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Australian* Hearing®
National Acoustic Laboratories

REPORT ATF749K

Noise Emission Reduction due to Lagging a 100mm Diameter PVC pipe with "Soundlagg 4525"(25mm acoustic foam bonded to 4.5kg/m³ "Soundlagg")

Report Summary

The difference in noise energy emission from a 100mm diameter PVC pipe due to lagging with 25mm thick "Soundlagg 4525" (25mm thick acoustic foam bonded to 4.5kg/m² "Soundlagg"), was determined to be 19dB (linear) and 22.5dB (A-Weighted) when the energy difference (ie sound insertion loss) was summated over the frequency range 100Hz to 10kHz .

The reduction in noise energy within the frequency range 100Hz to 5kHz was also calculated to be 18.5dB (linear) and 22dB (A-Weighted). Sound Insertion loss within each one third octave band over the range 100Hz to 10kHz can be obtained from an attached spreadsheet (page 12).

Testing Requirement

The National Acoustic Laboratories was commissioned by CSR Bradford to evaluate the sound power reduction due to lagging a 100mm diameter PVC pipe with 50mm thick Bradford Supertel 32kg/m³ glasswool and covering the glasswool with a wrapping of 4.5kg/m² "Soundlagg".

Introduction

The PVC pipe test sample configuration (attached drawing and photographs) was chosen to simulate as closely as possible the situation in a building which commonly arises and produces noise due to water flowing in a pipe. It was also designed to generate as much water turbulence (and therefore noise emission) as was possible in the limited distance available for water to fall. This design ensured maximum noise emission possible within the dimensional constraints available therefore improving measurement accuracy where high sound transmission loss materials where used.

This test sample configuration was chosen in the absence of any available recognised procedure for testing noise emitted from PVC pipes installed for domestic and industrial purposes in buildings. The noise measurement methods and procedures follow those specified by international and local Standards.

The test installation was measured with and without the addition of acoustical noise reduction treatment and the energy reduction expressed as the noise "insertion" loss of the acoustical treatment material (all measurements are in deciBels re 1picoWatt).

Test Sample Description and Installation

A toilet pan was installed on the top of a "filler" wall constructed between two reverberation rooms at the National Acoustic Laboratories Acoustical test Facility in Sydney. The purpose of this wall was to ensure acoustical isolation between the "water source" room, which contained the water circulation system consisting of toilet pan, cistern, water pump and water reservoir and to provide a means of mounting the test sample.

The pan outlet was coupled to a 100mm diameter PVC pipe which passed through the wall via vibration-isolating acoustic seals, down the other side of the wall via a preconfigured geometry (see attached drawing), The sole purpose of which was to provide sufficient turbulence in water flow to generate a measurable level of noise in the measurement reverberation room. The pipes then passed back through vibration-isolating acoustic seals in the wall to the "water" source room and returned flushed water to the reservoir tank.

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Care was taken during installation to ensure that adequate clearance, as required by AS1217.2, was maintained between the closest sound diffusing elements, the measuring microphone and the PVC pipes when microphone measurement positions were changed. However, the method of mounting the PVC pipe test sample required close proximity of the pipe (noise source) to the test wall for approximately half of the pipe run.

Measurements

All measurements were carried out according to the methods and procedures outlined in AS1217.2 - 1985 *"Acoustics - Determination of Sound Power Levels of Noise Sources" - "Precision Methods for Broad-Band Sources in Reverberation Rooms."*

The wall transmission loss was measured before the test sample water circulation system, toilet pan and cistern were installed and was found to have a Sound Transmission Class rating of STC57.

To our knowledge, no standardised criteria for evaluating noise radiated from pipes exists. In the absence of a commonly used evaluation and presentation procedure the measurements were then processed according to the usual acoustical procedures, rounded to the nearest 0.5dB as required by AS1217.2, and presented in the body of the report. Analyses are compiled as follows:

(i) Sound energy reduction due to acoustical noise reduction treatment within each one third octave band in the frequency range 100Hz to 10000 Hz is calculated. A full analysis is presented on attached spreadsheets.

(ii) The reduction in sound emission summated over the frequency ranges 100Hz to 5000Hz as a linear measurement is presented. The A-Weighted energy was also included in the analysis since this frequency range covers that of most energies generated by speech. A full analysis is presented on the attached spreadsheets.

(iii) The reduction in sound emission, summated over the frequency ranges 100Hz to 10000Hz, is included as a linear measurement. The A-Weighted energy was also summated to complete the spreadsheet results. These measurements were summarised, rounded to the nearest 0.5dB place as required by the Standard and tabulated in the body of the report. A full analysis is presented on the attached spreadsheets.

Note. Sound emission reduction due to acousrtical treatment of the pipes can also be regarded as the "insertion loss" of the specified treatment.

Results

A complete set of measurements was obtained according to the direct method outlined in the Standard. The results were computer processed into sound emission reduction within each one third octave for further analysis. This noise energy was then treated in several ways as follows:

(a) The decibel attenuation in each one third octave band was calculated.

(b) The energy in each one third octave band was summed in the bandwidths 100Hz to 10kHz and 100Hz to 5kHz and expressed as a single figure "linear" sound power decibel reduction in noise emission.

(c) The energy in each one third octave band was then A-Weighted and summed and expressed as a single figure A-Weighted sound power decibel reduction in emission within each stated bandwidth.

A summation of one-third octave transmission loss results to the nearest half deciBel (as required by Australian Standard AS1217.2) is tabulated as follows:

Frequency Bandwidth	Linear Insertion Loss (dB re 1pW)	A-Weighted Insertion Loss (dB re 1pW)
100 to 10kHz	19	22.5
100 to 5kHz	18.5	22

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Measurement Accuracies

- Negative sound insertion loss where listed in the attached spreadsheets and summarised in the body of the report can be interpreted as an increase in noise emission within that one third octave band.

- The spreadsheet summaries (attached) specify deciBel precision at the 95% confidence level for each frequency 100Hz to 5kHz. The uncertainties have been calculated on the basis of there being not more than five chances in one hundred that any value differs from the true value by more than the stated uncertainty. There is an additional uncertainty at 8kHz and 10kHz due to the low reverberation time measurements. However, the error is small compared to the sound pressure levels (refer formula 2 on page of this report) and for practical purposes may be neglected.

Conclusion

The difference in noise energy emission from a 100mm diameter PVC pipe due to lagging with 25mm thick "Soundlagg 4525" (25mm thick acoustic foam bonded to 4.5kg/m^2 "Soundlagg"), was determined to be 19dB (linear) and 22.5dB (A-Weighted) when the energy difference (ie sound insertion loss) was summated over the frequency range 100Hz to 10kHz .

The reduction in noise energy within the frequency range 100Hz to 5kHz was also calculated to be 18.5dB (linear) and 22dB (A-Weighted). Sound Insertion loss within each one third octave band over the range 100Hz to 10kHz can be obtained from an attached spreadsheet (page 12).

Date of test: 1st June 1999

Signatory

for ....

Peter Alway, Manager,
Acoustical Test Facilities
7th July 1999

Reverberation Rooms

Each acoustical test facility reverberation room is approximately 200 cubic metres in volume and fully air conditioned by a special temperature and humidity controlled and acoustically attenuated air conditioning system. The floors are pentagonally shaped, the ceilings are inclined to the plane of the floors and the overall construction ensures that internal opposite facing surfaces are not parallel. Reverberation room construction detail conforms with the sound field diffusivity, volume and shape requirements of International Standardisation Organisation document ISO354 - 1985 "Acoustics, Measurement of sound absorption in a reverberation room".

The reverberation rooms are inside separate isolating rooms which serve as plenum chambers. This construction ensures freedom from flanking noise transmission problems even when very high acoustical sound pressure levels are generated inside either reverberation room.

A sample testing space of approximately 10 square metres is located within an opening in the common wall between the plenum chambers. This wall is part of the sound shell construction and effectively isolates the sample from any vibrational energy which may be generated inside either vibration isolated reverberation room. Any control or test wall constructed as part of a measurement requirement is constructed in this space and is carefully sealed in place to ensure maximum acoustical isolation between the two reverberation rooms

Exposure of either side of any construction filling this test space (to a sound field for the purposes of acoustical transmission loss testing) is achieved via apertures in each reverberation room wall which align with the opening in the common wall of the plenum chambers. Acoustical sealing (at the location of the openings between the reverberation rooms and the wall holding the construction forming part of a measurement requirement) is achieved by means of compliant, high transmission-loss gaskets installed between the reverberation rooms and the common wall between the plenum chambers.

The 300 mm thick walls, floor and ceiling of the reverberation rooms and plenum chambers are made from a heavily reinforced, high density concrete which was poured on site during the construction of the Acoustical Test Facility. The reverberation rooms are vibrationally suspended on damped, high tensile springs resting on neoprene rubber. The each reverberation room suspension assembly forms a two-pole resonant suspension system which is tuned below 5Hz.

The complete mounting system of springs, dampers and high compliance acoustical seals around the test apertures ensures negligible vibrational coupling between the reverberation rooms and minimum interference from outside vibrational sources for all frequencies within the operating range of the two reverberation rooms. Entry to both reverberation rooms and plenum chambers is by means of bi-parting doors.

Sound diffusion within the rooms to ISO Standards testing requirements is achieved by means of non-parallel room smooth concrete surfaces coupled with careful placing of randomly - oriented, suspended panels (19mm thick plywood sheets with a total surface area of 40 square metres heavily coated with epoxy resin).

The panels were suspended in accordance with the tuning requirements of International Standards Organisations Document ISO 354-1985, *"Acoustics-Measurement of sound absorption in a reverberation room"*.

Each room size, geometry, and suspended diffusers ensures that the acoustical performance characteristics fully meet requirements of Australian Standard AS1191-1985.

Sound Power Test Procedure

The microphone in each room was calibrated before the test sequence commenced. Acoustical noise background level was measured in each room to ensure that sewerage pipe measurements obtained were at least 12 dB higher than the background noise.

Twenty four sets of reverberation time measurements were obtained using combinations of three microphone and two loudspeaker positions. Each of the twenty four sets of data contained a measurement of reverberation time in each of the one third octave bands from 50Hz to 10000Hz. Different combinations of loudspeaker and microphone were used to gather a total of twenty four sets of reverberation time measurements.

The toilet cisterns, installed as previously described, were filled with water pumped up from the water reservoir before the measurement sequence commenced. The first pan was flushed and three seconds later a real-time analyser measurement sequence was initiated averaging over a period of 4 seconds. This procedure was repeated for each of the four test set-ups and for six separate microphone positions in the measurement reverberation room.

These six measurement positions had been previously chosen within the "measurement" reverberation room to meet the requirements of AS1217.2 as follows-

a. At least 1700mm distance between measurement positions.
b. Greater than a minimum distance of 0.7 meters from the item under test
c. Positions did not lie in a plane parallel to any surface within the room.
d. A minimum distance of 1 meter from the walls or floor the room.

Six sets of sound pressure level measurements were obtained with the microphone approximately one and a half metres from the floor and a second set of six measurements were taken with the microphone about three metres above the floor. Each measurement was obtained during the period the water was in transit through the pipes.

The purpose of the multiple measurements is to allow a calculation of the mean and standard deviation of each parameter and thus a determination of the measurement accuracy. The microphone calibration, was rechecked after the test sequence was completed. Temperature, humidity and barometric air pressure were recorded at completion of testing.

Calculations

(A) Sound power (**Lw**) in a diffuse sound field is calculated by the following formula

$$Lw = Lp - 10\log_{10}(T/T_0) + 10\log_{10}(V/V_0) + 10\log_{10}(1 + Sl/8V) - 10\log_{10}(B/1000) - 14 \quad \ldots\ldots (1)$$

Where

- L_p = Mean one third octave band sound pressure level (dB re 20uPa)
- V = room volume (cubic Metres)
- V_0 = One cubic metre
- S = room surface area (in Metres)
- B = barometric pressure (in millibars)
- T = Mean reverberation time in room at each frequency (in seconds)
- T_0 = one second
- l = one-third octave band centre frequency wavelength (in Hz)

Equation (1) can be simplified for each one third octave band to

$$Lw = Lp - 10\log_{10}(T/T_0) + 10\log(1 + 0.115\lambda) + 8.9 \quad \ldots\ldots (2)$$

Where is λ is the wavelength of the one third octave band centre frequency
Mean sound pressure level (**Lp**) is determined by the following expression:

$$Lp = 10\log_{10}\{1/n\,(10^{\wedge 0.1L1} + 10^{\wedge 0.1L2} + \ldots 10^{\wedge 0.1Ln})\} \quad \ldots\ldots (3)$$

Errors are determined by means of the following equation:

$$Error = tsdn^{(-0.5)} \quad \ldots\ldots (4)$$

Where

- n = number of microphone positions sampled
- t = students t factor
- sd = resultant standard deviation obtained from the sets of acoustical measurements
- $L_1..L_n$ = r.m.s sound pressures in the various measurement positions 1 to **n** (in dB re 20uPa)
- L_n = the n^{th} sound pressure level (in dB re 20uPa)

Instrumentation

1. Brüel and Kjaer real time analyser type 2123, S/N 1446593
2. Brüel and Kjaer rotating microphone boom type 3923 EO No 14585
3. Brüel and Kjaer cathode follower type 2639, S/N 1447624
4. Brüel and Kjaer cathode follower type 2660, S/N 1337994
5. Brüel and Kjaer microphone type 4144, S/N 1304867, S/N 736654
6. Brüel and Kjaer microphone type 4179, S/N 1307353
7. Yamaha professional sound sources type S500, S/N 1068 and S/N 1069
8. Murray 100 Watt Amplifier type MA534, S/N 15
9. Brüel and Kjaer Sound Calibrator type 4231, S/N 2095393

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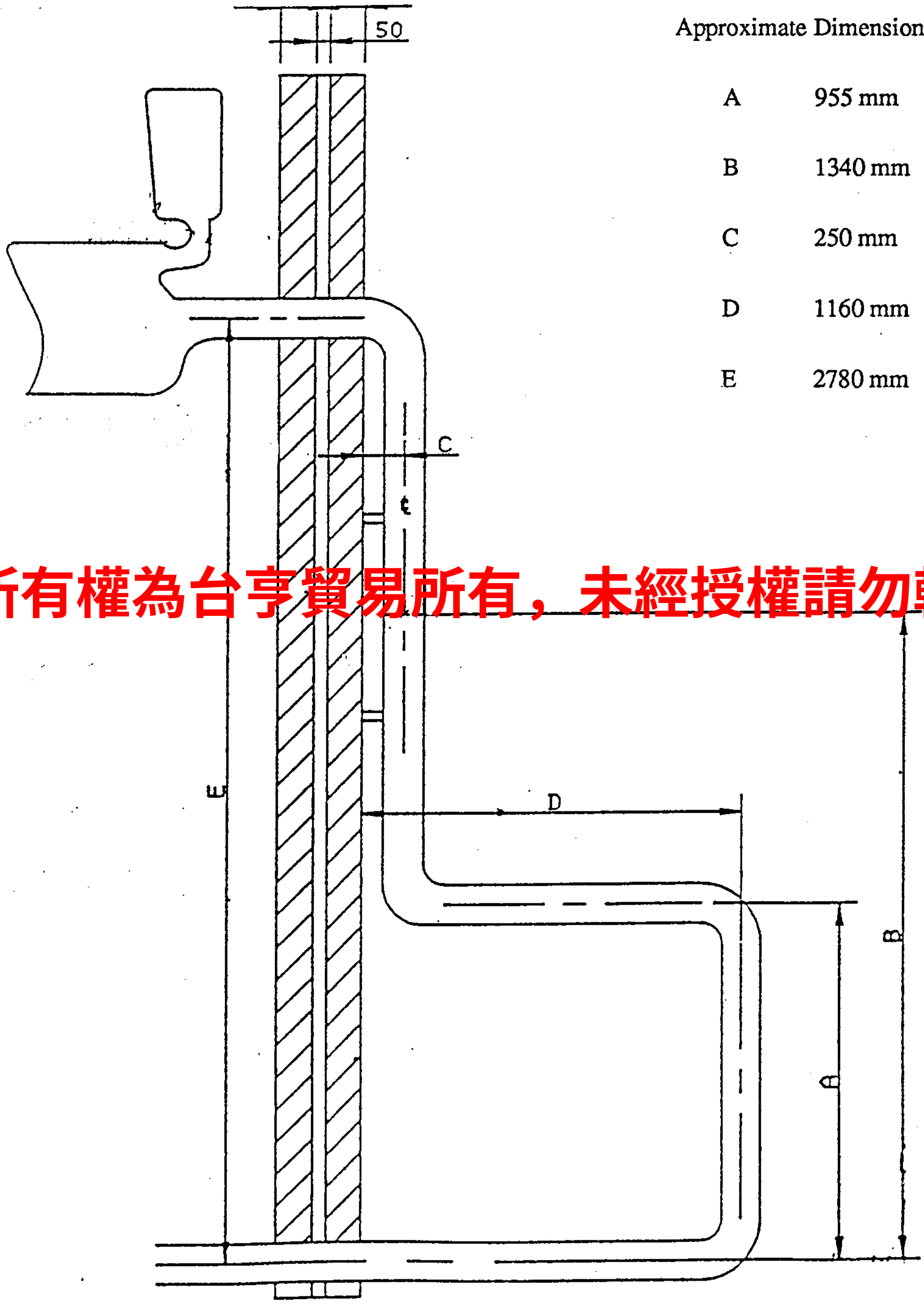
Diagram of the test sample pipe and toilet system assembly detailing approximate dimensions of the various elements



Approximate Dimensions

A	955 mm
B	1340 mm
C	250 mm
D	1160 mm
E	2780 mm

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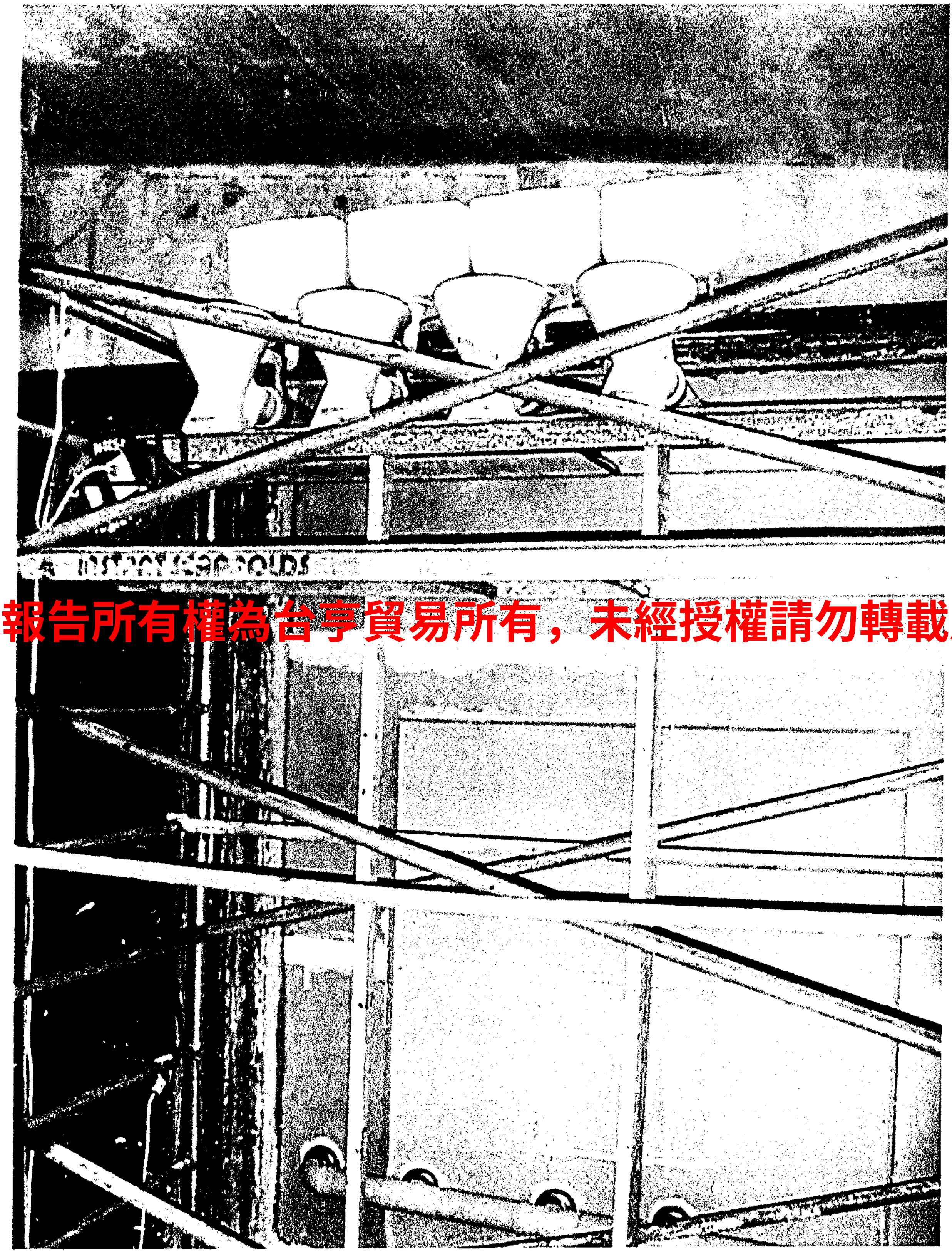
Toilet pan and cistern assembly in the "water source" reverberation room



Pipe assembly showing PVC acoustical treatment in progress in the "measurement" reverberation room

ATF Sound Power Test

Client Name: CSR Bradford

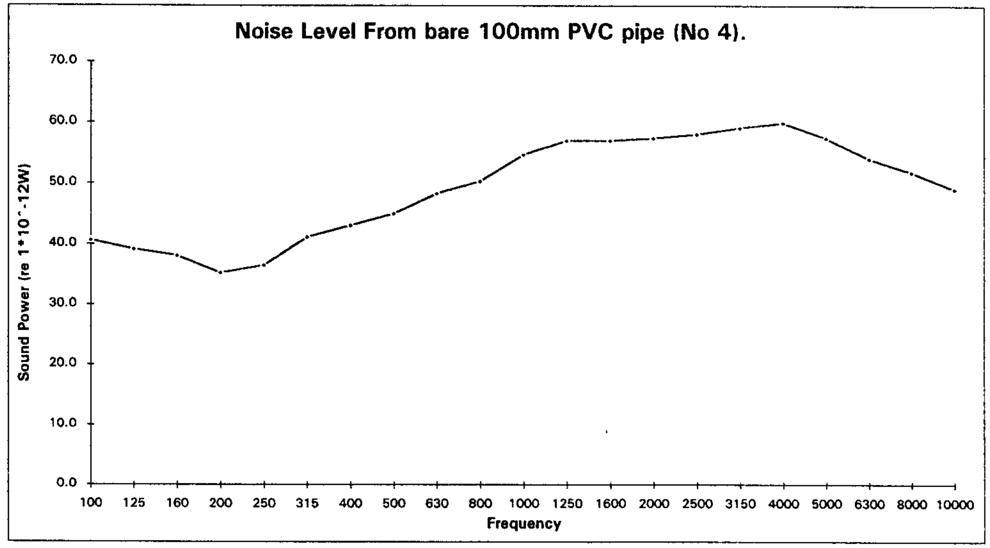
Testing Officer: G. Colin-Thome
G. Hardy

Date of Test: 27-MAY-99

Temperature (°C) 21 | Barometric Pressure (hPa) 1013.6 | Relative Humidity (%) 69

EACH SET IS AN AVERAGE OF
SIX REVERBORATION TIME MEASUREMENTS

Frequency	Av. set 1	Av. set 2	Av. set 3	Av. set 4	Average Rev.Time	95% STD
50	5.55	5.98	5.65	4.75	5.48	1.67
63	3.86	3.79	3.88	4.13	3.92	0.47
80	5.66	4.67	5.46	4.89	5.17	1.48
100	5.81	5.25	5.31	5.28	5.41	0.84
125	7.66	7.59	7.15	7.24	7.41	0.80
160	7.91	8.47	8.09	8.41	8.22	0.84
200	8.76	8.66	8.41	8.24	8.51	0.75
250	8.15	8.27	8.52	8.31	8.31	0.49
315	6.84	7.32	7.25	6.92	7.08	0.76
400	6.73	6.68	6.63	6.76	6.70	0.19
500	6.12	6.29	6.07	5.87	6.09	0.55
630	5.96	5.90	5.74	5.84	5.86	0.30
800	5.36	5.32	5.25	5.28	5.30	0.15
1000	4.80	4.61	4.74	4.62	4.69	0.30
1250	4.41	4.11	4.29	4.24	4.26	0.40
1600	3.86	3.90	3.88	3.91	3.89	0.07
2000	3.34	3.44	3.39	3.38	3.38	0.13
2500	2.95	2.98	2.95	3.01	2.97	0.10
3150	2.65	2.60	2.58	2.65	2.62	0.11
4000	2.31	2.27	2.24	2.27	2.27	0.09
5000	1.96	1.97	1.97	1.99	1.97	0.05
6300	1.62	1.60	1.61	1.60	1.61	
8000	1.28	1.28	1.26	1.26	1.27	
10000	1.00	1.01	1.02	1.02	1.01	



SOUND PRESSURE LEVEL MEASUREMENTS

Frequency	Av. Pos 1	Av. Pos 2	Av. Pos 3	Av. Pos 4	Av. Pos 5	Av. Pos 6	Mean Sound Pressure Level (Lp)	Sound Power (Lw)	95% STD
50	37.08	34.89	38.23	38.40	39.70	38.30	38.00	42.1	
63	34.56	39.88	37.50	42.19	39.61	36.49	39.06	44.2	
80	39.91	39.57	34.81	37.03	38.54	34.41	37.88	41.5	
100	36.87	39.23	35.90	37.14	37.85	37.00	37.46	40.6	2.9
125	39.11	39.03	35.82	36.09	37.17	37.35	37.62	39.1	3.6
160	37.67	37.01	37.69	36.63	38.01	36.05	37.23	38.0	1.9
200	35.37	34.40	34.91	34.51	34.91	34.46	34.78	35.3	1.0
250	36.22	35.81	35.65	36.35	36.33	35.75	36.03	36.5	0.8
315	39.91	39.72	39.87	41.09	40.11	39.92	40.13	41.1	1.3
400	41.85	41.55	42.55	41.70	42.35	41.45	41.93	43.1	1.1
500	43.42	43.95	43.41	43.61	43.46	42.85	43.46	45.0	0.9
630	47.10	46.90	46.20	46.88	46.57	46.37	46.68	48.3	0.9
800	48.66	48.20	47.85	48.65	48.40	48.02	48.31	50.3	0.9
1000	52.20	52.00	51.96	52.07	52.71	51.80	52.13	54.6	0.8
1250	53.90	53.85	53.80	54.71	54.60	53.75	54.12	57.0	1.1
1600	53.85	53.45	53.21	54.21	54.00	53.35	53.70	56.9	1.0
2000	53.85	53.65	53.35	53.83	53.55	53.40	53.61	57.4	0.5
2500	54.10	53.80	53.55	53.64	53.50	53.50	53.69	58.0	0.6
3150	54.80	54.30	53.95	54.08	54.15	54.10	54.24	59.1	0.8
4000	54.95	54.50	54.00	54.31	54.30	54.25	54.40	59.9	0.8
5000	51.85	51.35	50.60	51.26	51.20	51.10	51.24	57.3	1.0
6300	47.75	47.20	46.25	46.81	46.90	46.90	46.99	54.0	
8000	44.70	44.11	42.95	43.56	43.51	43.55	43.76	51.8	
10000	41.31	40.61	39.05	39.60	39.75	39.55	40.05	49.0	

ATF Report No: 749A

CALCULATIONS TO ENABLE THE DETERMINATION OF SOUND POWER

Frequency	LAMDA	10log*(1+(S*LAMDA/8*V)	10logV/Vo	10LOG(T/To
50	6.82	2.51	23.01	7.39
63	5.41	2.10	23.01	5.93
80	4.26	1.73	23.01	7.14
100	3.41	1.44	23.01	7.33
125	2.73	1.19	23.01	8.70
160	2.13	0.95	23.01	9.15
200	1.71	0.78	23.01	9.30
250	1.36	0.63	23.01	9.20
315	1.08	0.51	23.01	8.50
400	0.85	0.41	23.01	8.26
500	0.68	0.33	23.01	7.84
630	0.54	0.26	23.01	7.68
800	0.43	0.21	23.01	7.24
1000	0.34	0.17	23.01	6.71
1250	0.27	0.13	23.01	6.30
1600	0.21	0.11	23.01	5.90
2000	0.17	0.08	23.01	5.30
2500	0.14	0.07	23.01	4.73
3150	0.11	0.05	23.01	4.19
4000	0.09	0.04	23.01	3.56
5000	0.07	0.03	23.01	2.95
6300	0.05	0.03	23.01	2.06
8000	0.04	0.02	23.01	1.04
10000	0.03	0.02	23.01	0.06

ATF Sound Power Test

Client Name: CSR Bradford

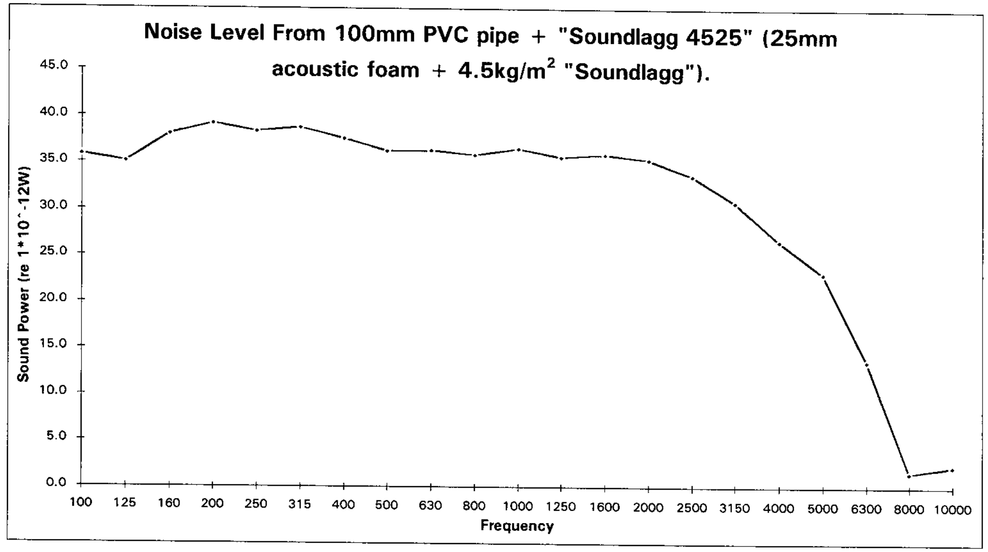
Testing Officer: G. Colin-Thome
G. Hardy

Date of Test: 1-JUN-99

Temperature (°C) 22 | Barometric Pressure (hPa) 1021.9 | Relative Humidity (%) 64

EACH SET IS AN AVERAGE OF
SIX REVERBORATION TIME MEASUREMENTS

Frequency	Av. set 1	Av. set 2	Av. set 3	Av. set 4	Average Rev.Time	95% STD
50	4.19	5.98	5.47	4.81	5.11	2.48
63	3.59	3.38	3.57	3.55	3.52	0.30
80	5.30	5.15	4.45	4.39	4.82	1.50
100	5.41	5.03	5.45	5.19	5.27	0.63
125	6.76	7.39	7.79	7.81	7.44	1.57
160	7.94	7.45	7.04	7.32	7.44	1.20
200	7.31	7.41	7.65	7.58	7.49	0.50
250	7.97	7.64	7.65	7.83	7.77	0.51
315	6.75	6.69	6.81	6.68	6.73	0.19
400	6.34	6.12	5.97	5.98	6.10	0.55
500	5.57	5.75	5.96	5.70	5.74	0.51
630	5.43	5.74	5.48	5.39	5.51	0.49
800	5.15	4.99	5.16	5.06	5.09	0.25
1000	4.34	4.31	4.29	4.27	4.31	0.10
1250	4.16	4.10	4.11	4.02	4.10	0.19
1600	3.84	3.71	3.76	3.72	3.76	0.19
2000	3.27	3.13	3.15	3.23	3.19	0.21
2500	2.86	2.88	2.91	2.88	2.88	0.07
3150	2.58	2.59	2.65	2.58	2.60	0.11
4000	2.24	2.20	2.26	2.20	2.23	0.09
5000	1.89	1.90	1.90	1.91	1.90	0.03
6300	1.56	1.56	1.57	1.55	1.56	
8000	1.21	1.20	1.24	1.22	1.22	
10000	1.00	1.00	1.01	0.99	1.00	



SOUND PRESSURE LEVEL MEASUREMENTS

Frequency	Av. Pos 1	Av. Pos 2	Av. Pos 3	Av. Pos 4	Av. Pos 5	Av. Pos 6	Mean Sound Pressure Level (Lp)	Sound Power (Lw)	95% STD
50	39.58	37.19	39.81	38.05	37.48	41.60	39.24	**43.7**	
63	33.01	31.39	33.24	33.09	31.29	35.96	33.29	**38.9**	
80	33.16	36.73	33.20	30.45	31.16	32.39	33.36	**37.3**	
100	31.21	33.57	30.95	33.13	32.50	33.51	32.60	**35.8**	3.0
125	34.11	34.96	32.61	32.56	32.77	33.90	33.58	**35.1**	2.5
160	37.07	36.64	37.00	36.97	35.41	37.22	36.76	**38.0**	1.7
200	38.25	38.51	38.10	37.76	37.31	38.35	38.07	**39.1**	1.1
250	37.60	38.03	37.87	37.55	37.01	37.40	37.59	**38.3**	0.9
315	37.98	37.51	37.80	37.32	36.60	37.70	37.51	**38.7**	1.3
400	36.36	35.91	36.05	36.49	34.97	36.15	36.02	**37.6**	1.4
500	34.85	34.75	34.80	34.42	33.96	34.30	34.53	**36.3**	0.9
630	34.61	34.71	34.68	34.37	33.51	34.60	34.43	**36.3**	1.2
800	33.45	33.96	33.55	34.18	32.91	33.75	33.65	**35.8**	1.1
1000	33.76	34.05	33.79	33.75	33.25	33.40	33.68	**36.5**	0.7
1250	32.61	32.81	33.15	32.45	32.27	32.45	32.63	**35.6**	0.8
1600	32.81	32.61	32.91	32.45	31.91	32.35	32.52	**35.9**	0.9
2000	31.55	31.66	30.91	31.35	30.85	31.25	31.27	**35.3**	0.8
2500	29.45	29.66	28.85	29.00	28.81	28.90	29.12	**33.6**	0.9
3150	26.15	26.21	25.65	25.80	25.41	25.85	25.85	**30.8**	0.8
4000	21.45	21.30	20.95	21.10	20.50	20.90	21.04	**26.6**	0.9
5000	17.45	17.10	16.60	16.70	16.30	16.70	16.82	**23.1**	1.0
6300	7.15	6.85	6.35	6.40	6.00	6.50	6.56	**13.7**	
8000	-6.25	-6.45	-6.80	-6.70	-6.90	-6.65	-6.62	**1.6**	
10000	-6.60	-6.70	-6.80	-6.80	-6.95	-6.85	-6.78	**2.2**	

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CALCULATIONS TO ENABLE THE DETERMINATION OF SOUND POWER

Frequency	LAMDA	10log*(1+(S*LAMDA/8*V)	10logV/Vo	10LOG(T/To
50	6.82	2.51	23.01	7.09
63	5.41	2.10	23.01	5.47
80	4.26	1.73	23.01	6.83
100	3.41	1.44	23.01	7.22
125	2.73	1.19	23.01	8.71
160	2.13	0.95	23.01	8.71
200	1.71	0.78	23.01	8.74
250	1.36	0.63	23.01	8.90
315	1.08	0.51	23.01	8.28
400	0.85	0.41	23.01	7.86
500	0.68	0.33	23.01	7.59
630	0.54	0.26	23.01	7.41
800	0.43	0.21	23.01	7.07
1000	0.34	0.17	23.01	6.34
1250	0.27	0.13	23.01	6.13
1600	0.21	0.11	23.01	5.75
2000	0.17	0.08	23.01	5.04
2500	0.14	0.07	23.01	4.60
3150	0.11	0.05	23.01	4.15
4000	0.09	0.04	23.01	3.47
5000	0.07	0.03	23.01	2.79
6300	0.05	0.03	23.01	1.94
8000	0.04	0.02	23.01	0.86
10000	0.03	0.02	23.01	0.00

ATF749K
"Soundlagg 4525" (P4)

Linear Calculations

ATF749K | ATF749A

Frequency (Hz)	"Soundlagg 4525" (P4)	SPL/10	$10^{(SPL/10)}$	PIPE-4	SPL/10	$10^{(SPL/10)}$	1/3 Octave insertion Loss
100	35.83	3.58	3827.7072	40.57	4.06	11406.6634	4.7[illegible]
125	35.06	3.51	3207.34	39.12	3.91	8159.53	4.0[illegible]
160	38.01	3.80	6318.66	38.04	3.80	6372.11	0.04
200	39.11	3.91	8151.43	35.26	3.53	3359.88	-3.8[illegible]
250	38.33	3.83	6805.40	36.47	3.65	4440.40	-1.[illegible]
315	38.75	3.87	7492.45	41.15	4.11	13021.12	2.40
400	37.58	3.76	5724.26	43.08	4.31	20343.35	5.5[illegible]
500	36.27	3.63	4237.97	44.96	4.50	31317.17	8.69
630	36.30	3.63	4260.96	48.28	4.83	67237.37	11.9[illegible]
800	35.80	3.58	3803.95	50.28	5.03	106733.37	14.[illegible]
1000	36.51	3.65	4479.86	54.60	5.46	288378.34	18.0[illegible]
1250	35.65	3.56	3672.50	56.97	5.70	497756.47	21.[illegible]
1600	35.89	3.59	3877.42	56.91	5.69	491042.42	21.03
2000	35.32	3.53	3405.91	57.41	5.74	550753.85	22.09
2500	33.61	3.36	2293.95	58.03	5.80	635715.26	24.[illegible]
3150	30.77	3.08	1194.22	59.12	5.91	816399.52	28.3[illegible]
4000	26.62	2.66	459.52	59.89	5.99	973969.50	33.[illegible]
5000	23.08	2.31	203.31	57.34	5.73	541739.18	34.26
6300	13.66	1.37	23.22	53.97	5.40	249322.09	40.31
8000	1.56	0.16	1.43	51.76	5.18	149981.64	50.20
10000	2.25	0.22	1.68	49.02	4.90	79770.64	46.7[illegible]

	$10 \cdot \mathrm{Log}(\mathrm{SUM}(10^{(SPL/10)}))$		$10 \cdot \mathrm{Log}(\mathrm{SUM}(10^{(SPL/10)}))$
(A) SUM (100Hz - 10kHz)	48.66	(B) SUM (100Hz - 10kHz)	67.44
(C) SUM (100Hz - 5kHz)	48.66	(D) SUM (100Hz - 5kHz)	67.05

Broadband Insertion Loss

(B minus A)	18.78	(dB) 100Hz - 10kHz
(D minus C)	18.39	(dB) 100Hz - 5kHz

A-Weighted Calculations

Frequency (Hz)	A-Weighted Adjustment	A-Weighted "Soundlagg 4525" (P4)	SPL/10	$10^{(SPL/10)}$	A-Weighted PIPE-4	SPL/10	$10^{(SPL/10)}$
100	-19.1	16.73	1.67	47.0911	21.47	2.15	140.3326
125	-16.1	18.96	1.90	78.73	23.02	2.30	200.29
160	-13.4	24.61	2.46	288.82	24.64	2.46	291.26
200	-10.9	28.21	2.82	662.57	24.36	2.44	273.10
250	-8.6	29.73	2.97	939.41	27.87	2.79	612.95
315	-6.6	32.15	3.21	1639.17	34.55	3.45	2848.71
400	-4.8	32.78	3.28	1895.48	38.28	3.83	6736.32
500	-3.2	33.07	3.31	2028.42	41.76	4.18	14989.34
630	-1.9	34.40	3.44	2751.11	46.38	4.64	43412.09
800	-0.8	35.00	3.50	3163.99	49.48	4.95	88776.95
1000	0	36.51	3.65	4479.86	54.60	5.46	288378.34
1250	0.6	36.25	3.62	4216.59	57.57	5.76	571500.89
1600	1	36.89	3.69	4881.38	57.91	5.79	618185.78
2000	1.2	36.52	3.65	4489.86	58.61	5.86	726034.97
2500	1.3	34.91	3.49	3094.45	59.33	5.93	857556.29
3150	1.2	31.97	3.20	1574.28	60.32	6.03	1076224.17
4000	1	27.62	2.76	578.50	60.89	6.09	1226154.95
5000	0.5	23.58	2.36	228.11	57.84	5.78	607841.35
6300	-0.1	13.56	1.36	22.69	53.87	5.39	243646.82
8000	-1.1	0.46	0.05	1.11	50.66	5.07	116422.81
10000	-2.5	-0.25	-0.03	0.94	46.52	4.65	44858.33

	$10 \cdot \mathrm{Log}(\mathrm{SUM}(10^{(SPL/10)}))$		$10 \cdot \mathrm{Log}(\mathrm{SUM}(10^{(SPL/10)}))$
(E) SUM (100Hz - 10kHz)	45.69	(F) SUM (100Hz - 10kHz)	68.15
(G) SUM (100Hz - 5kHz)	45.69	(H) SUM (100Hz - 5kHz)	67.87

Broadband A-Weighted Insertion Loss

(F minus E)	22.46	(dB) 100Hz - 10kHz
(H minus G)	22.19	(dB) 100Hz - 5kHz

2/1/99