (kg)	201	4.9	109	284	62	6.8	116	116
linear density (kg/m)	*	*	*	6.2	*	0.2	*	*
surface density (kg/m^2)	12	0.2	6.8	*	4.1	*	7.8	7.7
fastener spacing #1 (mm)	*	*	152 edges	*	*	*	610	305
fastener spacing #2 (mm)	*	*	305 field	*	*	*	*	*

* indicates not applicable

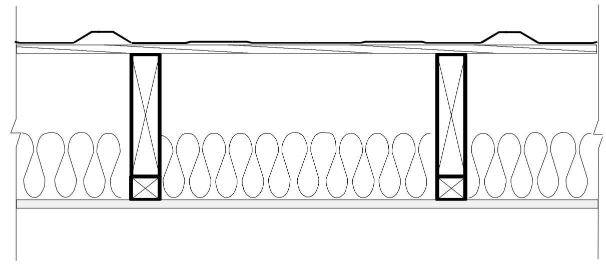
Freq, Hz	TL, dB
50	19
63	27
80	27
100	31
125	36
160	40
200	45
250	50
315	55
400	60
500	64
630	67
800	69
1000	71
1250	72
1600	72
2000	72
2500	73
3150	75
4000	78
5000	81
STC	60
OITC	43



National Research
Council Canada

TLF-98-131a
STE0.3_WFUR19(406)_RHWT1626_GFB152_G13
Construction Type: roof

Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board

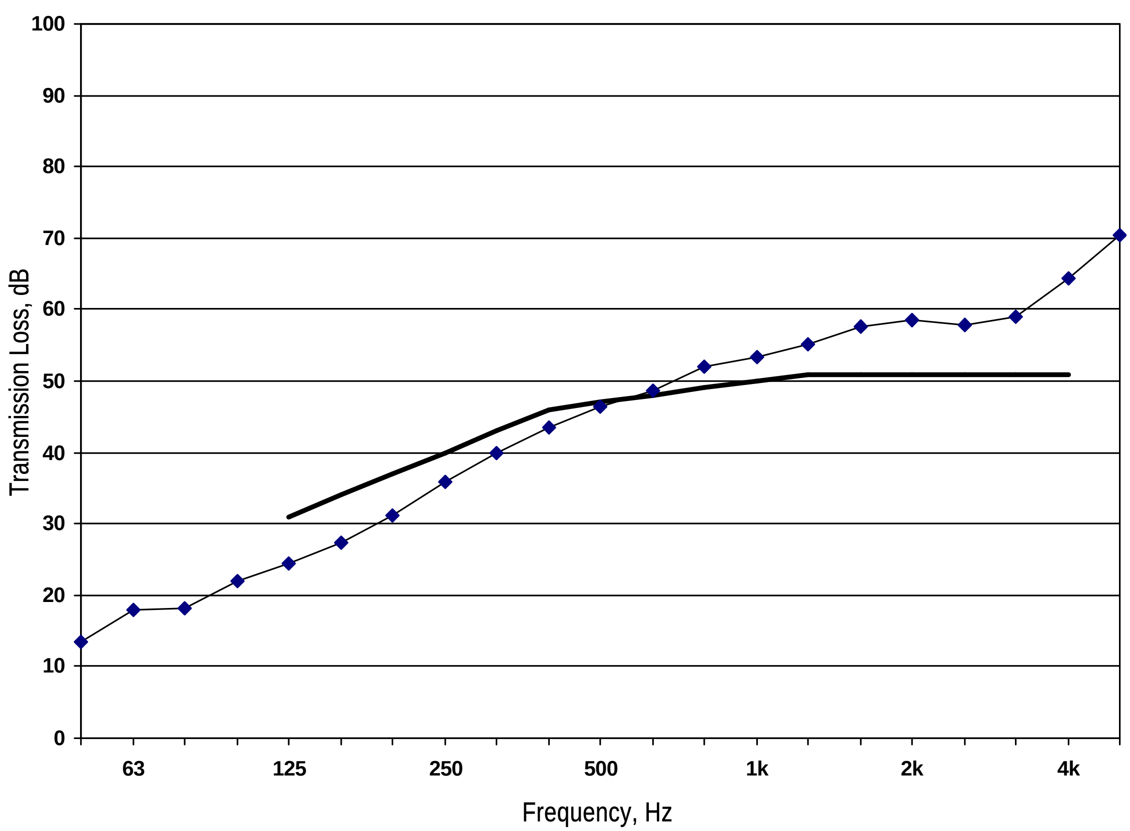


Vents: not installed

	element 1	element 2	element 3	element 4	element 5
type	decking	furring	RH truss	insulation	gypsum board
material	steel	wood	wood	glass fibre	regular
thickness (mm)	0.3	19	1626	152	13
spacing (mm)	*	406	610	*	*
total mass (kg)	51	51	284	22	116
linear density (kg/m)	*	0.87	6.2	*	*
surface density (kg/m^2)	2.8	*	*	1.5	7.7
fastener spacing #1 (mm)	*	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*

* indicates not applicable

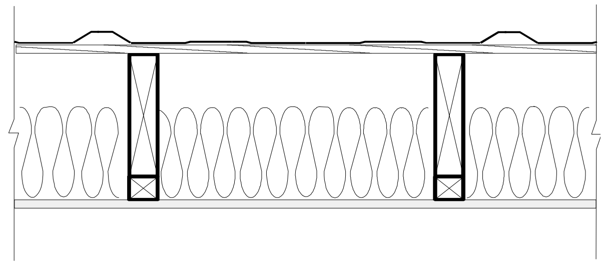
Freq, Hz	TL, dB
50	13
63	18
80	18
100	22
125	24
160	27
200	31
250	36
315	40
400	44
500	46
630	49
800	52
1000	53
1250	55
1600	58
2000	58
2500	58
3150	59
4000	64
5000	70
STC	47
OITC	33



NRC-CNRC National Research Council Canada

TLF-98-137a
STE0.3_WFUR19(406)_RHWT1626_GFB264_G13
Construction Type: roof

Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	264 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board

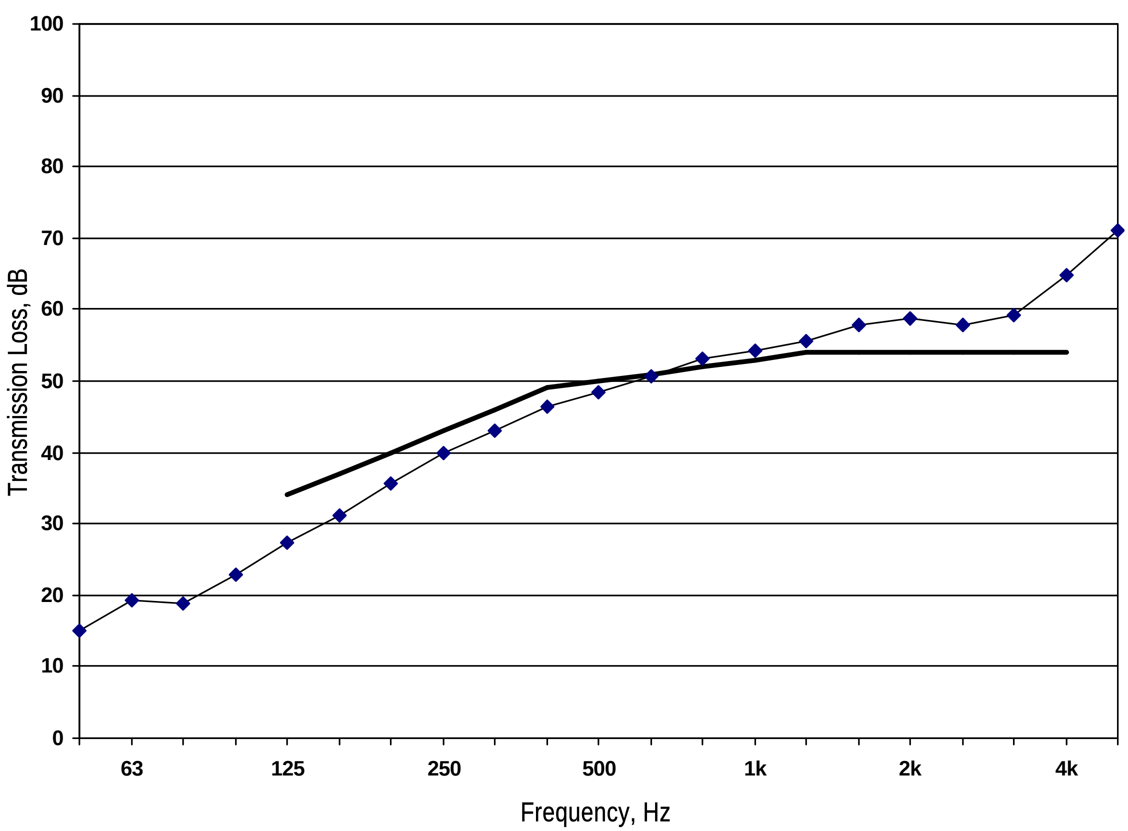


Vents: not installed

	element 1	element 2	element 3	element 4	element 5
type	decking	furring	RH truss	insulation	gypsum board
material	steel	wood	wood	glass fibre	regular
thickness (mm)	0.3	19	1626	264	13
spacing (mm)	*	406	610	*	*
total mass (kg)	51	51	284	62	116
linear density (kg/m)	*	*	6.2	*	*
surface density (kg/m^2)	2.8	0.87	*	4.1	7.7
fastener spacing #1 (mm)	*	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*

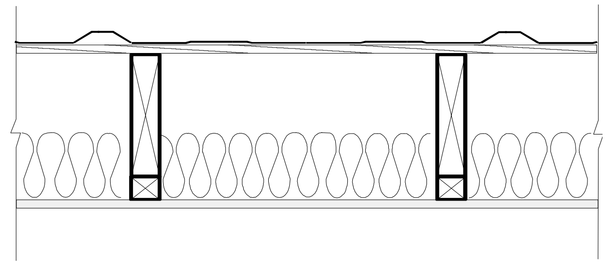
* indicates not applicable

Freq, Hz	TL, dB
50	15
63	19
80	19
100	23
125	27
160	31
200	36
250	40
315	43
400	46
500	49
630	51
800	53
1000	54
1250	55
1600	58
2000	59
2500	58
3150	59
4000	65
5000	71
STC	50
OITC	35



TLF-98-133a
STE0.3_WFUR19(406)_RHWT1626_GFB152_G13
Construction Type: roof

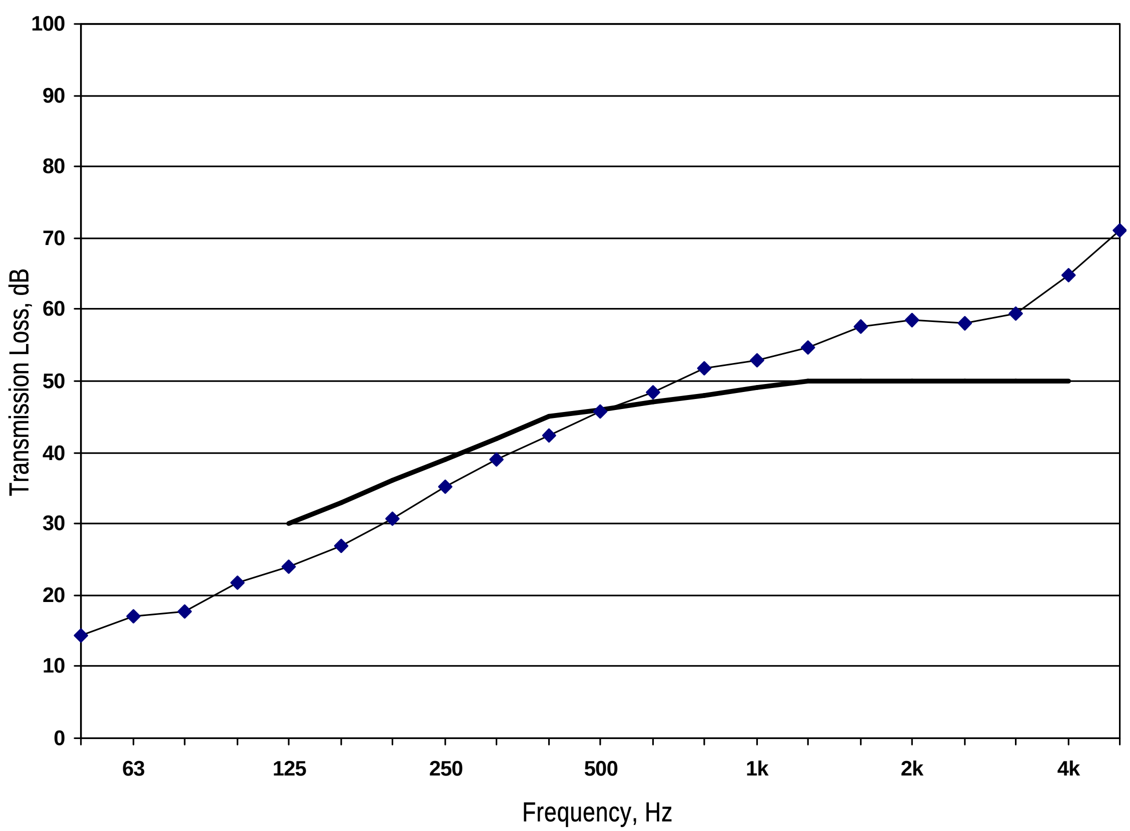
Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	152 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board



Vents: ridge	element 1	element 2	element 3	element 4	element 5
type	decking	furring	RH truss	insulation	gypsum board
material	steel	wood	wood	glass fibre	regular
thickness (mm)	0.3	19	1626	152	13
spacing (mm)	*	406	610	*	*
total mass (kg)	51	51	284	22	116
linear density (kg/m)	*	0.87	6.2	*	*
surface density (kg/m^2)	2.8	*	*	1.5	7.7
fastener spacing #1 (mm)	*	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*

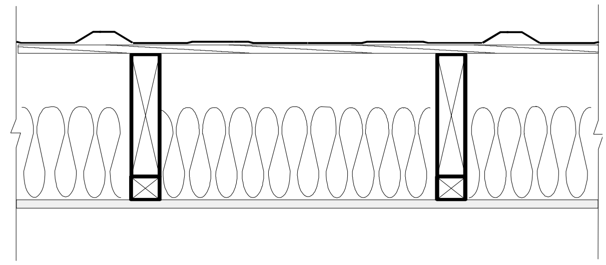
* indicates not applicable

Freq, Hz	TL, dB
50	14
63	17
80	18
100	22
125	24
160	27
200	31
250	35
315	39
400	42
500	46
630	48
800	52
1000	53
1250	55
1600	58
2000	58
2500	58
3150	60
4000	65
5000	71
STC	46
OITC	33



TLF-98-135a
STE0.3_WFUR19(406)_RHWT1626_GFB264_G13
Construction Type: roof

Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	264 mm thick glass fibre insulation in cavity
5	13 mm thick regular gypsum board

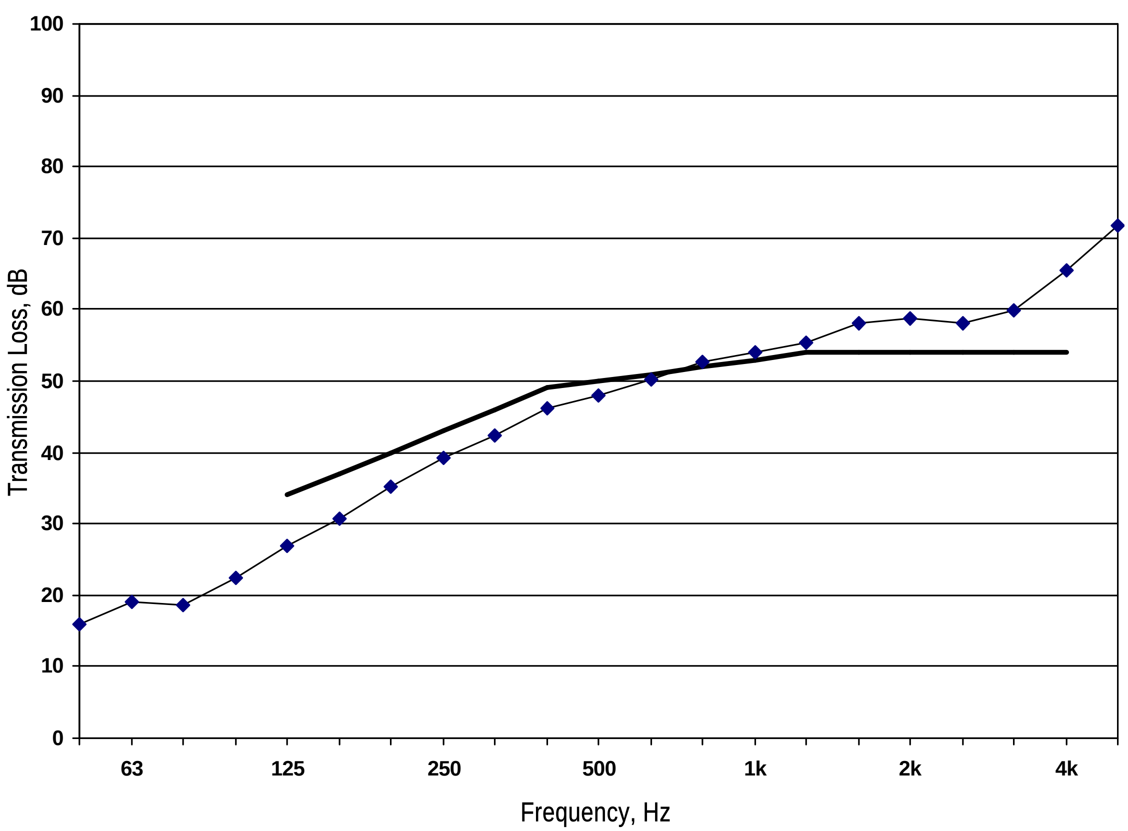


Vents: ridge

	element 1	element 2	element 3	element 4	element 5
type	decking	furring	RH truss	insulation	gypsum board
material	steel	wood	wood	glass fibre	regular
thickness (mm)	0.3	19	1626	264	13
spacing (mm)	*	406	610	*	*
total mass (kg)	51	51	284	62	116
linear density (kg/m)	*	0.87	6.2	*	*
surface density (kg/m^2)	2.8	*	*	4.1	7.7
fastener spacing #1 (mm)	*	*	*	*	305
fastener spacing #2 (mm)	*	*	*	*	*

* indicates not applicable

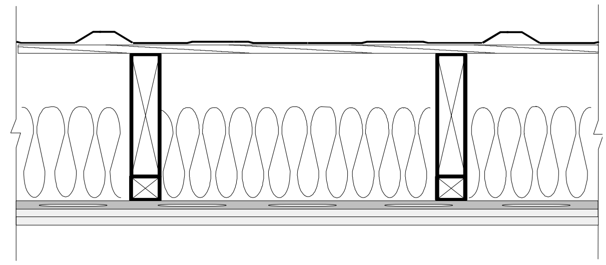
Freq, Hz	TL, dB
50	16
63	19
80	19
100	22
125	27
160	31
200	35
250	39
315	42
400	46
500	48
630	50
800	53
1000	54
1250	55
1600	58
2000	59
2500	58
3150	60
4000	65
5000	72
STC	50
OITC	34



NRC-CNRC National Research Council Canada

TLF-98-139a
STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13
Construction Type: roof

Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	264 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board

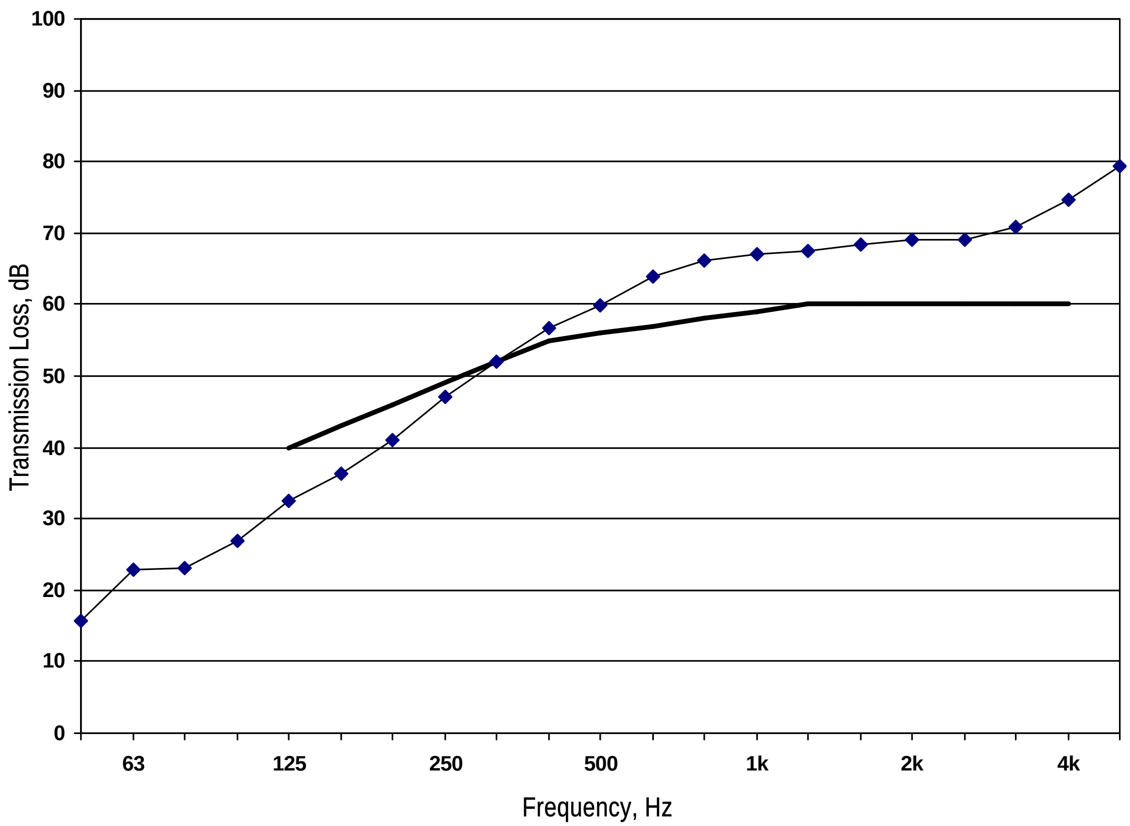


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	decking	furring	RH truss	insulation	resilient chan.	gypsum board	gypsum board
material	steel	wood	wood	glass fibre	GP	regular	regular
thickness (mm)	0.3	19	1626	264	13	13	13
spacing (mm)	*	406	610	*	610	*	*
total mass (kg)	51	51	284	62	6.7	117	117
linear density (kg/m)	*	0.87	6.2	*	0.2	*	*
surface density (kg/m^2)	2.8	*	*	4.1	*	7.8	7.9
fastener spacing #1 (mm)	*	*	*	*	*	610	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*

* indicates not applicable

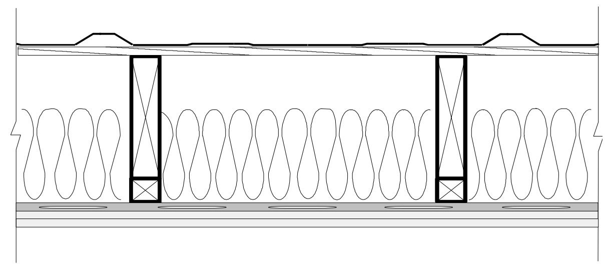
Freq, Hz	TL, dB
50	16
63	23
80	23
100	27
125	32
160	36
200	41
250	47
315	52
400	57
500	60
630	64
800	66
1000	67
1250	68
1600	68
2000	69
2500	69
3150	71
4000	75
5000	79
STC	56
OITC	39



NRC-CNRC National Research Council Canada

TLF-98-141a
STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13
Construction Type: roof

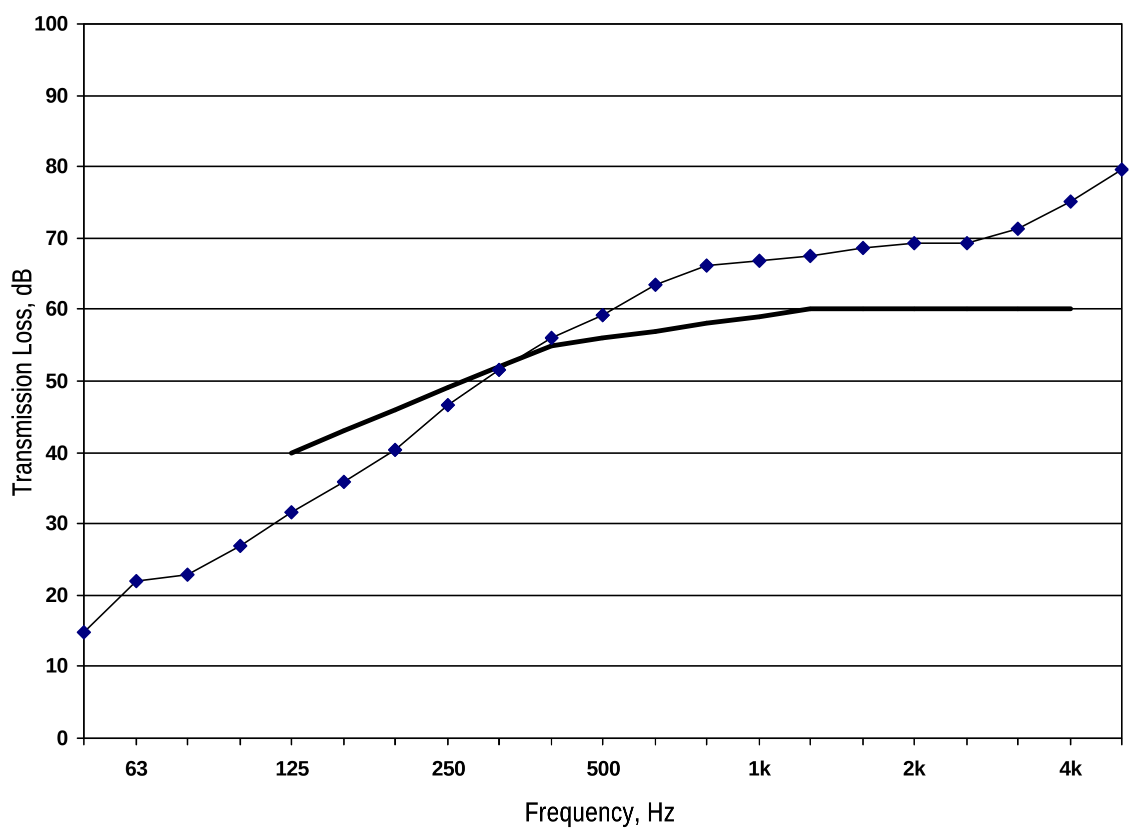
Element	Description
1	0.3 mm of steel decking
2	19 mm thick wood furring at 406 mm on centre
3	1626 mm deep raised heel wood truss
4	264 mm thick glass fibre insulation in cavity
5	13 mm resilient channel at 610 mm on centre
6	13 mm thick regular gypsum board
7	13 mm thick regular gypsum board



Vents: ridge	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	decking	furring	RH truss	insulation	resilient chan.	gypsum board	gypsum board
material	steel	wood	wood	glass fibre	GP	regular	regular
thickness (mm)	0.3	19	1626	264	13	13	13
spacing (mm)	*	406	610	*	610	*	*
total mass (kg)	51	51	284	62	6.7	117	117
linear density (kg/m)	*	0.87	6.2	*	0.2	*	*
surface density (kg/m^2)	2.8	*	*	4.1	*	7.8	7.9
fastener spacing #1 (mm)	*		*	*	*	610	305
fastener spacing #2 (mm)	*	*	*	*	*	*	*

* indicates not applicable

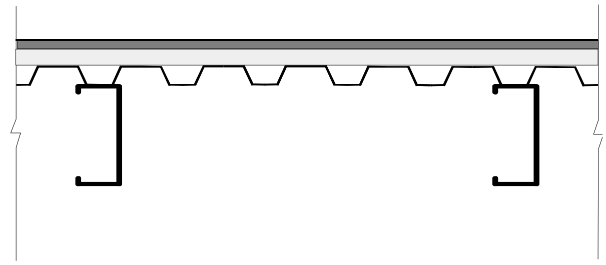
Freq, Hz	TL, dB
50	15
63	22
80	23
100	27
125	32
160	36
200	40
250	47
315	52
400	56
500	59
630	63
800	66
1000	67
1250	68
1600	69
2000	69
2500	69
3150	71
4000	75
5000	80
STC	56
OITC	39



NRC-CNRC National Research Council Canada

TLF-99-007a
GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)
Construction Type: roof

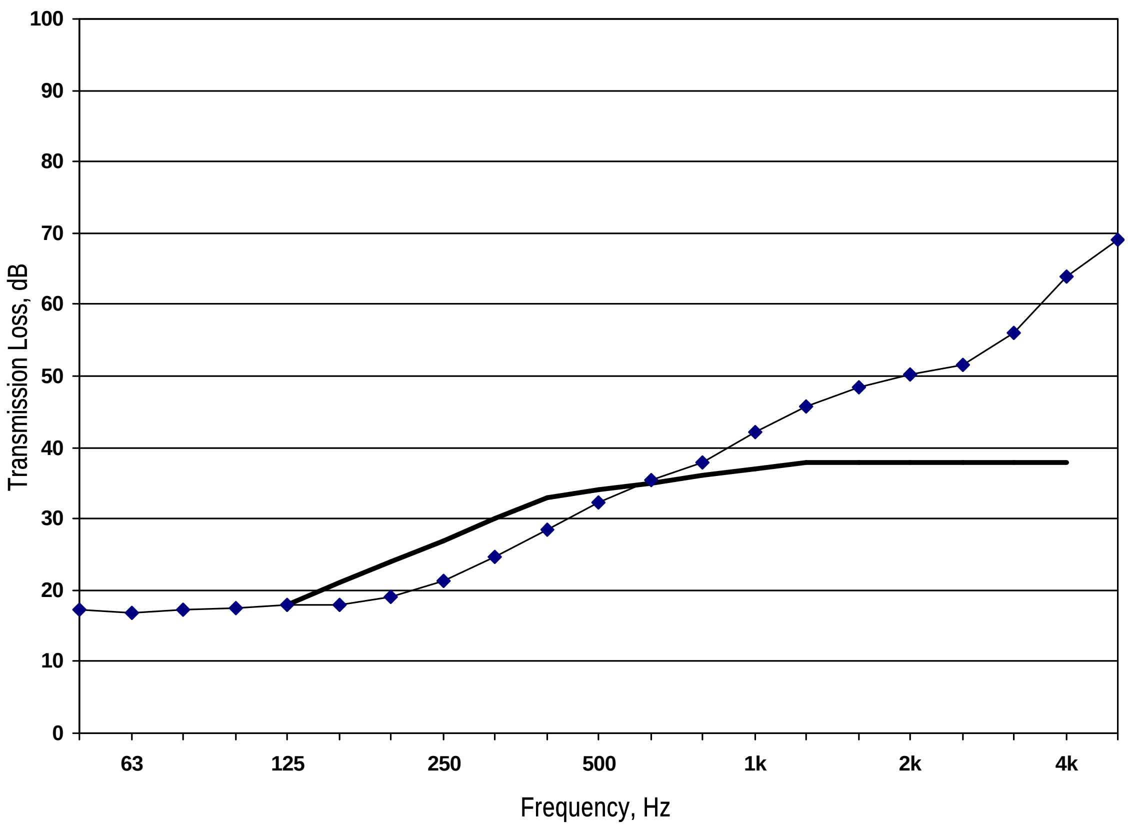
Element	Description
1	4 mm thick granular membrane
2	0.2 mm thick peel and stick membrane
3	13 mm thick wood fibre board
4	70 mm thick polyisocyanurate insulation
5	0.3 mm thick kraft paper
6	0.7 mm of steel decking
7	254 mm deep steel joist 1610 mm on centre



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6	element 7
type	membrane	membrane	fiber board	insulation	paper	steel	joists
material	granular	peel & stick	wood	polyisocyan.	kraft	decking	steel
thickness (mm)	4.2	2.5	13	70	0.3	0.7	254
spacing (mm)	*	*	*	*	*	*	1610
total mass (kg)	132	67	62	49	5.6	148	136
linear density (kg/m)	*	*	*	*	*	*	8.5
surface density (kg/m^2)	6.6	3.3	3.1	2.5	0.3	8.8	*
fastener spacing #1 (mm)	*	*	*	*	*	*	*
fastener spacing #2 (mm)	*	*	*	*	*	*	*

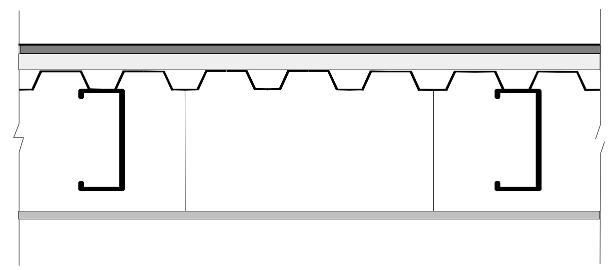
* indicates not applicable

Freq, Hz	TL, dB
50	17
63	17
80	17
100	18
125	18
160	18
200	19
250	21
315	25
400	28
500	32
630	35
800	38
1000	42
1250	46
1600	48
2000	50
2500	51
3150	56
4000	64
5000	69
STC	34
OITC	26



TLF-99-011a
GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16
Construction Type: roof

Element	Description
1	4 mm thick granular membrane
2	0.2 mm thick peel and stick membrane
3	13 mm thick wood fibre board
4	70 mm thick polyisocyanurate insulation
5	0.3 mm thick kraft paper
6	0.7 mm of steel decking
7	254 mm deep steel joist 1610 mm on centre
8	352 mm airspace
9	16 mm thick ceiling tile

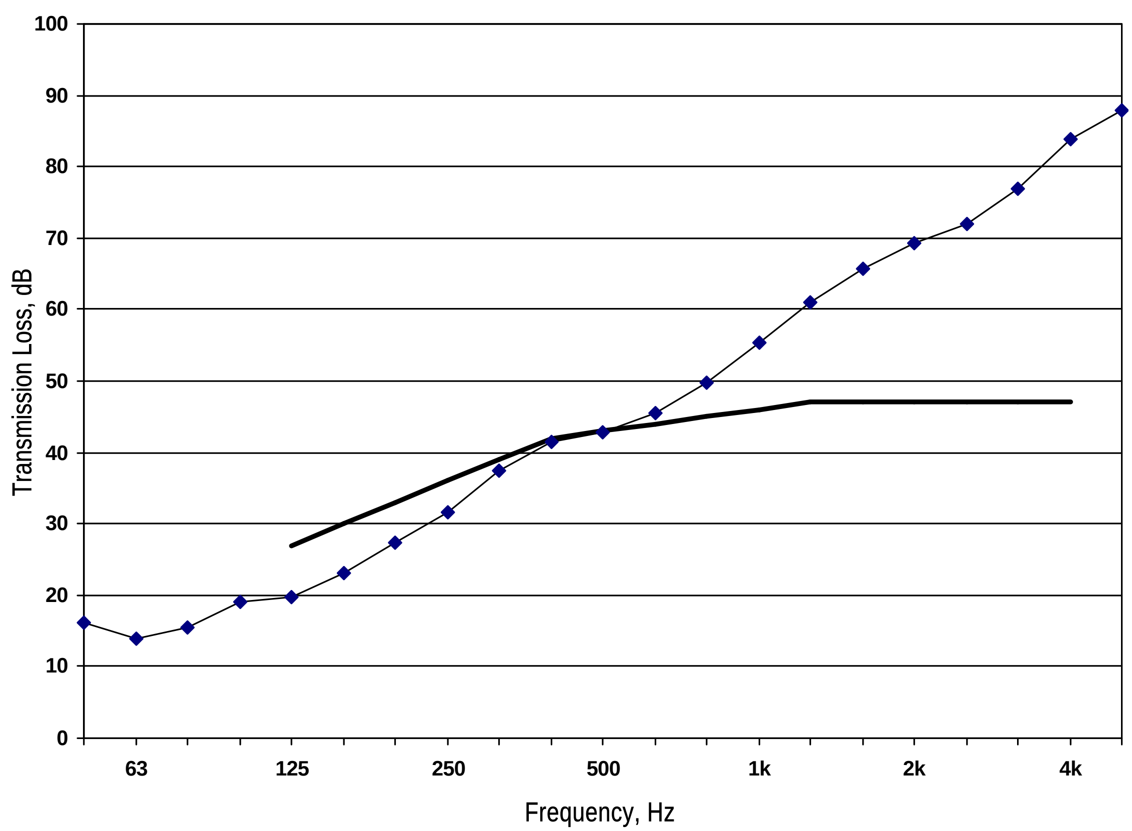


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9
type	fiber board	insulation	paper	decking	joists	air	ceiling tiles	membrane	membrane
material	wood	polyisocyan.	kraft	steel	steel	*	*	granular	peel & stick
thickness (mm)	13	70	0.3	0.7	254	352	16	4.2	2.5
spacing (mm)	*	*	*	*	1610	*	*	*	*
total mass (kg)	62	49	5.6	148	136	*	58	132	67
linear density (kg/m)	*	*	*	*	8.5	*	*	*	*
surface density (kg/m^2)	3.1	2.5	0.3	8.8	*	*	3.3	6.6	3.3
fastener spacing #1 (mm)	*	*	*	*	*	*	*	*	*
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*	*

* indicates not applicable

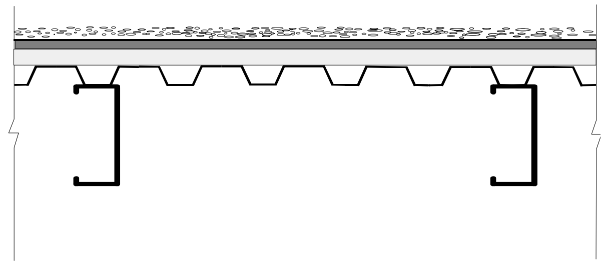
Freq, Hz	TL, dB
50	16
63	14
80	15
100	19
125	20
160	23
200	27
250	32
315	37
400	41
500	43
630	46
800	50
1000	55
1250	61
1600	66
2000	69
2500	72
3150	77
4000	84
5000	88
STC	43
OITC	29



National Research
Council Canada

TLF-99-015a
PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)
Construction Type: roof

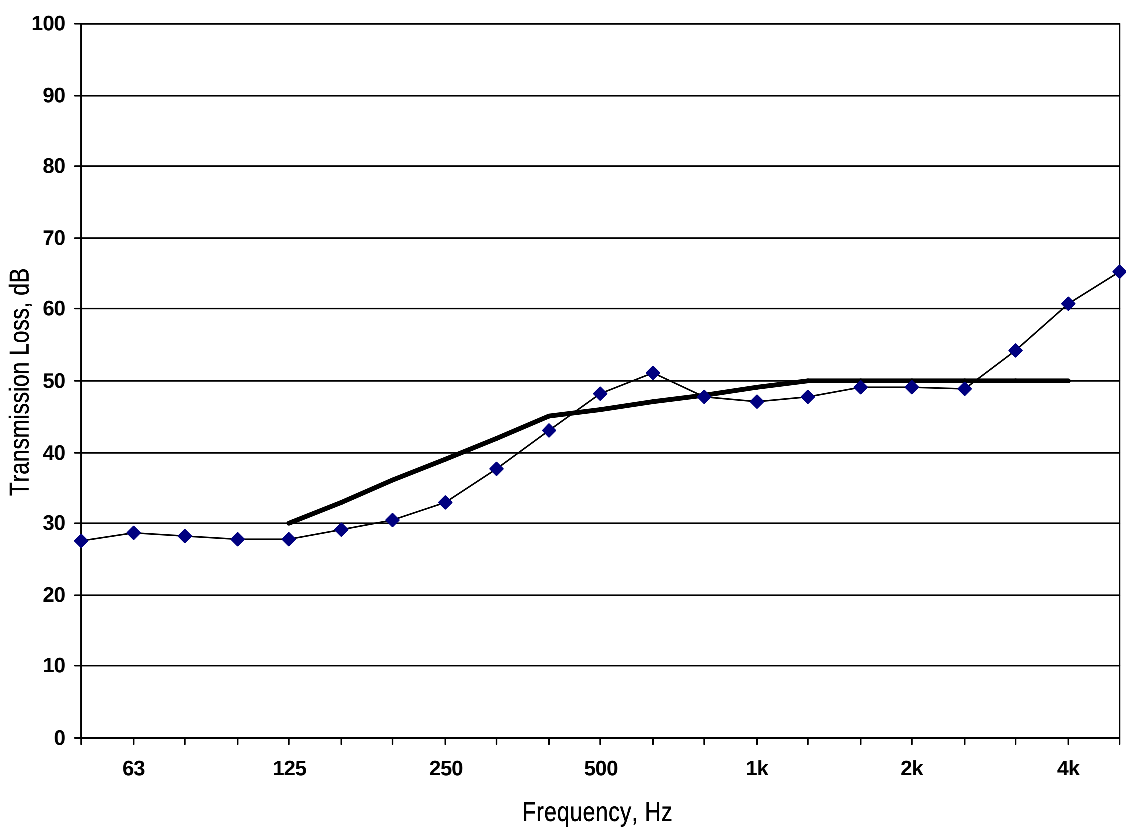
Element	Description
1	25 mm thick riverwashed pebbles
2	4 mm thick granular membrane
3	0.2 mm thick peel and stick membrane
4	13 mm thick wood fibre board
5	70 mm thick polyisocyanurate insulation
6	0.3 mm thick kraft paper
7	0.7 mm of steel decking
8	254 mm deep steel joist 1610 mm on centre



Vents: not installed	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8
type	pebbles	membrane	membrane	fiber board	insulation	paper	decking	joists
material	riverwashed	granular	peel & stick	wood	polyisocyan.	kraft	steel	steel
thickness (mm)	27	4.2	2.5	13	70	0.3	0.7	254
spacing (mm)	*	*	*	*	*	*	*	1610
total mass (kg)	836	132	67	62	49	5.6	148	136
linear density (kg/m)	*	*	*	*	*	*	*	8.5
surface density (kg/m^2)	42	6.6	3.3	3.1	2.5	0.3	8.8	*
fastener spacing #1 (mm)	*	*	*	*	*	*	*	*
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*

* indicates not applicable

Freq, Hz	TL, dB
50	27
63	29
80	28
100	28
125	28
160	29
200	31
250	33
315	38
400	43
500	48
630	51
800	48
1000	47
1250	48
1600	49
2000	49
2500	49
3150	54
4000	61
5000	65
STC	46
OITC	37



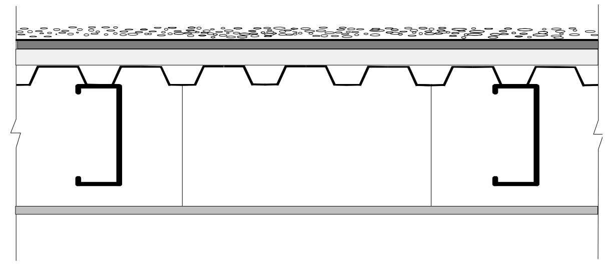
National Research Council Canada

TLF-99-013a

PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16

Construction Type: roof

Element	Description
1	25 mm thick riverwashed pebbles
2	4 mm thick granular membrane
3	0.2 mm thick peel and stick membrane
4	13 mm thick wood fibre board
5	70 mm thick polyisocyanurate insulation
6	0.3 mm thick kraft paper
7	0.7 mm of steel decking
8	254 mm deep steel joist 1610 mm on centre
9	352 mm airspace
10	16 mm thick ceiling tile

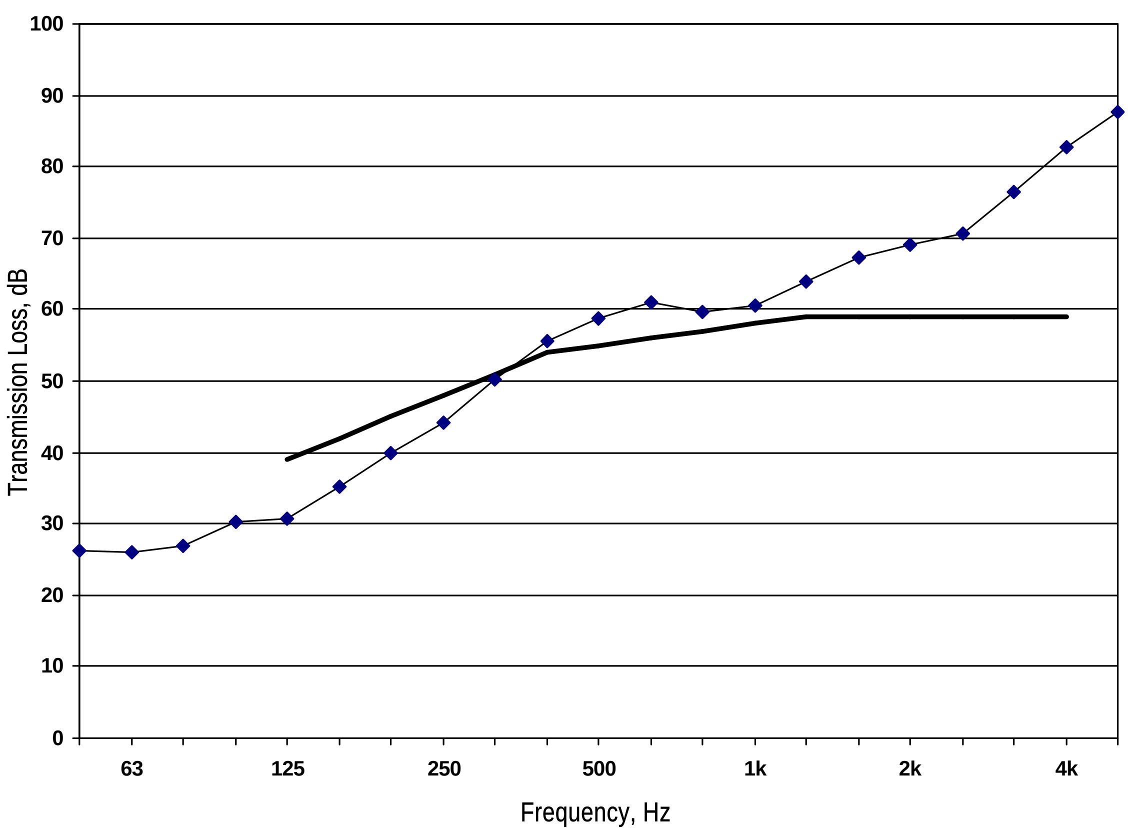


Vents: not installed

	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9	element 10
type	pebbles	membrane	membrane	fiber board	insulation	paper	decking	joists	air	ceiling tiles
material	riverwashed	granular	peel & stick	wood	polyisocyan.	kraft	steel	steel	*	*
thickness (mm)	27	4.2	2.5	13	70	0.3	0.7	254	352	16
spacing (mm)	*	*	*	*	*	*	*	1610	*	*
total mass (kg)	836	132	67	62	49	5.6	148	136	*	58
linear density (kg/m)	*	*	*	*	*	*	*	8.5	*	*
surface density (kg/m^2)	42	6.6	3.3	3.1	2.5	0.3	8.8	*	*	3.3
fastener spacing #1 (mm)	*	*	*	*	*	*	*	*	*	*
fastener spacing #2 (mm)	*	*	*	*	*	*	*	*	*	*

* indicates not applicable

Freq, Hz	TL, dB
50	26
63	26
80	27
100	30
125	31
160	35
200	40
250	44
315	50
400	56
500	59
630	61
800	60
1000	60
1250	64
1600	67
2000	69
2500	71
3150	76
4000	83
5000	88
STC	55
OITC	41



Index of Constructions by Test ID

Walls by Test ID

Windows by Test ID

Roofs by Test ID

Test ID	OITC	Description	Vents	Page
TLF-98-049a	26	OSB11_PL38(406)_WJ235(406)_GFB203_G13………	none	134
TLF-98-053a	30	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13………	none	135
TLF-98-057a	29	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13………	roof (6)	136
TLF-98-059a	37	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13………	roof (6)	138
TLF-98-061a	40	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13………	none	137
TLF-98-063a	43	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13………	none	139
TLF-98-065a	42	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13………	roof (6)	140
TLF-98-067a	41	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13………	holes (6)	141
TLF-98-069a	27	OSB11_WT356(406)_GFB264_G13………	none	142
TLF-98-073a	32	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13………	none	143
TLF-98-075a	31	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13………	roof (6)	144
TLF-98-077a	43	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13………	roof (6)	146
TLF-98-079a	44	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13………	none	145
TLF-98-083a	19	OSB11_RHWT1626………	none	147
TLF-98-087a	18	SHN3_BPAP0.7_OSB11_RHWT1626………	roof (6)	149
TLF-98-093a	33	SHN3_BPAP0.7_OSB11_RHWT1626_G13………	roof (6)	152
TLF-98-095a	36	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13………	roof (6)	155
TLF-98-097a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13………	none	154
TLF-98-099a	41	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13………	none	159
TLF-98-101a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13………	roof (6)	160
TLF-98-103a	41	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13………	roof (6)	162
TLF-98-105a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13………	none	161
TLF-98-107a	42	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13………	none	163
TLF-98-109a	40	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13………	roof (6)	164
TLF-98-111a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13………	roof (6)	166
TLF-98-113a	44	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13………	none	165
TLF-98-115a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13………	ridge	167
TLF-98-117a	19	SHN3_BPAP0.7_OSB11_RHWT1626………	ridge	150
TLF-98-119a	25	SHN3_BPAP0.7_OSB11_RHWT1626………	none	148
TLF-98-121a	36	SHN3_BPAP0.7_OSB11_RHWT1626_G13………	none	151
TLF-98-123a	33	SHN3_BPAP0.7_OSB11_RHWT1626_G13………	ridge	153
TLF-98-125a	37	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13………	ridge	158
TLF-98-127a	38	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13………	roof (3)	156
TLF-98-129a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13………	roof (1)	157
TLF-98-131a	33	STE0.3_WFUR19(406)_RHWT1626_GFB152_G13………	none	168
TLF-98-133a	33	STE0.3_WFUR19(406)_RHWT1626_GFB152_G13………	ridge	170
TLF-98-135a	34	STE0.3_WFUR19(406)_RHWT1626_GFB264_G13………	ridge	171
TLF-98-137a	35	STE0.3_WFUR19(406)_RHWT1626_GFB264_G13………	none	169
TLF-98-139a	39	STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13………	none	172
TLF-98-141a	39	STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13………	ridge	173
TLF-99-007a	26	GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)………	none	174
TLF-99-011a	29	GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16………	none	175
TLF-99-013a	41	PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16..	none	177
TLF-99-015a	37	PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)………	none	176

Index of Constructions by Outdoon-Indoor Transmission Class (OITC)

Walls by Test OITC

Windows by Test OITC

Test ID	OITC	Description	Seals taped	Storm window	Page
TLA-99-197a	22	glazing unit: aluminum spacer - air	-	-	112
TLA-99-201a	22	glazing unit: aluminum spacer - air	-	-	113
TLA-99-203a	22	glazing unit: swiggle spacer - air	-	-	114
TLA-99-205a	22	glazing unit: swiggle spacer - air	-	-	115
TLA-99-207a	22	glazing unit: swiggle spacer - argon	-	-	117
TLA-99-157a	23	vinyl double slider window	no	-	131
TLA-99-177a	23	aluminum casement window	no	-	124
TLA-99-209a	23	glazing unit: aluminum spacer - argon	-	-	116
TLA-99-159a	24	vinyl double slider window	yes	-	132
TLA-99-179a	24	aluminum casement window	yes	-	125
TLA-99-143a	25	vinyl casement window	no	-	120
TLA-99-145a	25	vinyl casement window	yes	-	121
TLA-99-149a	25	vinyl slider window	no	-	128
TLA-99-151a	25	vinyl slider window	yes	-	129
TLA-99-161a	25	wood casement window	no	-	118
TLA-99-163a	25	wood casement window	yes	-	119
TLA-99-173a	25	vinyl clad casement window	no	-	122
TLA-99-185a	25	aluminum casement window	no	yes (25mm)	126
TLA-99-153a	26	vinyl slider window	no	yes (25mm)	130
TLA-99-175a	26	vinyl clad casement window	yes	-	123
TLA-99-165a	27	vinyl double slider window	no	yes (25mm)	133
TLA-99-187a	30	aluminum casement window	no	yes (76mm)	127

Roofs by Test OITC

Test ID	OITC	Description	Vents	Page
TLF-98-087a	18	SHN3_BPAP0.7_OSB11_RHWT1626	roof (6)	149
TLF-98-083a	19	OSB11_RHWT1626	none	147
TLF-98-117a	19	SHN3_BPAP0.7_OSB11_RHWT1626	ridge	150
TLF-98-119a	25	SHN3_BPAP0.7_OSB11_RHWT1626	none	148
TLF-98-049a	26	OSB11_PL38(406)_WJ235(406)_GFB203_G13	none	134
TLF-99-007a	26	GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)	none	174
TLF-98-069a	27	OSB11_WT356(406)_GFB264_G13	none	142
TLF-98-057a	29	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13	roof (6)	136
TLF-99-011a	29	GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16	none	175
TLF-98-053a	30	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_G13	none	135
TLF-98-075a	31	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13	roof (6)	144
TLF-98-073a	32	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_G13	none	143
TLF-98-093a	33	SHN3_BPAP0.7_OSB11_RHWT1626_G13	roof (6)	152
TLF-98-123a	33	SHN3_BPAP0.7_OSB11_RHWT1626_G13	ridge	153
TLF-98-131a	33	STE0.3_WFUR19(406)_RHWT1626_GFB152_G13	none	168
TLF-98-133a	33	STE0.3_WFUR19(406)_RHWT1626_GFB152_G13	ridge	170
TLF-98-135a	34	STE0.3_WFUR19(406)_RHWT1626_GFB264_G13	ridge	171
TLF-98-137a	35	STE0.3_WFUR19(406)_RHWT1626_GFB264_G13	none	169
TLF-98-095a	36	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	roof (6)	155
TLF-98-121a	36	SHN3_BPAP0.7_OSB11_RHWT1626_G13	none	151
TLF-98-059a	37	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13	roof (6)	138
TLF-98-125a	37	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	ridge	158
TLF-99-015a	37	PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)	none	176
TLF-98-127a	38	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	roof (3)	156
TLF-98-097a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	none	154
TLF-98-101a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13	roof (6)	160
TLF-98-129a	39	SHN3_BPAP0.7_OSB11_RHWT1626_GFB152_G13	roof (1)	157
TLF-98-139a	39	STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13	none	172
TLF-98-141a	39	STE0.3_WFUR19(406)_RHWT1626_GFB264_RC13(610)_2G13	ridge	173
TLF-98-061a	40	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_G13	none	137
TLF-98-109a	40	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13	roof (6)	164
TLF-98-067a	41	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13	holes (6)	141
TLF-98-099a	41	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_G13	none	159
TLF-98-103a	41	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13	roof (6)	162
TLF-99-013a	41	PEB25_GMEM4_PSMEM0.2_WFB13_POLYISO70_PAP0.3_STE0.7_SJ254(1610)_AIR352_CTILE16	none	177
TLF-98-065a	42	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13	roof (6)	140
TLF-98-107a	42	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_G13	none	163
TLF-98-063a	43	SHN3_BPAP0.7_OSB11_PL38(406)_WJ235(406)_GFB203_RC13(610)_2G13	none	139
TLF-98-077a	43	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13	roof (6)	146
TLF-98-105a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_2G13	none	161
TLF-98-111a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13	roof (6)	166
TLF-98-115a	43	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13	ridge	167
TLF-98-079a	44	SHN3_BPAP0.7_OSB11_WT356(406)_GFB264_RC13(610)_2G13	none	145
TLF-98-113a	44	SHN3_BPAP0.7_OSB11_RHWT1626_GFB264_RC13(610)_2G13	none	165