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RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY FLOOR/CEILING ASSEMBLIES IN WOOD CONSTRUCTION

EXECUTIVE SUMMARY

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY FLOOR/CEILING ASSEMBLIES IN WOOD CONSTRUCTION

EXECUTIVE SUMMARY

MJM ACOUSTICAL CONSULTANTS INC. has been selected by the Canada Mortgage & Housing Corporation to conduct the first phase of a research project on the sound isolation provided by floor/ceiling assemblies in wood constructions. This report contains the results of our findings. The main objective of this first phase was to investigate the acoustical performance of different materials to be incorporated from the underside of the floor/ceiling assemblies. These include the sound absorptive materials in the floor cavity along with ceiling finishes and installation methods. All the airborne and impact sound insulation tests have been conducted at the laboratories of the National Research Council of Canada under the direction of Dr. A.C.C. Warnock. The results of these tests are presented in table no 1 appearing at the end of this summary; this table contains a schematic representation of the assemblies tested and their detailed composition, complete with their Sound Transmission Class (STC) and Impact Insulation Class (IIC) ratings.

In resumé, the conclusions reached during the first phase of the study are outlined in the paragraphs below.

- The spacing of the joists à 16 in. c.c. seems to generate a sub panel resonance in the plywood subfloor, at 160 Hz.

In many of the floor tested the STC rating was governed by the low transmission loss at this frequency.

- The four different types of resilient furrings tested provided an almost identical sound isolation performance.

- Resilient furrings are highly recommended in the construction of floor/ceiling assemblies separating dwellings. The use of wood furrings is not advisable since the mechanical coupling it provides between the floor and the ceiling greatly reduced the performance of the assemblies tested.

- Doubling the mass of a drywall ceiling installed on resilient furrings led to an improvement of roughly 5 dB in the STC rating and in the transmission loss at all frequencies. Doubling the mass of a drywall ceiling on wood furrings led to no improvement in the STC rating, and in the transmission loss at low frequencies for which the mechanical coupling was important; it also led to an improvement of 3 points in the IIC rating.

- Filling the joists cavity with different types of materials provides approximately the same performance in terms of STC. Benocoustics, the "acoustical" blown-in material manufactured by Benolec, did not provide a significantly better performance than a standard cellulose blown-in attic insulation. It is not recommended to pay a premium for this material.

- The insertion of a wood fiber board between the joists and resilient furrings is often encountered on site, this practice did not provide any improvements in terms of STC.

- The most efficient way of improving the performance of an existing floor/ceiling assembly, is to build an additional ceiling under it. In the present study, a ceiling consisting in 1/2 in. drywall, fastened to 2 1/2 in. standard metal studs, with batt insulation between the studs, provided the best results: an improvement of 15 STC points.

- The independently joisted floor/ceiling measured in this study tested STC 40, whereas the more conventional floor/ceiling assembly built with resilient furrings tested around STC 45. The use of independantly joisted ceilings is not recommended.

- Many of the assemblies tested with compositions which conform to that specified in table 9.10.3.B of the NBC, 1985 edition, (floors no 7A to 7F of this study) did not comply with the STC 45 minimum requirement referred to in section 9.11 of the code.

A second phase to complete this research project will be undertaken shortly to answer some of the questions raised during the first phase and to investigate the benefit to be gained by installing different materials from the top of the assembly.

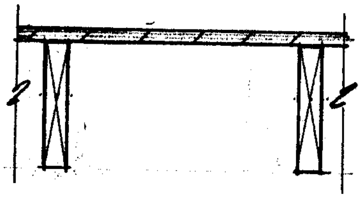
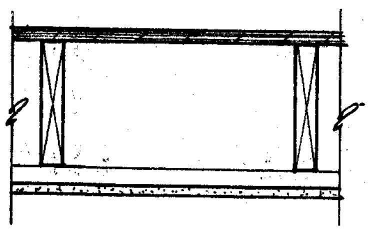
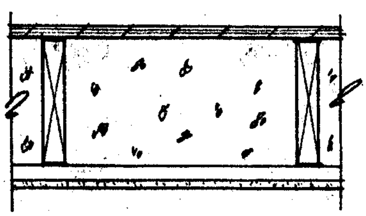
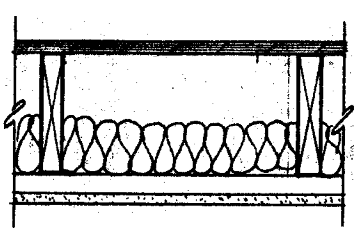
CMHC RESEARCH PROJECT		SUMMARY OF THE RESULTS	PROJECT 177.881	
TEST No.	SCHEMATIC REPRESENTATION	COMPOSITION	STC RATING	IIC RATING
1		BASIC FLOOR ASSEMBLY - 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. NOTE: This basic floor assembly remained the same throughout the study; changes have been made only on the materials composing the cavity sound absorption and the ceilings to obtain the assemblies described below.	24	20
2		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 1 in. x 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. x 2 in. wood furrings.	38	37
3		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - Space between the joists filled with different blown-in insulation materials - 1 in. x 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. x 2 in. wood furrings.		
3A	--------------------------->>	- Cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd.	49	44
3B	--------------------------->>	- Mineral blown-in attic insulation: RED TOP manufactured by CGC.	48	45
4		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - 1 in. x 2 in. wood furring strips. - 1/2 in. gypsum board screwed to the 1 in. x 2 in. wood furrings.		
4A	--------------------------->>	- Wood furrings @ 24 in. c.c.	44	41
4B	--------------------------->>	- Wood furrings @ 16 in. c.c.	37	32

TABLE 1 - PAGE 2

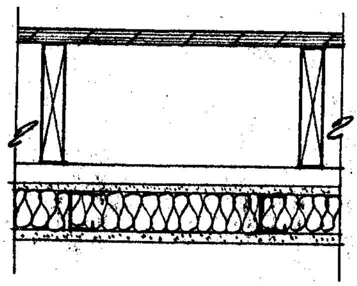
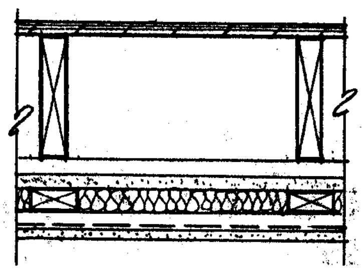
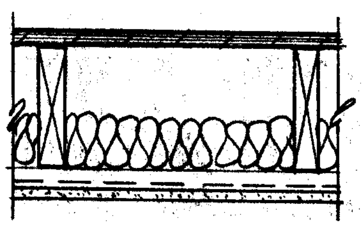
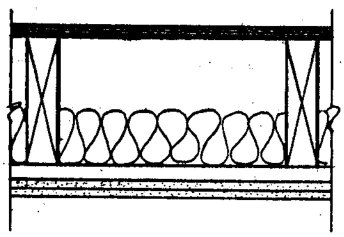
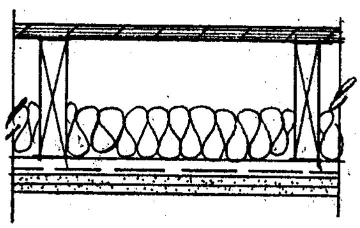
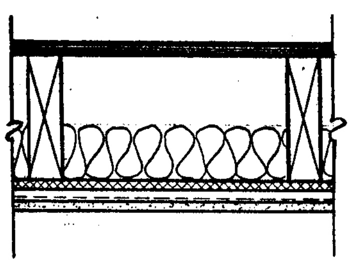
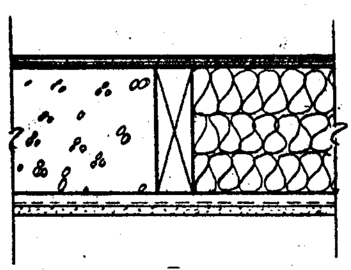
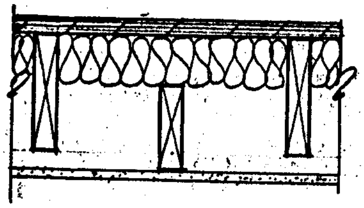
TEST No.	SCHEMATIC REPRESENTATION	COMPOSITION	STC RATING	IIC RATING
5		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 1 in. x 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. x 2 in. wood furrings. - 2 1/2 in. Standard metal studs (25 GA.) spaced 24 in. c.c. and screwed to the wood furrings. - 2 1/2 in. thick pink glass fibre insulation between the studs - 1/2 in. gypsum board screwed to the metal studs	53	45
6		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 1 in. x 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. x 2 in. wood furrings. - 2 in x 3in. installed on the flat side at 24 in c.c. , and screwed to the wood furring strips. - 1 1/2 in. thick glass fiber batt insulation between the wood blockings @ 24 in. c.c. - 1/2 in. thick resilient metal channel screwed to the wood blockings. - 1/2 in. gypsum board screwed to the resilient furrings.	46	42
7		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - different types of 1/2 in. thick resilient metal channel screwed to the joists @ different spacings. - 1/2 in. gypsum board screwed to the resilient furrings.		
7A	---------------------------->>	- Resilient furrings by PICHETTE METAL @ 24 in. c.c	44	43
7B	---------------------------->>	- Resilient furrings by RL METAL @ 24 in. c.c	44	43
7C	---------------------------->>	- Resilient furrings by TREBORD @ 24 in. c.c	44	43
7D	---------------------------->>	- Resilient furrings RC-1 by CGC, @ 24 in. c.c.	45	44
7E	---------------------------->>	- Resilient furrings RC-1 by CGC, @ 16 in. c.c.	44	42
7F	---------------------------->>	- Resilient furrings RC-1 by CGC, @ 16 in. c.c., installed parallel to the joists.	45	42

TABLE 1 - PAGE 3

TEST No.	SCHEMATIC REPRESENTATION	COMPOSITION	STC RATING	IIC RATING
8		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - 1 in. x 2 in. wood furring strips @ 16 in. c.c - 2 x 1/2 in. gypsum boards screwed to the 1 in. x 2 in. wood furrings.	37	35
9		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - Resilient furrings RC-1 by CGC, screwed to the joists @ 24 in. c.c. - 2 x 1/2 in. gypsum boards screwed to the resilient furrings.	50	49
10		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - 1/2 in. wood fiber board screwed directly to the underside of the joists - Resilient furrings RC-1 by CGC, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furrings.	45	42
11		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - Different types of sound absorptive materials to completely fill the cavity between the joists. - Resilient furrings RC-1 by CGC, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furrings.		
11A	--------------------------->>	- 3 layers of 3 1/2 in. pink glass fiber batt insulation.	51	46
11B	--------------------------->>	- Cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd.	49	47
11C	--------------------------->>	- Acoustical blown-in insulation: BENOCOUSTICS by Benolec.	51	47

TEST No.	SCHEMATIC REPRESENTATION	COMPOSITION	STC RATING	IIC RATING
12		- 5/8 in. thick plywood - 2 in. x 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists. - 2 in. x 6 in. ceiling joists supported by the common 2 in. x 10 in. plate at the perimeter of the test opening. - 1/2 in. gypsum board screwed directly to the ceiling joists.	40	38

REPORT

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY FLOOR/CEILING ASSEMBLIES IN WOOD CONSTRUCTION

TABLE OF CONTENTS

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY FLOOR/CEILING ASSEMBLIES IN WOOD CONSTRUCTION

1.0 INTRODUCTION

MJM ACOUSTICAL CONSULTANTS INC. has been retained by the CANADA MORTAGE & HOUSING CORPORATION to conduct a research project on the noise isolation provided by floor/ceiling assemblies in wood structures. The project has been planned in two phases by the CMHC: the first phase is dedicated to researching the acoustical performance of different ceiling assemblies and sound absorptive materials in the joist cavity; the second phase will be dedicated to investigate the effect of different floor treatments, and to complete the aspects which were left unanswered in the first phase of the research project. This report outlines the results of the Sound Transmission Loss and Impact Insulation tests performed during Phase I. The tests were conducted at the acoustical laboratories of the NATIONAL RESEARCH COUNCIL OF CANADA under the supervision of Dr. A.C.C. Warnock, and under the direction of the undersigned.

The results of the measurements performed during the research project are summarized in the table no 1 appearing in the executive summary of this report. This table contains a graphic representation of the floors tested, complete with their description and the STC and IIC ratings measured. The numbering used in this table to designate the floor/ceiling assemblies will be used throughout the report to refer quickly to the assemblies being discussed.

2.0 OBJECTIVES OF THE STUDY

The study was planned and conducted to attain two objectives:

1) To provide builders and construction professionals with practical information on the acoustical performance of different materials and techniques.

2) To provide acousticians with reliable data which could allow them to deduct the insertion losses resulting from adding and deleting materials.

The builders and construction professionals should find most of the information which should be of interest to them in section 3.0 entitled ANALYSIS OF THE RESULTS and in ANNEX I which contains the graphs pertaining to this section.

Acousticians will refer to ANNEX II for the complete information pertaining to all the tests performed on the 21 assemblies tested. This portion of the report was prepared by Dr. A.C.C. Warnock of the NATIONAL RESEARCH COUNCIL OF CANADA.

3.0 ANALYSIS OF THE RESULTS

It is well documented that the main factors influencing the airborne sound isolation performance of a floor/ceiling assembly are:

- the mass and rigidity of the floor and ceiling membranes composing the assembly;

- the amount of mechanical coupling between these membranes;
- the depth of the floor cavity, and the presence of sound absorption in it.

The floor/ceiling assemblies tested in this study, were selected in an endeavour to isolate the noise isolation contribution of the different materials and methods of installation entering in the composition of the assemblies tested. Our findings are summarized in the paragraphs below. The graphs of ANNEX I illustrating our comments are referenced in the right margin.

3.1 AIRBORNE NOISE ISOLATION

.1 Sub-panel resonance related to joists spacings

We have noticed the presence of a dip, at 160 Hz, in the transmission loss of many floor/ceiling assemblies tested. This dip is believed to be caused by a sub-panel resonance developing in the plywood subfloor when it is supported by 2" X 10" joists at 16 in. c.c. In many instances, the STC rating of the floor/ceiling assemblies was governed by the 8 dB rule at this frequency; successful attempts at damping this resonance resulted in an increase of the STC of the floor.

.2 Wood furrings VS resilient furrings

Assemblies built with wood furrings (floor no 4A) and resilient furrings (floor no 7A to 7D) provided identical STC ratings when spaced at 24 in. c.c; with a spacing of 16 in. c.c. the STC rating of the assembly with wood furrings (floor 4B) is 7 dB below that of the assembly with resilient furrings (floor 7E). Since most drywall installers recommend a furring spacing of 16 in. c.c. to avoid any bowing of the drywall when it is installed on the ceiling, the use of resilient furrings is highly recommended in the composition of interdwelling floor/ceiling assemblies.

graph 1

graph 2

.3 Resilient furrings

Tests were conducted on four different resilient furrings (floors 7A to 7D) currently installed in the Montreal region. The results of these tests indicated that the resilient furrings tested can be considered equivalent. Changing the spacing of the furrings from 24 in. (floor 7D) to 16 in. (floor 7E) or installing them parallel to the joists does not significantly affect their acoustical performance.

graph 3

graph 4

Full scale drawings showing the configuration of the furrings tested are appended in <u>Annexe III</u> of this report.

.4 Doubling the mass of the drywall

If the ceiling of an assembly is installed on wood furrings (floor no 8), one cannot by doubling the drywall on the ceiling, improve the STC rating of this assembly nor its sound transmission loss at low frequency. However, the addition of a drywall layer on a ceiling installed on resilient furrings (floor no 9) results in an improvement of roughly 5 dB at all frequencies, and in an increase of the STC rating of 5 points. A difference of 13 STC points exists between a double drywall ceiling installed on resilient furrings at 24 in.c.c. and a double drywall ceiling installed on wood furrings at 16 in.c.c.

graph 5

graph 6

graph 7

.5 Filling the joists cavity with absorption

With the wood furrings spaced at 24 in. (floors 3A & 3B), filling the joist cavity with cellulose or mineral attic insulation resulted in an improvement of approximately 10 STC points when compared to no absorption in the cavity

graph 8

(floor no 2), and 4 to 5 STC points when compared to placing glass fiber batt insulation 3 1/2 in. thick in the joist cavity (floor 4A). Based on the measurements performed on floors no 4A & 4B with the cavity partially filled with absorption, it is expected that with a spacing of 16 in. c.c. between the wood furrings, the improvement resulting from filling the joist cavity would be somehow reduced. However, this remains to be quantified in Phase II of the study. graph 9

Replacing the wood furrings at 24 in. c.c. (floor no 3A) by resilient furrings (floor 11B) on an assembly filled with cellulose insulation led to no improvement of STC. graph 10
However, for frequencies above 160 Hz, the increase in the transmission loss was significant and could reach as much as 10 to 12 dB at mid frequencies.

Assemblies built with resilient furrings, having their cavity filled with either glass fiber batt insulation, or cellulose blown-in insulation (floors no 11A, 11B, 11C) showed similar STC rating; however, the cellulose blown-in insulation provided a better transmission losses at mid-frequencies, than the glass fiber batt insulation. graph 11

.6 **Blown in sound absorptive material**

The three blown in insulation materials tested were found equivalent; among the material tested was Benocoustic (floor 11C) which is sold as a patented acoustical product. In general its special" composition of cellulose fiber and solid aggregates did not provide any significant improvement over the standard blown in attic thermal insulation. graph 11 graph 12

.7 **Doubling the drywall or filling the cavity**

On an assembly built with resilient furrings, doubling the drywall (floor no 9) appears to be equivalent to filling the cavity with sound absorptive materials (floors no 11A, 11B, 11C). graph 13 graph 14

.8 **Wood fiber board**

The insertion of a fiber board between the joists and the resilient furrings is often encountered on site (floor no 10). When compared with an assembly build without wood fiber board (floor 7D for example), it was found that this practice resulted in: graph 15

- no improvement at low frequency
- a slight degradation at mid frequency

- a slight improvement at high frequencies
- no improvement in terms of STC rating

In conclusion, installing a ceiling composed of 2 ayers of drywall screwed to the resilient furrings represents a more effective solution to improve the sound transmission loss of a floor/ceiling assembly. graph 16

.9 **Improving existing situations**

The complaints with regards to existing situations concerns the transmission of both impact and airborne noise. The mitigating measures usually adopted is the injection of loose fill cellulose or mineral insulation in the floor cavity (floor 3A or 3B) or the construction of a new drywall ceiling (floor no 5 & 6). Both solutions were investigated. graph 17

As mentioned earlier, it was found that filling the cavity of the basic floor with cellulose or mineral loose fill insulation resulted in an improvement of 10 dB at merely all frequencies. However, since the effect of the spacing of the furrings or the absence of furrings on the improvement obtained is yet to be determined, one cannot expect to obtain the above improvement in all conditions encountered on sites.

Two types of added ceilings were tested. The first consisted in a layer of 1/2 in. drywall fastened to 2 1/2" standard metal channel studs which are screwed to the underside of the basic floor assembly; batt insulation was inserted in the stud cavity (floor no 5). This added ceiling provided an improvement of 15 points ver the STC rating of the basic floor assembly. It appears to be the most effective way to increase the sound isolation of floors during the transformation of older multidwelling buildings into condominiums. graph 18

Another technique of building an additional ceiling using wood blockings and resilient furrings was also investigated (floor no 6) but proved to be not as effective at low frequencies. graph 19 graph 20

.10 Independantly joisted ceilings

Among the surprises of this study is the very poor performance of the independantly joisted drywall ceiling (floor no 12) compared to the more conventional drywall ceiling installed graph 21 on resilient furrings (floors no 7A to 7F). As a matter of fact, the independently joisted construction tested 4 to 5 STC points below the floors constructed with resilient furrings. Several tests have been performed by the NRC on the independantly joisted assembly to validate the measured sound transmission losses. These results were also compared to those of a study conducted in the laboratories of the Norwegian Building Research Institute; which objective was to compare the acoustical performance of a "Hoop and Batten" ceiling construction to that of an independently joisted ceiling (1). The results quoted in the above study were consistent with those which were obtained at the NRC laboratories.

We therefore conclude that the use of independantly joisted floor assemblies is not advisable between dwellings.

.11 National building code requirements

Floor composition no 7 of the present report is indicated in table 9.10.3.B of the NBC 1985 edition as having a STC rating between 45 and 50. It is interesting to note that five tests out of seven performed on this type of table 1 floor failed to meet the TC 45 minimum requirement contained in paragraph 9.11.21 of the National Building Code, 1985 edition.

3.2 IMPACT NOISE ISOLATION

Since the floor finishes are more likely to have a greater influence on the impact insulation performance of floor/ceiling assemblies, this aspect will be treated in more details during the second phase of this study. Our comments concerning the isolation of impact noise by means of adding sound absorption or modifying the ceiling composition and method of installation are outlined in the paragraphs below.

When refering to the graphs referenced in the right margin, one must bear in mind that the better performance is achieved by a floor when its impact sound pressure level in ordinate is low; i.e. the lower curves on the graphs are those of the assembly offering the best impact insulation performance.

The standard for measuring the Impact Sound Isolation provided by floor/ceiling assemblies (ASTM E 492) has been criticized by many acousticians because it is not possible to correlate the subjective evaluation of the impact insulation provided by a floor, with the results of objective measurements made in accordance with this standard. These criticisms mainly originate from the fact that the impacts generated by the tapping machine bear no resemblance with that produced by a human being. Consequently, until a new standard is developed, care must be exercised when using IIC ratings to specify the amount of Impact Noise Isolation provided by a floor/ceiling assembly.

.1 **Wood furrings VS resilient furrings**

Resilient furrings provide superior impact noise isolation than wood furrings. graph 22

.2 **Improvement by adding one layer of drywall to an existing ceiling**

Adding a layer of drywall on the ceiling of an assembly built with wood furrings at 16 in. c.c. (floor no 8) led to an improvement of 3 IIC points. When the same layer is applied on a ceiling with resilient furrings (floor no 9) an improvement of 5 IIC points resulted. graph 23 graph 24

.3 **Filling the joist cavity with absorption**

For assemblies built with wood (3A & 3B) and resilient furrings (floors 11A, graph 25 graph 26

11B & 11C), filling the joist cavity with sound absorption resulted in an improvement of only 3 to 4 IIC points when compared with placing 3 1/2 batt insulation in the cavity.

All sound absorptive material used provided overall performances which can be considered equivalent. graph 27

At low frequency, doubling the drywall of a ceiling mounted on resilient furrings provided a slightly better performance than filling the cavity with absorption. However the two assemblies can be considered equivalent. graph 28

.4 Added ceilings

In terms of IIC, filling the joist cavity of an existing floor with blown-in insulation (floor no 3A) seems to provide the same degree of Impact Noise Isolation than adding a drywall ceiling screwed to 2.5 in. metal channel studs with the cavity etween the studs filled with batt insulation (floor no 5). However, as shown on graph 29, starting a 160 Hz, the performance of the added ceiling is clearly superior. As for the airborne transmission loss test, the added ceiling on wood blockings and graph 29 graph 30 resilient furrings (floor no 6) provided a slightly inferior IIC performance than the ceiling on metal studs (floor no 5).

.5 **Independently joisted ceiling**

The independently joisted ceiling (floor no 12) provided a impact insulation performance similar to that of the basic floor (floor no 2) built with wood furrings with no batt insulation in the cavity. graph 31

4.0 CONCLUSIONS

.1 The spacing of the joists à 16 in. c.c. seems to generate a sub panel resonance in the plywood subfloor, at 160 Hz. In many of the floor tested the STC rating was governed by the low transmission loss at this frequency.

.2 The four different types of resilient furrings tested provided an almost identical sound isolation performance.

.3 Resilient furrings are highly recommended in the construction of floor/ceiling assemblies separating dwellings. The use of wood furrings is not advisable since the mechanical coupling it provides between the floor and the ceiling greatly reduced the performance of the assemblies tested.

.4 Doubling the mass of a drywall ceiling installed on resilient furrings led to an improvement of roughly 5 dB in the STC rating and in the transmission loss at all frequencies. Doubling the mass of a drywall ceiling on wood furrings led to no improvement in the STC rating, and in the transmission loss at low frequencies for which the mechanical coupling was important; its also led to an improvement of 3 points in the IIC rating.

.5 Filling the joists cavity with different types of materials provides approximately the same performance in terms of STC. Benocoustics, the "acoustical" blown-in material manufactured by Benolec, did not provide a significantly better performance than a standard cellulose blown-in attic insulation. It is not recommended to pay a premium for this material.

.6 The insertion of a wood fiber board between the joists and resilient furrings is often encountered on site, this practice did not provide any improvements in terms of STC.

.7 The most efficient way of improving the performance of an existing floor/ceiling assembly, is to build an additional ceiling under it. In the present study, a ceiling consisting in 1/2 in. drywall, fastened to 2 1/2 in. standard metal studs, with batt insulation between the studs, provided the best results: an improvement of 15 STC points.

.8 The independently joisted floor/ceiling measured in this study tested STC 40, whereas the more conventional floor/ceiling assembly built with resilient furrings tested around STC 45. The use of independantly joisted ceilings is not recommended.

.9 Many of the assemblies tested with compositions which conform to that specified in table 9.10.3.B of the NBC, 1985 edition, (floors no 7A to 7F of this study) did not comply with the STC 45 minimum requirement referred to in section 9.11 of the code.

.10 The presence of sound absorption in the joist cavity along with the mass and the resilient installation of the ceiling favourably affect the Impact Sound Isolation provided by a floor/ceiling assembly. The combined effect of these parameters with those related to the installation of the floor finishes will be addressed in more details in Phase II of this study.

Respectfully submitted
February 15, 1989
Revised April 11, 1990
MJM ACOUSTICAL CONSULTANTS INC.

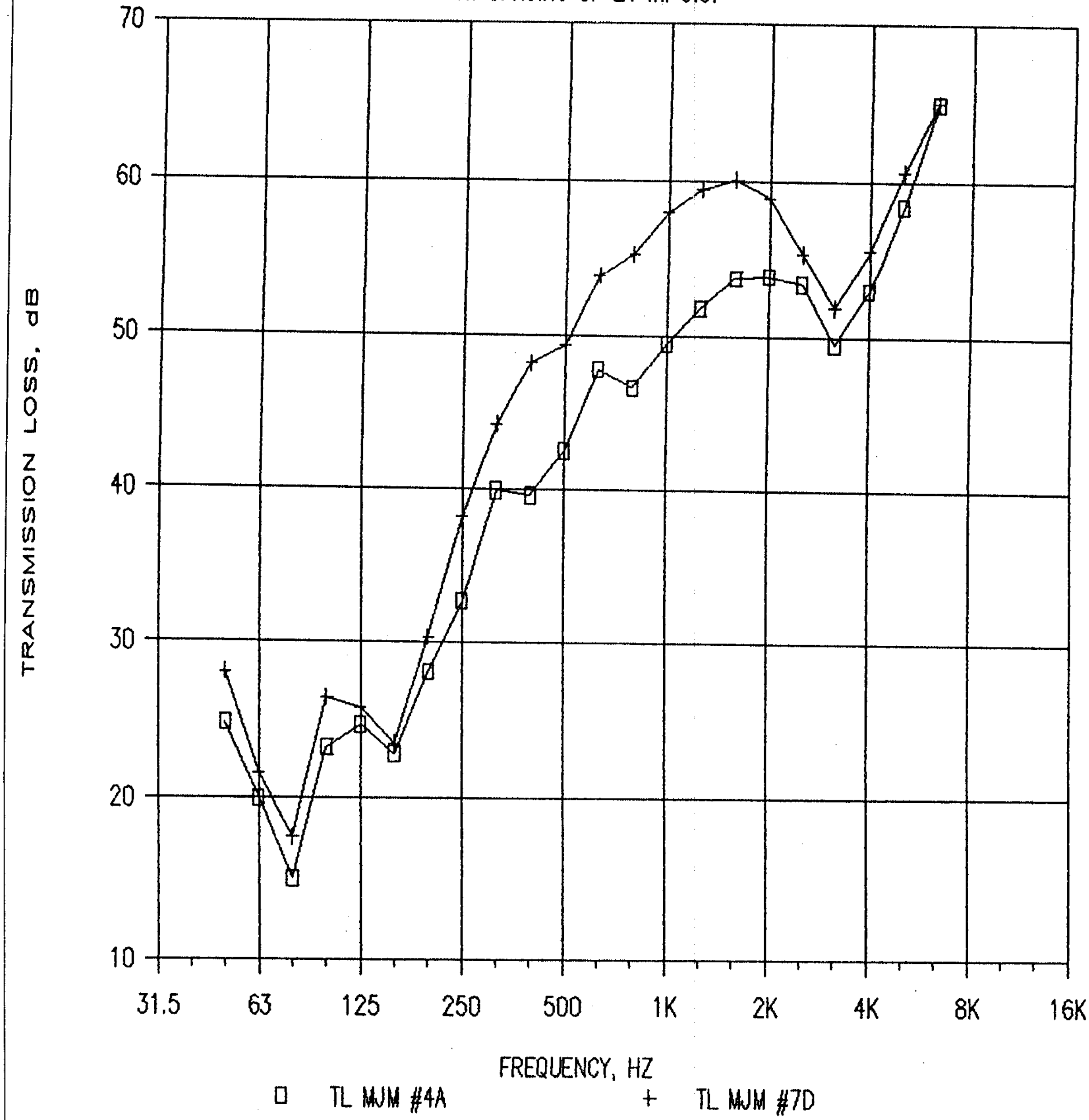
M. Morin

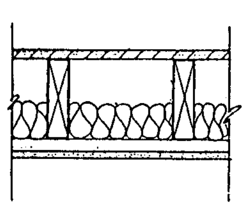
Michel Morin, architect
President

ANNEX I

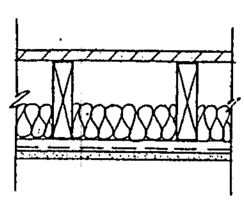
WOOD FURRINGS VS RESILIENT FURRINGS

AT SPACING OF 24 in. C.C.





Wood furrings
24 in. c.c.
STC 44

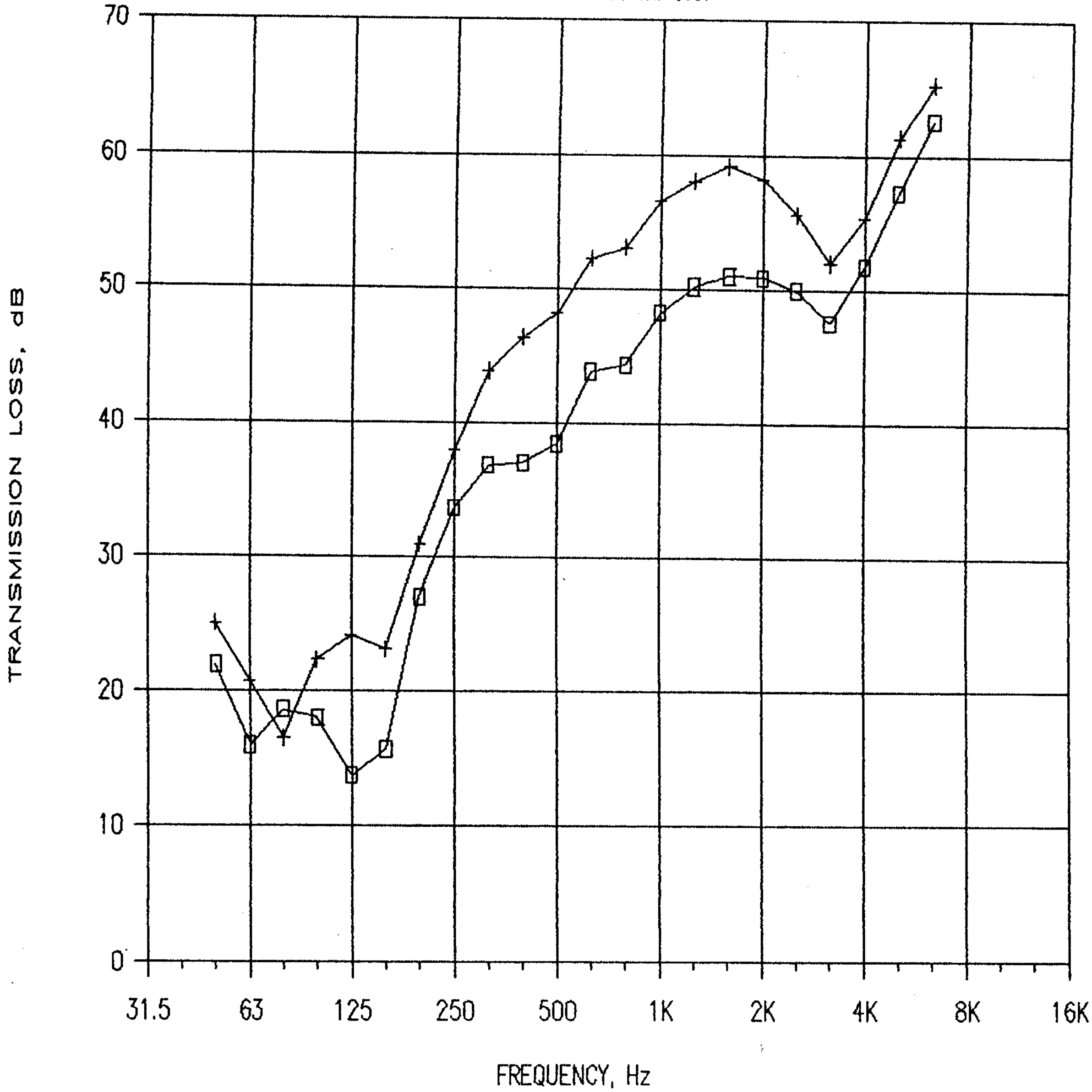


Resilient furrings
24 in. c.c.
STC 45

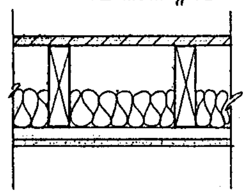
Graph no 1

WOOD FURRINGS VS RESILIENT FURRINGS

AT SPACING OF 16 in. C.C.

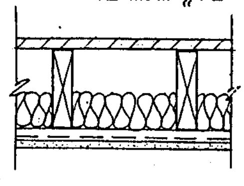


□ TL MJM #4B



Wood furrings
16 in. c.c.
STC 37

+ TL MJM #7E

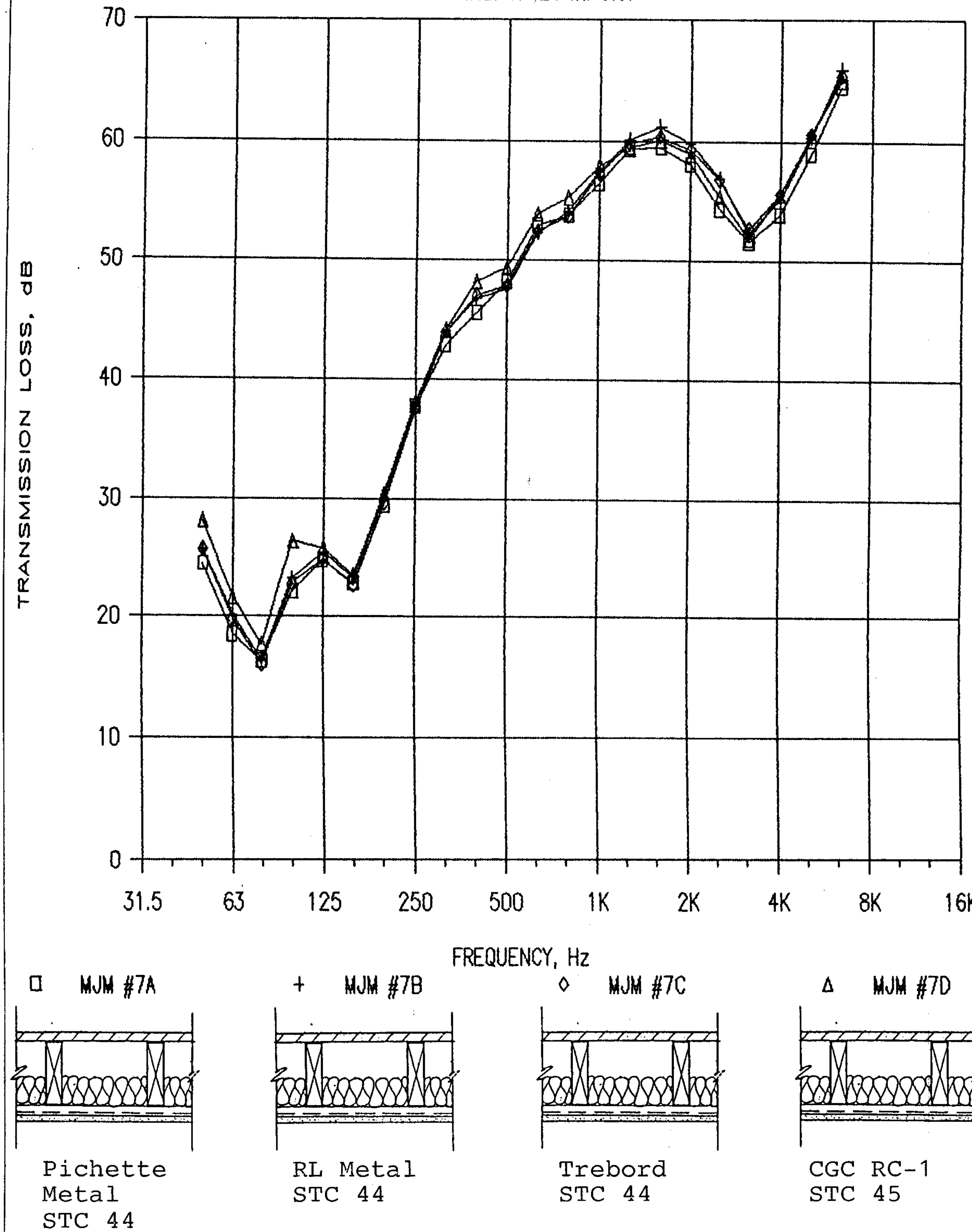


Resilient
furrings
16 in. c.c.
STC 44

Graph no 2

COMPARISON BETWEEN 4 RESILIENT FURRINGS

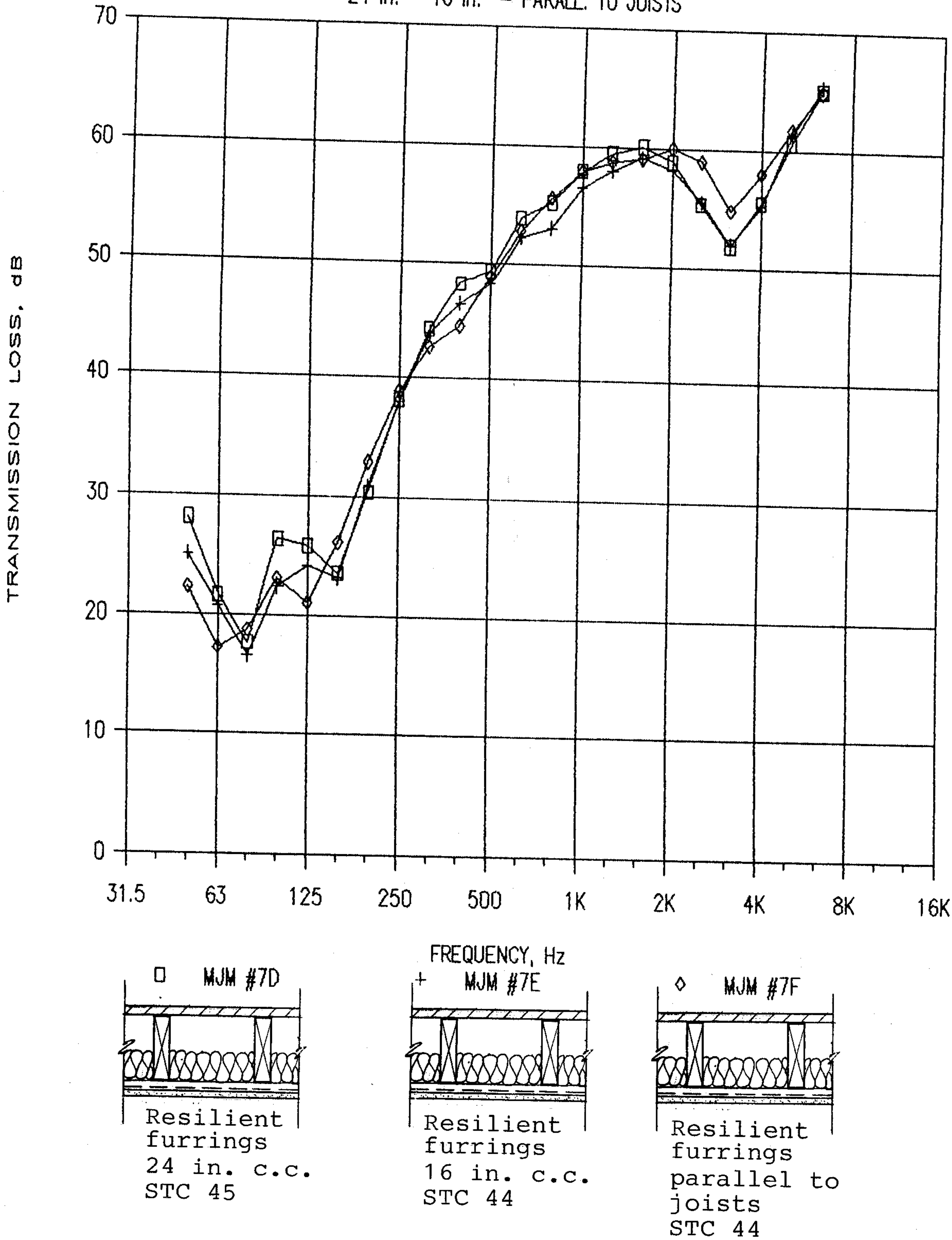
INSTALLED AT 24 in. C.C.



Graph no 3

RESILIENT FURRINGS – VARIOUS SPACINGS

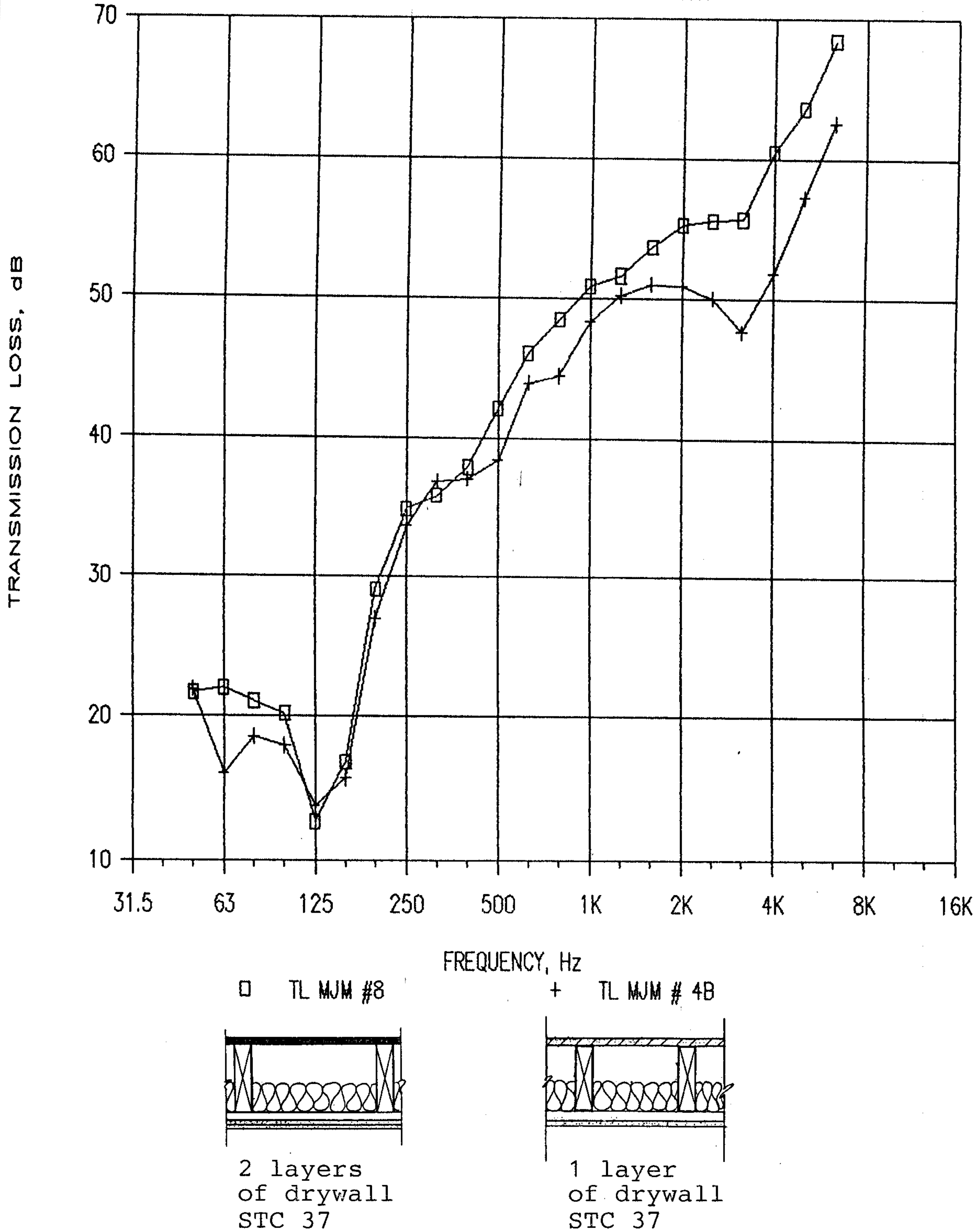
24 in. – 16 in. – PARALL. TO JOISTS



Graph no 4

COMPARISON BETWEEN 2 LAYERS VS 1 LAYER

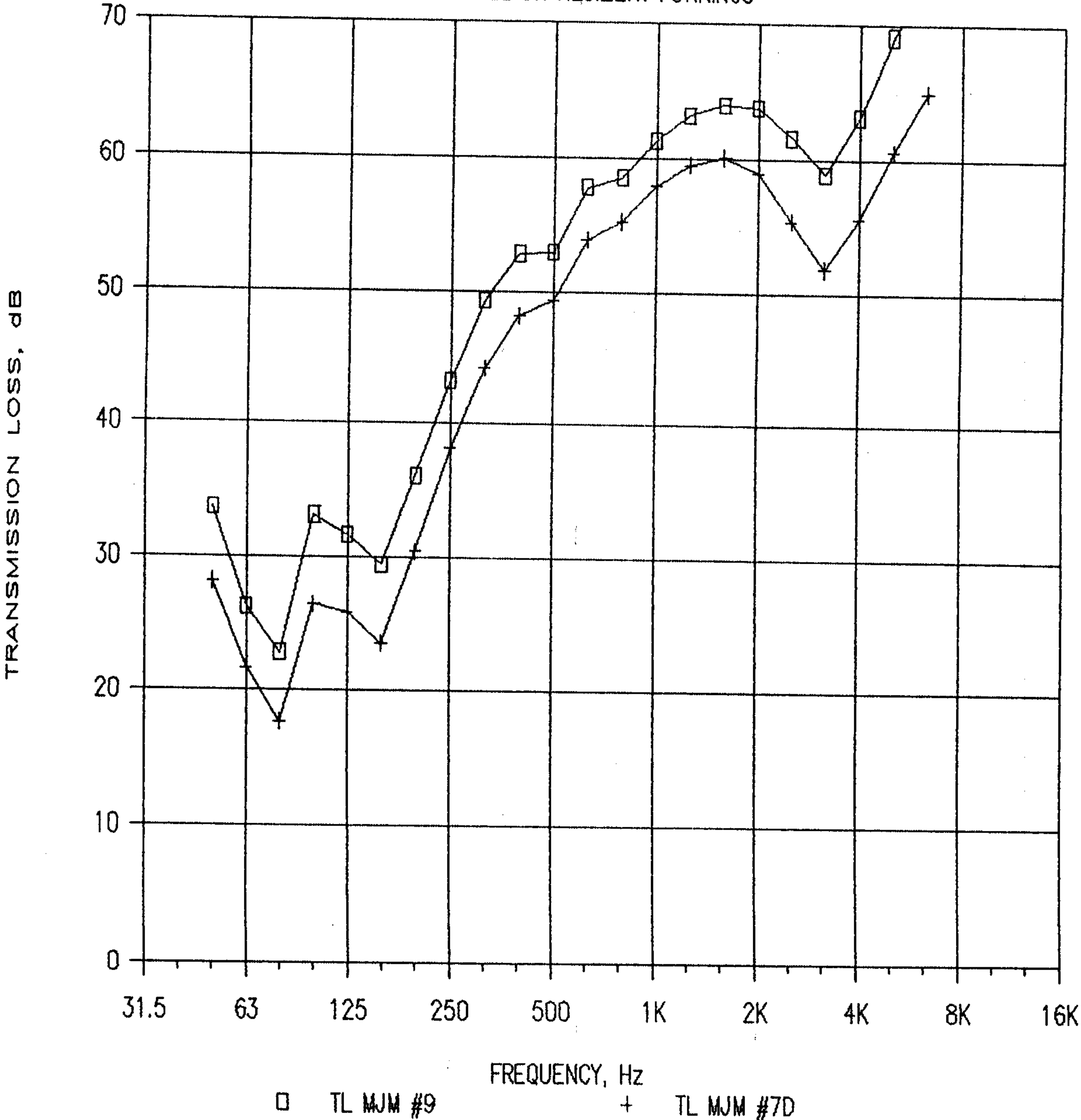
DRYWALL CEILING ON WD FUR. @ 16 in C.C.

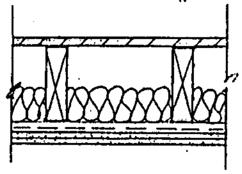


Graph no 5

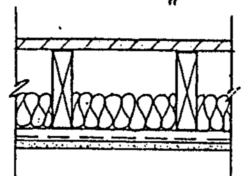
CEILING WITH 2 LAYERS VS 1 LAYER

OF DRYWALL ON RESILIENT FURRINGS





2 layers
of drywall
STC 50

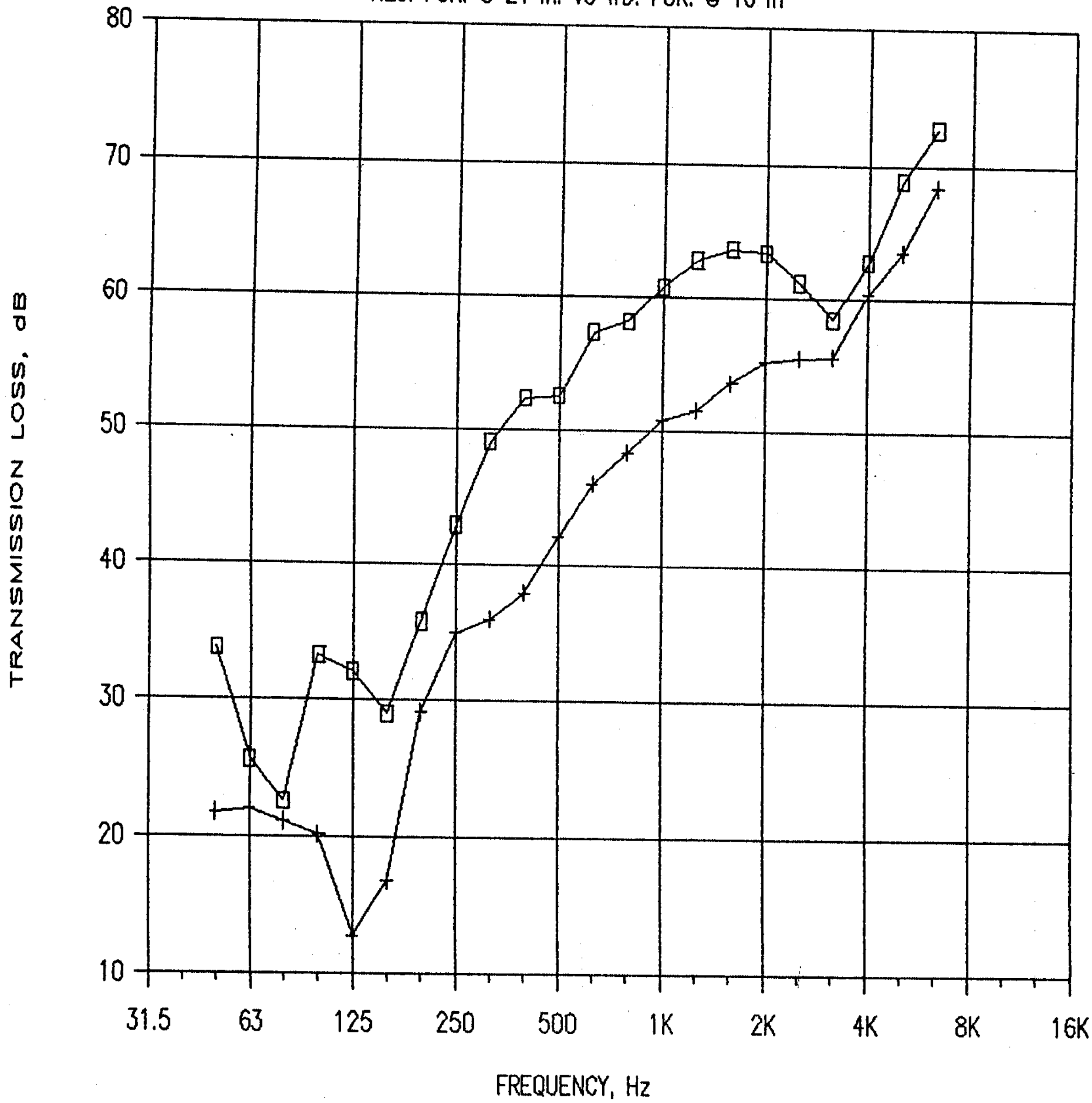


1 layer
of drywall
STC 45

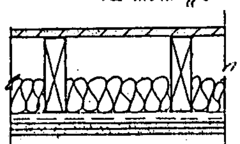
Graph no 6

2 LAYERS OF DRYWALL ON CEILING

RES. FUR. @ 24 in. VS WD. FUR. @ 16 in

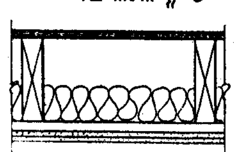


□ TL MJM #9



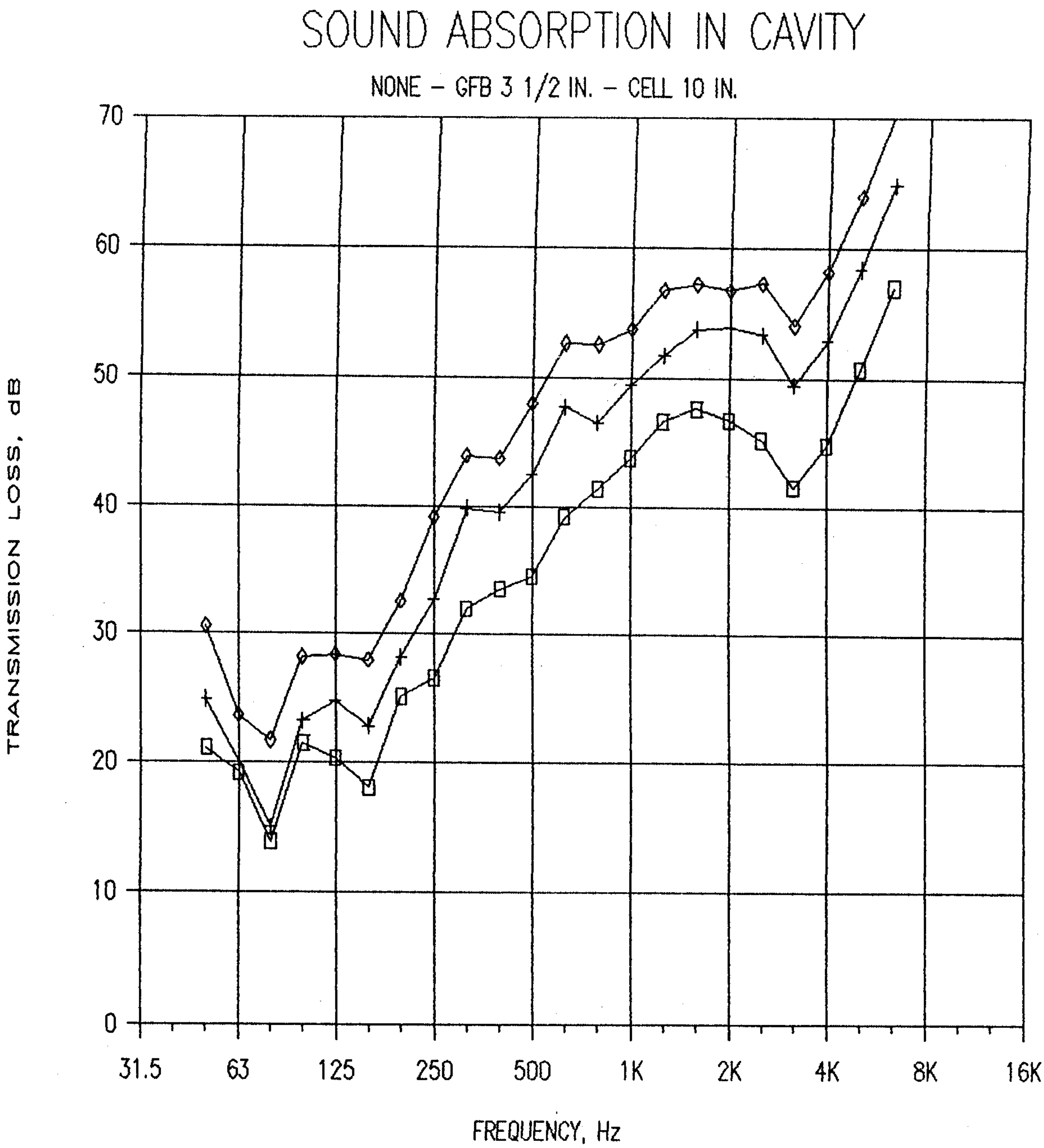
2 layers
of drywall
on resilient
furrings
24 in. c.c.
STC 50

+ TL MJM # 8

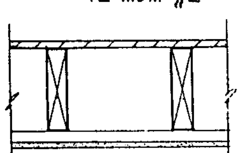


2 layers
of drywall
on wood
furrings
16 in. c.c.
STC 37

Graph no 7

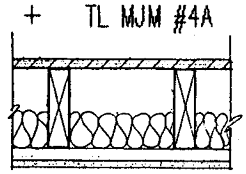


□ TL MJM #2



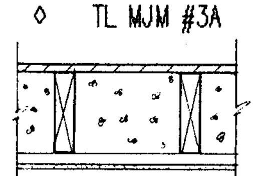
No absorption
in cavity;
wood furrings
24 in.c.c.
STC 38

+ TL MJM #4A



Pink glass fiber
batt insulation;
3 1/2" thick
Placed between
joists; wood
furrings 24 in.c.c.
STC 44

◊ TL MJM #3A

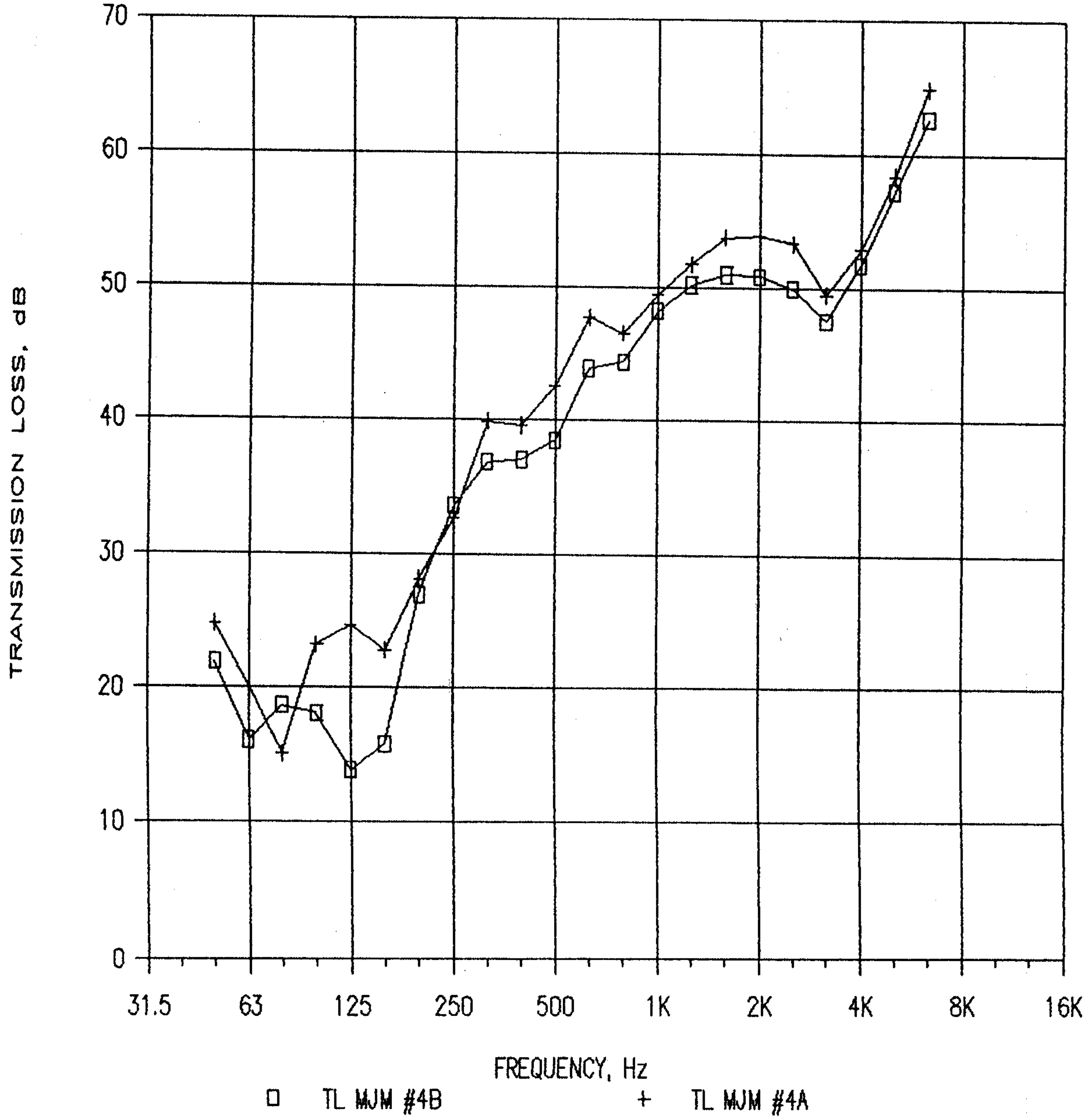


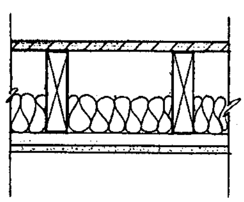
Cavity between
joists filled with
cellulose attic
insulation; wood
furrings 24 in.c.c.
STC 49

Graph no 8

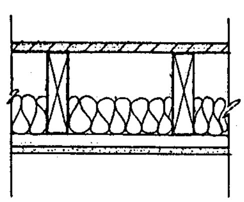
EFFECT OF SPACING – WOOD FURRINGS

16 PO. C.C VS 24 PO C.C.





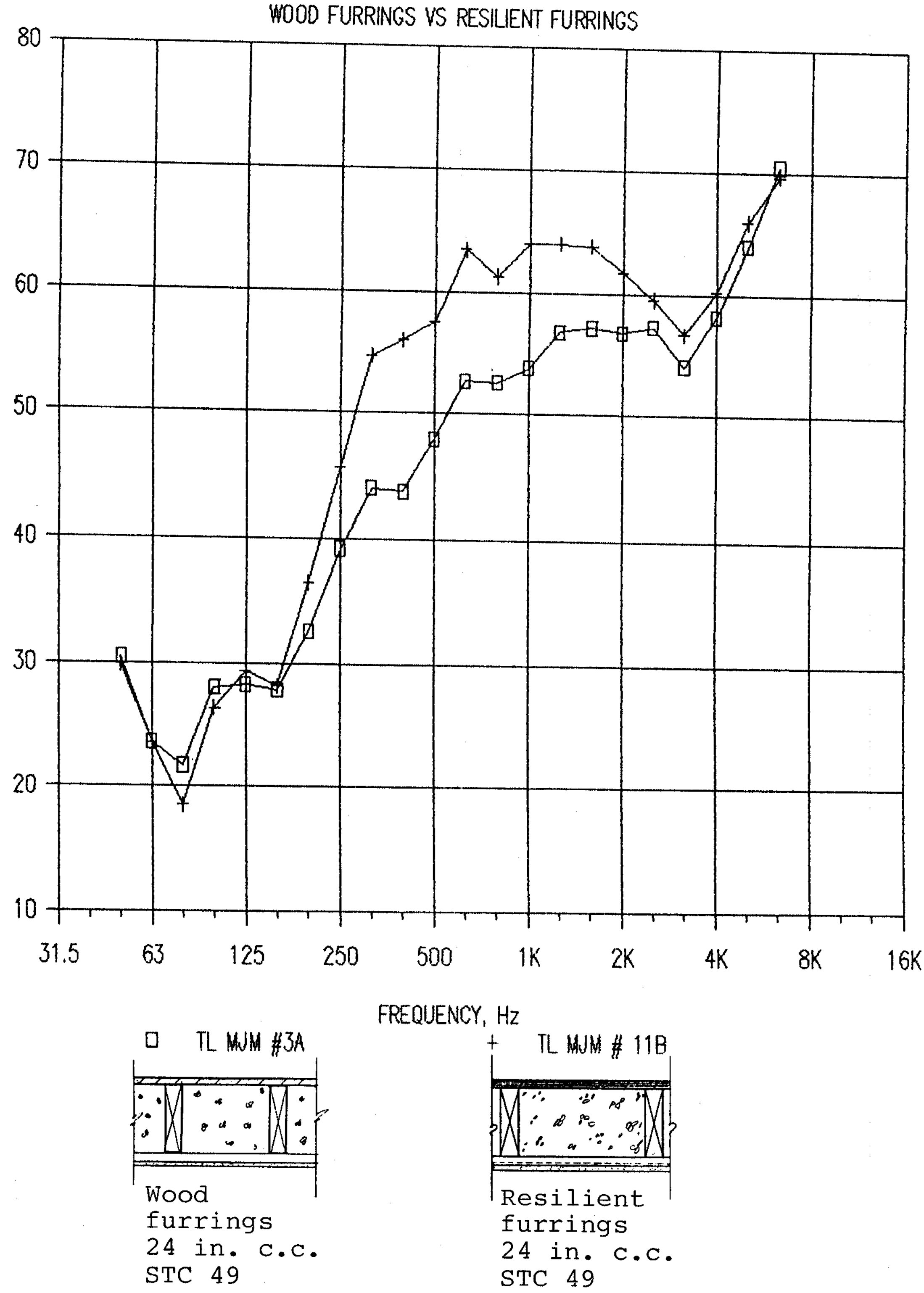
Wood furrings
16 in.c.c.
STC 37



Wood furrings
24 in.c.c.
STC 44

<u>Graph no 9</u>

CAVITY FILLED WITH BLOWN–IN INSULATION

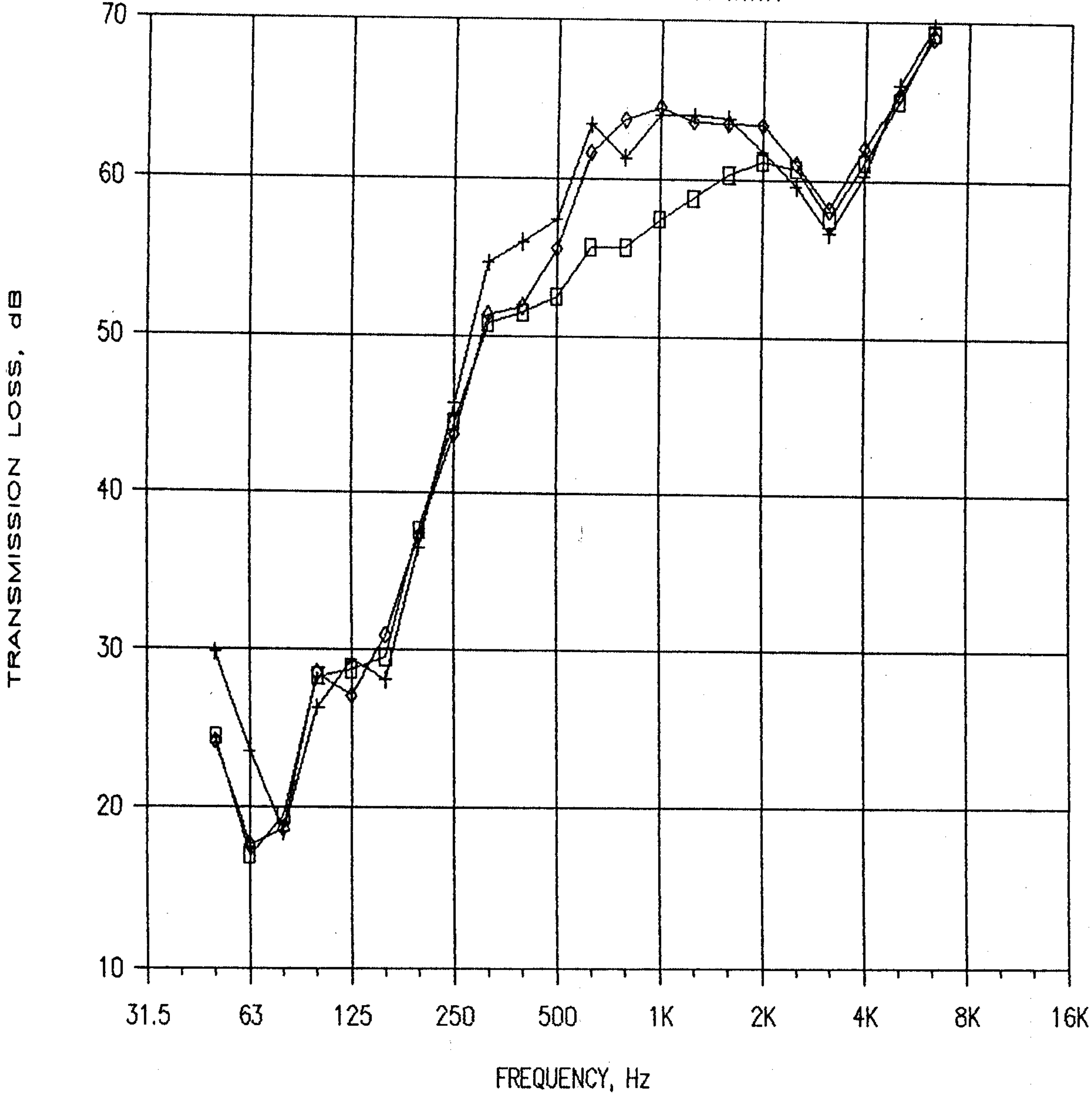


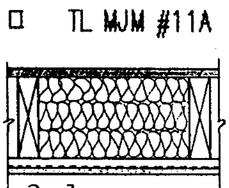
Graph no 10

mjm

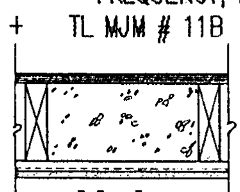
COMPARISON BETWEEN DIFFERENT TYPES OF

SOUND ABSORPTIBVE MATERIALS IN CAVITY

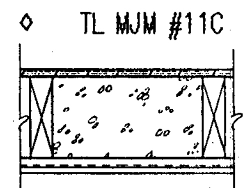




3 layers of 3 1/2" glass fiber batt insulation STC 51



cellulose blown in Attic insulation STC 49

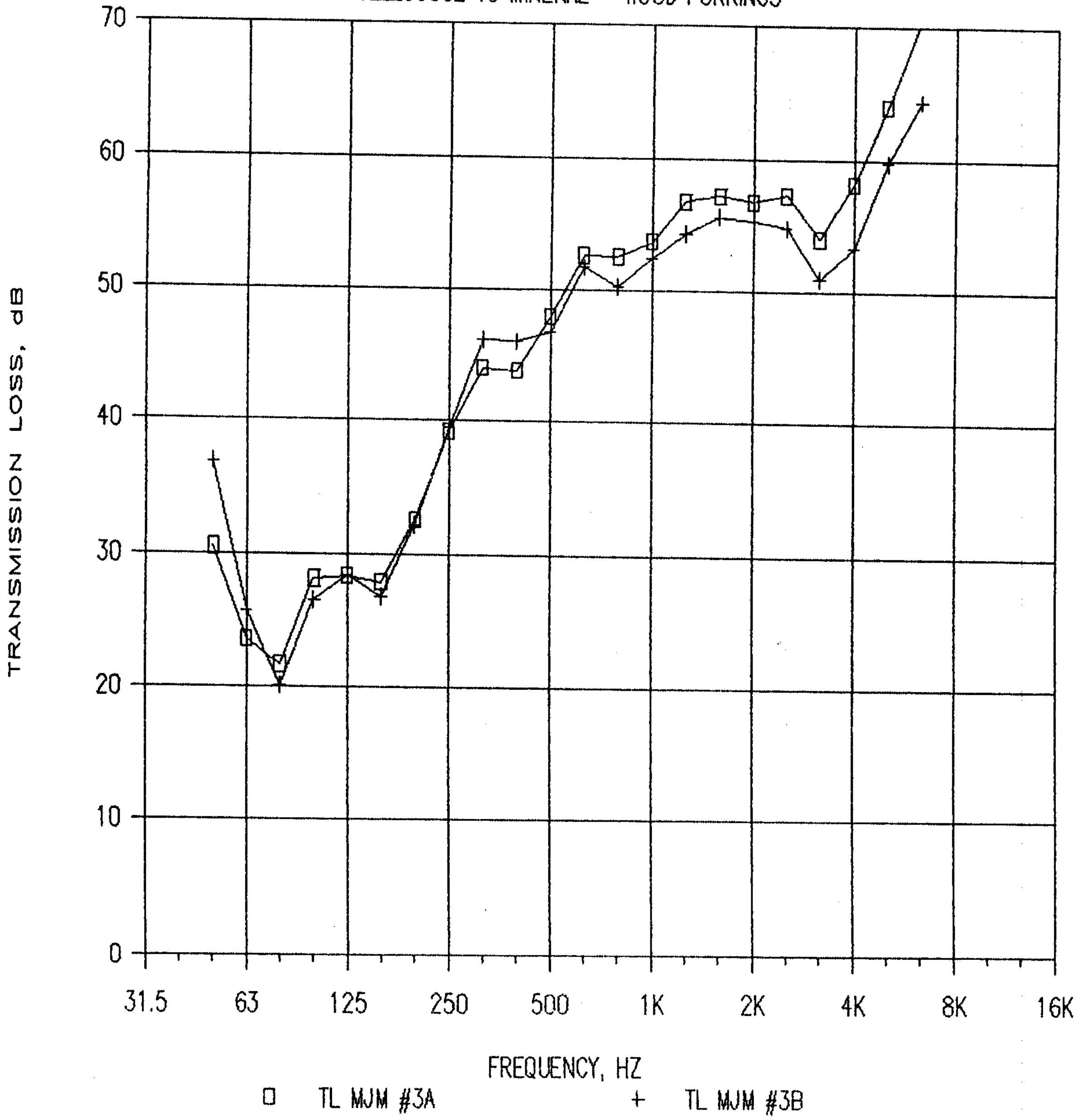


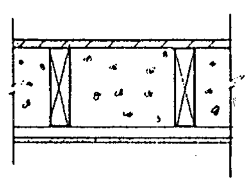
Benocoustic blown in insulation STC 51

Graph no 11

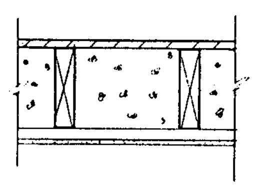
CAVITY FILLED WITH BLOWN IN MATERIAL

CELLUSOSE VS MINERAL – WOOD FURRINGS





Cellulose blown in
Attic insulation ;
Wood furrings
24 in.c.c.
STC 49

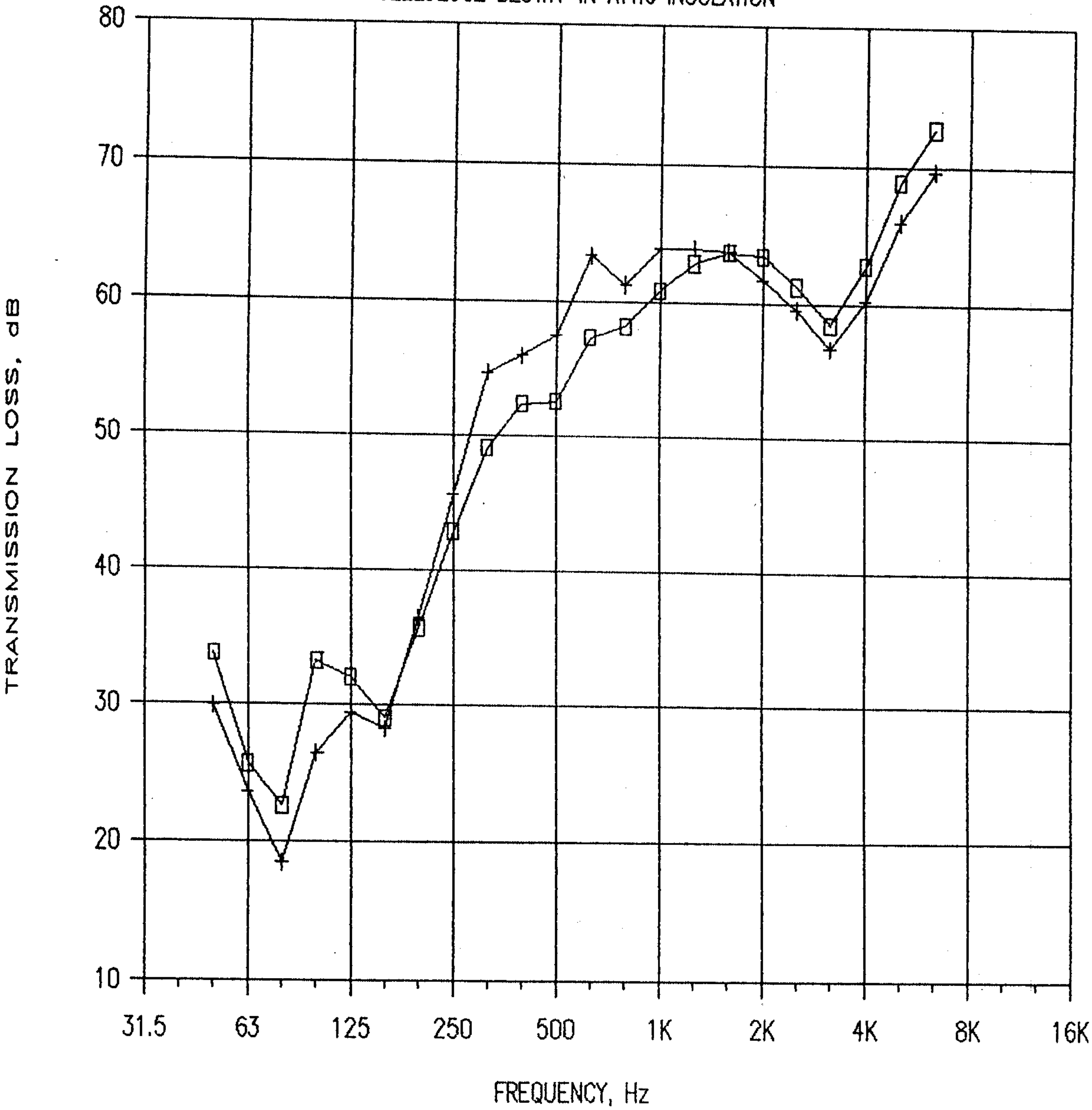


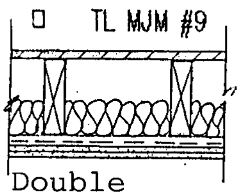
Mineral blown in
Attic insulation ;
Wood furrings
24 in. c.c.
STC 48

Graph no 12

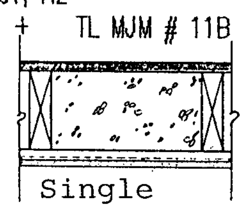
DOUBLE DRYWALL CEILING VS CAVITY FILLED

CELLULOSE BLOWN-IN ATTIC INSULATION





Double drywall ceiling on resilient furr.; 3 1/2" glass fiber insulation in cavity STC 50

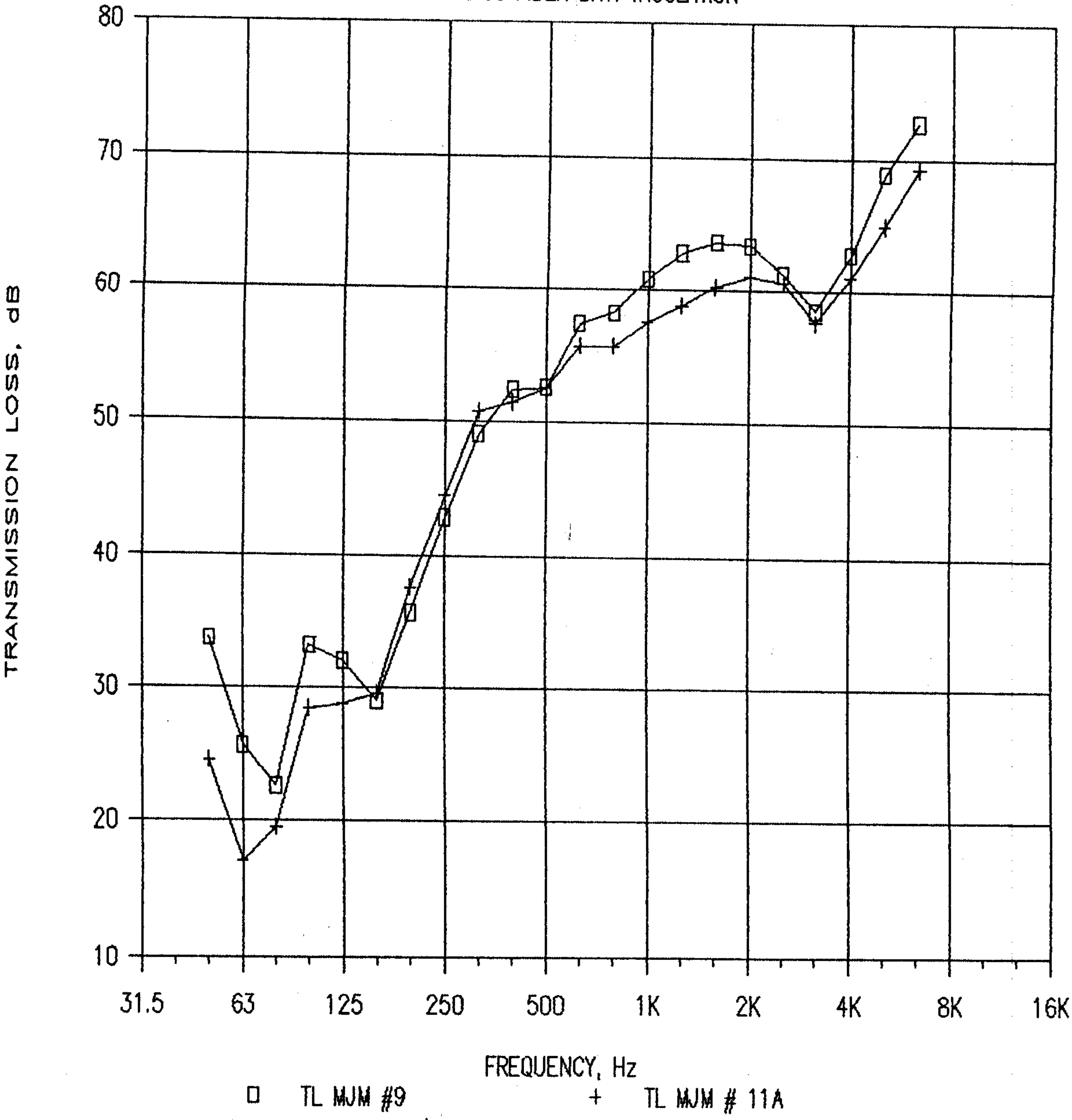


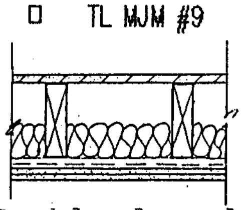
Single drywall ceiling on resilient furr.; cavity filled with cellulose blown-in Attic insulation; STC 51

Graph no 13

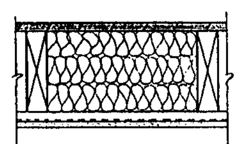
DOUBLE DRYWALL CEILING VS CAVITY FILLED

WITH GLASS FIBER BATT INSULATION



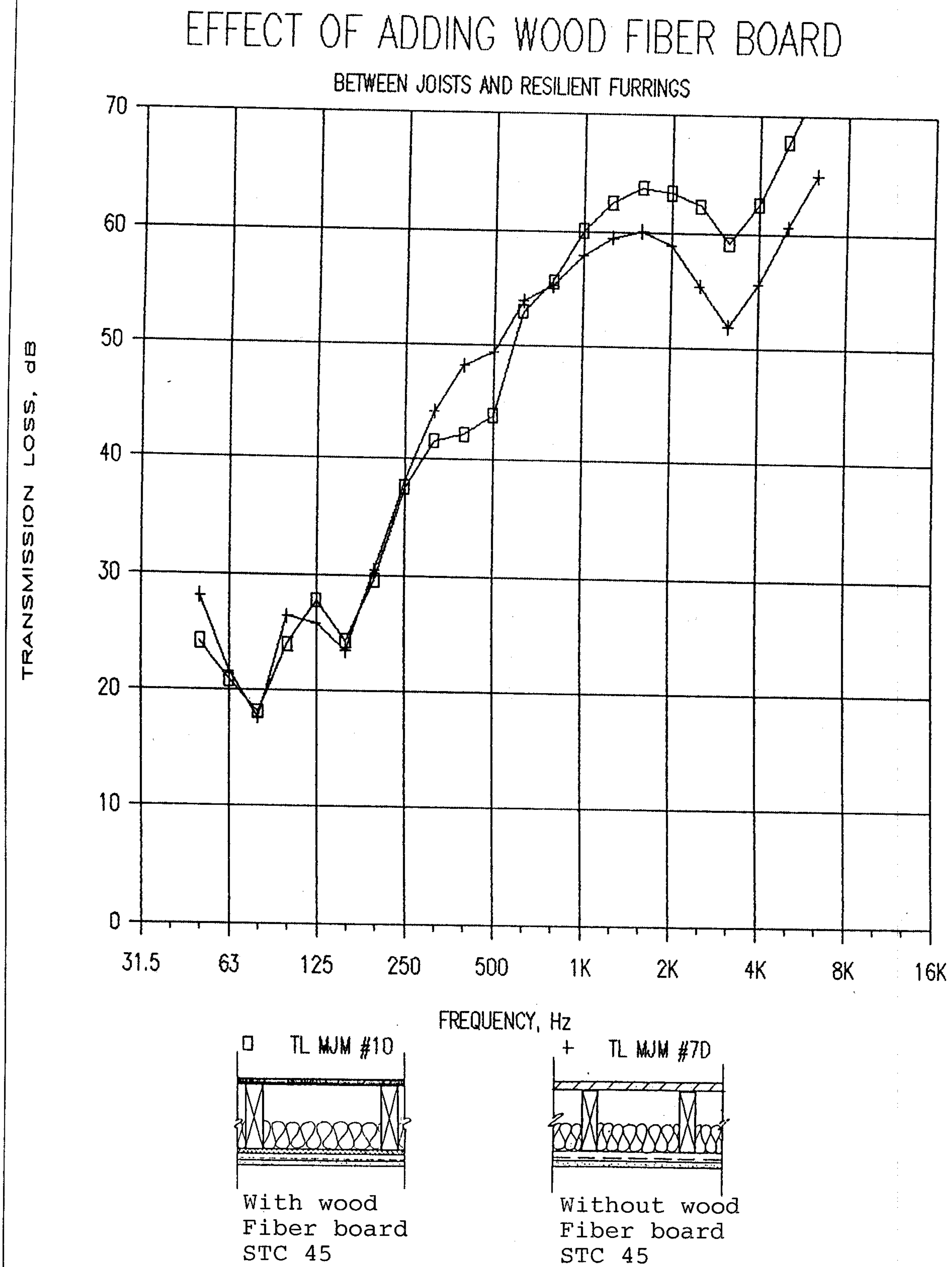


Double drywall ceiling on resilient furrings; 3 1/2" glass fiber batt insulation in cavity
STC 50



Single drywall ceiling on resilient furrings; cavity filled with 3 layers of 3 1/2" in glass fiber batt insul.
STC 51

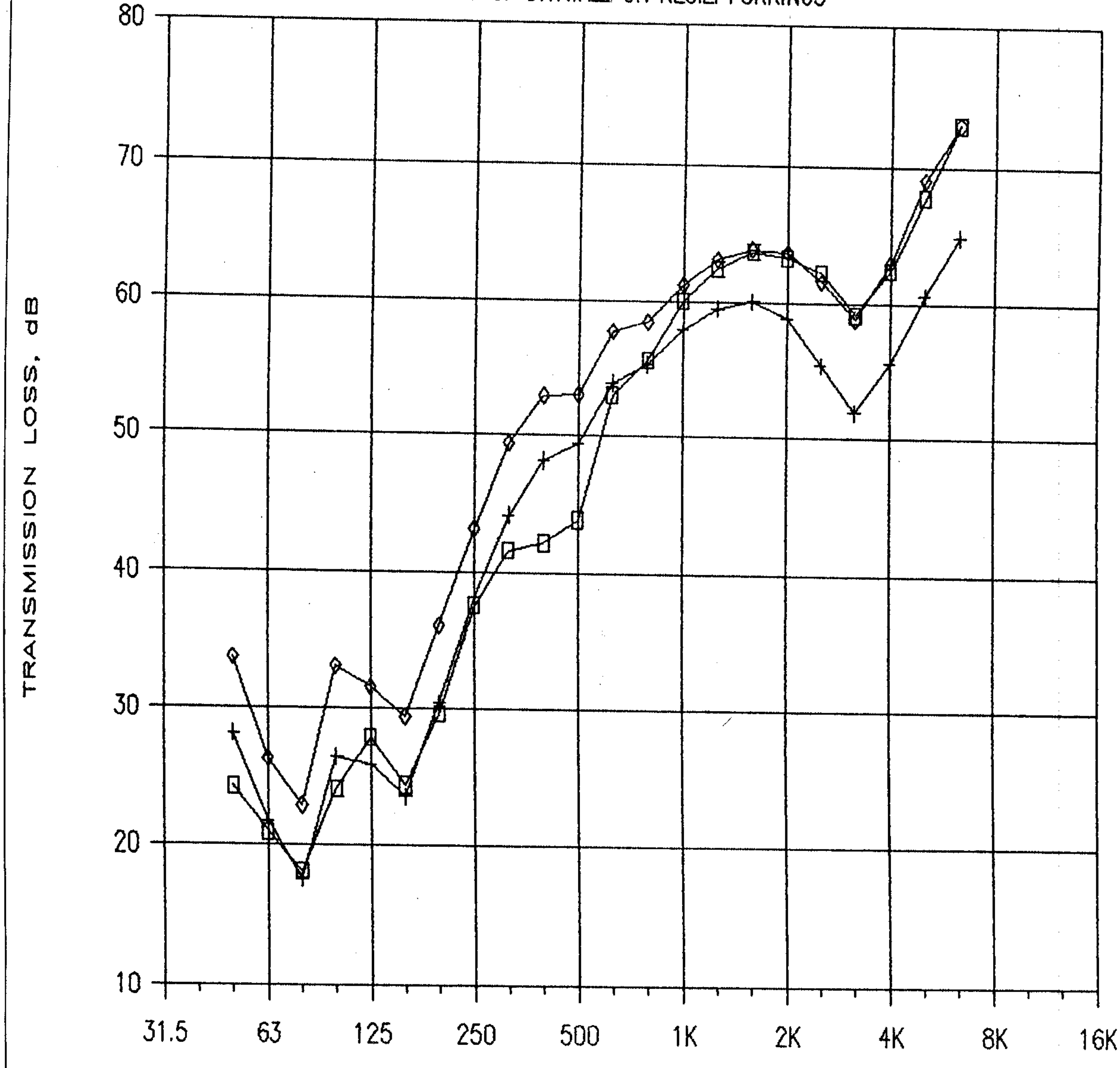
Graph no 14


EFFECT OF ADDING WOOD FIBER BOARD
BETWEEN JOISTS AND RESILIENT FURRINGS
TRANSMISSION LOSS, dB
70
60
50
40
30
20
10
0
31.5
63
125
250
500
1K
2K
4K
8K
16K
FREQUENCY, Hz
TL MJM #10
TL MJM #7D
With wood
Fiber board
STC 45
Without wood
Fiber board
STC 45

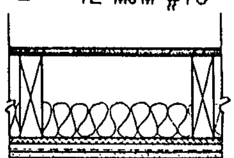
Graph no 15

COMPARISON BETWEEN 3 TYPES OF CEILINGS

COMPOSED OF DRYWALL ON RESIL. FURRINGS

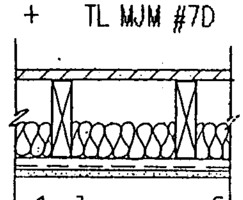


□ TL MJM #10



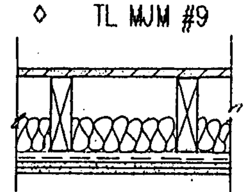
Fiber board between the joists and the resilient furrings; 1 layer of drywall attached to furr.
STC 45

+ TL MJM #7D



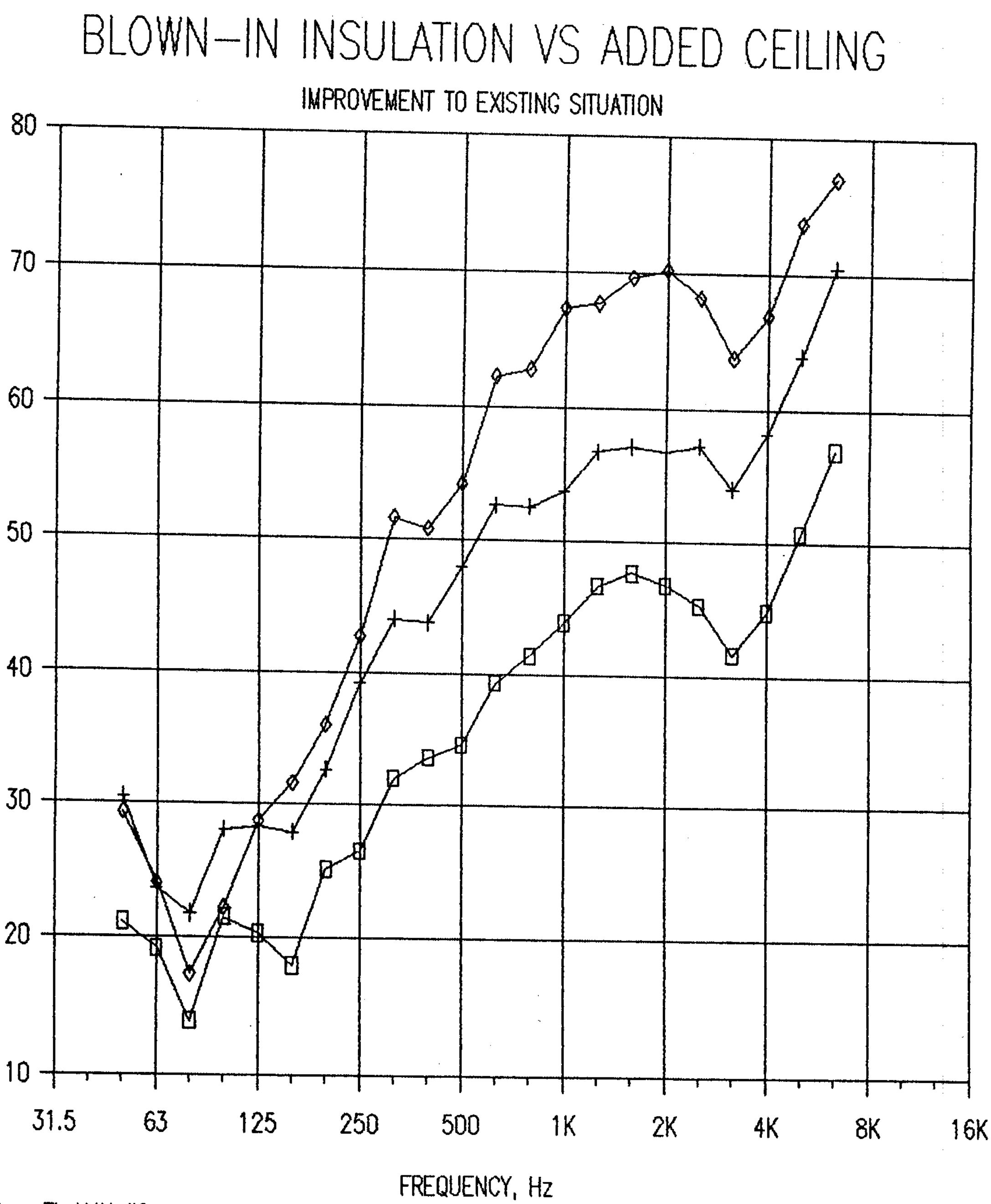
1 layer of drywall screwed to resilient furrings screwed to joists
STC 45

◇ TL MJM #9

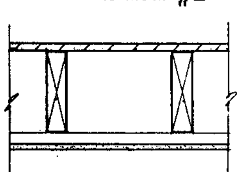


2 layers of drywall screwed to resilient furrings screwed to joists
STC 50

Graph no 16

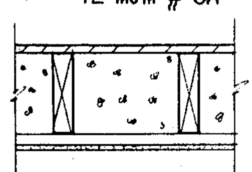


□ TL MJM #2



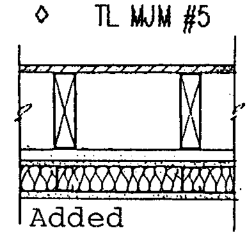
Basic floor assembly STC 38

+ TL MJM # 3A



Basic floor assembly with cavity filled with cellulose blown in attic insulation; STC 49

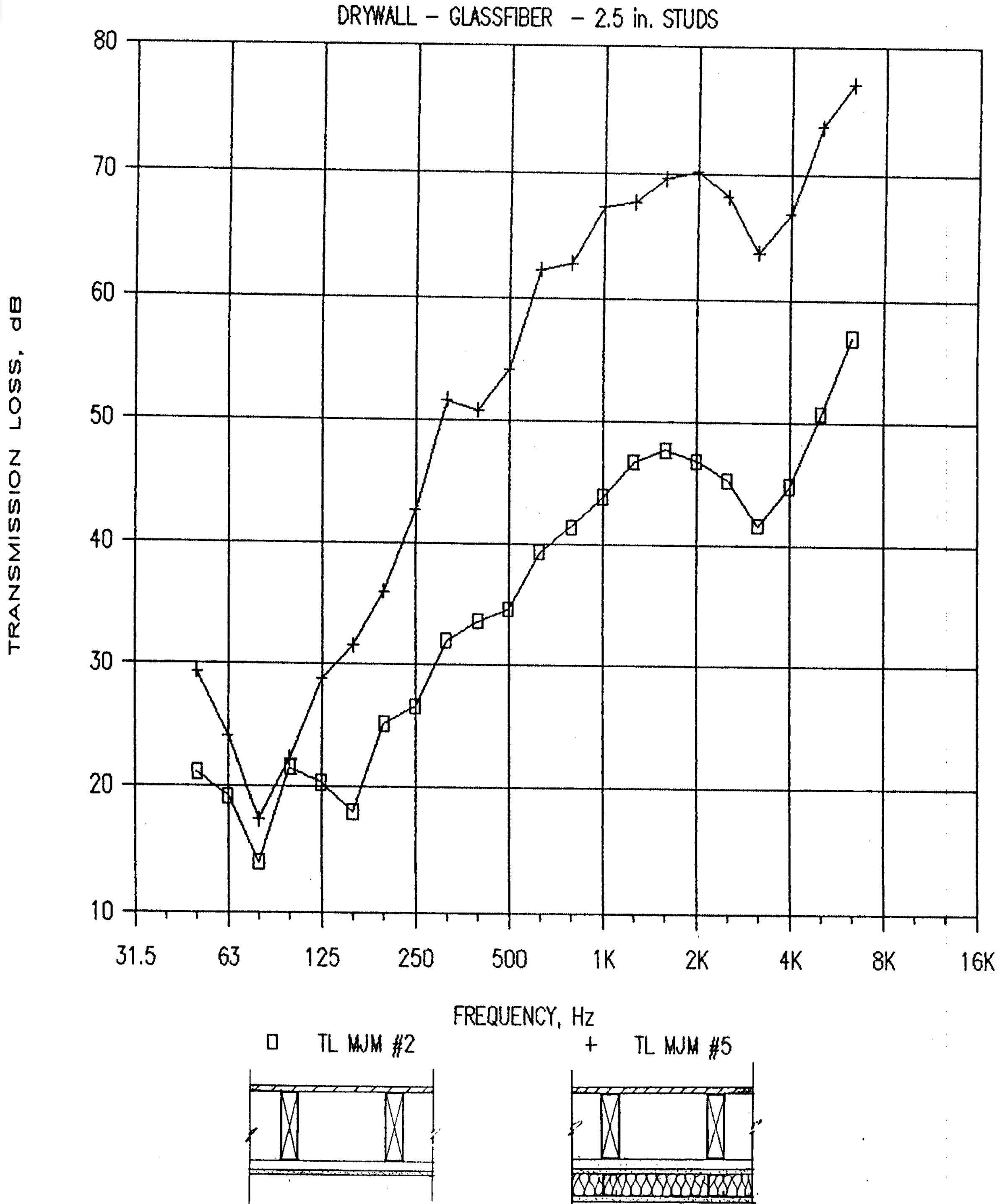
◊ TL MJM #5



Added ceiling on 2.5 in. metal studs with batt insulation between studs; STC 53

<u>Graph no 17</u>

CORRECTIVE MEASURE ON EXISTING FLOOR



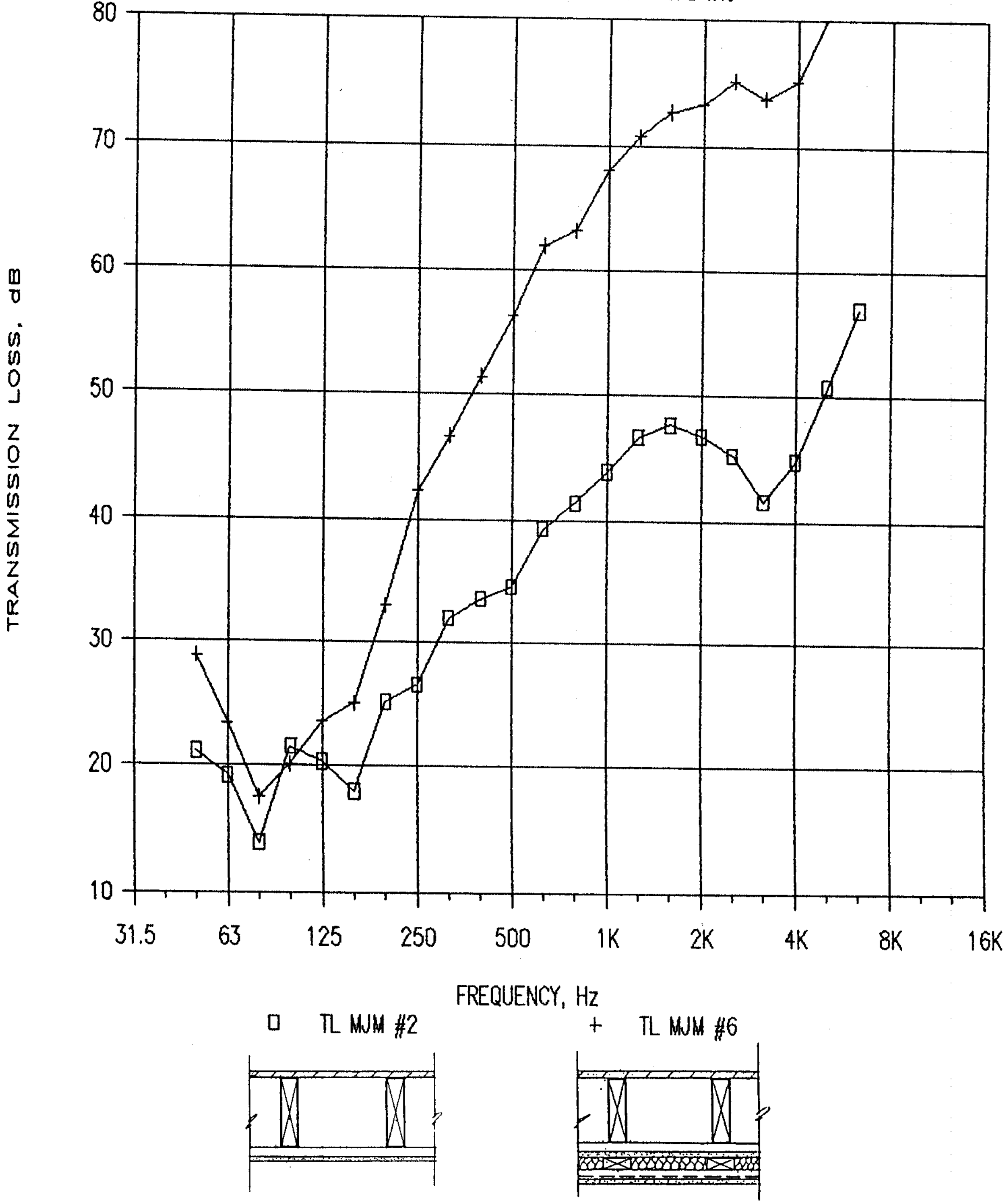
Before Corrective Measures STC 38

After Corrective Measures STC 53

Graph no 18

CORRECTIVE MEASURE ON EXISTING FLOOR

DRYWALL – 2" x 3" – RES. FUR. – GFB INS



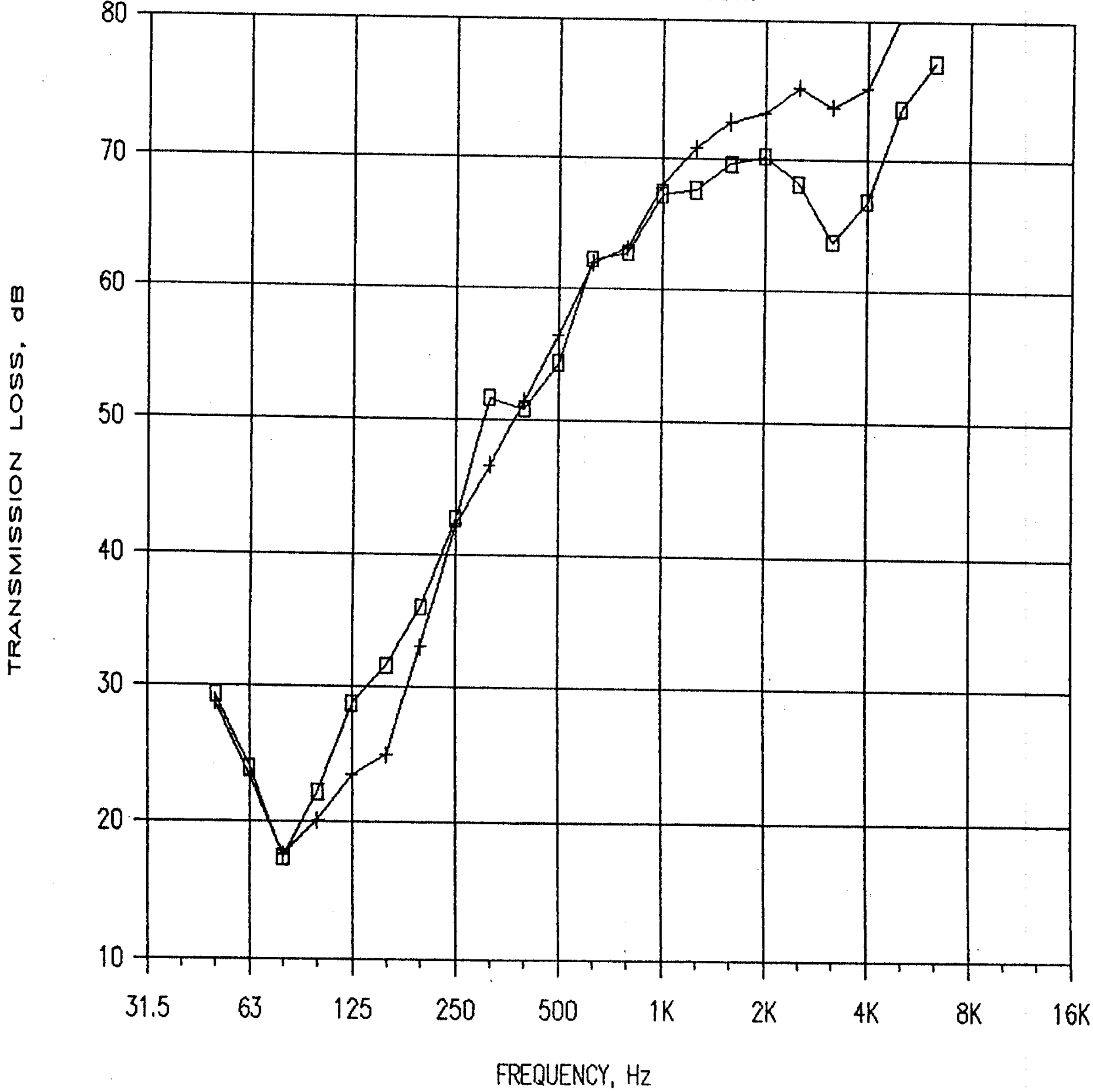
Before
Corrective
Measures
STC 38

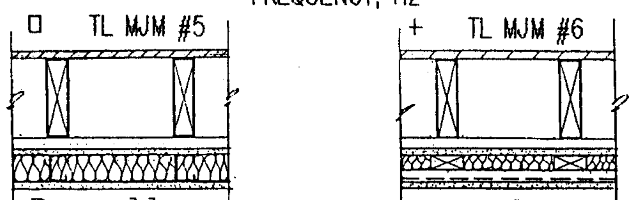
After
Corrective
Measures
STC 46

Graph no 19

CORRECTIVE MEASURE ON EXISTING FLOOR

COMPARISON BETWEEN ADDED CEILING





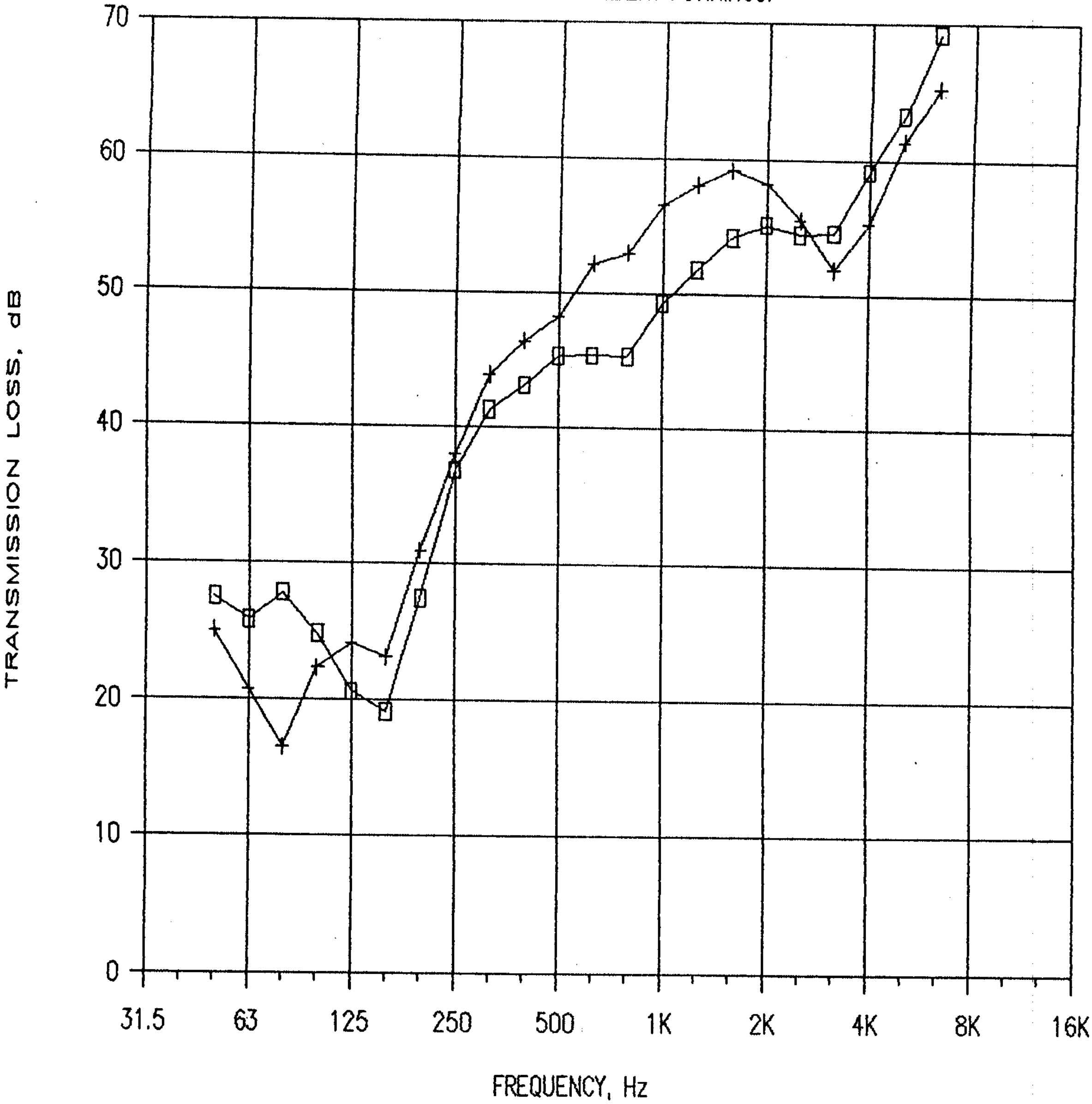
Drywall;
2.5 in.
Metal studs;
2.5 in.
batt insulation
between the studs.
STC 53

Drywall;
resilient
furrings;
2" X 3"
wood studs;
STC 46

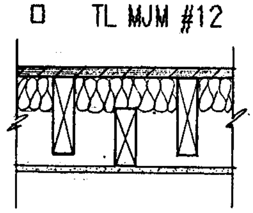
Graph no 20

INDEPENDANTLY JOISTED DRYWALL CEILING

VS DRYWALL ON RESILIENT FURRINGS.

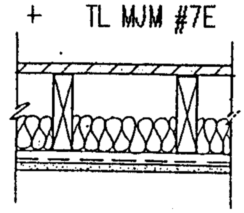


□ TL MJM #12



Independently
joisted ceiling
STC 40

\+ TL MJM #7E

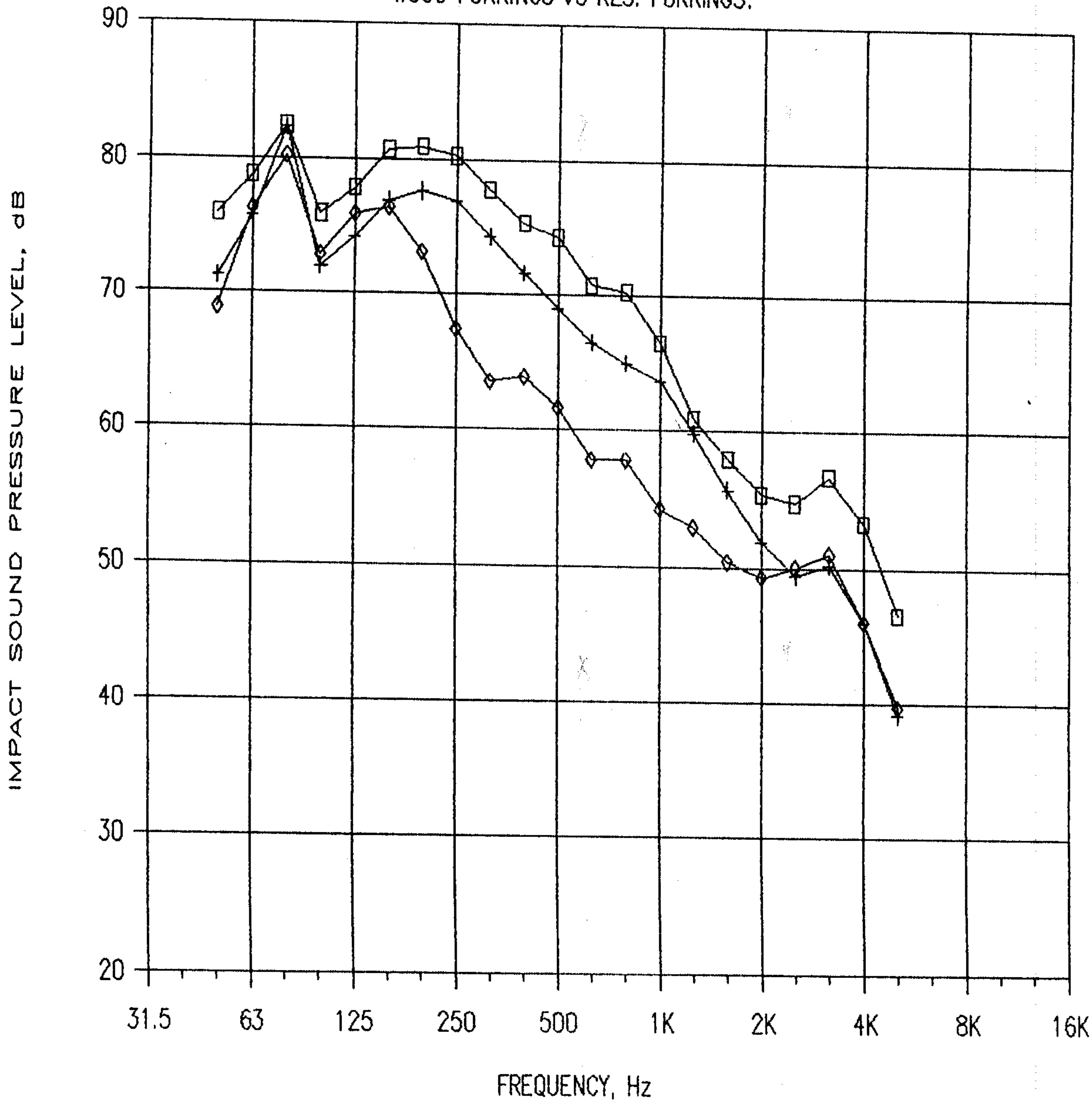


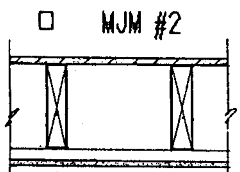
Drywall ceiling
on resilient
furrings
STC 45

Graph no 21

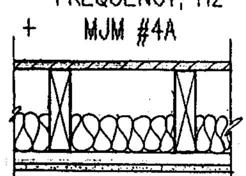
IMPACT INSULATION – GFB. BATT IN CAVITY

WOOD FURRINGS VS RES. FURRINGS.

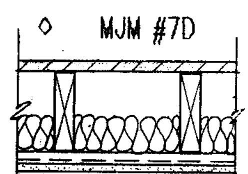




Basic floor assembly
IIC 37



Glass fiber batt insulation; drywall on furrings 24 in. c.c.
IIC 41

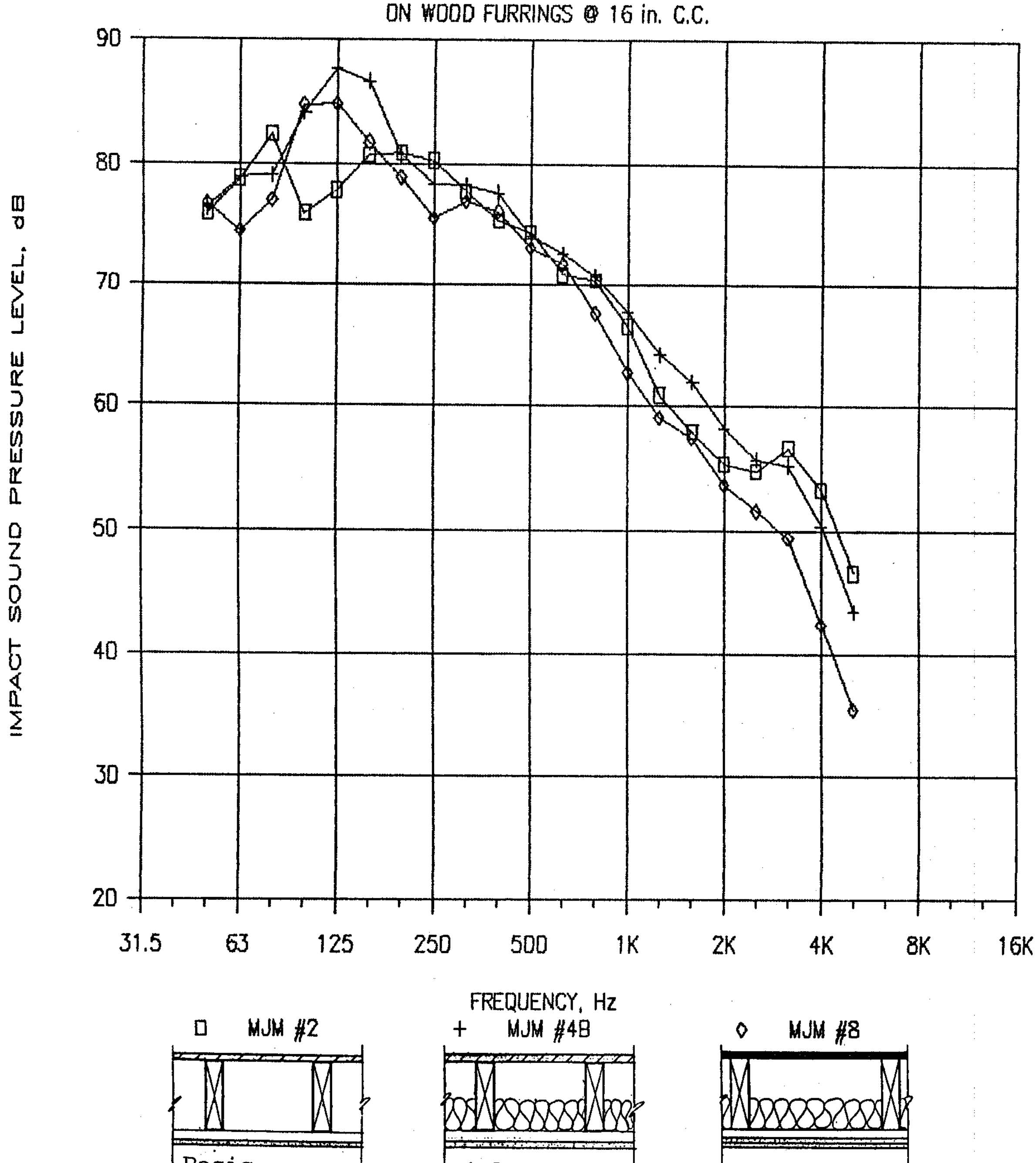


Glass fiber batt insulation; drywall on resilient furrings 24 in. c.c.
IIC 44

Graph no 22

IMPACT INSULATION – DOUBLE DRYWALL

ON WOOD FURRINGS @ 16 in. C.C.



Basic floor assembly IIC 37

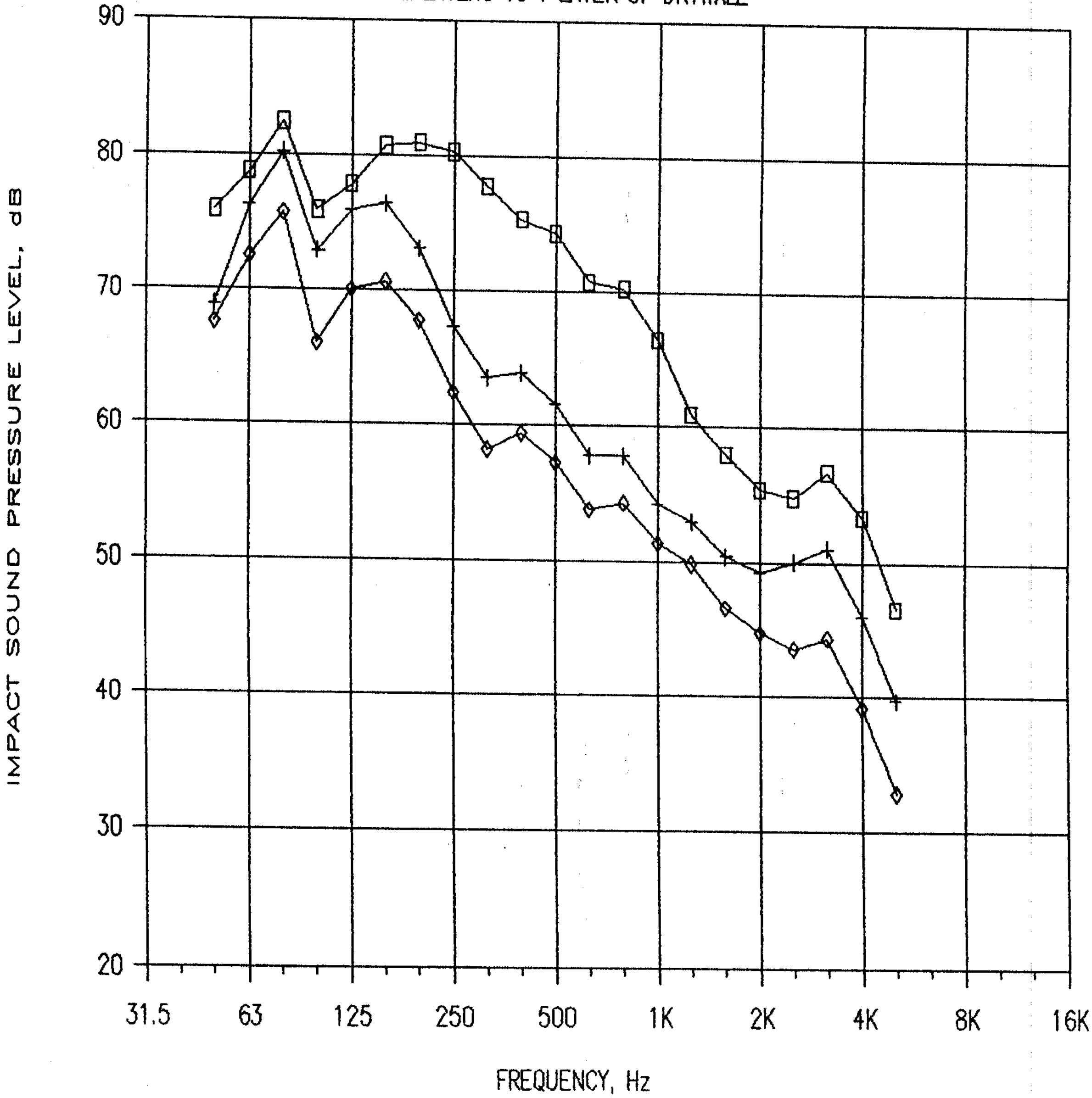
1 layer of drywall batt insulation IIC 32

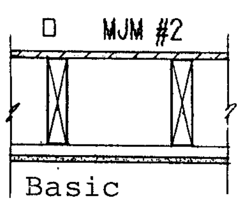
2 layers of drywall batt insulation IIC 35

Graph no 23

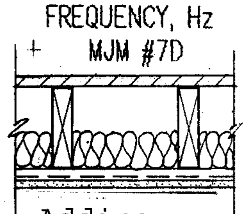
IMPACT INSULATION BY CEILINGS

2 LAYERS VS 1 LAYER OF DRYWALL

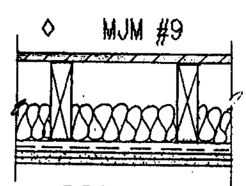




Basic floor assembly with wood furrings 24 in. c.c. IIC 37



Adding glass fiber batt insulation and drywall on resilient furr. 24 in. c.c. IIC 44

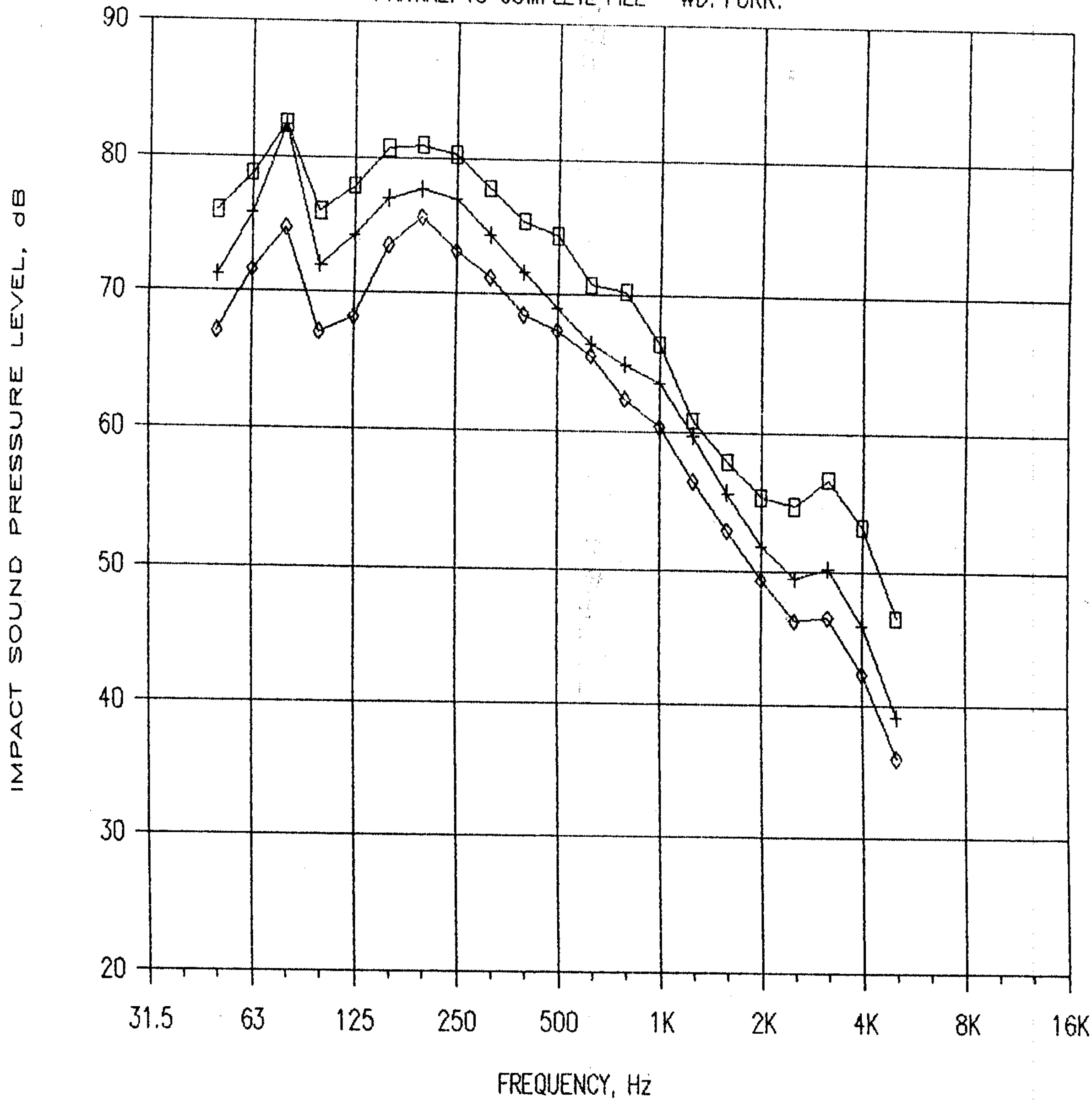


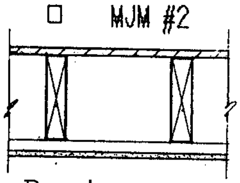
Adding glass fiber batt insulation and 2 layers of drywall on resilient furr. 24 in.c.c. IIc 49

Graph no 24

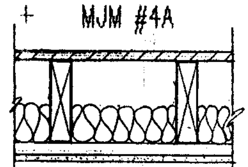
IMPACT INSULATION – SOUND ABSORPTION

PARTIAL. VS COMPLETE FILL – WD. FURR.

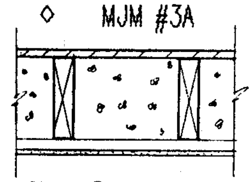




Basic floor assembly
IIC 37



Wood furrings 24 in. c.c.
3 1/2 in. batt insulation in cavity
IIC 41

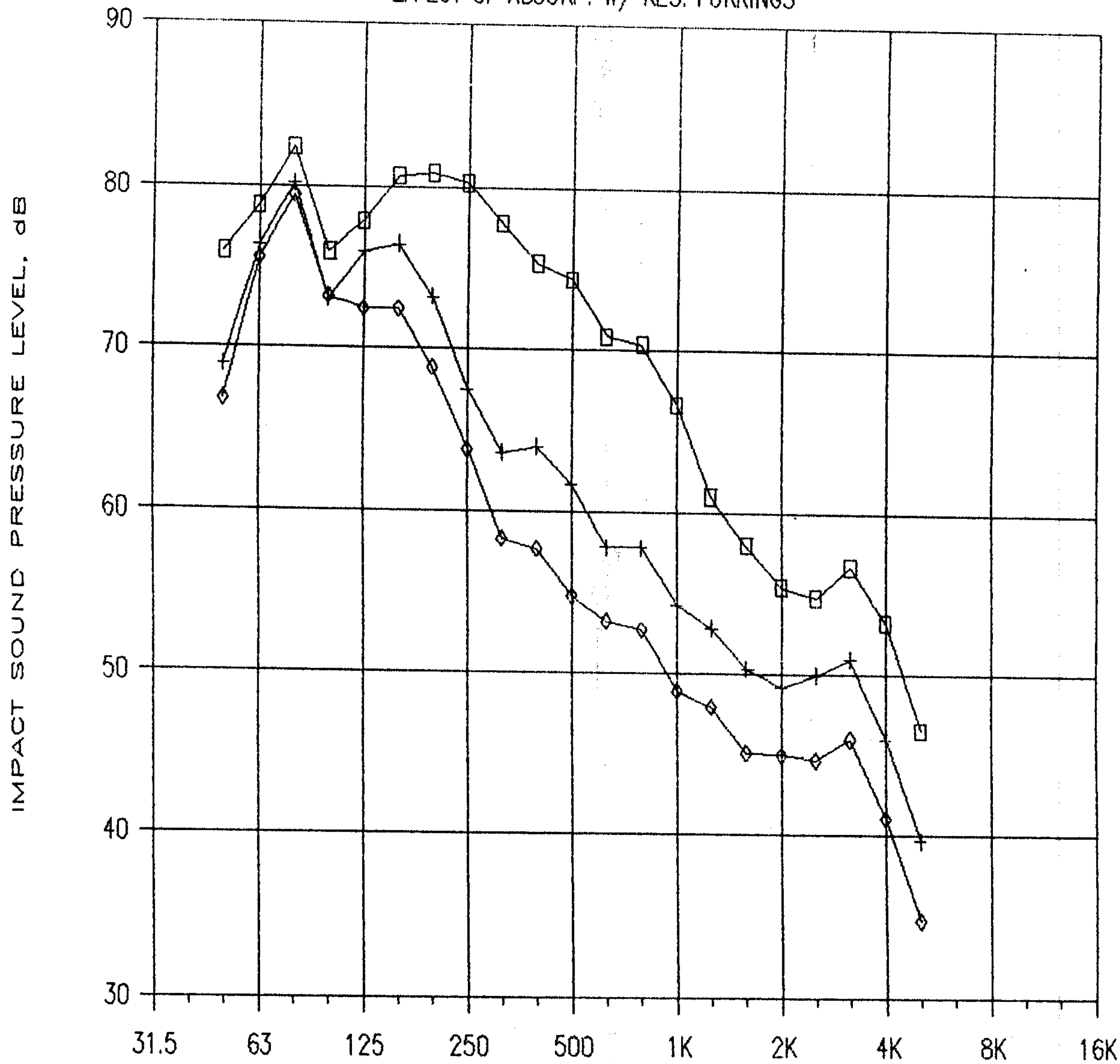


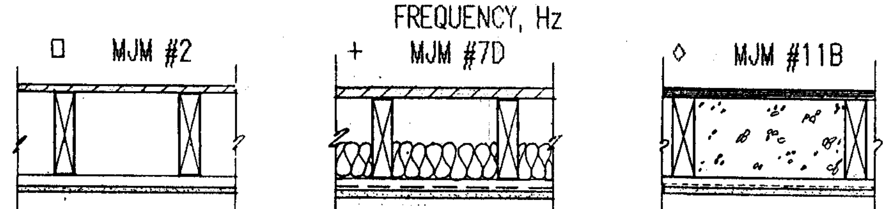
Wood furrings 24 in. c.c.
cavity filled with cellulose
IIC 44

Graph no 25

IMPACT INSULATION – SOUND ABSORPTION

EFFECT OF ABSORP. W/ RES. FURRINGS



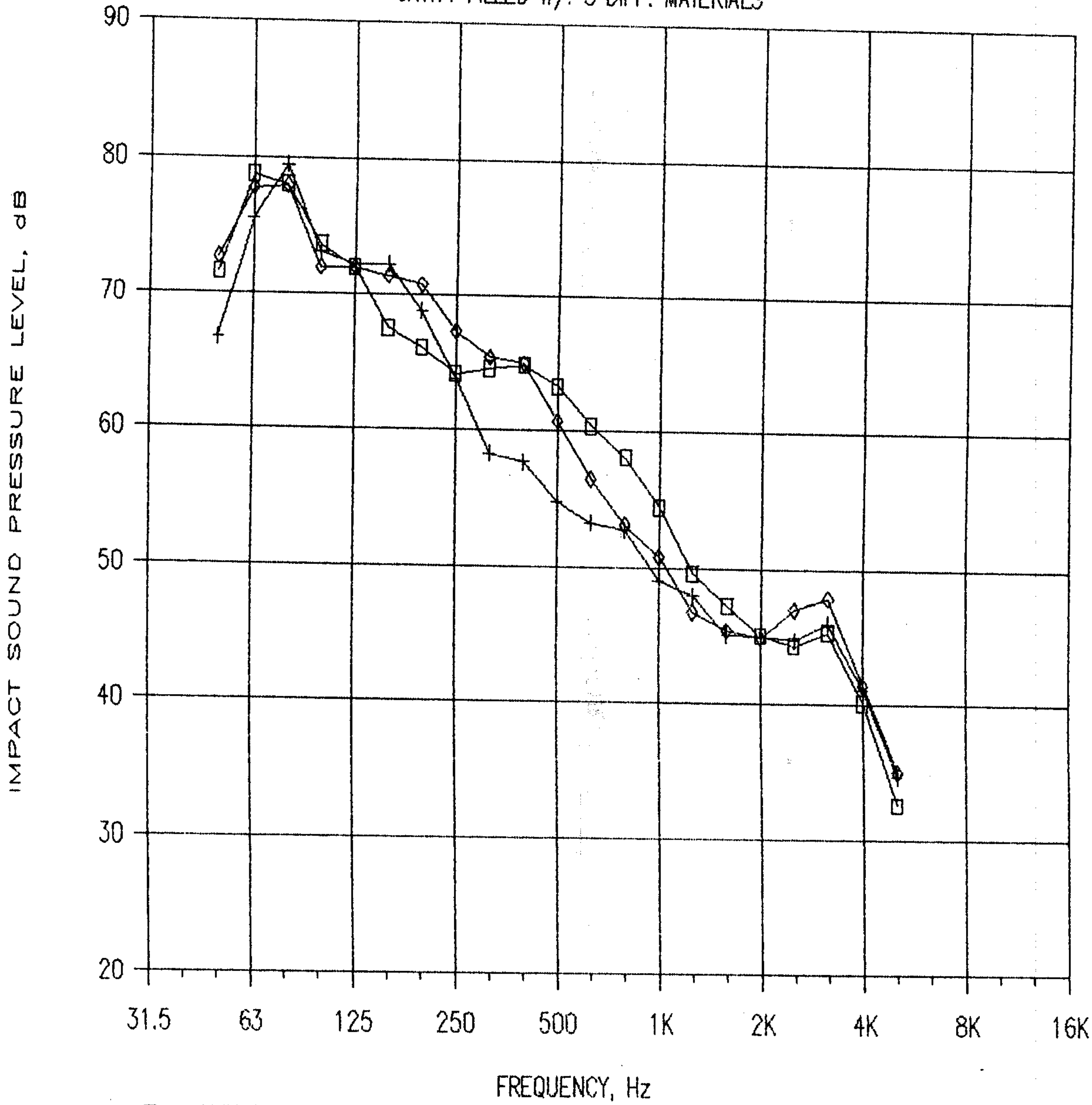


Basic floor assembly IIC 37	3 1/2 batt insulation in cavity IIC 44	cavity filled with cellulose blown in attic insulation IIC 47

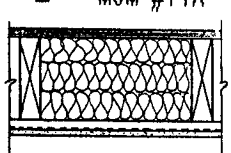
Graph no 26

IMPACT INSULATION -- BLOWN-IN INSULATION

CAVITY FILLED W/. 3 DIFF. MATERIALS

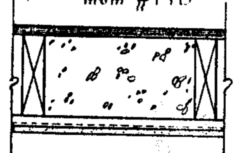


□ MJM #11A



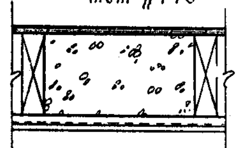
24 in. c.c.
3 layers of
batt insulation
IIC 46

+ MJM #11B



Standard
blown in
cellulose
Attic insu-
lation
IIC 47

◇ MJM #11C

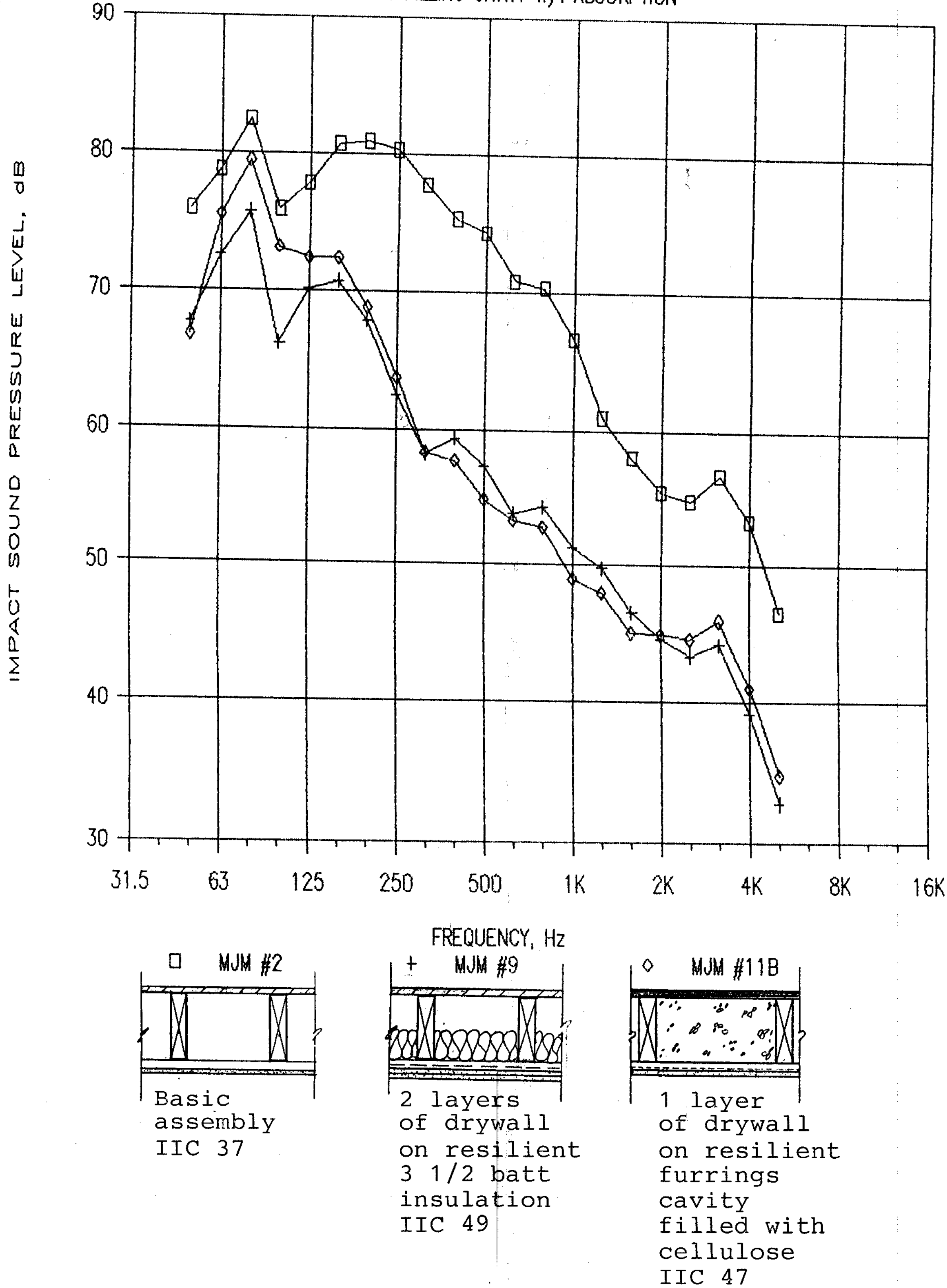


Benocoustics
IIC 47

Graph no 27

IMPACT INSULATION – DOUBLE DRYWALL

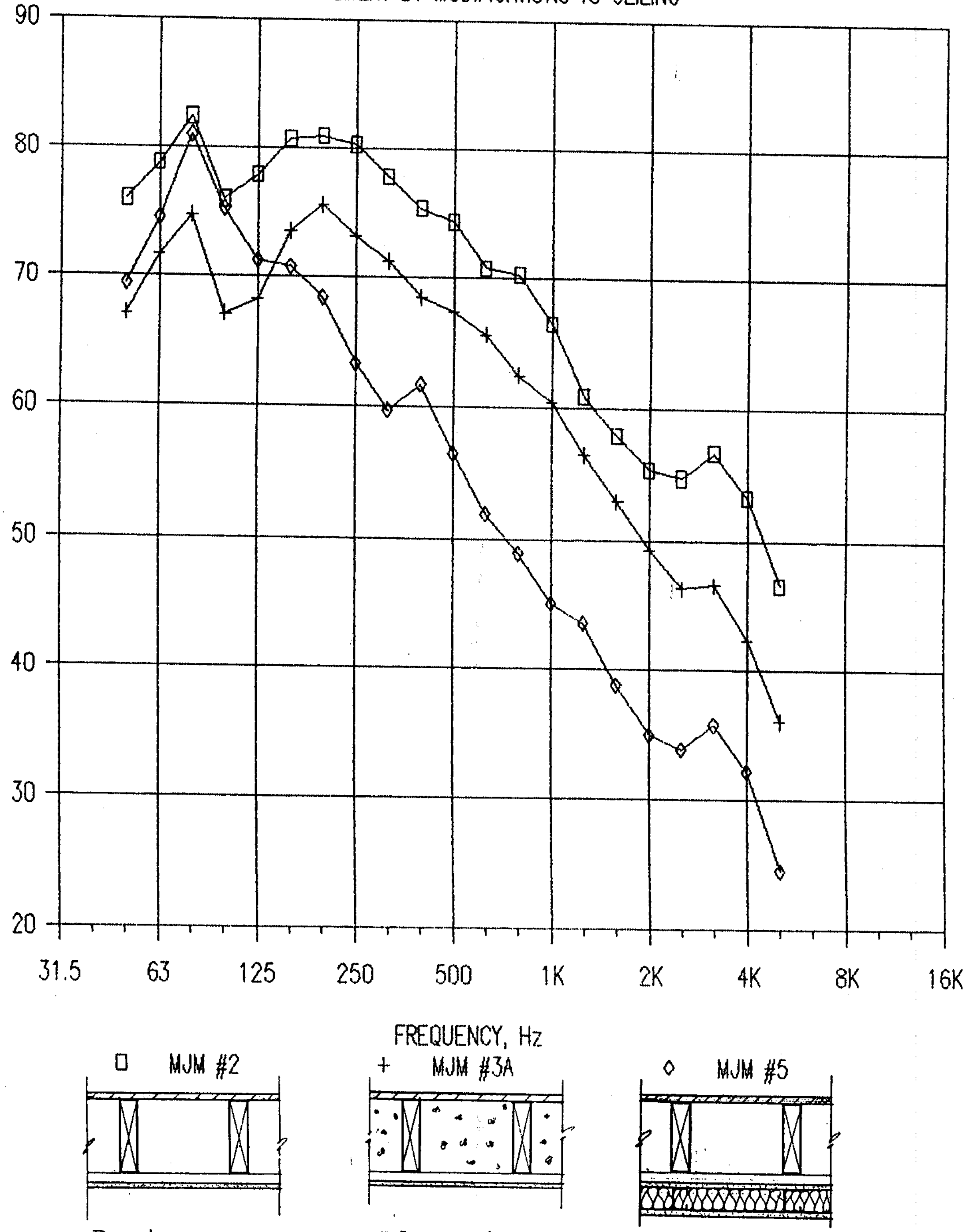
VERSUS FILLING CAVITY W/. ABSORPTION



Graph no 28

IMPACT INSULATION – EXISTING STRUCTURE

IMPROVEMENT BY MODIFICATIONS TO CEILING

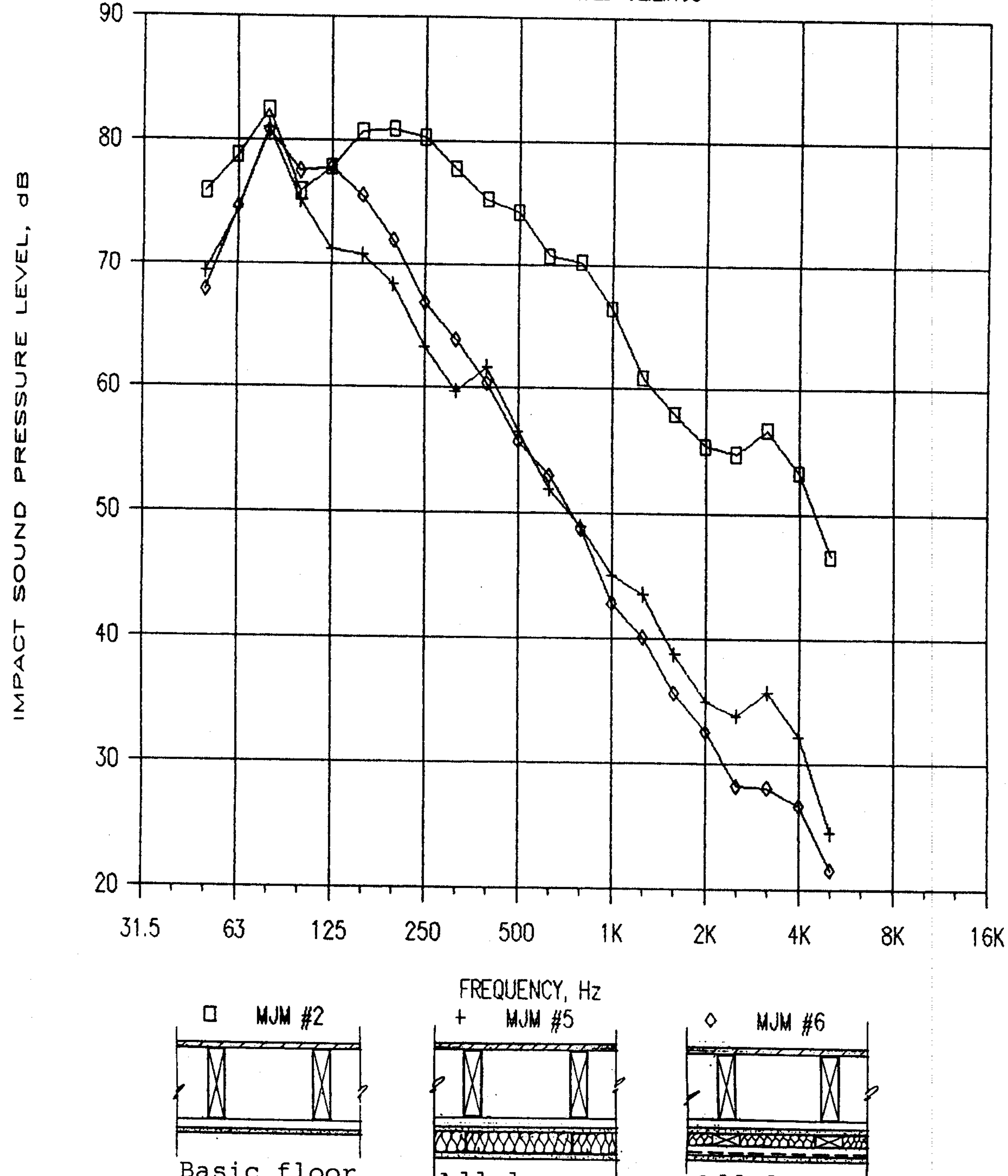


Basic floor assembly IIC 32	Blown in cellulose insulation IIC 44	Added drywall ceiling 2 1/2 steel studs IIC 45

Graph no 29

EXISTING STRUCTURES – IMPACT INSULATION

IMPROVEMENT WITH ADDED CEILINGS

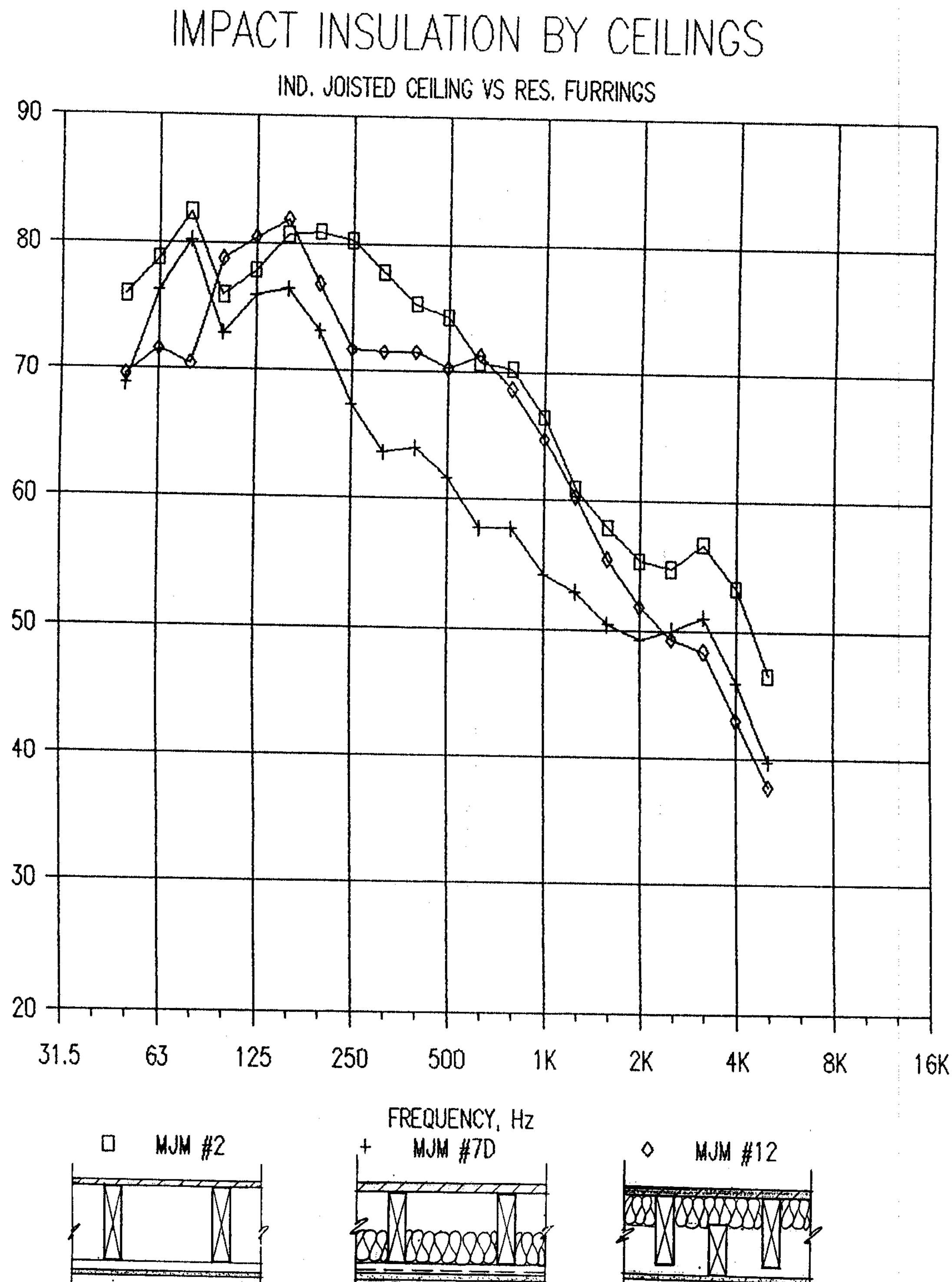


Basic floor assembly IIC 37

Added ceiling with 2 1/2" metal studs IIC 45

Added ceiling with wood blockings and resilient furrings IIC 42

Graph no 30



Basic Floor assembly
IIC 37

Glass fiber batt insulation and drywall on resilient furrings
IIC 44

Glass fiber batt insulation and drywall on independent ceiling joists
IIC 38

Graph no 31

ANNEX II

National Research Council Canada
Conseil national de recherches Canada

Institute for Research in Construction
Institut de recherche en construction

CLIENT REPORT

for

MJM Acoustical Consultants Inc.
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Airborne and Impact Sound Transmission Through a Wood Joist Floor With Different Ceiling Systems and Sound Absorbers

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Approved J.D. Quirt
Section Head

Approved W.A. Dalgliesh
Head, Quality Assurance

Report No. CR-5738.1
Report Date: 10 February 1989
Contract No. CR-5738
Reference: Application for test dated 8 July 1988
Section: Acoustics

49 Pages
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Canada

The sound transmission data presented in this report were collected as part of a measurement series to examine the effects of different methods of attaching drywall to the underside of a wood joist floor. The effects of different sound absorbing materials were also examined. The sound transmission and impact transmission data are presented in graphical and tabular form at the end of this report.

Measurement Facilities

In the IRC acoustical facility the floor test opening measures 2.4 × 2.4 m. The upper room has a volume of 120 m^3 while the lower room has a volume of 65 m^3. Each room contains 9 calibrated GenRad electret condenser microphones, four incoherently excited random noise sources and fixed and moving diffusing panels. For airborne and impact sound transmission the receiving room is the lower room.

Measurement Procedures

Measurements are controlled by a Data General Nova 4 computer interfaced to a GenRad 1921 real time analyzer. Five sound decays are averaged to get reverberation time at each of the nine microphone positions. These times are averaged to get reverberation times for the room.

Sound pressure levels are measured for 15 seconds at each microphone position and then averaged to get the mean value for the room.

Measurements and calculations of sound transmission were made in accordance with the requirements of ASTM E90.

Measurements of impact sound transmission were made in accordance with the requirements of ASTM E492 using the standard tapping machine and the prescribed four impact positions on the floor.

Basic Floor Description

A rectangular frame formed from 2 × 10 in. (38 × 235 mm) wood joists was bolted directly to the concrete of the upper part of test opening. 2 × 10 in. (38 × 235 mm) joists at 16 centres were attached to this frame using joist hangers and toe-nails. 5/8 in. (16 mm) tongued and grooved plywood was screwed on top of the joists with screws 16 in. (400 mm) on centres. All peripheral and other gaps were caulked to form an airtight seal. All other materials and systems were attached to this basic floor. The weight per unit area of the basic floor was 4.82 lb/ft^2 (23.5 kg/m^2).

Materials

Four different types of sound absorbing materials were used. These were:

- Weathershield Cellulose Fibre Attic Insulation by Thermo-Cell Insulation Ltd.
- Red Top Mineral Fibre Insulation by Canadian Gypsum Corporation
- Benocoustic acoustical insulation by Benolec.
- R12 glass fibre insulation batts by Fiberglas Canada Ltd.

The densities used in each case are given in the individual reports in Appendix A.

Four types of resilient metal furring were used. These were manufactured by:

- Pichette metal
- RL Metal
- Trebord
- Canadian Gypsum Corporation

<u>Summary of Results</u>

For convenience Table 1 gives a short description of each floor tested, the IRC test identifiers and the STC and IIC ratings.

Appendix A repeats the description for each floor system tested, tabulates and plots the data for sound transmission loss and impact sound transmission. For each test, in the frequency ranges governed by the appropriate standard, the required confidence limits were satisfied. To avoid needless repetition, however, the measured confidence limits are not given in this report.

TABLE 1

Floor Number	Description	Test Number	STC	Test Number	IIC
1	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c.	491	24	38	20
2	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	493	38	39	37
3A	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	497	49	43	44
3B	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - mineral blown-in attic insulation: RED TOP manufactured by *CGC* - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	496	48	42	45
4A	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	495	44	41	41
4B	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - 1 in. × 2 in. wood furring strips @ 16 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	530	37	63	32

TABLE 1 *(Continued)*

Floor Number	Description	Test Number	STC	Test Number	IIC
5	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring - 2 1/2 in. standard metal studs (25 ga.) spaced 24 in. c.c. and screwed to the wood furring - 2 1/2 in. thick glass fibre insulation between the studs - 1/2 in. gypsum board screwed to the metal studs	498	53	44	45
6	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring - 2 in. × 3 in. wood studs installed on the flat side and screwed to the wood furring strips - 1 1/2 in. thick glass fiber batt insulation between the wood studs - 1/2 in. deep resilient metal channel screwed to the wood studs - 1/2 in. gypsum board screwed to the resilient furring	499	46	45	42
7A	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *PICHETTE METAL* 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	505	44	47	43
7B	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *RL METAL* 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	506	44	48	43
7C	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *TREBORD* 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	507	44	49	43

TABLE 1 *(Continued)*

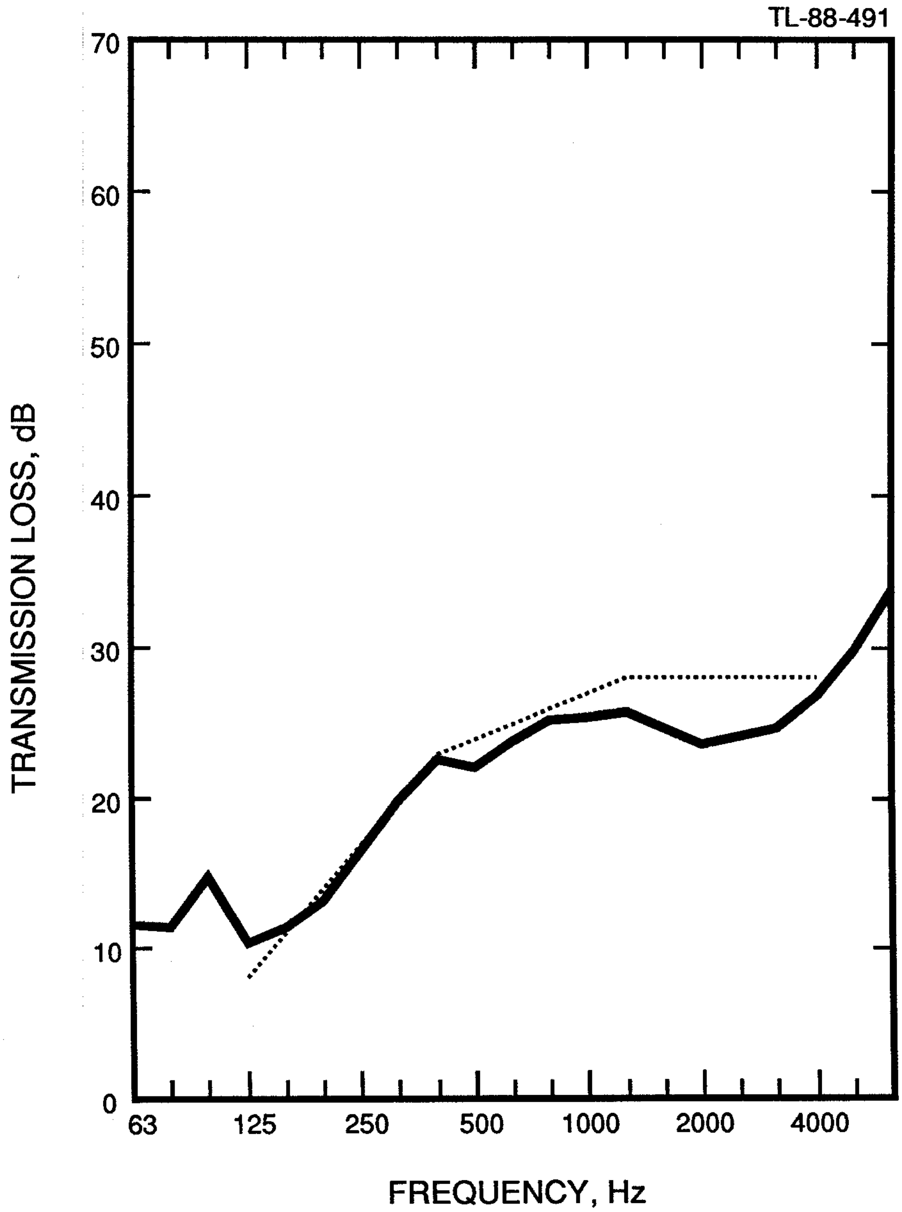
Floor Number	Description	Test Number	STC	Test Number	IIC
7D	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *CGC* RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	514	45	51	44
7E	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *CGC* RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 16 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	529	44	62	42
7F	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - *CGC* RC-1 1/2 in. deep resilient metal furring screwed parallel to the joists @ 16 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	565	45	69	42
8	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 1 in. × 2 in. wood furring strips @ 24 in. c.c. - 2 × 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring	566	37	70	35
9	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - resilient furring RC-1 by *CGC*, screwed to the joists @ 24 in. c.c. - 2 × 1/2 in. gypsum board screwed to the resilient furring	515	50	52	49

TABLE 1 *(Continued)*

Floor Number	*Description*	*Test Number*	*STC*	*Test Number*	*IIC*
10	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - 1/2 in. wood fiber board screwed directly to the underside of the joists - resilient furring RC-1 by *CGC*, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	527	45	60	42
11A	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 layers of 3 1/2 in. glass fiber batt insulation - resilient furring RC-1 by *CGC*, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	563	51	67	46
11B	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - resilient furring RC-1 by *CGC*, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	525	49	58	47
11C	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - acoustical blown-in insulation: BENOCOUSTICS by Benolec - resilient furring RC-1 by *CGC*, screwed to the joists @ 24 in. c.c. - 1/2 in. gypsum board screwed to the resilient furring	569	51	71	47
12	- 5/8 in. thick plywood - 2 in. × 10 in. joists @ 16 in. c.c. - 3 1/2 in. glass fiber batt insulation between floor joists - 2 in. × 6 in. ceiling joists supported by the common 2 in. × 10 in. plate at the perimeter of the test opening - 1/2 in. gypsum board screwed directly to the ceiling joists	532	40	64	38

APPENDIX A

Individual Sound Transmission Loss and Impact Sound Level Data

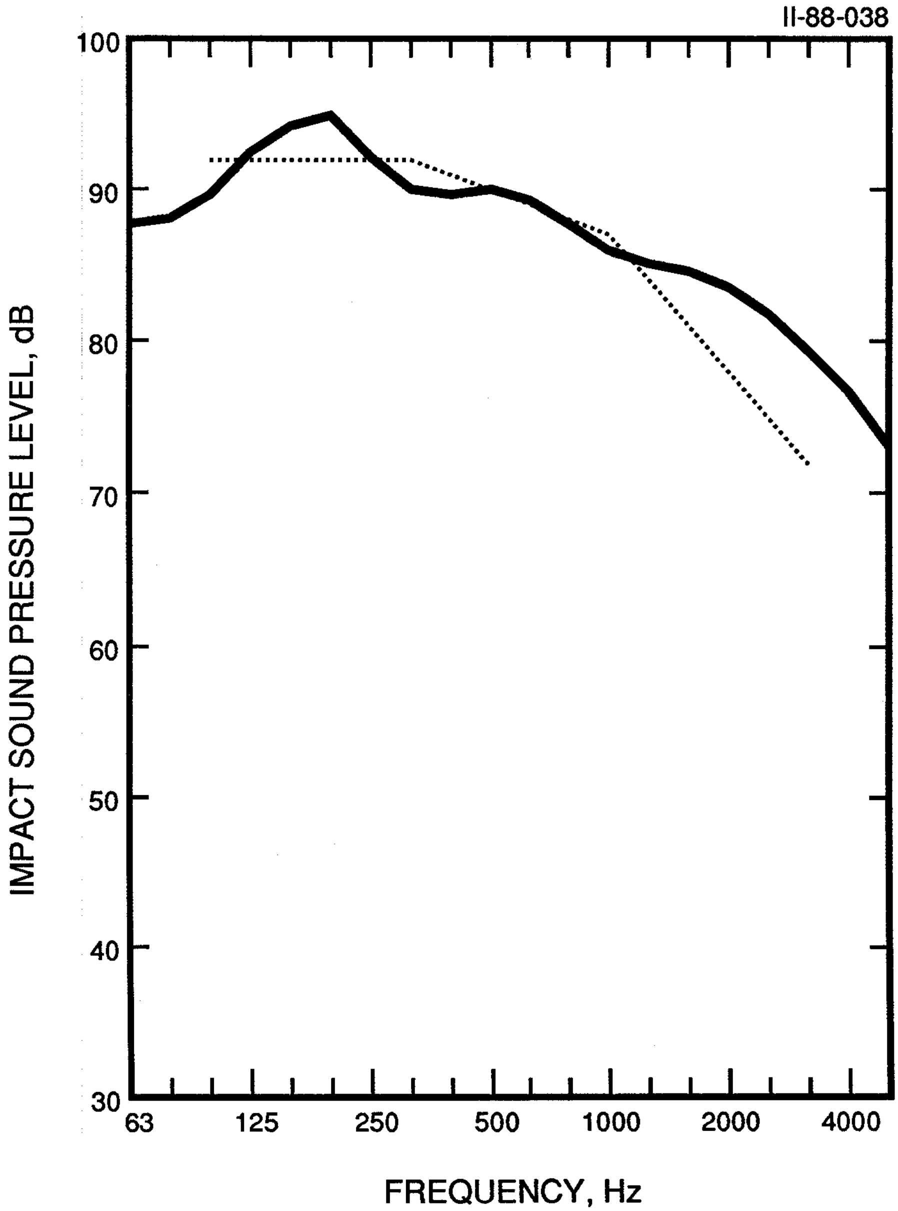


Frequency (Hz)	Transmission Loss (dB)
63	12
80	11
100	15
125	10
160	11
200	13
250	16
315	20
400	23
500	22
630	24
800	25
1000	25
1250	26
1600	25
2000	24
2500	24
3150	25
4000	27
5000	30
6300	34

STC 24

Floor 1: TL-88-491

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- Weight/Unit Area = 4.8 lbs/ft^2 (23.5 kg/m^2)

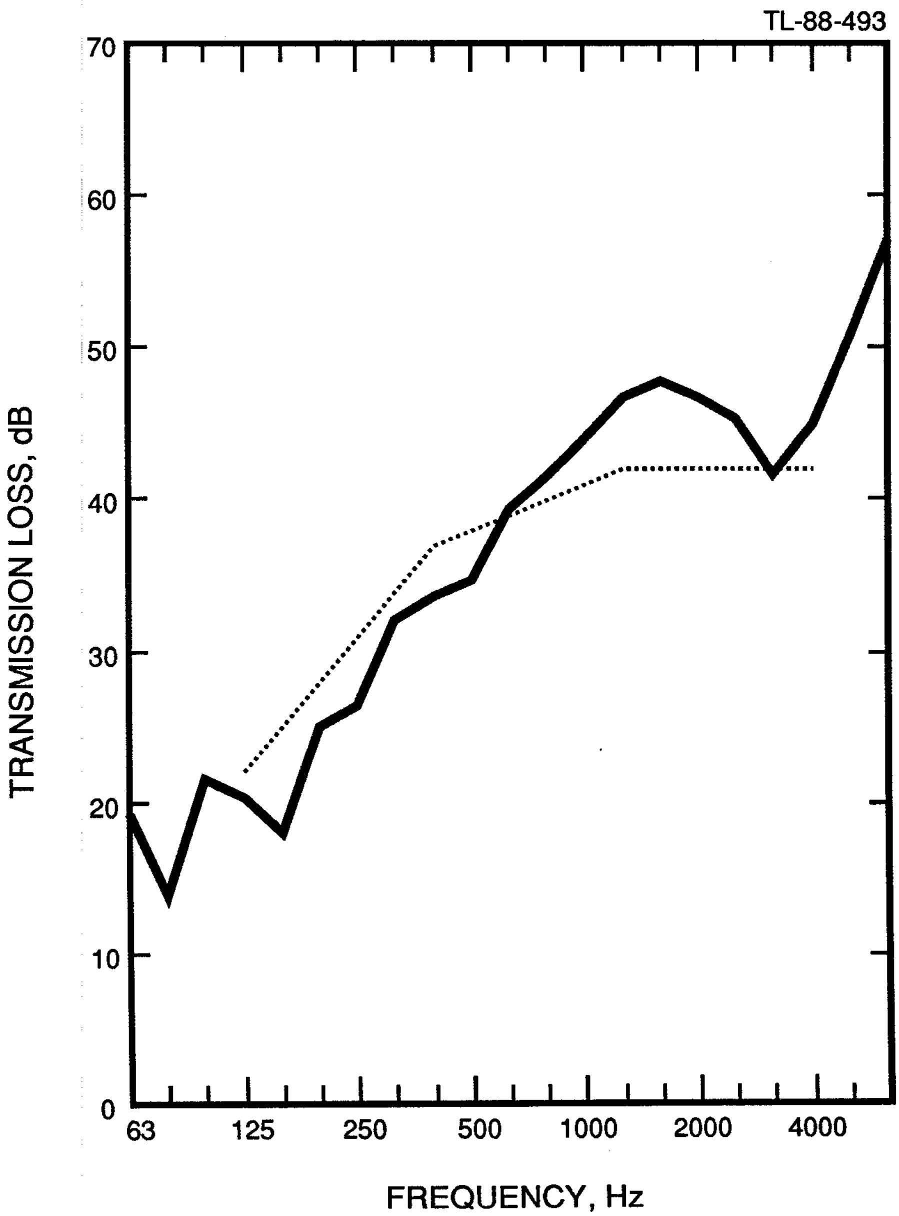


Frequency (Hz)	Impact SPL (dB)
63	88
80	88
100	90
125	93
160	94
200	95
250	92
315	90
400	90
500	90
630	89
800	88
1000	86
1250	85
1600	85
2000	84
2500	82
3150	79
4000	77
5000	73

IIC 20

Floor 1: II-88-38

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- Weight/Unit Area = 4.8 lbs/ft^2 (23.5 kg/m^2)

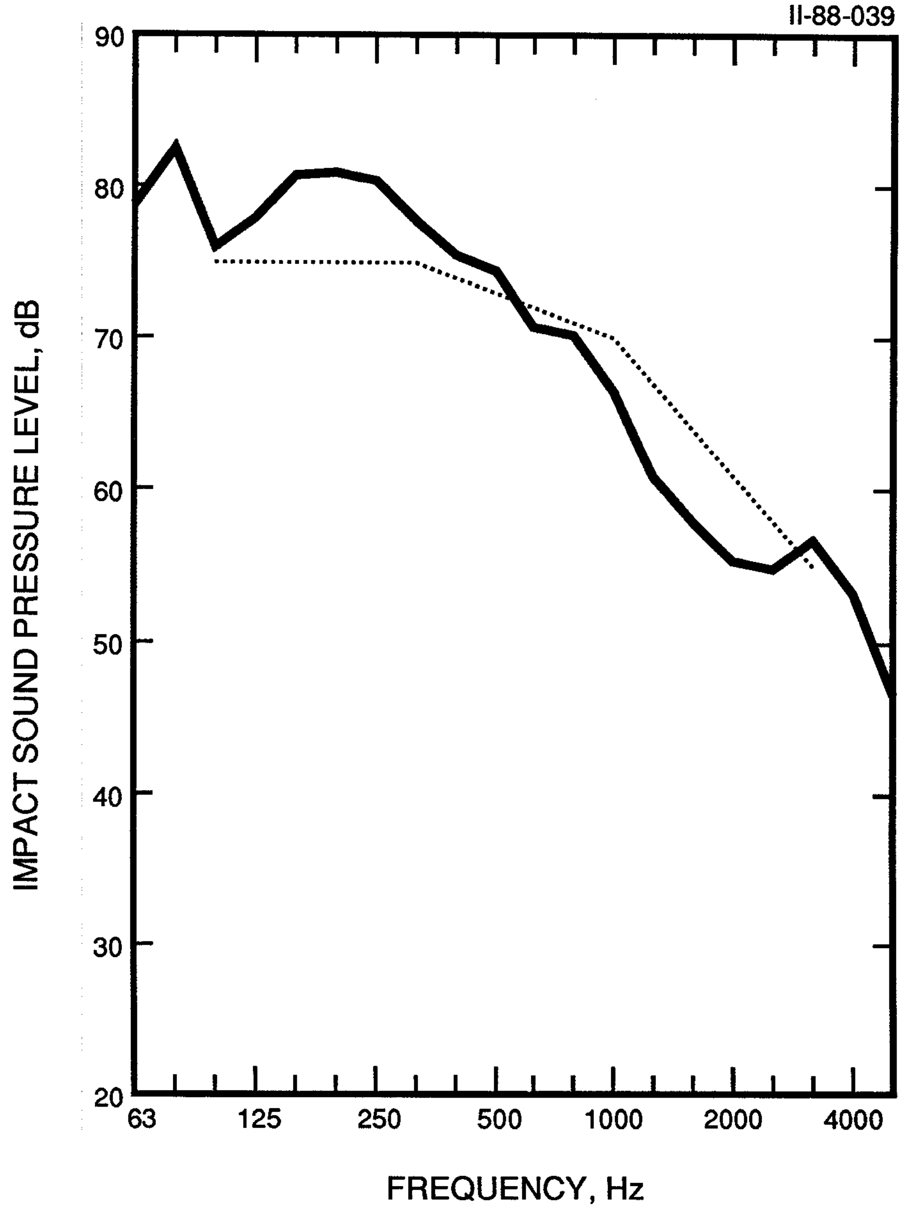


Frequency (Hz)	Transmission Loss (dB)
63	19
80	14
100	22
125	20
160	18
200	25
250	27
315	32
400	34
500	35
630	39
800	41
1000	44
1250	47
1600	48
2000	47
2500	45
3150	42
4000	45
5000	51
6300	57

STC 38

Floor 2: **TL-88-493**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 6.7 lbs/ft^2 (32.5 kg/m^2)

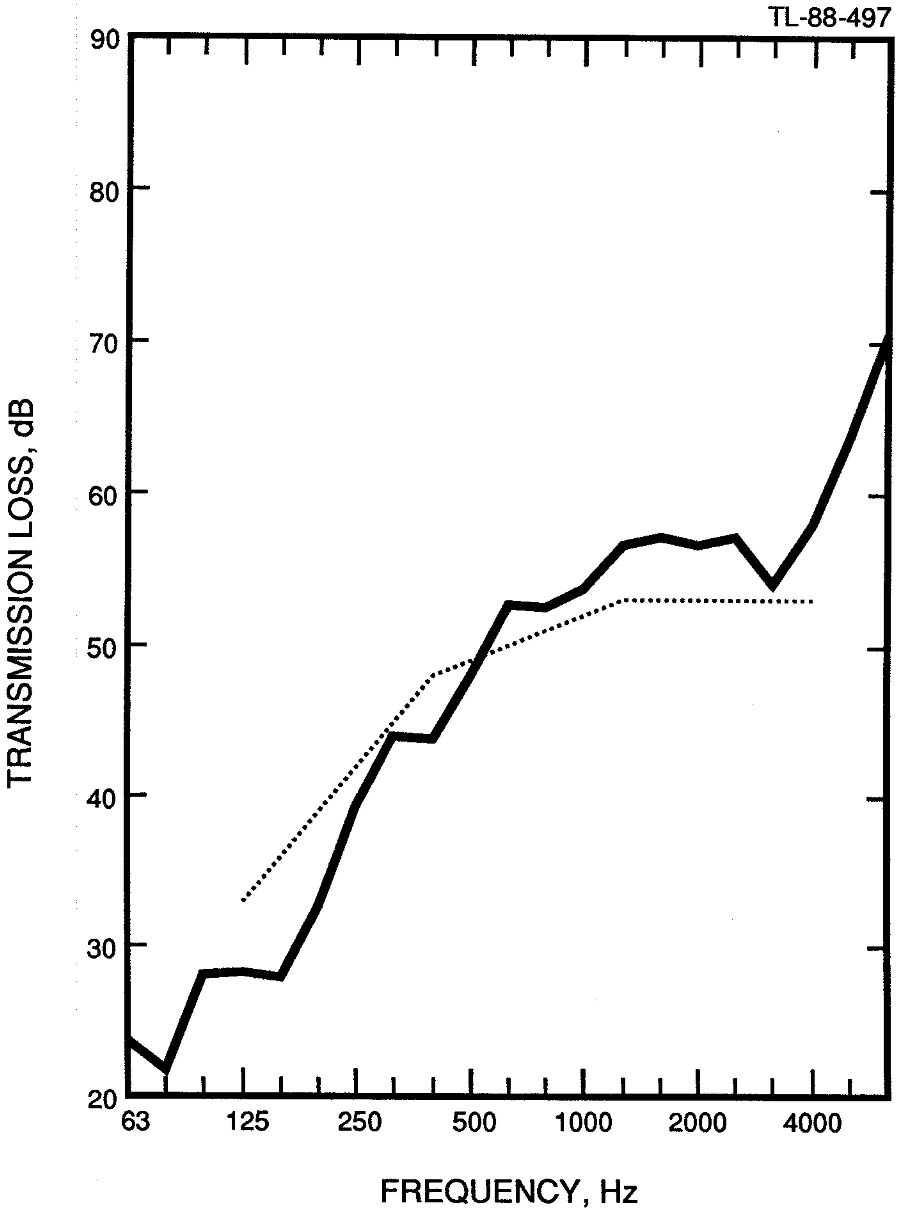


Frequency (Hz)	Impact SPL (dB)
63	79
80	82
100	76
125	78
160	81
200	81
250	80
315	78
400	75
500	74
630	71
800	70
1000	67
1250	61
1600	58
2000	55
2500	55
3150	57
4000	53
5000	47

IIC 37

Floor 2: II-88-39

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 6.7 lbs/ft^2 (32.5 kg/m^2)

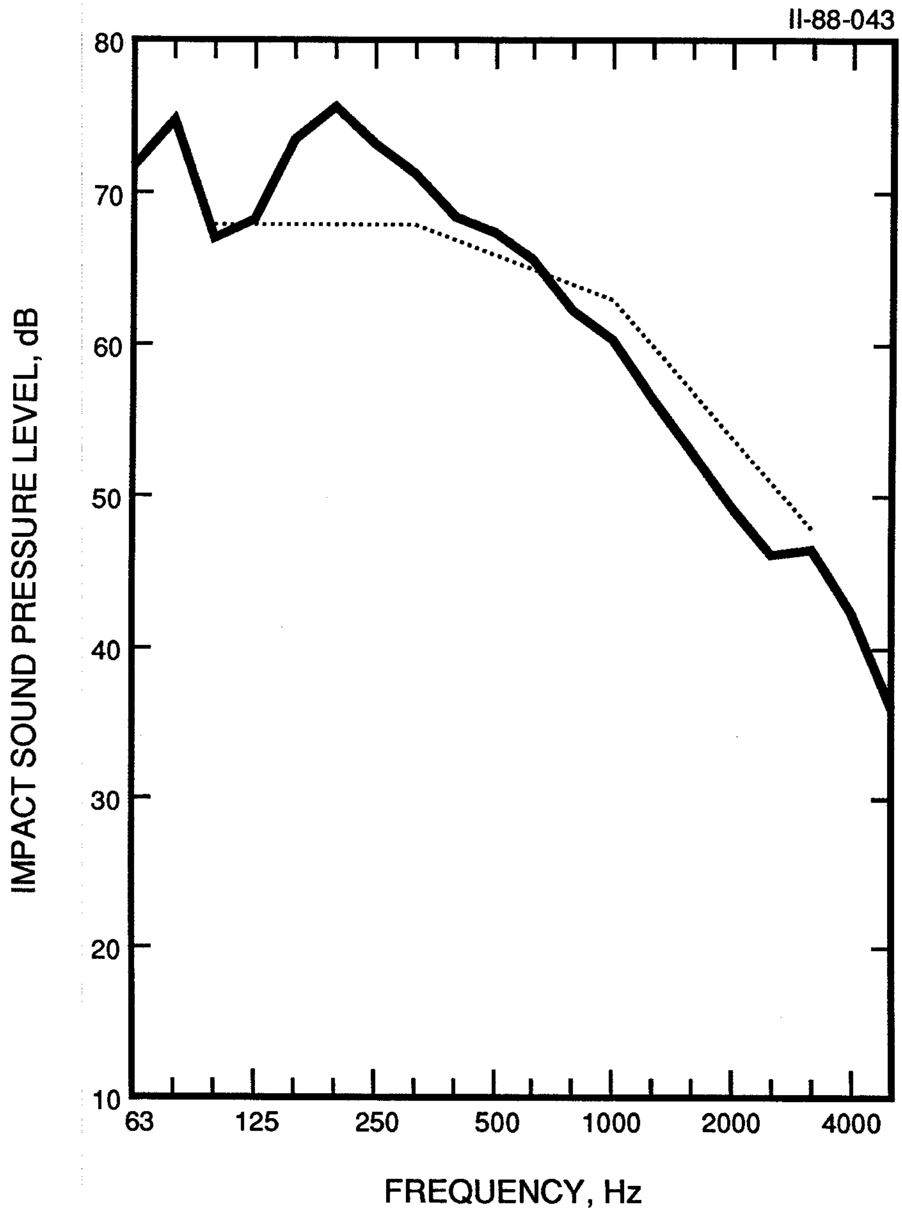


Frequency (Hz)	Transmission Loss (dB)
63	24
80	22
100	28
125	28
160	28
200	33
250	39
315	44
400	44
500	48
630	53
800	53
1000	54
1250	57
1600	57
2000	57
2500	57
3150	54
4000	58
5000	64
6300	71

STC 49

Floor 3a: TL-88-497

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - 68.0 kg/m³ (4.2 lb/ft)³
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 9.9 lbs/ft² (48.0 kg/m²)

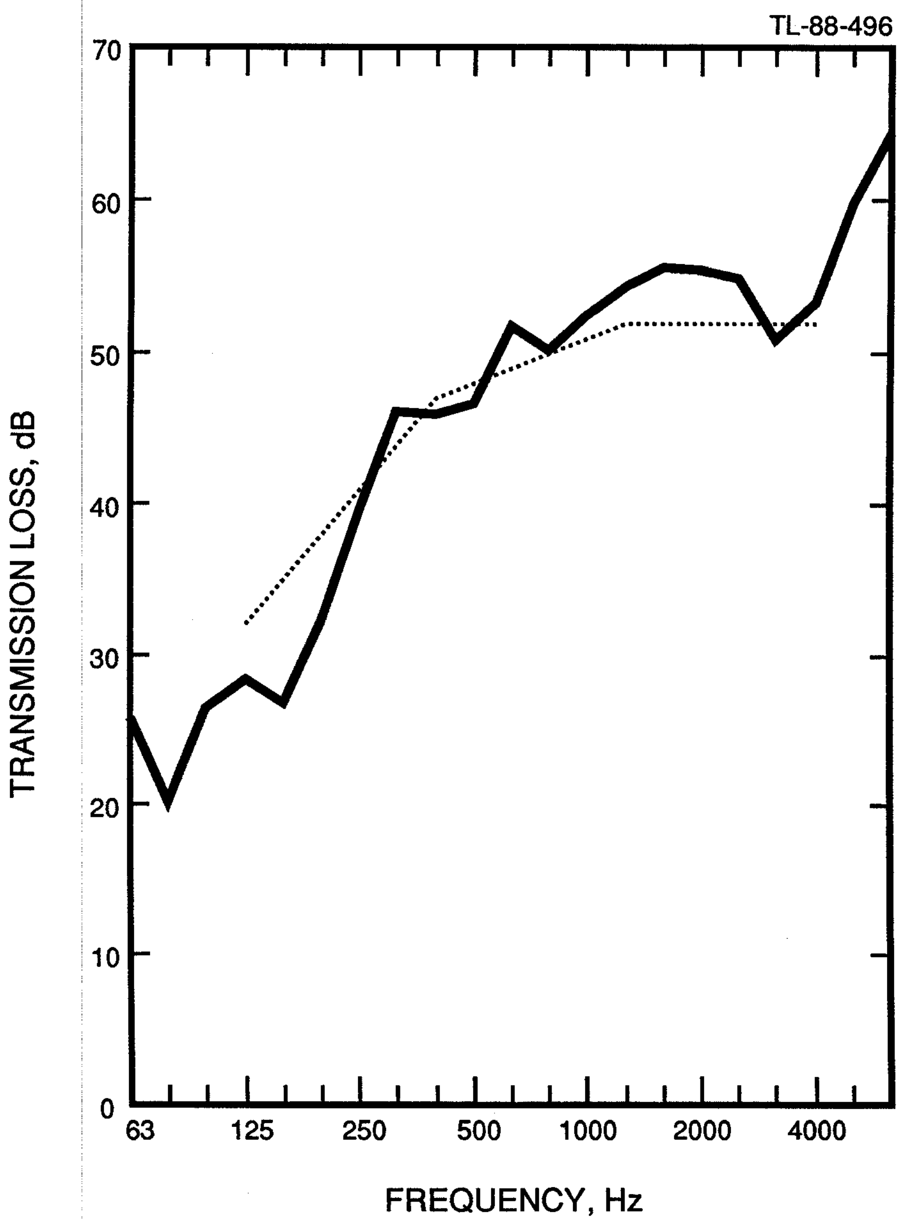


Frequency (Hz)	Impact SPL (dB)
63	72
80	75
100	67
125	68
160	74
200	76
250	73
315	71
400	69
500	67
630	66
800	62
1000	60
1250	57
1600	53
2000	49
2500	46
3150	47
4000	42
5000	36

IIC 44

Floor 3a: II-88-43

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - 68.0 kg/m^3 (4.2 lb/ft^3)
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 9.9 lbs/ft^2 (48.0 kg/m^2)

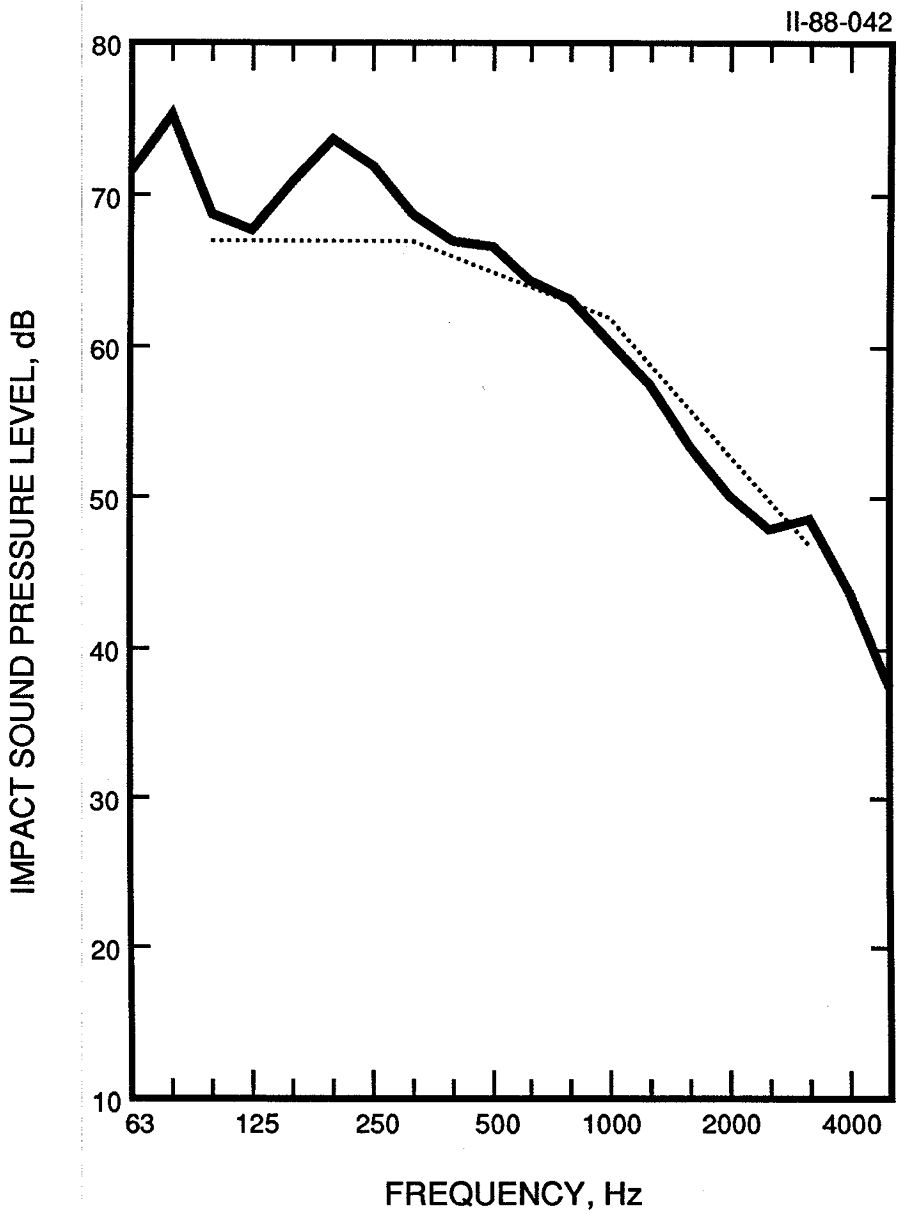


Frequency (Hz)	Transmission Loss (dB)
63	26
80	20
100	27
125	28
160	27
200	32
250	40
315	46
400	46
500	47
630	52
800	50
1000	53
1250	54
1600	56
2000	55
2500	55
3150	51
4000	53
5000	60
6300	64

STC 48

Floor 3b: TL-88-496

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- mineral blown-in attic insulation: RED TOP manufactured by CGC - 70.0 kg/m^3 (4.4 lb/ft^3)
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 10.0 lbs/ft^2 (48.5 kg/m^2)

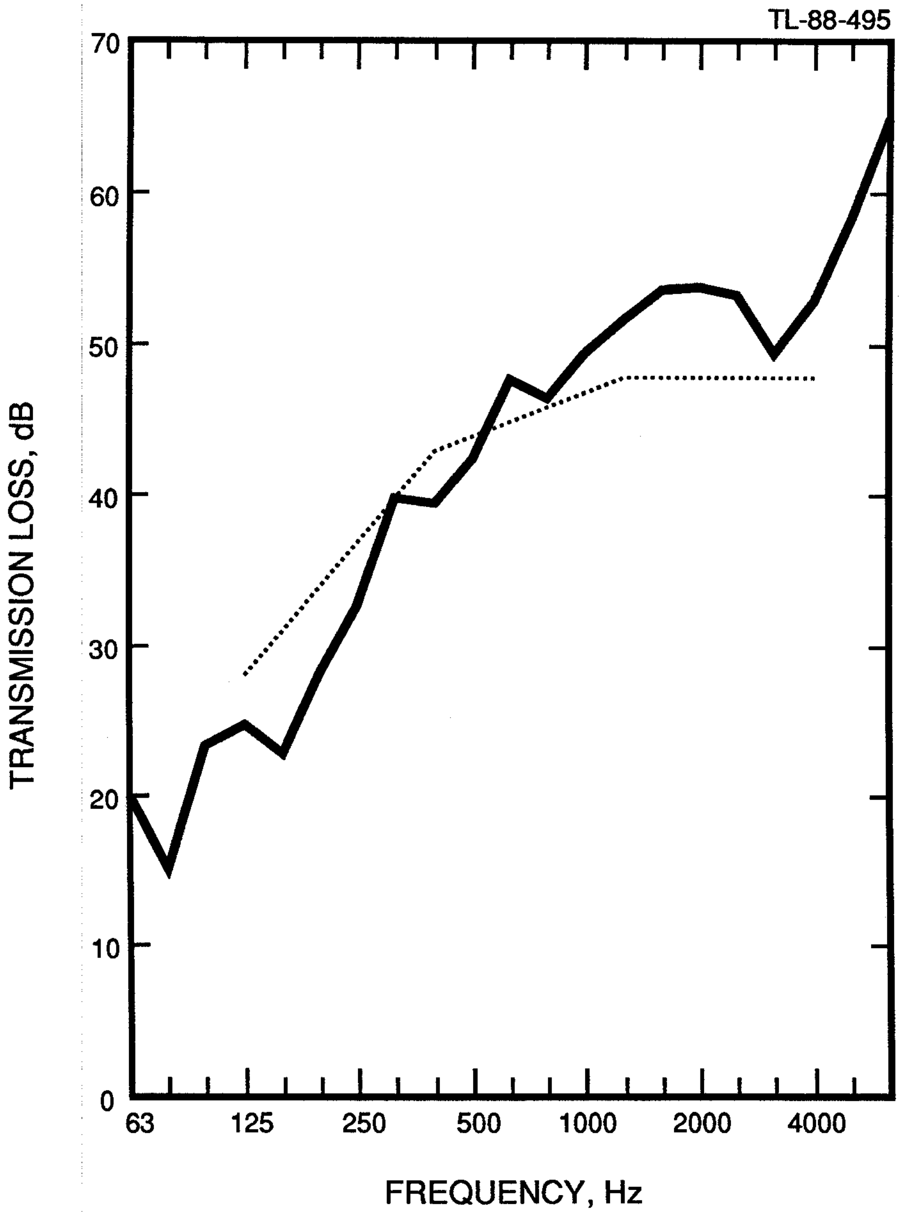


Frequency (Hz)	Impact SPL (dB)
63	72
80	75
100	69
125	68
160	71
200	74
250	72
315	69
400	67
500	67
630	65
800	63
1000	60
1250	58
1600	54
2000	50
2500	48
3150	49
4000	44
5000	38

IIC 45

Floor 3b: **II-88-42**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- mineral blown-in attic insulation: RED TOP manufactured by CGC - 70.0 kg/m^3 (4.4 lb/ft^3)
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 10.0 lbs/ft^2 (48.5 kg/m^2)

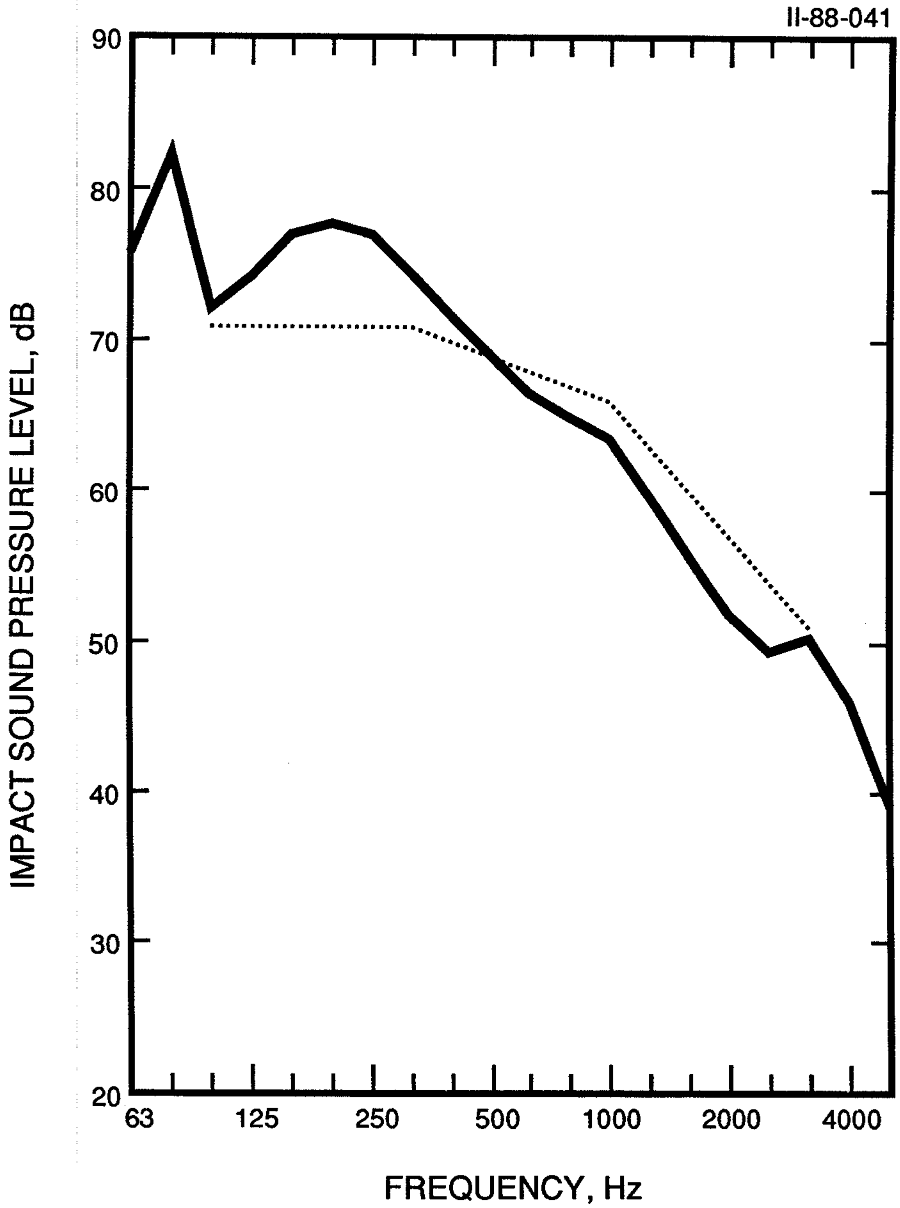


Frequency (Hz)	Transmission Loss (dB)
63	20
80	15
100	23
125	25
160	23
200	28
250	33
315	40
400	40
500	43
630	48
800	47
1000	50
1250	52
1600	54
2000	54
2500	53
3150	50
4000	53
5000	58
6300	65

STC 44

Floor 4a: **TL-88-495**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

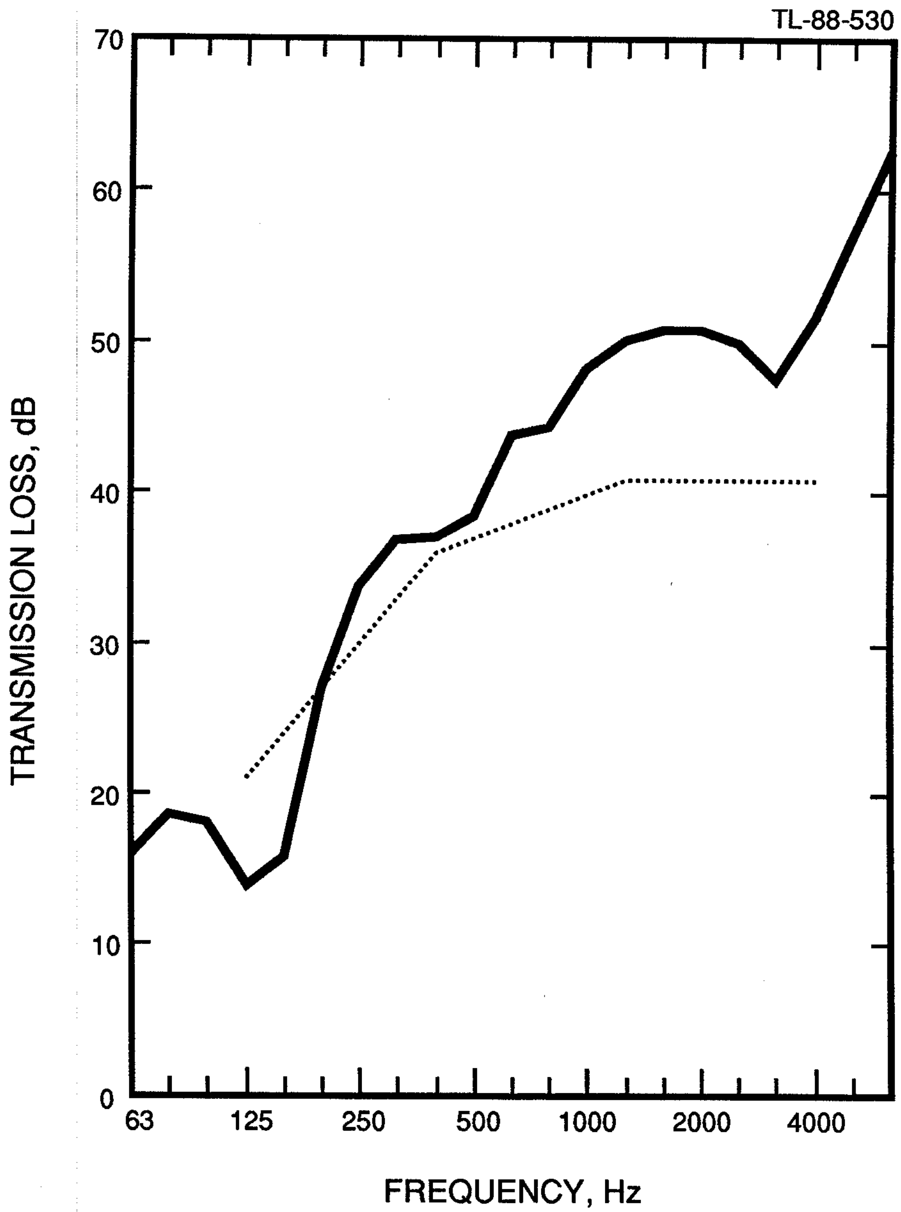


Frequency (Hz)	Impact SPL (dB)
63	76
80	82
100	72
125	74
160	77
200	78
250	77
315	74
400	72
500	69
630	67
800	65
1000	64
1250	60
1600	56
2000	52
2500	49
3150	50
4000	46
5000	39

IIC 41

Floor 4a: II-88-41

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

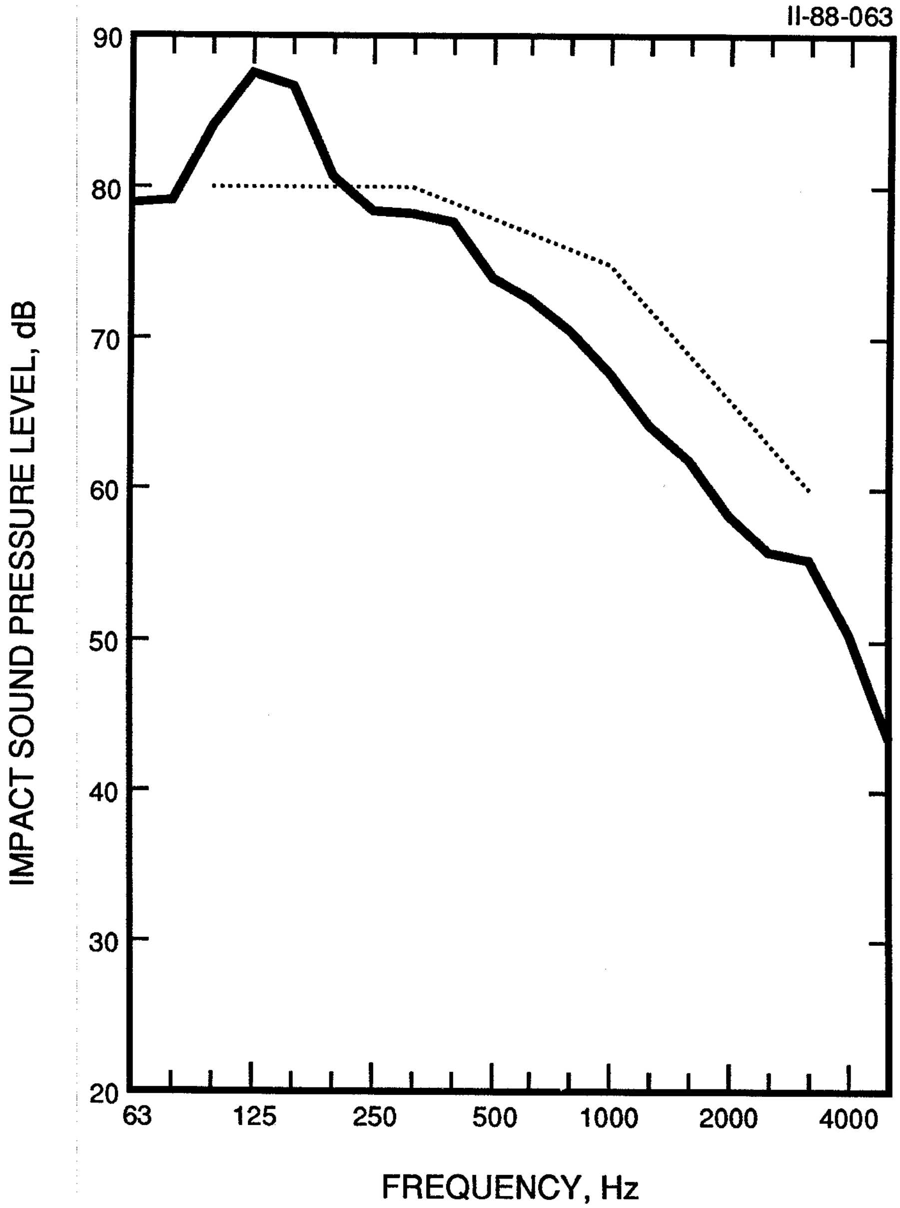


Frequency (Hz)	Transmission Loss (dB)
63	16
80	19
100	18
125	14
160	16
200	27
250	34
315	37
400	37
500	39
630	44
800	44
1000	48
1250	50
1600	51
2000	51
2500	50
3150	48
4000	52
5000	57
6300	63

STC 37

Floor 4b: TL-88-530

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1 in. × 2 in. wood furring strips @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

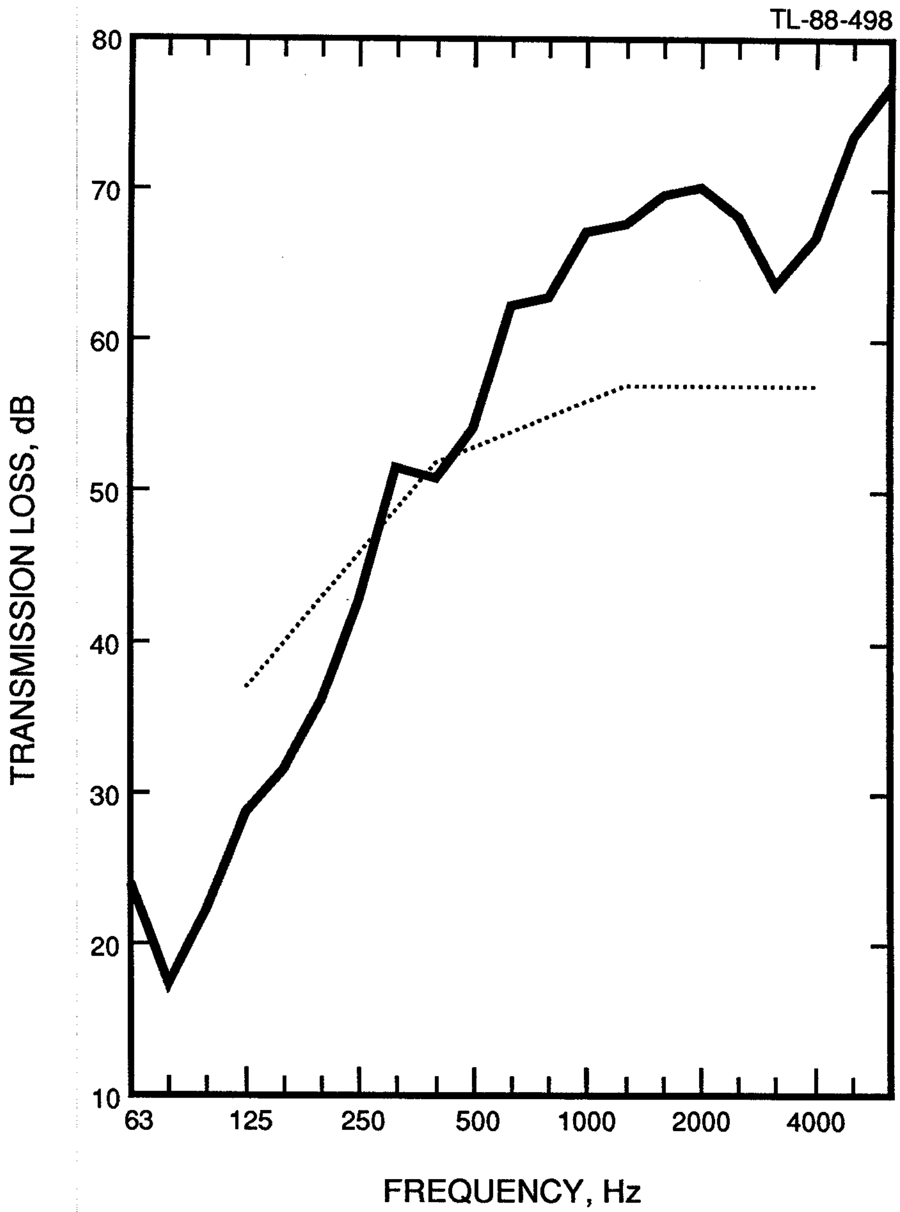


Frequency (Hz)	Impact SPL (dB)
63	79
80	79
100	84
125	88
160	87
200	81
250	78
315	78
400	78
500	74
630	73
800	71
1000	68
1250	64
1600	62
2000	58
2500	56
3150	55
4000	50
5000	44

IIC 32

Floor 4b: II-88-63

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1 in. × 2 in. wood furring strips @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

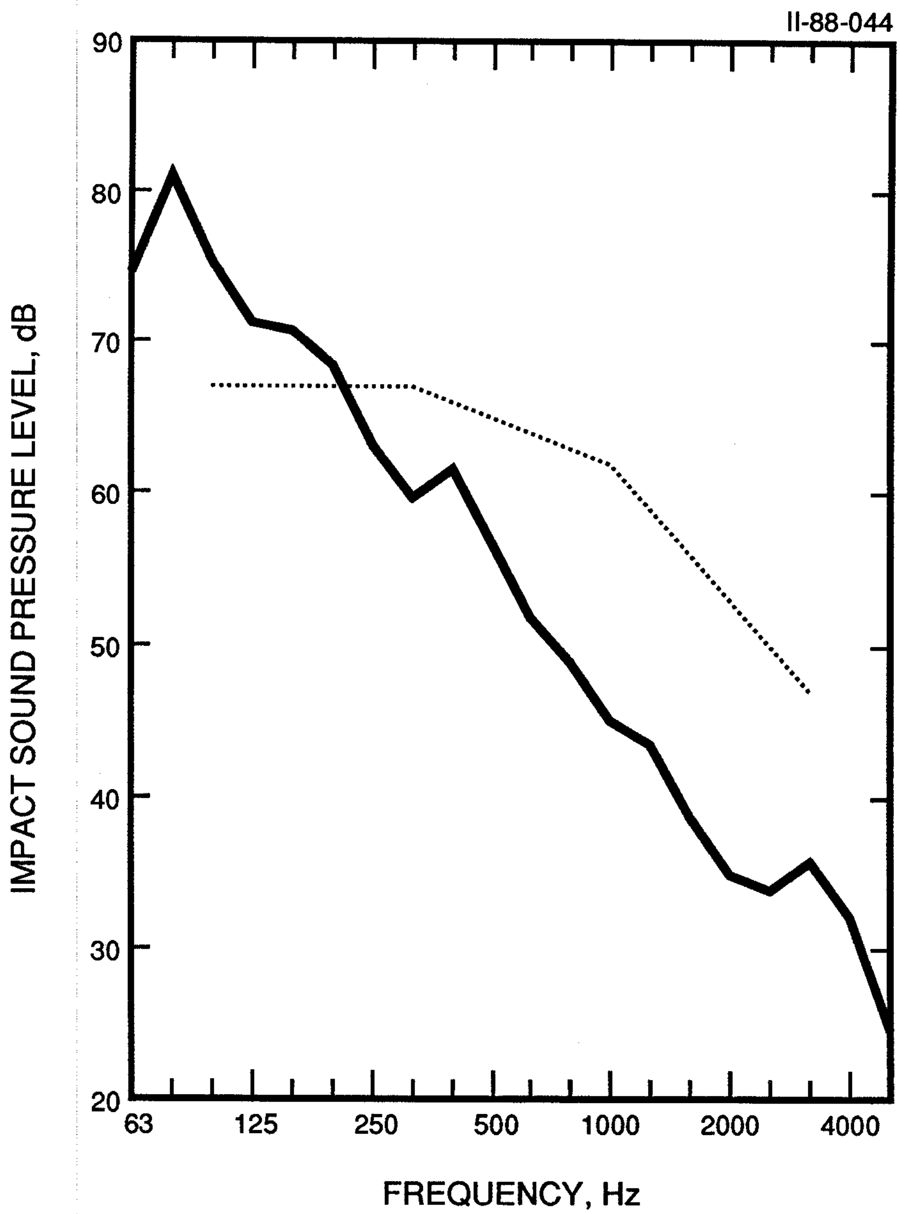


Frequency (Hz)	Transmission Loss (dB)
63	24
80	17
100	22
125	29
160	32
200	36
250	43
315	52
400	51
500	54
630	62
800	63
1000	67
1250	68
1600	70
2000	70
2500	68
3150	64
4000	67
5000	74
6300	77

STC 53

Floor 5: **TL-88-498**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- 2 1/2 in. standard metal studs (25 ga.) spaced 24 in. c.c. and screwed to the wood furring
- 2 1/2 in. thick glass fibre insulation between the studs
- 1/2 in. gypsum board screwed to the metal studs
- Weight/Unit Area = 8.9 lbs/ft^2 (43.5 kg/m^2)

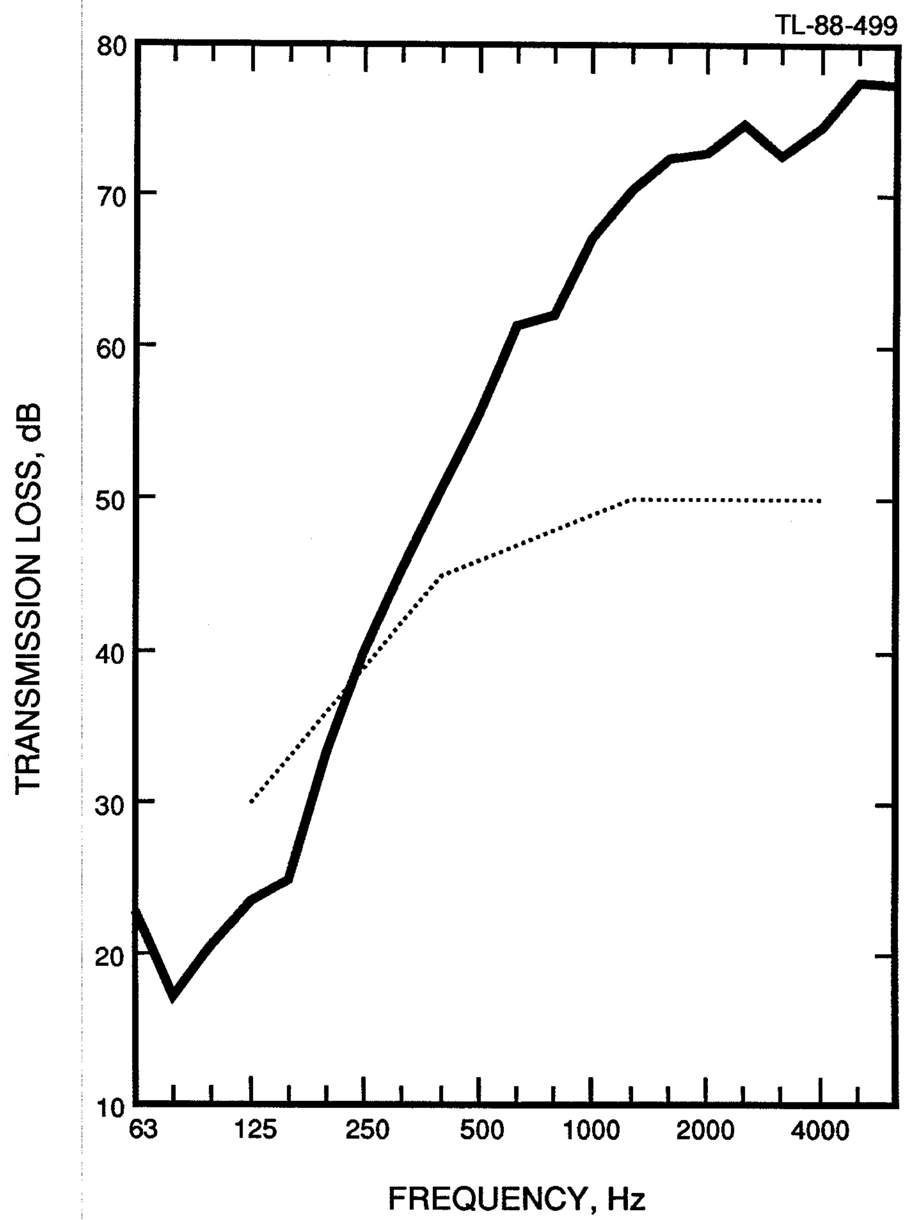


Frequency (Hz)	Impact SPL (dB)
63	75
80	81
100	75
125	71
160	71
200	68
250	63
315	60
400	62
500	57
630	52
800	49
1000	45
1250	44
1600	39
2000	35
2500	34
3150	36
4000	32
5000	25

IIC 45

Floor 5: **II-88-44**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- 2 1/2 in. standard metal studs (25 ga.) spaced 24 in. c.c. and screwed to the wood furring
- 2 1/2 in. thick glass fibre insulation between the studs
- 1/2 in. gypsum board screwed to the metal studs
- Weight/Unit Area = 8.9 lbs/ft^2 (43.5 kg/m^2)

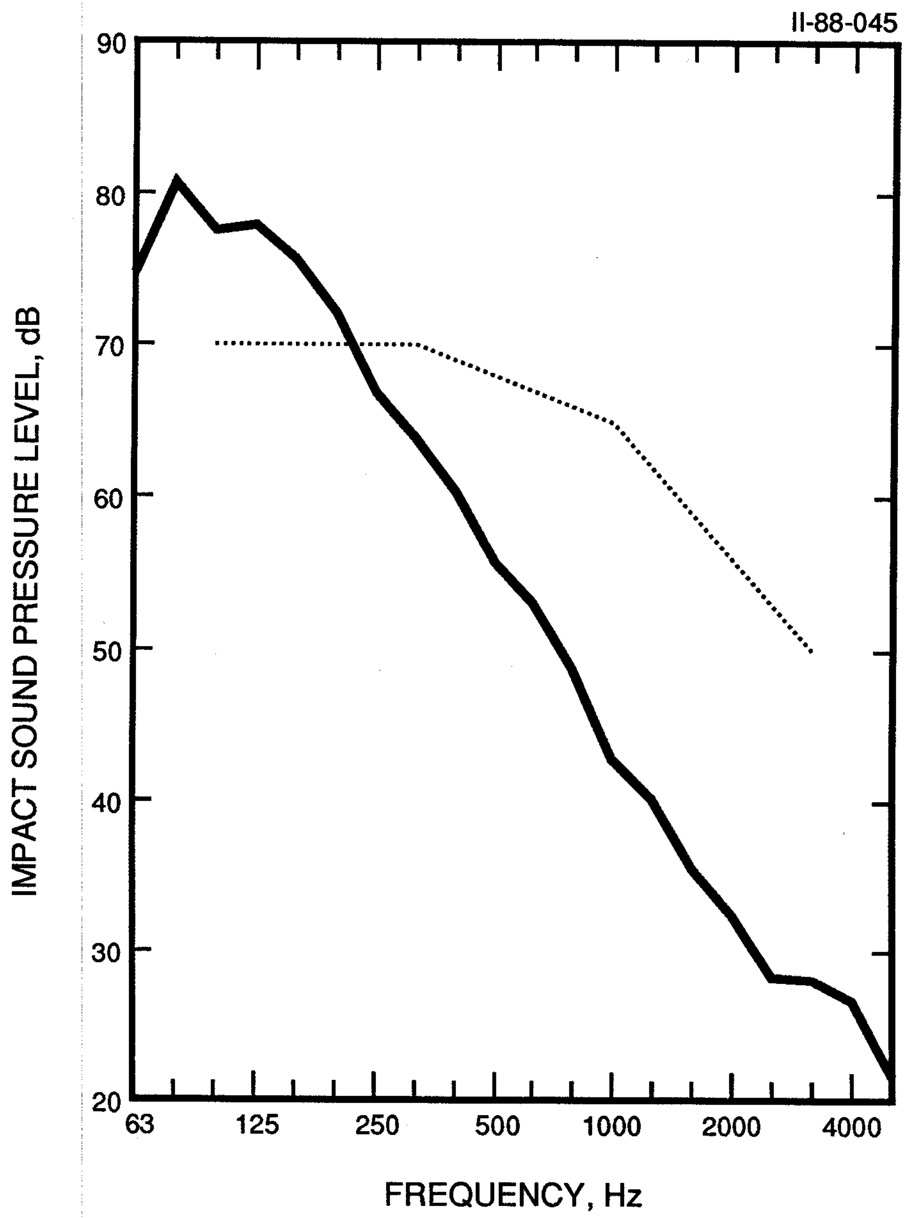


Frequency (Hz)	Transmission Loss (dB)
63	23
80	17
100	21
125	24
160	25
200	33
250	40
315	45
400	51
500	56
630	62
800	62
1000	67
1250	70
1600	72
2000	73
2500	75
3150	73
4000	75
5000	78
6300	77

STC 46

Floor 6: TL-88-499

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- 2 in. × 3 in. wood studs installed on the flat side and screwed to the wood furring strips
- 1 1/2 in. thick glass fiber batt insulation between the wood studs
- 1/2 in. deep resilient metal channel screwed to the wood studs
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.1 lbs/ft^2 (44.5 kg/m^2)

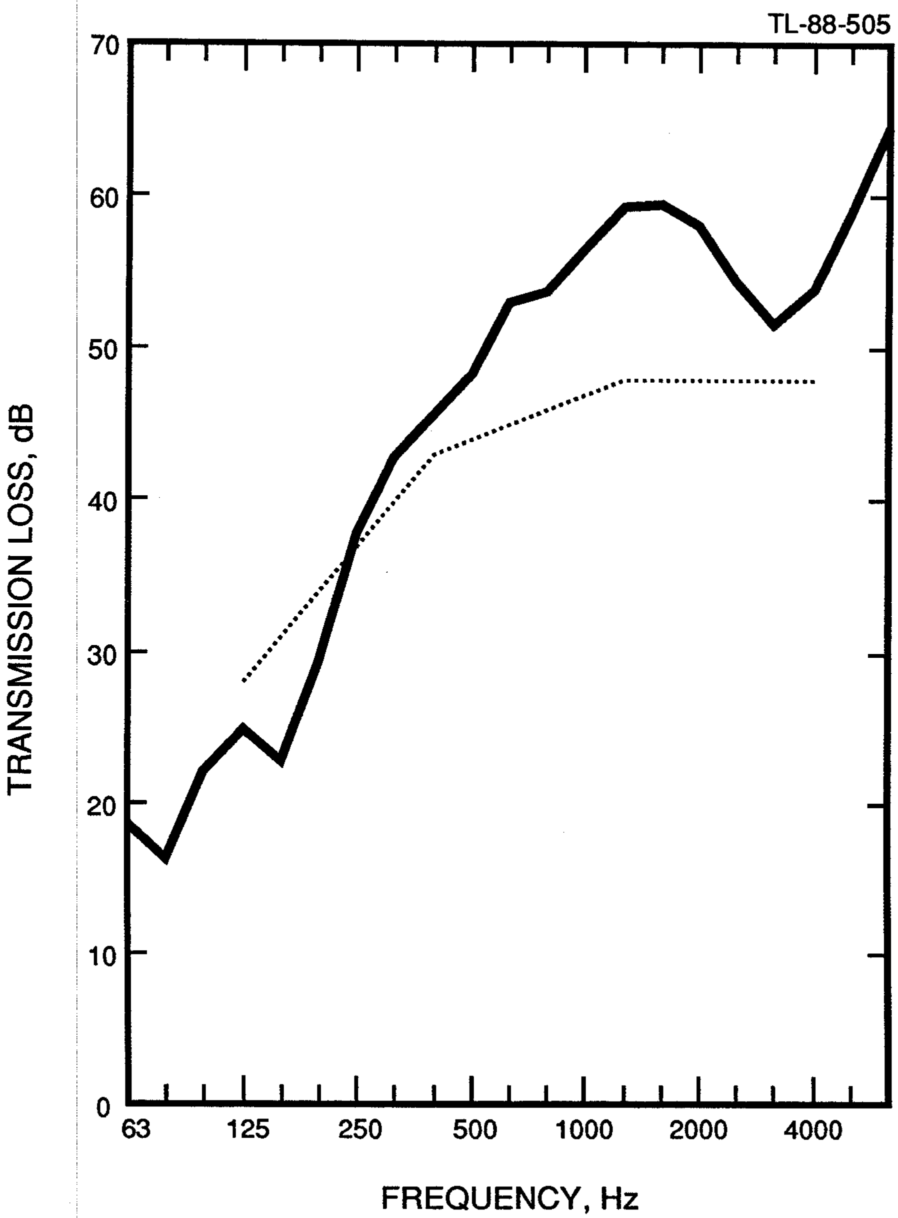


Frequency (Hz)	Impact SPL (dB)
63	75
80	81
100	78
125	78
160	76
200	72
250	67
315	64
400	60
500	56
630	53
800	49
1000	43
1250	40
1600	36
2000	33
2500	28
3150	28
4000	27
5000	22

IIC 42

Floor 6: **II-88-45**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- 2 in. × 3 in. wood studs installed on the flat side and screwed to the wood furring strips
- 1 1/2 in. thick glass fiber batt insulation between the wood studs
- 1/2 in. deep resilient metal channel screwed to the wood studs
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.1 lbs/ft^2 (44.5 kg/m^2)

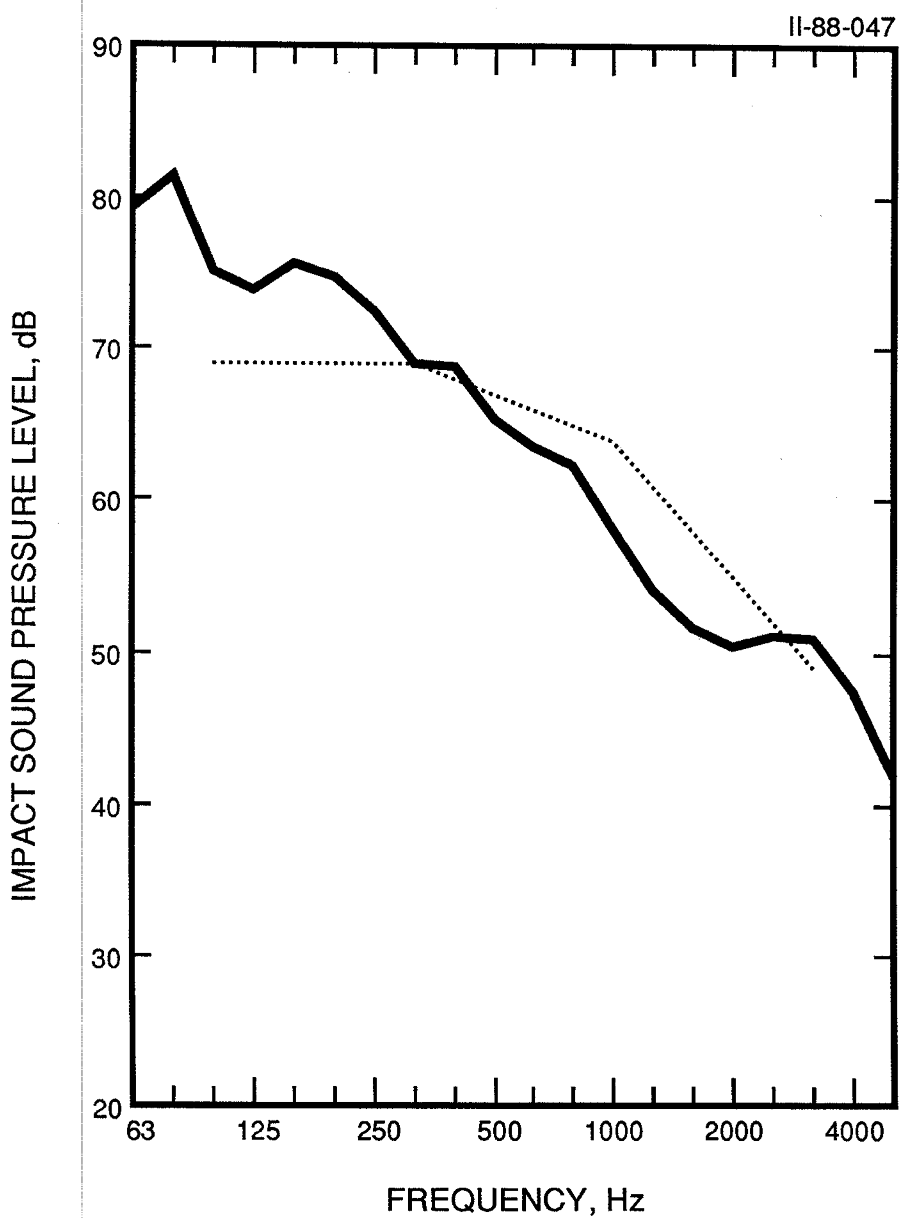


Frequency (Hz)	Transmission Loss (dB)
63	19
80	16
100	22
125	25
160	23
200	29
250	38
315	43
400	46
500	48
630	53
800	54
1000	57
1250	59
1600	60
2000	58
2500	54
3150	52
4000	54
5000	59
6300	65

STC 44

Floor 7a: TL-88-505

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- Pichette metal 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

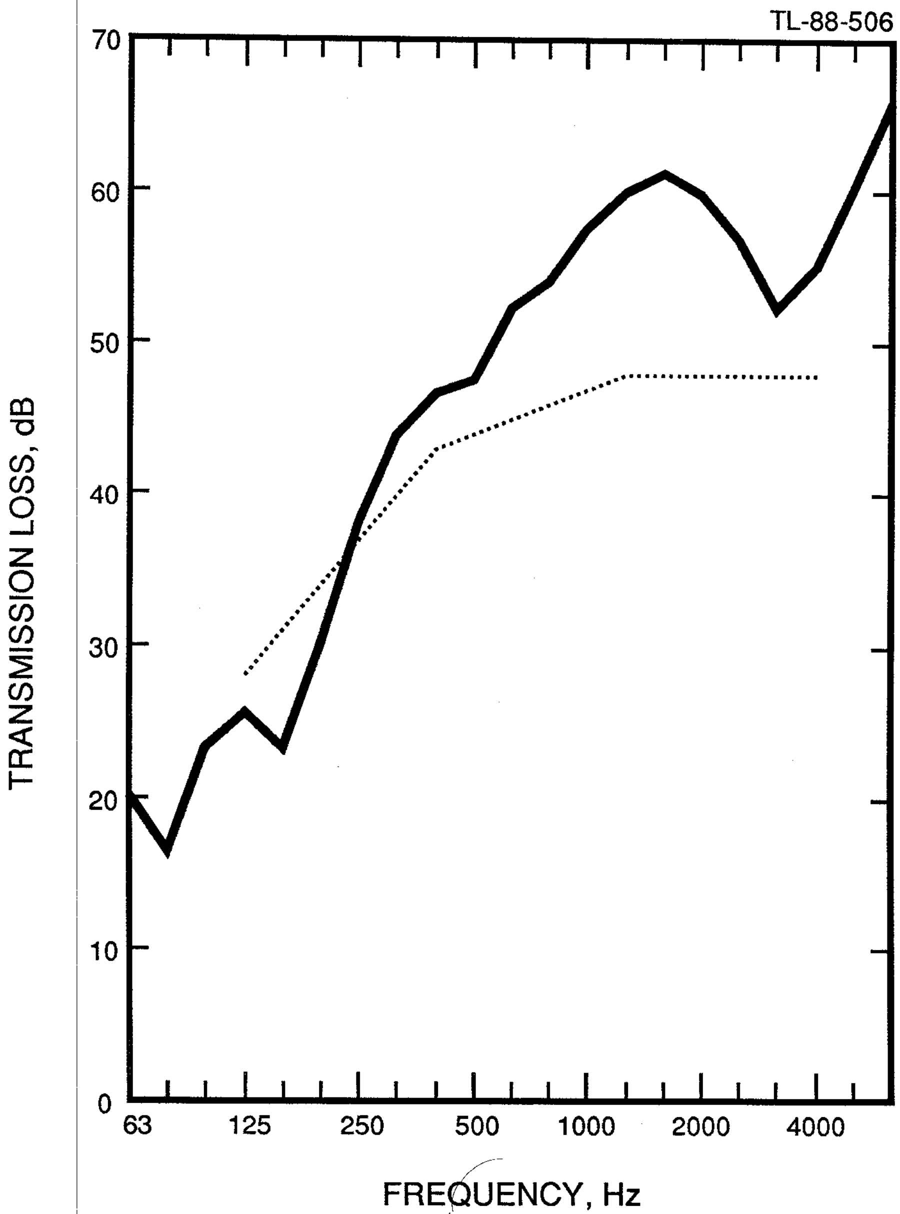


Frequency (Hz)	Impact SPL (dB)
63	79
80	81
100	75
125	74
160	76
200	75
250	73
315	69
400	69
500	65
630	64
800	62
1000	58
1250	54
1600	52
2000	51
2500	51
3150	51
4000	48
5000	42

IIC 43

Floor 7a: II-88-47

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- Pichette metal 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

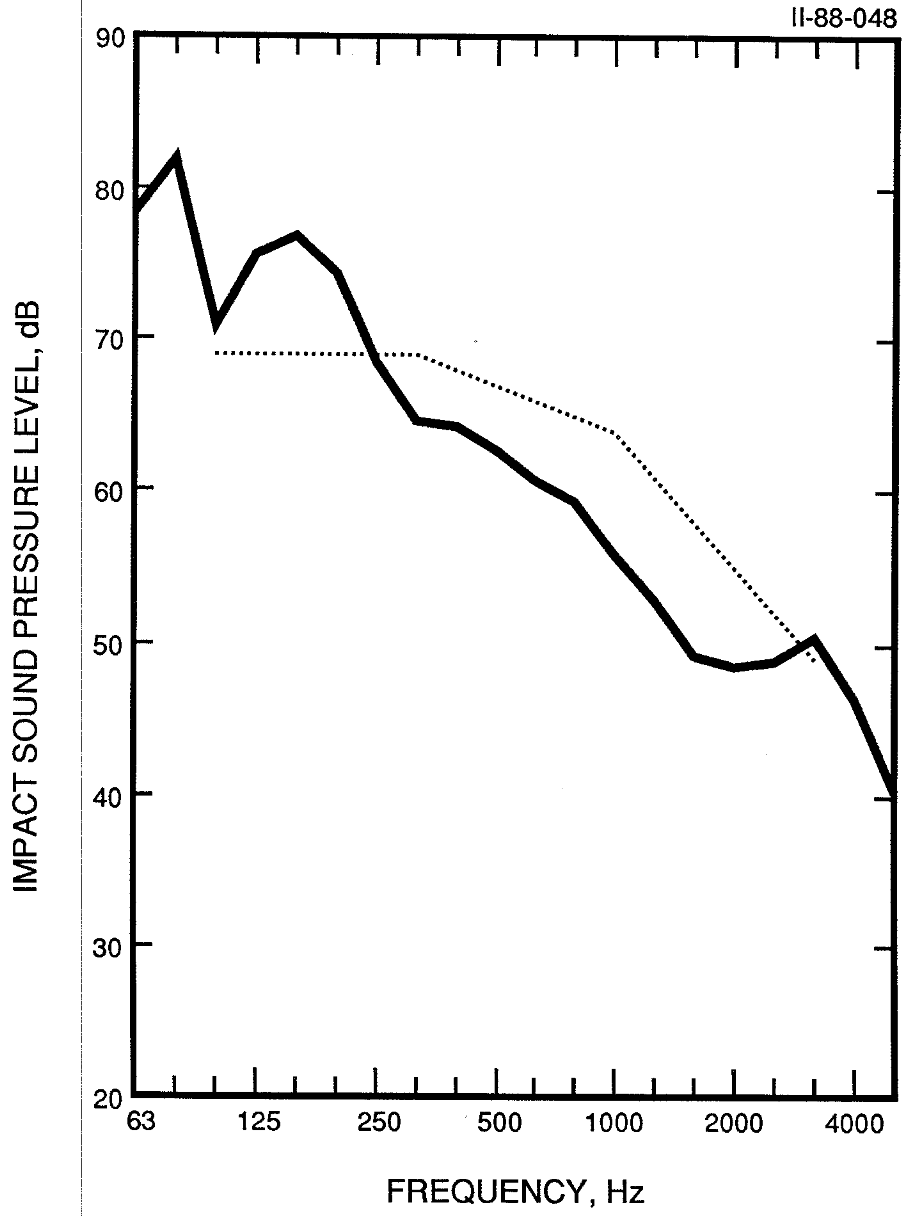


Frequency (Hz)	Transmission Loss (dB)
63	20
80	16
100	23
125	26
160	23
200	30
250	38
315	44
400	47
500	48
630	52
800	54
1000	58
1250	60
1600	61
2000	60
2500	57
3150	52
4000	55
5000	60
6300	66

STC 44

Floor 7b: TL-88-506

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- RL metal 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

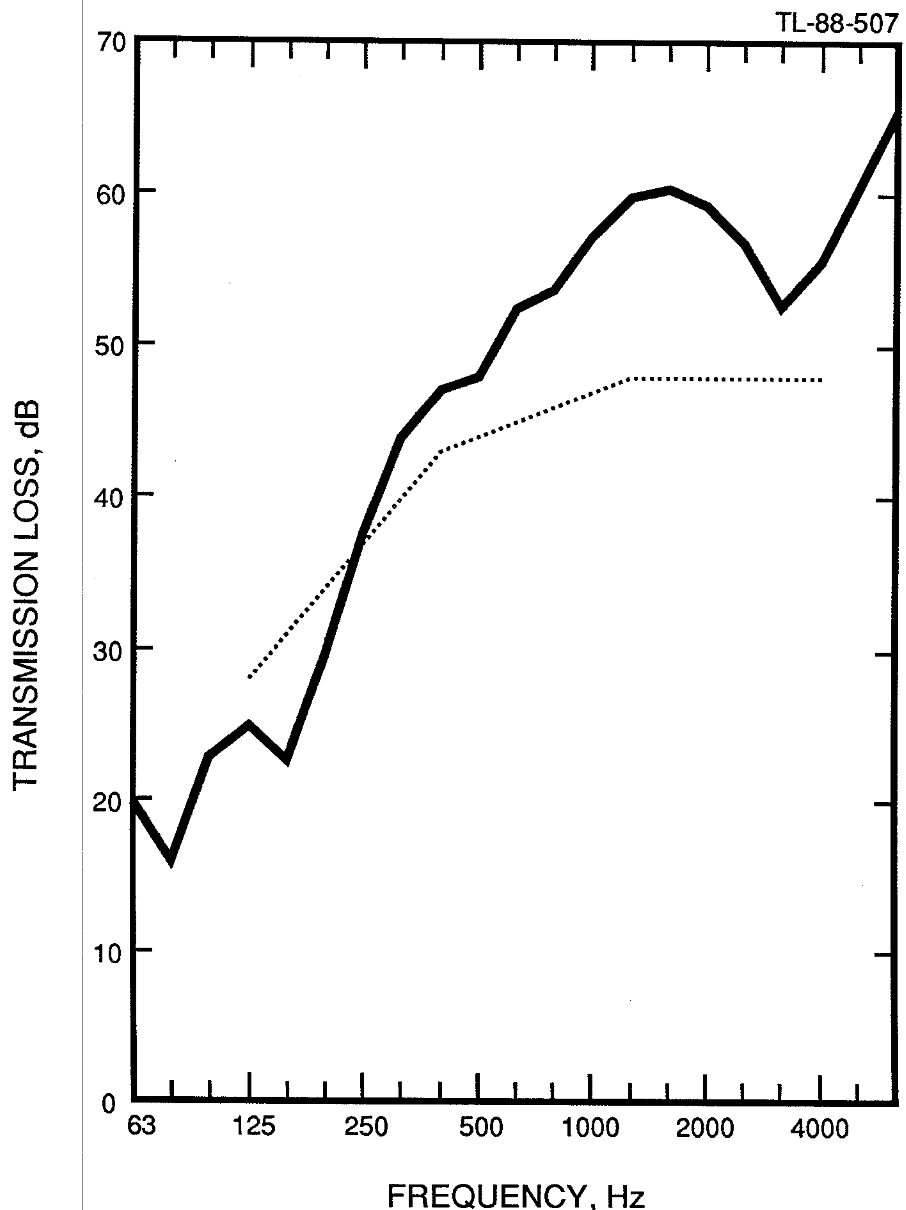


Frequency (Hz)	Impact SPL (dB)
63	79
80	82
100	71
125	76
160	77
200	74
250	69
315	65
400	64
500	63
630	61
800	59
1000	56
1250	53
1600	49
2000	49
2500	49
3150	50
4000	47
5000	40

IIC 43

Floor 7b: II-88-48

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- RL metal 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

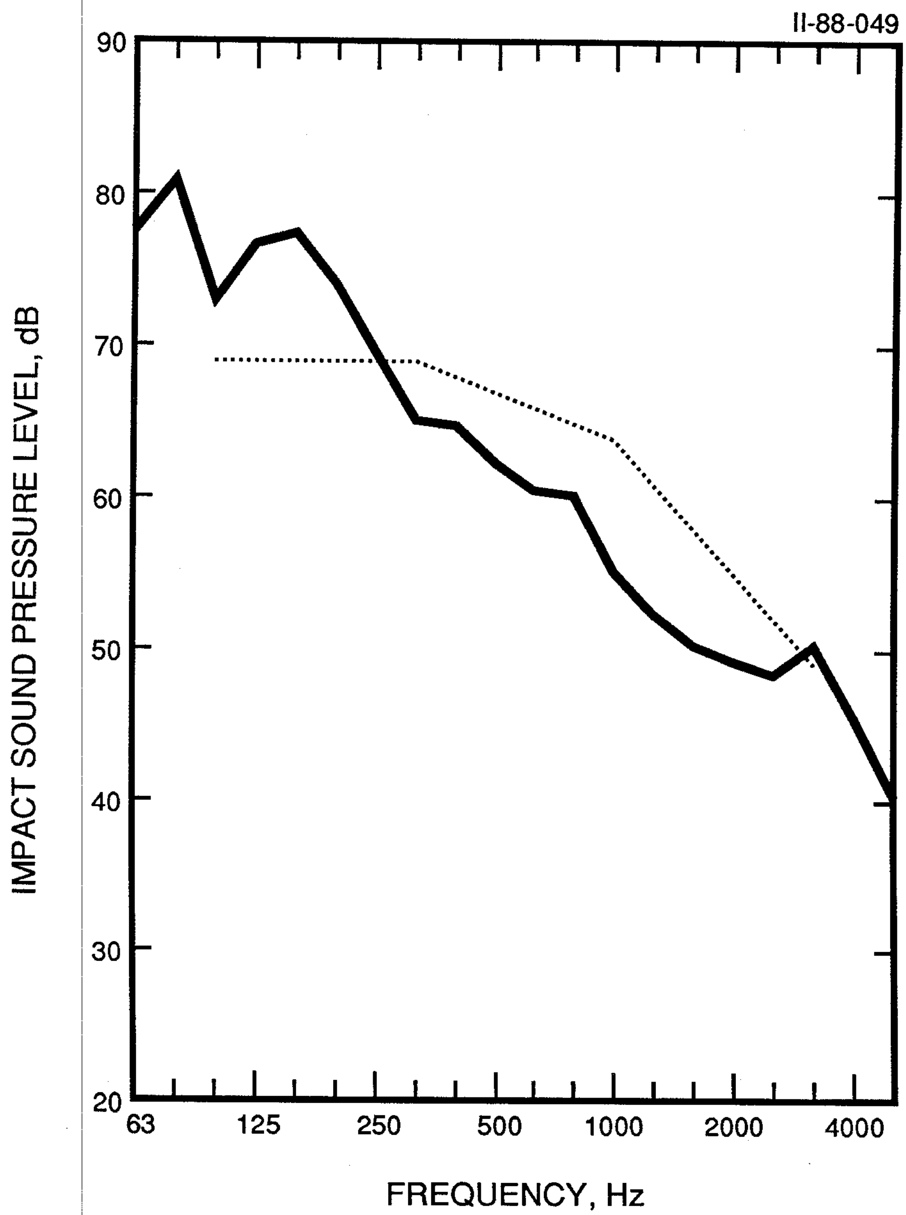


Frequency (Hz)	Transmission Loss (dB)
63	20
80	16
100	23
125	25
160	23
200	30
250	38
315	44
400	47
500	48
630	53
800	54
1000	57
1250	60
1600	60
2000	59
2500	57
3150	53
4000	56
5000	61
6300	65

STC 44

Floor 7c: TL-88-507

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- Trebord 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

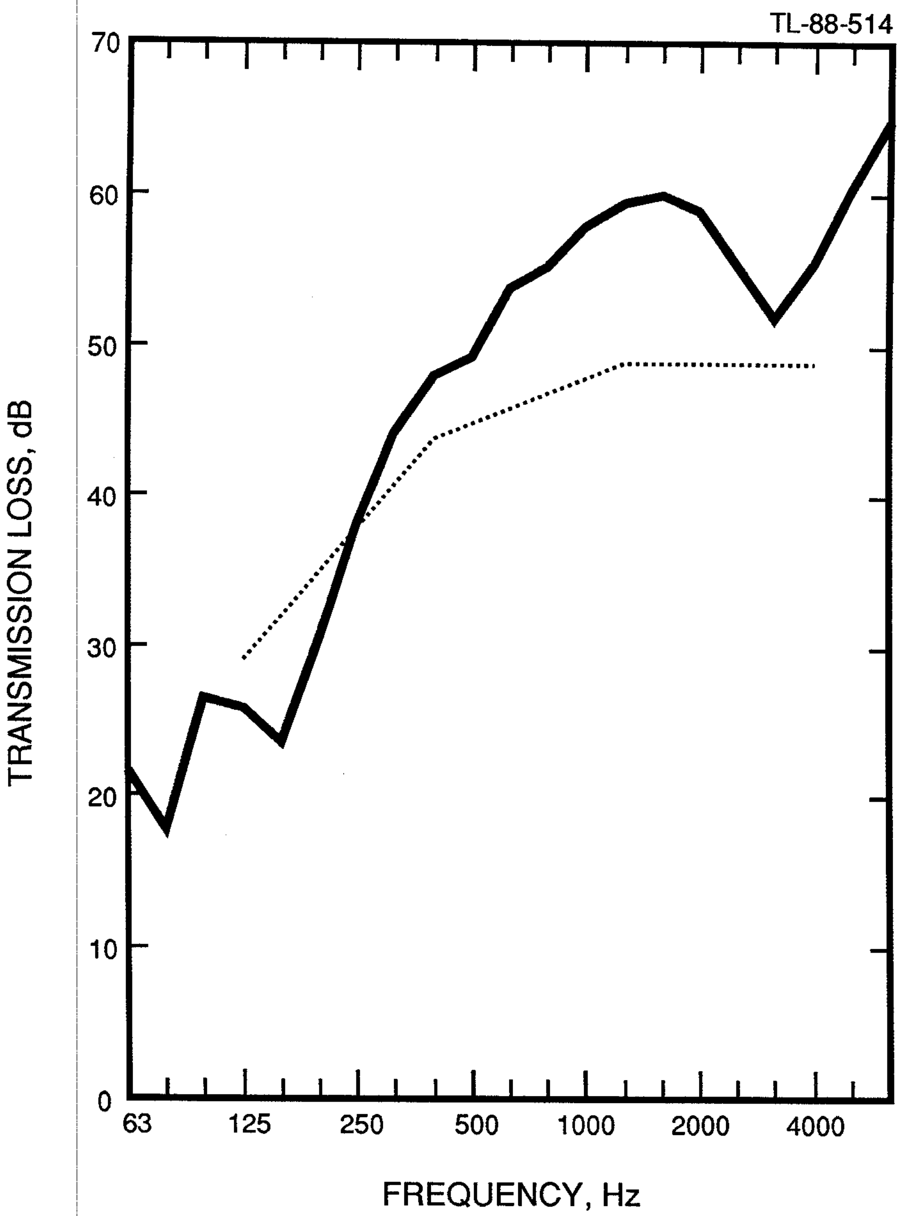


Frequency (Hz)	Impact SPL (dB)
63	78
80	81
100	73
125	77
160	77
200	74
250	70
315	65
400	65
500	62
630	61
800	60
1000	55
1250	52
1600	50
2000	49
2500	48
3150	50
4000	46
5000	40

IIC 43

Floor 7c: II-88-49

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- Trebord 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

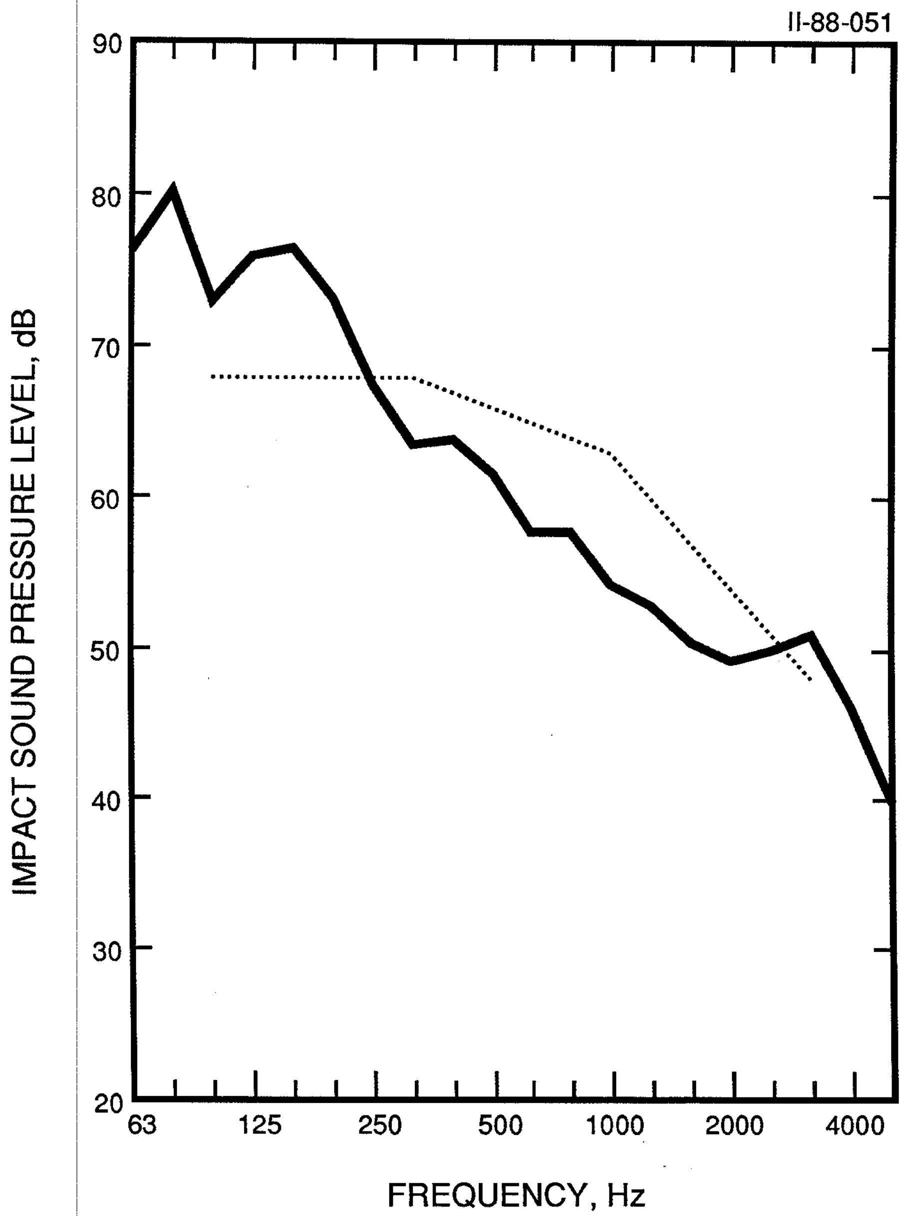


Frequency (Hz)	Transmission Loss (dB)
63	22
80	18
100	26
125	26
160	24
200	30
250	38
315	44
400	48
500	49
630	54
800	55
1000	58
1250	60
1600	60
2000	59
2500	55
3150	52
4000	56
5000	61
6300	65

STC 45

Floor 7d: TL-88-514

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

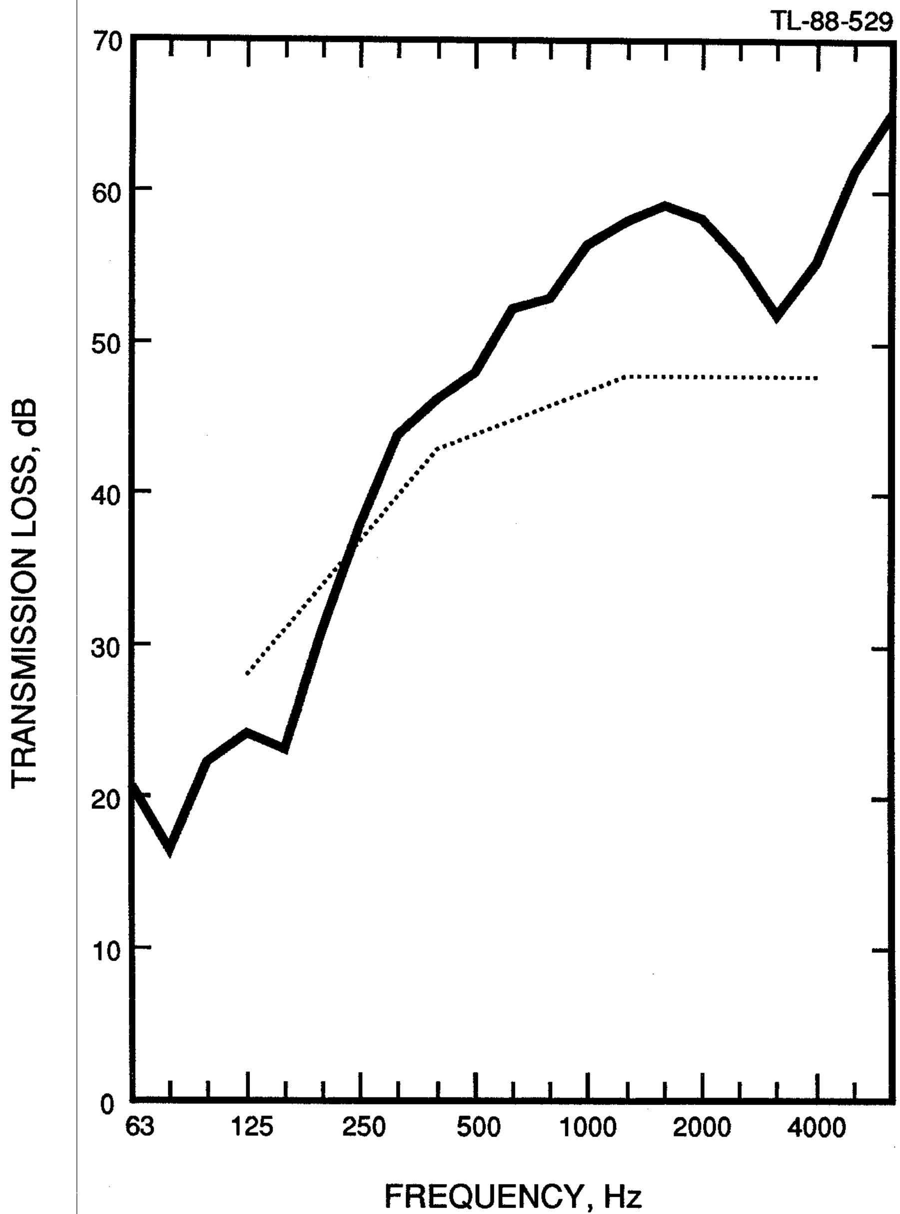


Frequency (Hz)	Impact SPL (dB)
63	76
80	80
100	73
125	76
160	77
200	73
250	67
315	64
400	64
500	62
630	58
800	58
1000	54
1250	53
1600	50
2000	49
2500	50
3150	51
4000	46
5000	40

IIC 44

Floor 7d: II-88-51

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

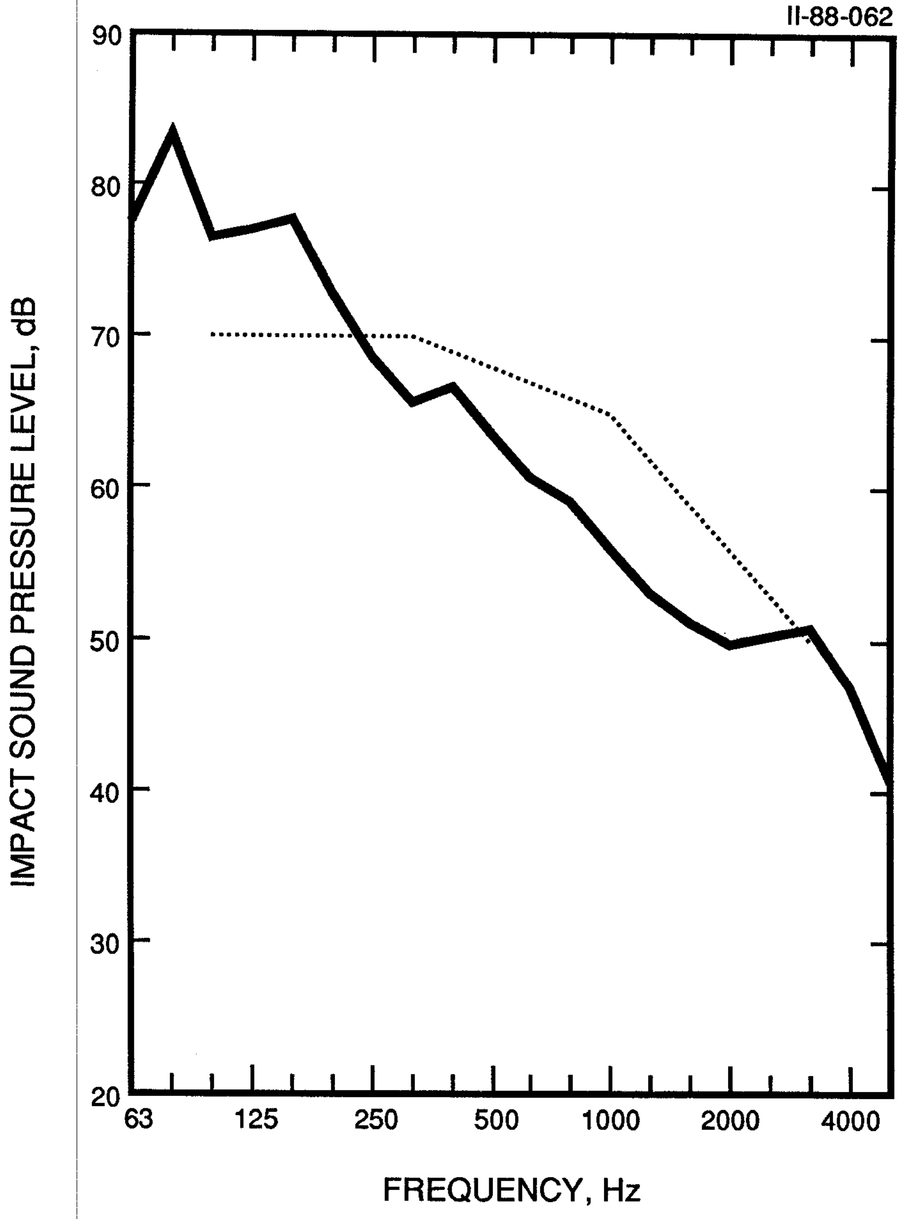


Frequency (Hz)	Transmission Loss (dB)
63	21
80	17
100	22
125	24
160	23
200	31
250	38
315	44
400	46
500	48
630	52
800	53
1000	57
1250	58
1600	59
2000	58
2500	56
3150	52
4000	55
5000	61
6300	65

STC 44

Floor 7e: TL-88-529

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

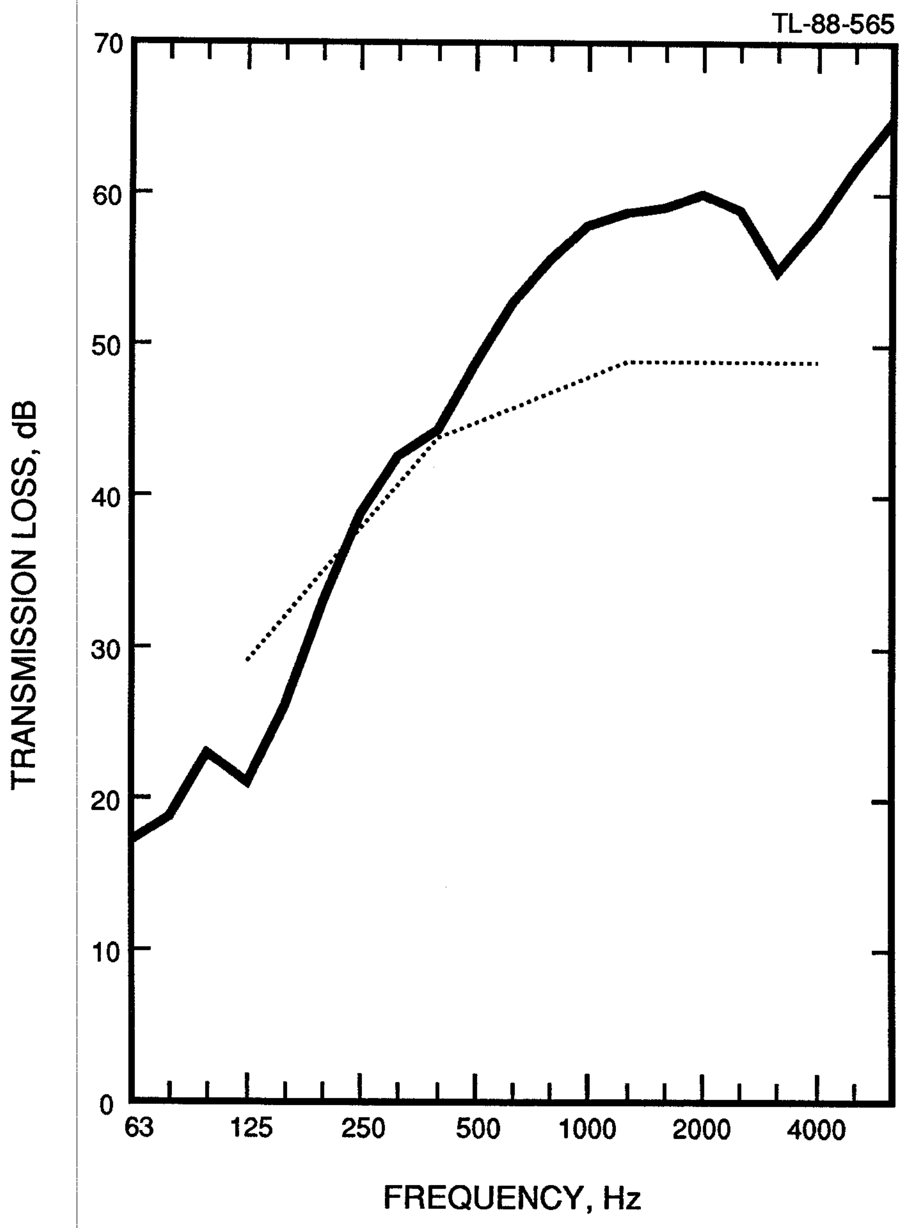


Frequency (Hz)	Impact SPL (dB)
63	78
80	83
100	77
125	77
160	78
200	73
250	69
315	66
400	67
500	64
630	61
800	59
1000	56
1250	53
1600	51
2000	50
2500	50
3150	51
4000	47
5000	41

IIC 42

Floor 7e: II-88-62

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed to the joists @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

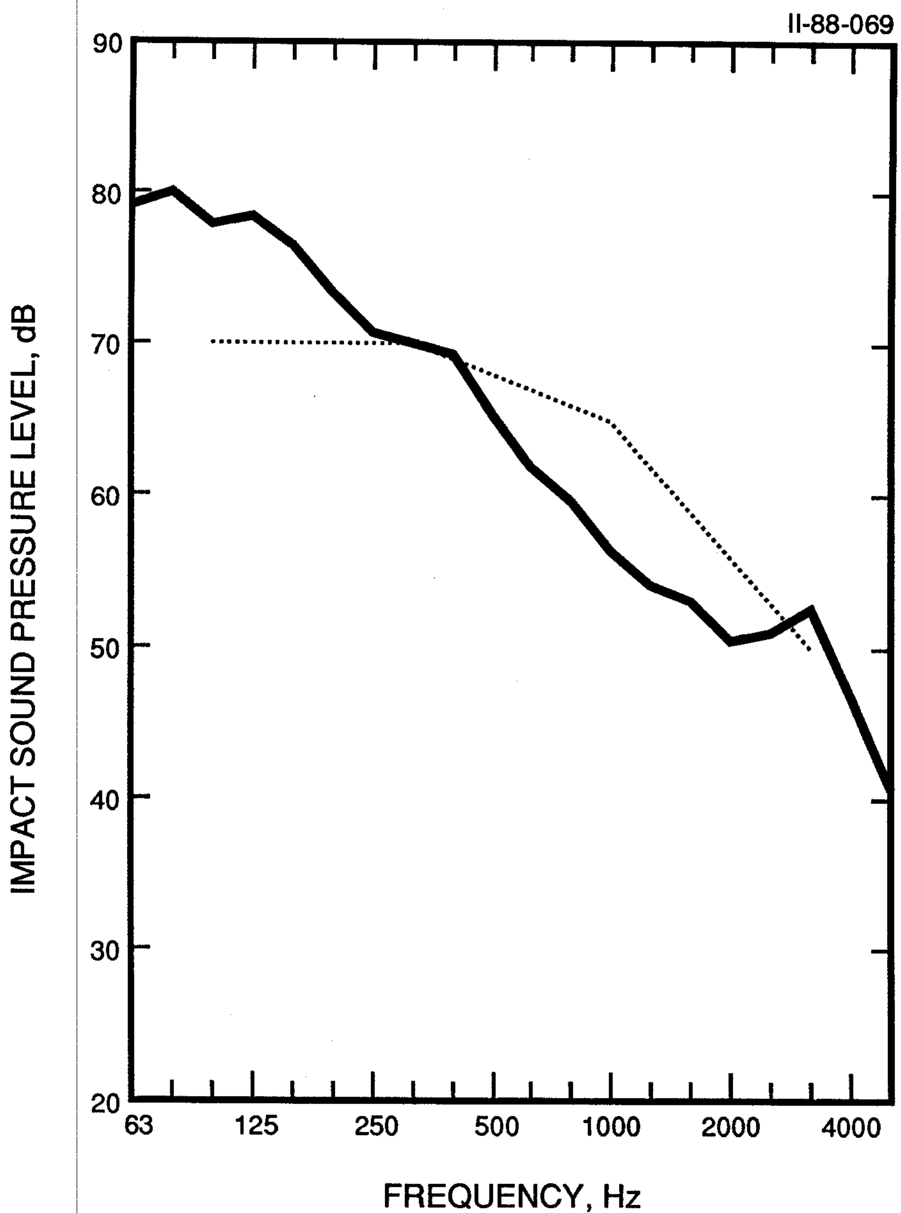


Frequency (Hz)	Transmission Loss (dB)
63	17
80	19
100	23
125	21
160	26
200	33
250	39
315	43
400	45
500	49
630	53
800	56
1000	58
1250	59
1600	59
2000	60
2500	59
3150	55
4000	58
5000	62
6300	65

STC 45

Floor 7f: TL-88-565

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed to the parallel to the joists @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

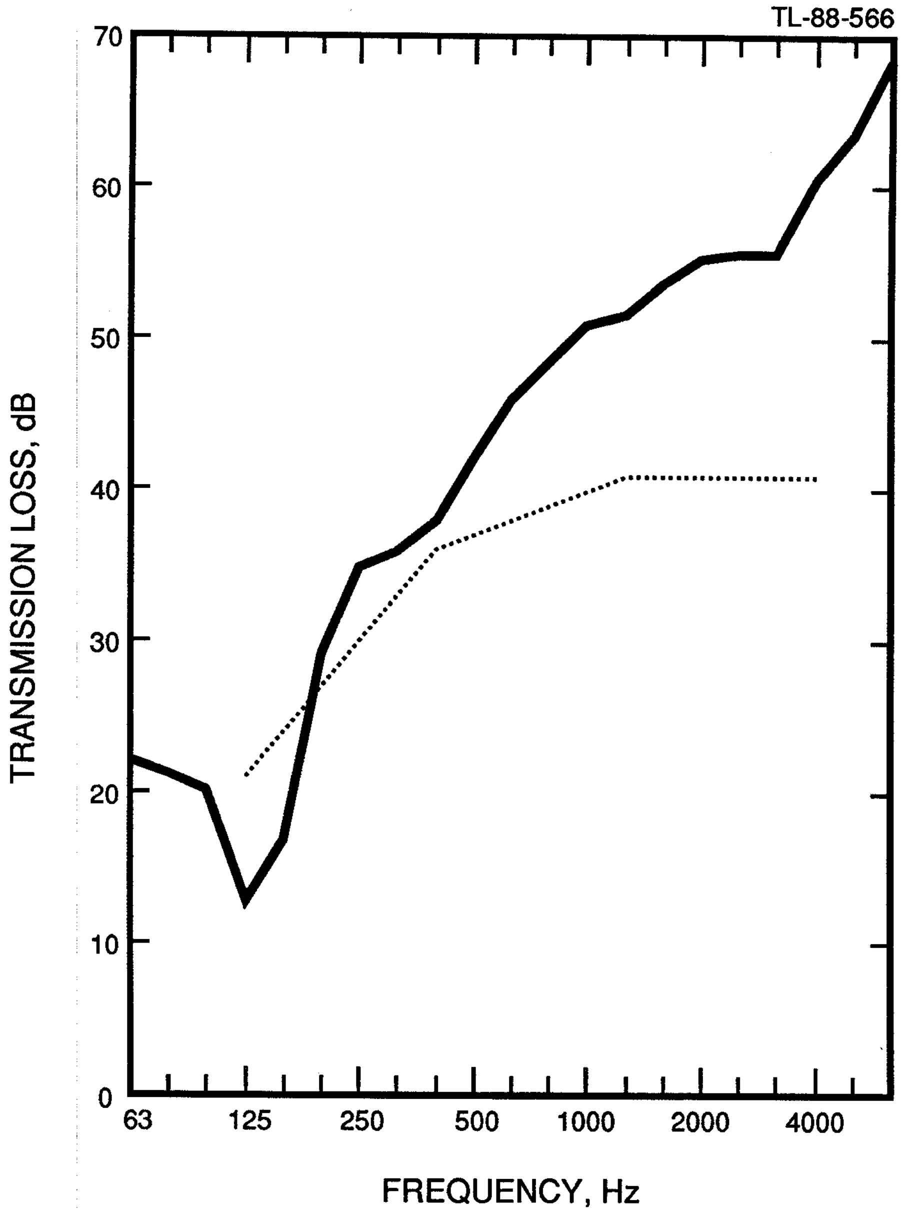


Frequency (Hz)	Impact SPL (dB)
63	79
80	80
100	78
125	79
160	77
200	73
250	71
315	70
400	69
500	65
630	62
800	60
1000	56
1250	54
1600	53
2000	51
2500	51
3150	53
4000	47
5000	41

IIC 42

Floor 7f: II-88-69

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- CGC RC-1 1/2 in. deep resilient metal furring screwed parallel to the to the joists @ 16 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.0 lbs/ft^2 (34.0 kg/m^2)

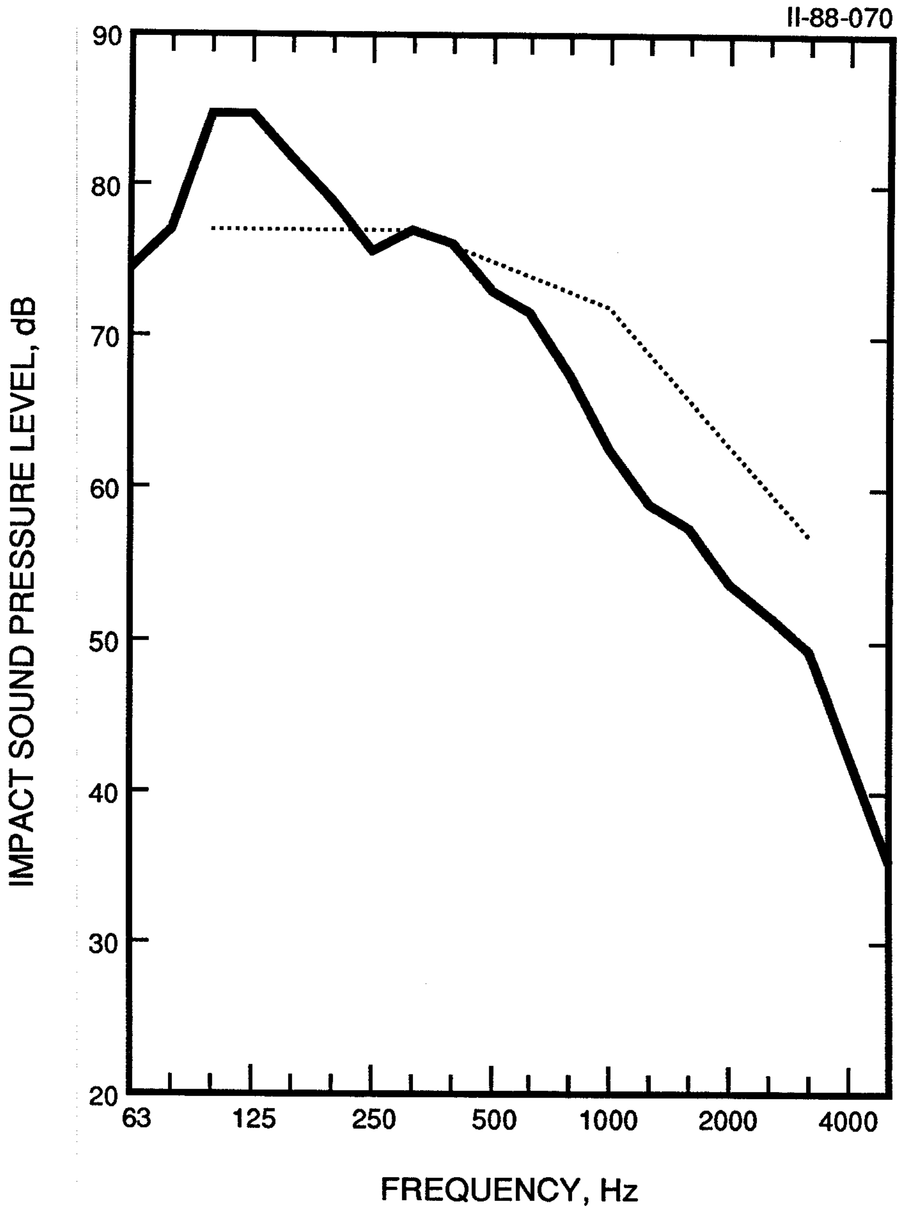


Frequency (Hz)	Transmission Loss (dB)
63	22
80	21
100	20
125	13
160	17
200	29
250	35
315	36
400	38
500	42
630	46
800	48
1000	51
1250	52
1600	54
2000	55
2500	56
3150	56
4000	61
5000	64
6300	68

STC 37

Floor 8: TL-88-566

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 2 × 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 8.8 lbs/ft^2 (43.0 kg/m^2)

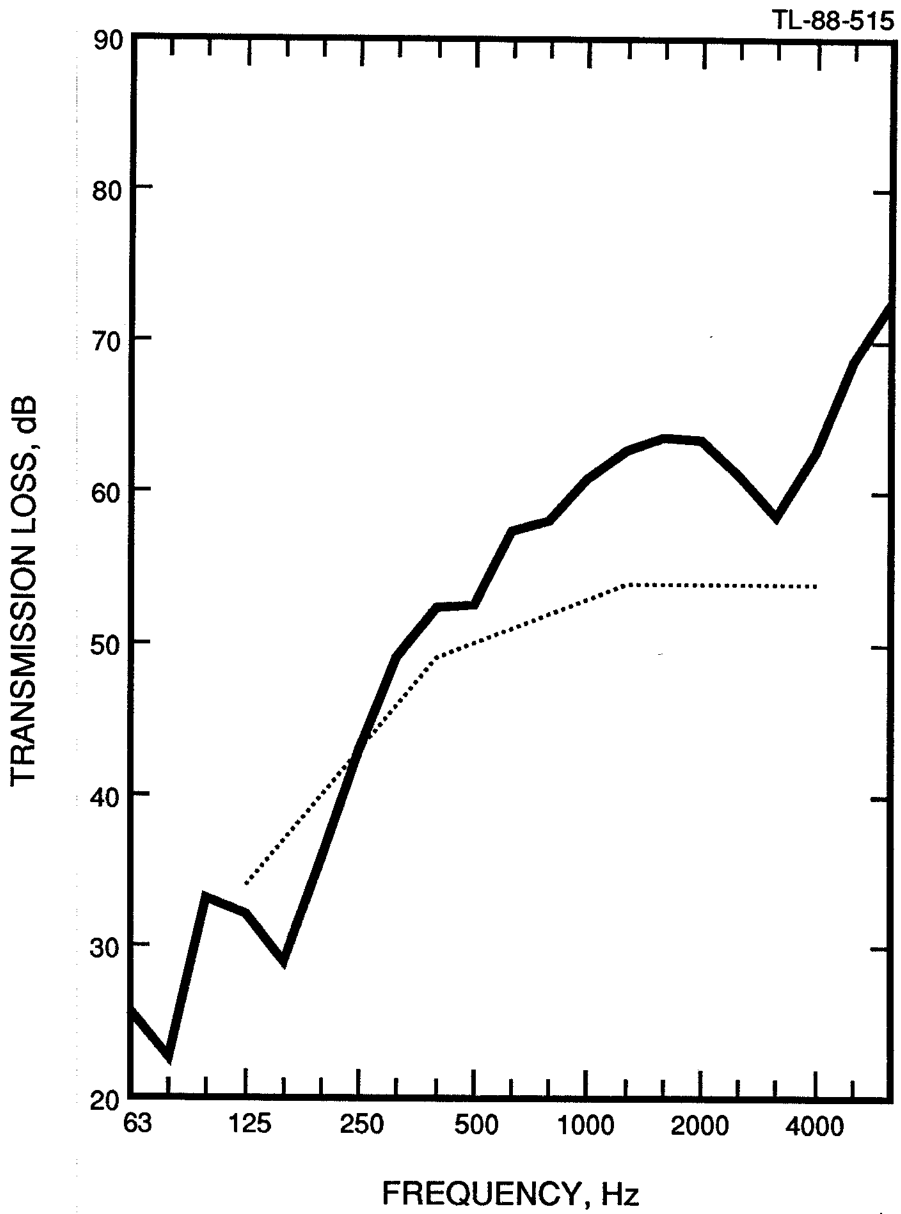


Frequency (Hz)	Impact SPL (dB)
63	75
80	77
100	85
125	85
160	82
200	79
250	76
315	77
400	76
500	73
630	72
800	68
1000	63
1250	59
1600	58
2000	54
2500	52
3150	49
4000	42
5000	35

IIC 35

Floor 8: II-88-70

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 1 in. × 2 in. wood furring strips @ 24 in. c.c.
- 2 × 1/2 in. gypsum board screwed to the 1 in. × 2 in. wood furring
- Weight/Unit Area = 8.8 lbs/ft^2 (43.0 kg/m^2)

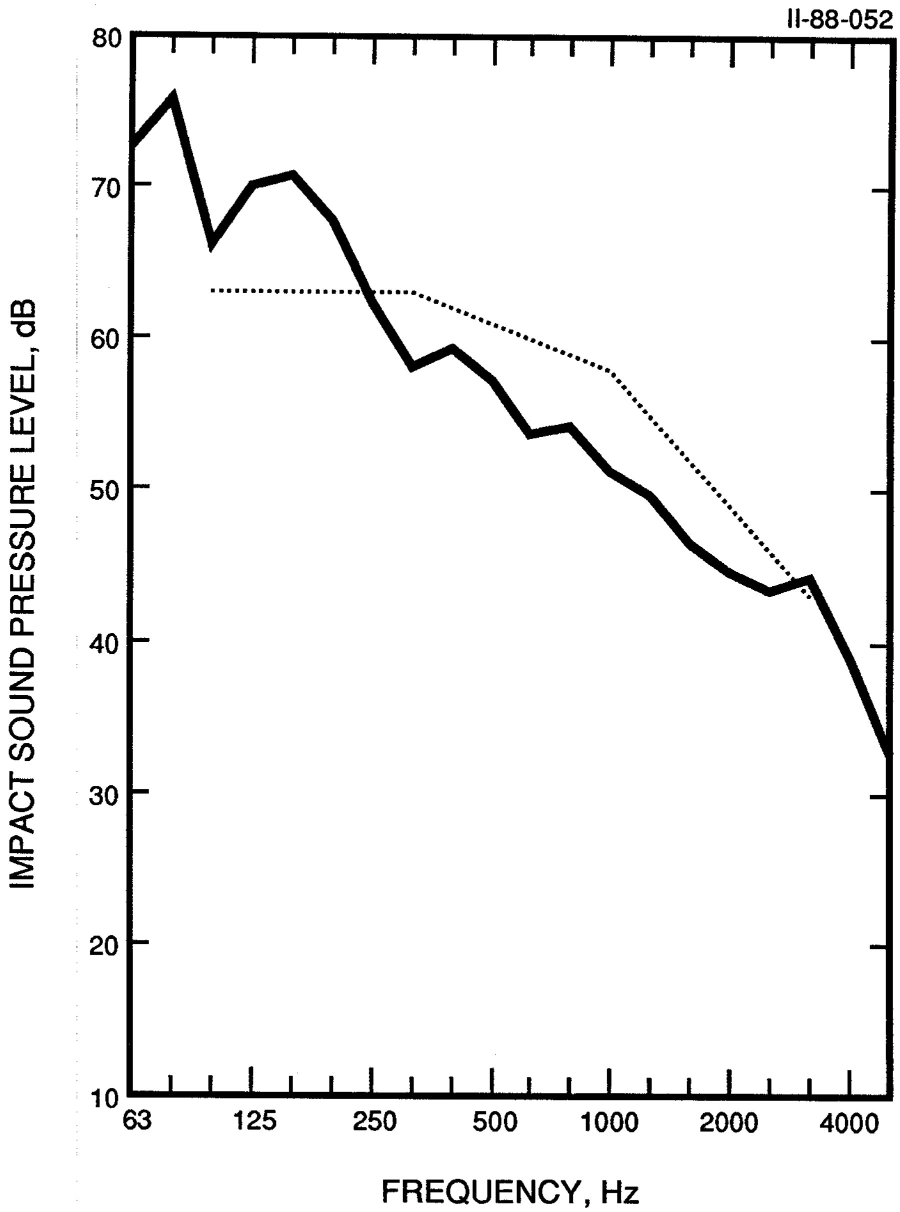


Frequency (Hz)	Transmission Loss (dB)
63	26
80	23
100	33
125	32
160	29
200	36
250	43
315	49
400	52
500	53
630	57
800	58
1000	61
1250	63
1600	64
2000	64
2500	61
3150	59
4000	63
5000	69
6300	73

STC 50

Floor 9: **TL-88-515**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 2 × 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 8.7 lbs/ft^2 (42.6 kg/m^2)

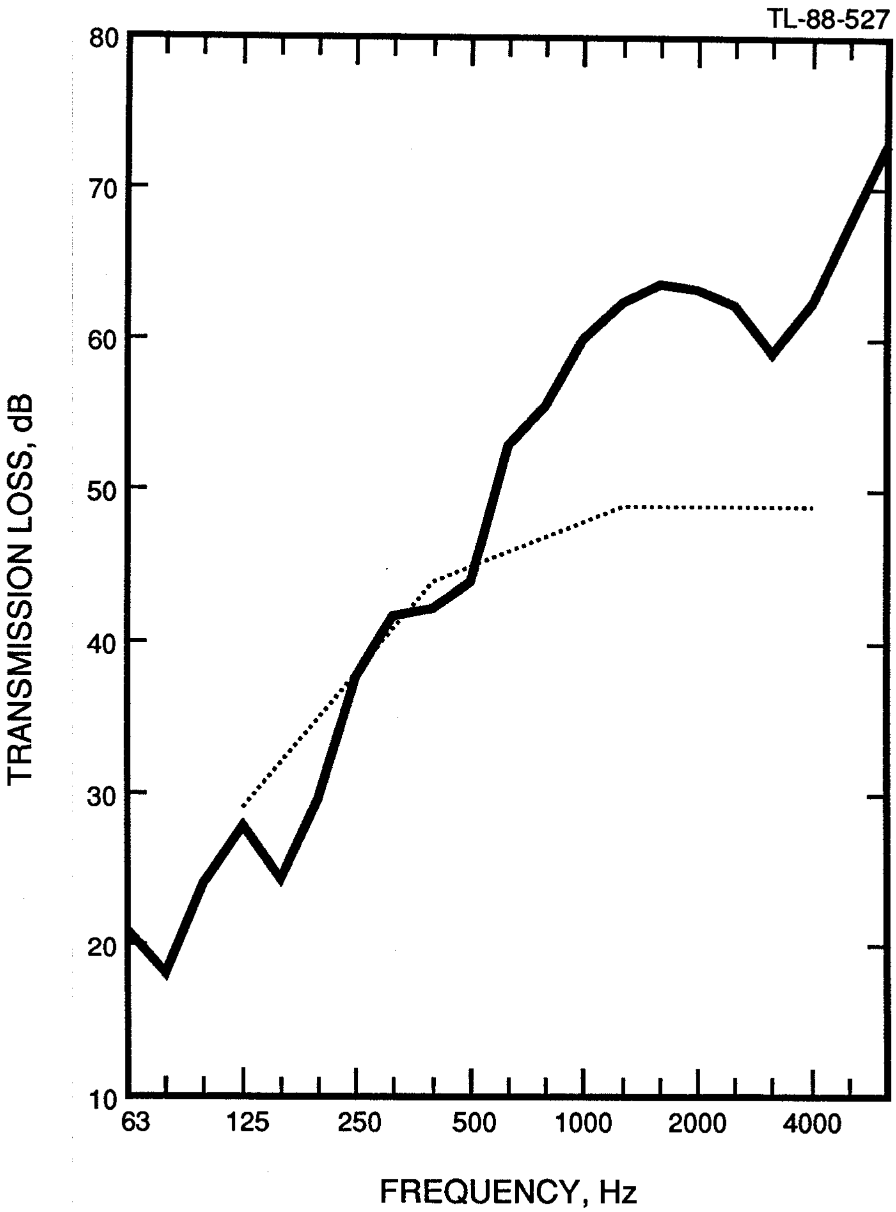


Frequency (Hz)	Impact SPL (dB)
63	73
80	76
100	66
125	70
160	71
200	68
250	62
315	58
400	59
500	57
630	54
800	54
1000	51
1250	50
1600	47
2000	45
2500	44
3150	44
4000	39
5000	33

IIC 49

Floor 9: II-88-52

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 2 × 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 8.7 lbs/ft^2 (42.6 kg/m^2)

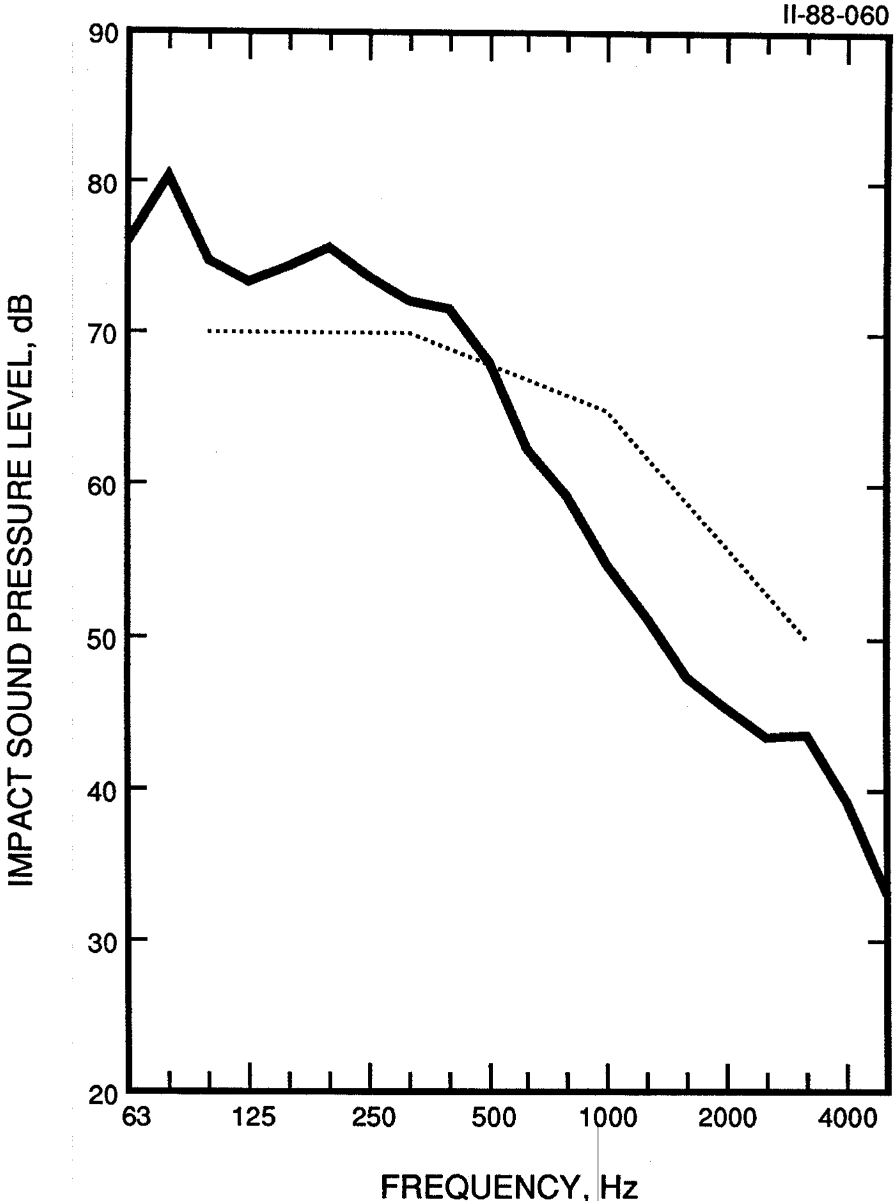


Frequency (Hz)	Transmission Loss (dB)
63	21
80	18
100	24
125	28
160	24
200	30
250	38
315	42
400	42
500	44
630	53
800	56
1000	60
1250	63
1600	64
2000	63
2500	62
3150	59
4000	63
5000	68
6300	73

STC 45

Floor 10: TL-88-527

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1/2 in. wood fiber board screwed directly to the underside of the joists
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.6 lbs/ft^2 (37.0 kg/m^2)

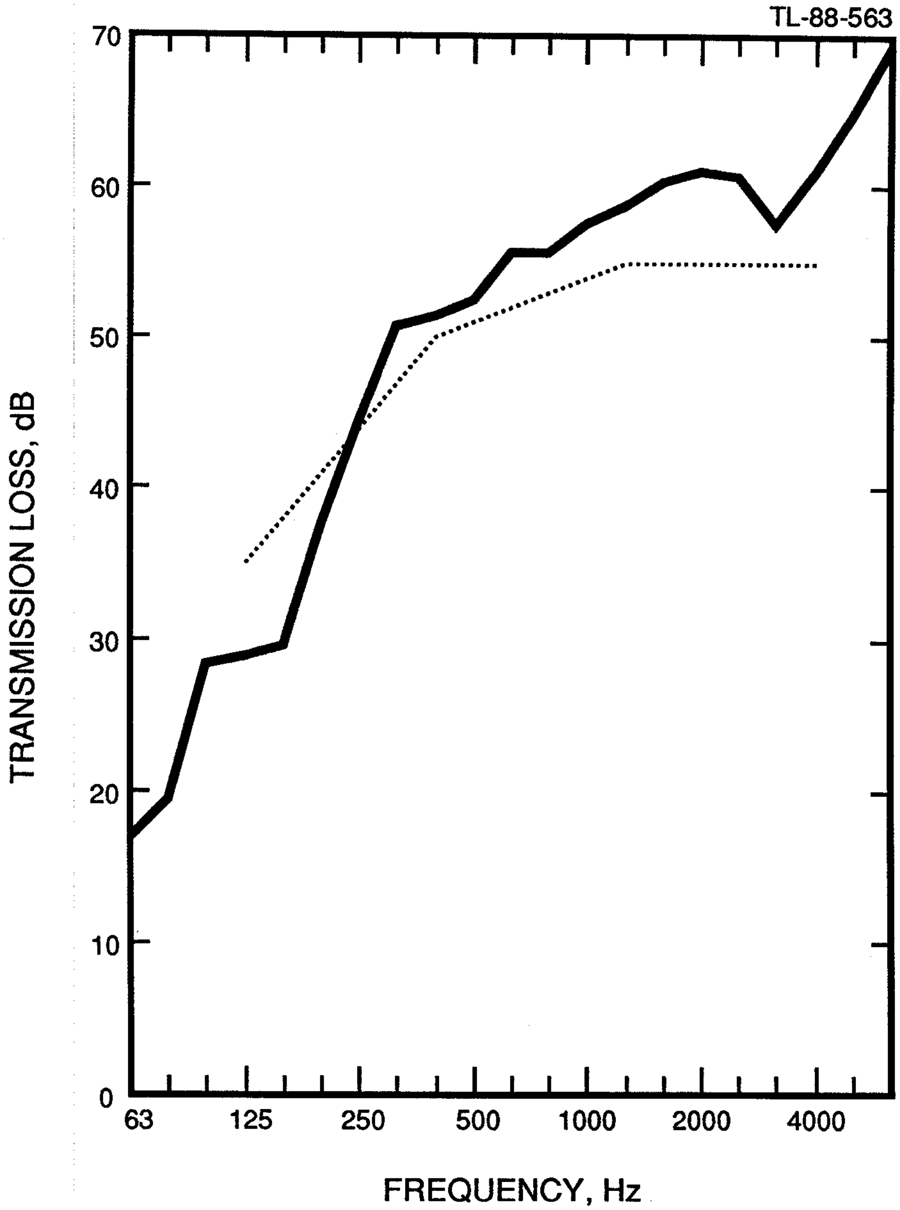


Frequency (Hz)	Impact SPL (dB)
63	76
80	80
100	75
125	73
160	74
200	76
250	74
315	72
400	72
500	68
630	63
800	59
1000	55
1250	51
1600	47
2000	45
2500	44
3150	44
4000	39
5000	33

IIC 42

Floor 10: II-88-60

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 1/2 in. wood fiber board screwed directly to the underside of the joists
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.6 lbs/ft^2 (37.0 kg/m^2)

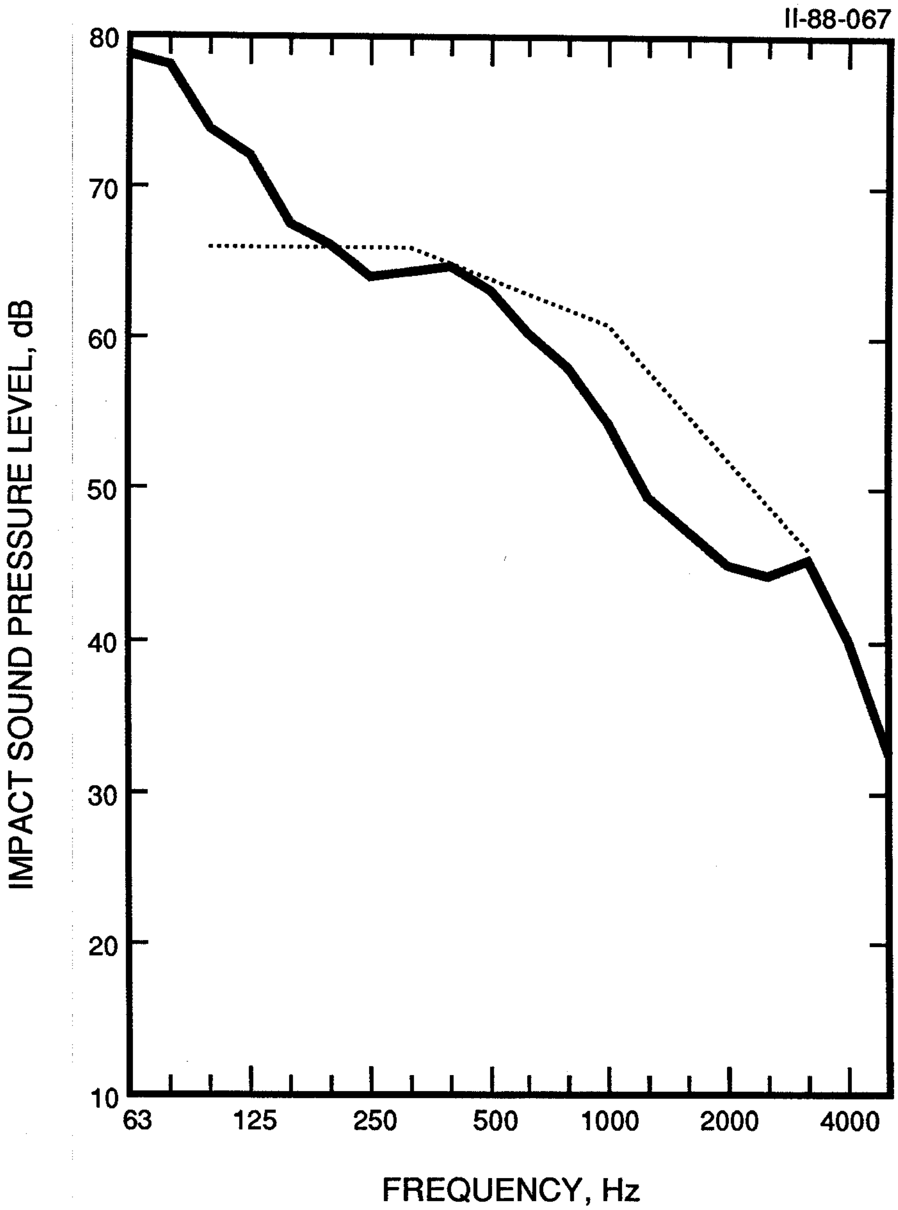


Frequency (Hz)	Transmission Loss (dB)
63	17
80	20
100	28
125	29
160	30
200	38
250	45
315	51
400	52
500	53
630	56
800	56
1000	58
1250	59
1600	60
2000	61
2500	61
3150	58
4000	61
5000	65
6300	69

STC 51

Floor 11a: TL-88-563

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 layers of 3 1/2 in. glass fiber batt insulation
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.4 lbs/ft^2 (36.1 kg/m^2)

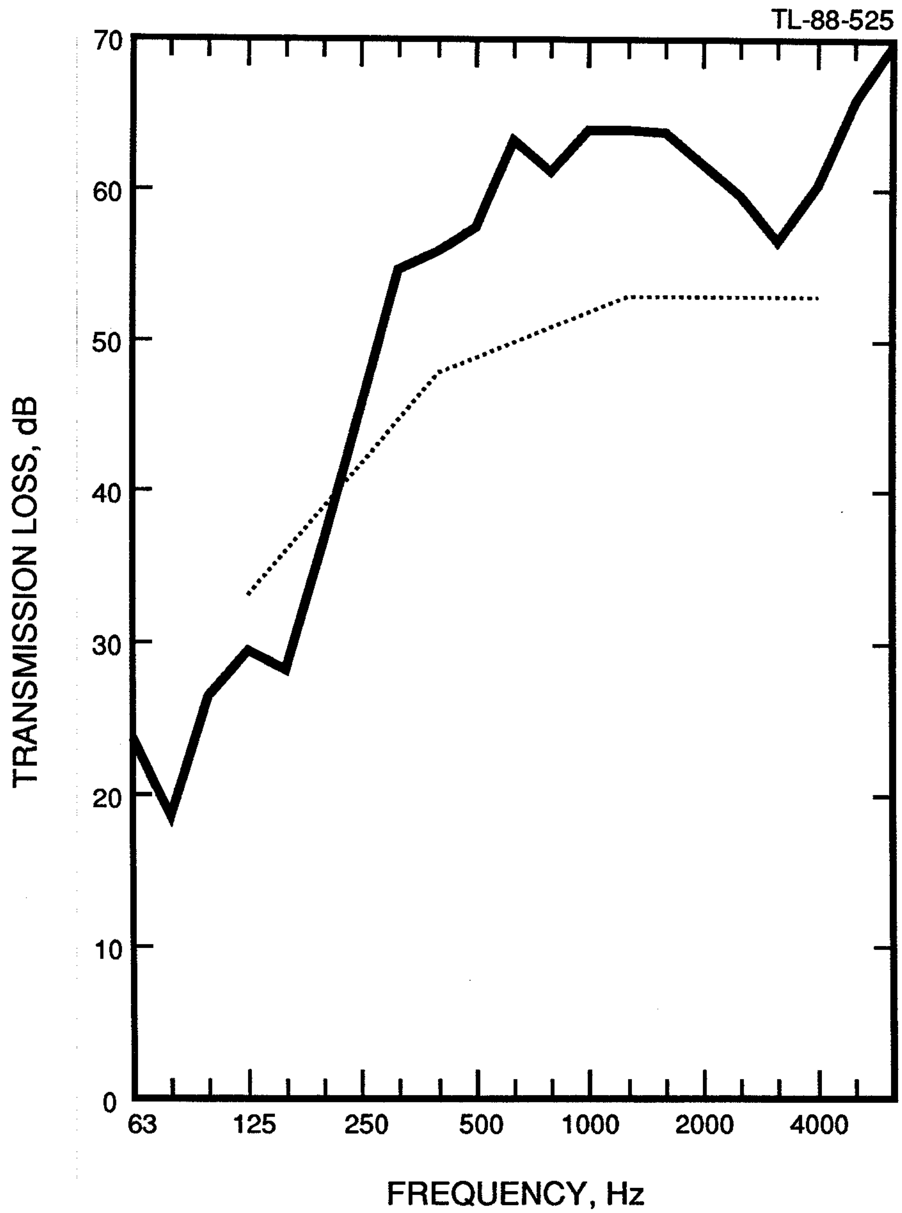


Frequency (Hz)	Impact SPL (dB)
63	79
80	78
100	74
125	72
160	68
200	66
250	64
315	65
400	65
500	63
630	60
800	58
1000	55
1250	50
1600	47
2000	45
2500	44
3150	45
4000	40
5000	33

IIC 46

Floor 11a: II-88-67

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 layers of 3 1/2 in. glass fiber batt insulation
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 7.4 lbs/ft^2 (36.1 kg/m^2)

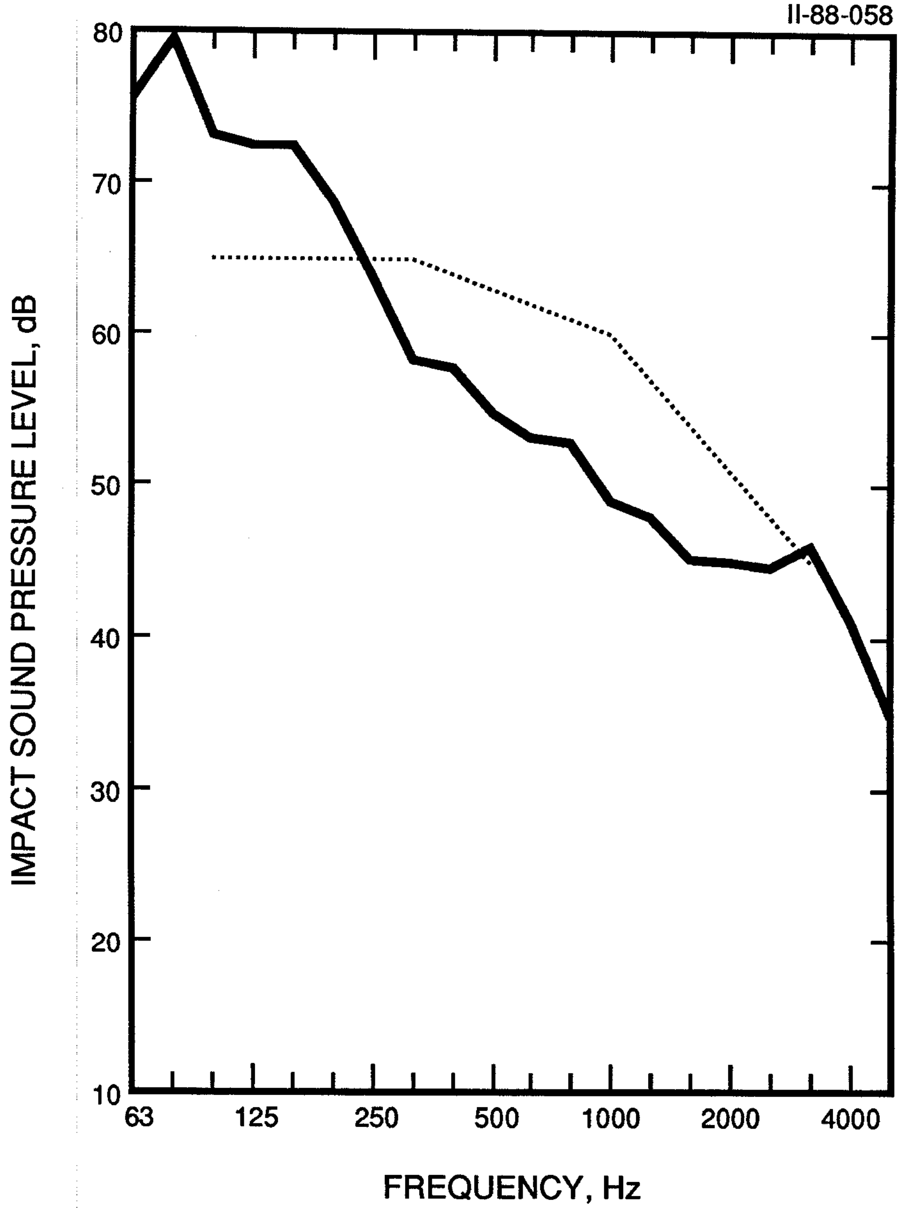


Frequency (Hz)	Transmission Loss (dB)
63	24
80	19
100	26
125	29
160	28
200	37
250	46
315	55
400	56
500	58
630	63
800	61
1000	64
1250	64
1600	64
2000	62
2500	60
3150	57
4000	60
5000	66
6300	70

STC 49

Floor 11b: **TL-88-525**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cavity filled with cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - 58.0 kg/m³ (3.6 lb/ft³)
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.4 lbs/ft² (46.0 kg/m²)

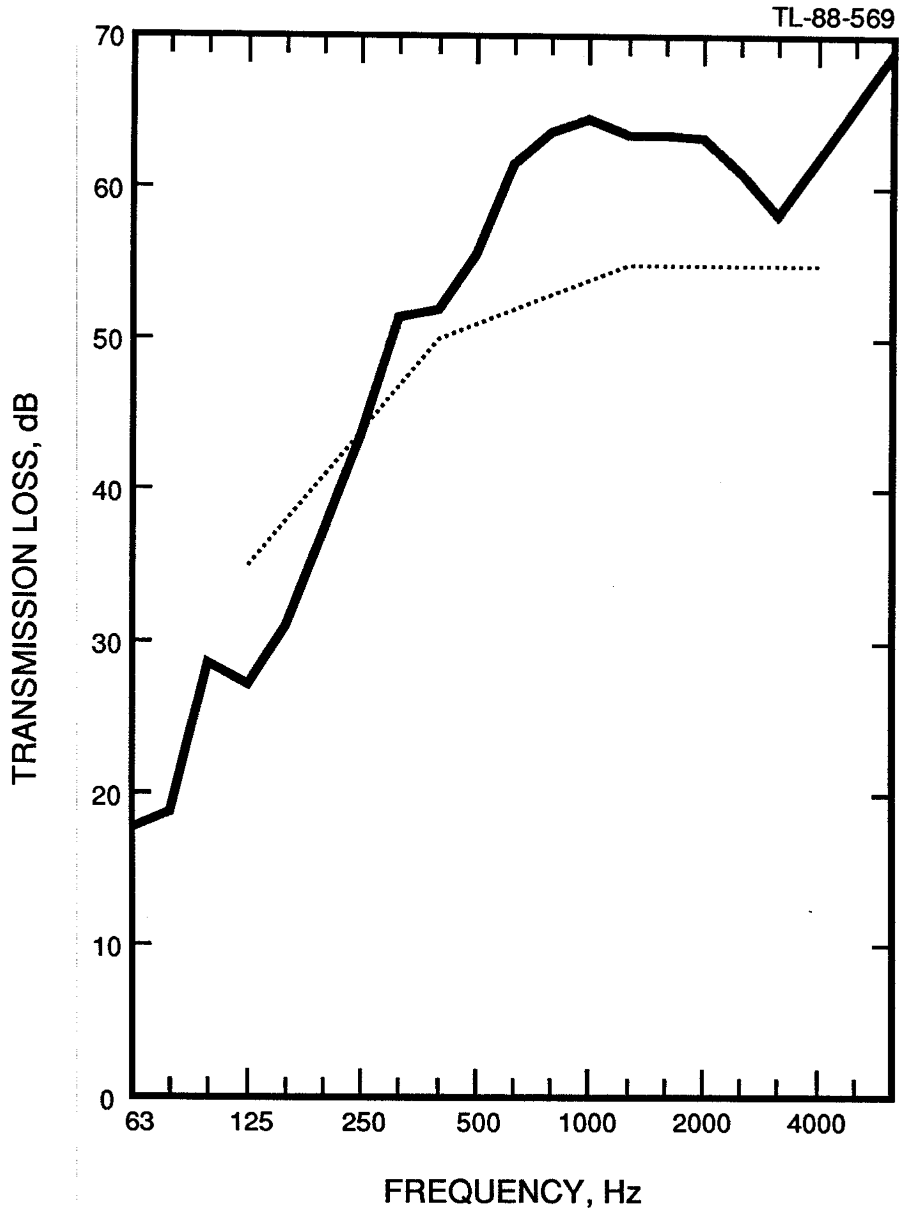


Frequency (Hz)	Impact SPL (dB)
63	76
80	80
100	73
125	72
160	72
200	69
250	64
315	58
400	58
500	55
630	53
800	53
1000	49
1250	48
1600	45
2000	45
2500	45
3150	46
4000	41
5000	35

IIC 47

Floor 11b: II-88-58

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cavity filled with cellulose blown-in attic insulation: WEATHERSHIELD by Thermo-Cell Insulation Ltd. - 58.0 kg/m³ (3.6 lb/ft³)
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.4 lbs/ft² (46.0 kg/m²)

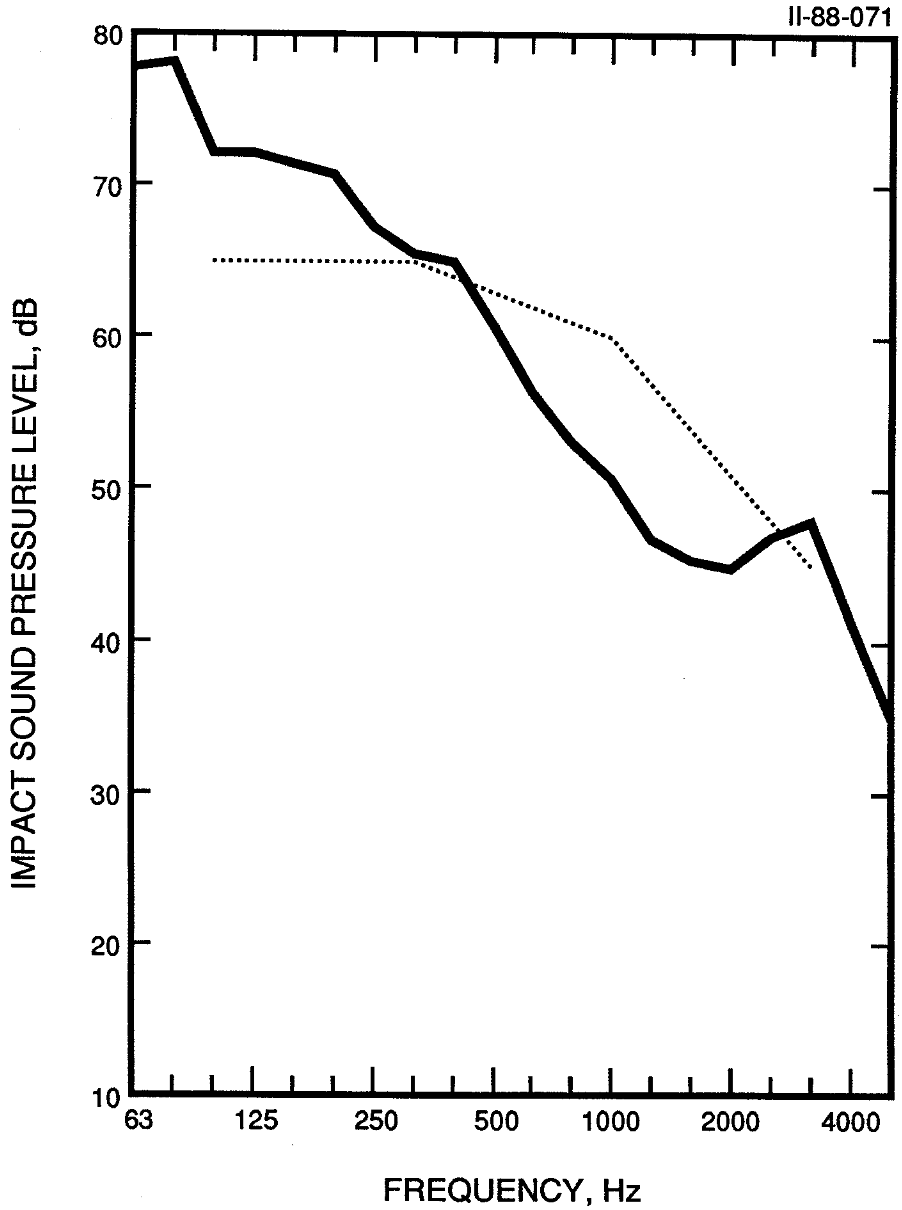


Frequency (Hz)	Transmission Loss (dB)
63	18
80	19
100	29
125	27
160	31
200	37
250	44
315	51
400	52
500	56
630	62
800	64
1000	65
1250	64
1600	64
2000	63
2500	61
3150	58
4000	62
5000	65
6300	69

STC 51

Floor 11c: TL-88-569

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cavity filled with acoustical blown-in insulation: BENOCOUSTICS by Benolec - 59.0 kg/m^3 (3.7 lb/ft^3)
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.4 lbs/ft^2 (46.0 kg/m^2)

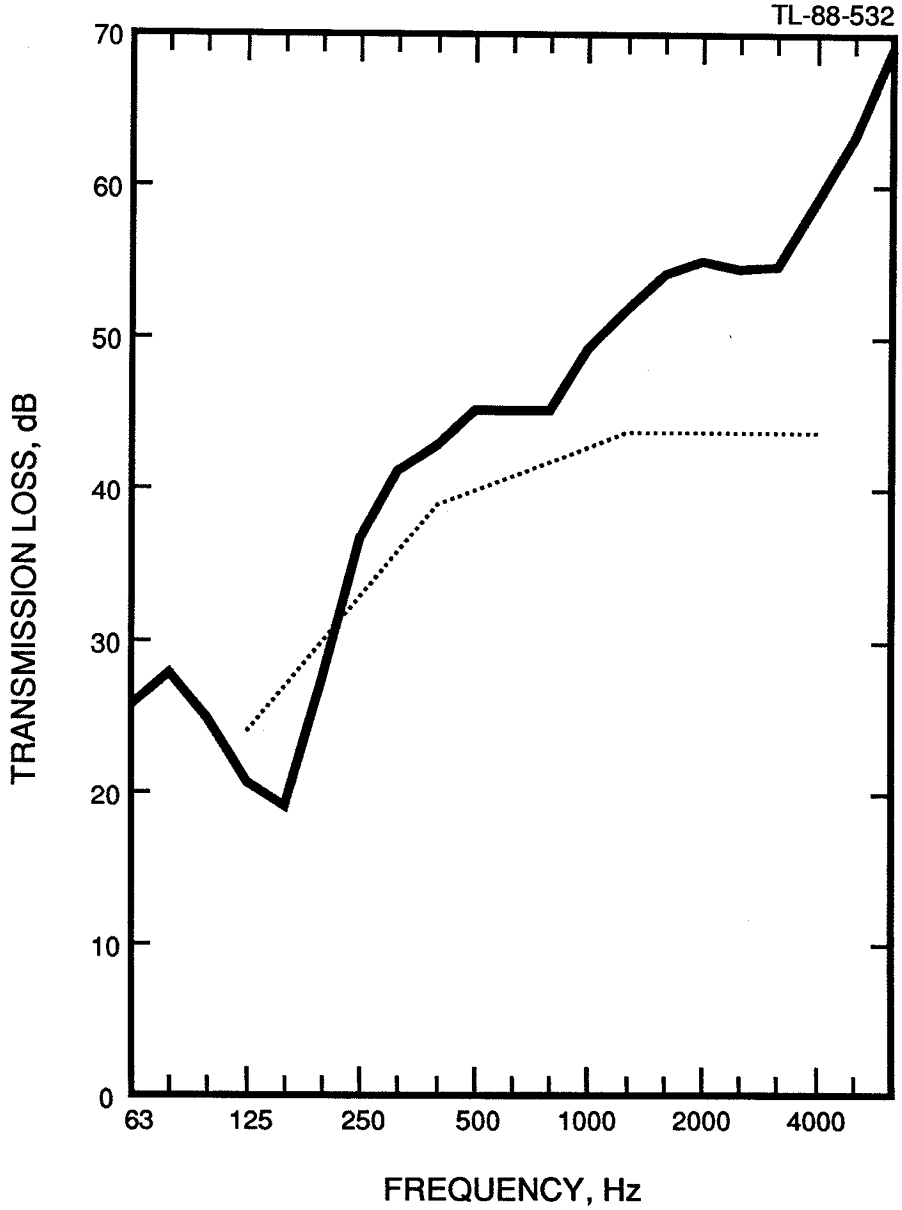


Frequency (Hz)	Impact SPL (dB)
63	78
80	78
100	72
125	72
160	72
200	71
250	67
315	65
400	65
500	61
630	57
800	53
1000	51
1250	47
1600	45
2000	45
2500	47
3150	48
4000	41
5000	35

IIC 47

Floor 11c: II-88-71

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- cavity filled with acoustical blown-in insulation: BENOCOUSTICS by Benolec - 59.0 kg/m^3 (3.7 lb/ft^3)
- resilient furring RC-1 by CGC, screwed to the joists @ 24 in. c.c.
- 1/2 in. gypsum board screwed to the resilient furring
- Weight/Unit Area = 9.4 lbs/ft^2 (46.0 kg/m^2)

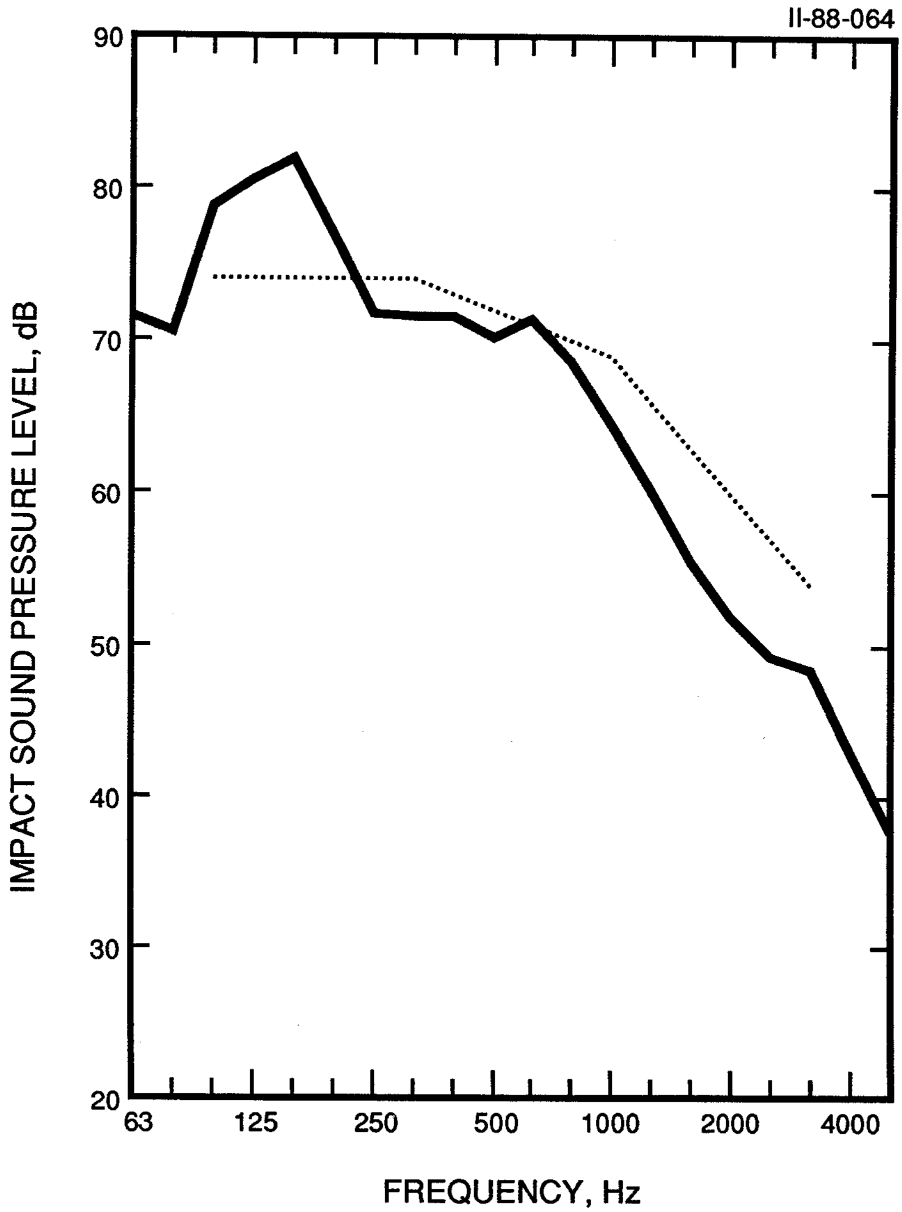


Frequency (Hz)	Transmission Loss (dB)
63	26
80	28
100	25
125	21
160	19
200	27
250	37
315	41
400	43
500	45
630	45
800	45
1000	49
1250	52
1600	54
2000	55
2500	55
3150	55
4000	59
5000	63
6300	69

STC 40

Floor 12: **TL-88-532**

- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 2 in. × 6 in. ceiling joists supported by the common 2 in. × 10 in. plate at the perimeter of the test opening
- 1/2 in. gypsum board screwed directly to the ceiling joists
- Weight/Unit Area = 8.2 lbs/ft^2 (40.0 kg/m^2)



Frequency (Hz)	Impact SPL (dB)
63	72
80	71
100	79
125	81
160	82
200	77
250	72
315	72
400	72
500	70
630	71
800	69
1000	65
1250	60
1600	56
2000	52
2500	49
3150	48
4000	43
5000	38

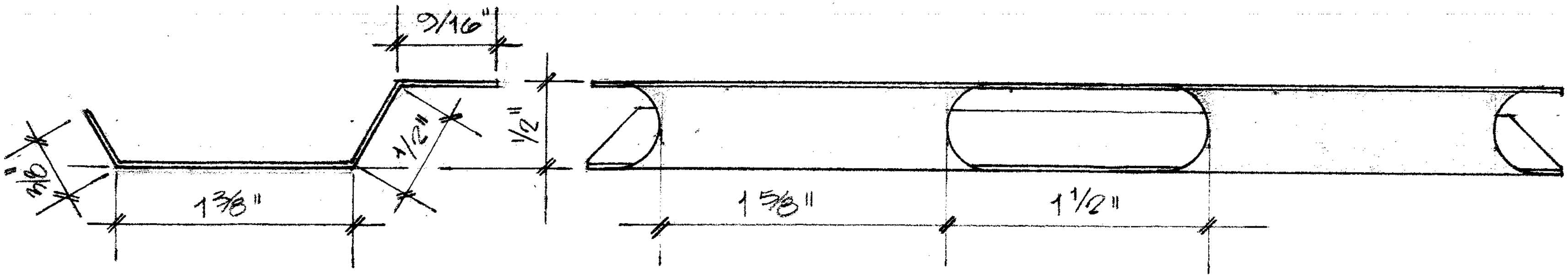
IIC 38

Floor 12: **II-88-64**

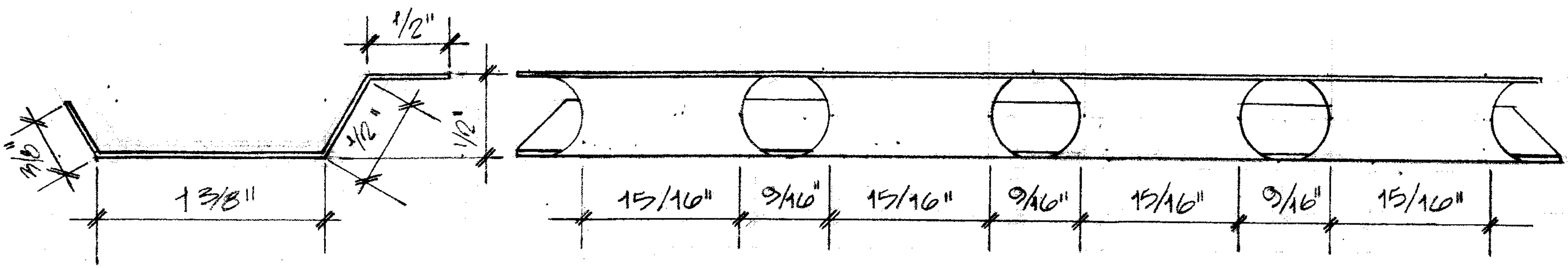
- 5/8 in. thick plywood
- 2 in. × 10 in. joists @ 16 in. c.c.
- 3 1/2 in. glass fiber batt insulation between floor joists
- 2 in. × 6 in. ceiling joists supported by the common 2 in. × 10 in. plate at the perimeter of the test opening
- 1/2 in. gypsum board screwed directly to the ceiling joists
- Weight/Unit Area = 8.2 lbs/ft^2 (40.0 kg/m^2)

ANNEX III

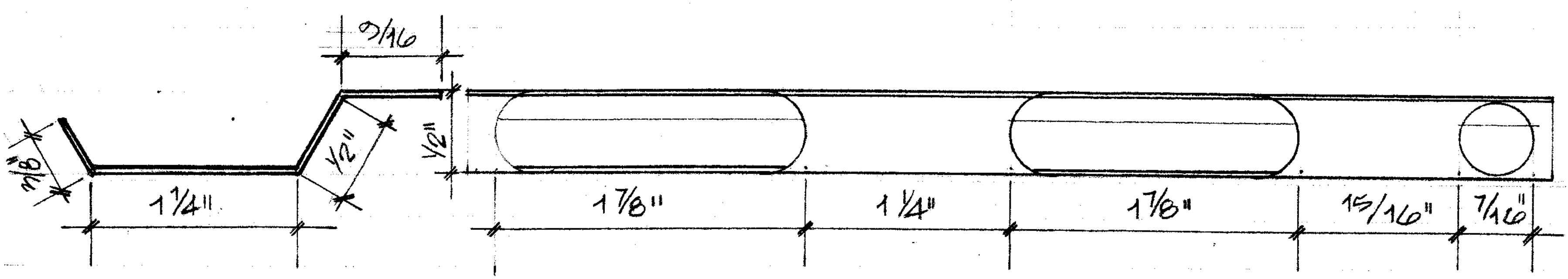
RESILIENT FURRINGS MANUFACTURED BY TREBORD



RESILIENT FURRINGS MANUFACTURED BY R. L. METALS

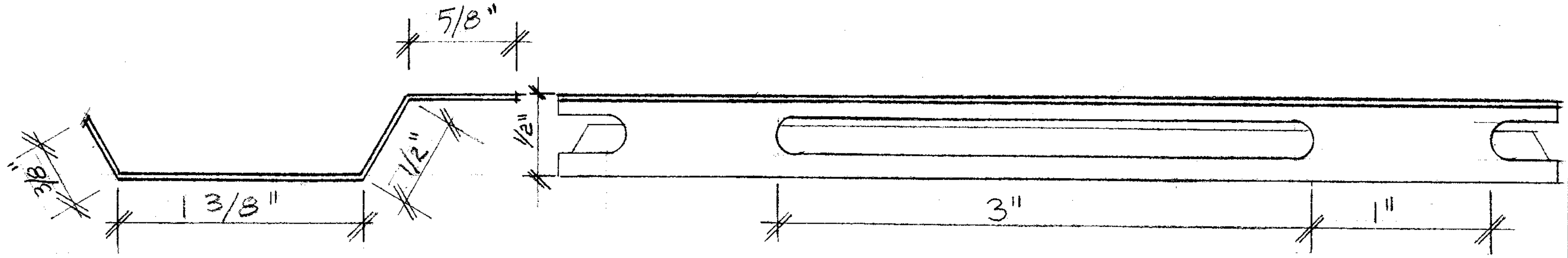


RESILIENT FURRINGS MANUFACTURED BY PICHETTE



mjm

RESILENT FURRINGS MANUFACTURED BY CGC



mjn