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RESEARCH PROJECT

ON PLUMBING NOISE IN MULTI-DWELLING BUILDINGS

ACKNOWLEDGEMENTS

The author wishes to thank the manufacturers who accepted to participate in this study.

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EXECUTIVE SUMMARY

RESEARCH PROJECT ON PLUMBING NOISE IN MULTI-DWELLING BUILDINGS

EXECUTIVE SUMMARY

MJM ACOUSTICAL CONSULTANTS INC. has been retained by the CANADA MORTGAGE AND HOUSING CORPORATION to conduct a research project on the noise produced by plumbing installations in multi-dwelling buildings. The main objective of this study was to investigate the acoustical performance of different plumbing installations using materials and techniques readily available in the construction industry. Over two hundred seventy-three (273) tests were conducted in the acoustical laboratories of the NATIONAL RESEARCH COUNCIL OF CANADA (NRCC) in Ottawa under the supervision of Doctor A.C.C. Warnock and under the direction of the undersigned.

The conclusions reached during this study are outlined in the paragraphs below.

- Using the ISO noise generator as a source, a variation of water pressure from 40 to 100 psi resulted in increases of 5, 7 and 9 dBA for pipe enclosure constructions of wood stud, metal stud, or studless partition respectively. However, when different faucets and water flows were used to generate plumbing noise, a 40 to 100 psi variation in water pressure resulted in an increase of plumbing noise level reaching 14 dBA. One must therefore conclude that in real installations, the water pressure is an important factor in the production of plumbing noise which should be taken into account during the design of plumbing system destined to multi-dwelling buildings.

- The results of the present study did not allow one to deduce that there would be a clear advantage to using pipes of a certain diameter in order to reduce the transmission of plumbing noise in multi-dwelling buildings.

- The material used to fabricate the pipes has an effect on the noise produced by the water flow. For supply pipes, using plastic instead of copper resulted in an approximate 5 to 10 dBA noise reduction when the pipes were fastened resiliently or rigidly to the wood studs. When considering waste pipes however, copper and cast iron are preferred to plastic by providing a 5 to 10 dBA additional noise reduction.

- The pipe attachment seems to be the most important single factor which should be considered during the installation of pipes and plumbing enclosures. It was demonstrated that using a resilient material between the pipes and the structure of the enclosure containing them resulted in an attenuation of the plumbing noise which could reach 20 dBA. The technique which appeared to provide the best performance in decoupling the pipes from the pipe enclosure structure was to insert, between the pipes and the studs, a 3" long sleeve of Armaflex 1/2" thick; this material is a preformed closed cell elastomer pipe insulation manufactured by Armstrong. The resilient pipe fasteners manufactured by Ancon Inc. called "Acousto-plumb system" were also tested: the noise isolation performance of these fasteners was revealed to be equal or inferior to that provided by Armaflex sleeves depending on the diameter of the pipe.

- For waste pipes, the absence of contact with the pipe enclosure is also very important: the presence of contact between a pipe and the enclosure could lead to an increase of 6, 9, or 15 dBA depending whether the pipe was made out of cast iron, plastic, or copper.

- The maximum benefit obtained by inserting sound absorption in the plumbing enclosure was approximately 5 dBA. This maximum was reached using cellulose fibre insulation in a wall cavity where pipes were rigidly fastened to wood studs, and by placing batt insulation in the cavity of partitions built with wood or metal studs, with pipes installed resiliently using Armaflex sleeves.

- Doubling the mass of the drywall of a pipe enclosure resulted in an improvement of 3 to 4 dBA regardless of how the pipes were fastened to the studs of the enclosure.

- The use of resilient furrings increased the plumbing noise isolation provided by a wood stud enclosure by approximately 6 to 10 dBA. Furthermore, the resilient furrings seem to provide an additional protection by avoiding direct contact between the pipe and the drywall of the pipe enclosure.

- The presence of domestic low density styrene pipe insulation similar to Armaflex on the entire surface of the pipe, instead of 3" long sleeves at the attachment point, provided a significant noise reduction in the order of 6 to 8 dBA. In the case where the pipes were installed with rigid contacts to the studs, and then covered with insulation, the benefit of covering the pipe was in the order of 1 to 2 dBA, which is not significant.

- At maximum flow, a difference of only 3 dBA was noted between the average noise level generated by the 5 faucets tested; this difference increased to 9 dBA with 1/2 of the flow and to 14 dBA with 1/4 of the flow. The quietest faucets tested were that fabricated by Moen at maximum flow, and that fabricated by Waltec at 1/4 and 1/2 of the flow.

- The faucets measured in the study reacted differently to an increase of water pressure, at a given flow rate. The maximum increase in noise level noted for a variation of pressure between 40 to 100 psi is 14 dBA, ranking the water pressure among the more important parameters influencing the production of plumbing noise. Also worth noting, some of the faucets made more noise at 1/2 flow than at maximum flow.

- Based on the results of this study, it appears that the following partition composition should achieve the best cost versus plumbing noise reduction performance:

Wood stud construction

One layer of drywall mounted on resilient furrings on each side of 2" x 4" wood studs, with batt insulation to fill the stud cavity.

Metal stud partition

Two layers of drywall on each side of metal studs with batt insulation in the stud cavity.

Shaft wall

One layer of 5/8" drywall laminated to 1" core board.

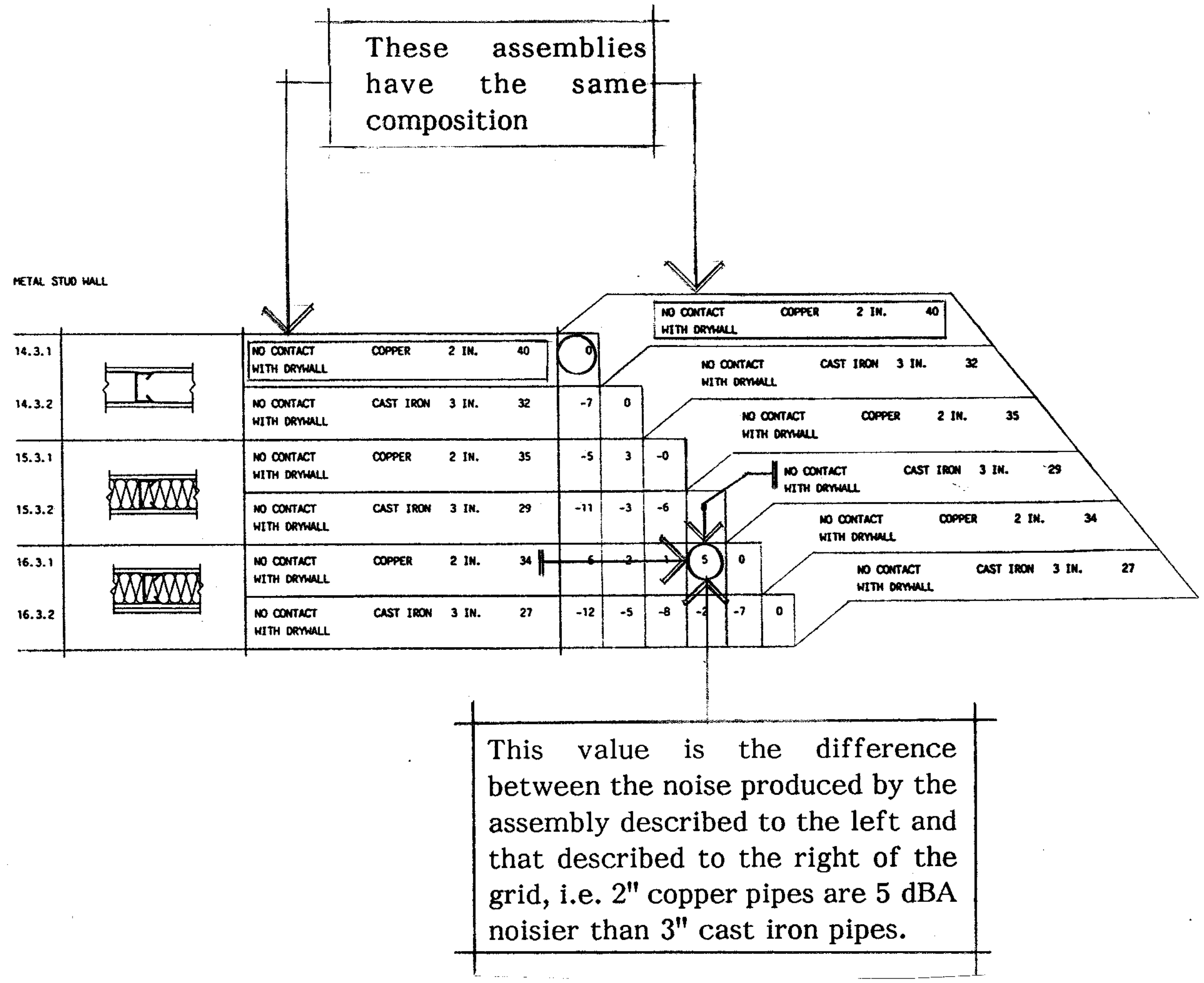
TABLES 1 TO 5 - HOW TO USE THEM

Tables 1 to 5 of this summary establish a comparison between the performance of different types of pipe attachment and partition composition. When looking at these tables, moving from left to right, one will find the test numbers, a schematic representation of the pipe enclosure, a description of the type of attachment (eg: 3 standard clamps, Armaflex sleeves, etc.) the pipe material, diameter and the plumbing noise level measured in dBA. (For a more detailed description of the partition and test results the reader is asked to use the test number appearing at the extreme left of the table and to refer to ANNEX III.) At the right of the table, on the other side of the grid, the attachment, pipe material, diameter and measured level are duplicated. The numbers in the grid represents the difference between the noise level obtained with the composition shown at the left of the table and that shown at the right. When the number is positive, the assembly described on the left is more noisy than that on the right, and vice versa. If you want to compare two assemblies, proceed as indicated on the example located on the next page. A quick way to verify that the table is being used correctly is to compare the value indicated in the grid to that obtained by subtracting the measured overall dBA level on the left of the grid from that appearing on the right: they should be the same.

overall dBA level on the left of the grid from that appearing on the right: they should be the same.

NOTE: When reading through the tables 1 to 5 of the executive summary, the presence of a black square in lieu of data indicates that it is suspected that an experimental error occured during the tests, which renders the validity of the results questionable.

EXAMPLE:



These assemblies have the same composition

This value is the difference between the noise produced by the assembly described to the left and that described to the right of the grid, i.e. 2" copper pipes are 5 dBA noisier than 3" cast iron pipes.

DOMESTIC WATER SUPPLY PIPES IN WOOD STUD PARTITIONS

NOTE: WATER PRESSURE= 40 PSI.
PIPE DIAMETER= 1/2"
SOURCE OF NOISE= ISO

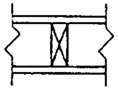
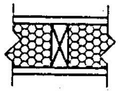
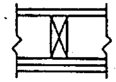
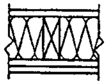
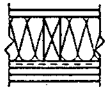
					3 STD CLAMPS COPPER 71	3 STD CLAMPS PLASTIC 59	ARMAFLEX COPPER 51	ARMAFLEX PLASTIC 46	ACOUSTOPLUM COPPER 56	FELT SLEEVE COPPER 61	CORK SLEEVE COPPER 66	WRAPPED INS. COPPER 45	3 STD CLAMPS COPPER 64	3 STD CLAMPS COPPER 70	ARMAFLEX COPPER 48	3 STD CLAMPS COPPER 61	ARMAFLEX COPPER 41	3 STD CLAMPS COPPER 68	ARMAFLEX COPPER 48	3 STD CLAMPS COPPER 66	ARMAFLEX COPPER 45	3 STD CLAMPS COPPER 54	ARMAFLEX COPPER 39
1.3.4		3 STD CLAMPS	COPPER	71	0																		
1.12.4		3 STD CLAMPS	PLASTIC	59	-12	0																	
1.6.4		ARMAFLEX	COPPER	51	-20	-8	0																
1.15.4		ARMAFLEX	PLASTIC	46	-25	-13	-5	0															
1.9.4		ACOUSTOPLUM	COPPER	56	-15	-3	5	10	0														
1.18.2		FELT SLEEVE	COPPER	61	-10	2	10	15	5	0													
1.21.2		CORK SLEEVE	COPPER	66	-5	6	14	20	10	5	0												
1.42.4		WRAPPED INS.	COPPER	45	-26	-14	-6	-1	-11	-16	-21	0											
2.1.4		3 STD CLAMPS	COPPER	64	-6	5	13	18	9	3	-1	19	0										
3.2.2		3 STD CLAMPS	COPPER	70	-1	11	19	24	14	9	5	25	6	0									
3.4.2		ARMAFLEX	COPPER	48	-23	-11	-3	2	-8	-13	-17	3	-16	-22	0								
4.2.2		3 STD CLAMPS	COPPER	61	-10	2	10	15	5	-0	-5	16	-3	-9	13	0							
4.4.2		ARMAFLEX	COPPER	41	-30	-18	-10	-5	-15	-20	-25	-4	-23	-29	-7	-20	0						
5.2.2		3 STD CLAMPS	COPPER	68	-3	9	17	22	12	7	2	23	4	-2	20	7	27	0					
5.4.2		ARMAFLEX	COPPER	48	-23	-11	-3	2	-8	-13	-17	3	-16	-22	0	-13	7	-20	0				
6.2.2		3 STD CLAMPS	COPPER	66	-5	7	15	20	10	5	0	21	2	-4	18	5	25	-2	18	0			
6.4.2		ARMAFLEX	COPPER	45	-25	-14	-6	-1	-10	-16	-20	0	-19	-25	-3	-16	4	-23	-3	-21	0		
7.2.2		3 STD CLAMPS	COPPER	54	-17	-5	3	8	-2	-7	-12	9	-11	-16	6	-7	13	-14	6	-12	8	0	
7.4.2		ARMAFLEX	COPPER	39	-32	-20	-12	-7	-17	-22	-27	-6	-25	-31	-9	-22	-2	-29	-9	-27	-6	-15	0

TABLE NO.1

WASTE PIPES IN WOOD PARTITIONS

NOTE: SOURCE OF NOISE= SINK EMPTYING

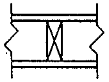
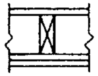
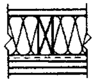
						NO CONTACT WITH DRYWALL COPPER 2 IN. 35	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 42	PIPE CONTACT WITH DRYWALL COPPER 2 IN. 49	PIPE CONTACT WITH DRYWALL PLASTIC 2 IN. 51	NO CONTACT WITH DRYWALL COPPER 2 IN. 33	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 41	PIPE CONTACT WITH DRYWALL COPPER 2 IN. 48	PIPE CONTACT WITH DRYWALL PLASTIC 2 IN. 49	NO CONTACT WITH DRYWALL COPPER 2 IN. 30	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 38	PIPE CONTACT WITH DRYWALL COPPER 2 IN. 38	NO CONTACT WITH DRYWALL COPPER 2 IN. 34	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 42	NO CONTACT WITH DRYWALL COPPER 2 IN. 31	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 36	NO CONTACT WITH DRYWALL COPPER 2 IN. 29	NO CONTACT WITH DRYWALL PLASTIC 2 IN. 34
1.22.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	35	0																
1.22.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	42	7	0															
1.22.6		PIPE CONTACT WITH DRYWALL	COPPER	2 IN.	49	14	7	0														
1.22.8		PIPE CONTACT WITH DRYWALL	PLASTIC	2 IN.	51	16	9	2	0													
3.5.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	33	-2	-9	-16	-18	0												
3.5.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	41	6	-1	-8	-10	8	0											
3.5.6		PIPE CONTACT WITH DRYWALL	COPPER	2 IN.	48	13	6	-1	-3	15	7	0										
3.5.8		PIPE CONTACT WITH DRYWALL	PLASTIC	2 IN.	49	14	7	0	-2	16	8	1	0									
4.5.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	30	-5	-12	-19	-21	-3	-11	-18	-19	0								
4.5.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	38	3	-4	-11	-13	5	-3	-10	-11	8	0							
4.5.6		PIPE CONTACT WITH DRYWALL	COPPER	2 IN.	38	3	-4	-11	-13	5	-3	-10	-11	8	0	0						
5.5.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	34	-1	-8	-16	-18	1	-8	-14	-16	3	-5	-5	0					
5.5.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	42	7	-0	-8	-10	9	0	-6	-8	11	3	4	8	0				
6.5.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	31	-4	-11	-18	-20	-2	-10	-17	-18	1	-7	-7	-2	-10	0			
6.5.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	36	1	-6	-13	-15	3	-5	-12	-13	6	-2	-2	3	-6	5	0		
7.5.2		NO CONTACT WITH DRYWALL	COPPER	2 IN.	29	-6	-13	-20	-23	-4	-13	-19	-21	-1	-10	-9	-5	-13	-3	-7	0	
7.5.4		NO CONTACT WITH DRYWALL	PLASTIC	2 IN.	34	-1	-8	-15	-17	1	-7	-14	-15	4	-4	-4	1	-7	3	-2	5	0

TABLE NO.2

WASTE PIPES IN WOOD PARTITIONS

NOTE: SOURCE OF NOISE= TOILET FLUSH

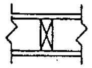
				NO CONTACT WITH DRYWALL CAST IRON 3 IN. ■	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 44	PIPE CONTACT WITH DRYWALL CAST IRON 3 IN. 37	PIPE CONTACT WITH DRYWALL PLASTIC 3 IN. 47	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 31	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 39	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 31	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 40	PIPE CONTACT WITH DRYWALL CAST IRON 3 IN. 37	PIPE CONTACT WITH DRYWALL PLASTIC 3 :N. 43	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 31	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 40	PIPE CONTACT WITH DRYWALL CAST IRON 3 IN. 32	NO CONTACT WITH DRYWALL CAST IRON 3 IN. ■	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 43	PIPE CONTACT WITH DRYWALL CAST IRON 3 IN. 35	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 30	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 38	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 29	NO CONTACT WITH DRYWALL PLASTIC 3 IN. 38
1.22.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. ■	■																			
1.22.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 44	■	0																		
1.22.5		PIPE CONTACT WITH DRYWALL	CAST IRON 3 IN. 37	■	-7	0																	
1.22.7		PIPE CONTACT WITH DRYWALL	PLASTIC 3 IN. 47	■	3	10	0																
2.2.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. 31	■	-13	-6	-16	0															
2.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 39	■	-5	2	-8	8	0														
3.5.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. 31	■	-13	-6	-16	-0	-8	0													
3.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 40	■	-4	3	-7	9	1	10	0												
3.5.5		PIPE CONTACT WITH DRYWALL	CAST IRON 3 IN. 37	■	-7	0	-10	6	-2	6	-3	0											
3.5.7		PIPE CONTACT WITH DRYWALL	PLASTIC 3 !N. 43	■	-1	6	-4	12	4	12	2	6	0										
4.5.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. 31	■	-13	-6	-16	-1	-9	-0	-10	-6	-12	0									
4.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 40	■	-4	3	-7	9	1	9	-1	3	-3	9	0								
4.5.5		PIPE CONTACT WITH DRYWALL	CAST IRON 3 IN. 32	■	-12	-5	-15	1	-7	2	-8	-5	-11	2	-8	0							
5.5.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. ■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
5.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 43	■	-1	6	-4	12	4	12	2	6	-0	12	3	11	■	0					
5.5.5		PIPE CONTACT WITH DRYWALL	CAST IRON 3 IN. 35	■	-9	-2	-12	4	-4	4	-6	-2	-8	4	-5	3	■	-8	0				
6.5.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. 30	■	-14	-7	-17	-1	-9	-1	-10	-7	-13	-1	-10	-2	■	-13	-5	0			
6.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 38	■	-6	1	-9	7	-1	7	-3	1	-5	7	-2	6	■	-5	3	8	0		
7.5.1		NO CONTACT WITH DRYWALL	CAST IRON 3 IN. 29	■	-15	-8	-18	-2	-10	-2	-12	-8	-14	-2	-11	-4	■	-14	-6	-1	-9	0	
7.5.3		NO CONTACT WITH DRYWALL	PLASTIC 3 IN. 38	■	-6	1	-9	7	-1	7	-3	1	-5	7	-2	6	■	-5	3	8	-0	9	0

TABLE NO.3

DOMESTIC WATER SUPPLY PIPES IN METAL STUD PARTITIONS

NOTE: WATER PRESSURE = 40 PSI.

PIPE DIAMETER= 1/2"

SOURCE OF NOISE= ISO

						RUNNING HORIZ. PLASTIC SLEEVE COPPER 1/2 IN. 62	RUNNING HORIZ. ARMAFLEX SLEEVE COPPER 1/2 IN. 53	RUNNING HORIZ. PLASTIC SLEEVE COPPER 1/2 IN. 59	RUNNING HORIZ. ARMAFLEX SLEEVE COPPER 1/2 IN. 48	RUNNING HORIZ. PLASTIC SLEEVE COPPER 1/2 IN. 58	RUNNING HORIZ. ARMAFLEX SLEEVE COPPER 1/2 IN. 46
14.1.4		RUNNING HORIZ. PLASTIC SLEEVE	COPPER	1/2 IN.	62	0					
14.2.4		RUNNING HORIZ. ARMAFLEX SLEEVE	COPPER	1/2 IN.	53	-9	0				
15.1.4		RUNNING HORIZ. PLASTIC SLEEVE	COPPER	1/2 IN.	59	-3	6	0			
15.2.4		RUNNING HORIZ. ARMAFLEX SLEEVE	COPPER	1/2 IN.	48	-14	-5	-11	0		
16.1.4		RUNNING HORIZ. PLASTIC SLEEVE	COPPER	1/2 IN.	58	-4	5	-1	10	0	
16.2.4		RUNNING HORIZ. ARMAFLEX SLEEVE	COPPER	1/2 IN.	46	-17	-8	-14	-2	-13	0

TABLE NO.4

WASTE PIPES IN METAL STUD PARTITIONS

NOTE: SOURCE OF NOISE= SINK EMPTYING

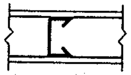
						NO CONTACT WITH DRYWALL COPPER 2 IN. 40	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 32	NO CONTACT WITH DRYWALL COPPER 2 IN. 35	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 29	NO CONTACT WITH DRYWALL COPPER 2 IN. 34	NO CONTACT WITH DRYWALL CAST IRON 3 IN. 27
14.3.1		NO CONTACT WITH DRYWALL	COPPER	2 IN.	40	0					
14.3.2		NO CONTACT WITH DRYWALL	CAST IRON	3 IN.	32	-7	0				
15.3.1		NO CONTACT WITH DRYWALL	COPPER	2 IN.	35	-5	3	-0			
15.3.2		NO CONTACT WITH DRYWALL	CAST IRON	3 IN.	29	-11	-3	-6	0		
16.3.1		NO CONTACT WITH DRYWALL	COPPER	2 IN.	34	-6	2	-1	5	0	
16.3.2		NO CONTACT WITH DRYWALL	CAST IRON	3 IN.	27	-12	-5	-8	-2	-7	0

TABLE NO.5

REPORT

RESEARCH PROJECT ON PLUMBING NOISE IN MULTI-DWELLING BUILDINGS

TABLE OF CONTENTS

RESEARCH PROJECT ON PLUMBING NOISE IN MULTI-DWELLING BUILDINGS

1.0 INTRODUCTION

MJM ACOUSTICAL CONSULTANTS INC. has been retained by the CANADA MORTGAGE AND HOUSING CORPORATION to conduct a research project on the noise produced by plumbing installations in multi-dwelling buildings. This report outlines the results of over two hundred seventy-three (273) measurements which were performed during the study with different plumbing installations and operation parameters. All the tests were conducted in the acoustical laboratories of the NATIONAL RESEARCH COUNCIL OF CANADA (NRCC) in Ottawa under the supervision of Doctor A.C.C. Warnock and under the direction of the undersigned.

The results of all the measurements performed are tabulated in ANNEX III of this report in the form of octave band sound pressure levels, and broadband "A" weighted levels. This ANNEX also contains a graphic representation of the plumbing installations tested, complete with the description of:

- the partition or plumbing shaft containing the pipes tested,
- the pipe material (copper, cast iron, or plastic),
- the pressure at which the tests were performed (40 to 100 psi),
- the type of attachment used to fasten the pipe to the plumbing shaft (solid or resilient, contact or no contact with the shaft),
- and the source used to generate plumbing noise (ISO source, faucet, sink emptying, toilet flush).

The numbering appearing in ANNEX III to designate all the installations tested is used throughout the report as a reference to give access to the complete information concerning the plumbing assembly being discussed.

2.0 OBJECTIVES OF THE STUDY

The study was planned and conducted to simulate plumbing installations in real situations. The two main objectives of the study were:

1) To provide builders and construction professionals with practical information on the acoustical performance of different pipe types, pipe shaft compositions, and pipe installation techniques.

2) To provide acousticians with reliable acoustical data which could allow them to deduce the insertion loss which could result from:
   a) adding or deleting materials as part of the composition of pipe shafts;
   b) installing pipes made out of different materials;
   c) modifying the pipe installation techniques by using resilient materials to fasten pipes to the structure of the building.
   d) varying the operating parameters such as pressure and flow through pipes and plumbing appliances, etc.

The builders and construction professionals should find most of the information which should be of interest to them in the EXECUTIVE SUMMARY at the beginning of the report, in SECTION 3.0 below entitled "ANALYSIS OF THE RESULTS", and in ANNEX I and II which contain the graphs and tables pertaining to this section.

Acousticians and readers interested in the complete results of the measurements performed and in the methodology used will refer to ANNEX III and IV. As previously mentioned ANNEX III presents the complete data pertaining to all the tests performed during the present study. ANNEX IV contains a description of the methods used to build the partitions around the pipes, to vary the pressure in the supply pipes without generating parasitic noise, to fasten the pipes while maintaining consistency throughout the study and all pertinent information relative to the noise measurement methods and techniques; the information contained in this annex has been prepared by Doctor A.C.C. Warnock of the NRCC.

3.0 ANALYSIS OF THE RESULTS

In the past five years, MJM ACOUSTICAL CONSULTANTS INC. has been involved in the noise isolation of several thousands of condominium units constructed in the Montreal area. It was our experience and the experience of others that the main factors influencing the transmission of plumbing noise from one dwelling to another were:

- the pressure, and the flow of the water inside the pipes and faucets;
- the material used to fabricate the pipes;
- the diameter of the pipes;
- the amount of mechanical coupling between the pipes and the pipe enclosure (wall, ceiling or shaft)
- the sound transmission loss of the membranes composing the pipe enclosure;
- the presence of sound absorption in the cavity of the pipe enclosure.

The different plumbing assemblies tested in this study were selected in an endeavour to determine the contribution of each of these factors in the production and transmission of plumbing noise. Our findings and conclusions appear in the paragraphs below. The graphs and tables pertaining to the text are referenced in the right margin.

3.1 WATER PRESSURE IN SUPPLY PIPES

Typically, the water pressure in the water supply pipes of most buildings located in urban areas of Canada varies between 40 to 100 pounds per square inch (psi). A number of tests have been performed in this study at pressures of 40, 60, 80 and 100 psi in an attempt to quantify the influence of this parameter combined with other factors such as pipe diameter, composition, attachment, etc.

ANNEX II
table 1

Typically the average noise level increase measured with varying the water pressure in pipes from 40 to 100 psi, using the ISO noise generator as a source, is as follows:

- 5 dBA for pipes running in wood stud wall construction with the pipes attached at 3 points along the studs;
- 7 dBA for pipes inserted in metal stud partition when they run horizontally through the stud punch holes;
- 9 dBA for pipes running vertically in studless shaft wall partitions with no contact between the pipes and the partition.

The above 5, 7 and 9 dBA average noise level increases with the increase of water pressure did not seem to be significantly affected by the pipe diameter, the pipe material, the type of attachment used, nor the presence of glass fibre insulation in the partition cavities. However, important noise variations were noted during tests involving different faucets at specific water flow rates (refer to article 3.7.2 for more details concerning the effect of varying the pressure using faucets).

Finally, using the ISO source, one could note that with one exception (1" diameter plastic pipe attached with standard clamps) the plumbing noise levels measured increased smoothly and gradually at all frequencies as the pressure was increased.

ANNEX I graphs 1A, 1B, 1C, 1D, 1E

3.2 PIPE DIAMETER IN SUPPLY PIPES

Several tests have been performed in order to establish the effect of pipe diameter on the transmission of plumbing noise. The measurements were made on pipes of diameters varying from 1/2" to 2", installed in different operating conditions. The comparative results of these measurements appear in table 2 of ANNEX II of this report. This table describes the context in which the pipes were installed and operated, the overall "A" weighted Sound Pressure Level (SPL) measured with a water pressure of 40 and 100 psi and the arithmetic average of these two SPL for each pipe diameter. Also appearing on this table is the maximum difference in decibels which was obtained by subtracting the SPL obtained for the smaller pipe diameter from that

ANNEX II table 2

obtained for the larger diameters. Negative values in the column entitled "Max Difference in dBA indicates that the smaller diameter produced less noise than the larger diameter. The lack of consistency in the results appearing in table 2 of ANNEX II and graphs 2A and 2B of ANNEX I does not allow one to deduce that there would be a clear advantage to use pipes of a certain diameter to reduce the transmission of the plumbing noise.

ANNEX I
graphs 2A, 2B

3.3 PIPE MATERIAL

.1 Supply pipes

Most of the supply pipes presently installed in multi-dwelling buildings are fabricated with copper. However, plastic supply pipes of various diameters are also available on the market. As can be seen by looking at graphs 3A, 3B, 3C and 3D of ANNEX I, the use of plastic pipes resulted in lower plumbing noise transmission. The benefit provided by plastic pipes is in the order of 10 dBA when the pipes are fastened to wood studs with standard clamps and 5 dBA when an armaflex sleeve is inserted between the pipe and the wood stud.

ANNEX I
graphs 3A, 3B, 3C, 3D

.2 Waste pipes

Depending on the codes applicable in different municipalities, plastic, copper or cast iron waste pipes are used in multi-dwelling buildings.

ANNEX II
table 3

Waste pipes with diameters smaller than 2" are usually fabricated with plastic or copper. With a sink emptying as a noise source, a 2" plastic waste pipe produced sound pressure levels consistently higher than those measured with a copper waste pipe of the same diameter. The benefit to be reaped by using copper instead of plastic for waste pipes varies between 5 to 8 dBA when there is no contact between the pipe and the plumbing enclosure. This benefit drops to 2 dBA when the pipes are in direct contact with the partition in which they are located (the influence of the contacts between the pipes and the plumbing enclosures will be discussed in article 3.4.4 further in this report).

ANNEX II
table 4

Waste pipes with diameter of 3" or larger are ususally fabricated with cast iron or plastic. When there is no contact between the waste pipe and the enclosing partition the results of this study indicates that the use of cast iron pipes will provide a noise reduction performance 8 to 10 dBA superior to plastic pipes using a toilet flush as a source of noise. When there is a contact with the plumbing enclosure the cast iron pipes provide a noise reduction 6 to 10 dBA superior to that of the plastic pipes.

3.4 PIPE INSTALLATION

It is the author's experience that, unless otherwise specified, pipes are fastened directly to the building structure using standard copper clamps or copper strapping.

In this study, several methods of fastening the pipes to the walls which contain them were investigated. The mechanical decoupling provided by different resilient materials inserted between the pipes and the studs was quantified.

.1 Supply pipes attachment - wood stud wall

ANNEX II
table 5

Tests were conducted on sleeves made out of 1/2" thick closed cell elastomer pipe insulation (Armstrong Armaflex), 1/2" thick felt and 1/8" cork. These sleeves were used in conjunction with oversized clamps to resiliently fasten the pipes to one of the wood studs composing the wall structure. A manufactured resilient pipe fastener called "Acousto-plumb" was also tested. The attenuations obtained with the resilient mounts compared with standard clamp attachment for pipes of 1/2", 3/4" and 1" diameter are summarized as follows:

ARMAFLEX : 15 to 19 dBA
FELT : 9 to 16 dBA
ACOUSTO-PLUMB : 13 to 15 dBA
CORK : 5 to 8 dBA

ANNEX I
graph 4A

Fastening the pipes to the studs using an Armaflex sleeve 1/2" thick, 3" long, appeared to be the most efficient way to reduce the noise transmitted mechanically to the pipes enclosure through the pipe attachment. It is worth noting that Armaflex is inexpensive, easily available, easy to cut, resistant to moisture; it also comes preformed to fit pipes of various diameters.

The noise isolation performance of felt sleeves degraded as the diameter of the pipe was smaller. It is the author's opinion that the ability of felt to absorb and retain moisture makes it unfit to be used as a cold water pipe fastener.

Acousto-plumb is a well presented resilient pipe fastener system whose noise isolation performance was equal or inferior to that provided by Armaflex sleeves depending on the diameter of the pipe. Although this product might present advantages related to ease of installation, it is not recommended to pay a premium for its use on the basis of acoustical performance alone.

.2 Supply pipes attachment - metal studs walls

EXECUTIVE
SUMMARY
table 4

A plastic sleeve is generally inserted in the punch holes of metal studs to avoid copper/steel contact while passing supply pipes in a metal stud partition. Replacing the plastic sleeve with an Armaflex sleeve resulted in a plumbing noise reduction of 9 to 13 dBA. However it is important to note that one must bend the sharp edges of the stud punch holes in order to avoid contact that, with time, may cut through the Armaflex allowing direct contact to develop between the stud and the pipe.

.3 Supply pipes attachment - shaft walls

As a general rule the pipes which are located in shaft walls are the main risers of 1 1/2" or 2" in diameter, which are supported exclusively from the floors of the building. No measurements were made to study alternate attachment methods.

.4 Waste pipes installation - 2" and 3" diameter

Ideally the vertical sections of waste pipes should be installed to be free standing in the pipe enclosure cavity with no contact with the studs or drywall. In reality however, poor workmanship and/or misalignment of pipes results in one or more contact with the pipe enclosure. Attempts were made to quantify the effect of such contacts by inserting a wood wedge between the pipe and the enclosure tested.

ANNEX II
table VI

Waste pipes having a 2" diameter are usually connected to appliances generating no solid waste such as sinks, baths, etc. These pipes are fabricated with copper or plastic. Using a sink emptying as a source of noise, the increase of transmitted plumbing noise was in the order of 15 dBA when a wood wedge was inserted between the drywall composing the pipe enclosure and the 2" copper pipe being tested. The wedging of a plastic pipe of same diameter resulted in an increase of 8 to 9 dBA; however the noise level transmitted was higher with the plastic pipe. Finally for a partition built with resilient furrings, the presence of contact between the copper pipe and the furrings resulted in an increase of the noise in the order of 8 dBA compared to no contact.

Waste pipes having a 3" diameter and over are usually used as main waste collectors. Using a toilet flush to generate noise, the same experiments as described earlier with the 2" pipes were conducted on cast iron and plastic pipes. One must note that the noise levels measured in some of the experiments involving cast iron pipes were very close to the background noise of the laboratory in some third-octave bands. In addition, due to inadequate pipe installation, the data collected during tests nos 1.22.1 and 5.5.1 could not be used. Consequently, it is the author's opinion that the quantitative information contained in the following paragraph and in table 7 of ANNEX II should be confirmed with further experiments.

ANNEX V
table VII

With cast iron pipes, the presence of contact with the drywall of the enclosure resulted in an increase of approximately 6 dBA in the noise produced by a toilet flush; when the pipe enclosure was built with resilient furrings, a contact between the resilient furring and the pipe resulted in an increase of only 2 dBA. For plastic pipes the presence of contact with drywall resulted in an increase of the noise level in the order of 3 dBA.

In most construction sites one can find waste pipes running horizontally inside wall cavities. These pipes sometimes need to be secured to the studs. Unfortunately this specific configuration was not measured during the present study.

3.5 PARTITIONS CONTAINING PLUMBING

In most multi-dwelling buildings the interior partitions of the dwellings are used to route the pipes. In general these partitions are constructed with the strict minimum: a layer of drywall on each side of wood or metal studs. Several tests were conducted on different wall compositions made with material and techniques readily available in the construction industry.

NOTE:
Since many of the noise measurements made with the waste pipes were close to the background noise of the laboratory, it was decided not to use them to establish the noise isolation performance of the partitions containing plumbing. Instead, only the results of the measurements made with the supply pipes and the ISO noise generator for which the signal to noise ratio was high, were used.

.1 Wood stud construction

.1 Sound absorption in the cavity

The effect of filling the pipe enclosure cavity with a sound absorptive material was assessed by making measurements when the cavity was empty and when it contained insulation. These measurements were made for different pressures, pipe diameters, pipe enclosure compositions, and pipe attachments.

- The insertion of cellulose fibre insulation in a wood stud wall cavity resulted in a reduction of the plumbing noise in the order of 5 dBA when the pipe was rigidly fastened to the studs.

  ANNEX I
  graph 5A

- The insertion of batt insulation to fill a wood stud cavity in which the pipes are fastened rigidly with standard clamps resulted in an improvement of 1 to 4 dBA. With the pipes fastened with Armaflex sleeves, filling the cavity led to an improvement of 3 to 5 dBA compared to an empty cavity.

  ANNEX I
  graphs 5A, 5B
  ANNEX III
  series 1.3, 3.2
  series 1.4, 3.3

- Finally, in metal stud construction, filling the cavity using batt insulation provided an additional noise isolation of 3 to 4 dBA when the pipes were supported by plastic sleeves, and 5 dBA when resiliently mounted.

  ANNEX II
  graph 5C
  ANNEX III
  series 14.1, 15.1
  series 14.2, 15.2

.2 Doubling the mass of the drywall

Doubling the mass of the drywall resulted in an improvement of 3 to 4 dBA regardless of how the pipes were fastened to the studs of the enclosure.

EXECUTIVE
SUMMARY
table 1

.3 Resilient furrings

The installation of resilient furrings seems an efficient way to increase the isolation provided by a wood stud enclosure, by decoupling the drywall from the studs to which the pipes are attached. When the pipes are fastened rigidly, the insertion of resilient furrings between the studs and the drywall provided a noise reduction in the order of 6 to 10 dBA.

ANNEX I
graphs 5A, 5B
ANNEX III
series 3.2, 4.5
series 3.3, 4.3

Inserting a resilient furring between the drywall and the studs of a pipe enclosure proved to be 5 dBA superior to doubling the drywall.

EXECUTIVE
SUMMARY
table 1

.2 Metal stud partitions

.1 Sound absorption in the cavity

Adding batt insulation in a metal stud wall enclosure containing pipes provided an additional plumbing noise reduction of 3 to 5 dBA depending on the pipe attachment.

EXECUTIVE
SUMMARY
table 4

.2 Doubling the mass of the drywall

Doubling the mass of the drywall of the pipe enclosure increased the noise reduction by 1 or 2 dBA.

.3 Shaft wall

Studless shaft walls having a 1 hour and 2 hour fire resistance were also part of this study. The shaft walls tested were selected because they were thought to be the most inexpensive to construct. The results of the tests showed that the difference in the noise reduction offered by these shafts is 1 to 6 dBA in favour of the 2 hour shaft.

ANNEX III measurement series 11.1, 11.2, 12.1, 12.2

3.6 ADDING PIPE INSULATION AROUND SUPPLY PIPES

For many builders, covering the pipes completely with domestic styrene insulation or Armaflex appears to be an effective mitigation measure to reduce plumbing noise. This method was tested in both wood stud and metal stud construction. In the wood stud construction the styrene insulation was first wrapped around the pipe and then fastened to the wood studs using oversized clamps. The presence of insulation on the entire surface of the pipe instead of 3" long sleeves at the attachment points provided a significant additional noise reduction in the order of 6 to 8 dBA.

ANNEX III measurement series 1.42, 1.6

In the other case the pipes were first installed through the metal stud punch holes using plastic sleeves and then wrapped with insulation. The benefit with this installation method is in the order of 1 to 2 dBA since most of the sound energy was transmitted mechanically from the pipe to the partition through the rigid contact between the pipe and stud.

ANNEX III measurement series 14.1, 14.4

3.7 NOISE PRODUCED BY FAUCETS

Five manufacturers out of the six who were invited provided a single lever faucet of comparable price for noise evaluation. The name of the manufacturers who agreed to participate are, in alphabetical order:

- American Standard
- Crane
- Delta
- Moen
- Waltec

The exact nomenclature of the faucets tested appear in ANNEX IV of this report. For those who wish to compare prices, it was suggested by the manufacturers that the All Priser Catalog should be used as a reference to evaluate the cost of the faucets.

.1 Comparison between faucets

The faucets were all tested at 1/4, 1/2 and maximum flow for pressures of 40, 60, 80 and 100 psi. At maximum flow, there was only a 3 dBA

ANNEX II table 8

difference between the arithmetic average of the noise levels generated by the faucets tested at these pressures. This difference went up to 9 dBA at 1/2 flow and to 14 dBA at 1/4 flow.

The quietest faucets were the Moen at maximum flow and the Waltec at 1/4 and 1/2 flow.

.2 Faucet noise vs water pressure

The influence of water pressure for different flows was also assessed for each faucet. For a given flow and faucet, varying the pressure between 40 to 100 psi resulted in an increase of noise level ranging from 5 to 14 dBA. This increase is considerably higher than the variations noted using the ISO noise generator. Therefore when recommending plumbing system noise control for real situations, the water pressure must be ranked among the more important parameters to consider.

ANNEX II
table 9

.3 Faucet noise vs water flow

The average noise produced with 1/4, 1/2 and maximum flow varied from 3 to 13 dBA depending on the faucet being tested. The noise produced by Delta and Waltec faucets increased with the flow of water. This was not observed with the other faucets: the faucets manufactured by Moen, Crane and American Standard produced highest noise levels at 1/2 flow.

ANNEX II
table 10

ANNEX I
graph 7A

3.8 SIMULATING REAL SITUATION

The author ran an evaluation of the plumbing noise which could be transmitted to a room having absorption characteristics approaching that of a typical bedroom with one of its walls containing the plumbing set-ups tested in this study. For supply pipes, this evaluation was made by combining the average of the five faucet noise level curves appearing on graph 7B with the data obtained for different partitions and attachment involving copper and cast iron pipes, and the absorption measured in the NRC reverberation chamber. In the case of waste pipes the sources used were a sink emptying and a toilet flushing.

ANNEX I
graph 7B

.1 Wood construction

For a plumbing system made out of copper and cast iron, the noise generated by supply pipes seems more important than that generated by the waste pipes. With pipes attached with Armaflex in a partition constructed of one layer of drywall mounted on resilient furrings on each side of 2" x 4" wood studs and batt insulation in the cavity, the plumbing noise levels transmitted should be below the average Canadian home ambient noise level measured in the absence of human activity during a study conducted by the NRCC[1] in

ANNEX I
graphs 8A, 8B
ANNEX II
tables 11, 12

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[1] Bradley, J.S.: "Acoustical Measurements in Some Canadian Homes", Canadian Acoustics, Vol. 14, No 4, pp. 24-26.

600 homes across Canada. This composition seems to be the most appropriate for wood stud partitions containing plumbing.

.2 **Metal stud partition**

With resiliently mounted pipes it appears that, to reduce plumbing noise to levels approaching or below the average Canadian home ambient noise levels, the following metal stud partition composition would be required: 2 layers of drywall on each side of metal studs with batt insulation to fill the stud cavity.

ANNEX I
graphs 8C, D
ANNEX II
tables 13, 14

.3 **Shaft wall**

The minimum fire rated shaft wall composition seems adequate to reduce the noise produced by waste pipes to levels below the average canadian home ambient noise level.

ANNEX I
graph E
ANNEX II
table 15

4.0 CONCLUSIONS

The conclusions reached during this study are outlined in the paragraphs below:

.1 Using the ISO noise generator as a source, a variation of water pressure from 40 to 100 psi resulted in increases of 5, 7 and 9 dBA depending on the pipe enclosure construction: wood stud, metal stud, or studless partition. However, when different faucets and water flows were used to generate plumbing noise, a 40 to 100 psi variation in water pressure resulted in an increase of plumbing noise level reaching 14 dBA. One must therefore conclude that in real installations, the water pressure is an important factor in the production of plumbing noise which should be taken into account during the design of plumbing system destined to multi-dwelling buildings.

.2 The results of the present study did not allow one to deduce that there would be a clear advantage to using pipes of a certain diameter in order to reduce the transmission of plumbing noise in multi-dwelling buildings.

.3 The material used to fabricate the pipes has an effect on the noise produced by the water flow. For supply pipes, using plastic instead of copper resulted in a 5 to 10 dBA noise reduction depending whether the pipes were fastened resiliently or rigidly to the wood studs. When considering waste pipes however, copper and cast iron are preferred to plastic by providing a 5 to 10 dBA additional noise reduction.

.4 The pipe attachment seems to be the most important single factor which should be considered during the installation of pipes and plumbing enclosures. It was demonstrated that using a resilient material between the pipes and the structure of the enclosure containing them resulted in an attenuation of the plumbing noise which could reach 20 dBA. The technique which appeared to provide the best performance in decoupling the pipes from the pipe enclosure structure was to insert, between the pipes and the studs, a 3" long sleeve of Armaflex 1/2" thick; this material is a preformed closed cell elastomer pipe insulation manufactured by Armstrong. The resilient pipe fasteners manufactured by Ancon Inc. called "Acousto-plumb system" were also tested: the noise isolation performance of these fasteners was revealed to be equal or inferior to that provided by Armaflex sleeves depending on the diameter of the pipe.

.5 For waste pipes, the absence of contact with the pipe enclosure is also very important: the presence of contact between a pipe and the enclosure could lead to an increase of 6, 9, or 15 dBA depending whether the pipe was made out of cast iron, plastic, or copper.

.6 The maximum benefit obtained by inserting sound absorption in the plumbing enclosure was approximately 5 dBA. This maximum was reached using cellulose fibre insulation in a wall cavity where pipes were rigidly fastened to wood studs, and by placing batt insulation in the cavity of partitions built with wood or metal studs, with pipes installed resiliently using Armaflex sleeves.

.7 Doubling the mass of the drywall of a pipe enclosure resulted in an improvement of 3 to 4 dBA regardless of how the pipes were fastened to the studs of the enclosure.

.8 The use of resilient furrings increased the plumbing noise isolation provided by a wood stud enclosure by approximately 6 to 10 dBA. Furthermore, the resilient furrings seem to provide an additional protection by avoiding direct contact between the pipe and the drywall of the pipe enclosure.

.9 The presence of domestic low density styrene pipe insulation similar to Armaflex on the entire surface of the pipe, instead of 3" long sleeves at the attachment point, provided a significant noise reduction in the order of 6 to 8 dBA. In the case where the pipes were installed with rigid contacts to the studs, and then covered with insulation, the benefit of covering the pipe was in the order of 1 to 2 dBA, which is not significant.

.10 At maximum flow, a difference of only 3 dBA was noted between the average noise level generated by the 5 faucets tested; this difference increased to 9 dBA with 1/2 of the flow and to 14 dBA with 1/4 of the flow. The quietest faucets tested were that fabricated by Moen at maximum flow, and that fabricated by Waltec at 1/4 and 1/2 of the flow.

.11 The faucets measured in the study reacted differently to an increase of water pressure, at a given flow rate. The maximum increase in noise level noted for a variation of pressure between 40 to 100 psi is 14 dBA, ranking the water pressure among the more important parameters influencing the production of plumbing noise. Also worth noting, some of the faucets made more noise at 1/2 flow than at maximum flow.

.12 Based on the results of this study, it appears that the following partition composition should achieve the best cost versus plumbing noise reduction performance:

<u>Wood stud construction</u>

One layer of drywall mounted on resilient furrings on each side of 2" x 4" wood studs, with batt insulation to fill the stud cavity.

<u>Metal stud partition</u>

Two layers of drywall on each side of metal studs with batt insulation in the stud cavity.

<u>Shaft wall</u>

One layer of 5/8" drywall laminated to 1" core board.

Respectfully submitted
September 28, 1990
MJM ACOUSTICAL CONSULTANTS INC.

Michel Morin, architect
President

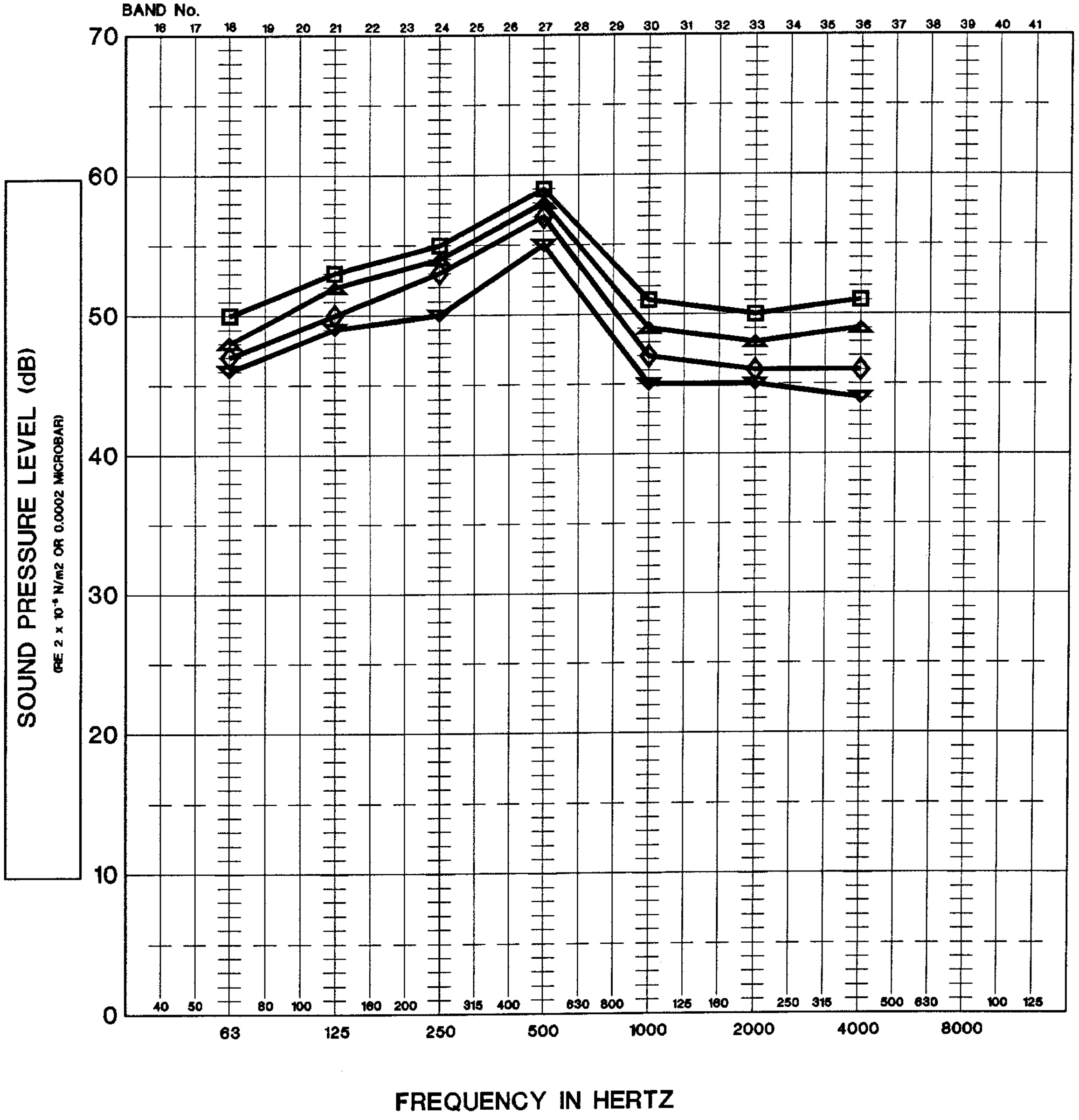
ANNEX I

GRAPH NUMBER	GRAPH TITLE	REFERENCE	
1A	INFLUENCE OF WATER PRESSURE -	ANNEX III	1.4.1
	WOOD STUD WALL -	ANNEX III	1.4.2
	ARMAFLEX ATTACHMENT	ANNEX III	1.4.3
	1" COPPER PIPE	ANNEX III	1.4.4
1B	INFLUENCE OF WATER PRESSURE -	ANNEX III	1.5.1
	WOOD STUD WALL -	ANNEX III	1.5.2
	ARMAFLEX ATTACHMENT	ANNEX III	1.5.3
	3/4"COPPER PIPE	ANNEX III	1.5.4
1C	INFLUENCE OF WATER PRESSURE -	ANNEX III	1.6.1
	WOOD STUD WALL -	ANNEX III	1.6.2
	ARMAFLEX ATTACHMENT	ANNEX III	1.6.3
	1/2" COPPER PIPE	ANNEX III	1.6.4
1D	INFLUENCE OF WATER PRESSURE -	ANNEX III	1.12.1
	WOOD STUD WALL -	ANNEX III	1.12.2
	STANDARD CLAMPS & ARMAFLEX ATTACHMENT	ANNEX III	1.12.3
	1/2" PLASTIC PIPE	ANNEX III	1.12.4
1E	INFLUENCE OF WATER PRESSURE -	ANNEX III	1.10.1
	WOOD STUD WALL -	ANNEX III	1.10.4
	STANDARD CLAMPS & ARMAFLEX ATTACHMENT	ANNEX III	1.13.1
	1" PLASTIC PIPE	ANNEX III	1.13.4
2A	INFLUENCE OF PIPE DIAMETER -	ANNEX III	1.1.4
	WOOD STUD WALL -	ANNEX III	1.2.4
	STANDARD & ARMAFLEX ATTACHMENT	ANNEX III	1.3.4
		ANNEX III	1.4.4
		ANNEX III	1.5.4
		ANNEX III	1.6.4

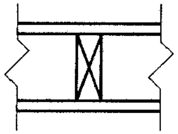
GRAPH NUMBER	GRAPH TITLE	REFERENCE	
2B	INFLUENCE OF PIPE DIAMETER - WOOD STUD WALL - FELT SLEEVE ATTACHMENT	ANNEX III ANNEX III ANNEX III	1.16.2 1.17.2 1.18.2
3A	INFLUENCE OF PIPE MATERIAL - WOOD STUD WALL - STANDARD CLAMPS ATTACHMENT WATER PRESSURE OF 100 PSI.	ANNEX III ANNEX III	1.3.1 1.12.1
3B	INFLUENCE OF PIPE MATERIAL - WOOD STUD WALL - STANDARD CLAMPS ATTACHMENT WATER PRESSURE OF 40 PSI.	ANNEX III ANNEX III	1.3.4 1.12.4
3C	INFLUENCE OF PIPE MATERIAL - WOOD STUD WALL - ARMAFLEX ATTACHMENT WATER PRESSURE OF 100 PSI.	ANNEX III ANNEX III	1.6.1 1.15.1
3D	INFLUENCE OF PIPE MATERIAL - WOOD STUD WALL - ARMAFLEX ATTACHMENT WATER PRESSURE OF 40 PSI.	ANNEX III ANNEX III	1.6.4 1.15.4
4A	INFLUENCE OF PIPE ATTACHMENT - WOOD STUD WALL - SUPPLY PIPE	ANNEX III ANNEX III ANNEX III ANNEX III ANNEX III	1.3.4 1.6.4 1.9.4 1.18.2 1.21.2
4B	INFLUENCE OF CONTACT WITH DRYWALL - WOOD STUD WALL - WASTE PIPE	ANNEX III ANNEX III	1.22.2 1.22.6

GRAPH NUMBER	GRAPH TITLE	REFERENCE	
5A	INFLUENCE OF SOUND ABSORPTION	ANNEX III	1.1.4
	AND RESILIENT FURRING -	ANNEX III	2.1.4
	WOOD STUD WALL -	ANNEX III	3.1.2
	STANDARD CLAMPS ATTACHMENT	ANNEX III	4.1.2
5B	INFLUENCE OF SOUND ABSORPTION	ANNEX III	1.6.4
	AND RESILIENT FURRING -	ANNEX III	3.4.2
	WOOD STUD WALL -	ANNEX III	4.4.2
	ARMAFLEX ATTACHMENT		
5C	INFLUENCE OF WALL COMPOSITION -	ANNEX III	14.1.4
	METAL STUD WALL -	ANNEX III	14.2.4
	PLASTIC AND ARMAFLEX SLEEVE ATTACHMENT	ANNEX III	15.2.4
		ANNEX III	16.2.4
6	INFLUENCE OF INSULATION ON THE PIPE -	ANNEX III	1.6.4
	WOOD STUD WALL -	ANNEX III	1.42.4
	ARMAFLEX ATTACHMENT		
7A	INFLUENCE OF FLOW IN FAUCET -	ANNEX III	1.23.4
	WOOD STUD WALL -	ANNEX III	1.29.4
	STANDARD CLAMPS ATTACHMENT	ANNEX III	1.36.4
7B	INFLUENCE OF THE TYPE OF FAUCET USED -	ANNEX III	1.23.4
	WOOD STUD WALL -	ANNEX III	1.24.4
	STANDARD CLAMPS ATTACHMENT	ANNEX III	1.25.4
		ANNEX III	1.26.4
		ANNEX III	1.27.4

GRAPH NUMBER	GRAPH TITLE	REFERENCE	
8A	INFLUENCE OF WALL COMPOSITION - WOOD STUD WALL - SOUND ABSORPTION OF A BEDROOM - SUPPLY PIPE	ANNEX II	TABLE 11
8B	INFLUENCE OF WALL COMPOSITION - WOOD STUD WALL - SOUND ABSORPTION OF A BEDROOM - SINK EMPTYING	ANNEX II	TABLE 12
8C	INFLUENCE OF WALL COMPOSITION - METAL STUD WALL - SOUND ABSORPTION OF A BEDROOM - SUPPLY PIPE	ANNEX II	TABLE 13
8D	INFLUENCE OF WALL COMPOSITION - METAL STUD WALL - SOUND ABSORPTION OF A BEDROOM - WASTE PIPE	ANNEX II	TABLE 14
8E	SHAFT WALL - SOUND ABSORPTION OF A BEDROOM - WASTE PIPE	ANNEX II	TABLE 15



LEGEND



WOOD STUD WALL
COPPER PIPE 1" DIAMETER
SOURCE: ISO
ARMAFLEX ATTACHMENT

□———□
PRESSURE OF 100 PSI.
TEST # 1.4.1 (dBA= 59)

△———△
PRESSURE OF 80 PSI.
TEST # 1.4.2 (dBA= 58)

◇———◇
PRESSURE OF 60 PSI.
TEST # 1.4.3 (dBA= 56)

▽———▽
PRESSURE OF 40 PSI.
TEST # 1.4.4 (dBA= 54)

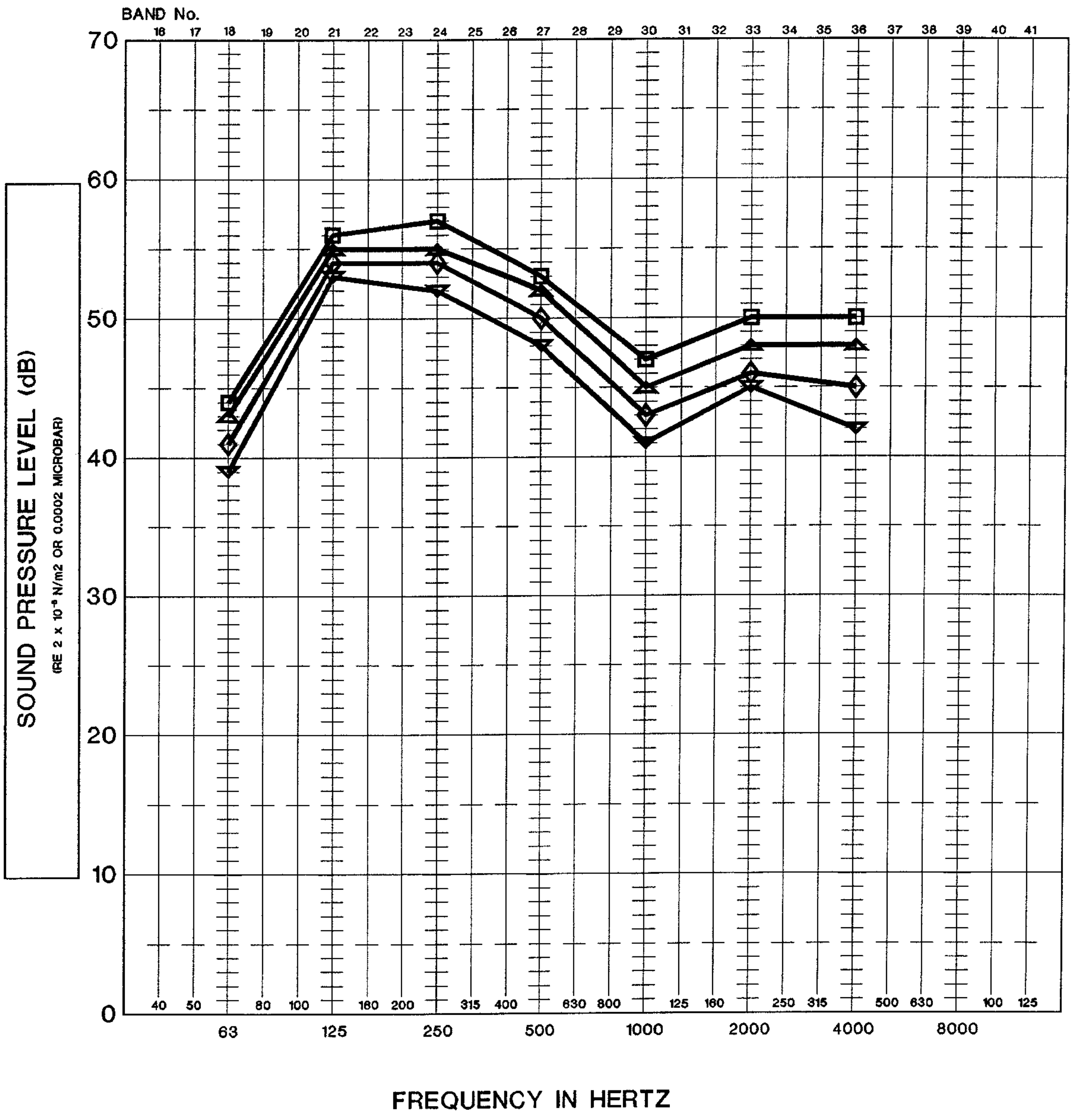
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF WATER PRESSURE –
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

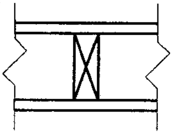
GRAPH NUMBER 1A

PROJECT NUMBER
177.891

DATE
90 09



LEGEND



WOOD STUD WALL
COPPER PIPE 3/4" DIAMETER
SOURCE: ISO
ARMAFLEX ATTACHMENT

☐——☐
PRESSURE OF 100 SPI.
TEST # 1.5.1 (dBA= 57)

△——△
PRESSURE OF 80 SPI.
TEST # 1.5.2 (dBA=55)

◇——◇
PRESSURE OF 60 PSI.
TEST # 1.5.3 (dBA= 53)

▽——▽
PRESSURE OF 40 PSI.
TEST # 1.5.4 (dBA= 51)

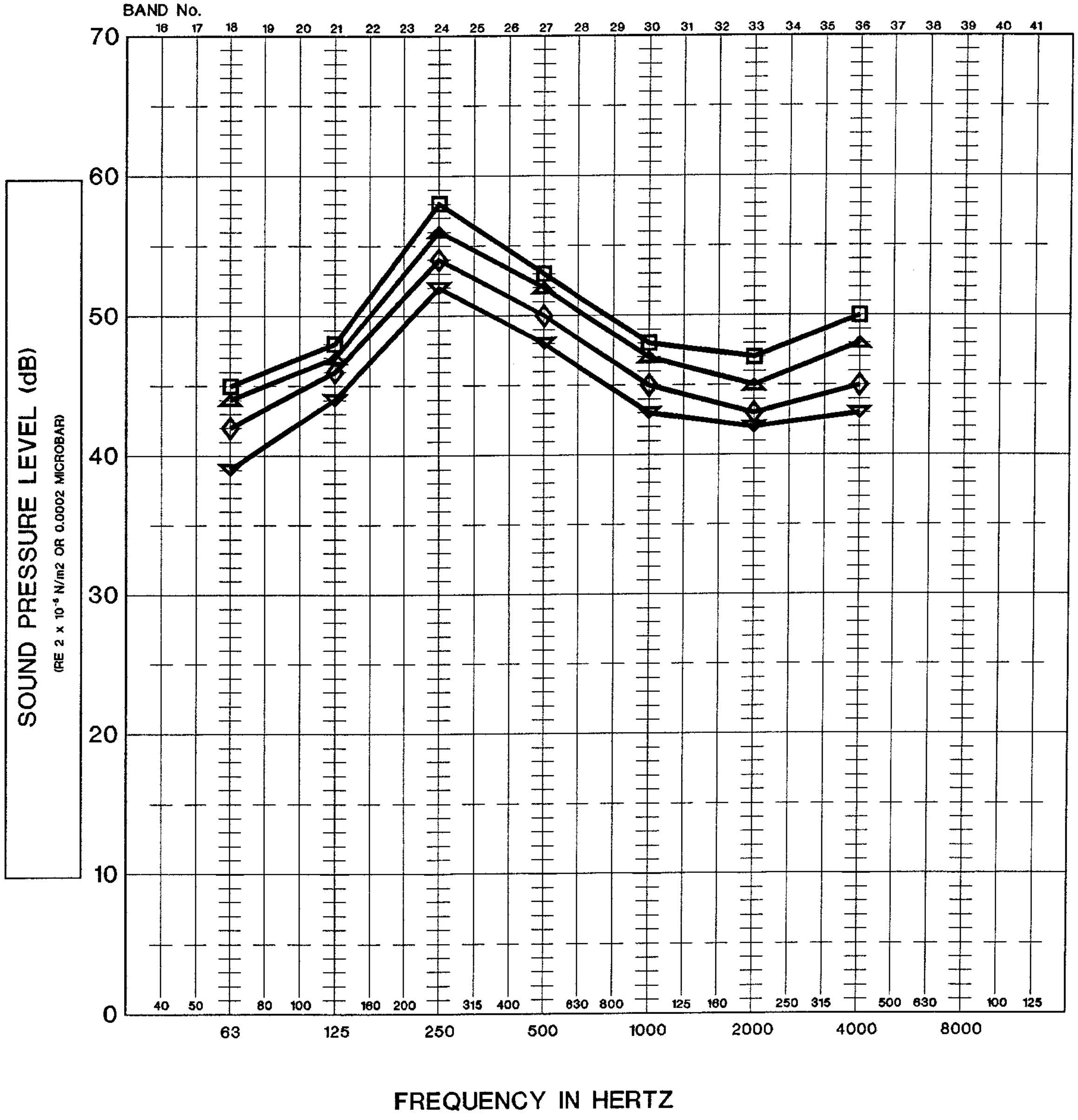
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF WATER PRESSURE
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

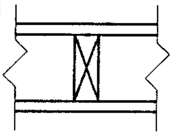
GRAPH NUMBER 1B

PROJECT NUMBER
177.891

DATE
90 09



LEGEND



WOOD STUD WALL
COPPER PIPE 1/2" DIAMETER
SOURCE: ISO
ARMAFLEX ATTACHMENT

☐———☐
PRESSURE OF 100 SPI.
TEST # 1.6.1 (dBA= 57)

△———△
PRESSURE OF 80 SPI.
TEST # 1.6.2 (dBA= 55)

◇———◇
PRESSURE OF 60 PSI.
TEST # 1.6.3 (dBA= 53)

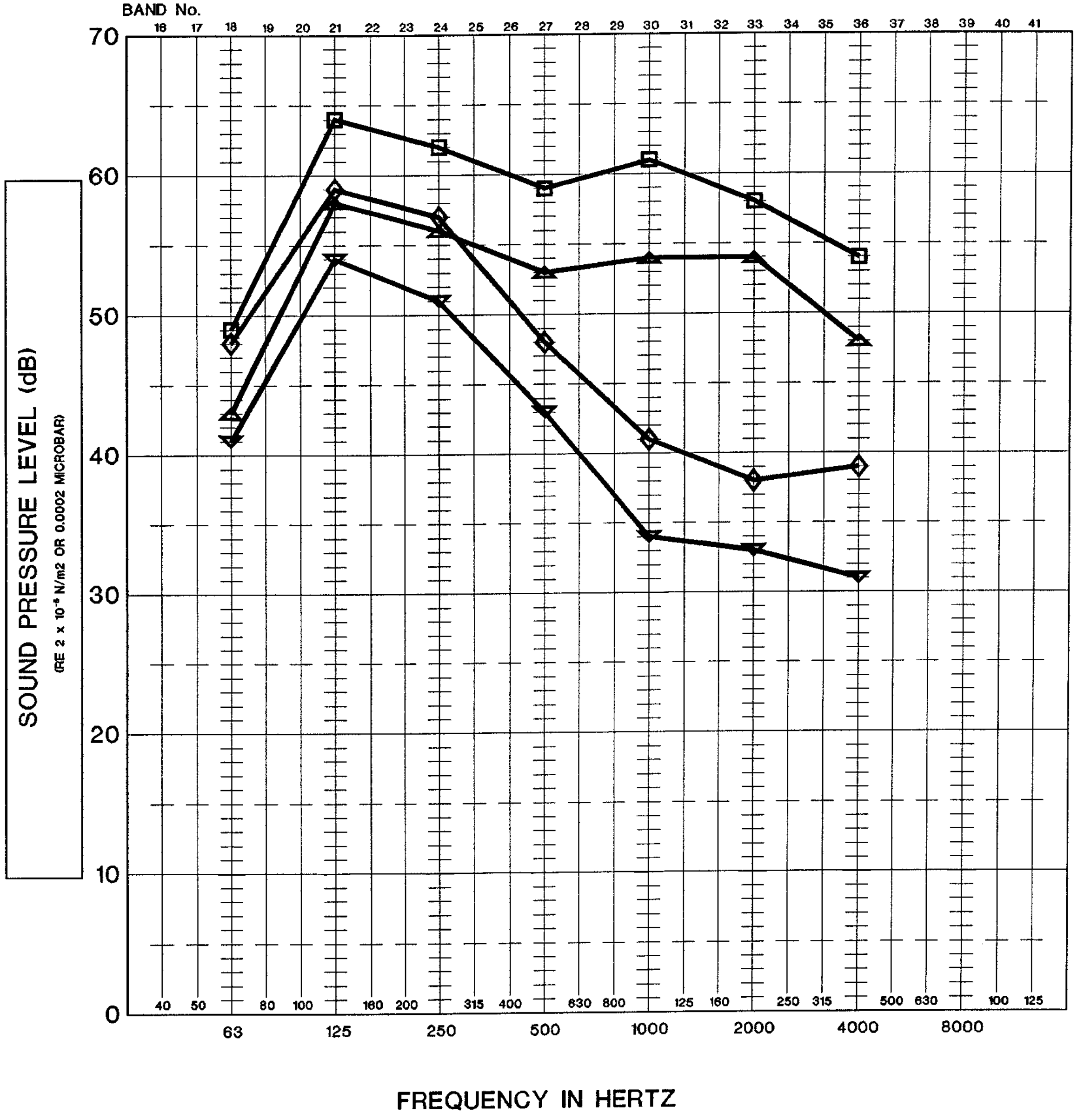
▽———▽
PRESSURE OF 40 PSI.
TEST # 1.6.4 (dBA= 51)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

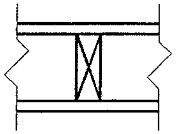
GRAPH TITLE
INFLUENCE OF WATER PRESSURE –
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

GRAPH NUMBER 1C

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
PLASTIC PIPE 1/2" DIAMETER
SOURCE: ISO
STANDARD & ARMAFLEX
ATTACHMENT

□——□
STANDARD CLAMPS ATTACHMENT
AT A PRESSURE OF 100 PSI.
TEST # 1.12.1 (dBA= 65)

△——△
STANDARD CLAMPS ATTACHMENT
AT A PRESSURE OF 40 PSI.
TEST # 1.12.4 (dBA= 59)

◇——◇
ARMALFEX WITH OVERSIZED CLAMPS
AT A PRESSURE OF 100 PSI.
TEST # 1.15.1 (dBA= 52)

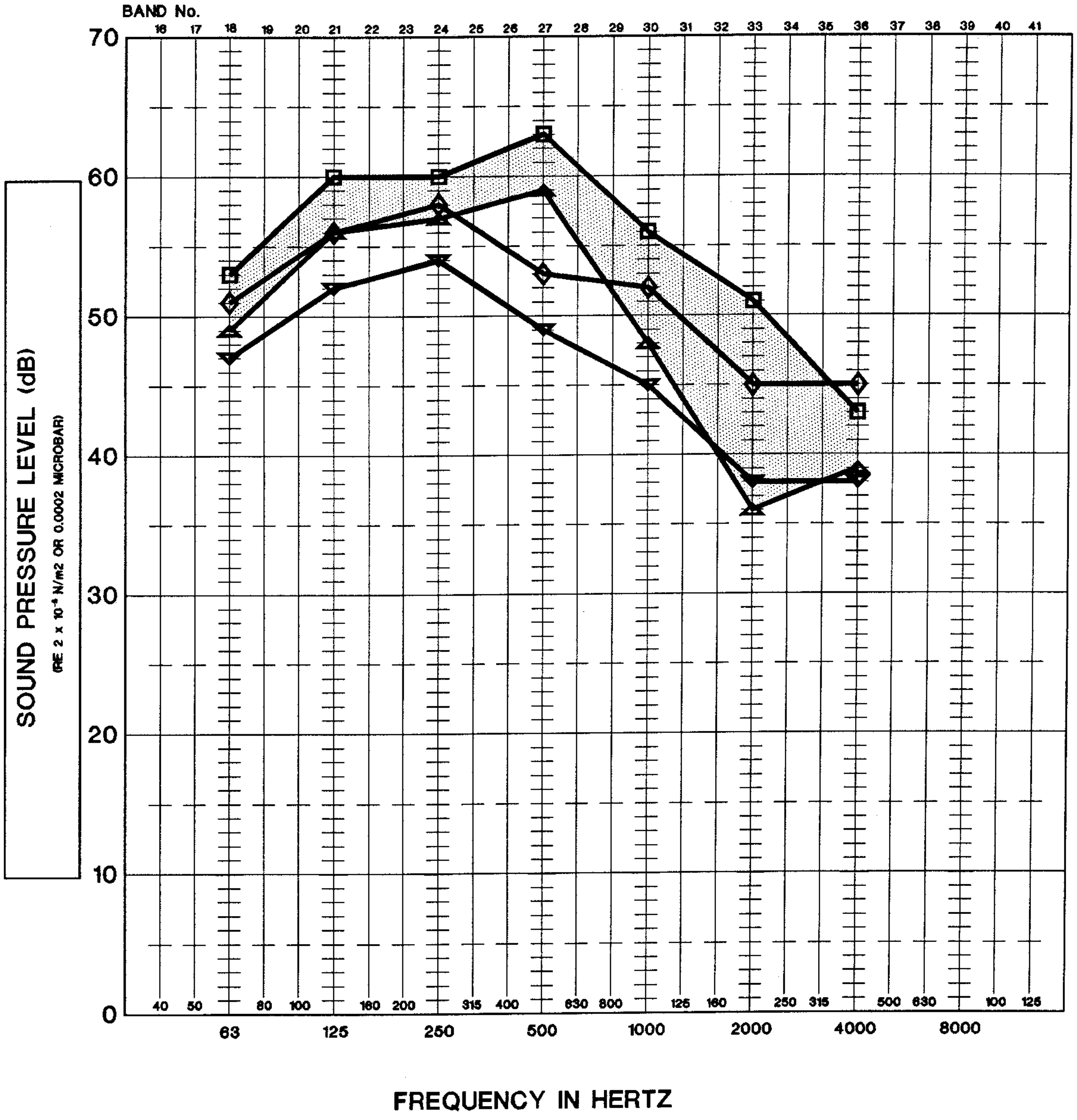
▽——▽
ARMAFLEX WITH OVERSIZED CLAMPS
AT A PRESSURE OF 40 PSI.
TEST # 1.15.4 (dBA= 46)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

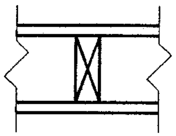
GRAPH TITLE
INFLUENCE OF WATER PRESSURE –
WOOD STUD WALL
STANDARD & ARMAFLEX ATTACHMENT

GRAPH NUMBER 1D

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
PLASTIC PIPE 1" DIAMETER
SOURCE: ISO
STANDARD & ARMAFLEX
ATTACHMENT

□——□
STANDARD CLAMPS ATTACHMENT
AT A PRESSURE OF 100 PSI.
TEST # 1.10.1 (dBA= 62)

◇——◇
ARMAFLEX WITH OVERSIZED CLAMPS
AT A PRESSURE OF 100 PSI.
TEST # 1.13.1 (dBA= 56)

△——△
STANDARD CLAMPS ATTACHMENT
AT A PRESSURE OF 40 PSI.
TEST # 1.10.4 (dBA= 57)

▽——▽
ARMAFLEX WITH OVERSIZED CLAMPS
AT A PRESSURE OF 40 PSI.
TEST # 1.13.4 (dBA= 51)

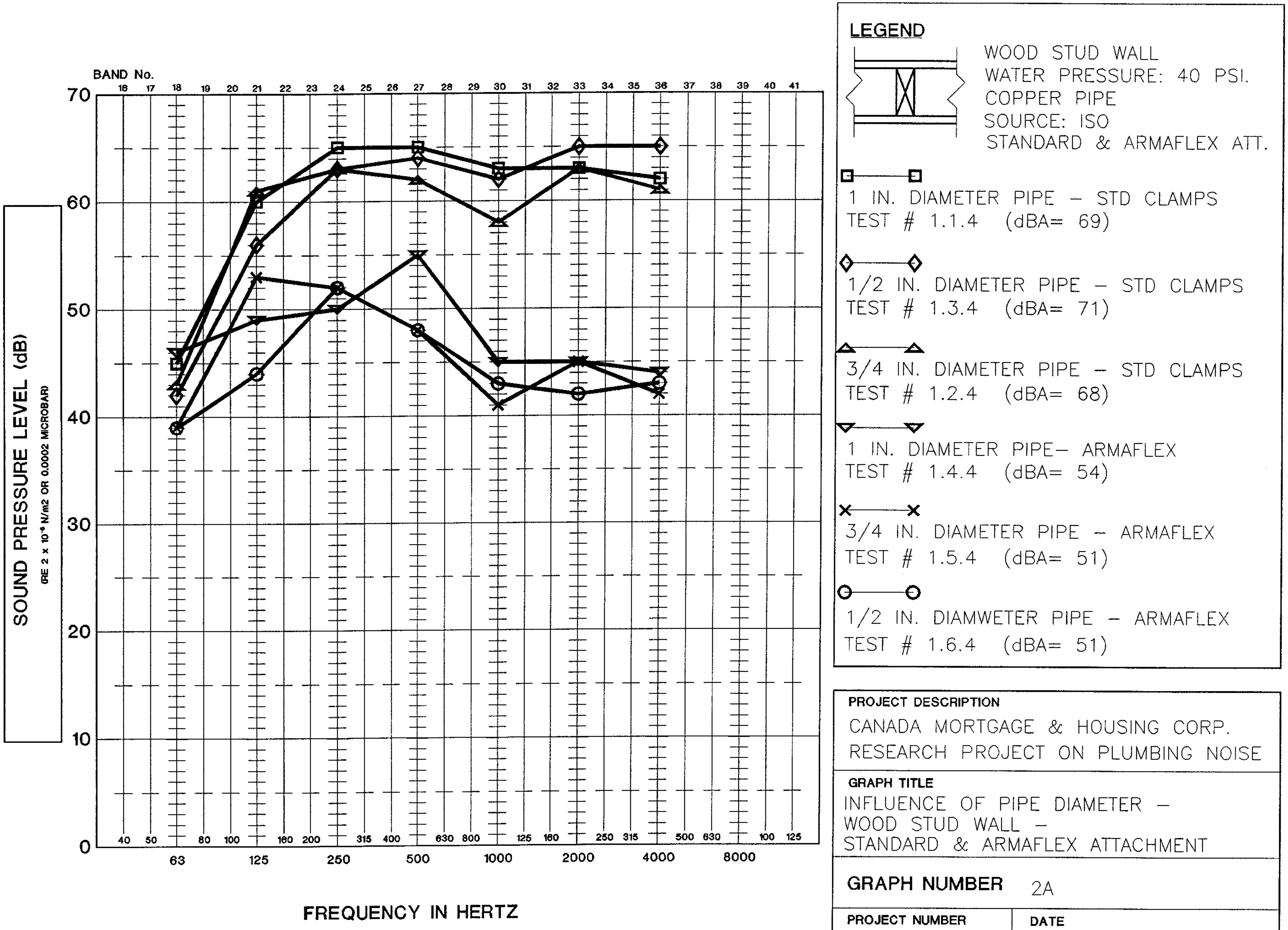
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF WATER PRESSURE –
WOOD STUD WALL
STANDARD & ARMAFLEX ATTACHMENT

GRAPH NUMBER 1E

PROJECT NUMBER	DATE
177.891	90 09

mjm

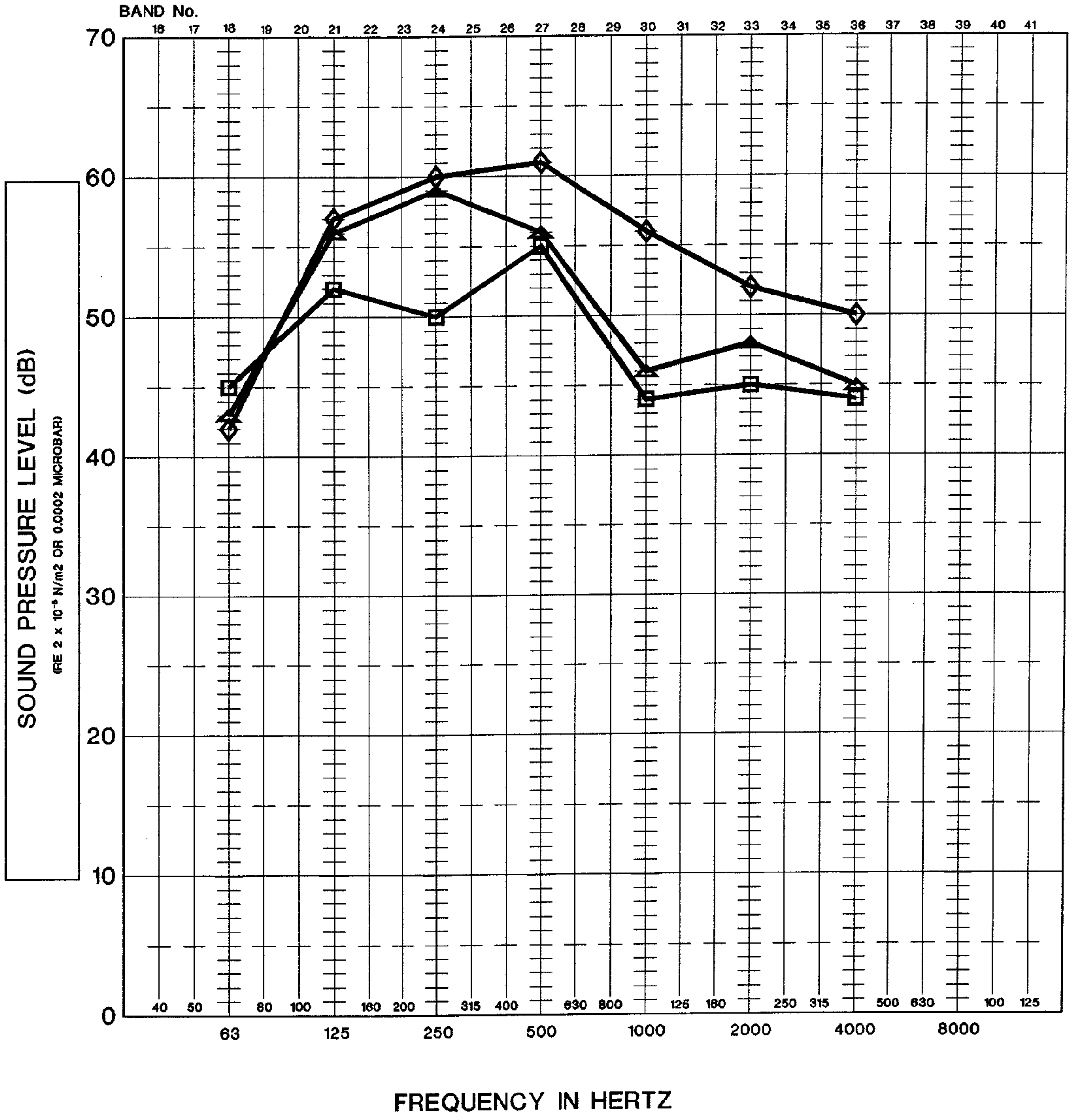


PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

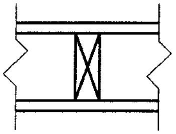
GRAPH TITLE
INFLUENCE OF PIPE DIAMETER -
WOOD STUD WALL -
STANDARD & ARMAFLEX ATTACHMENT

GRAPH NUMBER 2A

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE
SOURCE: ISO
FELT SLEEVE

◇——◇
1/2 IN. DIAMETER PIPE
TEST # 1.18.2 (dBA= 61)

△——△
3/4 IN. DIAMETER PIPE
TEST # 1.17.2 (dBA= 57)

□——□
1 IN. DIAMETER PIPE
TEST # 1.16.2 (dBA=54)

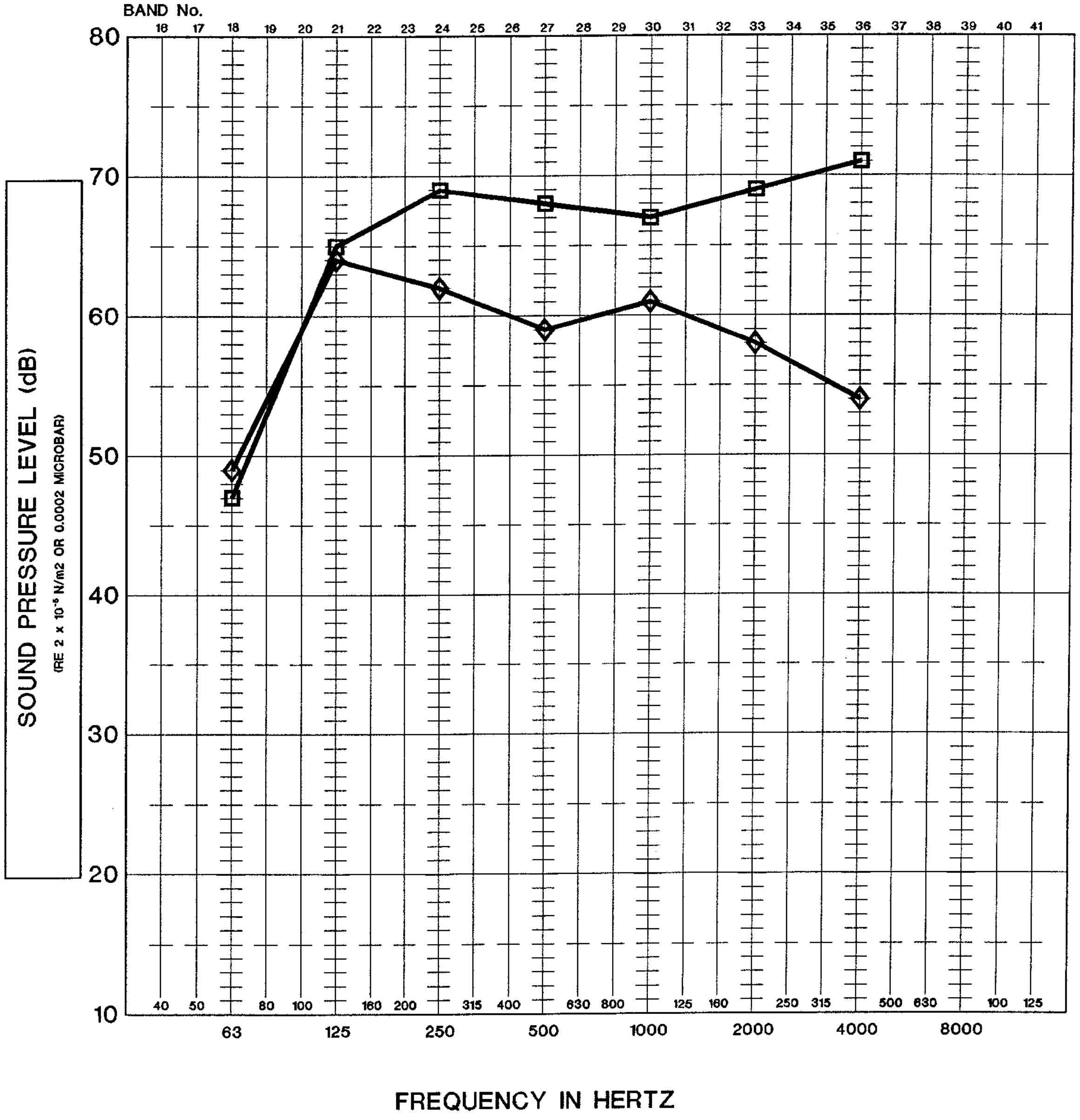
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF PIPE DIAMETER–
WOOD STUD WALL –
FELT SLEEVE

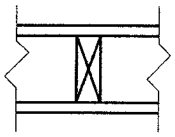
GRAPH NUMBER 2B

PROJECT NUMBER 177.891

DATE 90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 100 PSI.
1/2" DIAMETER PIPE
SOURCE: ISO
STANDARD CLAMPS ATT.

□——□

COPPER PIPE

TEST # 1.3.1 (dBA= 76)

◇——◇

PLASTIC PIPE

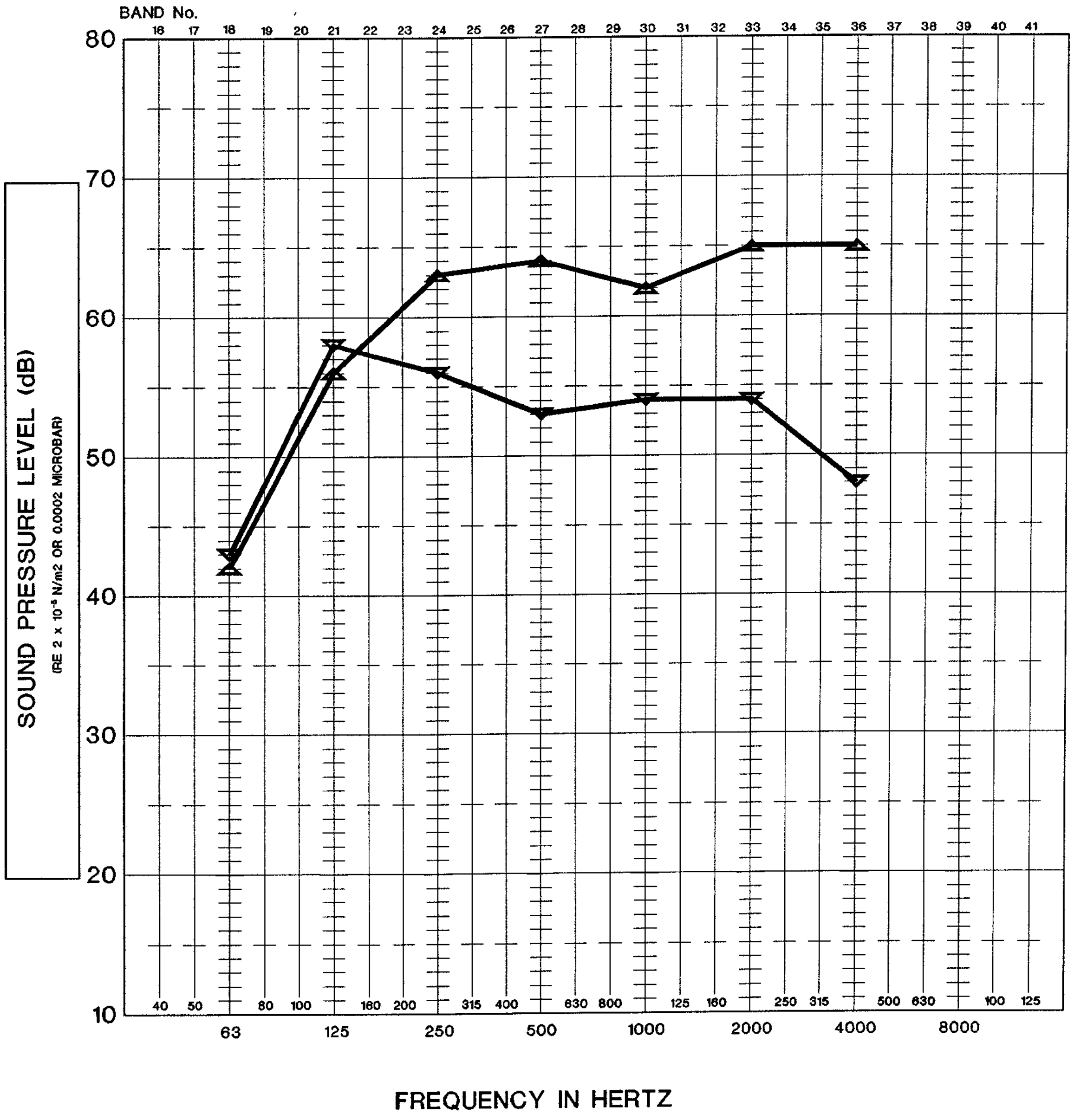
TEST # 1.12.1 (dBA= 65)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

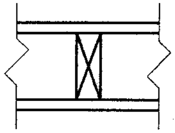
GRAPH TITLE
INFLUENCE OF PIPE MATERIAL –
WOOD STUD WALL –
3 STANDARD CLAMPS ATTACHMENT

GRAPH NUMBER 3A

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
1/2" DIAMETER PIPE
SOURCE: ISO
STANDARD CLAMPS ATT.

△——△

COPPER PIPE

TEST # 1.3.4 (dBA= 71)

▽——▽

PLASTIC PIPE

TEST # 1.12.4 (dBA= 59)

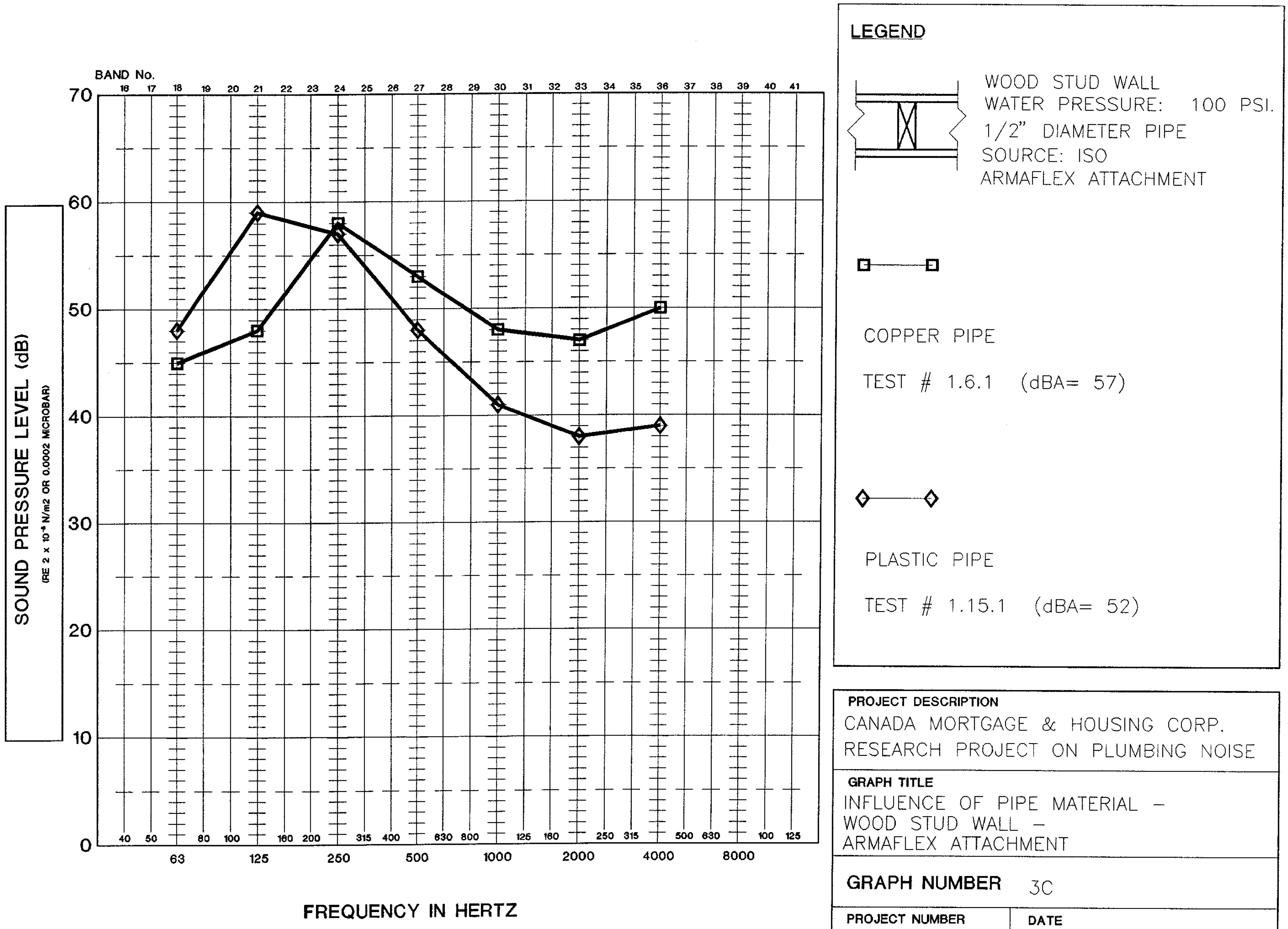
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF PIPE MATERIAL –
WOOD STUD WALL –
3 STANDARD CLAMPS ATTACHMENT

GRAPH NUMBER 3B

PROJECT NUMBER 177.891

DATE 90 09



PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

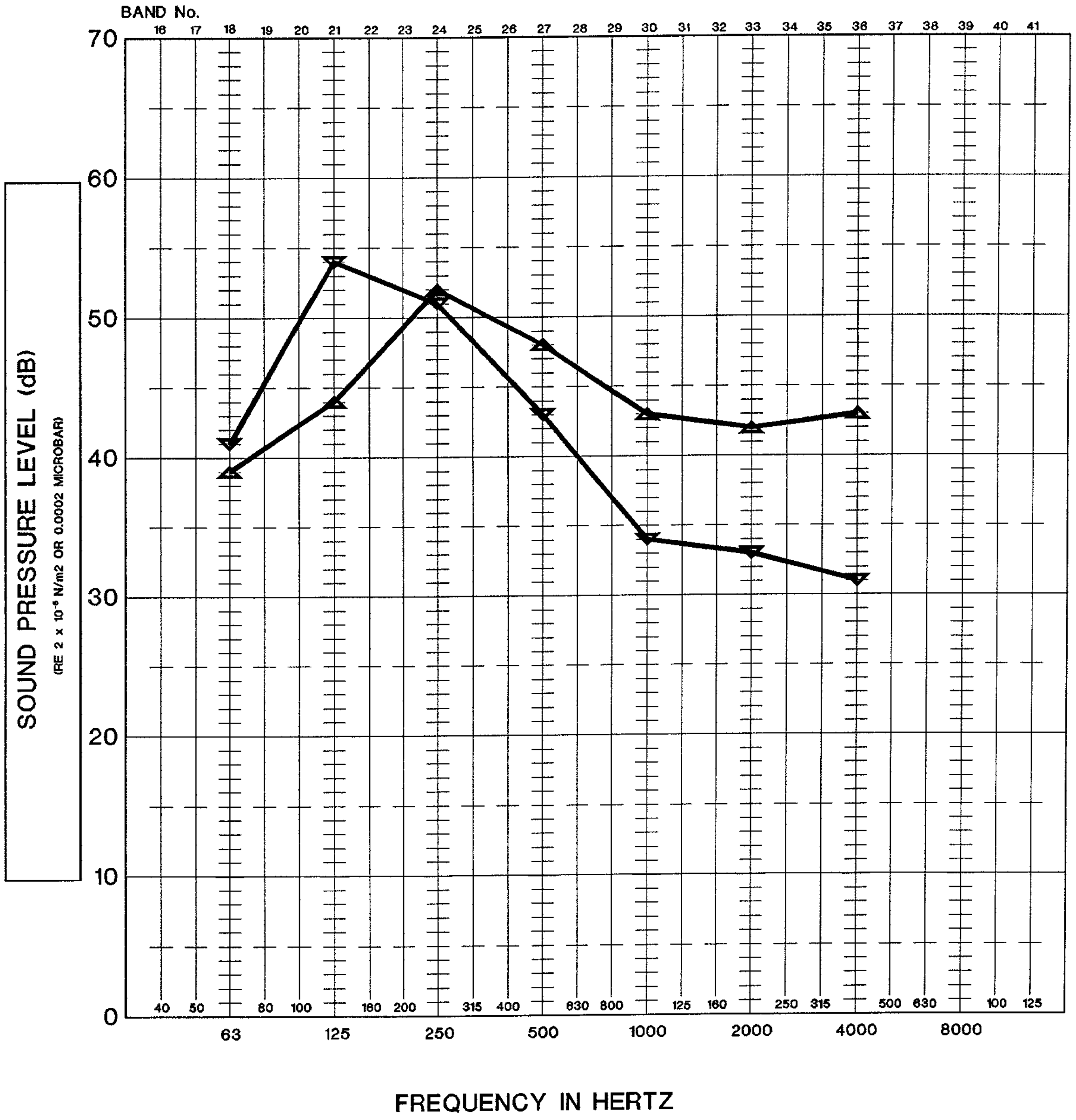
GRAPH TITLE
INFLUENCE OF PIPE MATERIAL –
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

GRAPH NUMBER 3C

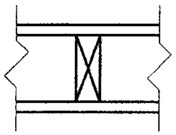
PROJECT NUMBER
177.891

DATE
90 09

mjm



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
1/2" DIAMETER PIPE
SOURCE: ISO
ARMAFLEX ATTACHMENT

△———△

COPPER PIPE

TEST # 1.6.4 (dBA= 51)

▽———▽

PLASTIC PIPE

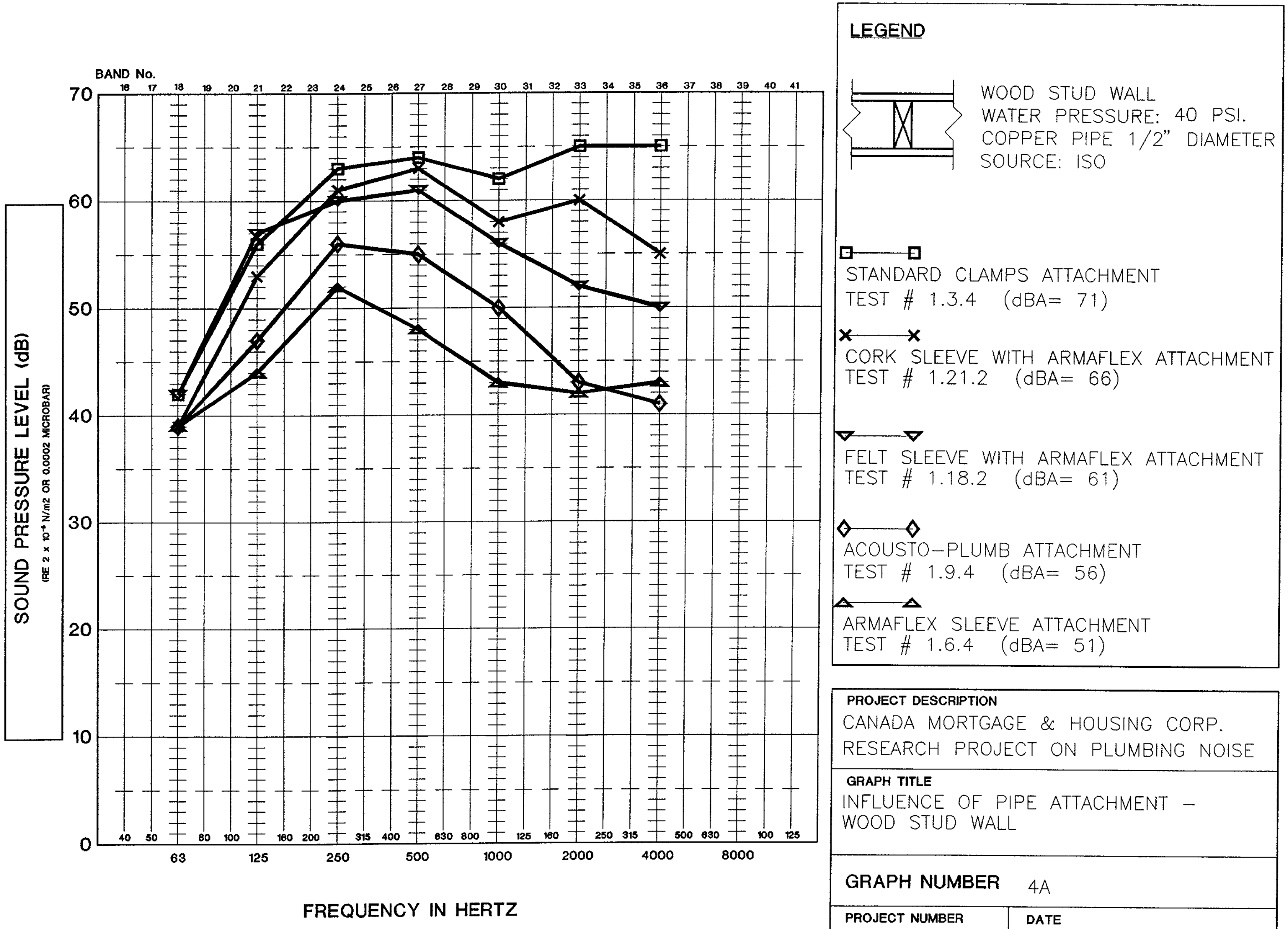
TEST # 1.15.4 (dBA= 46)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF PIPE MATERIAL –
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

GRAPH NUMBER 3D

PROJECT NUMBER	**DATE**
177.891	90 09



PROJECT DESCRIPTION

CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

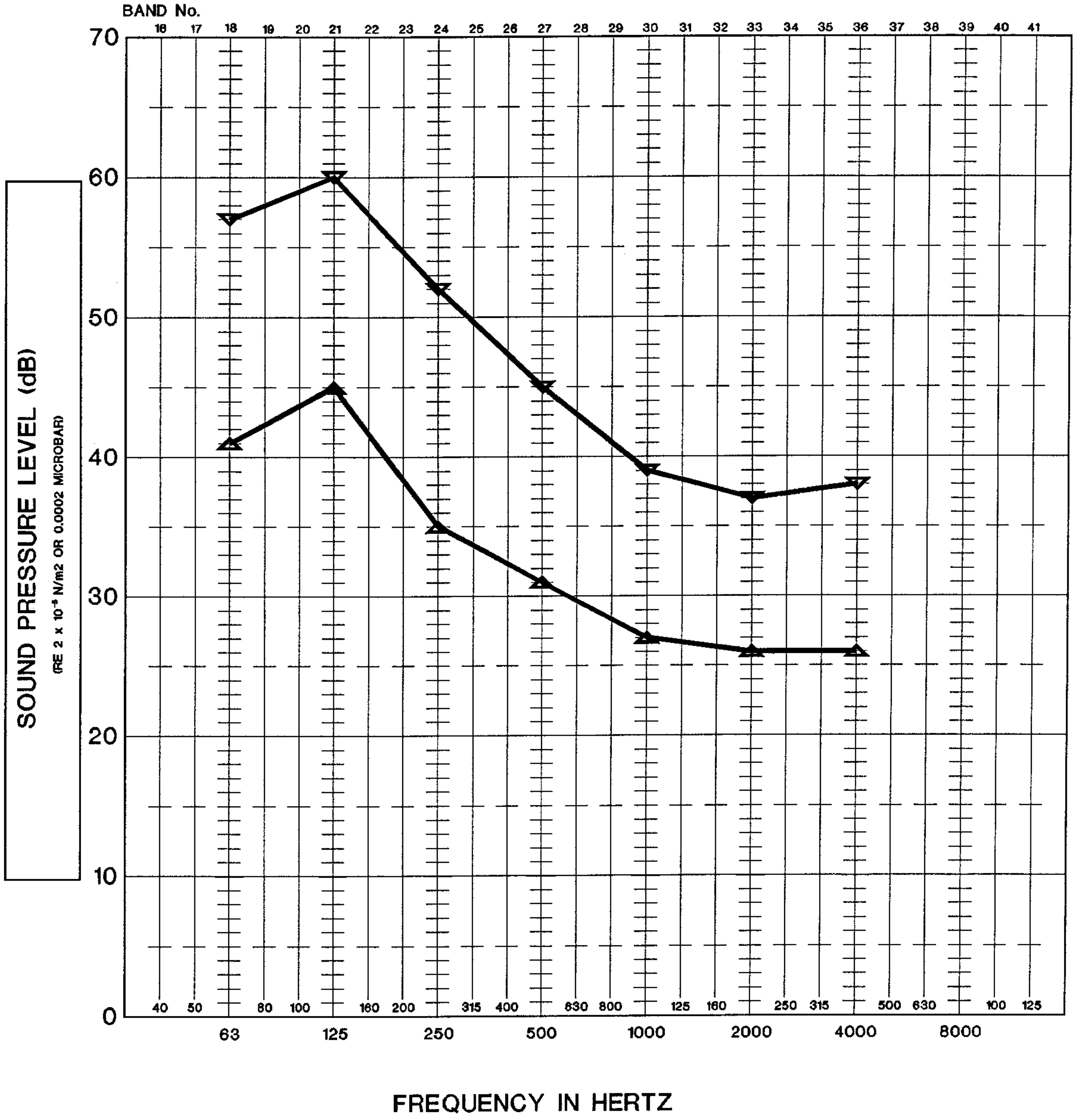
GRAPH TITLE

INFLUENCE OF PIPE ATTACHMENT –
WOOD STUD WALL

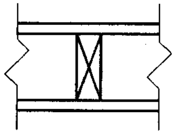
GRAPH NUMBER 4A

PROJECT NUMBER	**DATE**
177.891	90 09

mjm



LEGEND



WOOD STUD WALL
COPPER PIPE 2 IN. DIAMETER
SOURCE: SINK EMPTYING

▽———▽

PIPE CONTACT WITH DRYWALL
TEST # 1.22.6 (dBA= 49)

△———△

NO CONTACT WITH DRYWALL
TEST # 1.22.2 (dBA= 35)

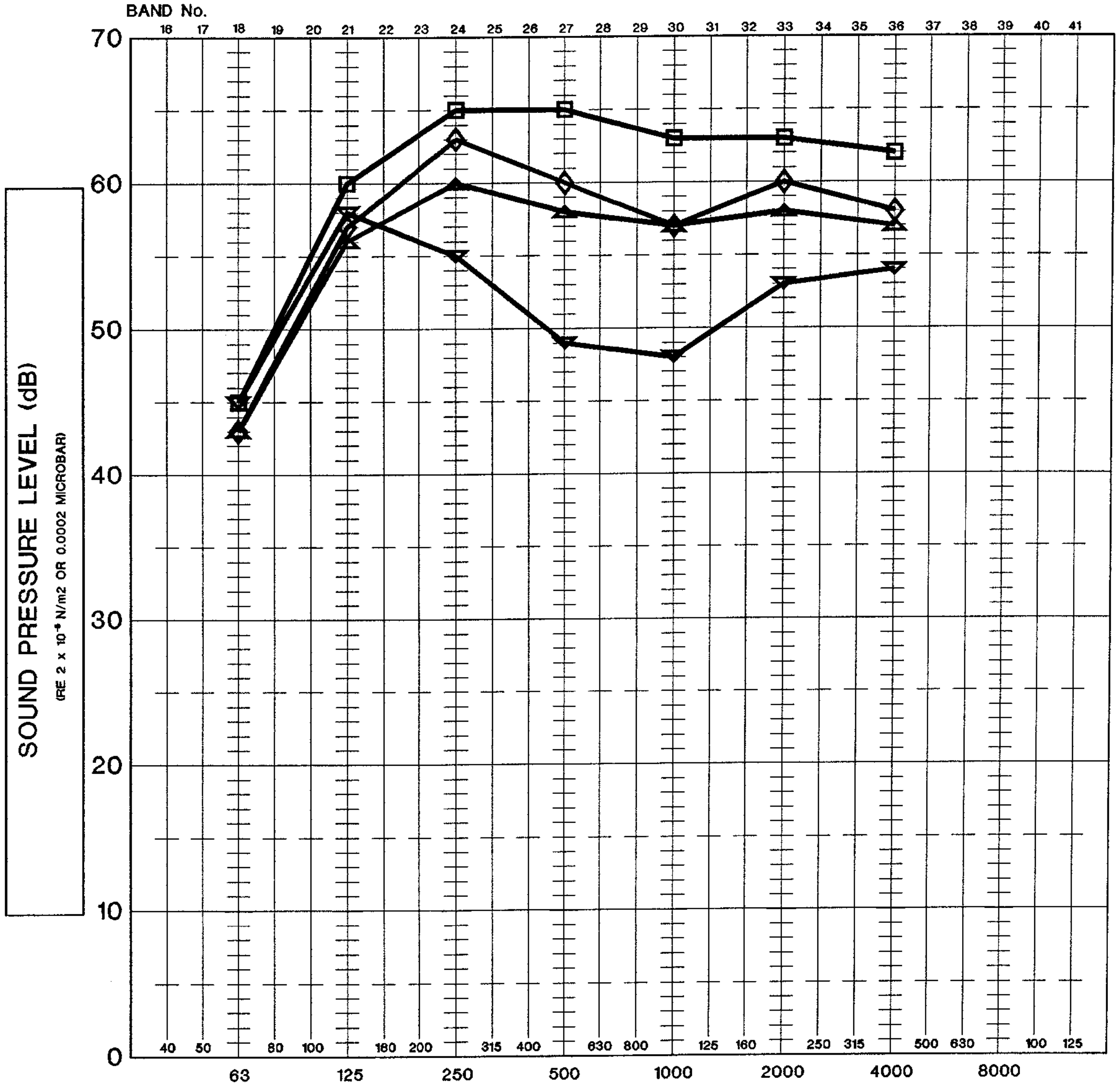
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF CONTACT WITH DRYWALL
FOR WASTE PIPE - WOOD STUD WALL

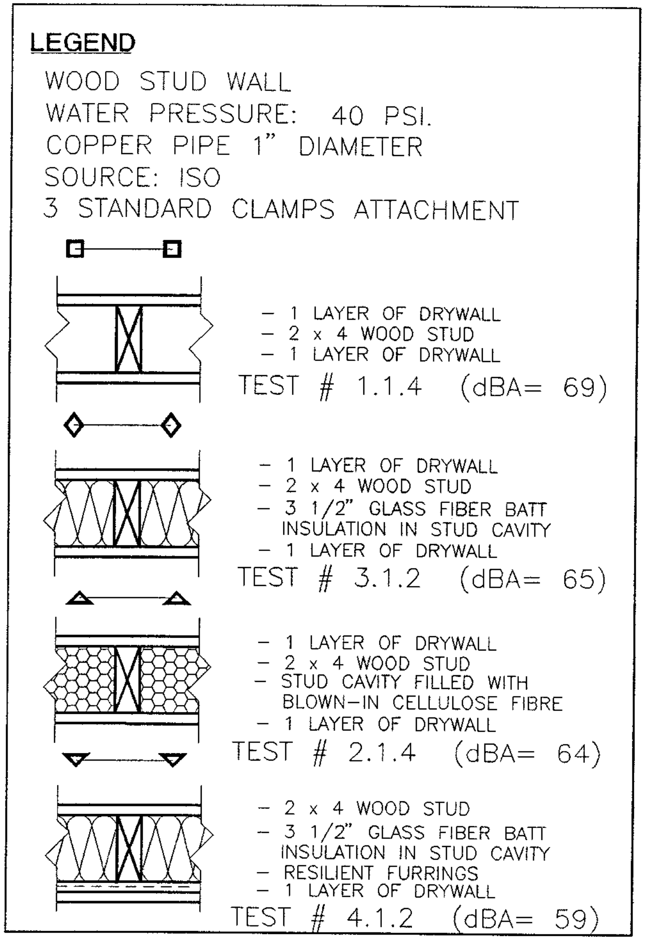
GRAPH NUMBER 4B

PROJECT NUMBER
177.891

DATE
90 09



FREQUENCY IN HERTZ



LEGEND

WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1" DIAMETER
SOURCE: ISO
3 STANDARD CLAMPS ATTACHMENT

□—□
- 1 LAYER OF DRYWALL
- 2 x 4 WOOD STUD
- 1 LAYER OF DRYWALL

TEST # 1.1.4 (dBA= 69)

◇—◇
- 1 LAYER OF DRYWALL
- 2 x 4 WOOD STUD
- 3 1/2" GLASS FIBER BATT INSULATION IN STUD CAVITY
- 1 LAYER OF DRYWALL

TEST # 3.1.2 (dBA= 65)

△—△
- 1 LAYER OF DRYWALL
- 2 x 4 WOOD STUD
- STUD CAVITY FILLED WITH BLOWN-IN CELLULOSE FIBRE
- 1 LAYER OF DRYWALL

TEST # 2.1.4 (dBA= 64)

▽—▽
- 2 x 4 WOOD STUD
- 3 1/2" GLASS FIBER BATT INSULATION IN STUD CAVITY
- RESILIENT FURRINGS
- 1 LAYER OF DRYWALL

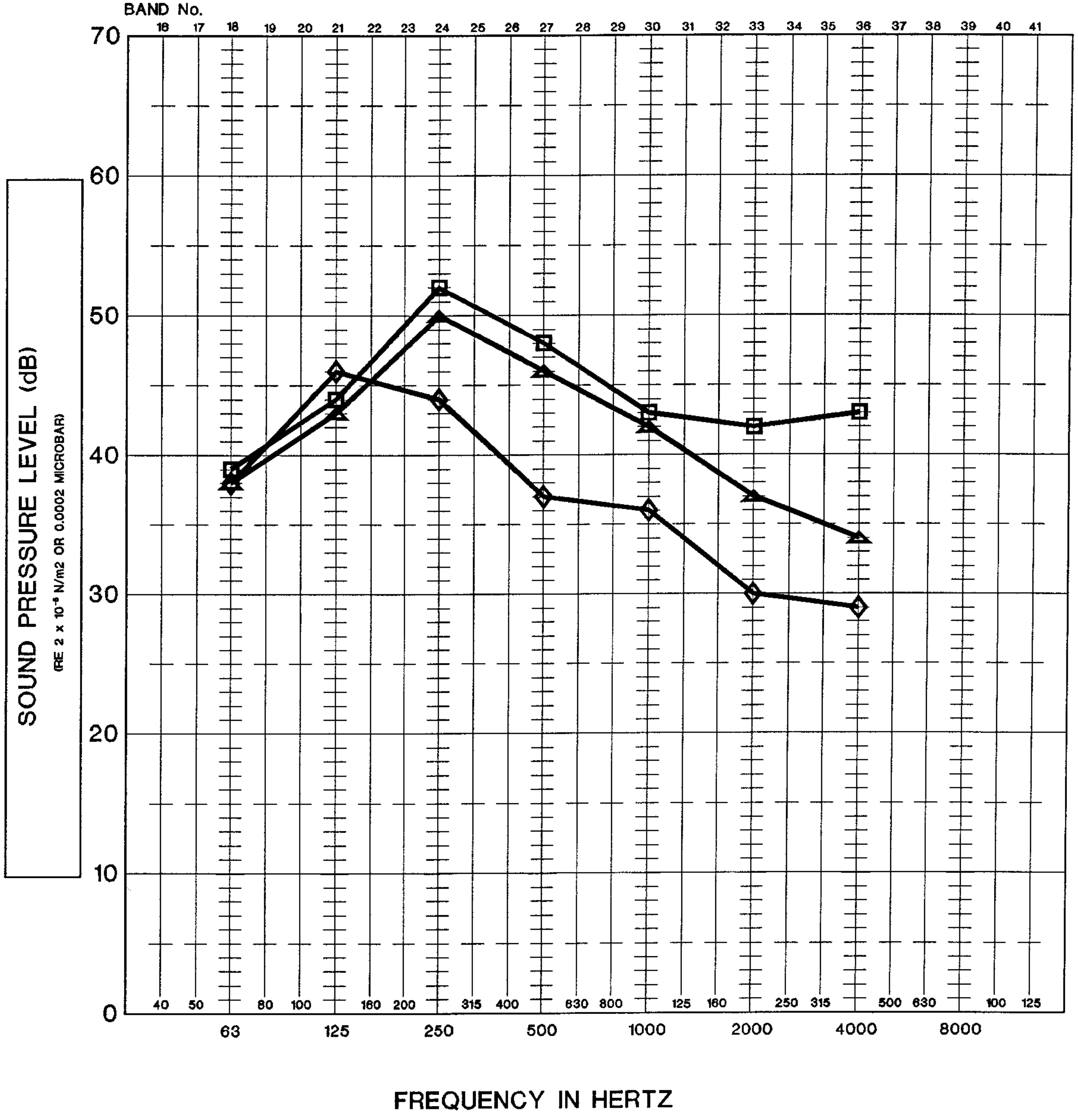
TEST # 4.1.2 (dBA= 59)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF SOUND ABSORPTION AND
RESILIENT FURRING – WOOD STUD WALL
3 STANDARD CLAMPS ATTACHMENT

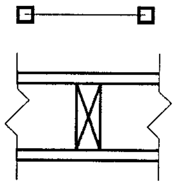
GRAPH NUMBER 5A

PROJECT NUMBER	**DATE**
177.891	90 09



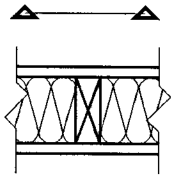
LEGEND

WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE: ISO
ARMAFLEX ATTACHMENT



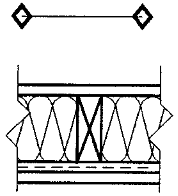
- 1 LAYER OF DRYWALL
- 2 x 4 WOOD STUD
- 1 LAYER OF DRYWALL

TEST # 1.6.4 (dBA= 51)



- 1 LAYER OF DRYWALL
- 2 x 4 WOOD STUD
- 3 1/2" GLASS FIBER BATT INSULATION IN STUD CAVITY
- 1 LAYER OF DRYWALL

TEST # 3.4.2 (dBA= 48)



- 2 x 4 WOOD STUD
- 3 1/2" GLASS FIBER BATT INSULATION IN STUD CAVITY
- RESILIENT FURRINGS
- 1 LAYER OF DRYWALL

TEST # 4.4.2 (dBA= 41)

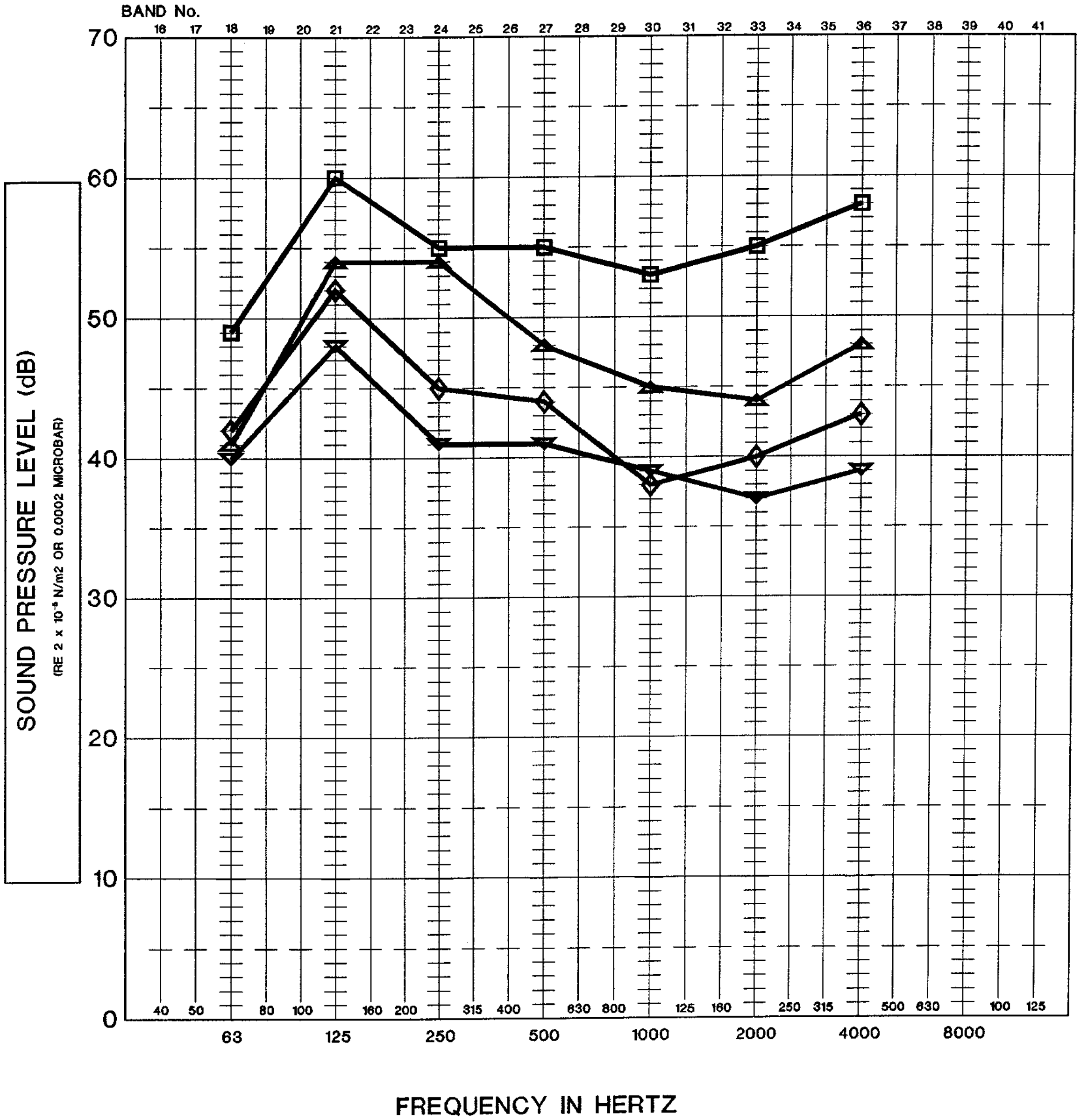
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF SOUND ABSORPTION AND
RESILIENT FURRING – WOOD STUD WALL
ARMAFLEX ATTACHMENT

GRAPH NUMBER 5B

PROJECT NUMBER 177.891

DATE 90 09



LEGEND

METAL STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE:ISO

□—□
PLASTIC SLEEVE
TEST # 14.1.4 (dBA= 62)

△—△
ARMAFLEX SLEEVE
TEST # 14.2.4 (dBA= 53)

◇—◇
ARMAFLEX SLEEVE
TEST # 15.2.4 (dBA=48)

▽—▽
ARMAFLEX SLEEVE
TEST # 16.2.4 (dBA= 46)

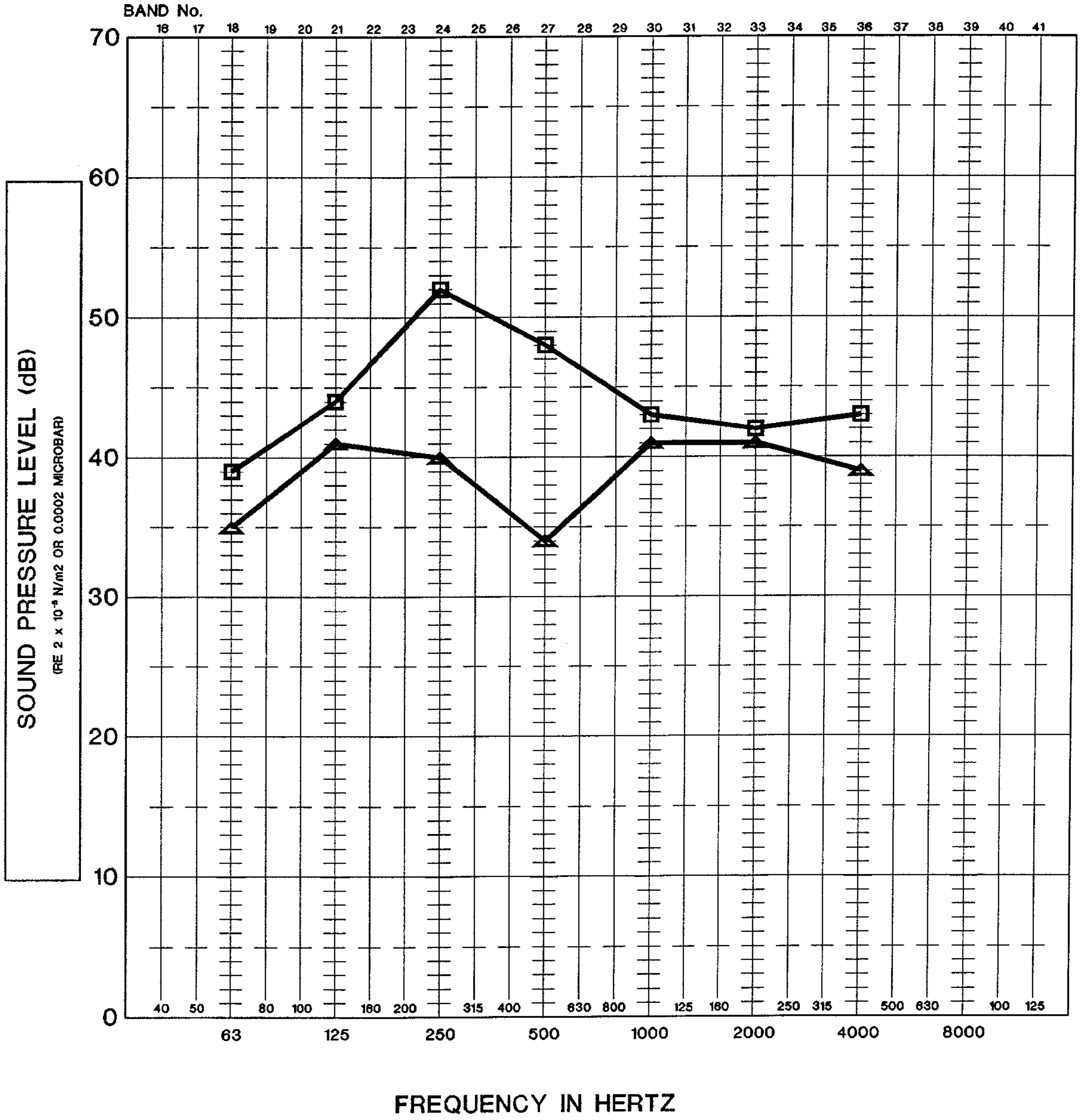
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INLFUENCE OF WALL COMPOSITION –
METAL STUD WALL –
PLASTIC AND ARMAFLEX SLEEVE ATT.

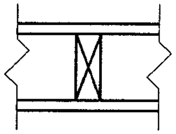
GRAPH NUMBER 5C

PROJECT NUMBER
177.891

DATE
90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE: ISO
ARMAFLEX ATTACHMENT

□——□

NO INSULATION ON THE PIPE
TEST # 1.6.4 (dBA=51)

△——△

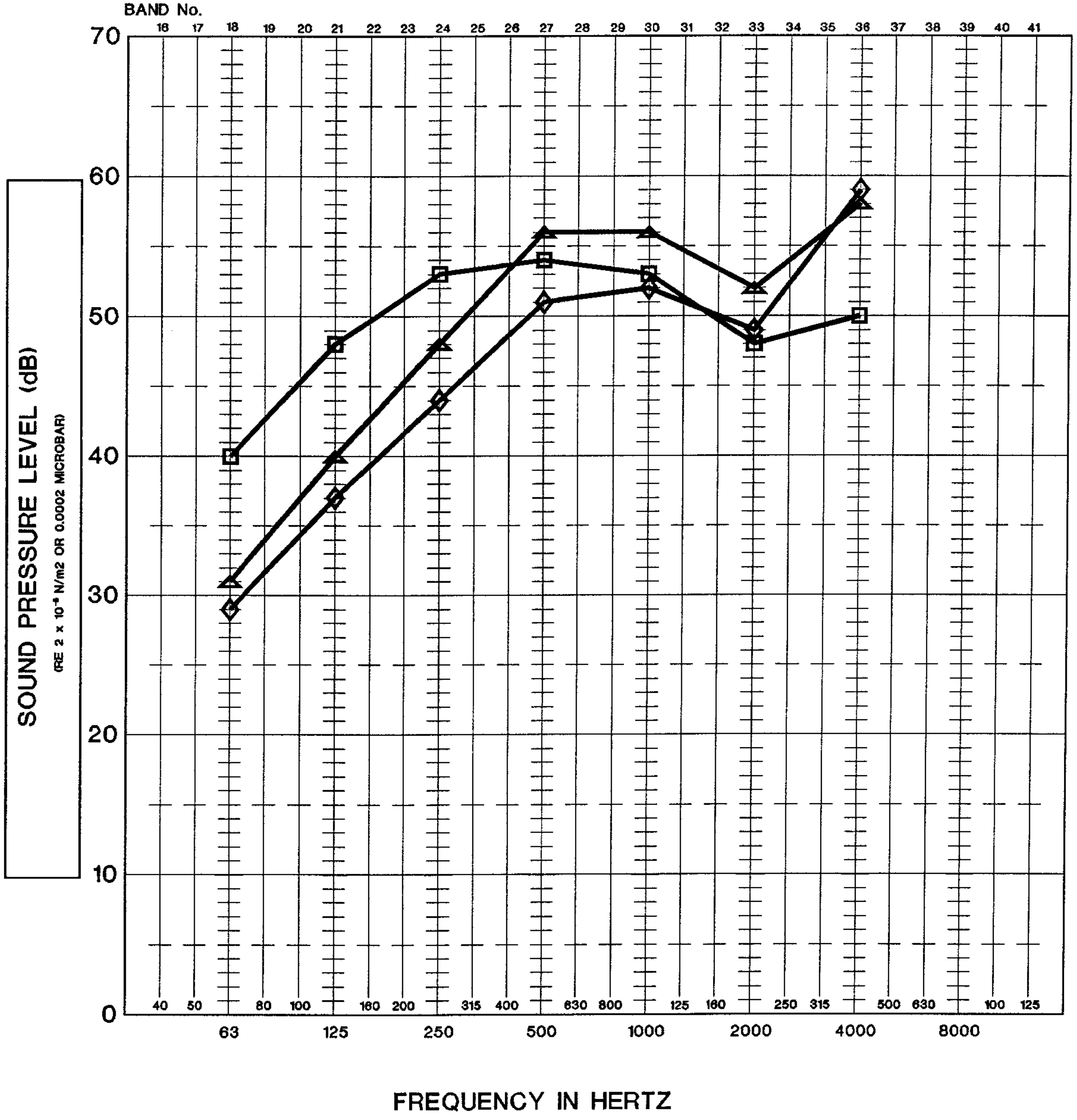
ARMAFLEX INSULATION ON THE PIPE
TEST # 1.42.4 (dBA= 45)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

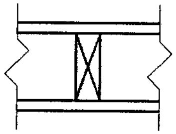
GRAPH TITLE
INFLUENCE OF INSULATION ON THE PIPE
WOOD STUD WALL –
ARMAFLEX ATTACHMENT

GRAPH NUMBER 6

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE: FAUCET # 1
AMERICAN STANDARD CERAMIX
STANDARD CLAMPS ATT.

□———□
MAXIMUM FLOW
TEST # 1.23.4 (dBA= 58)

△———△
1/2 OF MAXIMUM FLOW
TEST # 1.29.4 (dBA= 62)

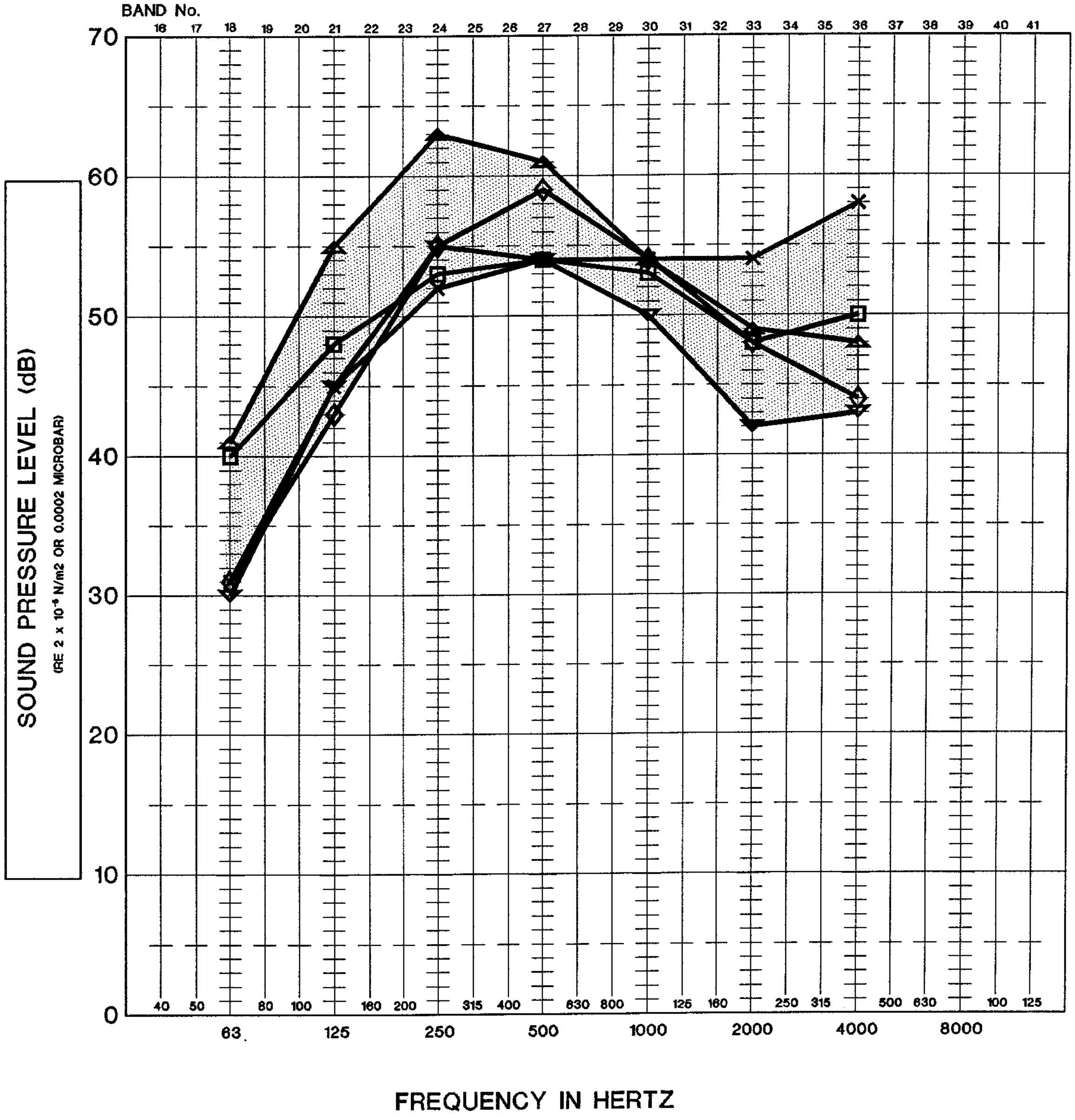
◇———◇
1/4 OF MAXIMUM FLOW
TEST # 1.36.4 (dBA= 61)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

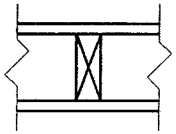
GRAPH TITLE
INFLUENCE OF FLOW IN FAUCET –
WOOD STUD WALL –
3 STANDARD CLAMPS ATTACHMENT

GRAPH NUMBER 7A

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE: FAUCET
FAUCET OPEN AT MAX. FLOW
STANDARD CLAMPS ATT.

△—△
FAUCET #2 DELTA
TEST # 1.24.4 (dBA= 61)

×—×
FAUCET #5 CRANE
TEST # 1.27.4 (dBA= 62)

□—□
FAUCET #1
AMERICAN STANDARD CERAMIX
TEST # 1.23.4 (dBA= 58)

◇—◇
FAUCET #3 WALTEC
TEST # 1.25.4 (dBA= 59)

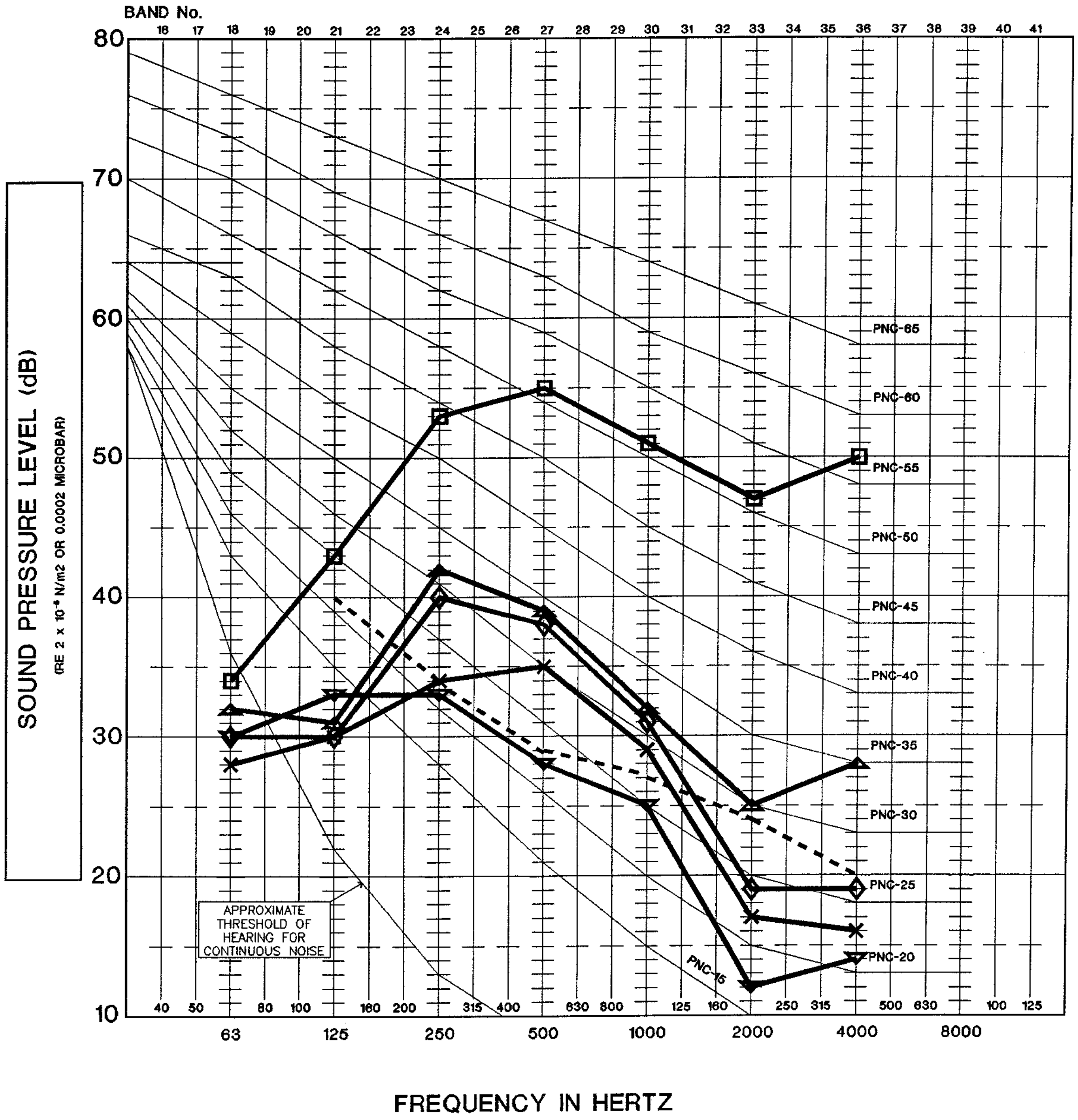
▽—▽
FAUCET #4 MOEN
TEST # 1.26.4 (dBA= 55)

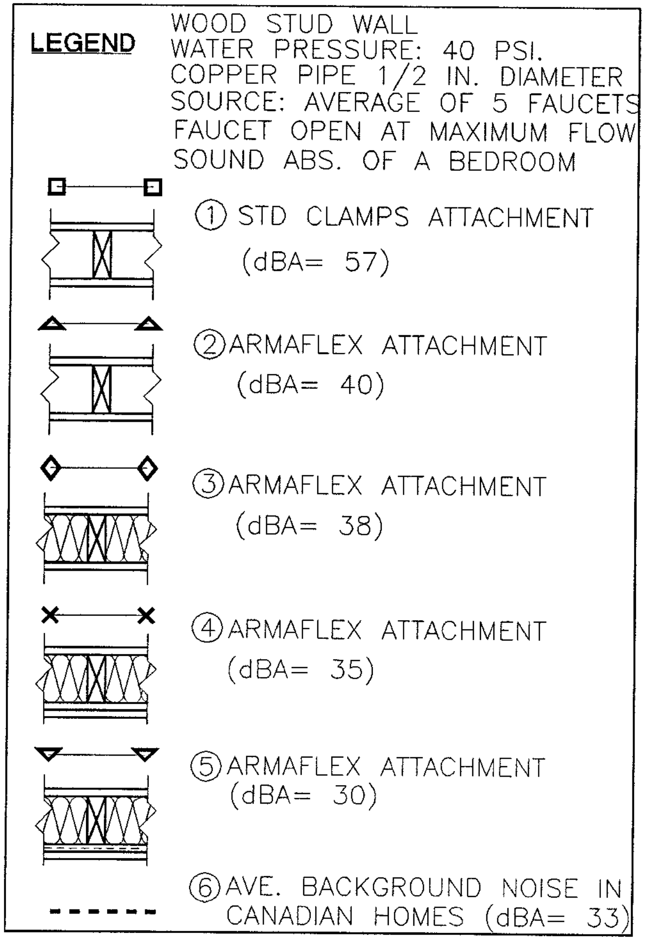
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF THE TYPE OF FAUCET USED
WOOD STUD WALL –
3 STANDARD CLAMPS ATTACHMENT

GRAPH NUMBER 7B

PROJECT NUMBER	**DATE**
177.891	90 09





LEGEND

WOOD STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2 IN. DIAMETER
SOURCE: AVERAGE OF 5 FAUCETS
FAUCET OPEN AT MAXIMUM FLOW
SOUND ABS. OF A BEDROOM

□—□ ① STD CLAMPS ATTACHMENT (dBA= 57)

△—△ ② ARMAFLEX ATTACHMENT (dBA= 40)

◇—◇ ③ ARMAFLEX ATTACHMENT (dBA= 38)

×—× ④ ARMAFLEX ATTACHMENT (dBA= 35)

▽—▽ ⑤ ARMAFLEX ATTACHMENT (dBA= 30)

- - - - - - ⑥ AVE. BACKGROUND NOISE IN CANADIAN HOMES (dBA= 33)

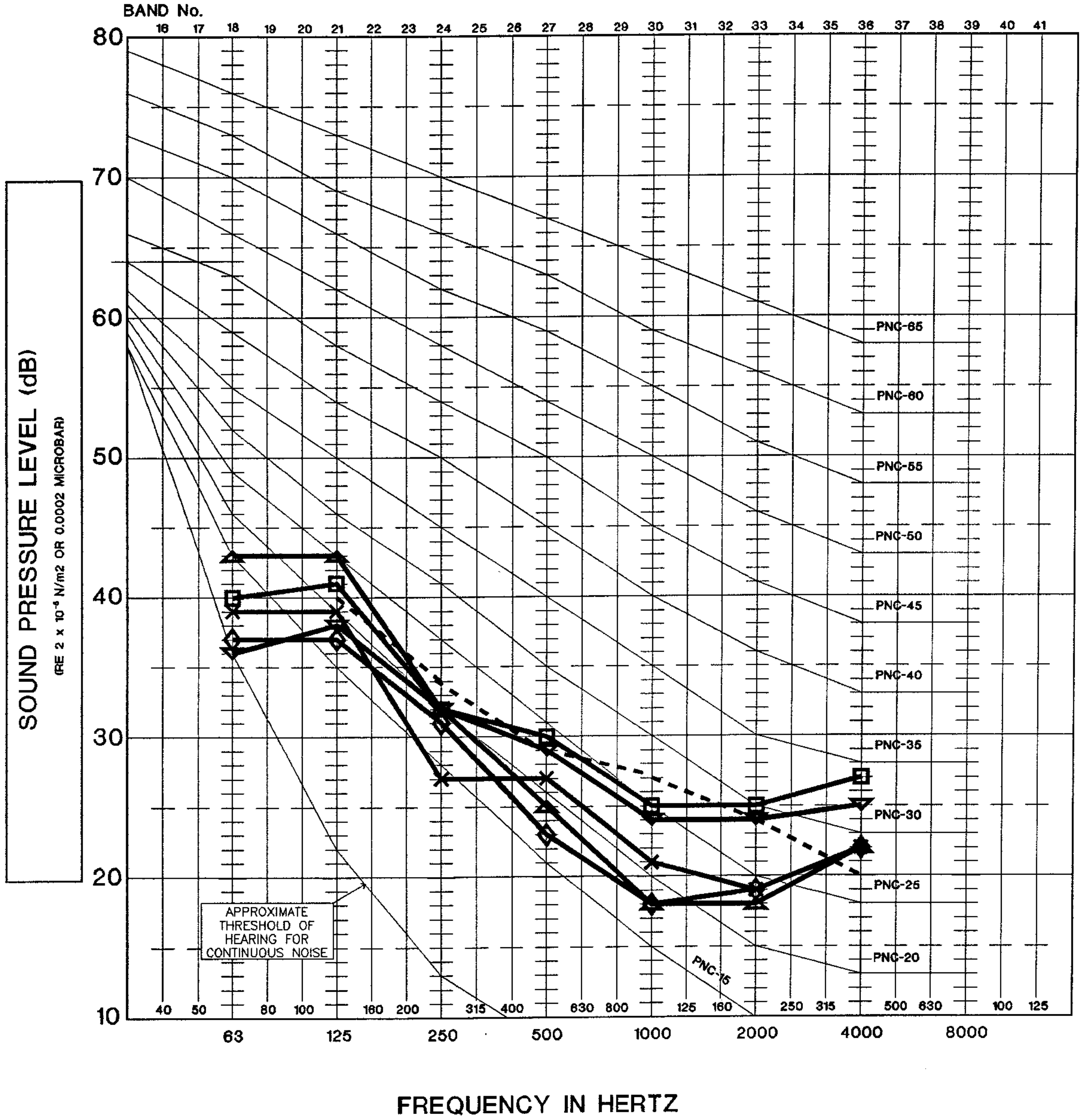
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

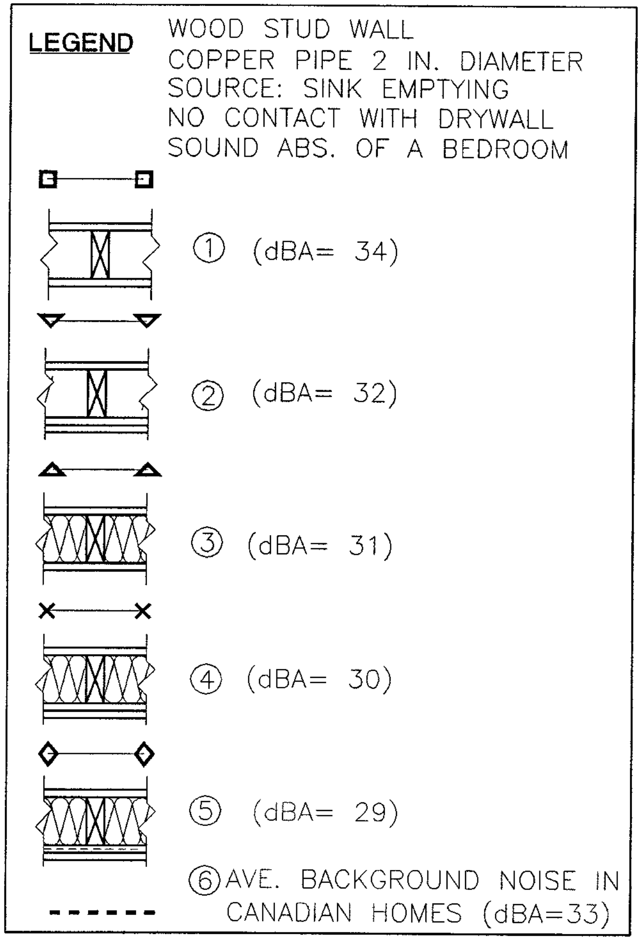
GRAPH TITLE
INFLUENCE OF WALL COMPOSITION –
WOOD STUD WALL –
SOUND ABSORPTION OF A BEDROOM

GRAPH NUMBER 8A

PROJECT NUMBER	**DATE**
177.891	90 09

mjm





PROJECT DESCRIPTION

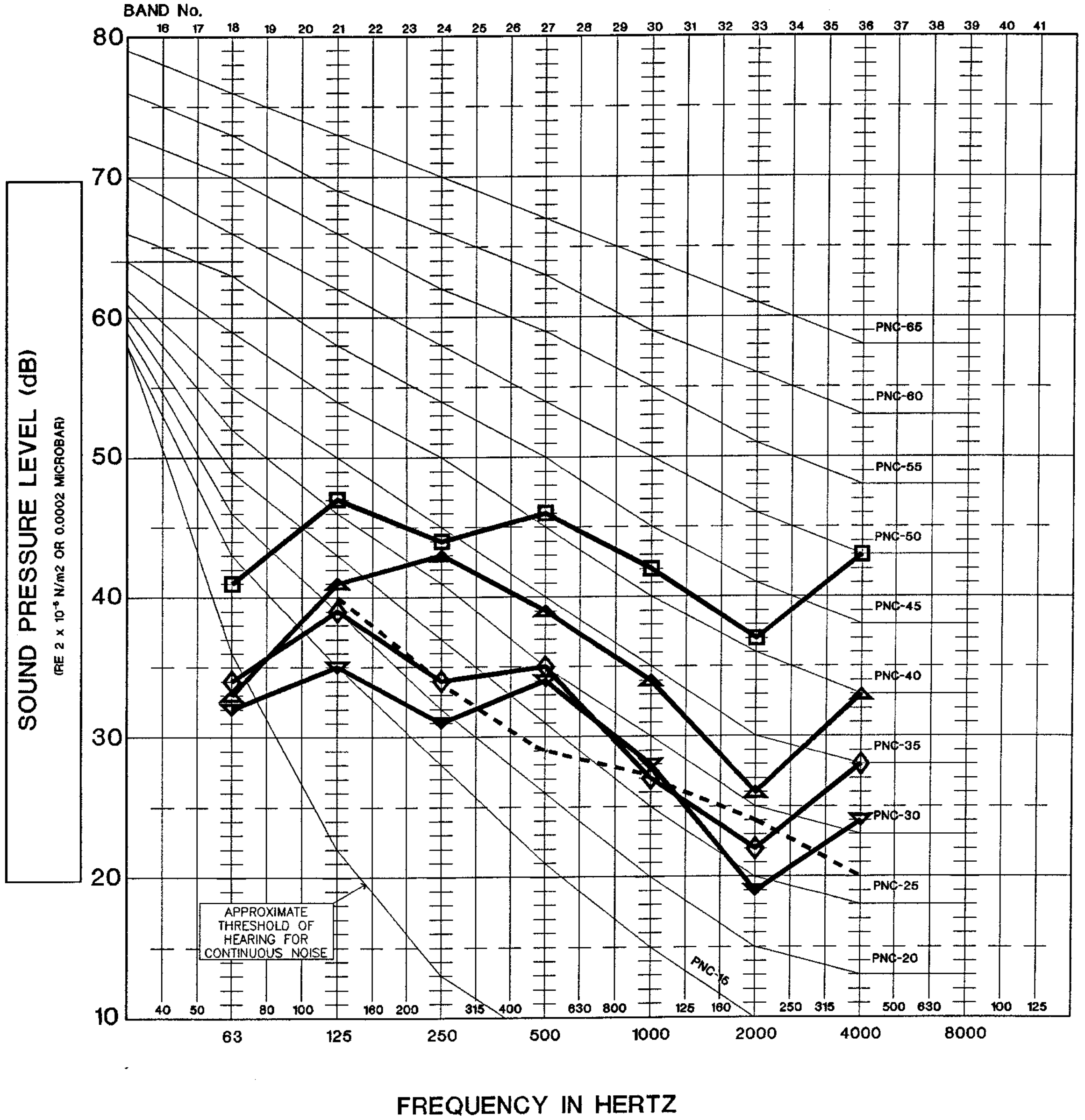
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE

INFLUENCE OF WALL COMPOSITION –
WOOD STUD WALL –
SOUND ABSORPTION OF A BEDROOM

GRAPH NUMBER 8B

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND

METAL STUD WALL
WATER PRESSURE: 40 PSI.
COPPER PIPE 1/2" DIAMETER
SOURCE: AVERAGE OF 5 FAUCETS
SOUND ABSORPTION OF A BEDROOM

□———□ ① PLASTIC SLEEVE (dBA= 49)

△———△ ② ARMAFLEX SLEEVE (dBA= 41)

◇———◇ ③ ARMAFLEX SLEEVE (dBA= 36)

▽———▽ ④ ARMAFLEX SLEEVE (dBA= 34)

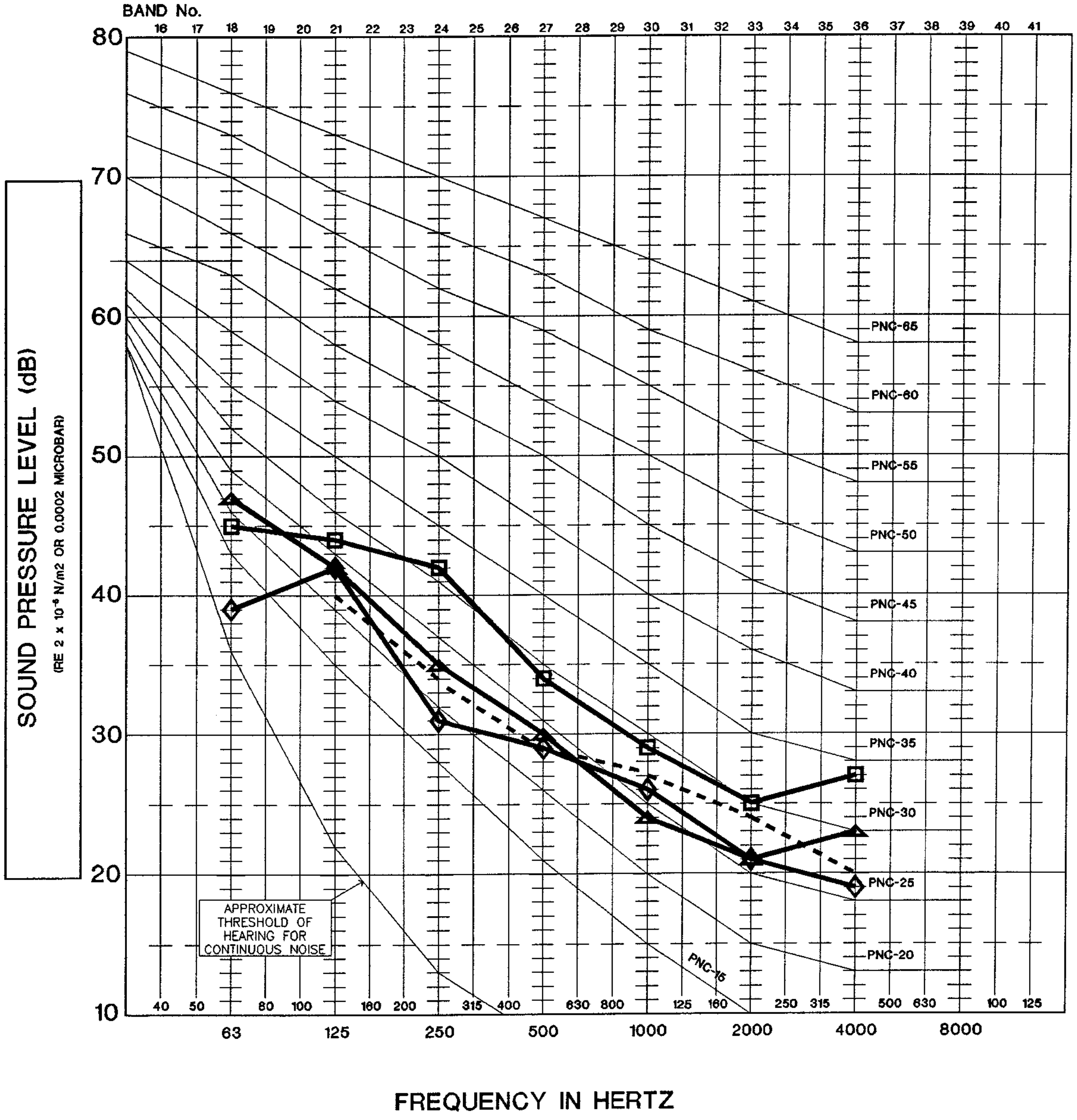
- - - - - - ⑤ AVE. BACKGROUND NOISE IN CANADIAN HOMES (dBA= 33)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
INFLUENCE OF WALL COMPOSITION –
METAL STUD WALL –
SOUND ABSORPTION OF A BEDROOM

GRAPH NUMBER 8C

PROJECT NUMBER	**DATE**
177891	90 09



LEGEND

METAL STUD WALL
COPPER PIPE 2 IN. DIAMETER
NO CONTACT WITH DRYWALL
SOURCE: SINK EMPTYING
SOUND ABSORPTION OF A BEDROOM

□—□ ① (dBA= 38)

△—△ ② (dBA= 33)

◇—◇ ③ (dBA= 32)

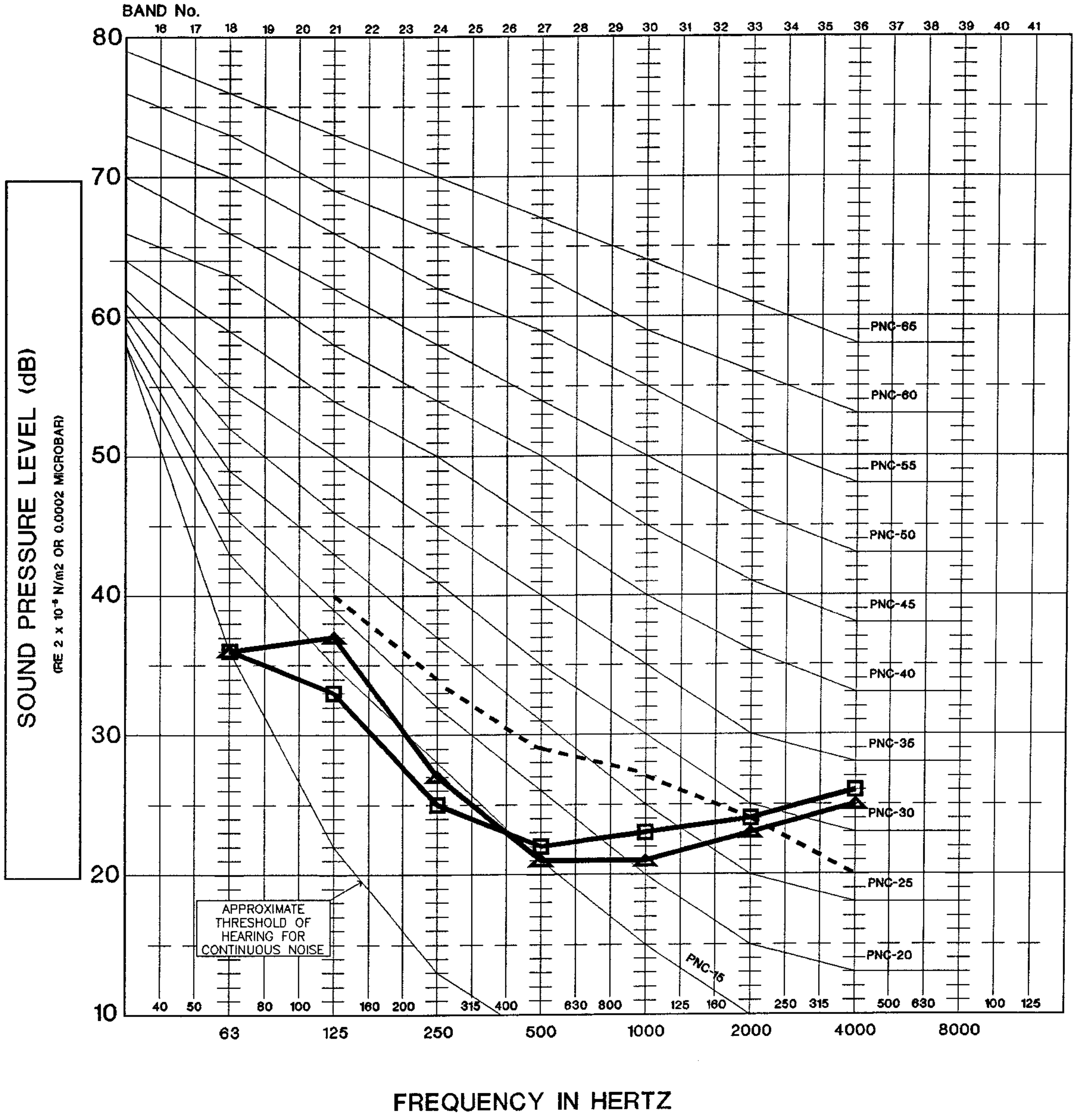
- - - - - - AVE. BACKGROUND NOISE IN CANADIAN HOMES (dBA= 33)

PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

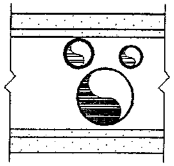
GRAPH TITLE
INLUENCE OF WALL COMPOSITION –
METAL STUD WALL –
SOUND ABSORPTION OF A BEDROOM

GRAPH NUMBER 8D

PROJECT NUMBER	**DATE**
177.891	90 09



LEGEND



SHAFT WALL
CAST IRON 4 IN. DIAMETER
NEOPRENE PADS
NO CONTACT WITH DRYWALL
SOUND ABS. OF A BEDROOM

△——△ ① SOURCE: SINK EMPTYING
(dBA= 30)

□——□ ② SOURCE: TOILET FLUSH
(dBA= 31)

- - - - - ③ AVE. BACKGROUND NOISE IN CANADIAN HOMES (dBA= 33)

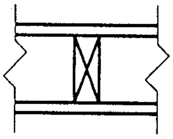
PROJECT DESCRIPTION
CANADA MORTGAGE & HOUSING CORP.
RESEARCH PROJECT ON PLUMBING NOISE

GRAPH TITLE
SHAFT WALL –
SOUND ABSORPTION OF A BEDROOM

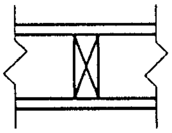
GRAPH NUMBER 8E

PROJECT NUMBER	DATE
177.891	90 09

ANNEX II

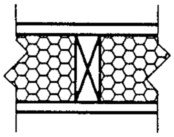
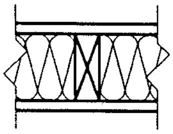
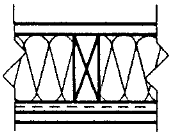
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
1.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	74.1	5
1.1.4	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	69.3	
	- 1 LAYER OF DRYWALL			ALONG SIDE			
1.2.1		COPPER	ISO	OF STUD.	100 PSI.	73.3	5
1.2.4		3/4 IN.	ISO		40 PSI.	68.1	
1.3.1		COPPER	ISO		100 PSI.	76.0	5
1.3.4		1/2 IN.	ISO		40 PSI.	70.7	
1.4.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	59.0	5
1.4.4		1 IN.	ISO	SLEEVE	40 PSI.	53.9	
				1/2" THICK			
1.5.1		COPPER	ISO	WITH OVER-	100 PSI.	56.9	6
1.5.4		3/4 IN.	ISO	SIZED CLAMPS	40 PSI.	51.2	
1.6.1		COPPER	ISO		100 PSI.	56.6	5
1.6.4		1/2 IN.	ISO		40 PSI.	51.1	
1.7.1		COPPER	ISO	ACOUSTO-	100 PSI.	60.0	6
1.7.4		1 IN.	ISO	PLUMB	40 PSI.	54.2	
				ATTACHMENT			
1.8.1		COPPER	ISO		100 PSI.	60.5	5
1.8.4		3/4 IN.	ISO		40 PSI.	55.3	
1.9.1		COPPER	ISO		100 PSI.	61.3	6
1.9.4		1/2 IN.	ISO		40 PSI.	55.7	
1.10.1		PLASTIC	ISO	3 STANDARD	100 PSI.	62.5	5
1.10.4		1 IN.	ISO	CLAMPS	40 PSI.	57.0	
				ALONG SIDE			
1.11.1		PLASTIC	ISO	OF STUD.	100 PSI.	65.4	6
1.11.4		3/4 IN.	ISO		40 PSI.	59.8	
1.12.1		PLASTIC	ISO		100 PSI.	65.1	6
1.12.4		1/2 IN.	ISO		40 PSI.	59.1	

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

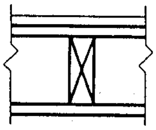
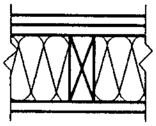
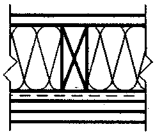
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
1.13.1		PLASTIC	ISO	3" ARMAFLEX	100 PSI.	56.0	5
1.13.4		1 IN.	ISO	SLEEVE	40 PSI.	51.0	
				1/2" THICK			
1.14.1		PLASTIC	ISO	WITH OVER-	100 PSI.	56.0	5
1.14.4		3/4 IN.	ISO	SIZED CLAMPS	40 PSI.	50.7	
1.15.1		PLASTIC	ISO		100 PSI.	51.7	6
1.15.4		1/2 IN.	ISO		40 PSI.	46.0	
1.16.1		COPPER	ISO	FELT	100 PSI.	58.0	4
1.16.2		1 IN.	ISO	SLEEVE	40 PSI.	53.9	
				WITH OVER-			
1.17.1		COPPER	ISO	SIZED CLAMPS	100 PSI.	61.4	5
1.17.2		3/4 IN.	ISO		40 PSI.	56.8	
1.18.1		COPPER	ISO		100 PSI.	67.0	6
1.18.2		1/2 IN.	ISO		40 PSI.	61.0	
1.19.1		COPPER	ISO	CORK	100 PSI.	66.0	5
1.19.2		1 IN.	ISO	SLEEVE	40 PSI.	61.2	
				WITH OVER-			
1.20.1		COPPER	ISO	SIZED CLAMPS	100 PSI.	66.0	5
1.20.2		3/4 IN.	ISO		40 PSI.	61.0	
1.21.1		COPPER	ISO		100 PSI.	70.8	5
1.21.2		1/2 IN.	ISO		40 PSI.	65.6	
1.42.1		COPPER	ISO	3 STANDARD	100 PSI.	50.2	5
1.42.4		1/2 IN.	ISO	ATTACHMENTS	40 PSI.	45.0	
				WRAPPED			
				INSULATION			

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

TABLE 1

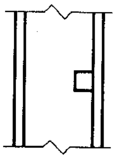
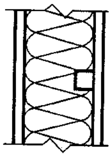
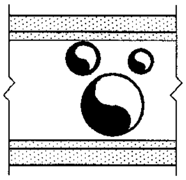
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
2.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	69.2	5
2.2.4	- 2 x 4 WOOD STUD	1 IN.	ISO	CLAMPS	40 PSI.	64.2	
	- STUD CAVITY FILLED			ALONG SIDE			
	WITH BLOWN-IN			OF STUD.			
	CELLULOSE FIBRE						
	- 1 LAYER OF DRYWALL						
							
3.1.1	- 1 LAYER OF DRYWALL	COPPPER	ISO	3 STANDARD	100 PSI.	70.7	6
3.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	65.0	
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE			
3.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	75.1	5
3.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	70.1	
	- 1 LAYER OF DRYWALL						
3.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	53.6	5
3.3.2		1 IN.	ISO	SLEEVE	40 PSI.	49.0	
				1/2" THICK			
3.4.1		COPPER	ISO	WITH OVER-	100 PSI.	53.2	5
3.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	48.1	
4.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	64.4	6
4.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	58.7	
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE			
4.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	65.9	5
4.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	60.8	
	- RESILIENT FURRINGS						
	- 1 LAYER OF DRYWALL						
4.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	46.1	5
4.3.2		1 IN.	ISO	SLEEVE	40 PSI.	41.3	
				1/2" THICK			
4.4.1		COPPER	ISO	WITH OVER-	100 PSI.	46.2	5
4.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	40.9	

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
5.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STD CLAMPS	100 PSI.	68.9	7
5.1.4	- 2 x 4 WOOD STUDS	1 IN.	ISO	ALONG SIDE	40 PSI.	* 62.3	
	- 2 LAYERS OF DRYWALL			OF STUD			
5.2.1		COPPER	ISO		100 PSI.	72.9	5
5.2.2		1/2 IN.	ISO		40 PSI.	67.8	
5.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	53.7	5
5.3.2		1 IN.	ISO	SLEEVE	40 PSI.	48.6	
				1/2" THICK			
5.4.1		COPPER	ISO	WITH OVER-	100 PSI.	52.9	5
5.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	48.1	
6.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	67.8	5
6.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	62.8	
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE			
6.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	70.4	5
6.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	65.9	
	- 2 LAYERS OF DRYWALL						
6.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	49.4	5
6.3.2		1 IN.	ISO	SLEEVE		44.6	
				1/2" THICK			
6.4.1		COPPER	ISO	WITH OVER-	100 PSI.	50.5	5
6.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	45.2	
7.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	58.9	5
7.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	53.9	
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE			
7.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	57.9	4
7.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	53.7	
	- RESILIENT FURRINGS						
	- 2 LAYERS OF DRYWALL						
7.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	45.1	5
7.3.2		1 IN.	ISO	SLEEVE	40 PSI.	40.3	
				1/2" THICK			
7.4.1		COPPER	ISO	WITH OVER-	100 PSI.	44.1	5
7.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	38.9	

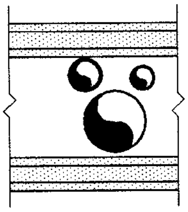
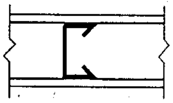
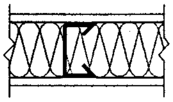
NOTE: * INDICATES THAT VALUES FOR THIS TEST HAVE BEEN EXTRAPOLATED

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

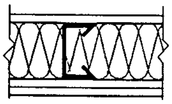
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
8.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	KNOTCH IN	100 PSI.	58.3	6
8.1.2	- 2 x 4 WOOD STUDS	1/2 IN.	ISO	3 WOOD STUDS	40 PSI.	52.1	
	- 1 LAYER OF DRYWALL			ARMAFLEX BET.			
				PIPE & STUDS			
9.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	KNOTCH IN	100 PSI.	50.1	5
9.1.2	- 2 x 4 WOOD STUDS	1/2 IN.	ISO	3 WOOD STUDS	40 PSI.	44.9	
	- 3 1/2 IN. GLASS FIBER BATT INSULATION IN			ARMAFLEX BET.			
	- 1 LAYER OF DRYWALL			PIPE & STUDS			
							
9.2.1		COPPER	ISO	KNOTCH IN	100 PSI.	71.6	5
9.2.2		1/2 IN.	ISO	3 WOOD STUDS	40 PSI.	66.1	
				SOLID CONTACT			
				WITH STUDS			
11.1.1	SHAFT WALL COMPOSED	COPPER	ISO	PIPE SUPPORTED	100 PSI.	38.3	9
11.1.4	OF:	2 IN.	ISO	FROM FLOOR ON	40 PSI.	29.4	
	- 1 IN. CORE BOARD			NEOPRENE PADS			
11.2.1	- 5/8 IN. TYPE "X"	COPPER	ISO	NO CONTACT W/.	100 PSI.	40.3	9
11.2.4	DRYWALL	1 1/2 IN.	ISO	SHAFT WALL.	40 PSI.	31.6	
	FIRE RESISTANCE: 1 HOUR						
							

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

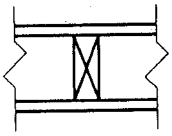
TABLE 1

TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
12.1.1 12.1.2	SHAFT WALL COMPOSED OF: - 5/8 IN. TYPE "X" DRYWALL - 1 IN. CORE BOARD - 5/8 IN. TYPE "X" DRYWALL FIRE RESISTANCE: 2 HOURS 	COPPER 2 IN.	ISO ISO	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS	100 PSI. 40 PSI.	36.8 26.5	10
12.2.1 12.2.2		COPPER 1 1/2 IN.	ISO ISO	NO CONTACT W/. SHAFT WALL.	100 PSI. 40 PSI.	35.0 25.6	9
14.1.1 14.1.4	- 1 LAYER OF DRYWALL - STANDARD 3 5/8 IN METAL STUDS (25 GA.) - 1 LAYER OF DRYWALL 	COPPER 1/2 IN.	ISO ISO	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH PLASTIC SLEEVE	100 PSI. 40 PSI.	69.8 62.3	7
14.2.1 14.2.4		COPPER 1/2 IN.	ISO ISO	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH ARMAFLEX SLEEVE	100 PSI. 40 PSI.	59.8 53.3	6
15.1.1 15.1.4	- 1 LAYER OF DRYWALL - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - STANDARD 3 5/8 IN METAL STUDS (25 GA.) - 1 LAYER OF DRYWALL 	COPPER 1/2 IN.	ISO ISO	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH PLASTIC SLEEVE	100 PSI. 40 PSI.	66.3 59.3	7
15.2.1 15.2.4		COPPER 1/2 IN.	ISO ISO	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH ARMAFLEX SLEEVE	100 PSI. 40 PSI.	55.0 48.1	7

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

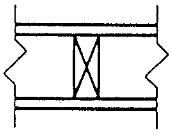
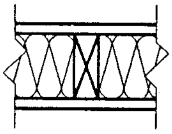
TEST NO.	PARTITION COMPOSITION	DIAM.	OPERATIN SOURCE	ATTACHMENT	PRESSURE	dBA	DIFFERENCE IN dBA
16.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	PIPE RUNNING	100 PSI.	65.3	7
16.1.4	- 3 1/2 IN. GLASS FIBER	1/2 IN.	ISO	HORIZONTALLY	40 PSI.	58.3	
	BATT INSULATION IN			3 STUD WIDTH			
	STUD CAVITY.			PLASTIC SLEEVE			
	- STANDARD 3 5/8 IN METAL						
16.2.1	STUDS (25 GA.)	COPPER	ISO	PIPE RUNNING	100 PSI.	52.2	7
16.2.4	- 2 LAYERS OF DRYWALL	1/2 IN.	ISO	HORIZONTALLY	40 PSI.	45.7	
				3 STUD WIDTH			
				ARMAFLEX			
				SLEEVE			

INFLUENCE OF WATER PRESSURE - SOURCE: ISO

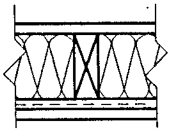
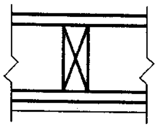
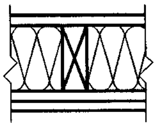
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	MAX. DIFF. IN dBA
1.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	74.1	71.7	
1.1.4	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	69.3		
	- 1 LAYER OF DRYWALL			ALONG SIDE				
1.2.1		COPPER	ISO	OF STUD.	100 PSI.	73.3	70.7	3
1.2.4		3/4 IN.	ISO		40 PSI.	68.1		
1.3.1		COPPER	ISO		100 PSI.	76.0	73.3	
1.3.4		1/2 IN.	ISO		40 PSI.	70.7		
1.4.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	59.0	56.5	
1.4.4		1 IN.	ISO	SLEEVE	40 PSI.	53.9		
				1/2" THICK				
1.5.1		COPPER	ISO	WITH OVER-	100 PSI.	56.9	54.0	-3
1.5.4		3/4 IN.	ISO	SIZED CLAMPS	40 PSI.	51.2		
1.6.1		COPPER	ISO		100 PSI.	56.6	53.9	
1.6.4		1/2 IN.	ISO		40 PSI.	51.1		
1.7.1		COPPER	ISO	ACOUSTO-	100 PSI.	60.0	57.1	
1.7.4		1 IN.	ISO	PLUMB	40 PSI.	54.2		
				ATTACHMENT				
1.8.1		COPPER	ISO		100 PSI.	60.5	57.9	1
1.8.4		3/4 IN.	ISO		40 PSI.	55.3		
1.9.1		COPPER	ISO		100 PSI.	61.3	58.5	
1.9.4		1/2 IN.	ISO		40 PSI.	55.7		
1.10.1		PLASTIC	ISO	3 STANDARD	100 PSI.	62.5	59.7	
1.10.4		1 IN.	ISO	CLAMPS	40 PSI.	57.0		
				ALONG SIDE				
1.11.1		PLASTIC	ISO	OF STUD.	100 PSI.	65.4	62.6	2
1.11.4		3/4 IN.	ISO		40 PSI.	59.8		
1.12.1		PLASTIC	ISO		100 PSI.	65.1	62.1	
1.12.4		1/2 IN.	ISO		40 PSI.	59.1		

INFLUENCE OF PIPE DIAMETER - SOURCE: ISO

ANNEX II TABLE 2

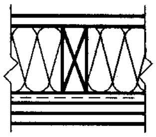
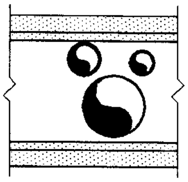
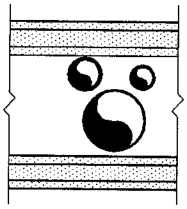
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	MAX. DIFF. IN dBA
1.13.1		PLASTIC	ISO	3" ARMAFLEX	100 PSI.	56.0	53.5	
1.13.4		1 IN.	ISO	SLEEVE	40 PSI.	51.0		
				1/2" THICK				
1.14.1		PLASTIC	ISO	WITH OVER-	100 PSI.	56.0	53.4	-5
1.14.4		3/4 IN.	ISO	SIZED CLAMPS	40 PSI.	50.7		
1.15.1		PLASTIC	ISO		100 PSI.	51.7	48.9	
1.15.4		1/2 IN.	ISO		40 PSI.	46.0		
1.16.1		COPPER	ISO	FELT	100 PSI.	58.0	55.9	
1.16.2		1 IN.	ISO	SLEEVE	40 PSI.	53.9		
				WITH OVER-				
1.17.1		COPPER	ISO	SIZED CLAMPS	100 PSI.	61.4	59.1	8
1.17.2		3/4 IN.	ISO		40 PSI.	56.8		
1.18.1		COPPER	ISO		100 PSI.	67.0	64.0	
1.18.2		1/2 IN.	ISO		40 PSI.	61.0		
1.19.1		COPPER	ISO	CORK	100 PSI.	66.0	63.6	
1.19.2		1 IN.	ISO	SLEEVE	40 PSI.	61.2		
				WITH OVER-				
1.20.1		COPPER	ISO	SIZED CLAMPS	100 PSI.	66.0	63.5	5
1.20.2		3/4 IN.	ISO		40 PSI.	61.0		
1.21.1		COPPER	ISO		100 PSI.	70.8	68.2	
1.21.2		1/2 IN.	ISO		40 PSI.	65.6		
3.1.1	- 1 LAYER OF DRYWALL	COPPPER	ISO	3 STANDARD	100 PSI.	70.7	67.9	
3.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	65.0		
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE				5
3.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	75.1	72.6	
3.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	70.1		
	- 1 LAYER OF DRYWALL							
3.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	53.6	51.3	
3.3.2		1 IN.	ISO	SLEEVE	40 PSI.	49.0		
				1/2" THICK				-1
3.4.1		COPPER	ISO	WITH OVER-	100 PSI.	53.2	50.6	
3.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	48.1		

INFLUENCE OF PIPE DIAMETER - SOURCE: ISO

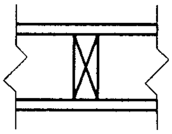
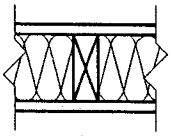
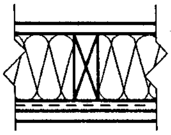
TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	MAX. DIFF. IN dBA
4.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	64.4	61.6	
4.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	58.7		
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE				2
4.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	65.9	63.4	
4.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	60.8		
	- RESILIENT FURRINGS							
	- 1 LAYER OF DRYWALL							
4.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	46.1	43.7	
4.3.2		1 IN.	ISO	SLEEVE	40 PSI.	41.3		
				1/2" THICK				-0
4.4.1		COPPER	ISO	WITH OVER-	100 PSI.	46.2	43.5	
4.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	40.9		
5.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	68.9	65.6	
5.1.4	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	* 62.3		
	- 2 LAYERS OF DRYWALL			ALONG SIDE				5
5.2.1		COPPER	ISO	OF STUD.	100 PSI.	72.9	70.3	
5.2.2		1/2 IN.	ISO		40 PSI.	67.8		
5.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	53.7	51.1	
5.3.2		1 IN.	ISO	SLEEVE	40 PSI.	48.6		
				1/2" THICK				-1
5.4.1		COPPER	ISO	WITH OVER-	100 PSI.	52.9	50.5	
5.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	48.1		
6.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	67.8	65.3	
6.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	62.8		
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE				3
6.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	70.4	68.1	
6.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	65.9		
	- 2 LAYERS OF DRYWALL							
6.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	49.4	47.0	
6.3.2		1 IN.	ISO	SLEEVE		44.6		
				1/2" THICK				1
6.4.1		COPPER	ISO	WITH OVER-	100 PSI.	50.5	47.9	
6.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	45.2		

NOTE: * INDICATES THAT VALUES FOR THIS TEST HAVE BEEN EXTRAPOLATED

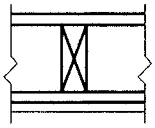
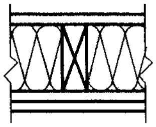
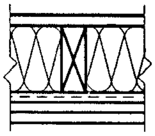
INFLUENCE OF PIPE DIAMETER - SOURCE: ISO

TEST NO.	PARTITION COMPOSITION	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	MAX. DIFF. IN dBA
7.1.1	- 1 LAYER OF DRYWALL	COPPER	ISO	3 STANDARD	100 PSI.	58.9	56.4	
7.1.2	- 2 x 4 WOOD STUDS	1 IN.	ISO	CLAMPS	40 PSI.	53.9		
	- 3 1/2 IN. GLASS FIBER			ALONG SIDE				-1
7.2.1	BATT INSULATION IN	COPPER	ISO	OF STUD.	100 PSI.	57.9	55.8	
7.2.2	STUD CAVITY.	1/2 IN.	ISO		40 PSI.	53.7		
	- RESILIENT FURRINGS							
	- 2 LAYERS OF DRYWALL							
7.3.1		COPPER	ISO	3" ARMAFLEX	100 PSI.	45.1	42.7	
7.3.2		1 IN.	ISO	SLEEVE	40 PSI.	40.3		
				1/2" THICK				-1
7.4.1		COPPER	ISO	WITH OVER-	100 PSI.	44.1	41.5	
7.4.2		1/2 IN.	ISO	SIZED CLAMPS	40 PSI.	38.9		
11.1.1	SHAFT WALL COMPOSED	COPPER	ISO	PIPE SUPPORTED	100 PSI.	38.3	33.9	
11.1.4	OF:	2 IN.	ISO	FROM FLOOR ON	40 PSI.	29.4		
	- 1 IN. CORE BOARD			NEOPRENE PADS				2
11.2.1	- 5/8 IN. TYPE "X"	COPPER	ISO	NO CONTACT W/.	100 PSI.	40.3	36.0	
11.2.4	DRYWALL	1 1/2 IN	ISO	SHAFT WALL.	40 PSI.	31.6		
	FIRE RESISTANCE: 1 HOUR							
								
12.1.1	SHAFT WALL COMPOSED	COPPER	ISO	PIPE SUPPORTED	100 PSI.	36.8	31.7	
12.1.2	OF:	2 IN.	ISO	FROM FLOOR ON	40 PSI.	26.5		
	- 5/8 IN. TYPE "X"			NEOPRENE PADS				-1
12.2.1	DRYWALL	COPPER	ISO	NO CONTACT W/.	100 PSI.	35.0	30.3	
12.2.2	- 1 IN. CORE BOARD	1 1/2 IN	ISO	SHAFT WALL.	40 PSI.	25.6		
	- 5/8 IN. TYPE "X"							
	DRYWALL							
	FIRE RESISTANCE: 2 HOURS							
								

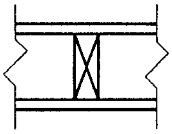
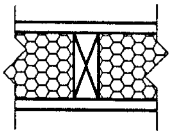
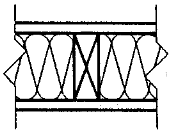
INFLUENCE OF PIPE DIAMETER - SOURCE: ISO

TEST NO.	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	SPL IN dBA	DIFFERENCE IN dBA
1.22.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH DRYWALL	35.0	7
1.22.4		PLASTIC 2 IN.		42.0	
1.22.6		COPPER 2 IN.	PIPE CONTACT WITH DRYWALL	49.2	2
1.22.8		PLASTIC 2 IN.		51.4	
3.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH DRYWALL	33.0	8
3.5.4		PLASTIC 2 IN.		41.4	
3.5.6		COPPER 2 IN.	PIPE CONTACT WITH DRYWALL	48.0	1
3.5.8		PLASTIC 2 IN.		49.4	
4.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 1 LAYER OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH RESILIENT CHANNEL	30.1	8
4.5.4		PLASTIC 2 IN.		38.4	

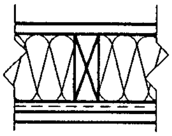
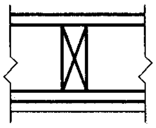
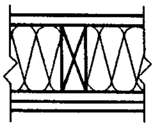
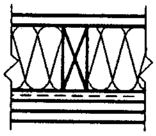
INFLUENCE OF PIPE MATERIAL - SOURCE: SINK EMPTYING

TEST NO.	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	SPL IN dBA	DIFFERERENCE IN dBA
5.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 2 LAYERS OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH DRYWALL	33.6	8
5.5.4		PLASTIC 2 IN.		41.6	
6.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 2 LAYERS OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH DRYWALL	31.3	5
6.5.4		PLASTIC 2 IN.		36.1	
7.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN - RESILIENT FURRINGS - 2 LAYERS OF DRYWALL 	COPPER 2 IN.	NO CONTACT WITH RESILIENT CHANNEL	28.7	5
7.5.4		PLASTIC 2 IN.		34.2	

INFLUENCE OF PIPE MATERIAL - SOURCE: SINK EMPTYING

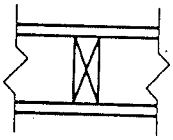
TEST NO.	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	dBA	DIFFERENCE IN dBA
1.22.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	EXPERIMENTAL ERROR	***
1.22.3		PLASTIC 3 IN.		44.4	
1.22.5		CAST IRON 3 IN.	PIPE CONTACT WITH DRYWALL	37.0	10
1.22.7		PLASTIC 3 IN.		47.1	
2.2.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - STUD CAVITY FILLED WITH BLOWN-IN CELLULOSE FIBER - 1 LAYER OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	31.2	8
2.5.3		PLASTIC 3 IN.		39.1	
3.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	30.7	10
3.5.3		PLASTIC 3 IN.		40.4	
3.5.5		CAST IRON 3 IN.	PIPE CONTACT WITH DRYWALL	37.0	6
3.5.7		PLASTIC 3 IN.		42.9	

INFLUENCE OF PIPE MATERIAL - SOURCE: TOILET FLUSH

	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	dBA	DIFFERECE IN dBA
4.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 1 LAYER OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH RESILIENT CHANNEL	30.6	9
4.5.3		PLASTIC 3 IN.		39.8	
5.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 2 LAYERS OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	EXPERIMENTAL ERROR	***
5.5.3		PLASTIC 3 IN.		42.8	
6.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 2 LAYERS OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	30.1	8
6.5.3		PLASTIC 3 IN.		37.8	
7.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN - RESILIENT FURRINGS - 2 LAYERS OF DRYWALL 	CAST IRON 3 IN.	NO CONTACT WITH RESILIENT CHANNEL	29.0	9
7.5.3		PLASTIC 3 IN.		37.8	

INFLUENCE OF PIPE MATERIAL - SOURCE: TOILET FLUSH

WALL COMPOSITION:



TEST NO.	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	DIFFERENCE BETWEEN STANDARD CLAMPS RESILIENT ATTACHMENT
1.01.4	COPPER	ISO	CLAMPS	100 PSI.	74.1	71.7	
1.01.1	1 IN.	ISO	3 STANDARD	40 PSI.	69.3		
1.19.2		ISO	CORK	100 PSI.	66.0	63.6	8
1.19.1		ISO	SLEEVE	40 PSI.	61.2		
1.07.4		ISO	ACOUSTO-	100 PSI.	60.0	57.1	15
1.07.1		ISO	PLUMB	40 PSI.	54.2		
1.04.1		ISO	3" ARMAFLEX	100 PSI.	59.0	56.5	15
1.04.4		ISO	SLEEVE	40 PSI.	53.9		
1.16.1		ISO	FELT	100 PSI.	58.0	55.9	16
1.16.2		ISO	SLEEVE	40 PSI.	53.9		
1.02.1	COPPER	ISO	3 STANDARD	100 PSI.	68.1	70.7	
1.02.4	3/4 IN.	ISO	CLAMPS	40 PSI.	73.3		
1.20.1		ISO	CORK	100 PSI.	61.0	63.5	7
1.20.2		ISO	SLEEVE	40 PSI.	66.0		
1.17.2		ISO	FELT	100 PSI.	61.4	59.1	12
1.17.1		ISO	SLEEVE	40 PSI.	56.8		
1.08.4		ISO	ACOUSTO-	100 PSI.	60.5	57.9	13
1.08.1		ISO	PLUMB	40 PSI.	55.3		
1.05.4		ISO	3" ARMAFLEX	100 PSI.	56.9	54.0	17
1.05.1		ISO	SLEEVE	40 PSI.	51.2		

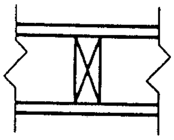
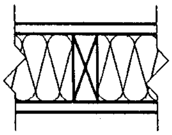
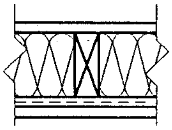
<u>INFLUENCE OF PIPE ATTACHMENT - SOURCE: ISO</u>

TEST NO.	DIAM.	SOURCE	ATTACHMENT	PRESSURE	dBA	AVERAGE IN dBA	DIFFERENCE BETWEEN STANDARD CLAMPS RESILIENT ATTACHMENT
1.03.1	COPPER	ISO	3 STANDARD	100 PSI.	76.0	73.3	
1.03.4	1/2 IN.	ISO	CLAMPS	40 PSI.	70.7		
1.21.1		ISO	CORK	100 PSI.	70.8	68.2	5
1.21.2		ISO	SLEEVE	40 PSI.	65.6		
1.18.1		ISO	FELT	100 PSI.	67.0	64.0	9
1.18.2		ISO	SLEEVE	40 PSI.	61.0		
1.09.1		ISO	ACOUSTO-	100 PSI.	61.3	58.5	15
1.09.4		ISO	PLUM	40 PSI.	55.7		
1.06.1		ISO	3" ARMAFLEX	100 PSI.	56.6	53.9	19
1.06.4		ISO	SLEEVE	40 PSI.	51.1		

INFLUENCE OF PIPE ATTACHMENT - SOURCE: ISO

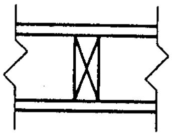
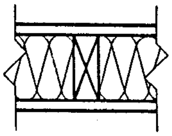
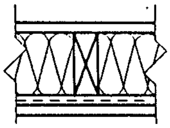
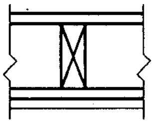
ANNEX II

TABLE 5

TEST NO.	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	SPL IN dB	DIFFERENCE IN dBA
1.22.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL	COPPER 2 IN.	NO CONTACT WITH DRYWALL	35.0	14
1.22.6			PIPE CONTACT WITH DRYWALL	49.2	
1.22.4		PLASTIC	NO CONTACT WITH DRYWALL	42.0	9
1.22.8		2 IN.	PIPE CONTACT WITH DRYWALL	51.4	
3.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL	COPPER 2 IN.	NO CONTACT WITH DRYWALL	33.0	15
3.5.6			PIPE CONTACT WITH DRYWALL	48.0	
3.5.4		PLASTIC 2 IN.	NO CONTACT WITH DRYWALL	41.4	8
3.5.8			PIPE CONTACT WITH DRYWALL	49.4	
4.5.2	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 1 LAYER OF DRYWALL	COPPER 2 IN.	NO CONTACT WITH RESILIENT CHANNEL	30.1	8
4.5.6			PIPE CONTACT WITH RESILIENT CHANNEL	38.1	

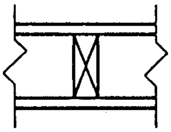
INFLUENCE OF PIPE ATTACHMENT - SOURCE: SINK EMPTYING

TABLE 6

TEST NO.	PARTITION COMPOSITION	DIAMETER	ATTACHMENT	SPL IN dBA	DIFFERENCE IN dBA
1.22.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	EXPERIMENTAL ERROR	***
1.22.5			PIPE CONTACT WITH DRYWALL	37.0	
1.22.3		PLASTIC 3 IN.	NO CONTACT WITH DRYWALL	44.4	3
1.22.7			PIPE CONTACT WITH DRYWALL	47.1	
3.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	30.7	6
3.5.5			PIPE CONTACT WITH DRYWALL	37.0	
3.5.3		PLASTIC 3 IN.	NO CONTACT WITH DRYWALL	40.4	2
3.5.7			PIPE CONTACT WITH DRYWALL	42.9	
4.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 1 LAYER OF DRYWALL	CAST IRON 3 IN.	NO CONTACT WITH RESILIENT CHANNEL	30.6	2
4.5.5			PIPE CONTACT WITH RESILIENT CHANNEL	32.2	
5.5.1	- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 2 LAYERS OF DRYWALL	CAST IRON 3 IN.	NO CONTACT WITH DRYWALL	EXPERIMENTAL ERROR	***
			PIPE CONTACT WITH DRYWALL	34.8	

INFLUENCE OF PIPE ATTACHMENT - SOURCE: TOILET FLUSH

NOTE: 1/2 IN. COPPER PIPE
STANDARD CLAMPS ATTACHMENT



TEST NO.	FAUCET TYPE	FLOW	PRESSURE	SPL IN dBA	AVERAGE SPL IN dBA	MAXIMUM DIFFERENCE IN dBA
1.24.1	FAUCET #2	MAXIMUM	100 PSI.	70.1	65.6	
1.24.4	DELTA	FLOW	40 PSI.	61.0		
1.27.1	FAUCET #5		100 PSI.	68.0	65.0	
1.27.4	CRANE		40 PSI.	61.9		
1.25.1	FAUCET #3		100 PSI.	67.6	63.3	
1.25.4	WALTEC		40 PSI.	59.1		3
1.23.1	FAUCET #1		100 PSI.	68.5	63.2	
1.23.4	AMERICAN STD CERAMIX		40 PSI.	58.0		
1.26.1	FAUCET #4		100 PSI.	69.4	62.3	
1.26.4	MOEN		40 PSI.	55.2		
1.34.1	FAUCET #5	1/2 MAXIMUM	100 PSI.	69.9	67.5	
1.34.4	CRANE	FLOW	40 PSI.	65.1		
1.29.1	FAUCET #1		100 PSI.	70.1	66.1	
1.29.4	AMERICAN STD CERAMIX		40 PSI.	62.1		
1.33.1	FAUCET #4		100 PSI.	66.1	62.5	9
1.33.4	MOEN		40 PSI.	58.8		
1.31.1	FAUCET #2		100 PSI.	64.6	60.4	
1.31.4	DELTA		40 PSI.	56.2		
1.32.1	FAUCET #3		100 PSI.	61.1	58.3	
1.32.4	WALTEC		40 PSI.	55.5		

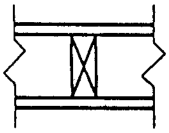
INFLUENCE OF THE TYPE OF FAUCET USED - SOURCE: FAUCET

TABLE 8

TEST NO.	FAUCET TYPE	FLOW	PRESSURE	SPL IN dBA	AVERAGE SPL IN dBA	MAXIMUM DIFFERENCE IN dBA
1.36.1	FAUCET #1	1/4 MAXIMUM	100 PSI.	67.7	64.4	
1.36.4	AMERICAN STD CERAMIX	FLOW	40 PSI.	61.1		
1.37.1	FAUCET #2		100 PSI.	61.5	58.0	
1.37.4	DELTA		40 PSI.	54.6		
1.40.1	FAUCET #5		100 PSI.	61.6	55.8	14
1.40.4	CRANE		40 PSI.	50.0		
1.39.1	FAUCET #4		100 PSI.	60.6	54.3	
1.39.4	MOEN		40 PSI.	47.9		
1.38.1	FAUCET #3		100 PSI.	54.5	50.6	
1.38.4	WALTEC		40 PSI.	46.7		

INFLUENCE OF THE TYPE OF FAUCET USED - SOURCE: FAUCET

NOTE: 1/2 IN. COPPER PIPE
STANDARD CLAMPS ATTACHMENT



TEST NO.	FAUCET TYPE	FLOW	PRESSURE	SPL IN dBA	DIFFERENCE IN dBA
1.23.1	FAUCET #1	MAXIMUM	100 PSI.	68	10
1.23.4	AMERICAN	FLOW	40 PSI.	58	
	STD CERAMIX				
1.24.1	FAUCET #2		100 PSI.	70	9
1.24.4	DELTA		40 PSI.	61	
1.25.1	FAUCET #3		100 PSI.	68	9
1.25.4	WALTEC		40 PSI.	59	
1.26.1	FAUCET #4		100 PSI.	69	14
1.26.4	MOEN		40 PSI.	55	
1.27.1	FAUCET #5		100 PSI.	68	6
1.27.4	CRANE		40 PSI.	62	
1.29.1	FAUCET #1	1/2 MAXIMUM	100 PSI.	70	8
1.29.4	AMERICAN	FLOW	40 PSI.	62	
	STD CERAMIX				
1.31.1	FAUCET #2		100 PSI.	65	8
1.31.4	DELTA		40 PSI.	56	
1.32.1	FAUCET #3		100 PSI.	61	6
1.32.4	WALTEC		40 PSI.	55	
1.33.1	FAUCET #4		100 PSI.	66	7
1.33.4	MOEN		40 PSI.	59	
1.34.1	FAUCET #5		100 PSI.	70	5
1.34.4	CRANE		40 PSI.	65	

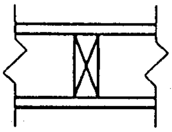
INFLUENCE OF WATER PRESSURE - SOURCE: FAUCET

ANNEX II TABLE 9

TEST NO.	FAUCET TYPE	FLOW	PRESSURE	SPL IN dBA	DIFFERENCE IN dBA
1.36.1	FAUCET #1	1/4 MAXIMUM	100 PSI.	68	7
1.36.4	AMERICAN	FLOW	40 PSI.	61	
	STD CERAMIX				
1.37.1	FAUCET #2		100 PSI.	61	7
1.37.4	DELTA		40 PSI.	55	
1.38.1	FAUCET #3		100 PSI.	54	8
1.38.4	WALTEC		40 PSI.	47	
1.39.1	FAUCET #4		100 PSI.	61	13
1.39.4	MOEN		40 PSI.	48	
1.40.1	FAUCET #5		100 PSI.	62	12
1.40.4	CRANE		40 PSI.	50	

INFLUENCE OF WATER PRESSURE - SOURCE: FAUCET

NOTE: 1/2 IN. COPPER PIPE
STANDARD CLAMPS ATTACHMENT



TEST NO.	FAUCET TYPE	FLOW TYPE	PRESSURE	SPL IN dBA	AVERAGE SPL IN dBA	MAXIMUM DIFFERENCE IN dBA
1.29.1	FAUCET #1	1/2 MAXIMUM	100 PSI.	70.1	66.1	
1.29.4	AMERICAN	FLOW	40 PSI.	62.1		
	STD CERAMIX					
1.36.1		1/4 MAXIMUM	100 PSI.	67.7	64.4	3
1.36.4		FLOW	40 PSI.	61.1		
1.23.1		MAXIMUM	100 PSI.	68.5	63.2	
1.23.4		FLOW	40 PSI.	58.0		
1.24.1	FAUCET #2	MAXIMUM	100 PSI.	70.1	65.6	
1.24.4	DELTA	FLOW	40 PSI.	61.0		
1.31.1		1/2 MAXIMUM	100 PSI.	64.6	60.4	8
1.31.4		FLOW	40 PSI.	56.2		
1.37.1		1/4 MAXIMUM	100 PSI.	61.5	58.0	
1.37.4		FLOW	40 PSI.	54.6		
1.25.1	FAUCET #3	MAXIMUM	100 PSI.	67.6	63.3	
1.25.4	WALTEC	FLOW	40 PSI.	59.1		
1.32.1		1/2 MAXIMUM	100 PSI.	61.1	58.3	13
1.32.4		FLOW	40 PSI.	55.5		
1.38.1		1/4 MAXIMUM	100 PSI.	54.5	50.6	
1.38.4		FLOW	40 PSI.	46.7		

<u>INFLUENCE OF FLOW IN FAUCET - SOURCE: FAUCET</u>

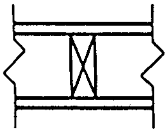
TABLE 10

TEST NO.	FAUCET TYPE	FLOW TYPE	PRESSURE	SPL IN dBA	AVERAGE SPL IN dBA	MAXIMUM DIFFERENCE IN dBA
1.33.1	FAUCET #4	1/2 MAXIMUM	100 PSI.	66.1	62.5	
1.33.4	MOEN	FLOW	40 PSI.	58.8		
1.26.1		MAXIMUM	100 PSI.	69.4	62.3	8
1.26.4		FLOW	40 PSI.	55.2		
1.39.1		1/4 MAXIMUM	100 PSI.	60.6	54.3	
1.39.4		FLOW	40 PSI.	47.9		
1.34.1	FAUCET #5	1/2 MAXIMUM	100 PSI.	69.9	67.5	
1.34.4	CRANE	FLOW	40 PSI.	65.1		
1.27.1		MAXIMUM	100 PSI.	68.0	65.0	12
1.27.4		FLOW	40 PSI.	61.9		
1.40.1		1/4 MAXIMUM	100 PSI.	61.6	55.8	
1.40.4		FLOW	40 PSI.	50.0		

INFLUENCE OF FLOW IN FAUCET - SOURCE: FAUCET

EVALUATION OF THE CORRECTION FACTORS

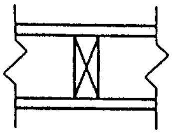
NOTE: WATER PRESSURE: 40 PSI.
STD CLAMPS ATTACHMENT
1/2 IN. COPPER PIPE
AVERAGE OF 5 FAUCETS
OPEN AT MAXIMUM FLOW



FREQUENCY IN HZ	SPL FAUCET IN dB (AVERAGE)	SPL ISO IN dB (TEST # 1.3.4)	CORRECTION FACTOR FAUCET/ISO	A LAB	A BEDROOM	CORRECTION FACTOR LAB/BEDROOM
63	35	42	7	13	16	0.8
125	47	56	9	9	22	3.8
250	56	63	8	7	14	2.9
500	57	64	7	7	10	1.3
1000	53	62	9	8	13	1.9
2000	48	65	17	11	13	0.7
4000	49	65	16	15	12	-1.1

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

NOTE: WATER PRESSURE: 40 PSI.
STD CLAMPS ATTACHMENT
1/2 IN. COPPER PIPE

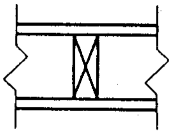


FREQUENCY IN HZ	SPL ISO IN dB (TEST # 1.3.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	42	7	0.8	34	
125	56	9	3.8	43	
250	63	8	2.9	53	
500	64	7	1.3	55	
1000	62	9	1.9	51	
2000	65	17	0.7	47	
4000	65	16	-1.1	50	57 dBA

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING WOOD STUD WALL

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

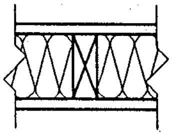
NOTE: WATER PRESSURE 40 PSI.
ARMAFLEX ATTACHMENT
1/2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL ISO IN dB (TEST # 1.6.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	NOISE IN A BEDROOM IN dB	
63	39	7	0.8	32	
125	44	9	3.8	31	
250	52	8	2.9	42	
500	48	7	1.3	39	
1000	43	9	1.9	32	
2000	42	17	0.7	25	
4000	43	16	-1.1	28	40 dBA

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

NOTE: WATER PRESSURE: 40 PSI.
ARMAFLEX ATTACHMENT
1/2 IN. COPPER PIPE

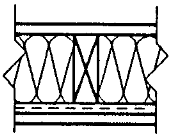


FREQUENCY IN HZ	SPL ISO IN dB (TEST # 3.4.2)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	38	7	0.8	30	
125	43	9	3.8	30	
250	50	8	2.9	40	
500	46	7	1.3	38	
1000	42	9	1.9	31	
2000	37	17	0.7	19	
4000	34	16	-1.1	19	38 dBA

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING
WOOD STUD WALL

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

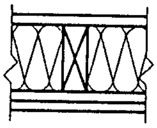
NOTE: WATER PRESSURE: 40 PSI.
ARMAFLEX ATTACHMENT
1/2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL ISO IN dB (TEST # 4.4.2)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	38	7	0.8	30	
125	46	9	3.8	33	
250	44	8	2.9	33	
500	37	7	1.3	28	
1000	36	9	1.9	25	
2000	30	17	0.7	12	
4000	29	16	-1.1	14	30 dBA

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

NOTE: WATER PRESSURE: 40 PSI.
ARMAFLEX ATTACHMENT
1/2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL ISO IN dB (TEST # 6.4.2)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	36	7	0.8	28	
125	43	9	3.8	30	
250	44	8	2.9	34	
500	44	7	1.3	35	
1000	40	9	1.9	29	
2000	35	17	0.7	17	
4000	31	16	-1.1	16	35 dBA

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING.
WOOD STUD WALL

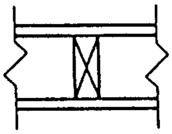
EVALUATION OF THE CORRECTION FACTOR

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE

FREQUENCY IN HZ	A LAB	A BEDROOM	CORRECTION FACTOR LAB/BEDROOM
63	13	16	0.8
125	9	22	3.8
250	7	14	2.9
500	7	10	1.3
1000	8	13	1.9
2000	11	13	0.7
4000	15	12	-1.1

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE

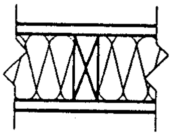


FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 1.22.2)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	41	0.8	40	
125	45	3.8	41	
250	35	2.9	32	
500	31	1.3	30	
1000	27	1.9	25	
2000	26	0.7	25	
4000	26	-1.1	27	34 dBA

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING WOOD STUD WALL

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

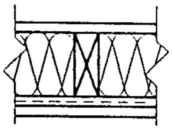
NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 3.5.2)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	44	0.8	43	
125	47	3.8	43	
250	35	2.9	32	
500	26	1.3	25	
1000	20	1.9	18	
2000	19	0.7	18	
4000	21	-1.1	22	31 dBA

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE

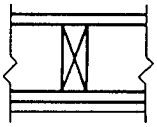


FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 4.5.2)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	38	0.8	37	
125	41	3.8	37	
250	33	2.9	31	
500	24	1.3	23	
1000	20	1.9	18	
2000	19	0.7	19	
4000	20	-1.1	22	29 dBA

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING
WOOD STUD WALL

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

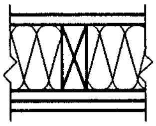
NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 5.5.2)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	37	0.8	36	
125	42	3.8	38	
250	35	2.9	32	
500	30	1.3	29	
1000	26	1.9	24	
2000	24	0.7	24	
4000	24	-1.1	25	32 dBA

ESTIMATION OF PLUMBING NOISE IN A BEDROOM

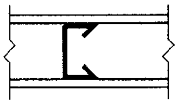
NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL
2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 6.5.2)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
125	42	3.8	39	
250	30	2.9	27	
500	28	1.3	27	
1000	23	1.9	21	
2000	20	0.7	19	
4000	21	-1.1	22	30 dBA

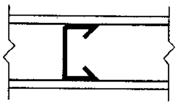
SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING WOOD STUD WALL

NOTE: WATER PRESSURE 40 PSI.
PLASTIC SLEEVE ATTACHEMENT
1/2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL ISO IN dB (TEST # 14.1.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	49	7 *	0.8 *	41	
125	60	9 *	3.8 *	47	
250	55	8 *	2.9 *	44	
500	55	7 *	1.3 *	46	
1000	53	9 *	1.9 *	42	
2000	55	17 *	0.7 *	37	
4000	58	16 *	-1.1 *	43	49 dBA

NOTE: WATER PRESSURE 40 PSI.
ARMAFLEX SLEEVE ATTACHEMENT
1/2 IN. COPPER PIPE

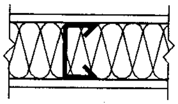


FREQUENCY IN HZ	SPL ISO IN dB (TEST # 14.2.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	41	7 *	0.8 *	33	
125	54	9 *	3.8 *	41	
250	54	8 *	2.9 *	43	
500	48	7 *	1.3 *	39	
1000	45	9 *	1.9 *	34	
2000	44	17 *	0.7 *	26	
4000	48	16 *	-1.1 *	33	41 dBA

* INDICATES THAT THOSE VALUES ARE TAKEN FROM TABLE 11

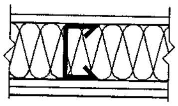
SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: FAUCET
METAL STUD WALL

NOTE: WATER PRESSURE 40 PSI.
ARMAFLEX SLEEVE ATTACHEMENT
1/2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL ISO IN dB (TEST # 15.2.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	42	7 *	0.8 *	42	
125	52	9 *	3.8 *	44	
250	45	8 *	2.9 *	32	
500	44	7 *	1.3 *	34	
1000	38	9 *	1.9 *	29	
2000	40	17 *	0.7 *	29	
4000	43	16 *	-1.1 *	25	36 dBA

NOTE: WATER PRESSURE 40 PSI.
ARMAFLEX SLEEVE ATTACHEMENT
1/2 IN. COPPER PIPE

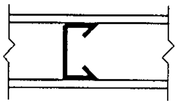


FREQUENCY IN HZ	SPL ISO IN dB (TEST # 16.2.4)	CORRECTION FACTOR FAUCET/ISO	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED FAUCET NOISE IN A BEDROOM IN dB	
63	40	7 *	0.8 *	40	
125	48	9 *	3.8 *	48	
250	41	8 *	2.9 *	41	
500	42	7 *	1.3 *	42	
1000	39	9 *	1.9 *	31	
2000	37	17 *	0.7 *	24	
4000	39	16 *	-1.1 *	29	34 dBA

* INDICATES THAT THOSE VALUES ARE TAKEN FROM TABLE 11

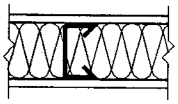
SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: FAUCET
METAL STUD WALL

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL OR STUD
2 IN. COPPER PIPE



FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 14.3.1)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	46	0.8 *	45	
125	48	3.8 *	44	
250	45	2.9 *	42	
500	35	1.3 *	34	
1000	31	1.9 *	29	
2000	26	0.7 *	25	
4000	26	-1.1 *	27	38 dBA

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL OR STUD
2 IN. COPPER PIPE

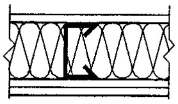


FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 15.3.1)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	47	0.8	47	
125	46	3.8	42	
250	38	2.9	35	
500	31	1.3	30	
1000	26	1.9	24	
2000	21	0.7	21	
4000	22	-1.1	23	33 dBA

* INDICATES THAT THOSE VALUES ARE TAKEN FROM TABLE 12

SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING METAL STUD WALL

NOTE: SINK EMPTYING
NO CONTACT WITH DRYWALL OR STUD
2 IN. COPPER PIPE

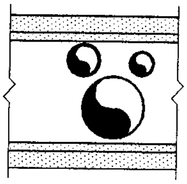


FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 16.3.1)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	40	0.8	39	
125	46	3.8	42	
250	34	2.9	31	
500	30	1.3	29	
1000	28	1.9	26	
2000	21	0.7	21	
4000	18	-1.1	19	32 dBA

* INDICATES THAT THOSE VALUES ARE TAKEN FROM TABLE 12

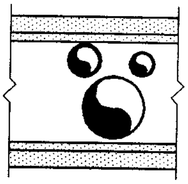
SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: SINK EMPTYING METAL STUD WALL

NOTE: TOILET FLUSH
NEOPRENE PADS
NO CONTACT WITH DRYWALL
4 IN. CAST IRON PIPE



FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 11.3.1)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED TOILET FLUSH NOISE IN A BEDROOM IN dB	
63	37	0.8 *	36	
125	36	3.8 *	33	
250	28	2.9 *	25	
500	23	1.3 *	22	
1000	25	1.9 *	23	
2000	25	0.7 *	24	
4000	25	-1.1 *	26	31 dBA

NOTE: SINK EMPTYING
NEOPRENE PADS
NO CONTACT WITH DRYWALL
4 IN. CAST IRON PIPE
TEST NO. 11.3.2

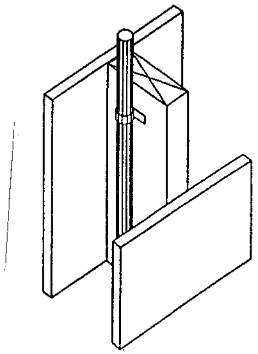
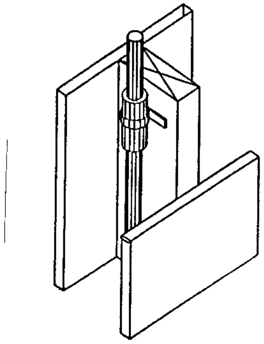


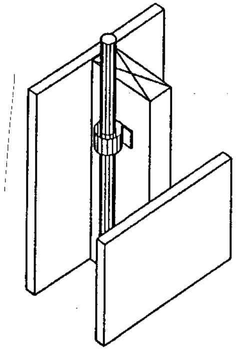
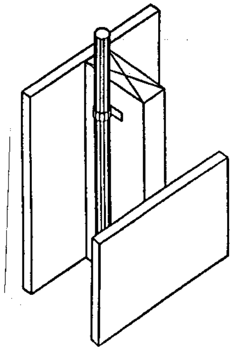
FREQUENCY IN HZ	SPL WASTE IN dB (TEST # 11.3.1)	CORRECTION FACTOR LAB/BEDROOM	ESTIMATED SINK EMPTYING NOISE IN A BEDROOM IN dB	
63	37	0.8 *	36	
125	41	3.8 *	37	
250	30	2.9 *	27	
500	22	1.3 *	21	
1000	23	1.9 *	21	
2000	24	0.7 *	23	
4000	24	-1.1 *	25	30 dBA

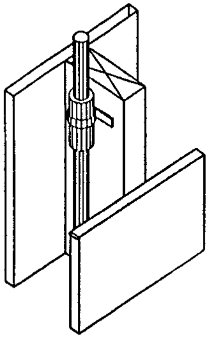
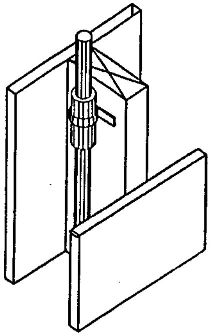
* INDICATES THAT THOSE VALUES ARE TAKEN FROM TABLE 12

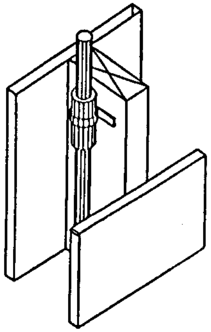
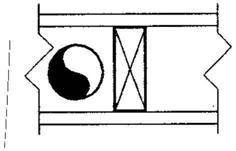
SIMULATION OF PLUMBING NOISE IN A TYPICAL BEDROOM - SOURCE: FAUCET SHAFT WALL

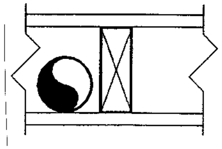
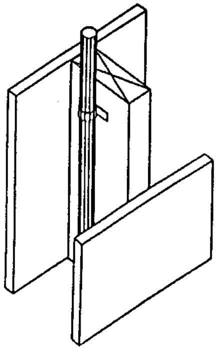
ANNEX III

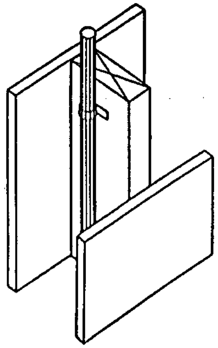
WOOD STUD	SCHEMATIC	TEST						OCTAVE							
PARTITION COMPOSITION	REPRESENTATION	NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	63	125	250	500	1000	2000	4000	dBA
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL		1.1.1	SUPPLY	COPPER	100 PSI.	3 STANDARD	ISO	52	64	69	68	67	68	68	74
		1.1.2		1 IN.	80 PSI.	CLAMPS	ISO	52	63	68	67	66	66	66	73
		1.1.3			60 PSI.	ALONG SIDE	ISO	47	61	66	66	64	64	64	71
		1.1.4			40 PSI.	OF STUD.	ISO	45	60	65	65	63	63	62	69
		1.2.1	SUPPLY	COPPER	100 PSI.	3 STANDARD	ISO	46	66	67	66	64	68	68	73
		1.2.2		3/4 IN.	80 PSI.	CLAMPS	ISO	45	64	66	65	63	66	66	72
		1.2.3			60 PSI.	ALONG SIDE	ISO	44	63	64	63	61	64	64	70
		1.2.4			40 PSI.	OF STUD.	ISO	43	61	63	62	58	63	61	68
		1.3.1	SUPPLY	COPPER	100 PSI.	3 STANDARD	ISO	47	65	69	68	67	69	71	76
		1.3.2		1/2 IN.	80 PSI.	CLAMPS	ISO	46	64	67	67	66	68	70	75
		1.3.3			60 PSI.	ALONG SIDE	ISO	44	59	65	66	64	66	67	72
		1.3.4			40 PSI.	OF STUD.	ISO	42	56	63	64	62	65	65	71
		1.4.1	SUPPLY	COPPER	100 PSI.	3" ARMAFLEX	ISO	50	53	55	59	51	50	51	59
		1.4.2		1 IN.	80 PSI.	SLEEVE	ISO	48	52	54	58	49	48	49	58
		1.4.3			60 PSI.	WITH OVER-	ISO	47	50	53	57	47	46	46	56
		1.4.4			40 PSI.	SIZED CLAMPS	ISO	46	49	50	55	45	45	44	54
		1.5.1	SUPPLY	COPPER	100 PSI.	3" ARMAFLEX	ISO	44	56	57	53	47	50	50	57
		1.5.2		3/4 IN.	80 PSI.	SLEEVE	ISO	43	55	55	52	45	48	48	55
		1.5.3			60 PSI.	WITH OVER-	ISO	41	54	54	50	43	46	45	53
		1.5.4			40 PSI.	SIZED CLAMPS	ISO	39	53	52	48	41	45	42	51
		1.6.1	SUPPLY	COPPER	100 PSI.	3" ARMAFLEX	ISO	45	48	58	53	48	47	50	57
		1.6.2		1/2 IN.	80 PSI.	SLEEVE	ISO	44	47	56	52	47	45	48	55
		1.6.3			60 PSI.	WITH OVER-	ISO	42	46	54	50	45	43	45	53
		1.6.4			40 PSI.	SIZED CLAMPS	ISO	39	44	52	48	43	42	43	51

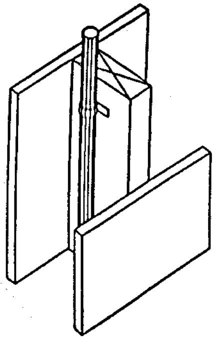
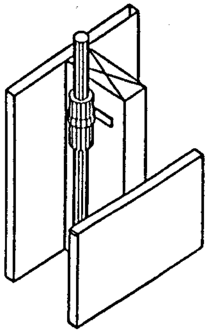
WOOD STUD	SCHEMATIC	TEST									OCTAVE				
PARTITION COMPOSITION	REPRESENTATION	NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	63	125	250	500	1000	2000	4000	dBA
		1.7.1	SUPPLY	COPPER	100 PSI.	ACOUSTO-	ISO	52	58	61	57	53	51	51	60
		1.7.2		1 IN.	80 PSI.	PLUMB	ISO	51	56	59	56	52	49	49	58
		1.7.3			60 PSI.	ATTACHMENT	ISO	49	55	57	54	50	46	46	56
		1.7.4			40 PSI.		ISO	48	53	55	52	48	46	43	54
		1.8.1	SUPPLY	COPPER	100 PSI.	ACOUSTO-	ISO	48	59	61	60	52	50	51	61
		1.8.2		3/4 IN.	80 PSI.	PLUMB	ISO	47	58	59	59	51	48	49	59
		1.8.3			60 PSI.	ATTACHMENT	ISO	44	57	57	57	49	46	46	57
		1.8.4			40 PSI.		ISO	43	55	56	55	47	45	44	55
		1.9.1	SUPPLY	COPPER	100 PSI.	ACOUSTO-	ISO	45	51	62	61	55	49	49	61
		1.9.2		1/2 IN.	80 PSI.	PLUMB	ISO	44	50	61	59	54	46	47	60
		1.9.3			60 PSI.	ATTACHMENT	ISO	42	48	58	57	52	44	44	58
		1.9.4			40 PSI.		ISO	39	47	56	55	50	43	41	56
		1.10.1	SUPPLY	PLASTIC	100 PSI.	3 STANDARD	ISO	53	60	60	63	56	51	43	62
		1.10.2		1 IN.	80 PSI.	CLAMPS	ISO	53	59	60	62	55	45	42	61
		1.10.3			60 PSI.	ALONG SIDE	ISO	51	58	58	60	51	41	40	59
		1.10.4			40 PSI.	OF STUD.	ISO	49	56	57	59	48	36	39	57
		1.11.1	SUPPLY	PLASTIC	100 PSI.	3 STANDARD	ISO	54	61	61	64	60	57	55	65
		1.11.2		3/4 IN.	80 PSI.	CLAMPS	ISO	53	60	60	62	59	55	54	64
		1.11.3			60 PSI.	ALONG SIDE	ISO	52	59	58	61	56	53	50	62
		1.11.4			40 PSI.	OF STUD.	ISO	50	57	56	59	54	52	49	60
		1.12.1	SUPPLY	PLASTIC	100 PSI.	3 STANDARD	ISO	49	64	62	59	61	58	54	65
		1.12.2		1/2 IN.	80 PSI.	CLAMPS	ISO	48	62	60	58	60	57	53	64
		1.12.3			60 PSI.	ALONG SIDE	ISO	45	60	58	56	57	55	49	61
		1.12.4			40 PSI.	OF STUD.	ISO	43	58	56	53	54	54	48	59

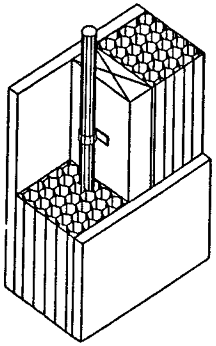
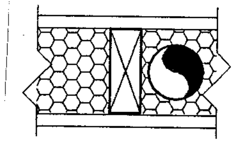
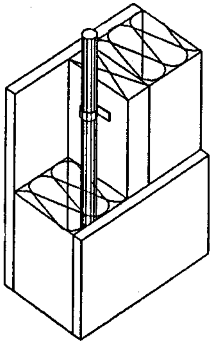
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		1.13.1	SUPPLY	PLASTIC	100 PSI.	3" ARMAFLEX	ISO	51	56	58	53	52	45	45	56
		1.13.2		1 IN.	80 PSI.	SLEEVE	ISO	50	55	57	52	51	42	44	55
		1.13.3			60 PSI.	WITH OVER-	ISO	48	53	56	50	48	40	41	53
		1.13.4			40 PSI.	SIZED CLAMPS	ISO	47	52	54	49	45	38	38	51
		1.14.1	SUPPLY	PLASTIC	100 PSI.	3" ARMAFLEX	ISO	53	62	60	51	48	44	45	56
		1.14.2		3/4 IN.	80 PSI.	SLEEVE	ISO	52	61	58	50	47	43	44	54
		1.14.3			60 PSI.	WITH OVER-	ISO	51	60	56	48	44	41	40	52
		1.14.4			40 PSI.	SIZED CLAMPS	ISO	50	59	55	47	42	39	39	51
		1.15.1	SUPPLY	PLASTIC	100 PSI.	3" ARMAFLEX	ISO	48	59	57	48	41	38	39	52
		1.15.2		1/2 IN.	80 PSI.	SLEEVE	ISO	46	58	55	47	40	36	37	50
		1.15.3			60 PSI.	WITH OVER-	ISO	44	56	53	45	37	34	33	48
		1.15.4			40 PSI.	SIZED CLAMPS	ISO	41	54	51	43	34	33	31	46
		1.16.1	SUPPLY	COPPER	100 PSI.	FELT	ISO	48	54	53	58	50	49	50	58
		1.16.2		1 IN.	40 PSI.	SLEEVE WITH OVER- SIZED CLAMPS	ISO	45	52	50	55	44	45	44	54
		1.17.1	SUPPLY	COPPER	100 PSI.	FELT	ISO	48	59	64	60	51	53	52	61
		1.17.2		3/4 IN.	40 PSI.	SLEEVE WITH OVER- SIZED CLAMPS	ISO	43	56	59	56	46	48	45	57
		1.18.1	SUPPLY	COPPER	100 PSI.	FELT	ISO	47	62	65	66	61	56	56	67
		1.18.2		1/2 IN.	40 PSI.	SLEEVE WITH OVER- SIZED CLAMPS	ISO	42	57	60	61	56	52	50	61

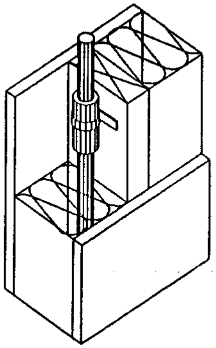
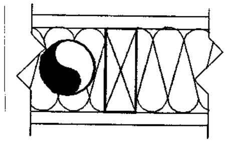
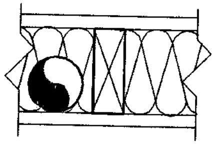
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		1.19.1	SUPPLY	COPPER 1 IN.	100 PSI.	CORK SLEEVE WITH OVER-SIZED CLAMPS	ISO	56	60	63	67	58	54	55	66
		1.19.2			40 PSI.		ISO	50	57	58	63	52	49	48	61
		1.20.1	SUPPLY	COPPER 3/4 IN.	100 PSI.	CORK SLEEVE WITH OVER-SIZED CLAMPS	ISO	46	65	67	65	58	58	56	66
		1.20.2			40 PSI.		ISO	41	61	62	60	53	53	49	61
		1.21.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	CORK SLEEVE WITH OVER-SIZED CLAMPS	ISO	44	58	67	68	64	64	62	71
		1.21.2			40 PSI.		ISO	39	53	61	63	58	60	55	66
		1.22.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	--------- EXPERIMENTAL ERROR ----------							
		1.22.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	41	45	35	31	27	26	26	35
		1.22.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	40	46	40	34	38	39	38	44
		1.22.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	41	46	39	34	35	36	36	42

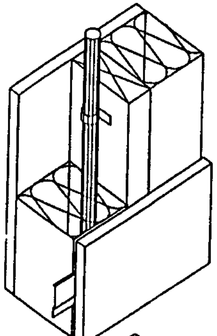
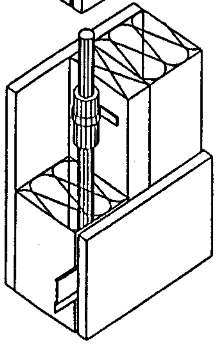
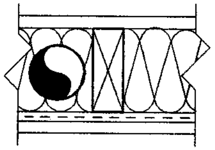
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							
								63	125	250	500	1000	2000	4000	dBA
		1.22.5	WASTE	CAST IRON 3 IN.	N/A	PIPE CONTACT WITH DRYWALL	TOILET FLUSH	43	45	42	32	29	26	24	37
		1.22.6	WASTE	COPPER 2 IN.	N/A	PIPE CONTACT WITH DRYWALL	SINK EMPTYING	57	60	52	45	39	37	38	49
		1.22.7	WASTE	PLASTIC 3 IN.	N/A	PIPE CONTACT WITH DRYWALL	TOILET FLUSH	45	50	47	40	40	40	39	47
		1.22.8	WASTE	PLASTIC 2 IN.	N/A	PIPE CONTACT WITH DRYWALL	SINK EMPTYING	52	55	51	49	44	43	42	51
		1.23.1	FAUCET #1	COPPER	100 PSI.	3 STANDARD	FAUCET	47	55	60	66	64	59	60	68
		1.23.2	AMERICAN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	45	54	58	64	64	57	58	67
		1.23.3	STD CERAMIX		60 PSI.	ALONG SIDE	FAUCET	42	51	55	58	60	55	53	63
		1.23.4	MAXIMUM FLOW		40 PSI.	OF STUD.	FAUCET	40	48	53	54	53	48	50	58
		1.24.1	FAUCET #2	COPPER	100 PSI.	3 STANDARD	FAUCET	46	60	68	69	64	60	61	70
		1.24.2	DELTA	1/2 IN.	80 PSI.	CLAMPS	FAUCET	45	58	67	69	63	59	59	69
		1.24.3	MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	43	56	64	65	60	52	50	65
		1.24.4	FLOW		40 PSI.	OF STUD.	FAUCET	41	55	63	61	54	49	48	61
		1.25.1	FAUCET #3	COPPER	100 PSI.	3 STANDARD	FAUCET	35	50	61	66	64	57	56	68
		1.25.2	WALTEC	1/2 IN.	80 PSI.	CLAMPS	FAUCET	34	48	60	65	62	56	54	66
		1.25.3	MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	32	45	57	62	57	51	48	62
		1.25.4	FLOW		40 PSI.	OF STUD.	FAUCET	31	43	55	59	54	48	44	59
		1.26.1	FAUCET #4	COPPER	100 PSI.	3 STANDARD	FAUCET	34	50	63	64	64	62	63	69
		1.26.2	MOEN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	33	49	61	62	61	60	62	68
		1.26.3	MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	31	47	59	58	57	55	59	64
		1.26.4	FLOW		40 PSI.	OF STUD.	FAUCET	30	45	55	54	50	42	43	55

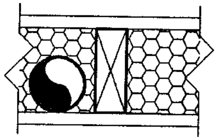
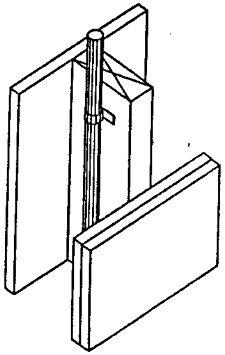
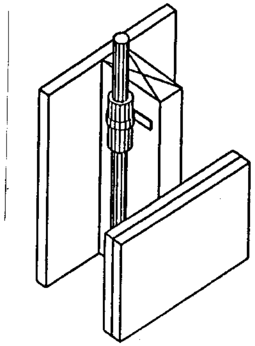
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE				OCTAVE				
								63	125	250	500	1000	2000	4000	dBA
		1.27.1	FAUCET #5	COPPER	100 PSI.	3 STANDARD	FAUCET	36	50	58	61	62	62	63	68
		1.27.2	CRANE	1/2 IN.	80 PSI.	CLAMPS	FAUCET	36	50	57	60	61	62	63	68
		1.27.3	MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	32	47	53	57	57	58	60	65
		1.27.4	FLOW		40 PSI.	OF STUD.	FAUCET	31	45	52	54	54	54	58	62
		1.29.1	FAUCET #1	COPPER	100 PSI.	3 STANDARD	FAUCET	37	48	58	60	60	61	67	70
		1.29.2	AMERICAN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	34	45	59	61	60	61	66	69
		1.29.3	STD CERAMIX		60 PSI.	ALONG SIDE	FAUCET	32	42	54	61	58	57	63	66
		1.29.4	1/2 MAXIMUM		40 PSI.	OF STUD.	FAUCET	31	40	48	56	56	52	58	62
			FLOW												
		1.31.1	FAUCET #2	COPPER	100 PSI.	3 STANDARD	FAUCET	38	54	62	60	58	58	58	65
		1.31.2	DELTA	1/2 IN.	80 PSI.	CLAMPS	FAUCET	36	52	61	59	56	56	56	63
		1.31.3	1/2 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	34	51	56	55	52	52	52	59
		1.31.4	FLOW		40 PSI.	OF STUD.	FAUCET	33	50	52	52	48	49	51	56
		1.32.1	FAUCET #3	COPPER	100 PSI.	3 STANDARD	FAUCET	30	41	51	55	56	55	53	61
		1.32.2	WALTEC	1/2 IN.	80 PSI.	CLAMPS	FAUCET	30	39	50	54	56	53	52	60
		1.32.3	1/2 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	29	36	47	51	53	50	49	57
		1.32.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	36	46	50	52	48	47	55
		1.33.1	FAUCET #4	COPPER	100 PSI.	3 STANDARD	FAUCET	30	42	54	61	60	59	60	66
		1.33.2	MOEN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	30	42	52	59	59	59	59	65
		1.33.3	1/2 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	29	38	46	55	56	56	57	63
		1.33.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	38	42	49	51	52	55	59
		1.34.1	FAUCET #5	COPPER	100 PSI.	3 STANDARD	FAUCET	36	50	52	55	60	63	67	70
		1.34.2	CRANE	1/2 IN.	80 PSI.	CLAMPS	FAUCET	35	49	52	55	60	62	67	70
		1.34.3	1/2 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	29	40	50	52	55	60	62	66
		1.34.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	39	48	50	52	60	61	65

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		1.36.1	FAUCET #1	COPPER	100 PSI.	3 STANDARD	FAUCET	31	43	54	55	53	57	66	68
		1.36.2	AMERICAN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	30	41	53	55	53	55	65	67
		1.36.3	STD CERAMIX		60 PSI.	ALONG SIDE	FAUCET	29	38	47	55	53	53	62	64
		1.36.4	1/4 MAXIMUM		40 PSI.	OF STUD.	FAUCET	29	37	44	51	52	49	59	61
			FLOW												
		1.37.1	FAUCET #2	COPPER	100 PSI.	3 STANDARD	FAUCET	30	42	54	53	55	54	57	61
		1.37.2	DELTA	1/2 IN.	80 PSI.	CLAMPS	FAUCET	30	40	52	52	53	53	55	60
		1.37.3	1/4 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	30	38	49	51	49	53	53	58
		1.37.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	36	43	46	43	48	51	55
		1.38.1	FAUCET #3	COPPER	100 PSI.	3 STANDARD	FAUCET	30	39	45	47	48	46	50	54
		1.38.2	WALTEC	1/2 IN.	80 PSI.	CLAMPS	FAUCET	30	38	44	47	46	45	49	53
		1.38.3	1/4 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	29	36	42	44	42	39	43	48
		1.38.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	35	40	41	40	37	43	47
		1.39.1	FAUCET #4	COPPER	100 PSI.	3 STANDARD	FAUCET	29	36	40	52	53	54	56	61
		1.39.2	MOEN	1/2 IN.	80 PSI.	CLAMPS	FAUCET	29	36	38	49	51	53	55	59
		1.39.3	1/4 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	28	33	35	44	47	50	52	56
		1.39.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	34	33	36	37	42	44	48
		1.40.1	FAUCET #5	COPPER	100 PSI.	3 STANDARD	FAUCET	29	38	41	47	53	53	59	62
		1.40.2	CRANE	1/2 IN.	80 PSI.	CLAMPS	FAUCET	29	37	40	47	53	52	58	61
		1.40.3	1/4 MAXIMUM		60 PSI.	ALONG SIDE	FAUCET	28	33	38	41	42	43	50	52
		1.40.4	FLOW		40 PSI.	OF STUD.	FAUCET	29	33	38	40	41	41	47	50
		1.42.1	SUPPLY	COPPER	100 PSI.	3 STD	ISO	35	43	44	38	35	45	46	50
		1.42.2		1/2 IN.	80 PSI.	ATTACHMENTS	ISO	36	43	43	38	34	43	44	48
		1.42.3			60 PSI.	WRAPPED	ISO	35	42	41	35	32	40	41	45
		1.42.4			40 PSI.	INSULATION	ISO	35	41	40	34	31	41	39	45

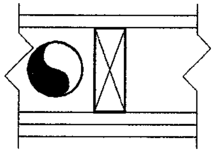
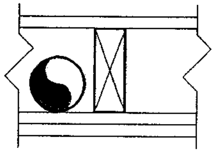
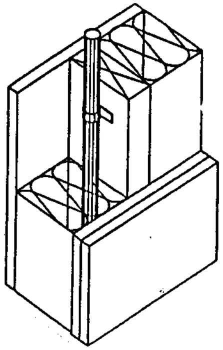
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							
								63	125	250	500	1000	2000	4000	dBA
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - STUD CAVITY FILLED WITH BLOWN-IN CELLULOSE FIBRE - 1 LAYER OF DRYWALL		2.1.1	SUPPLY	COPPER 1 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	52	61	65	63	62	63	63	69
		2.1.2			80 PSI.		ISO	49	60	64	62	61	61	62	68
		2.1.3			60 PSI.		ISO	45	58	62	61	59	59	61	66
		2.1.4			40 PSI.		ISO	43	56	60	58	57	58	57	64
		2.2.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	36	37	37	27	23	20	17	31
		2.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	39	41	37	33	34	32	32	39
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL		3.1.1	SUPPLY	COPPER	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	52	61	68	64	63	65	64	71
		3.1.2			40 PSI.		ISO	43	57	63	60	57	60	58	65
		3.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3 STANDARD CLAMPS	ISO	46	59	63	66	69	69	70	75
		3.2.2			40 PSI.		ISO	39	51	58	61	64	65	64	70

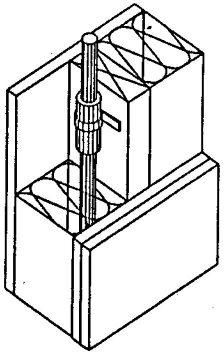
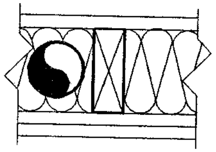
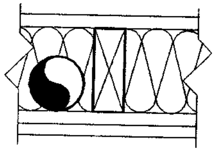
WOOD STUD	SCHEMATIC	TEST						OCTAVE							
PARTITION COMPOSITION	REPRESENTATION	NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	63	125	250	500	1000	2000	4000	dBA
		3.3.1	SUPPLY	COPPER 1 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	47	50	51	55	46	42	42	54
		3.3.2			40 PSI.		ISO	42	47	47	51	40	37	35	49
		3.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	43	47	55	51	47	41	41	53
		3.4.2			40 PSI.		ISO	38	43	50	46	42	37	34	48
		3.5.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	38	39	37	24	21	20	19	31
		3.5.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	44	47	35	26	20	19	21	33
		3.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	41	44	37	31	33	35	34	40
		3.5.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	47	46	42	35	37	33	31	41
		3.5.5	WASTE	CAST IRON 3 IN.	N/A	PIPE CONTACT WITH DRYWALL	TOILET FLUSH	41	44	43	33	26	24	22	37
		3.5.6	WASTE	COPPER 2 IN.	N/A	PIPE CONTACT WITH DRYWALL	SINK EMPTYING	55	60	48	42	38	37	37	48
		3.5.7	WASTE	PLASTIC 3 IN.	N/A	PIPE CONTACT WITH DRYWALL	TOILET FLUSH	42	48	43	37	35	37	34	43
		3.5.8	WASTE	PLASTIC 2 IN.	N/A	PIPE CONTACT WITH DRYWALL	SINK EMPTYING	54	52	48	46	43	42	41	49

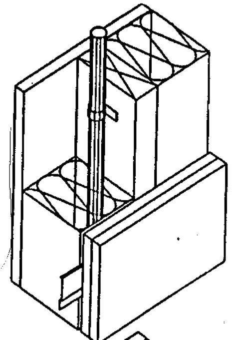
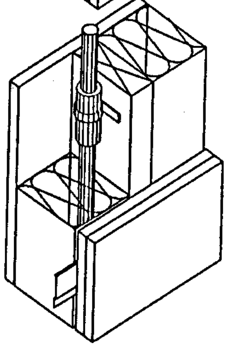
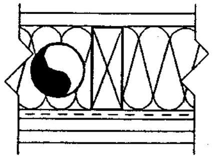
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 1 LAYER OF DRYWALL		4.1.1	SUPPLY	COPPER 1 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	51	62	59	53	54	58	60	64
		4.1.2			40 PSI.		ISO	45	58	55	49	48	53	54	59
		4.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	43	58	60	52	55	59	62	66
		4.2.2			40 PSI.		ISO	38	50	54	47	50	55	57	61
		4.3.1	SUPPLY	COPPER 1 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	52	49	48	42	36	38	39	46
		4.3.2			40 PSI.		ISO	47	46	44	38	30	33	33	41
		4.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	44	49	49	42	41	34	37	46
		4.4.2			40 PSI.		ISO	38	46	44	37	36	30	29	41
		4.5.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT W/ RES. CHANNEL	TOILET FLUSH	38	40	36	23	22	21	20	31
		4.5.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT W/ RES. CHANNEL	SINK EMPTYING	38	41	33	24	20	19	20	30
		4.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT W/ RES. CHANNEL	TOILET FLUSH	41	44	33	29	33	35	33	40
		4.5.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT W/ RES. CHANNEL	SINK EMPTYING	43	46	42	30	31	31	28	38

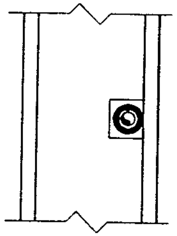
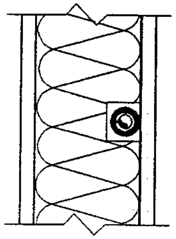
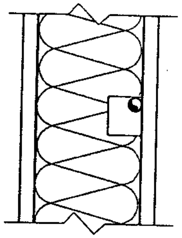
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		4.5.5	WASTE	CAST IRON 3 IN.	N/A	PIPE CONTACT W/ RES. CHANNEL	TOILET FLUSH	41	42	37	25	24	23	21	32
		4.5.6	WASTE	COPPER 2 IN.	N/A	PIPE CONTACT W/ RES. CHANNEL	SINK EMPTYING	48	49	38	37	28	23	25	38
- 1 LAYER OF DRYWALL - 2 × 4 WOOD STUDS - 2 LAYERS OF DRYWALL		5.1.1	SUPPLY	COPPER 1 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	50	61	65	64	63	62	61	69
		5.1.2			80 PSI.		ISO	48	60	68	63	61	61	59	68
		5.1.3			58 PSI.		ISO	45	58	62	62	59	58	57	65
		5.1.4			40 PSI.		ISO	*41	*56	*60	*59	*56	*55	*54	*62
		5.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	45	62	62	65	65	67	67	73
		5.2.2			40 PSI.		ISO	40	53	57	59	60	63	61	68
		5.3.1	SUPPLY	COPPER 1 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	45	49	47	54	46	46	44	54
		5.3.2			40 PSI.		ISO	41	46	43	49	40	41	37	49
		5.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	43	48	51	51	48	44	42	53
		5.4.2			40 PSI.		ISO	37	44	47	45	43	41	36	48

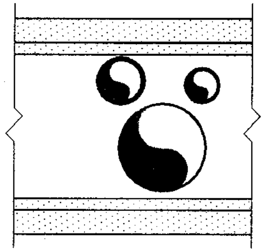
NOTE: * INDICATES THAT VALUES FOR THIS TEST HAVE BEEN EXTRAPOLATED

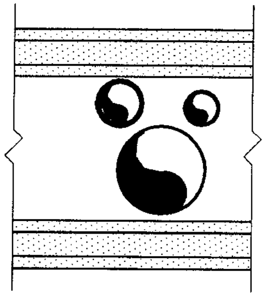
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE 63	125	250	500	1000	2000	4000	dBA
		5.5.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	--------- EXPERIMENTAL ERROR ----------							
		5.5.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	37	42	35	30	26	24	24	34
		5.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	40	44	37	37	37	37	35	43
		5.5.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	47	46	41	39	36	33	31	42
		5.5.5	WASTE	CAST IRON 3 IN.	N/A	PIPE CONTACT WITH DRYWALL	TOILET FLUSH	38	43	37	30	28	26	22	35
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 2 LAYERS OF DRYWALL		6.1.1	SUPPLY	COPPER 1 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	51	58	63	63	62	61	61	68
		6.1.2			40 PSI.		ISO	43	55	58	58	57	56	55	63
		6.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	44	58	61	62	62	65	65	70
		6.2.2			40 PSI.		ISO	39	50	56	57	57	61	60	66

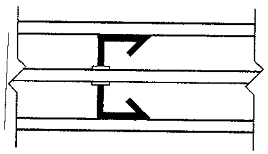
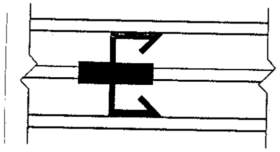
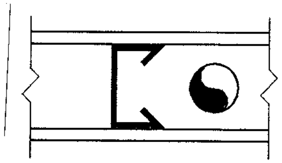
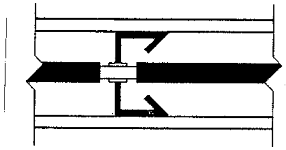
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		6.3.1	SUPPLY	COPPER 1 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER- SIZED CLAMPS	ISO	46	48	45	50	43	39	35	49
		6.3.2			40 PSI.		ISO	42	45	41	46	36	34	30	45
		6.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER- SIZED CLAMPS	ISO	41	46	50	49	46	39	37	51
		6.4.2			40 PSI.		ISO	36	43	44	44	40	35	31	45
		6.5.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	36	37	35	27	22	19	15	30
		6.5.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	40	42	30	28	23	20	21	31
		6.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT WITH DRYWALL	TOILET FLUSH	39	41	34	31	31	32	28	38
		6.5.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT WITH DRYWALL	SINK EMPTYING	42	43	36	32	30	29	25	36

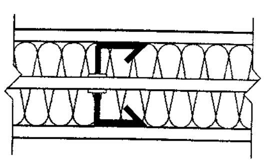
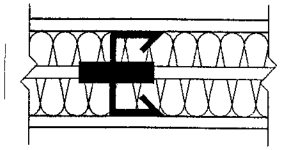
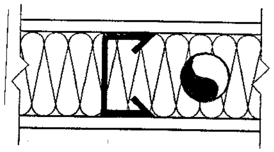
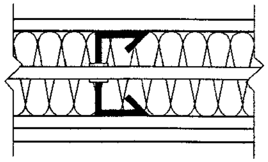
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - RESILIENT FURRINGS - 2 LAYERS OF DRYWALL		7.1.1	SUPPLY	COPPER 1 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	52	58	58	51	50	53	53	59
		7.1.2			40 PSI.		ISO	48	55	54	47	44	49	46	54
		7.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3 STANDARD CLAMPS ALONG SIDE OF STUD.	ISO	46	57	60	49	51	52	49	58
		7.2.2			40 PSI.		ISO	38	51	55	44	47	49	44	54
		7.3.1	SUPPLY	COPPER 1 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	54	48	50	40	37	37	34	45
		7.3.2			40 PSI.		ISO	49	45	46	36	30	31	27	40
		7.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	3" ARMAFLEX SLEEVE WITH OVER-SIZED CLAMPS	ISO	44	48	49	38	39	32	32	44
		7.4.2			40 PSI.		ISO	38	44	44	33	33	27	24	39
		7.5.1	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT W/ RES. CHANNEL	TOILET FLUSH	38	38	33	22	22	20	18	29
		7.5.2	WASTE	COPPER 2 IN.	N/A	NO CONTACT W/ RES. CHANNEL	SINK EMPTYING	39	39	32	23	20	19	18	29
		7.5.3	WASTE	PLASTIC 3 IN.	N/A	NO CONTACT W/ RES. CHANNEL	TOILET FLUSH	38	40	31	28	32	34	28	38
		7.5.4	WASTE	PLASTIC 2 IN.	N/A	NO CONTACT W/ RES. CHANNEL	SINK EMPTYING	42	42	36	28	27	27	24	34

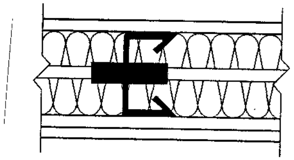
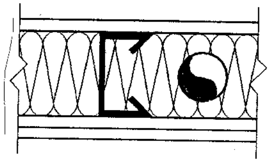
WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 1 LAYER OF DRYWALL		8.1.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	KNOTCH IN 3 WOOD STUDS ARMAFLEX BET. PIPE & STUDS	ISO	42	51	53	50	48	51	55	58
		8.1.2			40 PSI.		ISO	36	47	47	45	41	46	47	52
- 1 LAYER OF DRYWALL - 2 x 4 WOOD STUDS - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - 1 LAYER OF DRYWALL		9.1.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	KNOTCH IN 3 WOOD STUDS ARMAFLEX BET. PIPE & STUDS	ISO	41	51	49	47	43	42	42	50
		9.1.2			40 PSI.		ISO	37	47	44	42	37	38	36	45
		9.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	KNOTCH IN 3 WOOD STUDS SOLID CONTACT WITH STUDS	ISO	42	50	61	63	63	66	67	72
		9.2.2			40 PSI.		ISO	38	44	55	59	57	61	60	66

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE				OCTAVE				
								63	125	250	500	1000	2000	4000	dBA
SHAFT WALL COMPOSED OF: - 1 IN. CORE BOARD - 5/8 IN. TYPE "X" DRYWALL FIRE RESISTANCE: 1 HOUR		11.1.1	SUPPLY	COPPER 2 IN.	100 PSI.	PIPE SUPPORTED	ISO	27	32	28	22	34	33	30	38
		11.1.2			80 PSI.	FROM FLOOR ON	ISO	27	31	26	21	31	28	28	35
		11.1.3			60 PSI.	NEOPRENE PADS	ISO	27	30	23	19	27	23	24	31
		11.1.4			40 PSI.	NO CONTACT W/.	ISO	26	30	23	18	25	21	24	29
					40 PSI.	SHAFT WALL.									
		11.2.1	SUPPLY	COPPER 1 1/2 IN.	100 PSI.	PIPE SUPPORTED	ISO	47	47	34	29	33	36	32	40
		11.2.2			80 PSI.	FROM FLOOR ON	ISO	46	46	31	26	30	34	30	38
		11.2.3			60 PSI.	NEOPRENE PADS	ISO	39	41	28	23	24	27	27	33
		11.2.4			40 PSI.	NO CONTACT W/. SHAFT WALL.	ISO	36	39	28	21	22	25	26	32
		11.3.1	WASTE	CAST IRON 4 IN.	N/A	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	TOILET FLUSH	37	36	28	23	25	25	25	31
		11.3.2	WASTE	CAST IRON 4 IN.	N/A	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	SINK EMPTYING	37	41	30	22	23	24	24	31

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
SHAFT WALL COMPOSED OF: - 5/8 IN. TYPE "X" DRYWALL - 1 IN. CORE BOARD - 5/8 IN. TYPE "X" DRYWALL		12.1.1	SUPPLY	COPPER 2 IN.	100 PSI.	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	ISO	28	31	27	22	34	31	26	37
		12.1.2			40 PSI.		ISO	27	30	24	17	23	16	20	27
		12.2.1	SUPPLY	COPPER 1 1/2 IN.	100 PSI.	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	ISO	30	33	31	21	29	31	27	35
FIRE RESISTANCE: 2 HOURS		12.2.2			40 PSI.		ISO	27	31	23	18	19	18	20	26
		12.3.1	WASTE	CAST IRON 4 IN.	N/A	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	TOILET FLUSH	36	40	30	24	26	21	22	31
		12.3.2	WASTE	CAST IRON 4 IN.	N/A	PIPE SUPPORTED FROM FLOOR ON NEOPRENE PADS NO CONTACT W/. SHAFT WALL.	SINK EMPTYING	34	36	27	20	21	22	23	29

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
- 1 LAYER OF DRYWALL - STANDARD 3 5/8 IN METAL STUDS (25 GA.) - 1 LAYER OF DRYWALL		14.1.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH PLASTIC SLEEVE	ISO	52	66	61	62	59	63	66	70
		14.1.2			80 PSI.		ISO	51	64	60	61	57	61	64	68
		14.1.3			60 PSI.		ISO	49	63	57	59	56	58	61	65
		14.1.4			40 PSI.		ISO	49	60	55	55	53	55	58	62
		14.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH ARMAFLEX SLEEVE	ISO	45	59	59	53	50	52	55	60
		14.2.2			80 PSI.		ISO	44	57	58	52	49	50	54	58
		14.2.3			60 PSI.		ISO	43	55	56	50	48	48	51	56
		14.2.4			40 PSI.		ISO	41	54	54	48	45	44	48	53
		14.3.1	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	46	48	45	35	31	26	26	40
		14.3.2	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	40	42	36	29	21	21	22	32
		14.4.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HOR. 3 STUD WIDTH W/ FOAM STYRENE DOMESTIC LOW DENSITY INSULATION	ISO	53	66	62	60	57	61	65	68
		14.4.2			80 PSI.		ISO	52	65	61	59	56	59	63	67
		14.4.3			60 PSI.		ISO	50	63	58	57	54	56	60	64
		14.4.4			40 PSI.		ISO	49	61	56	55	52	53	57	61

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE 63	125	250	500	1000	2000	4000	dBA
- 1 LAYER OF DRYWALL - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - STANDARD 3 5/8 IN METAL STUDS (25 GA.) - 1 LAYER OF DRYWALL		15.1.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY	ISO	47	61	57	56	54	60	63	66
		15.1.2			80 PSI.	3 STUD WIDTH	ISO	46	60	56	55	53	58	61	65
		15.1.3			60 PSI.	PLASTIC	ISO	43	58	54	53	51	53	59	62
		15.1.4			40 PSI.	SLEEVE	ISO	44	57	52	51	49	52	56	59
		15.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY	ISO	46	57	50	50	43	48	50	55
		15.2.2			80 PSI.	3 STUD WIDTH	ISO	46	56	49	49	42	46	48	53
		15.2.3			60 PSI.	ARMAFLEX	ISO	44	54	46	47	40	44	46	51
		15.2.4			40 PSI.	SLEEVE	ISO	42	52	45	44	38	40	43	48
		15.3.1	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	47	46	38	31	26	21	22	35
		15.3.2	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	39	39	30	21	19	20	22	29
- 1 LAYER OF DRYWALL - 3 1/2 IN. GLASS FIBER BATT INSULATION IN STUD CAVITY. - STANDARD 3 5/8 IN METAL STUDS (25 GA.) - 2 LAYERS OF DRYWALL		16.1.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY	ISO	44	60	54	56	56	60	61	65
		16.1.2			80 PSI.	3 STUD WIDTH	ISO	43	59	53	55	54	58	59	64
		16.1.3			60 PSI.	PLASTIC SLEEVE	ISO	41	57	50	53	52	55	56	61
		16.1.4			40 PSI.		ISO	40	55	49	51	51	52	53	58

WOOD STUD PARTITION COMPOSITION	SCHEMATIC REPRESENTATION	TEST NO.	PIPE TYPE	DIAMETER	PRESSURE	ATTACHMENT	SOURCE	OCTAVE							dBA
								63	125	250	500	1000	2000	4000	
		16.2.1	SUPPLY	COPPER 1/2 IN.	100 PSI.	PIPE RUNNING HORIZONTALLY 3 STUD WIDTH ARMAFLEX SLEEVE	ISO	43	54	46	48	45	45	46	52
		16.2.2			80 PSI.		ISO	43	52	44	47	43	43	44	51
		16.2.3			60 PSI.		ISO	41	50	42	45	42	40	42	48
		16.2.4			40 PSI.		ISO	40	48	41	42	39	37	39	46
		16.3.1	WASTE	COPPER 2 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	40	46	34	30	28	21	18	34
		16.3.2	WASTE	CAST IRON 3 IN.	N/A	NO CONTACT WITH DRYWALL OR STUDS	SINK EMPTYING	36	37	30	22	19	17	16	27

ANNEX IV

ANNEX IV

MEASUREMENT PROCEDURES AND MATERIALS USED.

STEADY FLOW MEASUREMENTS WITH ISO SOURCE

Arrangement of Plumbing

Steady flow measurements were made for several different pipe systems. These systems were mounted inside test walls which were constructed in the test frame normally used to hold sound transmission loss specimens. The general physical layout of the piping system and the test walls is shown in Figure 1.

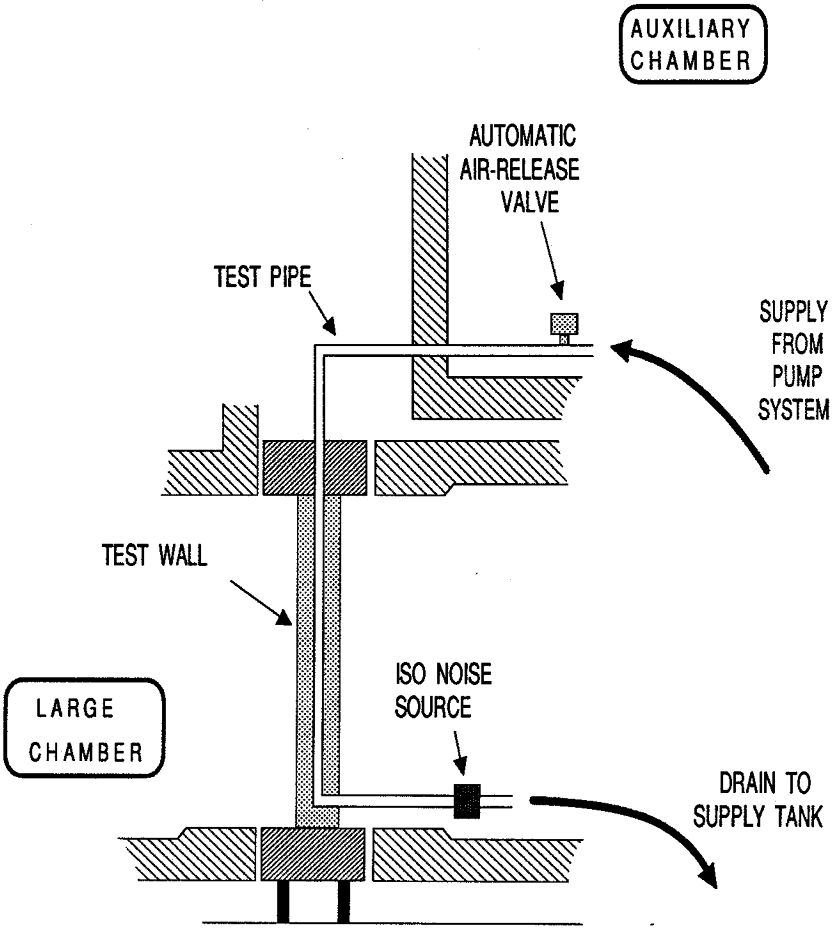


Figure 1: Arrangement of test wall and plumbing systems in the laboratory. Measurements of sound pressure level were made in the large reverberation chamber on the left.

Water from a reservoir was pumped up to the room above the test specimen and then passed down through the pipe systems. To generate noise in supply pipe systems, a hydraulic noise source was constructed in conformance with the specifications given in ISO 3822. A section through the source is shown in Figure 2.

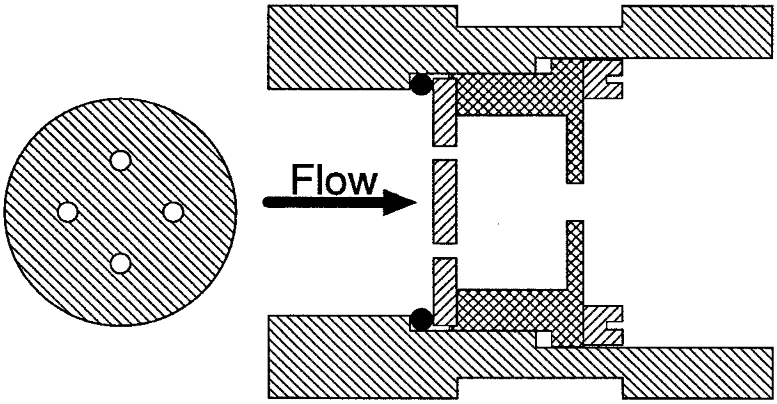
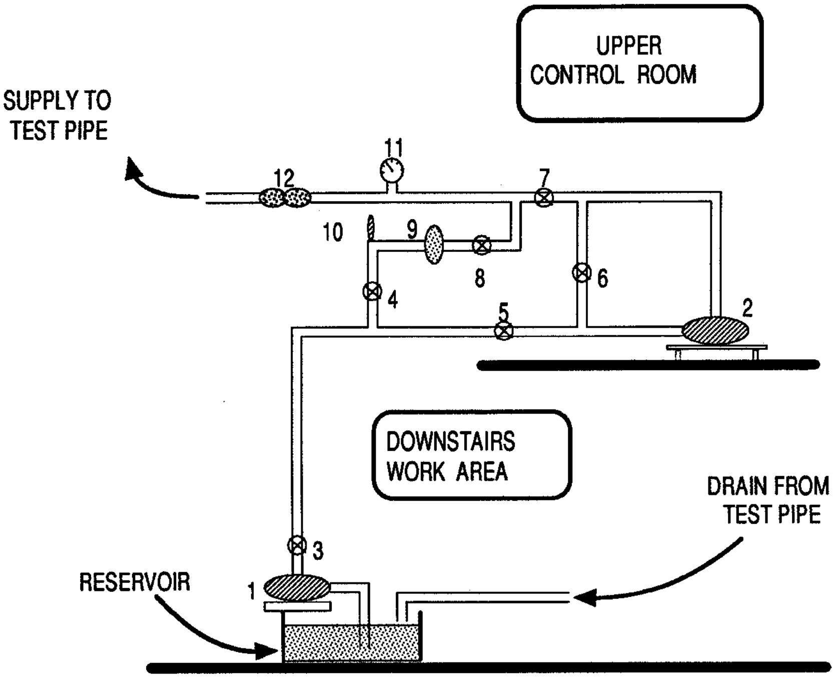


Figure 2: Section through the ISO 3822 standard hydraulic noise source. A front view of the first plate with its four holes is shown on the left. Each hole has a diameter of 2.5 mm. The hole at the right side of the source has a diameter of 5 mm.

The ISO noise source was placed in the pipe system just after the pipe emerged from the test wall. Tapered sections of pipe were inserted when necessary to establish a gradual change of diameter from the test pipes to the noise source; this gradual change in diameter prevented the creation of additional noise due to turbulence.

Supply pipes under test were installed vertically and attached at three points to a stud in the middle of the wall for most measurements. In some cases, noted elsewhere, the pipes were installed horizontally in contact with three studs.

The arrangement of pumps and valves used to set and control the water pressure is shown in Figure 3. The combination of pumps and control valves allowed the supply pressure to be varied from 40 to 100 psi in most circumstances. Automatic bleed valves were included in the system to allow trapped air to escape. It is also important that no air be trapped on the downstream side of the ISO source, so a transparent section of hose was included to allow a visual check for this. Table 1 shows the four standard pressures that were used and the corresponding flow rates achieved during the measurements with the ISO source. Flow rates were measured using a bucket and a stopwatch. The flow rates given are mean values for 13, 19, and 25 mm copper pipe systems. The rates did not change with pipe diameter as expected because flow rate for a given pressure is controlled by the size of the openings in the ISO hydraulic noise source.



1 - 1 HP MYERS HJ100 MAIN PUMP
2 - 1/2 HP MYERS HJ50 BOOSTER PUMP
3,4,5,7 & 8 FLOW VALVES
6 - BY-PASS VALVE
9 - PRESSURE REDUCING VALVE (PRV)
10 - AUTOMATIC AIR-RELEASE VALVE
11 - PRESSURE METER (PSI)
12 - NEOPRENE WATER SILENCER

Figure 3: System of pumps and valves used to control water pressure during steady-flow measurements with faucets and the ISO hydraulic noise source.

Table 1: Mean water flow rates with ISO noise source restricting the flow.

Pressure, psi	l/min
40	15.6
58	17.6
80	20.1
100	22.0

STEADY FLOW MEASUREMENTS WITH FAUCETS

Arrangement of Plumbing Systems

Five conventional bathtub faucets were evaluated. These replaced the ISO source in the water supply system. It was not always possible to set the system to supply all pressures in the set 40, 58, 80, and 100 psi because of the greater flow through the faucets. The area of the openings in the ISO source is 19.6 square mm, while the faucet openings were about four times larger. Table 2 gives the pressures and flow rates that could be achieved for each of the five faucets. Also shown are flow rates where the faucets were adjusted to reduce the flow to 1/2 and 1/4 of the maximum value.

Table 2: Supply pressures (psi) and flow rates (l/min) with the five standard faucets used during the measurements. Faucets are identified by number as follows:
#1 - Single Lever Ceramix (American Standard) #2000 - 302
#2 - Single Lever Delta Model 642CSOS
#3 - Single Lever Waltec Type 10W523
#4 - Single Lever Moen HI-FLOW
#5 - Dual Faucet Crane Basin Type. Cold side only.

#1		#2		#3		#4		#5	
psi	l/min	psi	l/min	psi	l/min	psi	l/min	psi	l/min
Maximum flow									
40	22.2	40	16.2	40	17.4	40	13.2	40	33.6
55	26.4	58	18.6	54	19.8	58	15.0	52	37.2
80	30.6	80	21.6	80	23.4	80	17.4	80	47.4
95	32.4	95	23.4	95	25.2	95	19.2	84	46.8
1/2 maximum flow									
95	16.2	95	12.6	95	12.0	95	9.0	84	24.6
1/4 maximum flow									
95	8.4	95	6.0	95	6.0	95	4.8	84	11.4

Acoustical Measurements

Measurements of sound pressure level were made in the large reverberation chamber which has a volume of 250 m^3. Nine microphones were used to sample the sound field in the room. The integration time at each microphone was 30 seconds. The frequency range was 63 to 5000 hertz. For most measurements, a rotating diffuser was in operation to improve sound field uniformity. When the radiated noise was too low, the diffuser was stopped to give the quietest condition that can be achieved in this room. Despite this, some measurements were too close to the background noise in the room to be valid.

WASTE WATER MEASUREMENTS

Plumbing System Arrangement

A standard toilet and a standard, stainless-steel, single-basin kitchen sink were used to generate noise for waste water measurements. These were placed in the auxiliary room just above the test wall and the waste water allowed to flow down through the pipes to an external drain. Waste pipes attached to the toilet ran vertically through the test wall. Waste pipes attached to the sink had a horizontal section in the middle of the test wall that extended for about 1.2 m and occupied three stud spaces.

Acoustical Measurements

The cistern or the sink was filled with water and then the flushing or draining process was started. Because of the transient nature of the events, the computer was programmed to measure the maximum sound pressure level measured in a 30 second interval after receipt of a trigger signal. (All events lasted less than 30 seconds). This maximum level corresponds to that which would be measured by a sound pressure level meter set on FAST. The procedure was repeated nine times for each wall/pipe configuration: once for each microphone.

In many cases where the waste pipe was isolated from the wall, the noise generated in the large reverberation room was too close to the background noise level in the room, so meaningful measurements could not be made. In some cases, where it was already clear that sound levels generated by the waste water flow would have been too close the background sound level in the large reverberation room, the scheduled tests were not run.

WALL CONSTRUCTIONS

Standard materials and normal construction practices were used to construct all walls and pipe systems. Walls were constructed with studs spaced 600 mm apart. Shaft walls used steel angle runners to support the gypsum coreboard. The following materials were used.

Supply Pipes

Standard 13, 19, and 25 mm copper pipe

13, 19, and 25 mm Schedule 80 plastic pipe. This pipe has a wall thickness of 5 mm.

Waste Pipes

50 mm copper, 50 mm plastic, 75 mm plastic, 75 mm cast iron, 100 mm cast iron

Resilient Materials for Pipe Wrapping

Armstrong A.P. Armaflex Foam Pipe Insulation, nominal wall thickness 13 mm.

Acousto-Plumb System Acousto-Clamp pipe supports, manufactured by Ancon Inc.

Double layer of cork with total thickness of 3 mm.

13 mm hair and fabric felt

Wall Construction Materials

13 mm drywall 7.8 kg/m^2
16 mm drywall 10.2 kg/m^2
25 mm gypsum coreboard 19.5 kg/m^2
38 x 89 mm wood studs at 600 mm o.c.
90 mm steel studs
Resilient metal channels, type RC-1 by Canadian Gypsum Corporation at 600 mm o.c.
90 mm glass fibre batts. Type R-12 Home Insulation, 1.2 kg/m^2.

Thermocell cellulose fibre: to install this material, 6 mil polythene sheet was attached to the studs leaving an opening at the top of each stud space. The cellulose fibre was then poured into the cavity through the opening. The opening at the top was gradually closed and the cavity filled completely. Drywall was then attached to the studs applied over the polythene sheet