RESEARCH REPORT

External Research Program

Noise Isolation Provided by Exterior Walls in Wood Construction

Canada

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NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTION

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MJM Acoustical Consultants inc.

19 October 1998

CMHC Project Officer: Ken Ruest

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the External Research Program (CMHC File 6585-M088-11). The views expressed are those of the author and do not represent the official views of the Corporation.

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RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTIONS

Prepared by

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Report submitted October 19, 1998 to

Mr. Ken Ruest,
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ACKNOWLEDGEMENTS

The author wishes to thank Mr. Jean-Marie Guérin and Ms. Graça Firmino of MJM Acoustical Consultants inc. whose contribution was very appreciated during the preparation of this report.

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RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTIONS

ABSTRACT

The external Research Program of CANADA MORTGAGE & HOUSING CORPORATION accepted the proposal by MJM ACOUSTICAL CONSULTANTS INC. to conduct a study on the noise isolation provided by exterior walls in wood construction. The report is addressed to acousticians, builders and construction professionals. A total of nine Sound Transmission Loss measurements were conducted on four exterior walls, which have a thermal insulation factor of RSI 3.5 (R_{20}): two walls with 38 mm x 140 mm (2" x 6") studs and two with 38 mm x 89 mm (2" x 4") studs. Five tests were carried on walls with no exterior finishes, and four on walls with PVC cladding. In order to establish the effect of varying the stud spacing, one sound transmission loss test was performed on a wall whose studs were spaced 600 mm (24") apart; the rest of the specimens were constructed with studs spaced at 400 mm (16") o.c. which corresponds to the stud spacing most often used for exterior walls in Canadian construction. The interior finish was the same for all the walls tested: 13 mm (½") drywall located on the receiving room side; the exterior side of the wall was located on the source room side.

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTIONS

EXECUTIVE SUMMARY

The external Research Program of CANADA MORTGAGE & HOUSING CORPORATION accepted the proposal by MJM ACOUSTICAL CONSULTANTS INC. to conduct a study on the noise isolation provided by exterior walls in wood construction.

At the time the proposal for this research project was submitted, the acoustical data available on exterior walls was almost inexistent. The main objective of this project was to fill this void by investigating the sound attenuation properties of four exterior walls commonly used in Canadian low cost residential housing.

A total of nine Sound Transmission Loss measurements were conducted on the four exterior walls selected: two walls with 38 mm x 140 mm (2" x 6") studs and two with 38 mm x 89 mm (2" x 4") studs. Five tests were carried on walls with no exterior finishes, and four on walls with PVC cladding. All the wall compositions selected had a thermal insulation factor of RSI 3.5 (R_{20}). In order to establish the effect of varying the stud spacing, one sound transmission loss test was performed on a wall whose studs were spaced 600 mm (24") apart; the rest of the specimens were constructed with studs spaced at 400 mm (16") o.c. which is presently the stud spacing most often used for exterior walls in Canadian construction. The interior finish was the same for all the walls tested: 13 mm (½") drywall located on the receiving room side (the large reverberation chamber). The exterior side of the wall was located on the source room side.

Tables 1, 2 and 3 (pages E-6, E-7 and E-8) contain a summary of the results obtained, expressed in terms of Sound Transmission Class (STC) and Outdoor-Indoor Transmission Class (OITC); they also contain the composition, the surface mass and the cost per unit area of the materials entering in the composition of the walls tested (it has been assumed that the cost of workmanship was approximately the same for all walls).

The conclusions reached during the present study are as follows:

- Spacing the 38 mm x 140 mm (2" x 6") studs of an exterior wall at 600 mm (24") o.c. [wall n° 1] instead of 400 mm (16") o.c. [wall n° 2] resulted in an increase of 6 points of STC and in an increase of 2 points of OITC. The 1/3 rd octave sound transmission loss values of the wall constructed with studs at 600 mm (24") o.c. are generally higher or in the same order that those of the wall constructed with studs at 400 mm (16") o.c. except for frequencies below 80 Hz for which the TL of the wall constructed with studs spaced at 400 mm (16") o.c. are greater.

- Exterior walls framed with 38 mm x 140 mm (2" x 6") studs, are generally constructed with OSB boards or asphalt impregnated wood fibre boards. The wall constructed with asphalt impregnated wood fibre boards instead of OSB boards provided a significantly better sound transmission loss for all frequencies above 125 Hz, even though the surface mass of the wood fibre boards is more than two times less than that of the OSB boards; below 125 Hz the OSB boards provide a slightly superior sound isolation. The difference of only 0 to 2 points between the STC and OITC ratings measured on walls constructed with asphalt impregnated wood fibre board and those measured on walls constructed with OSB boards can be misleading since it suggests that the walls provide similar acoustical performance when in fact, the transmission loss curves indicate that the wall constructed with the wood fibre board is clearly superior to that constructed with OSB boards. The effect of the 3 mm (1/8") airgap that the manufacturer recommends to leave between the OSB boards tested has not been fully investigated during this study and should be investigated further in a subsequent study.

- When using 38 mm x 89 mm (2" x 4") studs the most popular materials used to reach the RSI 3.5 (R_{20}) insulation factor and to provide suitable air barrier are either 38 mm (1 ½") thick semi-rigid fibrous insulation covered with a housewrap air barrier, or 38 mm (1 ½") extruded polystyrene insulation. The results of the present study suggest that walls constructed with a fibrous insulation covered with a housewrap air barrier provides a sound isolation performance significantly superior to that of walls built with a polystyrene insulation. The STC and OITC ratings measured were 2 to 3 points in favor of the fibrous material.

- In the case of the four types of exterior wall tested in this research, adding a PVC cladding had little or no effect on the transmission loss at low frequency (below 125 Hz). Since the OITC rating is governed mainly by the low frequency sound transmission loss, a variation of only 2 points was noted between the OITC ratings of the walls tested. The increase of STC rating caused by the addition of a PVC cladding is in the order of 1 to 4 points and is mainly governed by the sound transmission loss measured between 125 and 400 Hz. The PVC cladding provided the greatest sound transmission loss increase when it was installed on wall n° 8 constructed with 38 mm x 89 mm (2" x 4") studs and a semi-rigid 38 mm (1 ½") thick fibrous insulation covered with a housewrap air barrier. It was not in the scope of this research project to test several exterior finishes currently used in the Canadien residential construction industry.

- Comparing the results of the sound transmission loss measurements made on the four exterior walls studied in the present research project (walls n° 6 to 9), one notices that:

  - Although there is a variation of only one point in the OITC and 3 points in the STC ratings of the four walls tested with exterior finishes, one cannot conclude that they provide equivalent sound isolation for exterior noise sources having different spectra. In fact, the difference between the sound transmission loss provided at frequencies above 125 Hz by the four walls tested in this study can reach 10 dB.

  - Below 125 Hz, the walls tested provided an equivalent sound isolation. All the walls provided their minimum sound transmission loss at 80 Hz; the transmission loss at that frequency was approximately 12 dB.

- From 125 to 315 Hz wall n° 6 constructed with 38 mm x 140 mm (2" x 6") studs and asphalt impregnated wood fibre board provided the best sound isolation, followed by wall n° 8 constructed with 38 mm x 89 mm (2" x 4") studs and semi-rigid glass fibre insulation.

- From 315 Hz and above wall n° 8 provided the best sound isolation followed by wall n° 6.

- When expressed in terms of STC rating the walls constructed with 38 mm x 89 mm (2" x 4") studs provided a better sound isolation than those constructed with 38 mm x 140 mm (2" x 6") studs; the walls constructed with a PVC cladding ranked as follows starting from that providing the highest sound isolation:

Wall n° 8:	38 mm x 89 mm (2"x 4") with semi-rigid fibre insulation
Wall n° 6:	38 mm x 140 mm (2"x 6") with asphalt impregnated wood fibre board
Wall n° 9:	38 mm x 89 mm (2"x 4") with rigid polystyrene insulation
Wall n° 7:	38 mm x 140 mm (2"x 6") with OSB boards

- An evaluation based on noise spectra collected during a recent noise climate survey made by MJM Acoustical Consultants inc. and the results of the present study suggests that walls n° 6 to 9 should provide enough sound insulation to reduce exterior noise due to road and rail traffic from a $Leq^{1}_{(24H)}$ of 60 dB(A) outside to a $Leq_{(24H)}$ = 35 dB(A) inside a home and meet the CMHC noise level criteria not to be exceeded inside bedrooms of residential projects. However, wall compositions n° 6 to 9 should not be used in residential sites where the exterior noise due to vehicular or train traffic levels exceeds a $Leq_{(24H)}$ of 60 dB(A).

1 $Leq_{(duration)}$. Equivalent sound pressure level integrated over the sampling period or duration indicated between parenthesis. This quantity is useful to compare fluctuating noises; it corresponds to the sound pressure level of a steady state noise whose acoustical energy and duration are the same as the fluctuating noise measured.

- It is now relatively frequent in low cost developments incorporating “new house concepts” to build detached homes separated by a distance of only 4 to 5 feet. With the low frequency output of the contemporary home sound systems, it is probable that the low frequency content of music or films could be transmitted from home to home via exterior walls n° 6 to 9, in residential projects where homes are separated by only a few feet.

- This research was a preliminary attempt to obtain reliable sound transmission loss data on exterior walls with wood structure destined to low cost housing. Further research is required to confirm some of it findings and to determine ways of improving the acoustical performance of exterior walls of buildings to be constructed in noisy environments.

PROJET DE RECHERCHE SUR L'ISOLATION ACOUSTIQUE ASSURÉE PAR LES MURS EXTÉRIEURS DES IMMEUBLES À OSSATURE DE BOIS

RÉSUMÉ

Les responsables du Programme de subventions de recherche de la SOCIÉTÉ CANADIENNE D'HYPOTHÈQUES ET DE LOGEMENT ont accepté la proposition de MJM ACOUSTICAL CONSULTANTS INC. visant la réalisation d'une étude sur l'isolation sonore assurée par les murs extérieurs d'immeubles à ossature de bois.

Au moment où cette proposition de recherche a été soumise, les données sur la transmission du son par les murs extérieurs étaient presque inexistantes. Le principal objectif de ce projet était de combler cette lacune en étudiant les propriétés d'affaiblissement acoustique de quatre types de murs extérieurs couramment utilisés dans les logements canadiens à faible coût.

En tout, neuf mesures de la perte de transmission du son ont été prises pour chacun des quatre murs extérieurs choisis : deux murs en poteaux de 38 mm x 140 mm (2 po x 6 po) et deux en poteaux de 38 mm x 89 mm (2 po x 4 po). Cinq essais ont été faits sur des murs sans finition extérieure, et quatre sur des murs ayant un revêtement en PVC. Tous les murs choisis avaient un facteur d'isolation thermique de RSI 3,5 (R_{20}). Afin de déterminer l'effet d'un espacement différent des poteaux, on a fait un essai de la perte de transmission du son sur un mur dont les poteaux étaient espacés de 600 mm (24 po); le reste des spécimens étaient construits de poteaux à entraxes de 400 mm (16 po), ce qui est l'espacement des poteaux le plus souvent utilisé pour les murs extérieurs au Canada. La finition intérieure de tous les murs soumis aux essais était la même : des plaques de plâtre de 13 mm (½ po) du côté du local de réception (la grande enceinte de réverbération). Le côté extérieur du mur était situé du côté du local d'émission.

On trouvera dans les **tableaux 1, 2 et 3** (pages E-6, E-7 et E-8) un résumé des résultats obtenus exprimés selon l'indice de transmission du son (ITS) et l'indice de transmission intérieur-extérieur (ITSIE). On y trouve aussi la composition, la masse en surface et le coût par unité de surface des

matériaux entrant dans la composition des murs mis à l'essai (on a supposé que le coût de la main-d'oeuvre était à peu près le même pour tous les murs).

Voici les conclusions auxquelles on est arrivé pendant la présente étude :

- Le fait de placer les poteaux de 38 mm x 140 mm (2 po x 6 po) d'un mur extérieur à entraxes de 600 mm (24 po) [mur n° 1] plutôt qu'à entraxes de 400 mm (16 po) [mur n° 2] a entraîné une hausse de six points de l'ITS et de deux points de l'ITSIE. Les valeurs de perte de transmission du son par un tiers d'octave des murs construits de poteaux à entraxes de 600 mm (24 po) sont généralement supérieures ou du même ordre que celles des murs faits de poteaux à entraxes de 400 mm (16 po), sauf dans le cas des fréquences inférieures à 80 Hz qui sont davantage atténuées par les murs construits de poteaux à entraxes de 400 mm (16 po).

- Les murs extérieurs à ossature en poteaux de 38 mm x 140 mm (2 po x 6 po) sont généralement faits de panneaux de copeaux orientés (PPO) ou de panneaux de fibres de bois imprégnés d'asphalte. Le mur fait de panneaux de fibres de bois imprégnés d'asphalte au lieu de panneaux PPO assurait une perte de transmission du son considérablement meilleure pour toutes les fréquences supérieures à 125 Hz, même si la masse par unité de surface des panneaux de fibres de bois est plus de deux fois inférieure à celle des panneaux PPO; pour les fréquences inférieures à 125 Hz, les panneaux PPO assurent une isolation sonore légèrement supérieure. La différence de zéro à deux points seulement entre les valeurs de l'ITS et de l'ITSIE mesurées des murs construits de panneaux de fibres imprégnés d'asphalte et celles des murs de panneaux PPO peut induire en erreur puisqu'elle donne à entendre que les murs offrent une atténuation acoustique semblable alors qu'en réalité, les courbes de perte de transmission du son indiquent que le mur construit de panneaux de fibres est clairement supérieur à celui qui est construit de panneaux PPO. L'effet du vide de 3 mm (1/8 po) que le fabricant recommande de laisser entre les panneaux PPO des murs soumis aux essais n'a pas été étudié de façon approfondie pendant cette recherche et devrait faire l'objet d'une étude ultérieure.

- Lorsqu'on utilise des poteaux de 38 mm x 89 mm (2 po x 4 po), les matériaux les plus populaires utilisés pour atteindre un facteur d'isolation de RSI 3,5 (R_{20}) et constituer un pare-air suffisant sont soit un isolant fibreux semi-rigide de 38 mm (1½ po) d'épaisseur recouvert d'un pare-air en polyéthylène, soit un isolant en polystyrène extrudé de 38 mm (1½ po). Les résultats de la présente étude donnent à entendre que les murs comportant un isolant fibreux recouvert d'une pellicule servant de pare-air offrent un facteur d'isolation sonore considérablement supérieur à celui des murs isolés au polystyrène. Les ITC et ITCIE mesurés étaient de deux à trois points supérieurs dans le cas du matériau fibreux.

- Pour les quatre types de murs extérieurs mis à l'essai pendant cette recherche, l'ajout d'un revêtement en PVC n'a eu à peu près aucun ou aucun effet sur la perte de transmission du son à de basses fréquences (inférieures à 125 Hz). Puisque l'ITSIE mesure surtout la perte de transmission des sons de basses fréquences, une variation de deux points seulement a été relevée entre les valeurs de l'ITSIE des murs mis à l'essai. La hausse de l'ITS découlant de l'ajout d'un revêtement en PVC est de l'ordre de un à quatre points et est surtout attribuable à la perte de transmission du son mesurée entre 125 et 400 Hz. La perte de transmission du son obtenue grâce au revêtement de PVC a été la plus marquée dans le cas du mur n° 8 fait de poteaux de 38 mm x 89 mm (2 po x 4 po) et d'isolant fibreux de 38 mm (1½ po) d'épaisseur recouvert d'une pellicule servant de pare-air. L'essai de plusieurs matériaux de finition extérieure actuellement utilisés dans l'industrie canadienne du bâtiment résidentiel échappait à la portée de ce projet de recherche.

- En comparant les résultats des mesures de la perte de transmission du son obtenus pour quatre types de murs extérieurs étudiés dans le cadre du présent projet de recherche (murs n^os 6 à 9), on remarque ce qui suit :

    - Bien qu'il y ait un écart d'un point seulement de l'ITSIE et de trois points de l'ITS pour les quatre murs avec revêtement extérieur compris dans cette recherche, on ne peut pas conclure qu'ils offrent une isolation sonore équivalente des sources de bruits extérieurs ayant différents spectres. En fait, la différence entre la perte de transmission du son assurée aux fréquences supérieures à 125 Hz par les quatre murs étudiés dans cette étude peut atteindre 10 dB.

- En dessous de 125 Hz, les murs mis à l'essai offrent une isolation sonore équivalente. Tous les murs atténuaient le son le moins à 80 Hz; à cette fréquence, la perte de transmission du son correspondait à environ 12 dB.

- Entre 125 et 315 Hz, le mur n° 6 construit de poteaux de 38 mm x 140 mm (2 po x 6 po) et de panneaux de fibres imprégnés d'asphalte assurait la meilleure isolation phonique, suivi du mur n° 8 construit de poteaux de 38 mm x 89 mm (2 po x 4 po) et d'isolant semi-rigide en fibre de verre.

- Au-dessus de 315 Hz, c'est le mur n° 8 qui assurait la meilleure isolation sonore, suivi du mur n° 6.

- Si l'on utilise l'ITS, les murs faits de poteaux de 38 mm x 89 mm (2 po x 4 po) offraient une meilleure isolation sonore que ceux construits de poteaux de 38 mm x 140 mm (2 po x 6 po); les murs ayant un revêtement de PVC se sont classés comme suit, par ordre décroissant de la qualité de l'isolation sonore :

Mur n° 8 :	38 mm x 89 mm (2 po x 4 po) avec isolant fibreux semi-rigide
Mur n° 6 :	38 mm x 140 mm (2 po x 6 po) avec panneaux de fibres de bois imprégnés d'asphalte
Mur n° 9 :	38 mm x 89 mm (2 po x 4 po) avec isolant de polystyrène rigide
Mur n° 7 :	38 mm x 140 mm (2 po x 6 po) avec panneaux PPO

- Une évaluation se fondant sur les spectres de bruit recueillis pendant une récente enquête sur les milieux sonores réalisés par MJM Acoustical Consultants Inc. ainsi que les résultats de la présente étude donnent à entendre que les murs n^{os} 6 et 9 devraient assurer un niveau d'isolation sonore suffisant pour atténuer le bruit extérieur attribuable à la circulation routière et ferroviaire d'un $Neq^{1}_{(24H)}$ de 60 dB(A) à l'extérieur à un $Neq_{(24H)}$ de 35 dB(A) à l'intérieur d'une maison et répondre aux critères de la SCHL concernant le niveau sonore qui ne doivent pas

[1] $Neq_{(durée)}$: Niveau de pression acoustique équivalente intégré pendant la période d'échantillonnage ou la durée indiquée entre parenthèses. Cette quantité est utile pour comparer les bruits qui fluctuent; elle correspond au niveau de pression acoustique d'un bruit stationnaire lorsque l'énergie acoustique et la durée sont les mêmes que le bruit fluctuant mesuré.

être dépassés à l'intérieur des chambres à coucher d'ensembles résidentiels. Toutefois, les compositions des murs n^{os} 6 et 9 ne devraient pas être utilisées dans les ensembles résidentiels où le bruit extérieur attribuable au niveau de la circulation routière ou ferroviaire est supérieur à un $Neq_{(24H)}$ de 60 dB(A).

- Depuis un certain temps, il arrive assez souvent qu'on construise des ensembles résidentiels à faible coût intégrant les «nouveaux concepts d'habitation», dans lesquels les maisons individuelles ne sont séparées que par quatre à cinq pieds. Étant donné les basses fréquences dont sont capables les chaînes audiophoniques contemporaines, il est probable que les basses fréquences des musiques ou films pourraient être transmises d'une maison à l'autre par les murs extérieurs n^{os} 6 à 9 dans les ensembles résidentiels où les maisons ne sont séparées que par quelques pieds.

- Cette recherche est une tentative préliminaire pour obtenir des données fiables sur la perte de transmission du son assurée par les murs extérieurs à ossature de bois utilisés dans les logements à faible coût. D'autres recherches sont nécessaires pour confirmer une partie de ces constatations et déterminer des moyens d'améliorer le rendement sonore des murs extérieurs d'immeubles construits dans des milieux bruyants.

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WALL No 1

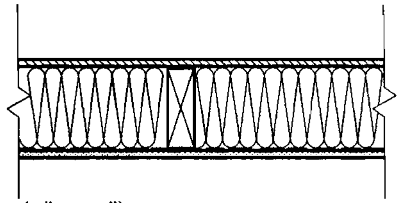
STC 44
OITC 26

- ASPHALT COATED BOARD : 0.56 lb/sq.ft.
- STUDS @24" o.c. : 1.62 lb/sq.ft.
- GLASS FIBRE BATT : 0.34 lb/sq.ft.
- VAPOUR BARRIER : 0.03 lb/sq.ft.
- GYPSUM BOARD : 1.56 lb/sq.ft.

SURFACE MASS : 4.11 lb/sq.ft.
: 20 Kg/sq.m.

ESTIMATED COST : 1.15$/sq.ft.
OF MATERIALS : 12.36$/sq.m.

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- ASPHALT COATED WOOD FIBRE BOARD 11mm (7 /16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @600mm (24") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981-1

WALL No 2

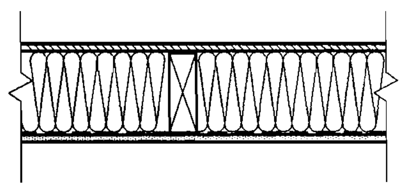
STC 38
OITC 24

- ASPHALT COATED BOARD : 0.56 lb/sq.ft.
- STUDS @16" o.c. : 2.13 lb/sq.ft.
- GLASS FIBRE BATT : 0.34 lb/sq.ft.
- VAPOUR BARRIER : 0.03 lb/sq.ft.
- GYPSUM BOARD : 1.56 lb/sq.ft.

SURFACE MASS : 4.62 lb/sq.ft.
: 22.55 Kg/sq.m.

ESTIMATED COST : 1.25$/sq.ft.
OF MATERIALS : 13.43$/sq.m.

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981-2

WALL No 3

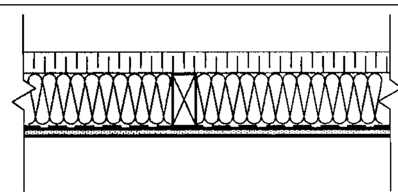
STC 38
OITC 26

- GLASS FIBRE SHEATING : 0.44 lb/sq.ft.
- STUDS @16" o.c. : 1.76 lb/sq.ft.
- GLASS FIBRE BATT : 0.21 lb/sq.ft.
- VAPOUR BARRIER : 0.03 lb/sq.ft.
- GYPSUM BOARD : 1.56 lb/sq.ft.

SURFACE MASS : 4 lb/sq.ft.
: 19.5 Kg/sq.m.

ESTIMATED COST : 1.10$/sq.ft.
OF MATERIALS : 11.82$/sq.m.

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- SEMI-RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981-3

WALL No 4

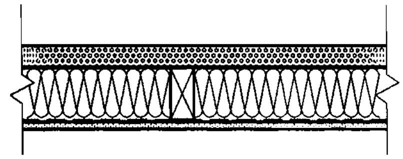
STC 35
OITC 23

- 177981-3 :4 lb/sq.ft.
- POLYESTYRENE INSULATION :+0.17 lb/sq.ft.
- SEMI-RIGID GLASS FIBRE :-0.44 lb/sq.ft.

SURFACE MASS : 3.73 lb/sq.ft.
: 18.2 Kg/sq.m.

ESTIMATED COST : 1.25$/sq.ft.
OF MATERIALS : 13.43$/sq.m.

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981-4

WALL No 5

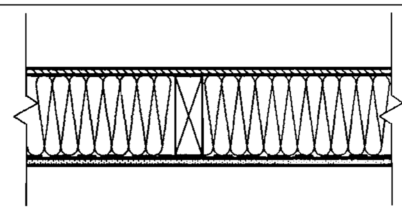
STC 37
OITC 25

- 177981-2 :4.62 lb/sq.ft.
- OSB BOARDS :+1.34 lb/sq.ft.
- ASPHALT COATED BOARD :-0.56 lb/sq.ft.

SURFACE MASS : 5.4 lb/sq.ft.
: 26.4 Kg/sq.m.

ESTIMATED COST : 1.45$/sq.ft.
OF MATERIALS : 15.58$/sq.m.

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981-5

WALL No 6

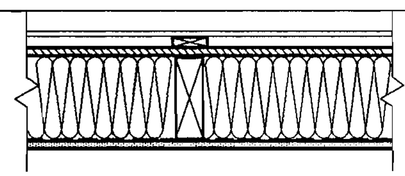
STC 40
OITC 25

- 177981-2 :4.62 lb/sq.ft.
- WOOD FURRINGS :+0.49 lb/sq.ft.
- P.V.C. CLADDING :+0.47 lb/sq.ft.

SURFACE MASS : 5.58 lb/sq.ft.
: 27.2 Kg/sq.m.

ESTIMATED COST : 2.25$/sq.ft.
OF MATERIALS : 24.19$/sq.m.

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

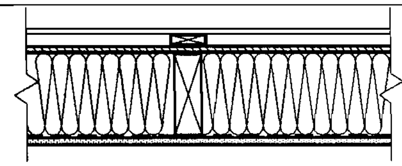
TEST No 177981-6

WALL No 7

STC 38
OITC 25

– 177981–5	:5.4 lb/sq.ft.
– WOOD FURRINGS	:+0.49 lb/sq.ft.
– P.V.C CLADDING	:+0.47 lb/sq.ft.
SURFACE MASS	: 6.36 lb/sq.ft.
	: 31 Kg/sq.m.
ESTIMATED COST OF MATERIALS	: 2.55$/sq.ft.
	: 27.41$/sq.m.

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1"x 3")
- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

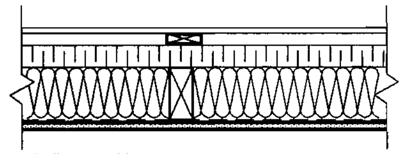
TEST No 177981–7

WALL No 8

STC 41
OITC 26

– 177981–3	:4 lb/sq.ft.
– WOOD FURRINGS	:+0.49 lb/sq.ft.
– P.V.C. CLADDING	:+0.47 lb/sq.ft.
SURFACE MASS	: 4.96 lb/sq.ft.
	: 24.2 Kg/sq.m.
ESTIMATED COST OF MATERIALS	: 2.20$/sq.ft.
	: 23.65$/sq.m.

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- SEMI–RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER, 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

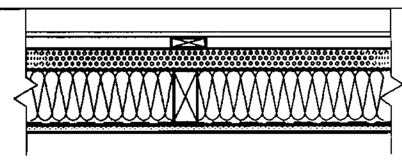
TEST No 177981–8

WALL No 9

STC 39
OITC 25

– 177981–4	:3.73 lb/sq.ft.
– WOOD FURRINGS	:+0.49 lb/sq.ft.
– P.V.C. CLADDING	:+0.47 lb/sq.ft.
SURFACE MASS	: 4.69 lb/sq.ft.
	: 22.9 Kg/sq.m.
ESTIMATED COST OF MATERIALS	: 2.30$/sq.ft.
	: 24.73$/sq.m.

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

TEST No 177981–9

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTIONS

TABLE OF CONTENTS

RESEARCH PROJECT ON THE NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN WOOD CONSTRUCTIONS

1.0 INTRODUCTION

The external research program of CANADA MORTGAGE & HOUSING CORPORATION accepted the proposal by MJM ACOUSTICAL CONSULTANTS INC. to conduct a study on the noise isolation provided by exterior walls in Canadian residential housing constructed with wood. This report, which is addressed to acousticians, builders and construction professionals, presents and discusses the results of the Sound Transmission Loss tests performed on common exterior wall compositions used across Canada. In total, nine walls were tested in the acoustical laboratory of the DOMTAR INNOVATION CENTRE located in Senneville Quebec. Mr. Jean-Marie Guérin, M.Sc.A., consultant at the employment of MJM ACOUSTICAL CONSULTANTS INC. carried out measurements and assisted the undersigned in the analysis of the results.

2.0 OBJECTIVES OF THE STUDY

At the time this research project was proposed to the External Research Program of the CMHC, the sound transmission loss data available on exterior walls constructed with wood studs was almost inexistent. The main objective of this study was to fill this void by investigating the sound attenuation properties of four types of exterior wall providing comparable thermal insulation. The following factors were taken into consideration during the selection of the exterior walls tested:

- cost of construction (low cost housing)
- acceptance of the construction techniques by Canadian builders
- availability of materials entering in the composition of the walls
- thermal insulation
- structural properties

The compositions of the walls which have been tested in this study are listed on **tables 1 to 3** of the **Executive Summary** (pages E- 6, E-7 and E- 8). Also appearing on **tables 1 to 3** are the STC[1] (Sound Transmission Class) and OITC[2] (Outdoor-Indoor Transmission Class) ratings, the surface mass measured for each specimen tested, and an estimation of the cost of the materials entering in each wall expressed in Canadian dollars[3].

3.0 STRUCTURE OF THE REPORT

This report is organized into an executive summary, a main report, and four annexes. Consumers, builders, and construction professionals should find most of the information of interest to them in the **Executive Summary**, in **sections 4.0, 5.0 and 6.0** of the main report respectively entitled COMMENTS AND OBSERVATIONS on the SAMPLE SELECTION, ANALYSIS OF RESULTS, and CONCLUSIONS, and in **Annex I** which contains the graphs pertaining to **section 5.0**.

Annexes II to IV should be of interest mostly to acousticians. **Annex II** contains the results of the sound Transmission Loss (TL) tests conducted on each wall, presented as required by ASTM E 90 in the form of graphs and tables for the sixteen one-third octave band ranging from 125Hz to 4000 Hz. **Annex III** contains graphs illustrating the results of the TL tests as required by ASTM E 1332 for frequencies ranging from 50 Hz to 5000 Hz and the Outdoor-Indoor Transmission Class (OITC) calculated for each wall. **Annex IV** contains a description of the test facility and of the experimental procedure followed during the measurements.

1 Sound Transmission Loss measurements made in conformance with ASTM E 90 standard entitled "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions".

2 Outdoor Indoor Transmission Class measurements made in conformance with ASTM E 1332 standard entitled "Standard Classification for Determination of Outdoor-Indoor Transmission Class".

3 See **Annex IV** for the price list which was used to calculate the cost/sq. ft. Please note that these costs could vary greatly depending of the supplier of materials and other variables (the cost of workmanship is deemed to be approximately the same for all walls).

4.0 COMMENTS AND OBSERVATIONS ON THE SAMPLE SELECTION

Following is a list of comments and observations on the wall samples selected and tested during the present research project:

4.1 THERMAL REQUIREMENTS

To comply with the energy conservation regulations in the province of Quebec, the exterior walls of new residential buildings must provide a minimum thermal insulation factor of RSI 3.5 (R_{20}), which is also the factor selected by most builders across Canada. When constructing exterior walls, the RSI 3.5 (R_{20}) thermal insulation factor is most often achieved:

a) by filling the cavity of the walls constructed with 38 mm x 140 mm (2" x 6") wood studs using glass fibre batt insulation, or

b) by filling the cavity of walls constructed with 38 mm x 89 mm (2" x 4") studs with RSI 2.1 (R_{12}) glass fibre insulation, and adding, on the exterior side of the wall, a 38 mm (1 ½") thick rigid polystyrene insulation or a semi-rigid glass fibre insulation coated with a housewrap air barrier.

4.2 STUD DIMENSIONS AND SPACING

Of the nine walls tested in this study, five of the walls were constructed with 38 mm x 140 mm (2" x 6") studs, and four were constructed with 38 mm x 89 mm (2" x 4") studs. With the exception of wall n° 1, for which the studs were installed at 600 mm (24") on centre (o.c.), all the walls were constructed with a stud spacing of 400 mm (16") o.c. which seems to be the standard stud spacing for exterior walls used across Canada.

4.3 INTERIOR FINISH AND VAPOUR BARRIER

All the walls had the same interior finish composed of one layer of 13 mm (½") thick drywall weighing approximately 7.5 Kg/m^2 (1.5 lb/ft^2) screwed to the studs using 30 mm (1 1/4") long screws spaced at 400 mm (16") o.c. starting from the bottom of the wall. A polyethylene vapour barrier 1.5 mm (6 mil) thick was inserted between the studs and the 13 mm (½") drywall prior to the installation of the drywall. The perimeter was caulked using latex caulking; the joints between the drywall sheets were caulked and then taped using duct seal tape.

4.4 INSULATION IN THE CAVITY

The stud cavity was filled with glass fibre batt insulation whose thickness was the same as the depth of the studs.

4.5 SHEATHINGS AND AIR BARRIERS

The test specimens were constructed with the following materials attached to the studs on the exterior side:

.1 **Walls constructed using 38 mm x 140 mm (2" x 6") studs:**

Wall n° 1, 2, and 6: 12 mm (11/16") Asphalt impregnated wood fibre board;

Walls n° 5 and 7: 13 mm (½") OSB boards installed horizontally as recommended by the manufacturer with a 3 mm (1/8") airspace between the boards;

.2 **Walls constructed using 38 mm x 89 mm (2" x 4") studs:**

Walls n° 3 and 8: A 38 mm (1 ½") thick semi-rigid glass fibre insulation board covered with a housewrap air barrier;

Walls n° 4 and 9: A 38 mm (1 ½") thick extruded polystyrene insulation board.

The OSB boards or the asphalt impregnated wood fibre board **were not covered** with building paper nor with a housewrap air barrier prior to installing the exterior finish.

4.6 EXTERIOR FINISH (Walls n° 6 to 9)

The most economical exterior finish, a PVC cladding, was installed on vertical 25 mm x 75 mm (1" x 3") wood furrings.

4.7 INSTALLATION OF THE SAMPLES INSIDE THE TEST OPENING[4]

Wall n° 1 for which the stud spacing is 600 mm (24") o.c. was installed directly inside the 2700 mm (9'-0") high by 3800 mm (10'-0") wide test opening of the laboratory. For walls n° 2 to 9 the width of the test opening was reduced to approximately 2800 mm (9'-4") in order to maintain the 400 mm (16") stud spacing. **Figure A4-2** of **Annex IV** illustrates the composition of the filler walls constructed on each side of the test frame and the typical installation of a sample wall. Since the filler wall composition is much more massive than the exterior walls under test, it has been assumed that the noise energy transmitted through the filler wall is insignificant compared to that transmitted through the exterior wall specimens.

5.0 ANALYSIS OF RESULTS

In total nine airborne noise isolation tests were performed: four on walls with the same exterior cladding and five without cladding. The Sound Transmission Class (STC) and the Outdoor-Indoor Transmission Class (OITC) ratings ranged from STC 38 to 41 and from OITC 25 to 26 for walls with exterior cladding (walls 6 to 9). For walls without cladding constructed with studs spaced 400 mm (16") apart (walls n° 2 to 5), the STC ratings ranged from 35 to 38 and the OITC ratings from 23 to 26; wall n° 1 with studs spaced at 600 mm (24") o.c. provided a STC of 44 and an OITC of 26. The difference between the highest and lowest rating measured is 9 points in the case of the STC and only 3 points in the case of the OITC.

In addition to **Annex I** which contains the graphs pertinent to the present section the reader should also consult:

4 Refer to **Annex IV** for complete details about the test set-up and method.

- **Tables 1, 2 and 3** in the **Executive summary** for a summary of the results obtained, expressed in terms of Sound Transmission Class (STC) and Outdoor-Indoor Transmission Class OITC); **tables 1, 2 and 3** also contain the composition, the surface mass, and the cost per unit area of the walls tested;

- **Annex II** for the complete Sound Transmission Loss (TL) data from 125 Hz to 4000 Hz for each assembly tested as per ASTM E 90. The data is presented in the form of graphs and tables; each graph of **Annex II** also provides the STC classification curve and a sketch describing the composition of the wall assembly tested.

- **Annex III** for the **graphs A3-1 to A3-9** on which are plotted the Sound Transmission Loss values for frequencies ranging from 50 to 5000 Hz measured for each specimen tested and the OITC classification curve associated to these values.

- **Annex IV** for the description of the test facility and the experimental procedure followed during measurements.

The paragraphs below contain an analysis of the principal factors studied in the present research:

5.1 SPACING OF THE STUDS

Graph 1 of **Annex I** presents the sound transmission loss measured on walls n° 1 and 2 whose compositions are identical except for the stud spacing, which is 600 mm (24") o.c. in the case of wall n° 1, and 400 mm (16") o.c. in the case of wall n° 2. The data plotted on **graph 1** suggests that there is an acoustical advantage to use a greater stud spacing: above 80 Hz the acoustical performance of wall n° 1 constructed with studs 600 mm (24") apart is superior to that of wall n° 2 for all but one frequency. Below 80 Hz the wall with studs at 400 mm (16") o.c. provides better sound transmission loss. It is at 125 Hz that the difference in the transmission loss provided by the two walls is maximum and reaches 6 dB; since the transmission loss at this frequency is what governs the STC rating of the walls, (refer to the classification curves on **graphs A2-1 and A2-2** of **Annex II**) the STC rating of wall n° 1 is 6 points superior to that of wall n° 2.

Due to limited funds, the effect of varying the stud spacing on the acoustical performance of exterior walls constructed with 38 mm x 89 mm (2" x 4") studs could not be investigated.

5.2 ORIENTED STRAND BOARD (OSB) VS ASPHALT IMPREGNATED WOOD FIBRE BOARDS

Wall n° 2 differs from wall n° 5 only by the material attached to the exterior side of the 38 mm x 140 mm (2" x 6") studs used to build these walls: OSB boards in the case of wall n° 5 and asphalt impregnated wood fibre board in the case of wall n° 2. **Graph 2 of Annex I** shows that, for frequencies above 125 Hz, the sound isolation provided by the wall constructed with asphalt impregnated wood fibre board is superior to that provided by the wall constructed with OSB, a material twice as massive; below 125 Hz however the sound transmission loss of the wall constructed with OSB is superior. The same observations are true for walls n° 6 and 7 on which a PVC cladding was installed (see **graph 8 of Annex I**).

Analysing the data in terms of single number rating reveals that with no PVC cladding the STC rating of wall n° 2 is one point superior to that of wall n° 5; inversely, OITC rating of wall n° 5 is one point higher than that of wall n° 2, mainly because of the better performance of OSB at low frequencies. With a PVC cladding the STC of the wall constructed with asphalt impregnated wood fibre board (wall n° 6) is 2 points higher than that of the wall constructed with OSB boards (wall n° 7), and the OITC ratings are the same for both walls.

Note: The OSB boards have been installed horizontally as recommended by the manufacturer with a 3 mm (1/8") airspace between boards; further tests with the OSB installed vertically with no space between boards have not been carried out to determine the effect of the airgap recommended by the manufacturer of the OSB boards on the sound isolation provided by the wall.

5.3 EXTRUDED POLYSTYRENE INSULATION VS SEMI-RIGID GLASS FIBRE INSULATION COVERED WITH A HOUSEWRAP AIR BARRIER

Graph 3 of **Annex I** compares the sound transmission loss of wall n° 3 constructed with a 38 mm (1 ½") thick semi-rigid fibrous insulation covered with a housewrap air barrier membrane to that of wall n° 4 constructed with a polystyrene insulation having the same thickness:

- below 80 Hz wall n° 3 and 4 provide the same sound isolation;
- from 80 Hz to 315 Hz and for frequencies above 2000 Hz the wall constructed with semi-rigid fibrous insulation provides superior sound isolation;
- from 400 to 1600 Hz the wall constructed with extruded polystyrene boards provides a slightly better sound isolating performance.

When installing a PVC cladding on walls n° 3 and 4 (see **graph 9**), the sound transmission loss provided by the wall constructed with the 38 mm (1 1/2") semi-rigid fibrous insulation is clearly superior to that built with a polystyrene insulation of same thickness for frequencies above 80 Hz; below 80 the polystyrene offers similar or slightly superior sound insulating performance.

5.4 ADDITIONAL SOUND ISOLATION PROVIDED BY A PVC CLADDING

The effect of adding a cladding on the four types of walls tested is documented on **graphs 4 to** 7.

- For walls constructed with 38 mm x 140 mm (2" x 6") studs and asphalt impregnated wood fibre board **(graph 4)**, adding a PVC cladding increases the TL approximately 1 to 2 dB for frequencies below 250 Hz, decreases the TL from 1 to 4 dB for frequencies between 250 and 1000 Hz, and improves the TL from 1 to 6 dB from 1000 Hz and up;

- For walls constructed with 38 mm x 140 mm (2" x 6") and OSB boards **(graph 5)**, adding a PVC cladding results in no significant change in the TL up to 1250 Hz, frequency after which a noticeable improvement in the TL occurs (from 3 to 13 dB);

- For walls constructed with 38 mm x 89 mm (2" x 4") and a semi-rigid fibrous insulation **(graph 6)**, the TL remains unchanged from 50 to 125 Hz, frequency at which one observes significant increase of the TL (up to 9 dB);

- For walls constructed with 38 mm x 89 mm (2" x 4") and a rigid polystyrene insulation **(graph** 7) adding a PVC cladding produces an increase of TL ranging from 1 to 5 dB between 80 to 500 Hz and from 3 to 12 dB from 1600 Hz to 5000 Hz; at other frequencies, there is no significant change.

Adding a PVC cladding had little or no effect on the OITC ratings (0 to 2 points), since this rating is mainly governed by the low frequency performance of the wall which remained unaffected by the addition of the PVC cladding; the increase of STC rating caused by the addition of a PVC cladding varies from 1 to 4 points depending on the composition of the wall on which the cladding was added.

5.5 DEPTH OF THE WALL CAVITY: 38 mm x 140 mm (2" x 6") studs vs 38 mm x 89 mm (2" x 4") studs

The actual trend in Canadian housing is to frame the exterior walls of new constructions with 38 mm x 140 mm (2" x 6") studs; however, in certain areas, 38 mm x 89 mm (2" x 4") studs are still used. **Graph 10** compares the sound isolating performance of the four walls with PVC exterior cladding tested in this study: two built with 38 mm x 140 mm (2" x 6") studs (walls n° 6 and 7), and two built with 38 mm x 89 mm (2" x 4") studs (walls n° 8 and 9).

As can be seen on this graph:

- below 125 Hz the four walls tested provide an equivalent sound isolation;

- from 125 to 315 Hz the walls tested ranked as follows starting from that providing the highest sound isolation:

  Wall n° 6: 38 mm x 140 mm (2"x 6") with asphalt impregnated wood fibre board
  Wall n° 8: 38 mm x 89 mm (2"x 4") with semi-rigid fibre insulation
  Wall n° 7: 38 mm x 140 mm (2"x 6") with OSB boards
  Wall n° 9: 38 mm x 89 mm (2"x 4") with rigid polystyrene insulation

- from 315 Hz and up, the walls tested ranked as follows starting from that providing the highest sound isolation:

  Wall n° 8: 38 mm x 89 mm (2"x 4") with semi-rigid fibre insulation
  Wall n° 6: 38 mm x 140 mm (2"x 6") with asphalt impregnated wood fibre board
  Wall n° 9: 38 mm x 89 mm (2"x 4") with rigid polystyrene insulation
  Wall n° 7: 38 mm x 140 mm (2"x 6") with OSB boards

5.6 ATTENUATION OF TRAIN AND VEHICULAR TRAFFIC NOISE

Graph 11 shows sound spectra of vehicular traffic noise and train noise measured during the completion of a recent noise climate study conducted by MJM ACOUSTICAL CONSULTANTS INC., and adjusted to a level of 55 dBA[5]. Using these spectra, the wall sound transmission loss data obtained during the present research project, and a quantity of sound absorption corresponding to a reverberation time of 0.5 seconds, the noise levels which would be transmitted to a 4 x 5 x 2.4 m (12' x 16' x 8') bedroom through walls n° 6 to 9 have been calculated and are presented on **graph 12** along with the "A" weighted global level. The results of these evaluations indicate that train and traffic noise with an outside level a $Leq^{6}_{(24H)}$ = 55 dB(A) should be reduced to a level slightly inferior to $Leq_{(24H)}$ = 30 dB(A). This implies that, if the $Leq_{(24H)}$ = 35 dB(A) criteria recommended by the CMHC inside bedrooms of residential projects is not to be exceeded, walls compositions n° 6 to 9 should not be constructed on residential sites where the exterior noise level due to road or rail traffic exceeds a $Leq_{(24H)}$ of 60 dB(A).

5.7 NOISE TRANSMISSION FROM HOUSE TO HOUSE

It is now relatively frequent in low cost developments incorporating "new house concepts" to see detached homes separated by a distance of only 4 to 5 feet. As can be seen on **graphs 6 to 9** of **Annex III**, the TL values measured at 80 Hz for walls n° 6 to 9 tested in this study are in the order of 12 dB. With the low frequency output of the contemporary home sound systems, it is probable that the sound of music or films could be transmitted from home to home via the exterior walls n° 6 to 9, in residential projects where homes are separated by only a few feet. This could be disturbing to buyers who have purchased a "detached" home with the intent of benefiting from a greater privacy than that offered by semi-detached homes.

5 The microphone was located at approximately 1200 mm (4 ft) from the ground and at a distance of approximately 50 m (165') from the centre of a four lane divided highway; the ground is acoustically soft. The measurements were made using a Larson-Davis 2800 real time analyser calibrated before and after the measurements using a Brüel & Kjær 4230 calibrator.

6 $Leq_{(duration)}$: Equivalent sound pressure level integrated over the sampling period or duration indicated between parenthesis. This quantity is useful to compare fluctuating noises; it corresponds to the sound pressure level of a steady state noise whose acoustical energy and duration are the same as the fluctuating noise measured.

6.0 CONCLUSIONS

6.1 Spacing the 38 mm x 140 mm (2" x 6") studs of an exterior wall at 600 mm (24") o.c. [wall n° 1] instead of 400 mm (16") o.c. [wall n° 2] resulted in an increase of 6 points of STC and in an increase of 2 points of OITC. The sound transmission loss values of the wall constructed with studs at 600 mm (24") o.c. are generally higher or in the same order that those of the wall constructed with studs at 400 mm (16") o.c. except for frequencies below 80 Hz for which the TL of the wall constructed with studs spaced at 400 mm (16") o.c. are greater.

6.2 Exterior walls framed with 38 mm x 140 mm (2" x 6") studs, are generally constructed with OSB boards or asphalt impregnated wood fibre boards. The wall constructed with asphalt impregnated wood fibre boards instead of OSB boards provided a significantly better sound transmission loss for all frequencies above 125 Hz, even though the surface mass of the wood fibre boards is more than two times less than that of the OSB boards; below 125 Hz the OSB boards provide a slightly superior sound isolation. The difference of only 0 to 2 points between the STC and OITC ratings measured on walls constructed with asphalt impregnated wood fibre board and those measured on walls constructed with OSB boards can be misleading since it suggests that the walls provide similar acoustical performance when in fact, the transmission loss curves indicate that the wall constructed with the wood fibre board is clearly superior to that constructed with OSB boards. The effect of the 3 mm (1/8") airgap that the manufacturer recommends to leave between the OSB boards tested has not been fully investigated during this study and should be investigated further in a subsequent study.

6.3 When using 38 mm x 89 mm (2" x 4") studs the most popular materials used to reach the RSI 3.5 (R_{20}) insulation factor and to provide suitable air barrier are either 38 mm (1 ½") thick semi-rigid fibrous insulation covered with a housewrap air barrier, or 38 mm (1 ½") extruded polystyrene insulation. The results of the present study suggest that walls constructed with a fibrous insulation covered with a housewrap air barrier provides a sound isolation performance significantly superior to that of walls built with polystyrene insulation. The STC and OITC ratings measured were 2 to 3 points in favour of the fibrous material.

6.4 In the case of the four types of exterior wall tested in this research, adding a PVC cladding had little or no effect on the transmission loss at low frequency (below 125 Hz). Since the OITC rating is governed mainly by the low frequency sound transmission loss, a variation of only 2 points was noted between the OITC ratings of the walls tested. The increase of STC rating caused by the addition of a PVC cladding is in the order of 1 to 4 points and is mainly governed by the sound transmission loss measured between 125 and 400 Hz. The PVC cladding provided the greatest sound transmission loss increase when it was installed on wall n° 8 constructed with 38 mm x 89 mm (2" x 4") studs and a semi-rigid 38 mm (1 ½") thick fibrous insulation covered with a housewrap air barrier. It was not in the scope of this research project to test several exterior finishes currently used in the Canadian residential construction industry.

6.5 Comparing the results of the sound transmission loss measurements made on the four exterior walls studied in the present research project (walls n° 6 to 9), one notices that:

- Although there is a variation of only one point in the OITC and 3 points in the STC ratings of the four walls tested with exterior finishes, one cannot conclude that they provide equivalent sound isolation for exterior noise sources having different spectra. In fact, the difference between the sound transmission loss provided at frequencies above 125 Hz by the four walls tested in this study can reach 10 dB.

- Below 125 Hz, the walls tested provided an equivalent sound isolation. All the walls provided their minimum sound transmission loss at 80 Hz; the transmission loss at that frequency was approximately 12 dB.

- From 125 to 315 Hz wall n° 6 constructed with 38 mm x 140 mm (2" x 6") studs and asphalt impregnated wood fibre board provided the best sound isolation, followed by wall n° 8 constructed with 38 mm x 89 mm (2" x 4") studs and semi-rigid glass fibre insulation.

- From 315 Hz and above wall n° 8 provided the best sound isolation followed by wall n° 6.

- When expressed in terms of STC rating the walls constructed with 38 mm x 89 mm (2" x 4") studs provided a better sound isolation than those constructed with 38 mm x 140 mm (2" x 6") studs; the walls constructed with a PVC cladding ranked as follows starting from that providing the highest sound isolation:

Wall n° 8:	38 mm x 89 mm (2"x 4") with semi-rigid fibre insulation
Wall n° 6:	38 mm x 140 mm (2"x 6") with asphalt impregnated wood fibre board
Wall n° 9:	38 mm x 89 mm (2"x 4") with rigid polystyrene insulation
Wall n° 7:	38 mm x 140 mm (2"x 6") with OSB boards

6.6 An evaluation based on noise spectra collected during a recent noise climate survey made by MJM Acoustical Consultants Inc. and the results of the present study suggests that walls n° 6 to 9 should provide enough sound insulation to reduce exterior noise due to road and rail traffic from a $Leq_{(24H)}$ of 60 dB(A) outside to a $Leq_{(24H)}$ = 35 dB(A) inside a home and meet the CMHC noise level criteria not to be exceeded inside bedrooms of residential projects. However, wall compositions n° 6 to 9 should not be used in residential sites where the exterior noise due to vehicular or train traffic levels exceeds a $Leq_{(24H)}$ of 60 dB(A).

6.7 It is now relatively frequent in low cost developments incorporating "new house concepts" to build detached homes separated by a distance of only 4 to 5 feet. With the low frequency output of the contemporary home sound systems, it is probable that the low frequency content of music or films could be transmitted from home to home via exterior walls n° 6 to 9, in residential projects where homes are separated by only a few feet.

6.8 This research was a preliminary attempt to obtain reliable sound transmission loss data on exterior walls with wood structure destined to low cost housing. Further research is required to confirm some of it findings and to determine ways of improving the acoustical performance of exterior walls of buildings to be constructed in noisy environments.

Respectfully submitted October 19, 1998

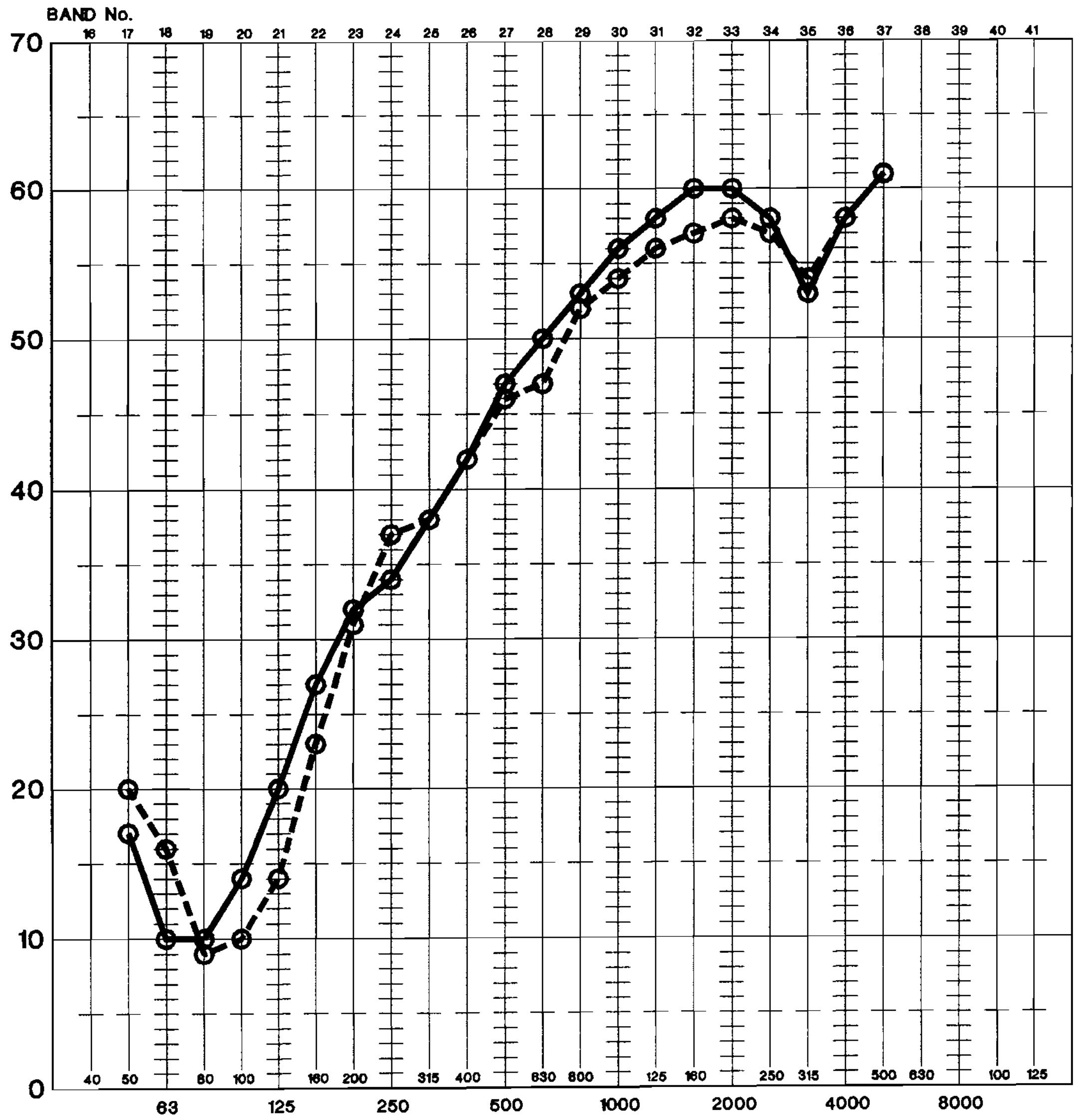
Michel Morin, OAQ, ASA
President and principal consultant of

MJM ACOUSTICAL CONSULTANTS INC.

ANNEX I

COMPARISON No : 1

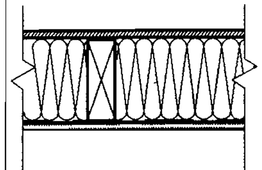
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

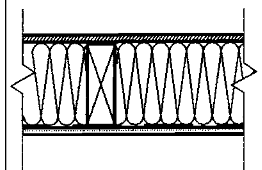
TRANSMISSION LOSS (TL)

W1 : TEST A3-1 OITC 26
STC 44



– WOOD STUDS 38 X 140mm (2" X 6")
@600mm (24") o.c.

W2 : TEST A3-2 OITC 24
STC 38



– WOOD STUDS 38 X 140mm (2" X 6")
@400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

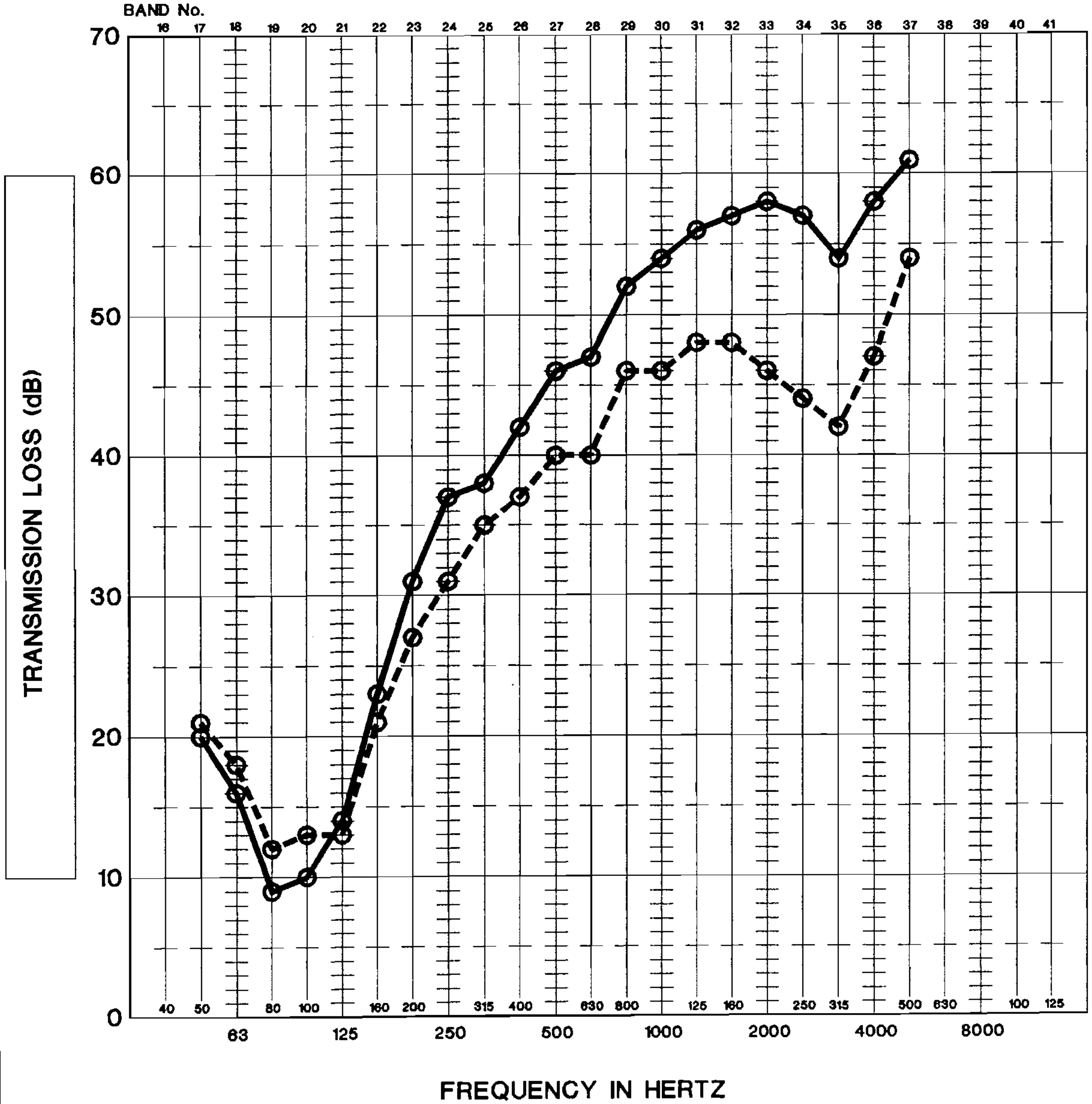
AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W1 & W2

GRAPH NUMBER: 1	FILE NAME: 177-CP1
PROJECT NUMBER 177.981	DATE 98 10

MJM

COMPARISON No : 2

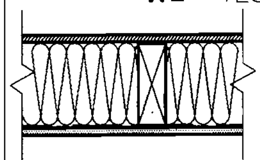
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

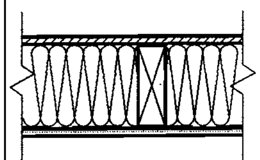
TRANSMISSION LOSS (TL)

W2 : TEST A3-2 OITC 24
STC 38



- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

W5 : TEST A3-5 OITC 25
STC 37



- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

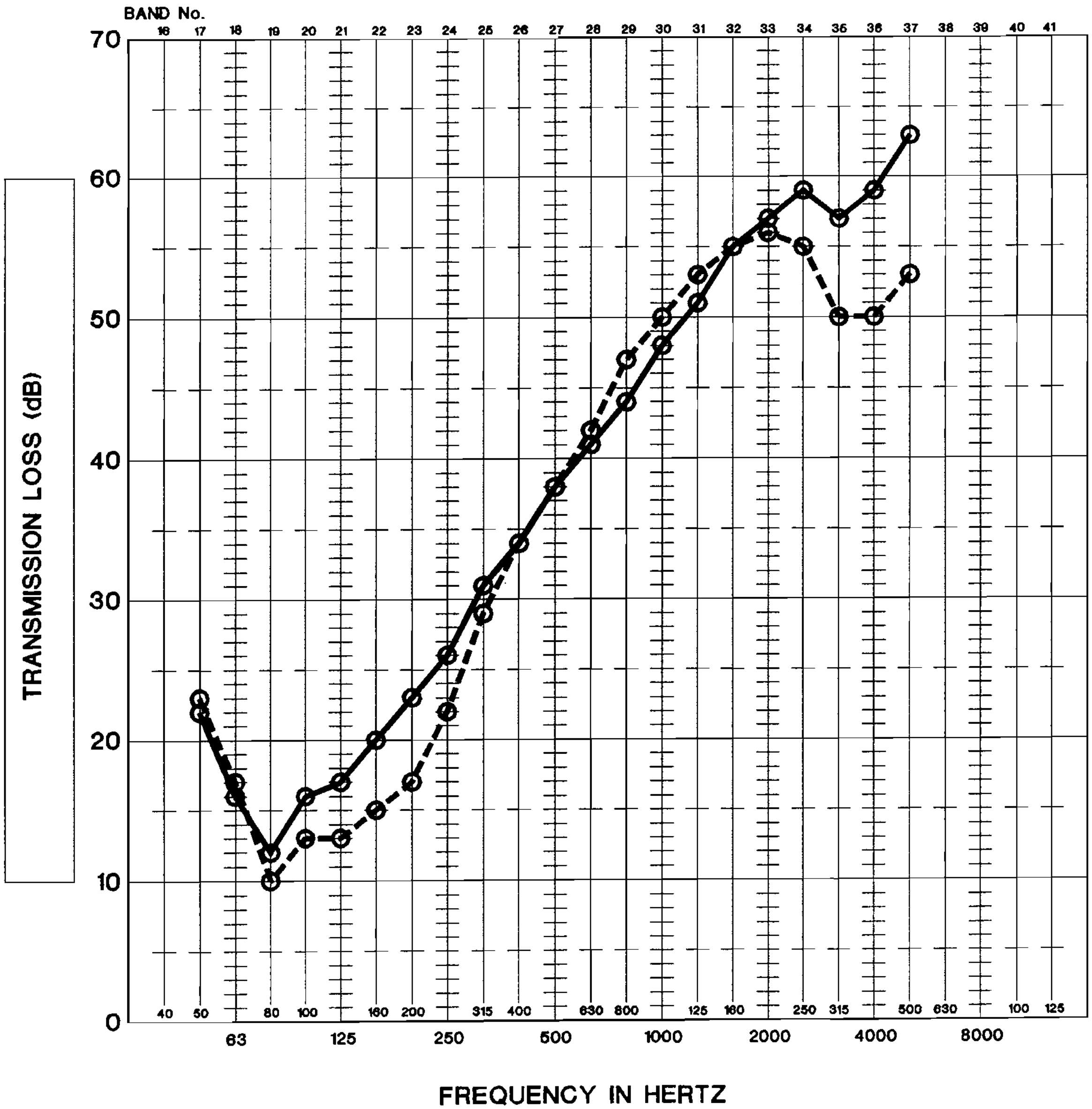
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W2 & W5

GRAPH NUMBER: 2	**FILE NAME:** 177-CP2
PROJECT NUMBER 177.981	**DATE** 98 10

COMPARISON No : 3

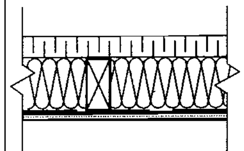
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

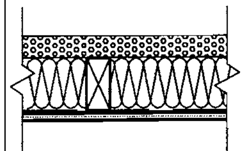
TRANSMISSION LOSS (TL)

W3 : TEST A3-3 OITC 26
STC 38



- SEMI-RIGID GLASS FIBRE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

W4 : TEST A3-4 OITC 23
STC 35



- POLYESTYRENE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W3 & W4

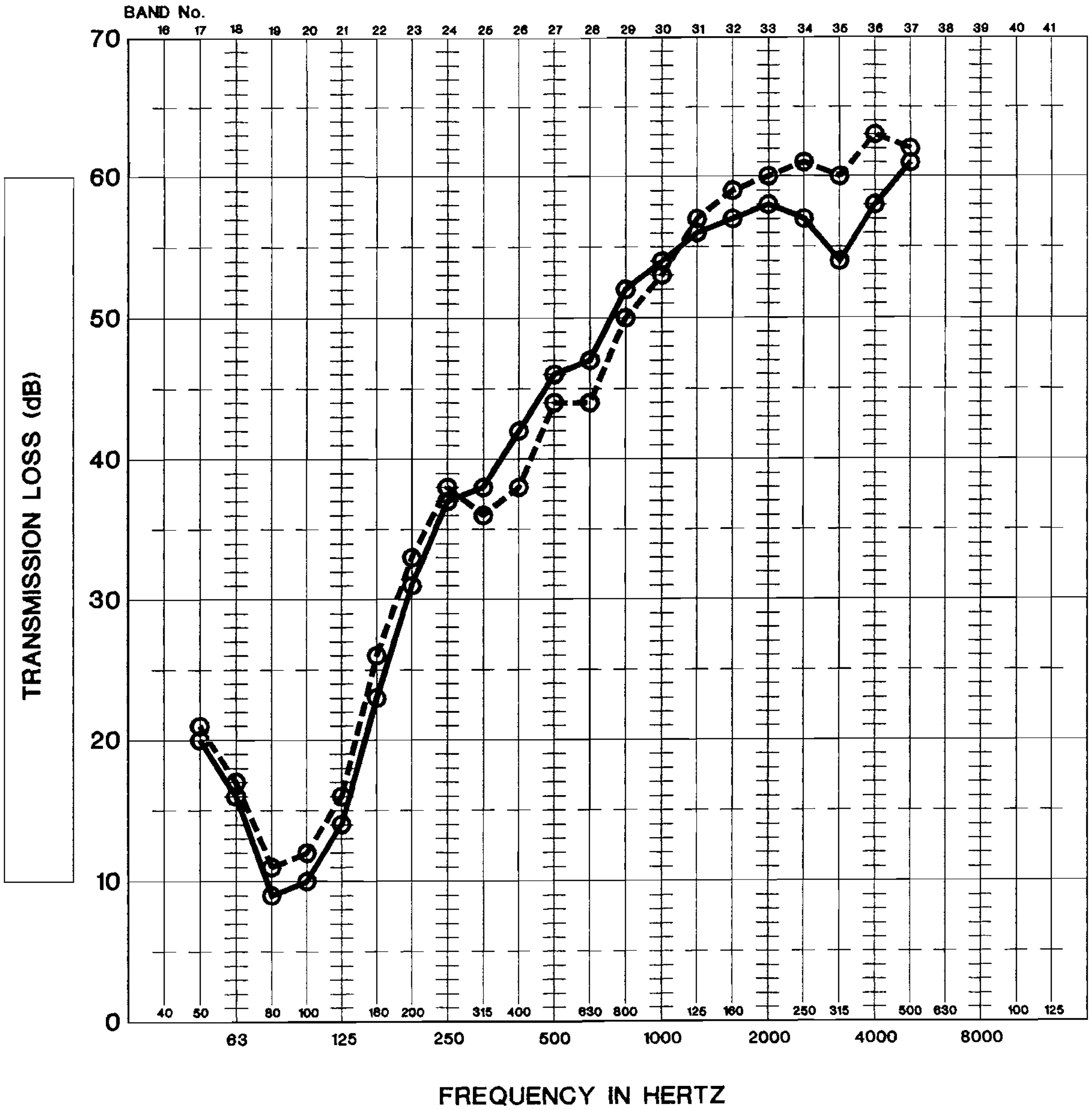
GRAPH NUMBER: 3 **FILE NAME:** 177-CP3

PROJECT NUMBER 177.981 **DATE** 98 10

mjm

COMPARISON No : 4

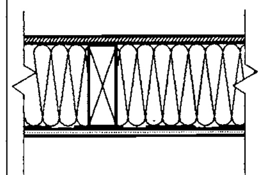
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

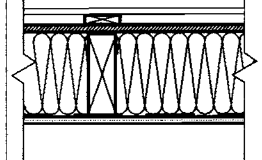
TRANSMISSION LOSS (TL)

W2 : TEST A3-2 OITC 24
STC 38



- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

W6 : TEST A3-6 OITC 25
STC 40



- **P.V.C. CLADDING**
- **WOOD FURRINGS 25 x 75mm (1" x 3")**
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

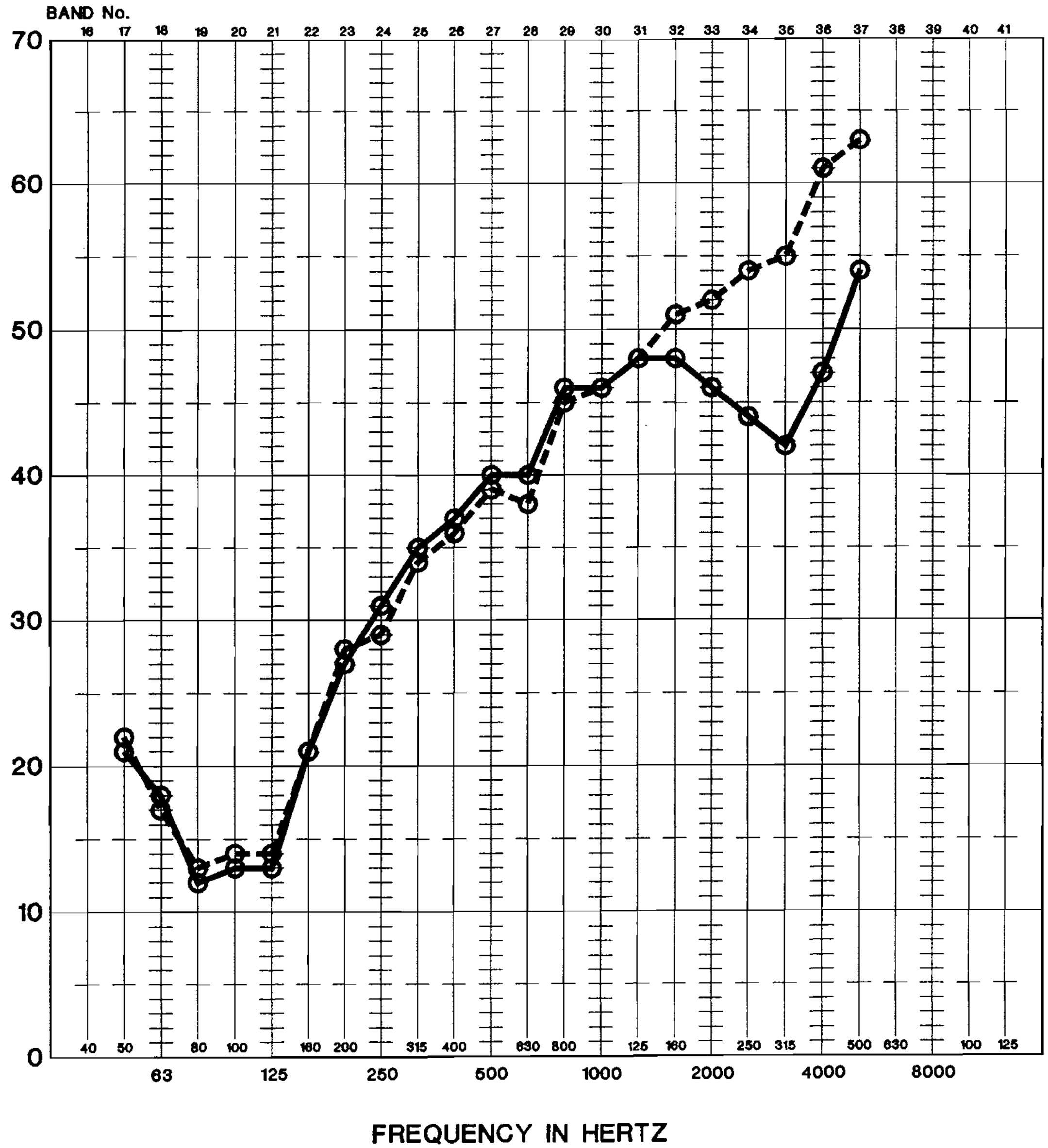
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS COMPARISON BETWEEN EXTERIOR WALLS No : W2 & W6

GRAPH NUMBER: 4	**FILE NAME:** 177-CP4
PROJECT NUMBER 177.981	**DATE** 98 10

COMPARISON No : 5

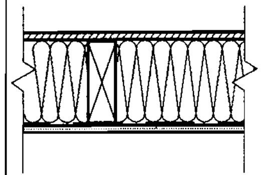
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

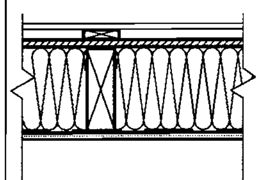
TRANSMISSION LOSS (TL)

W5 : TEST A3-5 OITC 25
STC 37



- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

W7 : TEST A3-7 OITC 25
STC 38

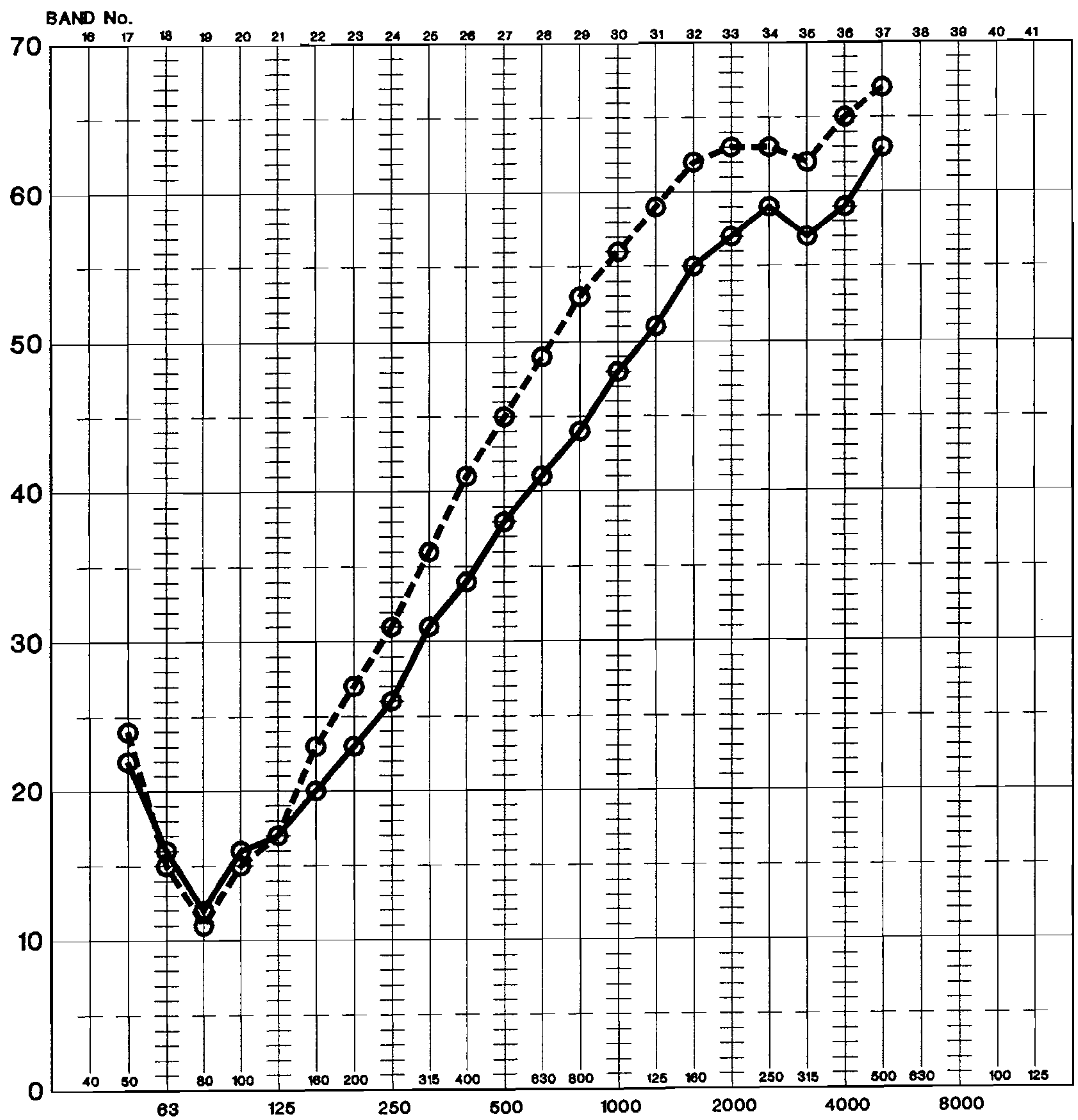


- **P.V.C. CLADDING**
- **WOOD FURRINGS 25 x 75mm (1" x 3")**
- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W5 & W7	
GRAPH NUMBER: 5	**FILE NAME:** 177-CP5
PROJECT NUMBER 177.981	**DATE** 98 10

COMPARISON No : 6

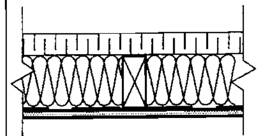
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

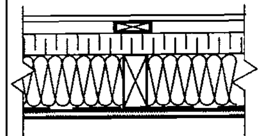
TRANSMISSION LOSS (TL)

W3 : TEST A3-3 OITC 26
STC 38



- SEMI-RIGID GLASS FIBRE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

W8 : TEST A3-8 OITC 26
STC 41



- **P.V.C. CLADDING**
- **WOOD FURRINGS 25 x 75mm (1" x 3")**
- SEMI-RIGID GLASS FIBRE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

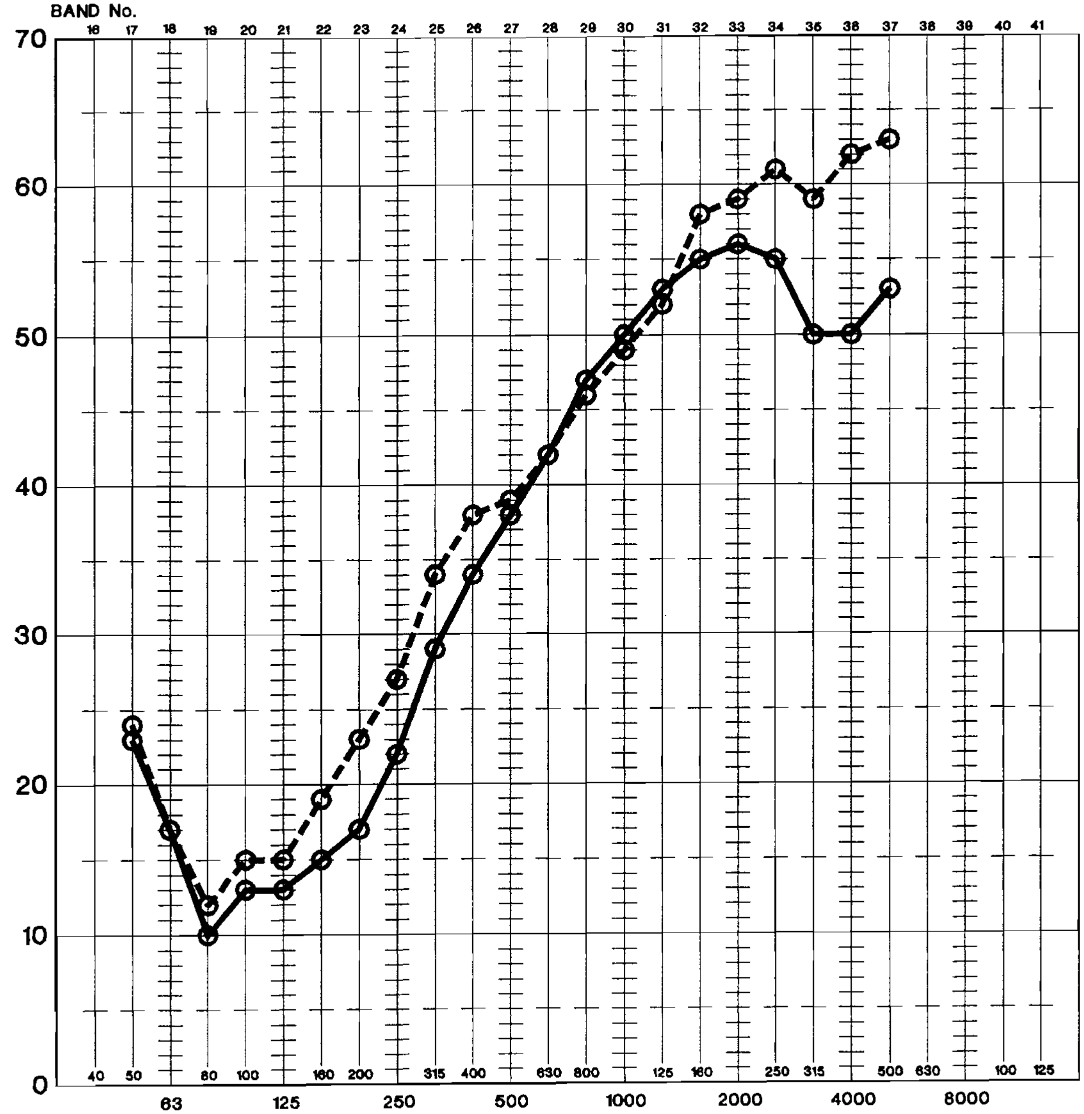
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W3 & W8

GRAPH NUMBER: 6	**FILE NAME:** 177-CP6
PROJECT NUMBER 177.981	**DATE** 98 10

COMPARISON No : 7

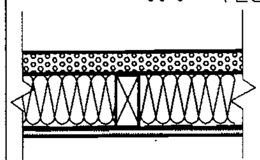
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

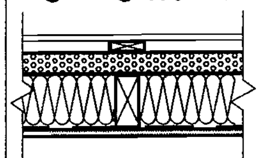
TRANSMISSION LOSS (TL)

W4 : TEST A3-4 OITC 23
STC 35



- POLYESTYRENE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

W9 : TEST A3-9 OITC 25
STC 39



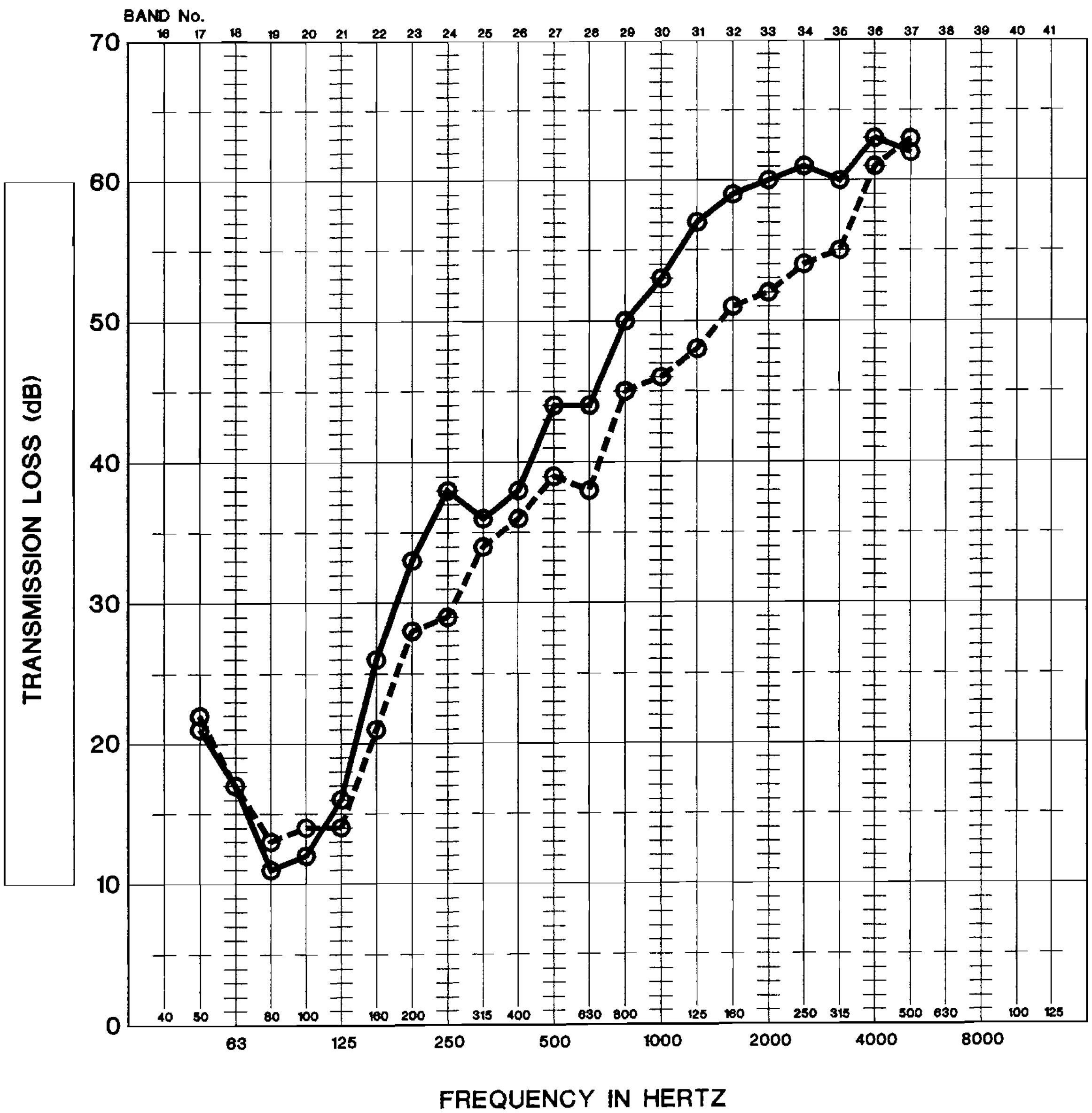
- **P.V.C. CLADDING**
- **WOOD FURRINGS 25 x 75mm (1" x 3")**
- POLYESTYRENE INSULATION 38mm (1 1/2") THICK
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W4 & W9	
GRAPH NUMBER: 7	**FILE NAME:** 177-CP7
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

COMPARISON No : 8

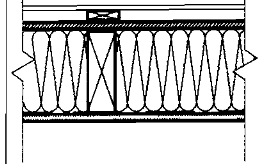
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

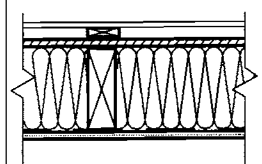
TRANSMISSION LOSS (TL)

W6 · TEST A3-6 OITC 25
STC 40



- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- **ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK**
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

W7 · TEST A3-7 OITC 25
STC 38



- P.V.C. CLADDING
- WOOD FURRINGS 25 x75mm (1" x 3")
- **OSB BOARDS 11mm (7 /16") THICK**
- WOOD STUDS 38 X 140mm (2" X 6") @400mm (16") o.c.

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

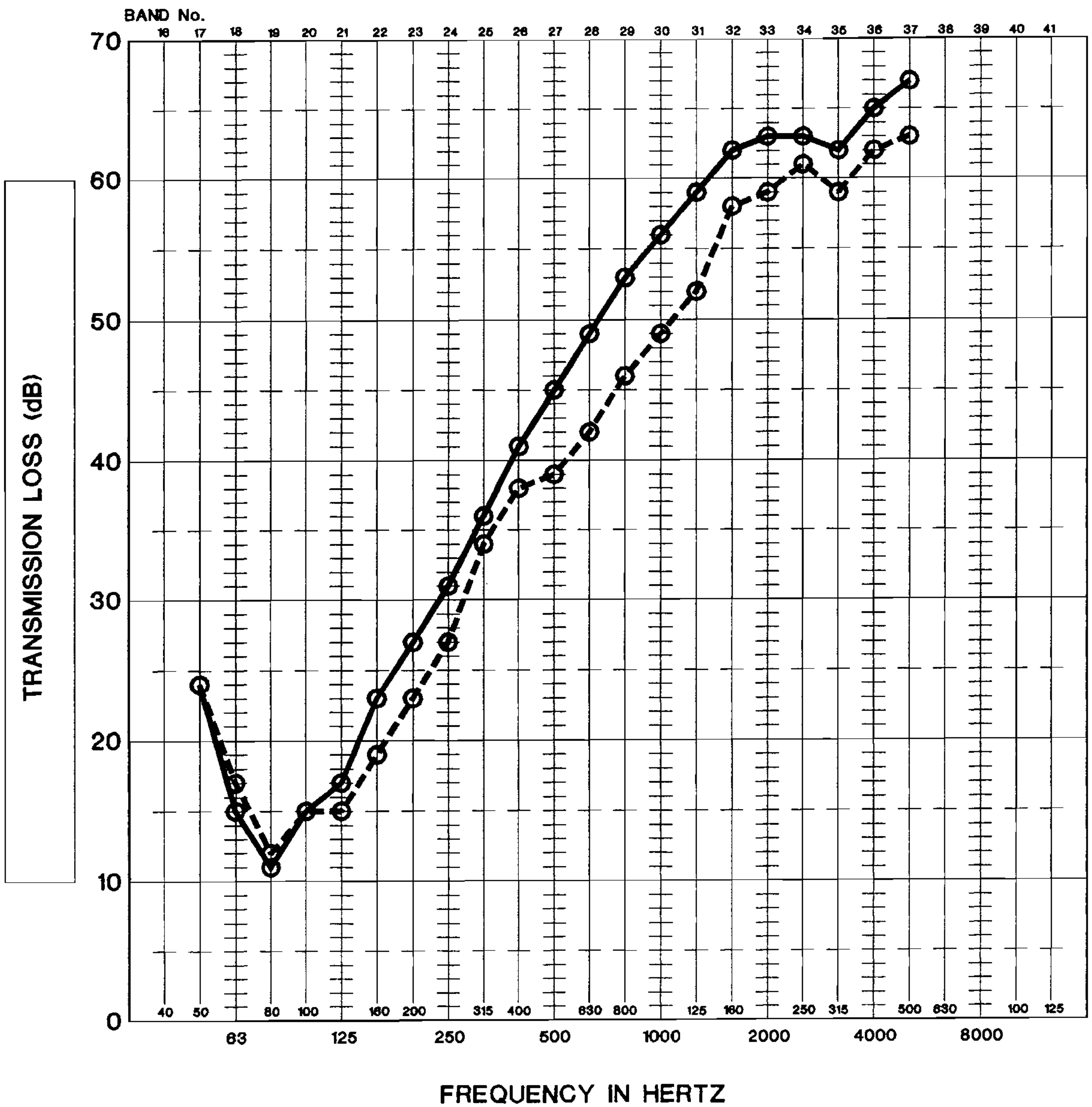
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W6 & W7

GRAPH NUMBER: 8	**FILE NAME:** 177-CP8
PROJECT NUMBER 177.981	**DATE** 98 10

COMPARISON No : 9

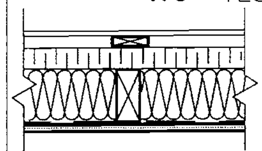
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

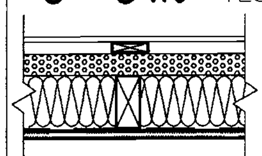
TRANSMISSION LOSS (TL)

W8 · TEST A3–8 OITC 26 STC 41



- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- **SEMI-RIGID GLASS FIBRE INSULATION 38mm (1 1/2") THICK**
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

W9 · TEST A3–9 OITC 25 STC 39



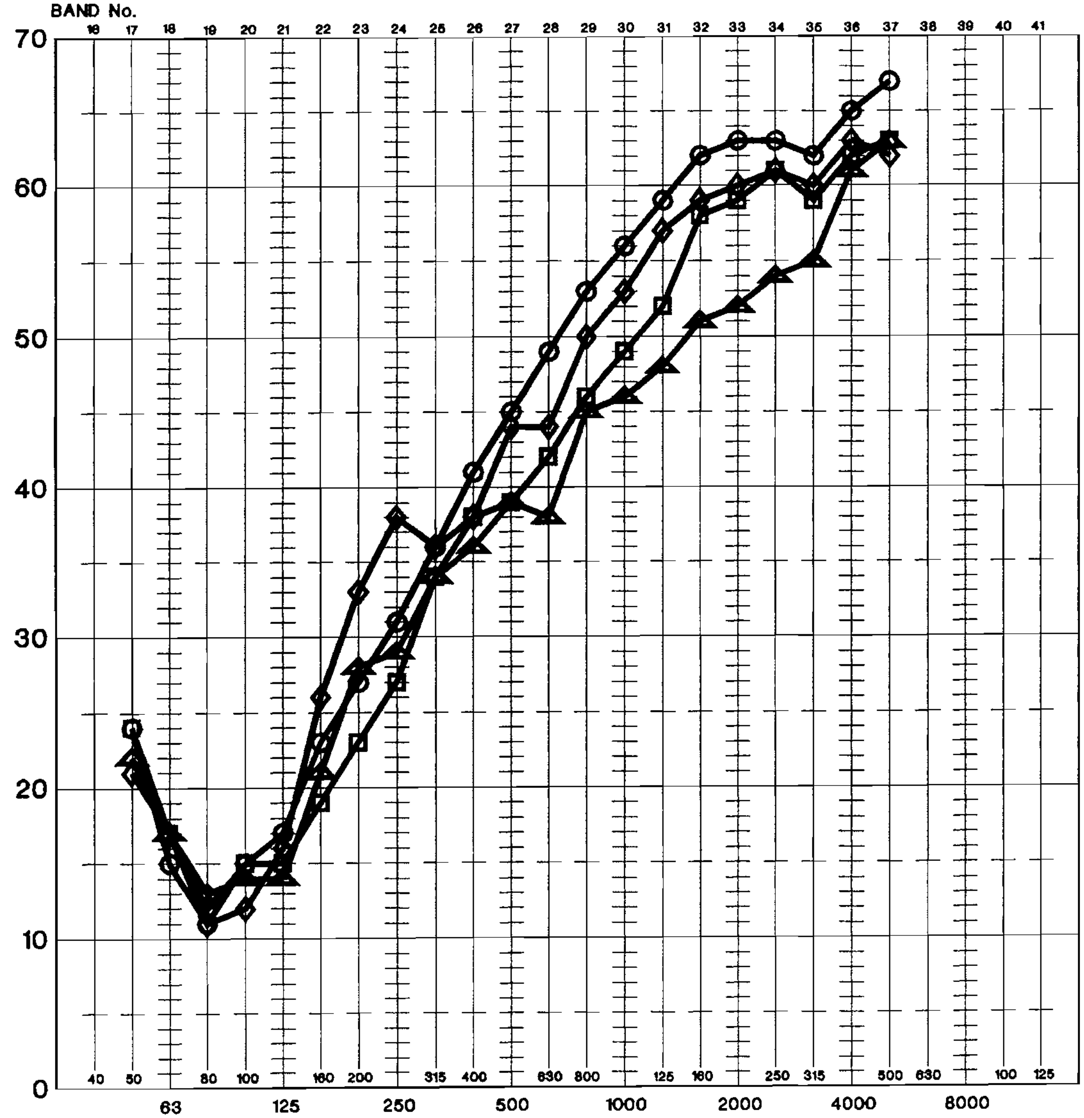
- P.V.C. CLADDING
- WOOD FURRINGS 25 x75mm (1" x 3")
- **POLYESTYRENE INSULATION 38mm (1 1/2") THICK**
- WOOD STUDS 38 X 89mm (2" X 4") @400mm (16") o.c.

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W8 & W9	
GRAPH NUMBER: 9	**FILE NAME:** 177–CP9
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

COMPARISON No : 10

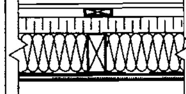
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

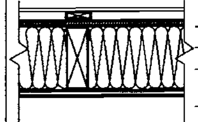
TRANSMISSION LOSS (TL)

W8 · TEST A3-8 OITC 26 STC 41



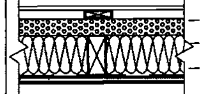
- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- **SEMI-RIGID GLASS FIBRE INSULATION 38mm (1 1/2") THICK**
- WOOD STUDS 38 X 89mm (2" X 4")

W6 · TEST A3-6 OITC 25 STC 40



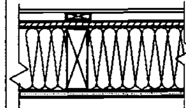
- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- **ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK**
- WOOD STUDS 38 X 140mm (2" X 6")

W9 · TEST A3-9 OITC 25 STC 39



- P.V.C. CLADDING
- WOOD FURRINGS 25 x75mm (1" X 3")
- **POLYESTYRENE INSULATION 38mm (1 1/2") THICK**
- WOOD STUDS 38 X 89mm (2" X 4")

W7 · TEST A3-7 OITC 25 STC 38



- P.V.C. CLADDING
- WOOD FURRINGS 25 x75mm (1" x 3")
- **OSB BOARDS 11mm (7 /16") THICK**
- WOOD STUDS 38 X 140mm (2" X 6")

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

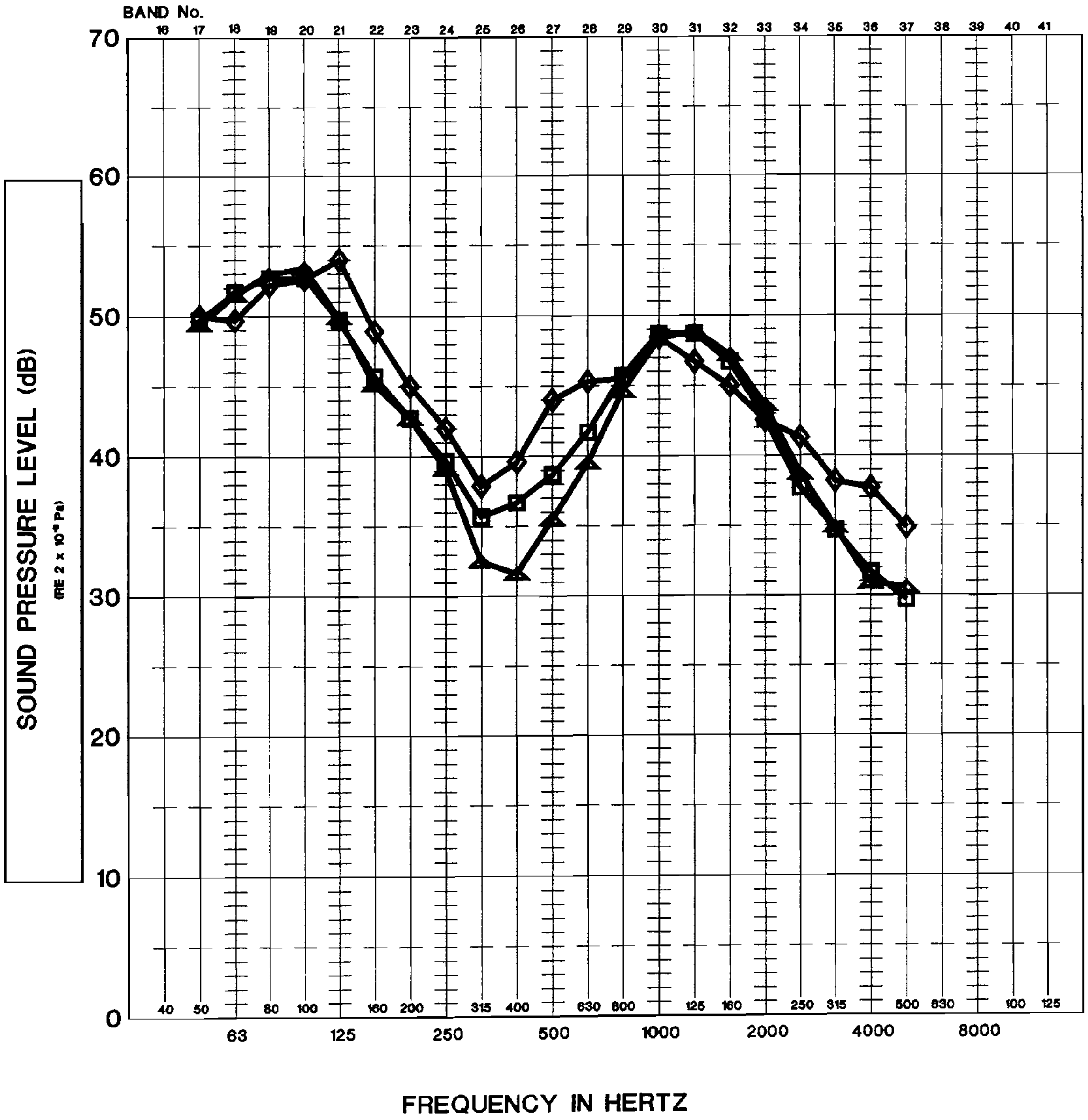
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : COMPARISON BETWEEN EXTERIOR WALLS No : W6 & W7 AND W8 & W9

GRAPH NUMBER: 10	**FILE NAME:** 177-CP12
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

NOISE SPECTRA OBTAINED DURING A NOISE CLIMATE STUDY A 50m (165ft) FROM A DIVIDED 4 LANE HIGHWAY AND RAILROAD TRACK

(1) ◇—◇

TRAIN PASS BY; SPECTRA OBTAINED ON A TYPICAL SAMPLE CASTING 10 SECONDS AND AJUSTED TO A GLOBAL LEVEL OF 55 dB(A)

(2) □—□

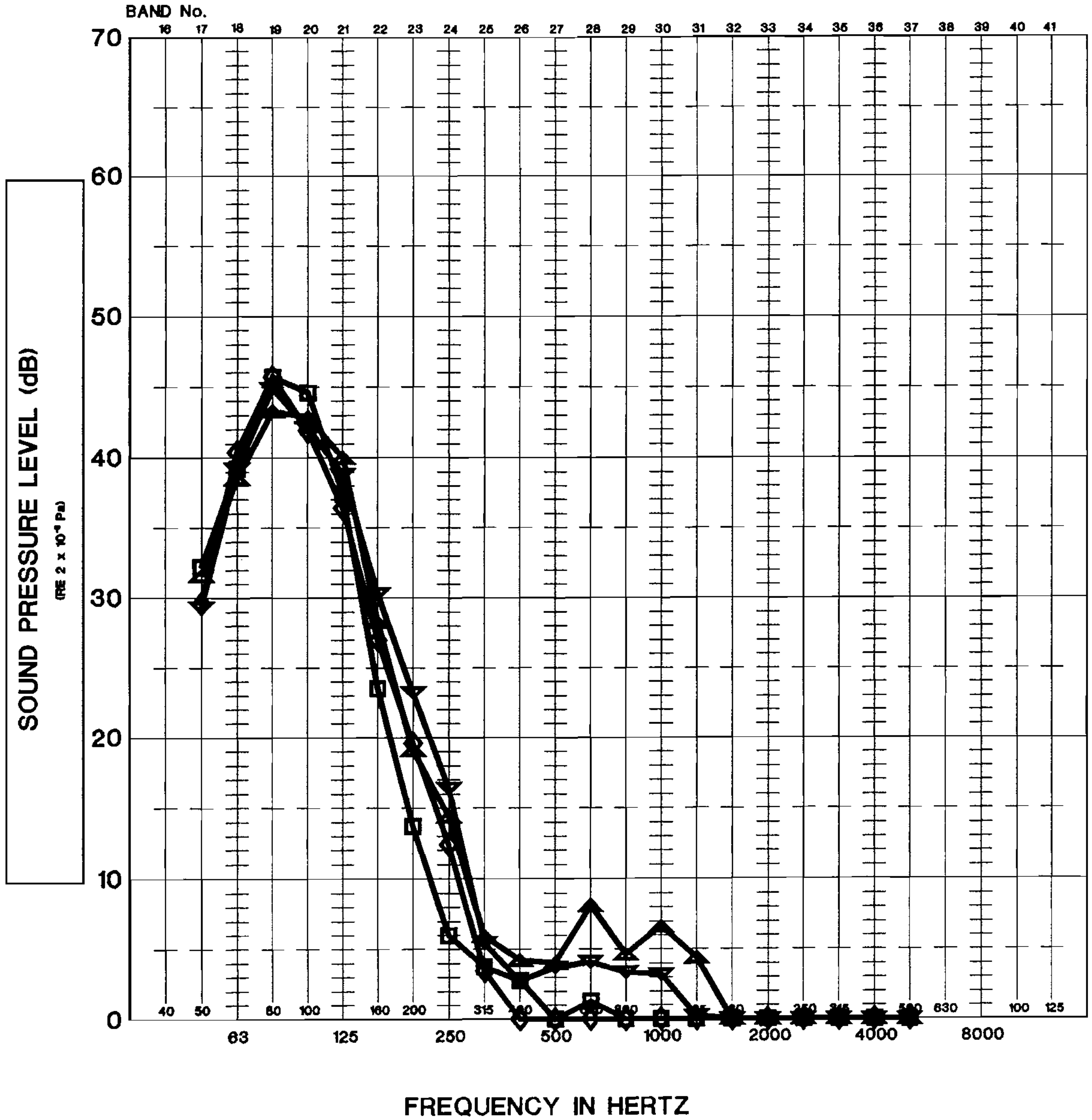
TRAIN AND CAR NOISE; SPECTRA RESULTING FROM NOTILY 4000 VEHICULES AND 3 TRAINS DURING 80 MINUTES SAMPLE, AND AJUSTED TO A GLOBAL LEVEL OF 55 dB(A)

(3) △—△

CAR NOISE; SPECTRA RESULTING FROM APROXIMATLY 1000 CARS DURING A PERIOD OF 15 MINUTES

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALL IN RESIDENTIAL PROJECTS	
GRAPH TITLE TRAIN AND TRAFFIC NOISE SPECTRA	
GRAPH NUMBER 11	**FILE** 177.GRP11
PROJECT NUMBER 177.981	**DATE** 98 10

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

ESTIMATION OF THE ROADS AND RAIL NOISE (GRAPH No11 CURVE No2, GLOBAL LEVEL = 55 dB(A)) TROUGH EXTERIOR WALLS No 6 TO 9 (NO WINDOWS).

- WALL No 7 (28 dB(A))
- WALL No 9 (28 dB(A))
- WALL No 8 (28 dB(A))
- WALL No 6 (29 dB(A))

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE EVALUATION OF THE SOUND PRESSURE LEVELS TRANSMITTED INSIDE A BEDROOM THROUGH WALL No 6 TO 9	
GRAPH NUMBER 12	**FILE** 177.GRP12
PROJECT NUMBER 177.981	**DATE** 98 10

ANNEX II

REPORT No: 177981-1

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	20	± 1.9	8
160	27	± 1.6	4
200	32	± 1.0	2
250	34	± 0.7	3
315	38	± 0.7	2
400	42	± 0.5	1
500	47	± 0.5	0
630	50	± 0.5	0
800	53	± 0.3	0
1000	56	± 0.4	0
1250	58	± 0.3	0
1600	60	± 0.3	0
2000	60	± 0.4	0
2500	58	± 0.4	0
3150	53	± 0.4	0
4000	58	± 0.4	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 44	STC 42	STC 46	20

<u>SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W1</u>

REPORT No: 177981-2

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	14	± 1.7	8
160	23	± 1.5	2
200	31	± 1.0	0
250	37	± 0.8	0
315	38	± 0.5	0
400	42	± 0.4	0
500	46	± 0.5	0
630	47	± 0.6	0
800	52	± 0.5	0
1000	54	± 0.6	0
1250	56	± 0.4	0
1600	57	± 0.4	0
2000	58	± 0.6	0
2500	57	± 0.6	0
3150	54	± 0.4	0
4000	58	± 0.5	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 38	STC 37	STC 40	10

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W2

REPORT No: 177981-3

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	17	± 1.3	5
160	20	± 1.5	5
200	23	± 1.3	5
250	26	± 0.9	5
315	31	± 0.9	3
400	34	± 0.7	3
500	38	± 0.7	0
630	41	± 0.4	0
800	44	± 0.6	0
1000	48	± 0.5	0
1250	51	± 0.4	0
1600	55	± 0.6	0
2000	57	± 0.6	0
2500	59	± 0.4	0
3150	57	± 0.4	0
4000	59	± 0.4	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 38	STC 37	STC 39	26

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W3

REPORT No: 177981-4

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	13	± 1.3	6
160	15	± 1.7	7
200	17	± 1.3	8
250	22	± 1.1	6
315	29	± 0.8	2
400	34	± 0.5	0
500	38	± 0.5	0
630	42	± 0.4	0
800	47	± 0.3	0
1000	50	± 0.4	0
1250	53	± 0.2	0
1600	55	± 0.3	0
2000	56	± 0.3	0
2500	55	± 0.4	0
3150	50	± 0.4	0
4000	50	± 0.4	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 35	STC 33	STC 36	29

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W4

REPORT No: 177981-5

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	13	± 1.6	8
160	21	± 1.3	3
200	27	± 0.9	0
250	31	± 0.7	0
315	35	± 0.7	0
400	37	± 0.4	0
500	40	± 0.4	0
630	40	± 0.4	0
800	46	± 0.3	0
1000	46	± 0.3	0
1250	48	± 0.2	0
1600	48	± 0.3	0
2000	46	± 0.4	0
2500	44	± 0.3	0
3150	42	± 0.3	0
4000	47	± 0.4	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 37	STC 36	STC 39	11

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W5

REPORT No: 177981-6

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	16	± 1.7	8
160	26	± 1.3	1
200	33	± 1.0	0
250	38	± 0.8	0
315	36	± 0.7	0
400	38	± 0.6	1
500	44	± 0.5	0
630	44	± 0.5	0
800	50	± 0.4	0
1000	53	± 0.4	0
1250	57	± 0.4	0
1600	59	± 0.3	0
2000	60	± 0.4	0
2500	61	± 0.4	0
3150	60	± 0.3	0
4000	63	± 0.3	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 40	STC 39	STC 42	10

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W6

REPORT No: 177981-7

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	14	± 1.5	8
160	21	± 1.4	4
200	28	± 1.0	0
250	29	± 0.8	2
315	34	± 0.7	0
400	36	± 0.5	1
500	39	± 0.5	0
630	38	± 0.5	1
800	45	± 0.3	0
1000	46	± 0.4	0
1250	48	± 0.3	0
1600	51	± 0.3	0
2000	52	± 0.4	0
2500	54	± 0.3	0
3150	55	± 0.3	0
4000	61	± 0.3	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 38	STC 36	STC 39	16

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W7

REPORT No: 177981-8

Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	17	± 1.5	8
160	23	± 1.8	5
200	27	± 1.2	4
250	31	± 1.0	3
315	36	± 0.7	1
400	41	± 0.6	0
500	45	± 0.5	0
630	49	± 0.4	0
800	53	± 0.3	0
1000	56	± 0.3	0
1250	59	± 0.3	0
1600	62	± 0.4	0
2000	63	± 0.4	0
2500	63	± 0.3	0
3150	62	± 0.3	0
4000	65	± 0.3	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 41	STC 40	STC 43	21

<u>SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W8</u>

REPORT No: 177981-9

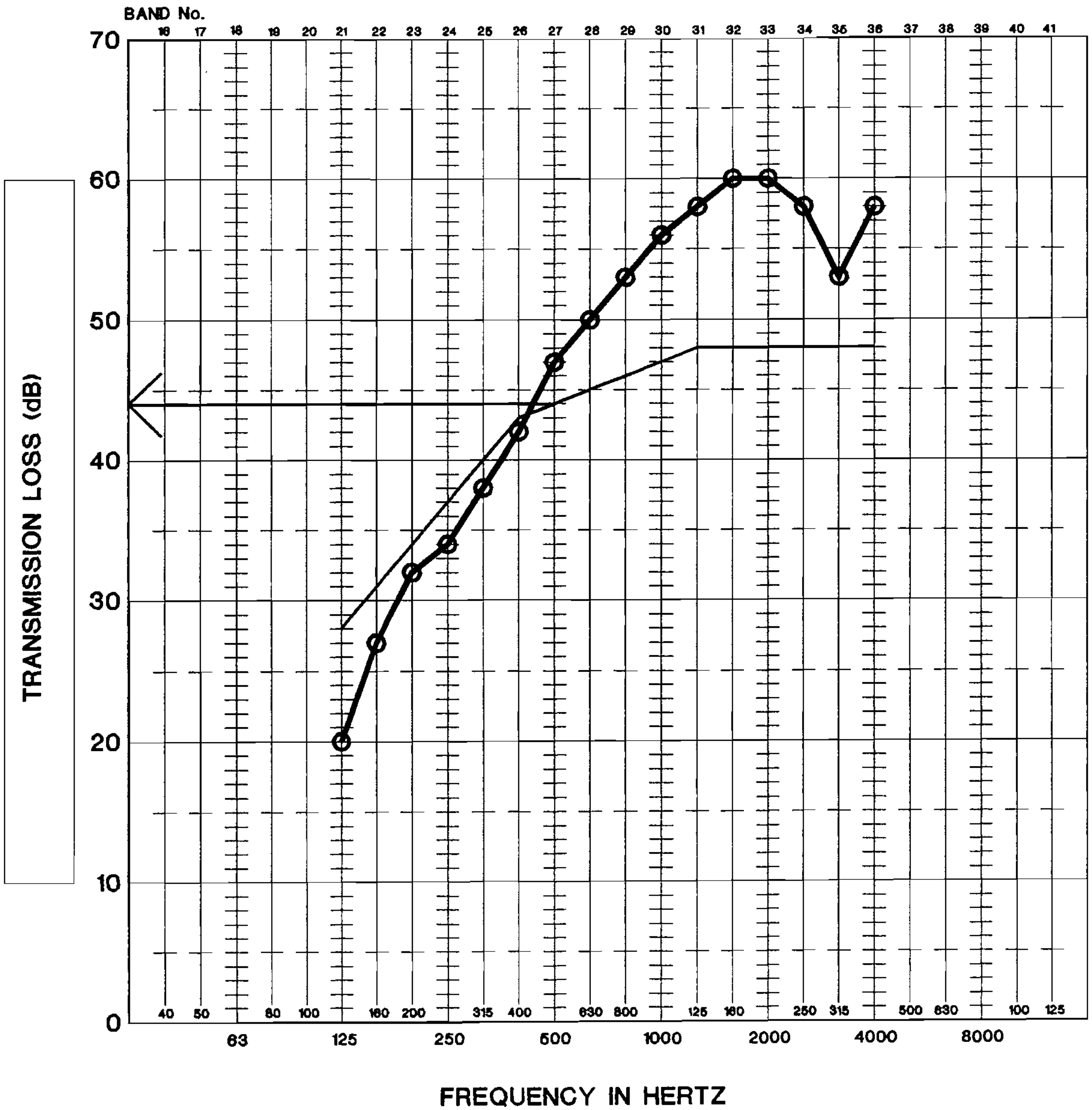
Frequency (Hz)	Sound Transmission Loss (TL)	95% confidence limits	Deficiencies under classification curve
125	15	± 1.5	8
160	19	± 1.8	7
200	23	± 1.2	6
250	27	± 0.8	5
315	34	± 0.6	1
400	38	± 0.4	0
500	39	± 0.5	0
630	42	± 0.4	0
800	46	± 0.4	0
1000	49	± 0.3	0
1250	52	± 0.3	0
1600	58	± 0.3	0
2000	59	± 0.4	0
2500	61	± 0.2	0
3150	59	± 0.3	0
4000	62	± 0.4	0

STC Rating	95% confidence limits		Sum of the deficiencies below the curve
	MIN	MAX	
STC 39	STC 37	STC 40	27

SOUND TRANSMISSION LOSS MEASUREMENT : EXTERIOR WALL W9

TEST No : 177981-1

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



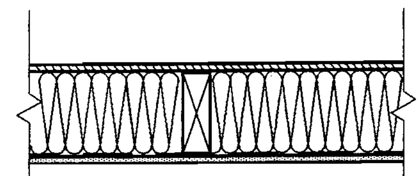
LEGEND

Transmission Loss (TL)

STC contour (ASTM E 413-87)

Sound Transmission Class
STC = 44

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- ASPHALT COATED WOOD FIBRE BOARD 11mm (7 /16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @600mm (24") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION
NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W1

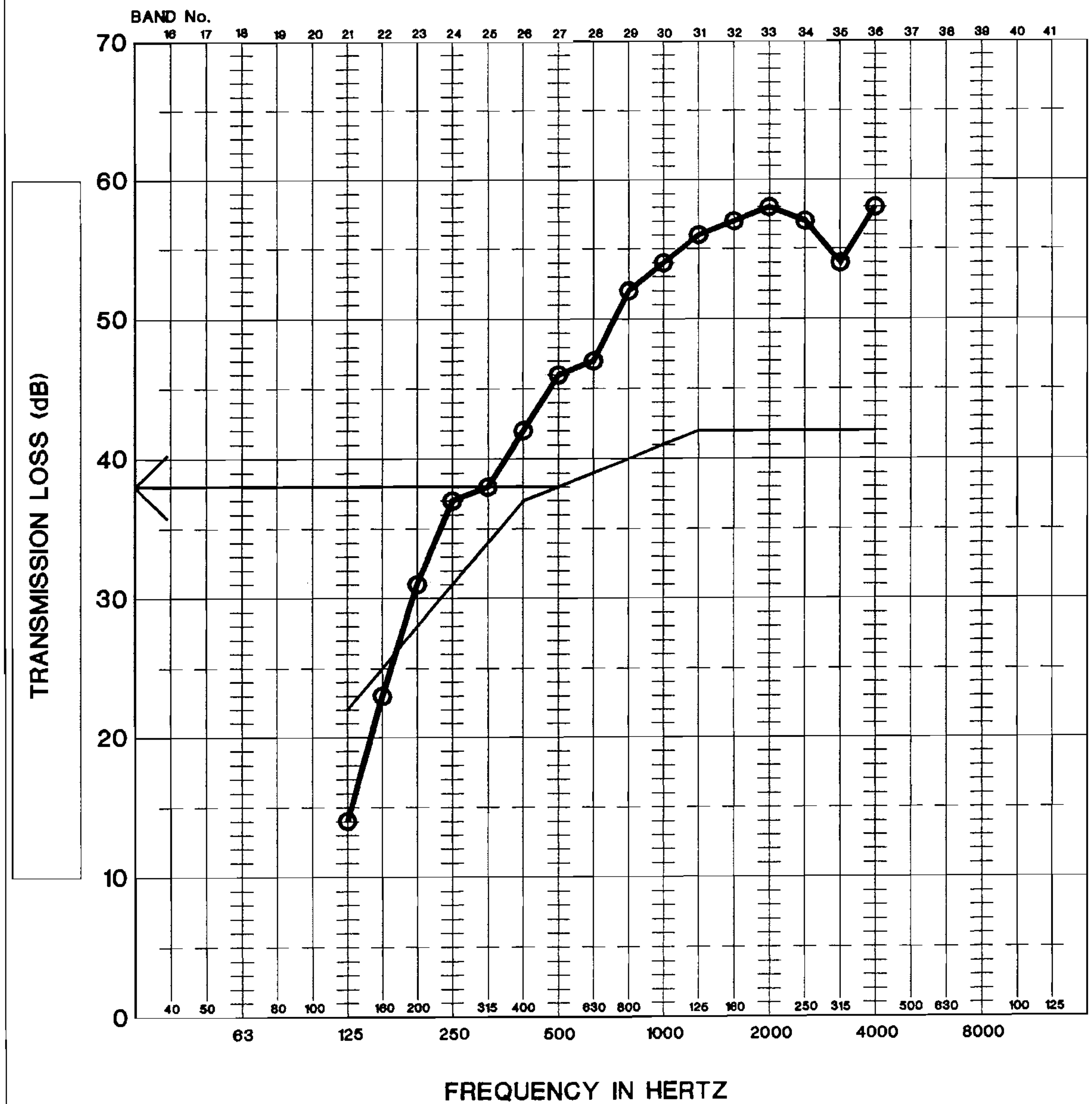
GRAPH NUMBER: A2-1 **FILE NAME:** 177981-1

PROJECT NUMBER 177.981 **DATE** 98 10

mjm

TEST No : 177981-2

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



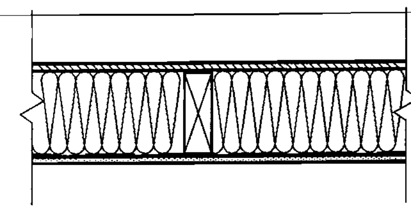
LEGEND

Transmission Loss (TL)

STC contour (ASTM E 413–87)

Sound Transmission Class
STC = 38

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

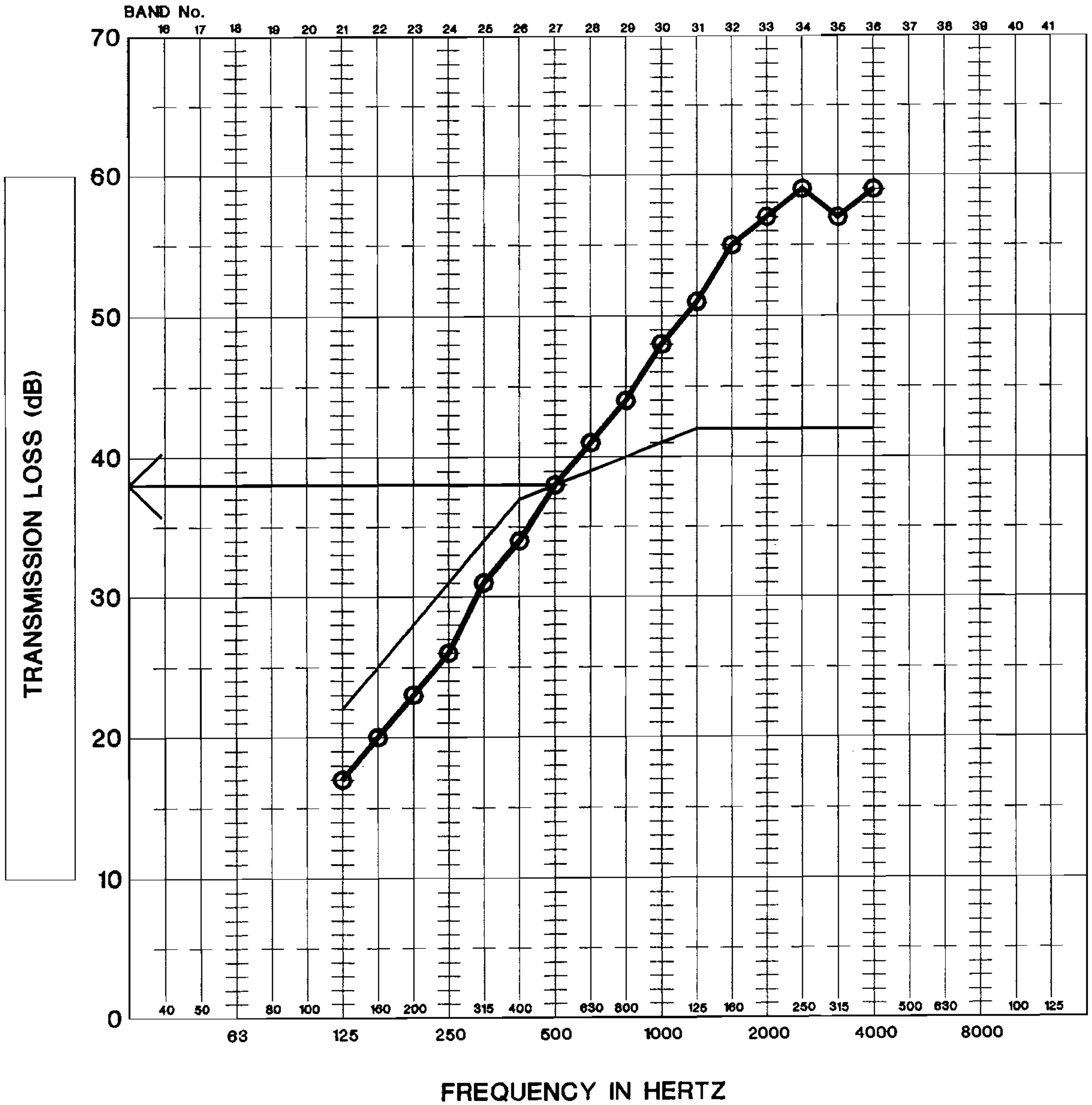
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION	
NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W2	
GRAPH NUMBER: A2–2	**FILE NAME:** 177981–2
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No · 177981-3

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

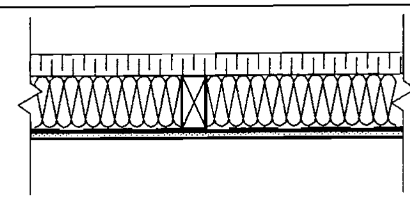
Transmission Loss (TL)

STC contour (ASTM E 413-87)

Sound Transmission Class

STC = 38

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- SEMI-RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER, 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

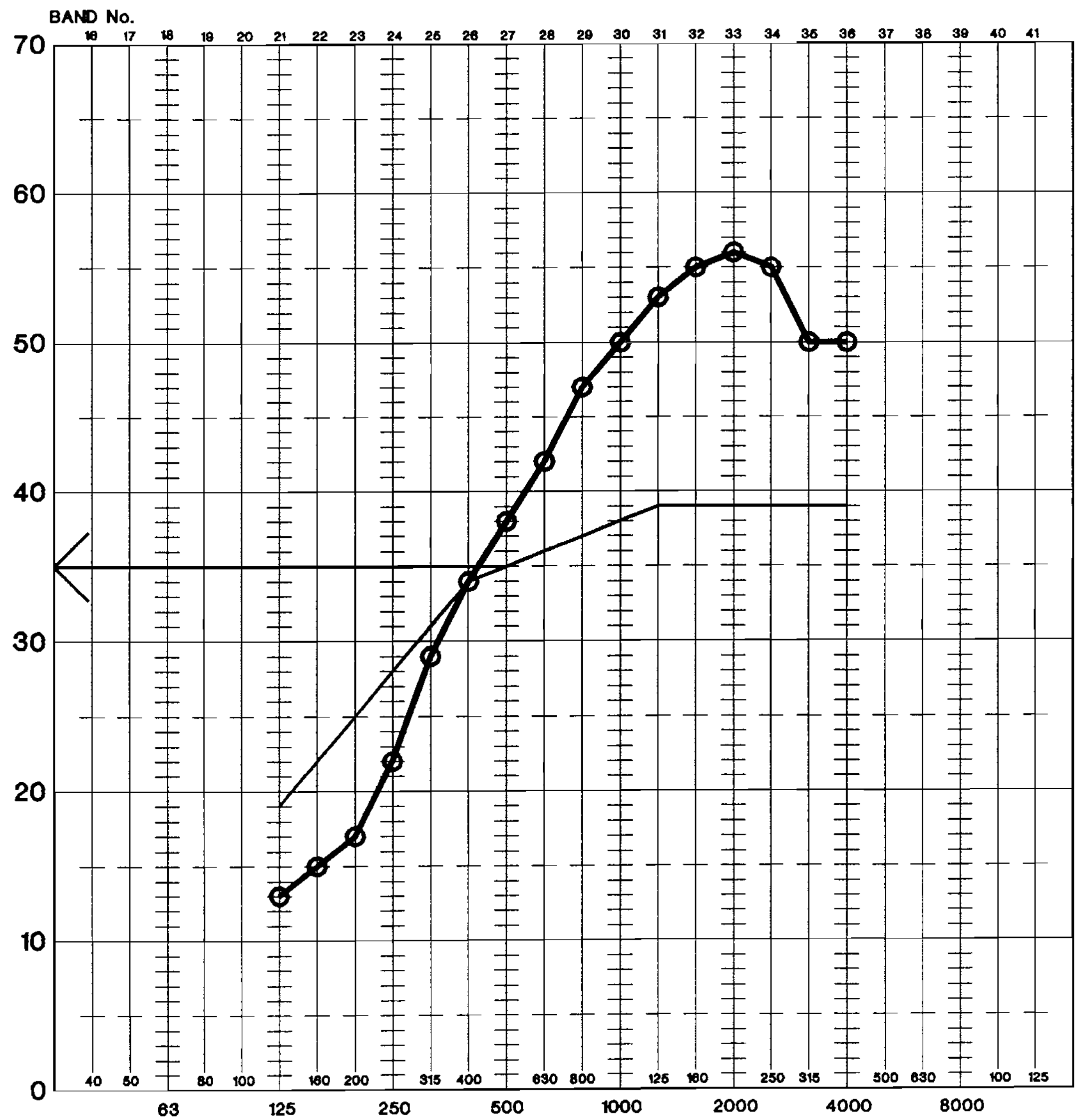
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W3

GRAPH NUMBER: A2-3	**FILE NAME:** 177981-3
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-4

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND

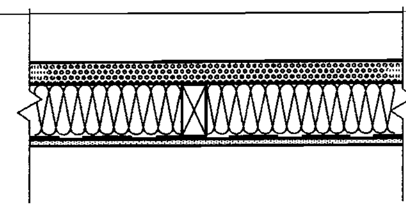
Transmission Loss (TL)

STC contour (ASTM E 413–87)

Sound Transmission Class

STC = 35

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

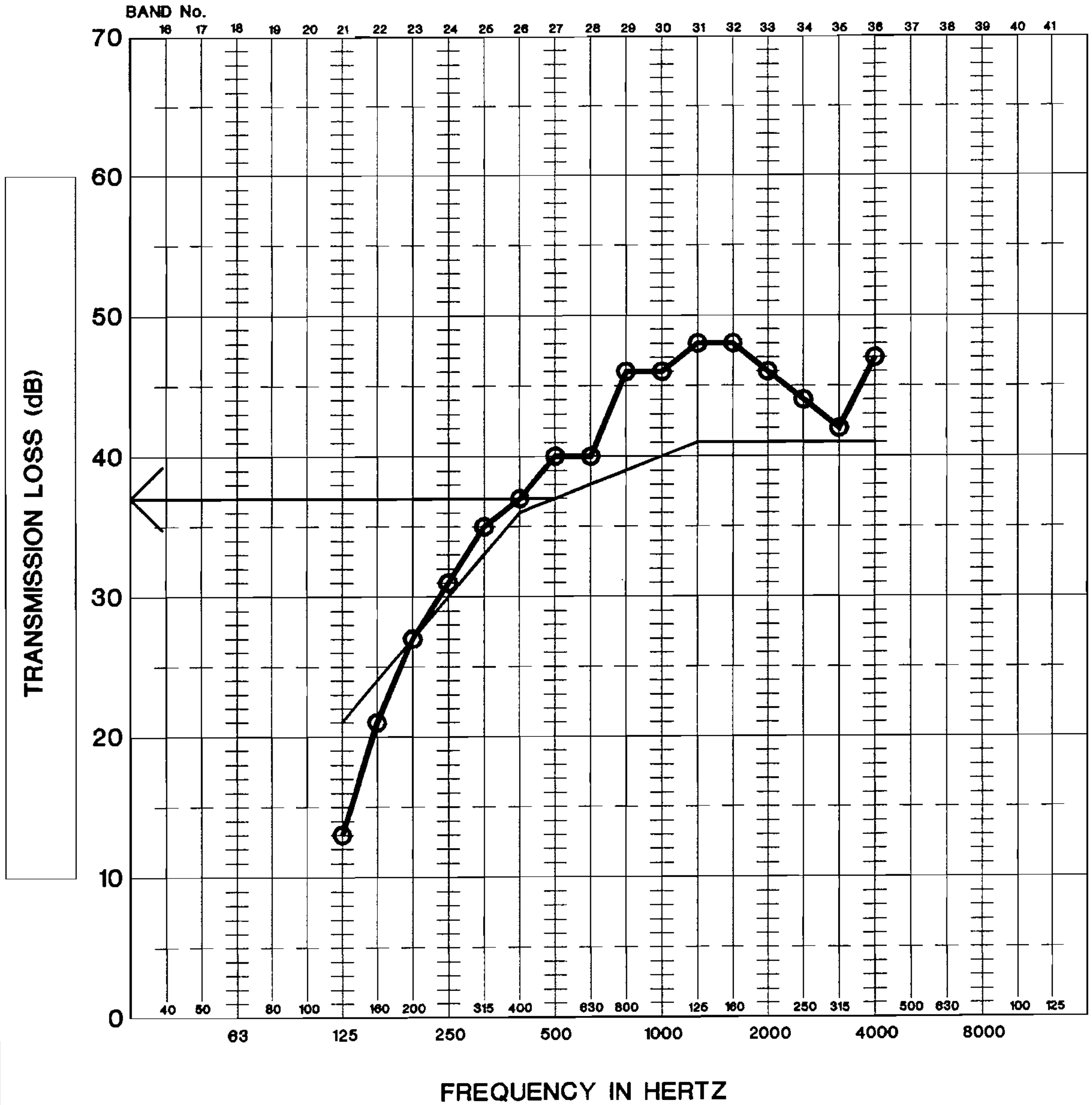
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W4

GRAPH NUMBER: A2–4	**FILE NAME:** 177981–4
PROJECT NUMBER 177.981	**DATE** 98 10

TEST No : 177981-5

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



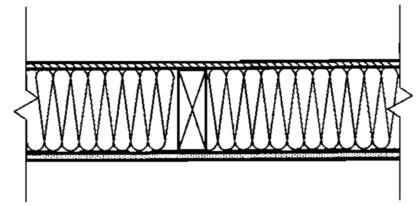
LEGEND

Transmission Loss (TL)

STC contour (ASTM E 413-87)

Sound Transmission Class
STC = 37

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

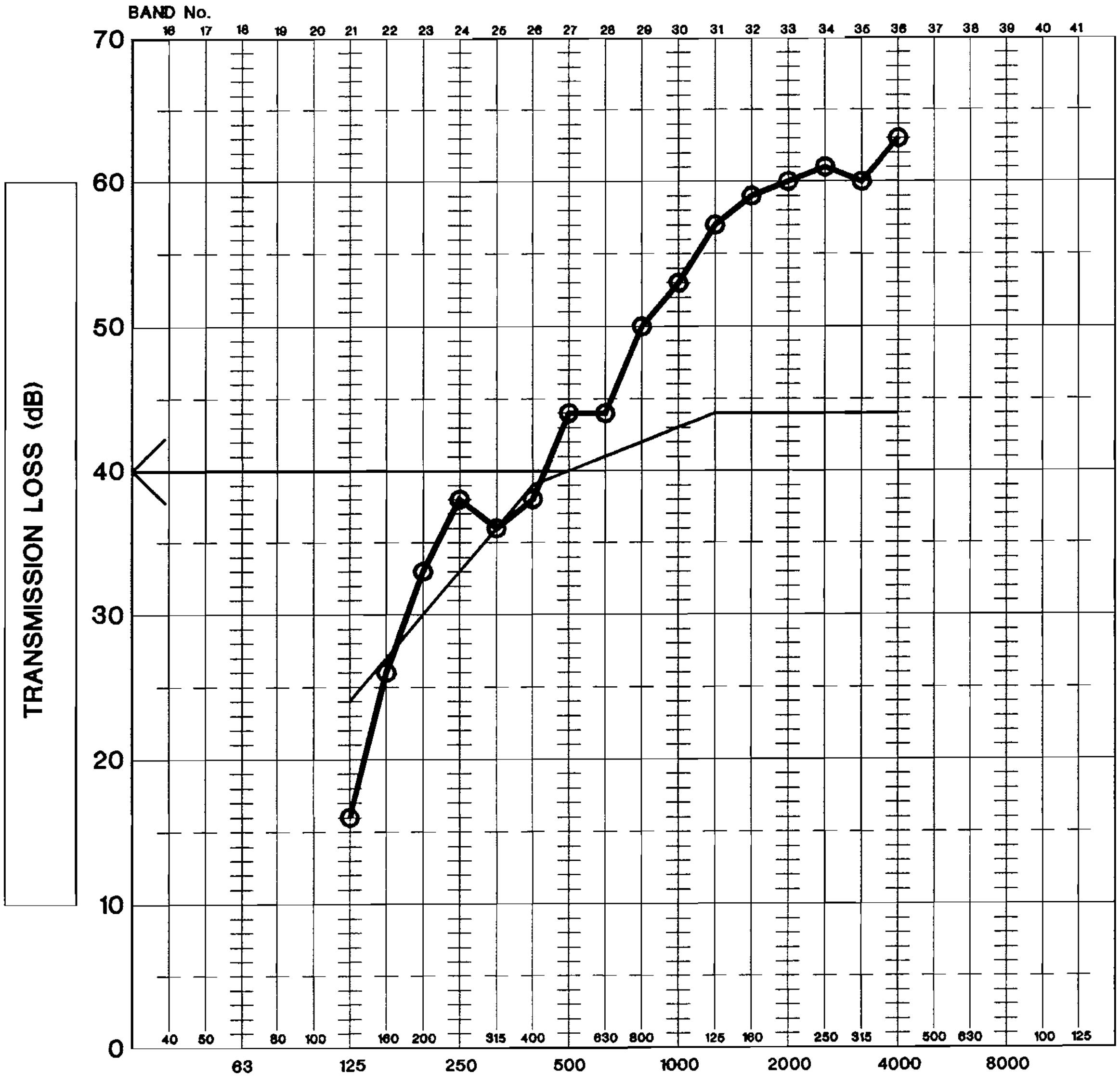
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W5

GRAPH NUMBER: A2-5	**FILE NAME:** 177981-5
PROJECT NUMBER 177.981	**DATE** 98 10

TEST No : 177981-6

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



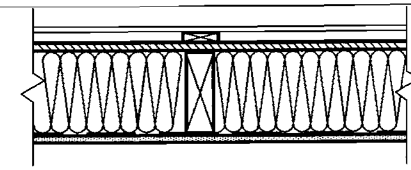
LEGEND

Transmission Loss (TL)

STC contour (ASTM E 413-87)

Sound Transmission Class
STC = 40

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

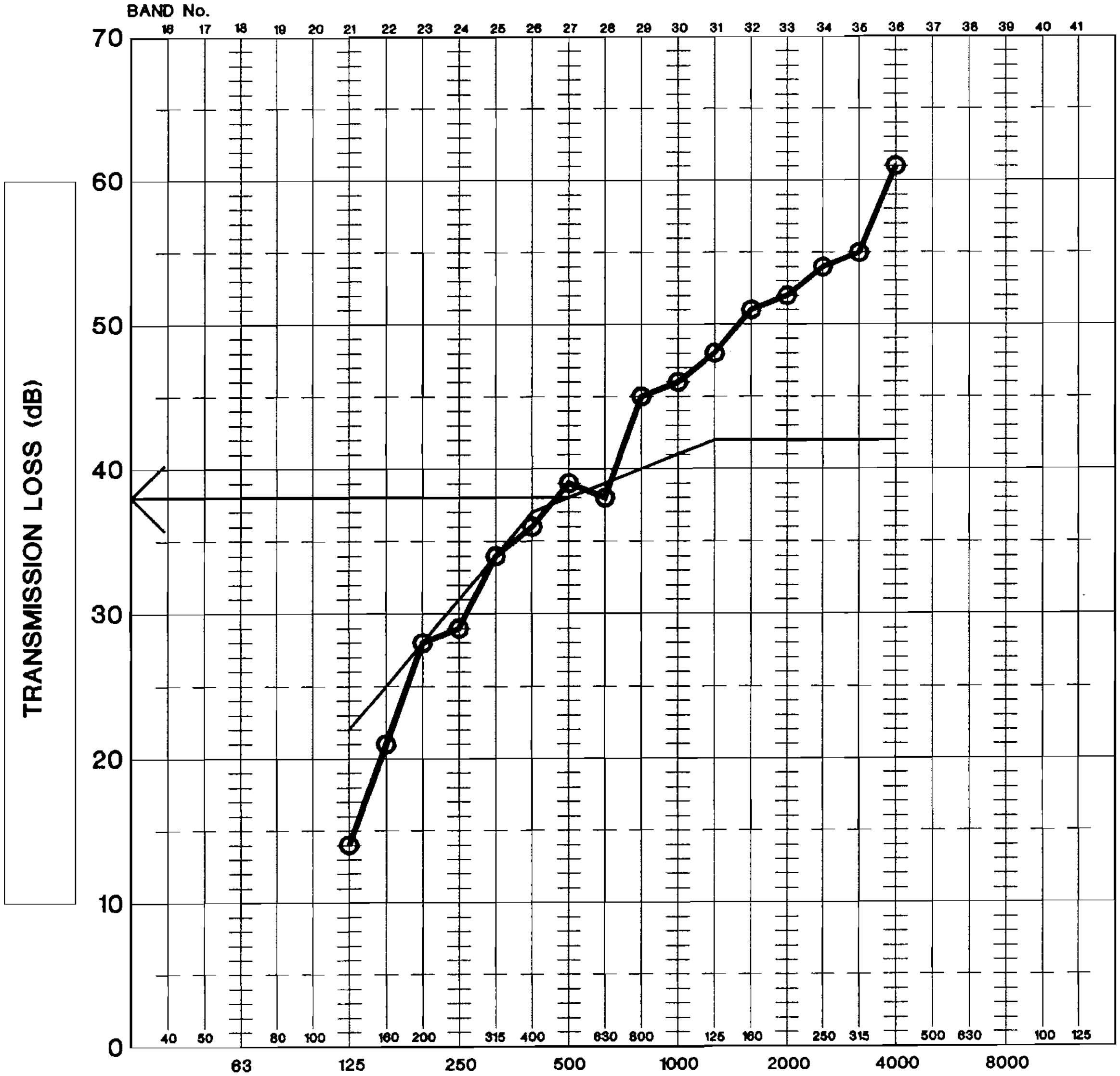
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W6

GRAPH NUMBER: A2-6	**FILE NAME:** 177981-6
PROJECT NUMBER 177.981	**DATE** 98 10

TEST No : 177981-7

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



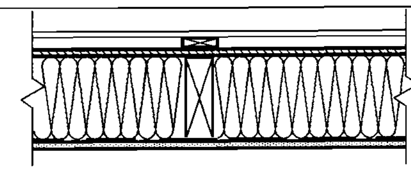
LEGEND

Transmission Loss (TL)

STC contour (ASTM E 413-87)

Sound Transmission Class
STC = 38

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1"x 3")
- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W7

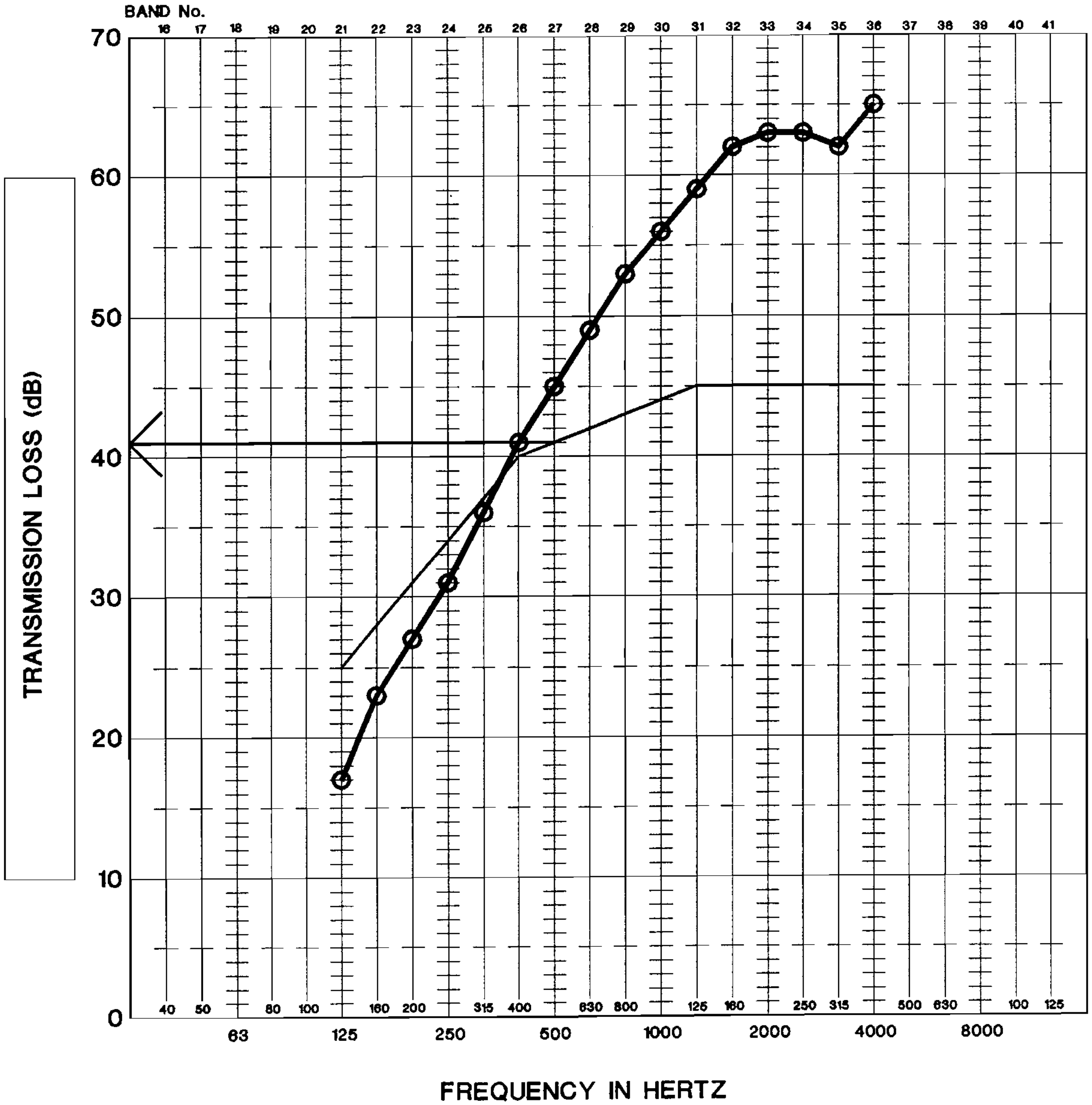
GRAPH NUMBER: A2-7 **FILE NAME:** 177981-7

PROJECT NUMBER 177.981 **DATE** 98 10

mjm

TEST No : 177981-8

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



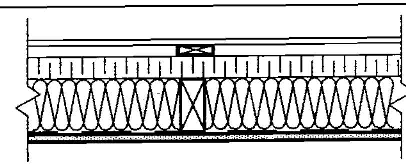
LEGEND

Transmission Loss (TL)

STC contour
(ASTM E 413-87)

Sound Transmission Class
STC = 41

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- SEMI-RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R20), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

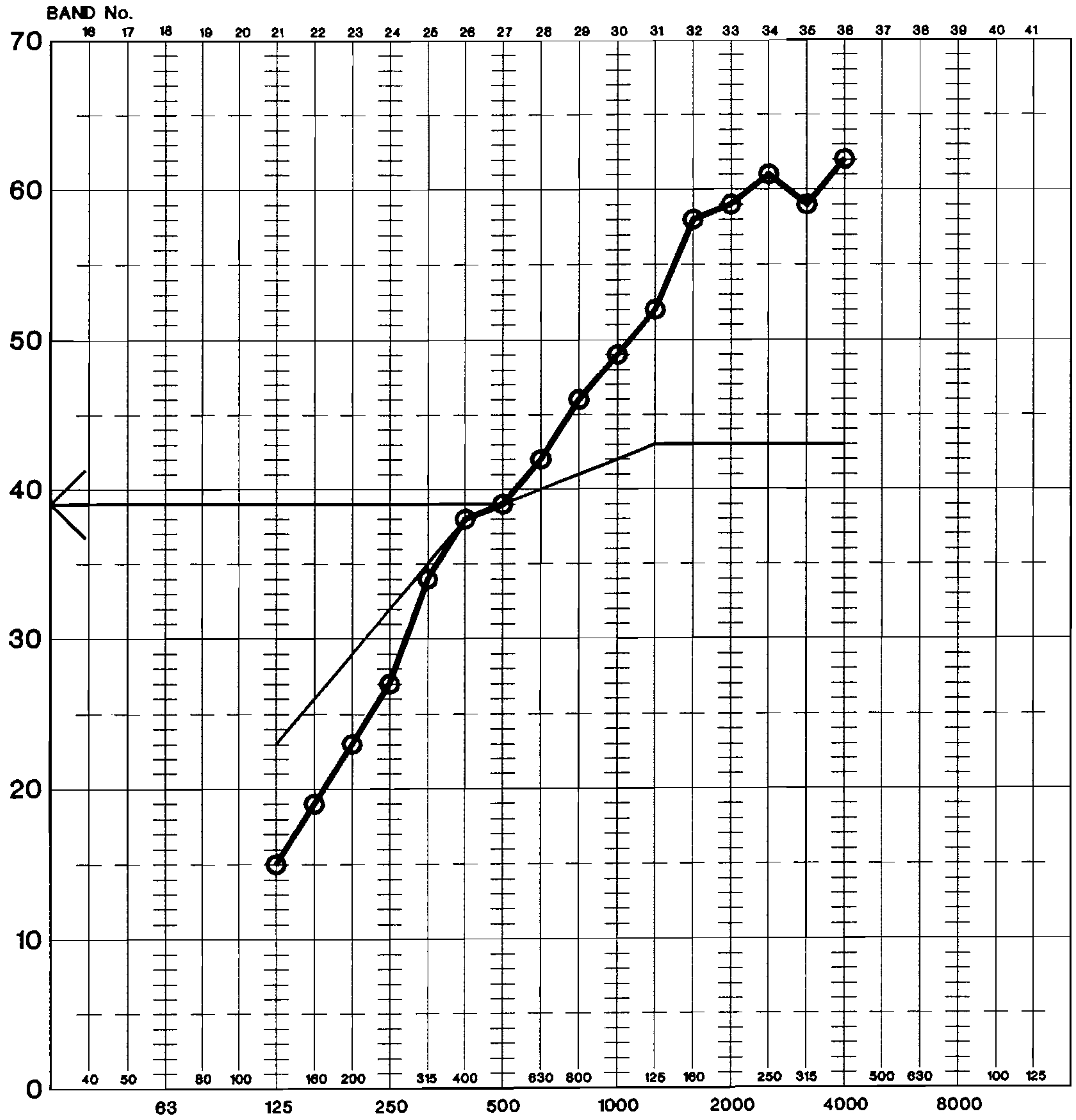
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W8

GRAPH NUMBER: A2-8	**FILE NAME:** 177981-8B
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-9

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



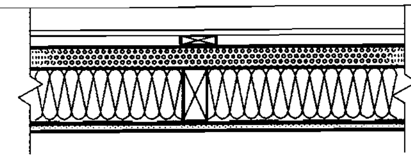
LEGEND

Transmission Loss (TL)

STC contour
(ASTM E 413-87)

Sound Transmission Class
STC = 39

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W9

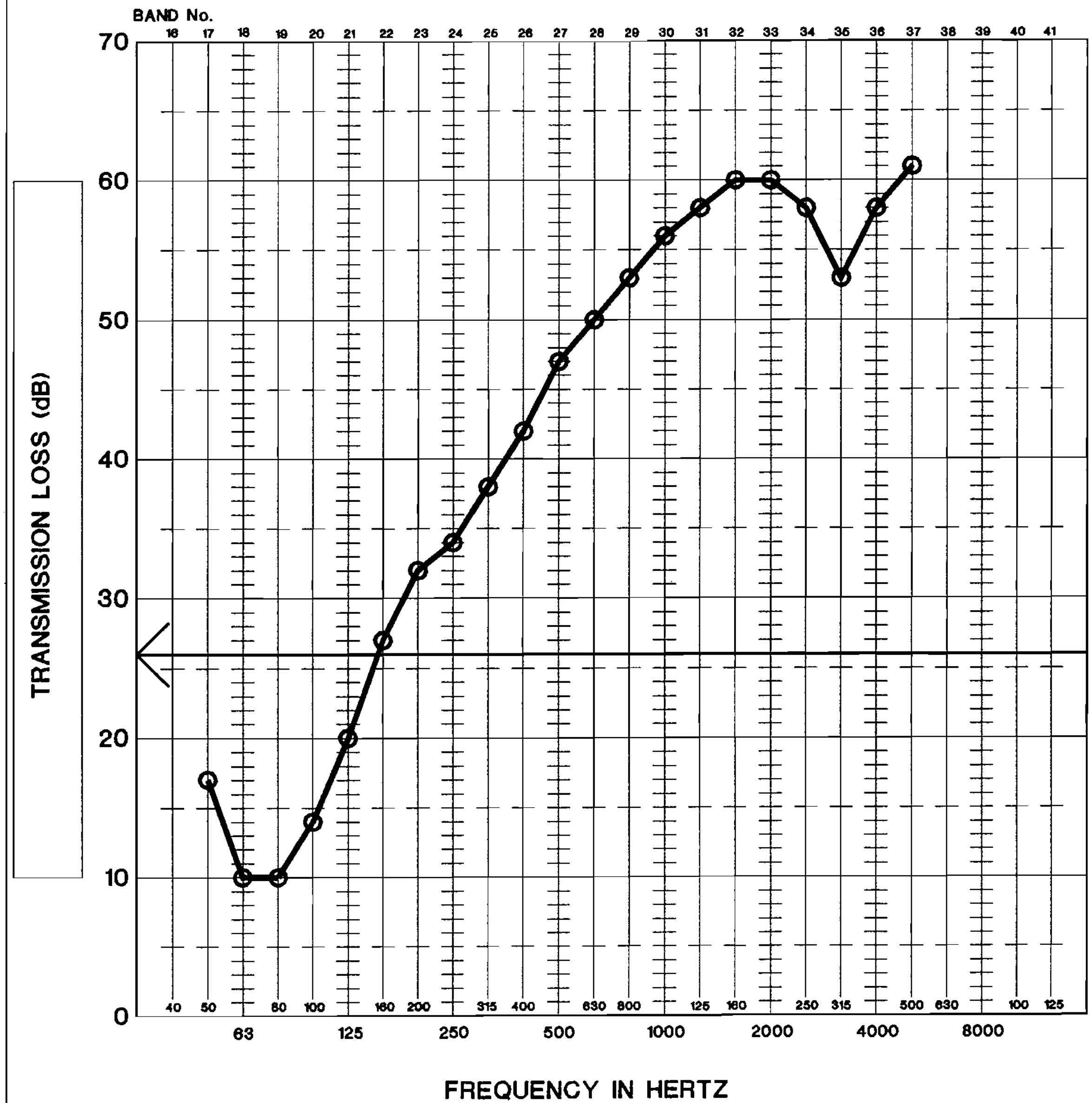
GRAPH NUMBER: A2-9	**FILE NAME:** 177981-9
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

ANNEX III

TEST No : 177981-1

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



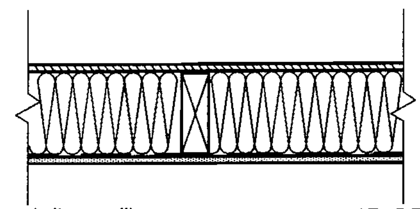
LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class

OITC = 26
ASTM E1332

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

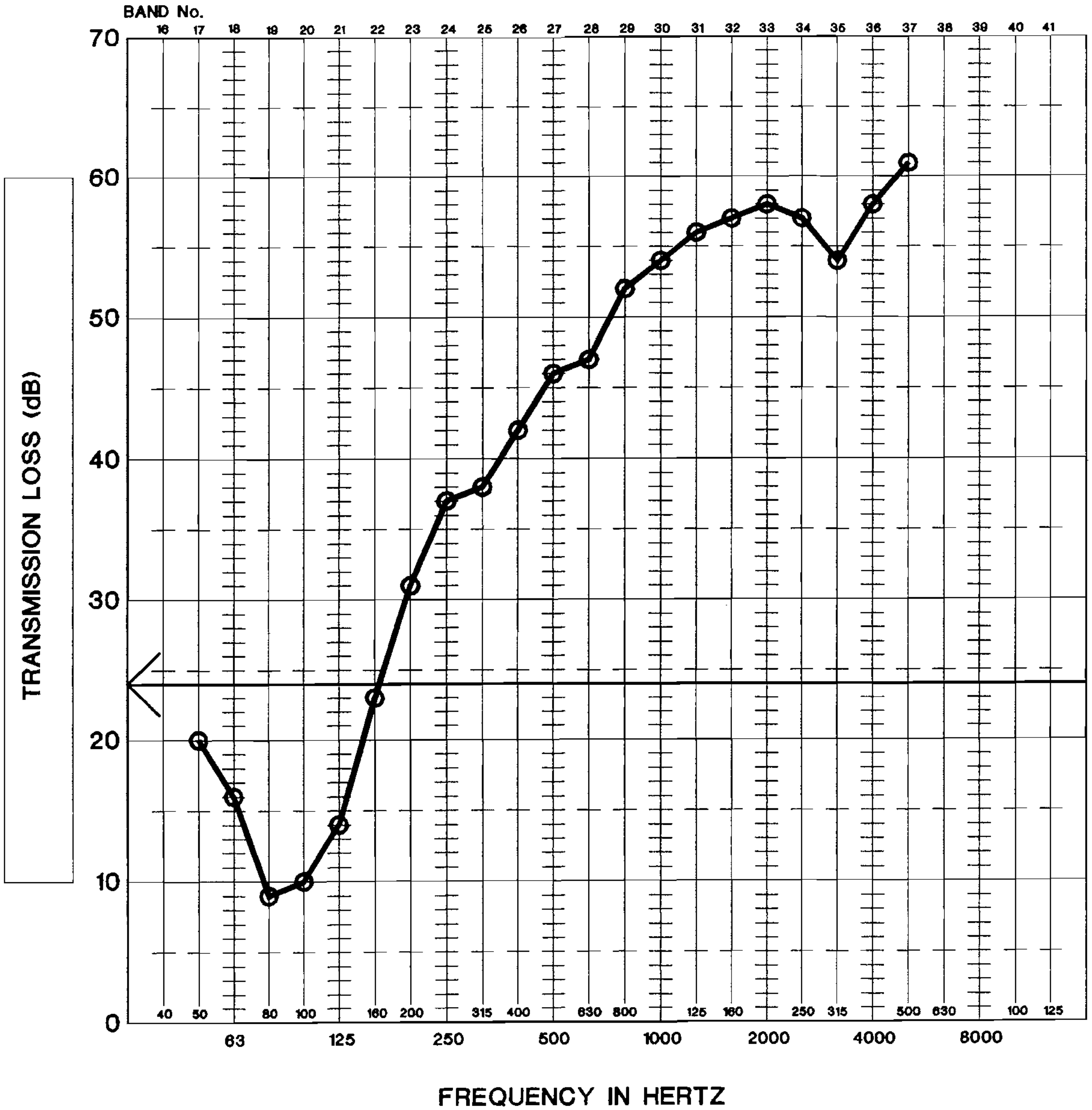
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7 /16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @600mm (24") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W1	
GRAPH NUMBER: A3–1	**FILE NAME:** 177OITC–1
PROJECT NUMBER 177.981	**DATE** 98 10

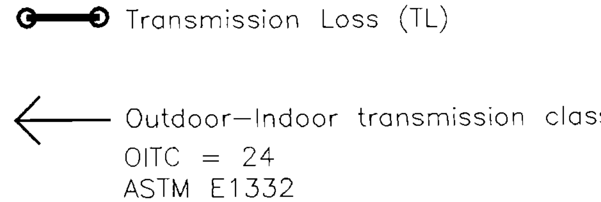
MJM

TEST No · 177981-2

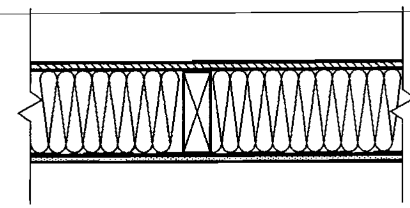
NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT



LEGEND



SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

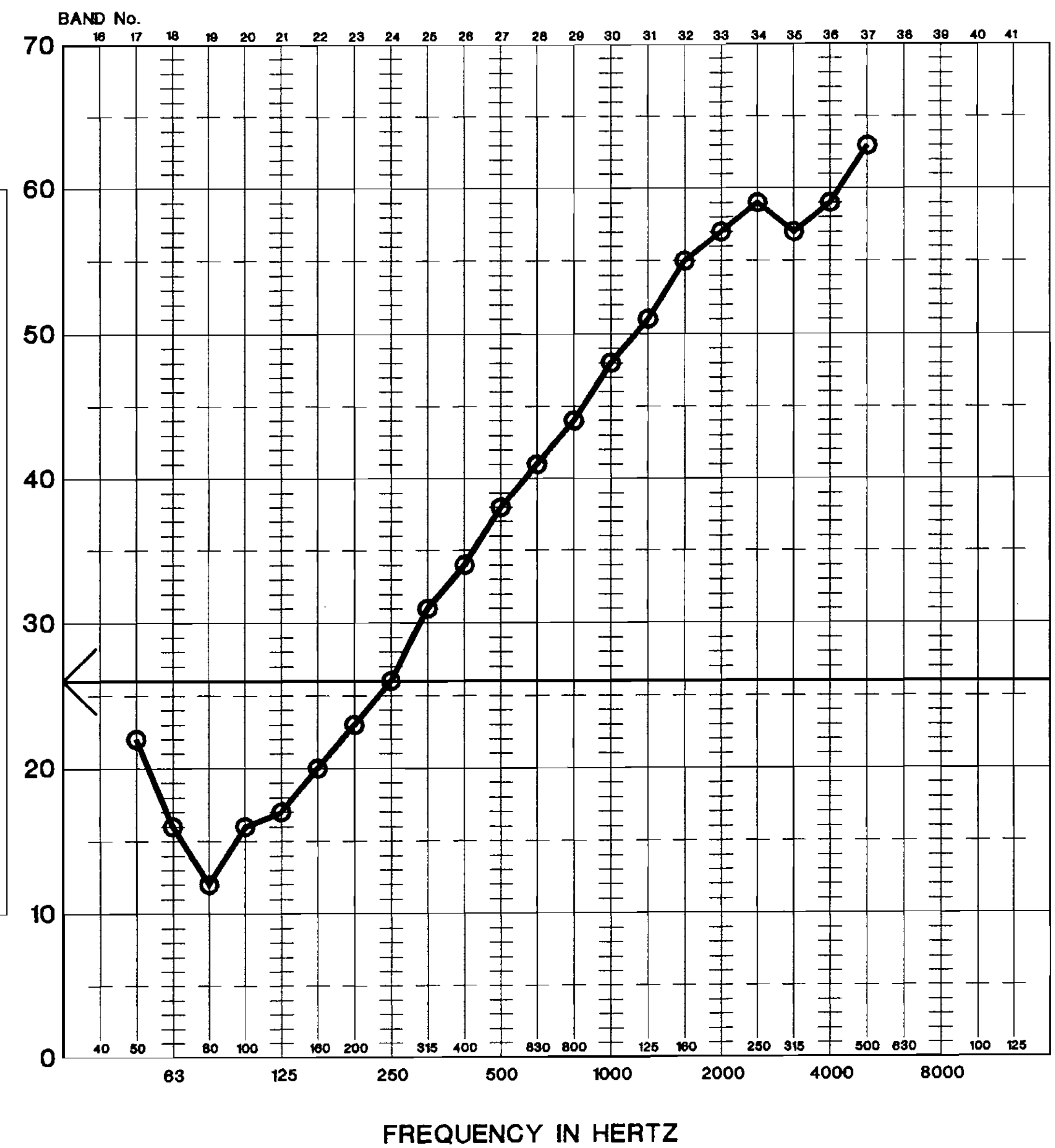
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W2

GRAPH NUMBER: A3–2	**FILE NAME:** 1770ITC–2
PROJECT NUMBER 177.981	**DATE** 98 10

TEST No : 177981-3

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

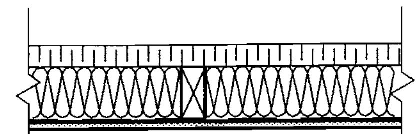


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 26
ASTM E1332

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- SEMI–RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

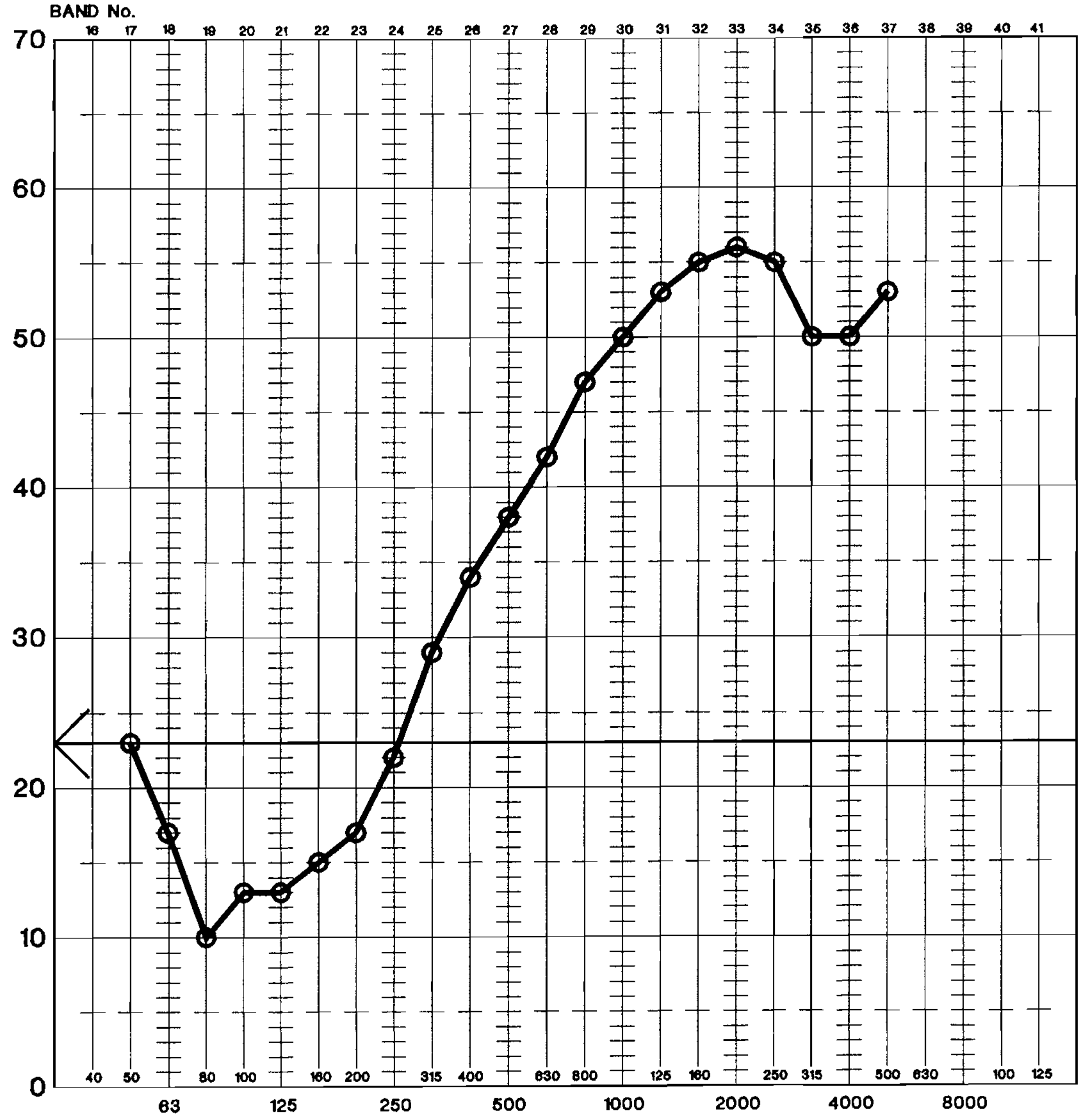
GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W3

GRAPH NUMBER: A3–3	**FILE NAME:** 177OITC–3B
PROJECT NUMBER 177.981	**DATE** 98 10

TEST No : 177981-4

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

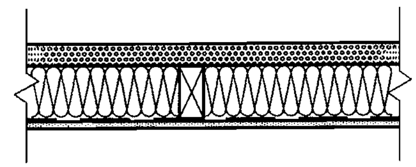


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 23
ASTM E1332

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

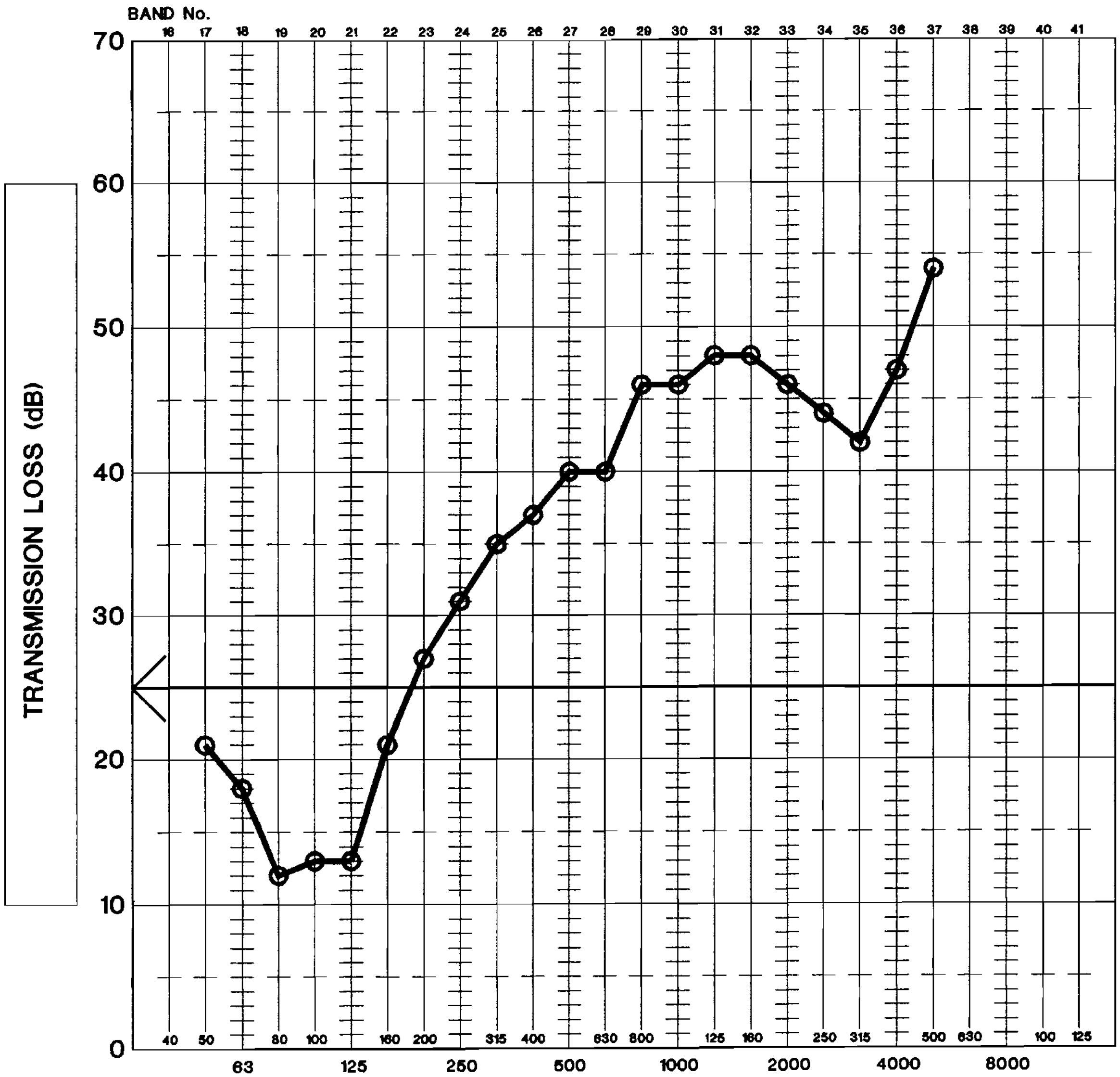
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W4

GRAPH NUMBER: A3–4	**FILE NAME:** 1770ITC–4
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-5

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

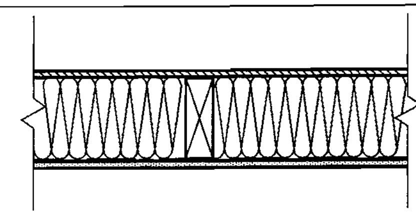


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 25
ASTM E1332

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

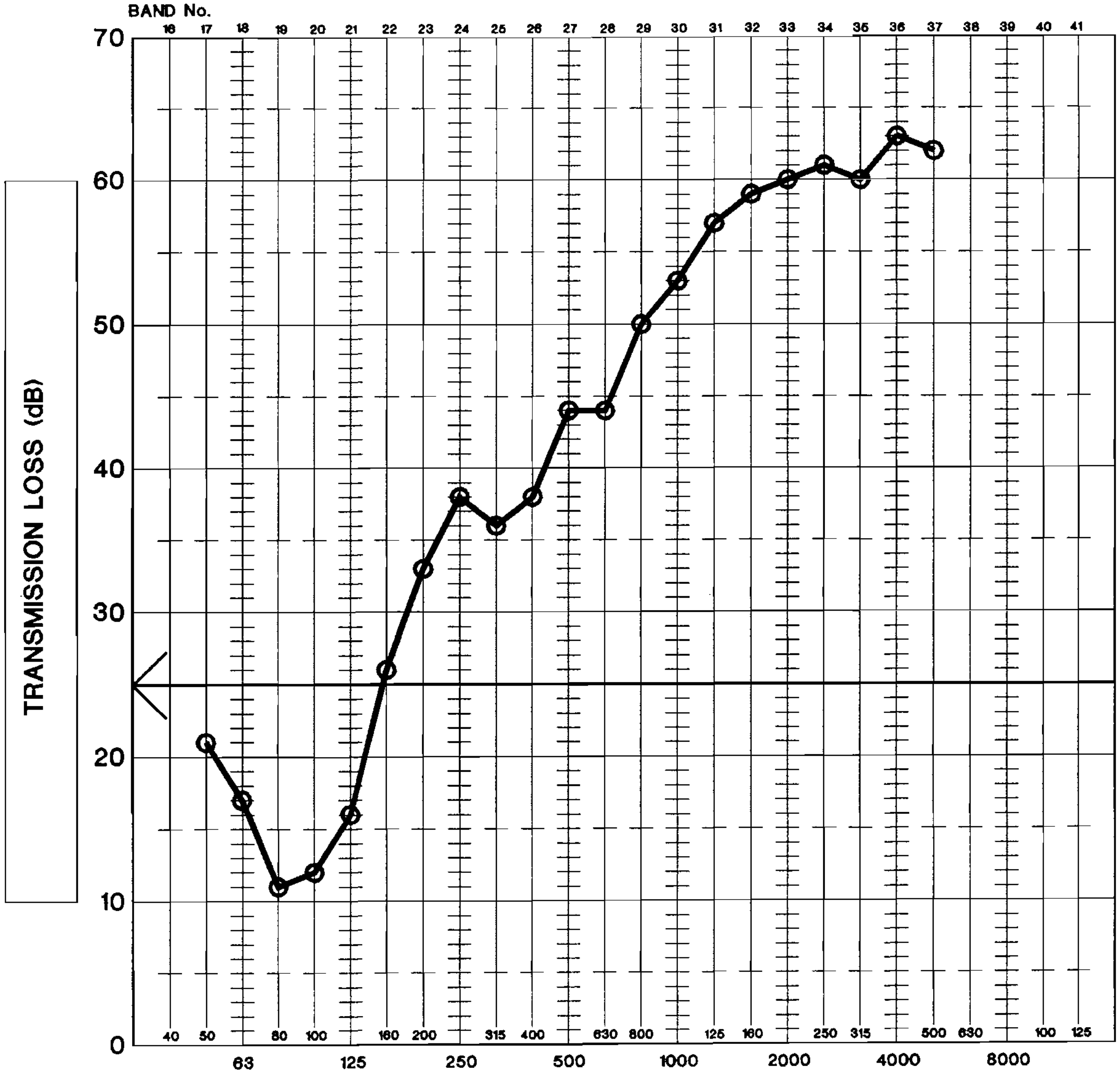
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W5

GRAPH NUMBER: A3–5	**FILE NAME:** 1770ITC–5
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-6

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

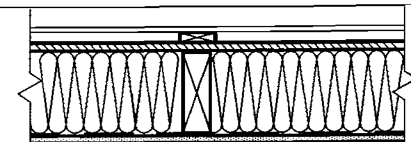


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 25
ASTM E1332

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" x 3")
- ASPHALT COATED WOOD FIBRE BOARD 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

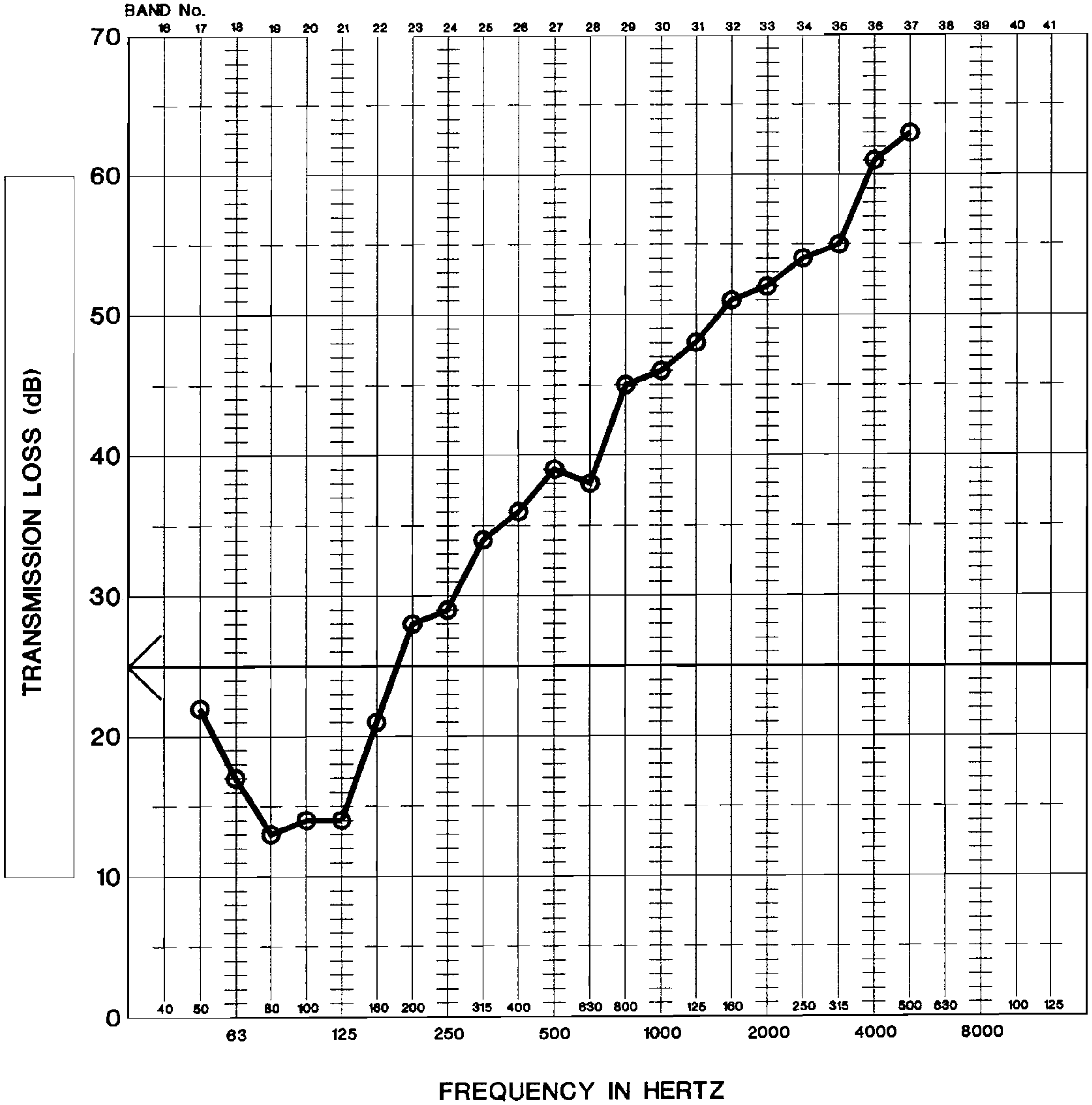
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W6

GRAPH NUMBER: A3–6	**FILE NAME:** 1770ITC–6
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-7

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

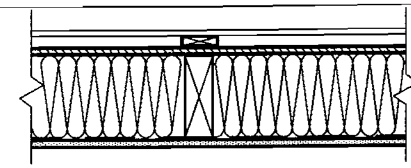


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 25
ASTM E1332

SECTION



38 x 140mm (2" X 6") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1"x 3")
- OSB BOARDS 11mm (7/16") THICK
- WOOD STUDS 38 x 140mm (2" X 6") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 3.5 (R20), 140mm (5 1/2") THICK
- VAPOR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

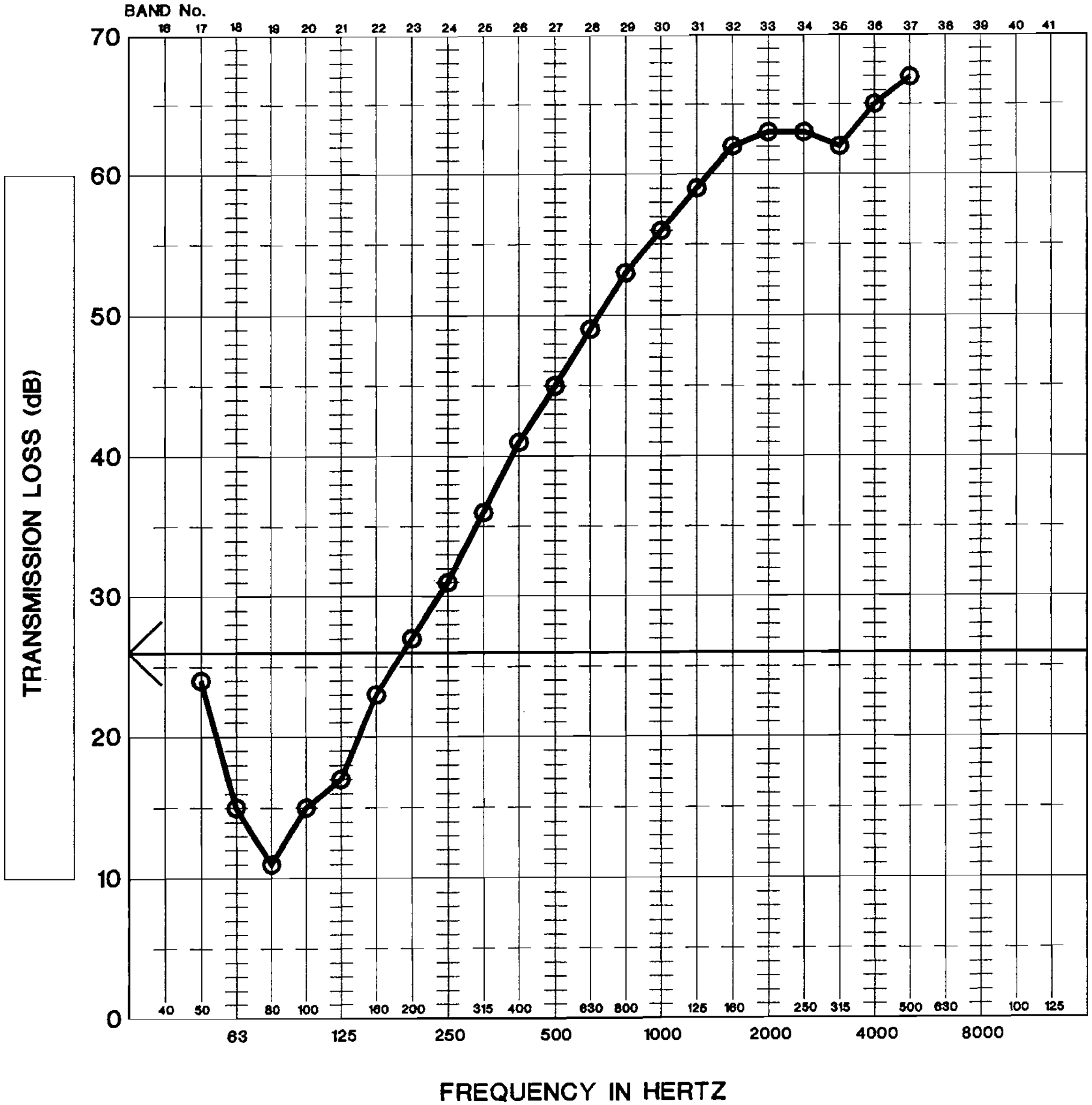
AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W7

GRAPH NUMBER: A3–7	**FILE NAME:** 177OITC–7
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-8

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

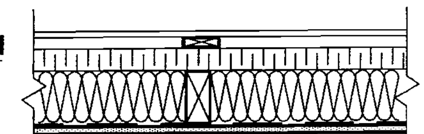


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 26
ASTM E1332

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

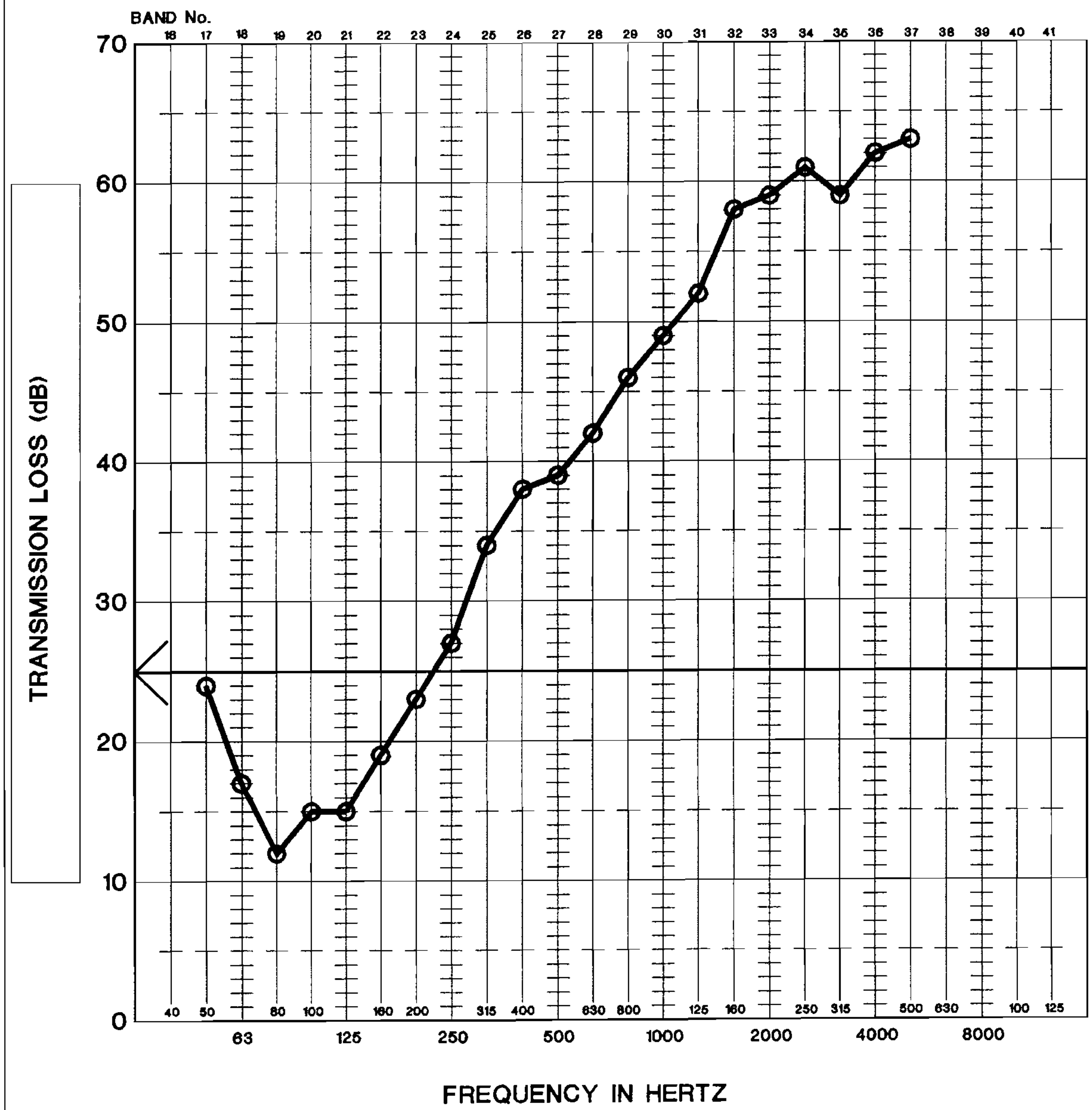
- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- SEMI-RIGID GLASS FIBRE INSULATION WITH HOUSEWRAP AIR BARRIER 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS	
GRAPH TITLE AIRBORNE SOUND TRANSMISSION LOSS . EXTERIOR WALL No W8	
GRAPH NUMBER: A3–8	**FILE NAME:** 177OITC–8B
PROJECT NUMBER 177.981	**DATE** 98 10

mjm

TEST No : 177981-9

NOTE: THIS GRAPH ALONE DOES NOT REPRESENT A COMPLETE REPORT

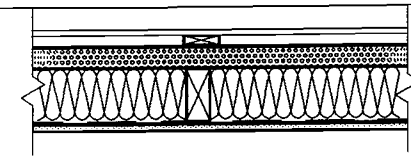


LEGEND

Transmission Loss (TL)

Outdoor–Indoor transmission class
OITC = 25
ASTM E1332

SECTION



38 x 89mm (2" X 4") WOOD STUD STRUCTURE

- P.V.C. CLADDING
- WOOD FURRINGS 25 x 75mm (1" X 3")
- EXTRUDED POLYESTYRENE INSULATION BOARDS 38mm (1 1/2") THICK
- WOOD STUDS 38 x 89mm (2" X 4") @400mm (16") o.c.
- GLASS FIBRE BATT INSULATION BETWEEN STUDS RSI 2.1 (R12), 89mm (3 1/2") THICK
- VAPOUR BARRIER (POLYETHYLENE)
- GYPSUM 13mm (1/2") THICK

PROJECT DESCRIPTION

NOISE ISOLATION PROVIDED BY EXTERIOR WALLS IN RESIDENTIAL PROJECTS

GRAPH TITLE

AIRBORNE SOUND TRANSMISSION LOSS : EXTERIOR WALL No W9

GRAPH NUMBER: A3-9	**FILE NAME:** 1770ITC-9
PROJECT NUMBER 177.981	**DATE** 98 10

ANNEX IV

ANNEX IV

SOUND TRANSMISSION LOSS TESTS AT THE DOMTAR ACOUSTICAL LABORATORY IN SENNEVILLE, QUEBEC, CANADA; LEASED AND OPERATED BY MJM ACOUSTICAL CONSULTANTS INC.

1.0 INTRODUCTION

All the tests performed in the present research project have been conducted in the acoustical laboratory of the DOMTAR INNOVATION CENTRE in Senneville, Quebec, by the firm MJM ACOUSTICAL CONSULTANTS INC. whose offices are located in Montreal, Quebec. The test facility, the standards used to perform the tests and the methods used to install the samples are presented in the paragraphs below and in the figures attached to this section.

2.0 APPLICABLE STANDARDS

All the sound transmission loss measurements described in this report have been conducted in accordance to the ASTM E 90-90 standard entitled "Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions"; the Sound Transmission Loss values of the exterior walls tested were then classified to obtain:

- the Sound Transmission Class (STC) rating using the ASTM E 413 standard entitled "Classification for Rating Sound Insulation".

- the Outdoor Indoor Transmission Class (OITC) rating using the ASTM E 1332 standard entitled "Standard Classification for Determination of Outdoor-Indoor Transmission Class".

3.0 MEASUREMENT METHOD

The method described in the ASTM E90 Standard to measure the sound transmission loss of a building element consists in installing this element between two reverberant rooms which are structurally independent from each other, in a frame which is itself structurally independent from the reverberant rooms. A broadband steady state noise is generated in the source room and its level is measured; the portion of the sound which has been transmitted through the element tested inside the receiving room is also measured. By subtracting the sound pressure level measured in the receiving room from that measured in the source room, one can calculate the Noise Reduction (NR) values for each 1/3 octave band from 50 Hz to 5000 Hz. The sound transmission loss (TL) values are obtained by normalizing the NR values in function of the surface of the building element tested and of the absorption in the receiving room, this latter quantity being determined by measuring the reverberation time in the receiving room.

The TL values are then classified as per ASTM E 413[1] and ASTM E 1332[2] to respectively obtain the Sound Transmission Class (STC) and the Outdoor Indoor Transmission Class (OITC). The STC is a single number rating allowing to quickly compare the sound isolation provided by buildings elements. The OITC is a single number rating used to compare the sound isolation protection provided by exterior walls against exterior noises generated by airplane, rail, and road traffic.

4.0 DESCRIPTION OF THE ACOUSTICAL LABORATORY LOCATED IN THE DOMTAR INNOVATION CENTRE

The facility consists in three reverberant rooms which are structurally decoupled from one another. The dimensions, volume, construction, and weight of each room and the number of springs on which they rest (for the source and reverberant room) appear in the paragraphs below, along with the dimensions of the test openings. **Figure A4-1** provides a plan and a section of the laboratory.

1 From 125 Hz to 4000 Hz
2 From 80 Hz to 4000 Hz

Each room is equipped with a microphone transverse carrier which travels on a chain along a diagonal of the room. A stepping motor moves the microphone at ten preset positions. Both the source room (90 m^3) and the receiving rooms (255 m^3) are equipped with rotating diffusers to maintain a proper reverberant field; all three rooms are also equipped with stationary diffusers. For airborne and impact measurements on floor/ceiling assemblies, the receiving room is that located below the impact room.

SOURCE ROOM

Room dimension	4.394 m x 5.436 m x 3.404 m (14'5" x 17'10" x 11'2")
Room surface area	114.27 m^2 (1 230 pi^2)
Room volume	90.33 m^3 (3 190 pi^3)
Room weight	89 metric tons (97 imperial tons)
Wall thickness	305 mm (1')
Number of springs	208

RECEIVING (REVERBERATION) ROOM

Room dimension	6.477 m x 7.976 m x 4.877 m (21'3" x 26'2" x 16')
Room surface area	243.41 m^2 (2 620 ft^2)
Room volume	255.42 m^3 (9 020 ft^3)
Room weight	178.7 metric tons (197 imperial tons)
Wall thickness	305 mm (1')
Number of springs	432

IMPACT ROOM

Room dimension	5.004 m x 5.639 m x 3.453 m (16'5" x 18'6" x 11'4")
Room surface area	130.1 m^2 (1 400 ft^2)
Room volume	97.41 m^3 (3 440 ft^3)
Wall thickness	305 mm (1')

TEST OPENINGS

Walls	3.05 mm x 2.743 mm (10' x 9')*
Floors and ceilings	2.438 mm x 3.05 mm (8' x 10')

*** Note:** A filler wall may be constructed to accommodate smaller samples.

INSTRUMENTATION AND MEASUREMENT PROCEDURES

Measurements are controlled by a microcomputer interfaced with a Larson-Davis 2800 real time frequency analyser, to which are connected two Brüel & Kjær type 4145 condenser microphones mounted on two Larson-Davis type 900 B preamplifiers; one microphone is located in the source room and the other is located in the receiving room. Both microphones are calibrated before and after each tests using a Brüel & Kjær type 4230 calibrator.

Sound pressure levels are measured and integrated over a 20 seconds period at each of the ten microphone positions in the source and receiving room, and averaged to get the mean sound pressure levels in each room. One reverberation time measurement is performed in the reverberant room for each of the ten microphone positions and averaged to obtain the mean reverberation time value.

5.0 SAMPLE INSTALLATION

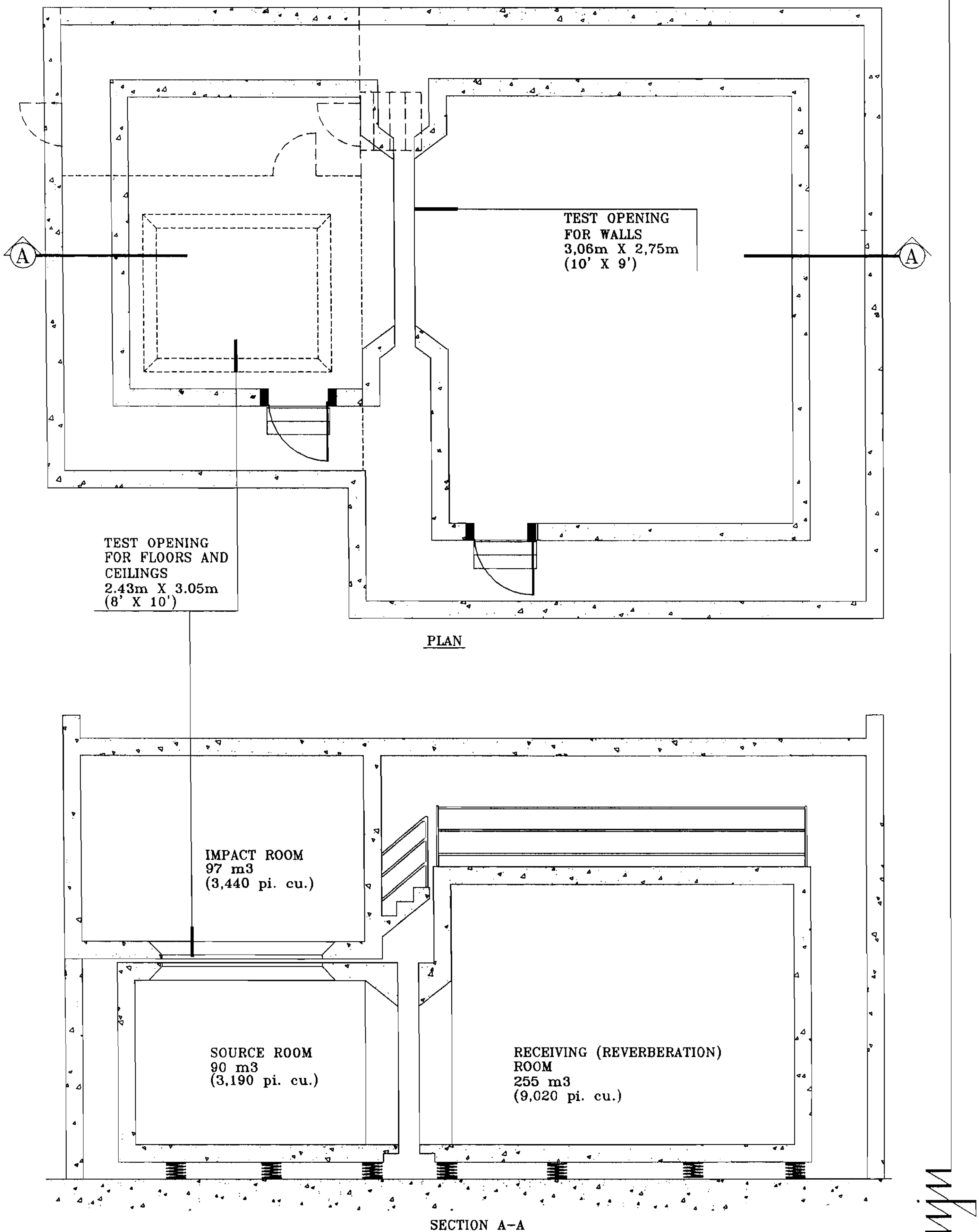
The perimeter of the test frame was lined using 13 mm x 300 mm (½" x 12") plywood strips with a saw cut in the middle. The plywood lining was carefully caulked to the frame using acoustical caulking complying with the standard ONGP 19GP21M.

Wall n° 1 for which the stud spacing is 600 mm (24") o.c. was installed directly inside the laboratory test opening which is 2700 mm (9'-0") high by 3800 mm (10'-0") wide. For walls n° 2 to 9, the width of the test opening was reduced to approximately 2800 mm (9'-4") in order to maintain a 400 mm (16") stud spacing. This width reduction was achieved by constructing lateral 95 mm (3 3/4") thick filler walls on each side of the test frame. **Figure A4-2** of this annex illustrates the composition of the filler walls constructed on each side of the test frame and the typical installation of a sample wall (in this instance wall n° 4). Since the filler wall composition is much more massive than the exterior walls under test, it has been assumed that the noise energy transmitted through the filler wall is insignificant compared to that transmitted through the exterior wall specimens.

6.0 COST EVALUATION OF THE MATERIALS

The following price list was used to evaluate the cost of the materials entering in the composition of the walls tested; this evaluation appears for each wall on **Tables 1, 2 and 3** of the executive summary.

- wood studs 38 mm x 89 mm x 3800 mm (2" x 4" x 10')	= 2.93 \$/each
- wood studs 38 mm x 140 mm x 3800 mm (2" x 6" x 10')	= 4.70 \$/each
- OSB boards 11 mm x 1200 mm x 2400 mm (7/16" x 4' x 8')	= 0.47 \$ ft^2
- asphalt coated wood fibre board	= 0.175 \$ ft^2
- glass fibre RSI 3.5 (R_{20})	= 0.25 \$ ft^2
- glass fibre RSI 2.1 (R_{12})	= 0.170 \$ ft^2
- gypsum 13 mm (½")	= 0.20 \$ ft^2
- extruded polystyrene insulation	= 0.53 \$ ft^2
- semi-rigid glass fibre insulation	= 0.41 \$ ft^2
- PVC cladding	= 1.00 \$ ft^2

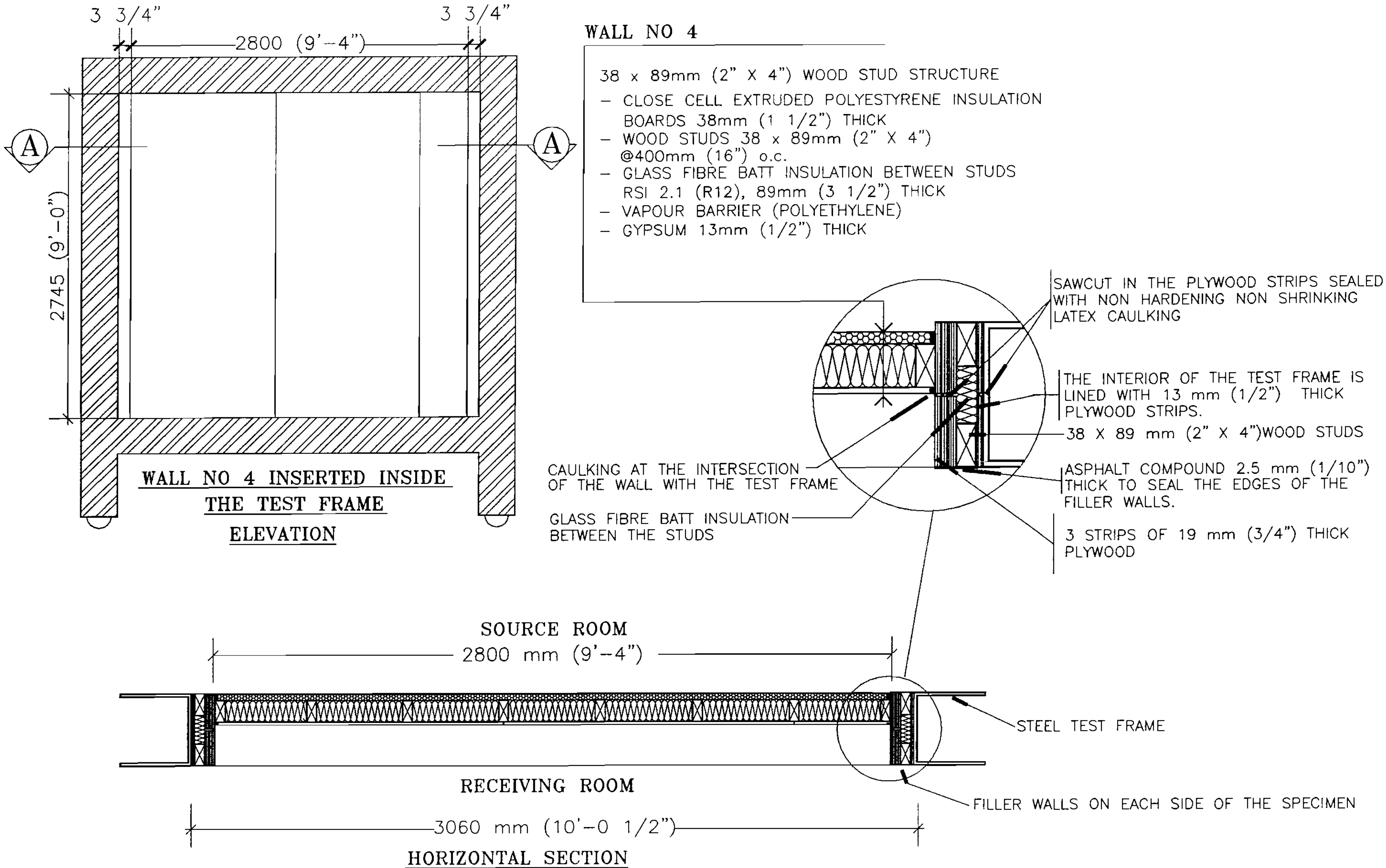


DOMTAR ACOUSTICAL LABORATORY

FIGURE A4-1

177.981
17798A41

98 10



WALL NO 4.0 CONSTRUCTED IN THE TEST OPENING

PROJET 177.981
17798A42

FIGURE A4-2

98 10