

Hearing Protector Attenuation Testing



Commissioned By:
EAR-O-TEC

Series 153

From: 2nd to 10th April 2007

Prepared for Ergotec BV
Proprietor of the Variphone Hearing Protector

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1

Introduction

The National Acoustic Laboratories (NAL)¹ was commissioned by EAR-O-TEC to certify “Variphone” attenuation adjustable clear acrylic personally moulded earplugs in accordance with Australian and New Zealand Standard AS/NZS 1270:2002.

These devices were:

- 010407A – Variphone Earplug adjusted to 34 dB (maximum attenuation).
- 010407B – Variphone Earplug adjusted to 30 dB.
- 010407C – Variphone Earplug adjusted to 25 dB.
- 010407D – Variphone Earplug adjusted to 20 dB.

Twenty-two samples of the Variphone Earplug was supplied for testing. Mechanical and Attenuation tests were performed on all samples.

AS/NZS1270: 2002 specifies a minimum of sixteen test subjects for testing earmuffs and twenty subjects required for testing earplugs.

Twenty-two test subjects were selected in conformance with AS/NZS1270: 2002 (ten male and twelve female subjects).

Testing was carried out from the 2nd to 10th April 2007 the results of both the mechanical and attenuation tests are presented on pages 12, 13, 14 and 15 of this report

¹ *The National Acoustic Laboratories is a division of Australian Hearing, a Commonwealth Government Authority*

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Test Environment

All commercial hearing protectors tested by the National Acoustic Laboratories (NAL) except for disposable earplugs, are subjected to a series of both physical and attenuation tests carried out in accordance with Australian and New Zealand Standard AS/NZS 1270-2002 (Acoustics – Hearing Protectors)

Test Facility

The test room meets the requirement of the standard in both the background noise levels and the uniformity of the sound field produced in the subject's position. Both of these sets of parameters were determined from acoustic measurements using certified equipment.

Test Procedure

The attenuation of a hearing protector is determined by measuring each subject's hearing threshold with and without a hearing protector fitted. The difference between these two thresholds is the so-called real-ear attenuation of the protector. A number of test subjects must be used to obtain an accurate estimate of the attenuation. The AS/NZS 1270 standard specifies at least sixteen subjects for earmuffs and earmuffs mounted on helmets, and at least 20 test subjects for earplugs, semi-insert devices, or when earplug/earmuff combinations are being tested. NAL has adopted the same number of test subjects (i.e. sixteen and twenty respectively) in its testing procedure. All test subjects are between the age of eighteen years and forty years old and undergo a hearing test before they are accepted (rejection occurs if their audiogram shows any hearing thresholds below 20dB HTL).

During the hearing protector testing free field hearing thresholds are measured using a fixed-frequency "Bekesy" technique. This is implemented using a computer with signal acquisition/generation hardware and a computer program to automate the test procedure and compile data from the test series.

A pulsed signal comprising a 1/3 octave filtered pink noise of known sound pressure level is presented to the subject. The subject presses a response switch to reduce the sound level (at 2.5dB per second) until they hear the sound disappear, then release the switch increasing the sound level (again at 2.5dB per second) until they hear it again. After five cycles the hearing threshold is determined from the mean of the maximum and minimum values of the last three cycles. Test frequencies are selected automatically in a 1/1-octave step sequence from 125Hz to 8kHz.

The test series recorded with each subject comprise a minimum of two practice open-ear thresholds, one reference open-ear threshold, and an occluded-ear threshold (with hearing protector device) for each device tested.

Real-ear attenuation of a particular device is calculated by subtracting the reference open-ear threshold from the occluded ear threshold for that device.

Test Setup

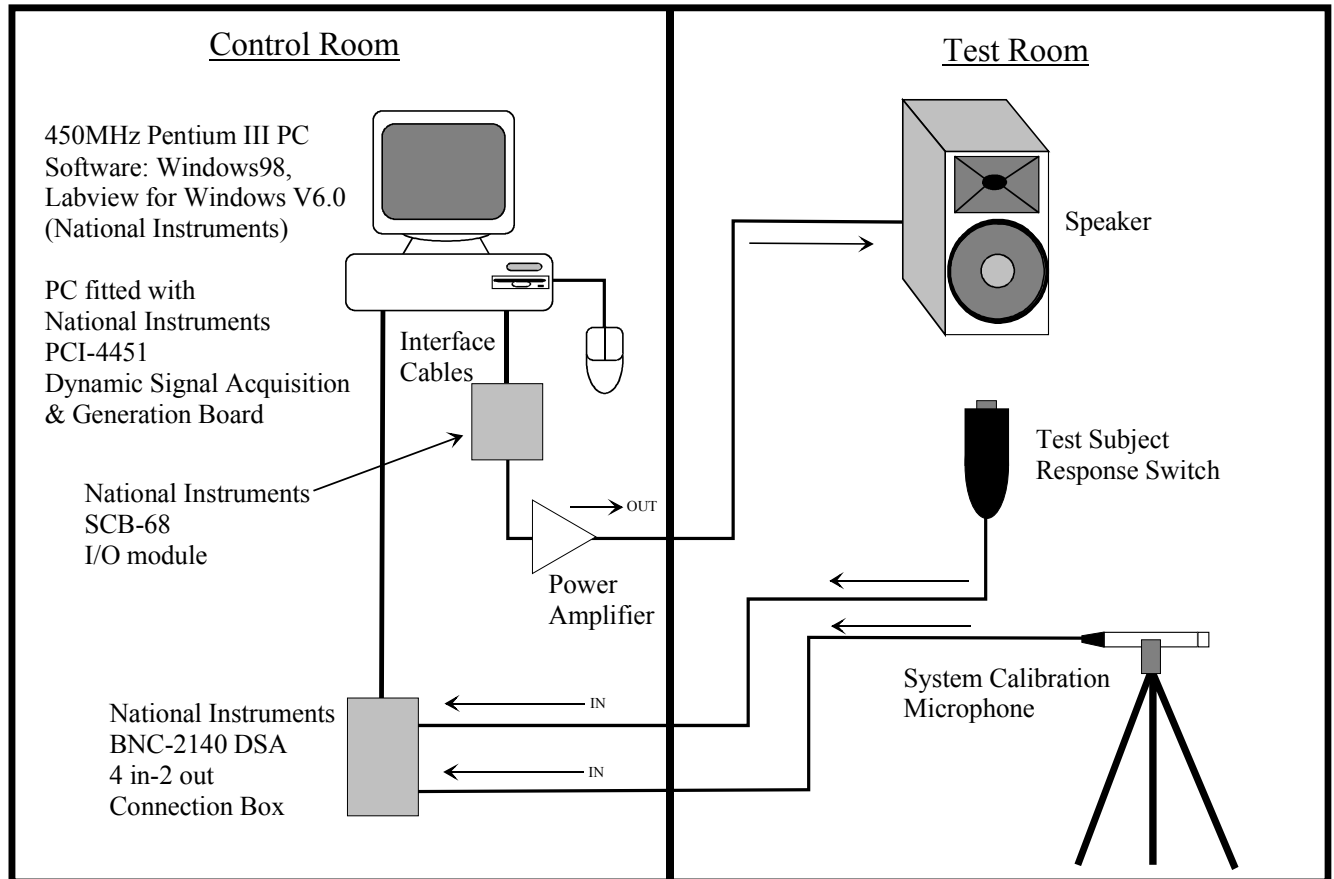


Figure 1 Showing Schematic of Test Equipment

Figure 1 shows the automated test set-up used for attenuation measurements. The test room is parallelepiped in shape with painted concrete walls and carpet covering the floor. The speaker is located in the corner of the room, facing the wall and shielded from the test subject by a glass barrier to shield the test subject from any direct sound. Narrow band sound absorbing panels and Perspex diffusers are placed inside the room ensure that the room meets the reverberation time and sound field diffusion and directionality requirements of the AS/NZS 1270: 2002 Standard.

Before testing commences, the test room sound field is calibrated to ensure a constant sound pressure level is produced across the entire test frequency range. The subject is seated in the middle and slightly towards the rear of the room approximately four metres from the speaker and can be seen by the person conducting the test at all times. A 75dB wide-band noise is available to assist the test subject in adjusting the hearing protector for optimal noise reduction.

Computation of Results, SLC₈₀ and Class

The mean real-ear attenuation and standard deviation at each octave frequency for each device is computed from the test results from all the test subjects using the following formulae: (AS/NZS1270: 2002 p27)

$$\text{Mean} := \frac{\sum_{i=1}^N X_i}{N} \quad \text{Standard_Deviation} := \sqrt{\frac{\sum_{i=1}^N d_i^2}{N-1}}$$

Where: X_i is the attenuation of the i th subject
 d_i is the difference between the mean and the i th subjects attenuation

Standard deviation values indicate the degree of variability of performance of the hearing protector, the larger the value, the greater the variability.

The SLC₈₀ (Sound Level Conversion) value is defined as the difference between the C-weighted sound level of the environment in which the hearing protector is worn and the A-weighted sound level reaching the wearer's ears. The SLC value determined by NAL incorporates a mean minus one standard deviation correction to ensure that the stated degree of noise reduction is obtained on 80% of occasions. For this reason it is called SLC₈₀, the subscript indicating the percentage protection rate.

To compute SLC₈₀, one subtracts the value of the mean minus the standard deviation values from the "Specified Band Levels For Calculation Of SLC₈₀" for each octave band (see Table-1).

Table – 1 Determination of SLC₈₀ (AS/NZS 1270:2002, Appendix-A, pp30-31)

Octave Band Centre Frequency, Hz	125	250	500	1000	2000	4000	8000
(1) Specified Band Level dB	71	81	89	93	95	93	86
(2) Mean-minus-standard deviation, (from test results) dB	6.1	8.4	15.1	26	34.2	34.9	24.3
Attenuated Level (1 – 2) dB	64.9	72.6	73.9	67	60.8	58.1	61.7

SLC₈₀ value is 100 minus the logarithmic summation of all the attenuated level values.

$$\begin{aligned} \text{SLC}_{80} &:= 100 - 10 \log \left(10^{\frac{64.9}{10}} + 10^{\frac{72.6}{10}} + 10^{\frac{73.9}{10}} + 10^{\frac{67}{10}} + 10^{\frac{60.8}{10}} + 10^{\frac{58.1}{10}} + 10^{\frac{61.7}{10}} \right) \\ &= 100 - 77.3 \\ &= 23 \text{ dB (rounded to nearest decibel)} \end{aligned}$$

Hearing protector class is determined from the following table (see table-2)

Table – 2 Specified SLC_{80} for Determination of Class (AS/NZS1270: 2002, Appendix-A, pp30-31)

Class	Specified SLC_{80} dB
1	10 to 13
2	14 to 17
3	18 to 21
4	22 to 25
5	26 or greater

3

Mechanical Testing

Hearing protectors must be subjected to a series of mechanical tests and an attenuation test in order to be certified under the AS/NZS 1270: 2002 standard. Each device must pass the mechanical tests to qualify continuation on to the attenuation measurements. Table 3 shows the mechanical test requirement for each type of hearing protector device.

Table-3 showing required tests (marked with an “X”) for each type of hearing protector.

Type Of Test	Hearing Protector Type				
	Disposable or User Formable Earplugs	Other Earplugs	Ear Canal Caps	Earmuff	Helmet Mounted Earmuffs
A: Physical Examination	X	X	X	X	X
B: Preparation	X	X	X	X	X
C₁: Clamping Force (Test 1)	-	-	X	X	X
D: Dry Heat	-	X	X	X	X
E: Low Temperature Drop Test	-	-	X	X	X
F: Headband Flexing	-	-	X	X	X
C₂: Clamping Force (Test 2)	-	-	X	X	X
G: Attenuation Test	X	X	X	X	X

Here are more detailed descriptions of the mechanical tests “A” to “E” in Table-3 (AS/NZS 1270:2002, Section-2 pp 6-8, & Section-3 pp 9-16).

A: Physical Examination - The hearing protector shall be examined visually to ensure:

- ◆ all parts are free from sharp edges and irregularities that could be a potential hazard or cause discomfort to the wearer.
- ◆ there is no significant damage or distortion present in the device.

B: Preparation - The hearing protector shall be prepared for use according to the manufacturers instructions.

C₁- C₂: Clamping Force - A clamping force measurement is required from each sample of the hearing protector device before and after the temperature tests and the headband flexing (“D” & “E”). Results from the second clamping force test must not vary by more than 20% from the first and will be stated in “Newtons” on the final report.

D: Dry Heat - The hearing protectors are placed in an environmental test chamber and the temperature ramped up to 50°C at a rate of approximately 1°C per 2.5 minutes. This temperature must be maintained for at least 16 hours.

E: Low Temperature Drop Test - The temperature in the environmental test chamber is ramped down to -6°C at a rate of approximately -1°C per 2.5 minutes. This temperature must be maintained for at least 4 hours. Each sample of the hearing protector device must be removed from the environmental test chamber and in the case of head and neckband hearing protectors, dropped once from a height of 1.5 metres on to a 10mm thick steel plate. For helmet mounted hearing protectors each sample is swung once on a 1.0 metre long pendulum against a vertically mounted 10 mm steel plate.

F: Headband Flexing – Each hearing protector is placed on a device designed to flex the hearing protector clamping mechanism through its “normal” operating range over 1000 cycles

Samples Submitted for Testing

Table-4 Hearing protector devices submitted for testing.

	<i>Device Details</i>	<i>Number</i>	<i>Mechanical Test</i>	<i>Mechanical Test Result</i>	<i>Attenuation Test</i>
HP1	Variphone personally moulded adjustable earplug	All	All	<i>Passed</i>	All

Notes on Mechanical Testing

All the devices were examined and prepared for testing according to Section-3 of AS/NZS 1270-2002. All the earplugs were subjected to dry heat testing.

None of the devices showed any evidence of mechanical failure before, during and after testing.

4

Fitting Instructions

Under the test procedures detailed in Section 4.5 of the AS/NZS 1270:2002 standard, the tester must not influence the subject in any way regarding the selection, adjustment or fitting of the device under test. Because of this prohibition, the only information available to the subject is that provided by the manufacturer. However, if the hearing protector is a custom-moulded earplug and it is the manufacture's condition of supply that a competent fitter must train the wearer to fit them. This section details the information supplied by the manufacturer/supplier and used by the subjects to assist them to fit and adjust the device.

Variphone Personally Moulded Earplug.

Each of the test subjects was instructed in fitting the Variphone Ear Plug by a trained representative from EAR-O-TEC. The following fitting instructions are supplied with the Variphone kit.

How to protect your hearing effectively?

- Make it a habit to always wear your Variphone® hearing protectors in noisy environments.
- Never remove the red and blue caps (Fig. 1).
- The attenuation level, based on the noise load in your work environment, is set by the valve opening. **Please do not ever attempt to change this setting.** This must only be done by your supplier.
- Clean your hearing protectors regularly and have them cleaned thoroughly by your supplier annually. Checking the hearing protectors on attenuation and leaktightness is very important for the efficiency of the hearing protector.

Should you have any problems with the level of fitting comfort, please contact your supplier.

How to properly fit the Variphone® hearing protectors in your ears?

1. Take the Variphone® hearing protector with clean hands out of the case. The Variphone® hearing protector with the blue cap fits the left ear and the one with the red cap is for the right ear.
2. Using the right hand thumb and index finger, hold the attenuation valve stem of the right hearing protector. The red cap should be pointed towards you.
3. Place the hearing protector into your right ear whilst turning it about a ¼ turn downwards. The red cap should be pointing towards the ground (Fig. 2). Then set in place.
4. Take the left hearing protector into the left hand and follow the same procedure.

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Test Results

Detailed in this section are the test result certificates for each device listed in Table-6

Table-5 Test Results

Test Certificate Number	Report Page	Device Details
010407A	12	Variphone Earplug adjusted to maximum attenuation (34 dB)
010407B	13	Variphone Earplug adjusted to 30 dB
010407C	14	Variphone Earplug adjusted to 25 dB
010407D	15	Variphone Earplug adjusted to 20 dB

Test Certificate – Variphone Earplug set at 34 dB

*This Certificate details the results of Hearing Protector testing carried out by
The National Acoustic Laboratories*

NAL Certificate No: 010407A **Test Series:** 153
Device Tested: Variphone - Variable Personally Moulded Earplugs - Set to 34 (dB)
Manufactured By: Variphone Hearing Protector

Date Tested: 2nd- 10th April 2007

Test Commissioned By: EAR-O-TEC



Description of Device Tested: A hard clear acrylic personally moulded variable attenuation earplug. The earpieces are connected (corded) via a black plastic cord and the right and left earpiece are fitted with red and blue marker, respectively. These devices were set to 34 (dB), maximum attenuation.

This hearing protector device has been tested mechanically, and its sound attenuation was measured in accordance with Australian and New Zealand Standard AS/NZS 1270-2002.

Mean Reference Thresholds re 20uPa						
125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
32.5	24.9	11.9	11.5	8.9	6.5	11.6

Real-ear attenuation values (dB) at designated octave frequencies							
Subject ID	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
S1	26	29	35	35	36	37	41
S2	31	36	31	30	35	44	48
S3	29	28	36	43	35	39	36
S4	34	36	37	32	37	39	40
S5	28	28	28	29	31	48	40
S6	34	35	39	42	41	38	38
S7	34	41	45	43	32	41	53
S8	24	24	30	31	34	44	39
S9	29	30	37	35	36	39	45
S10	33	31	33	40	38	40	45
S11	26	26	33	34	31	47	42
S12	26	27	27	27	36	42	45
S13	24	20	27	33	37	45	44
S14	26	26	30	30	37	40	36
S15	37	32	36	36	37	45	46
S16	30	32	35	36	37	45	40
S17	30	31	37	40	32	45	41
S18	31	31	36	39	40	46	43
S19	28	26	38	35	38	40	40
S20	36	36	31	39	41	43	50
S21	28	26	22	26	38	44	33
S22	40	39	41	35	36	49	47
Mean	30.1	30.4	33.8	34.8	35.9	42.6	42.3
Standard Deviation	4.3	5.1	5.3	5.0	2.8	3.4	4.7
Mean minus SD	25.8	25.3	28.5	29.8	33.1	39.2	37.6



SLC₈₀ Rating	33	Mass varies from 6 to 12 grams
	CLASS 5	
	Clamping Force N/A	
Newtons		

Signatory: **Dated:**
 (Gordon Jarvis, NAL Research, Acoustic Test Facility)

Test Certificate – Variphone Earplug set at 30 dB

*This Certificate details the results of Hearing Protector testing carried out by
The National Acoustic Laboratories*

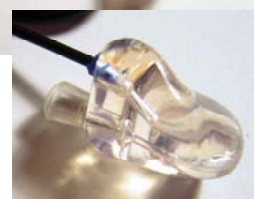
NAL Certificate No: 010407B **Test Series:** 153
Device Tested: Variphone - Variable Personally Moulded Earplugs - Set to 30 (dB)
Manufacture By: Variphone Hearing Protector

Date Tested: 2nd- 10th April 2007

Test Commissioned By: EAR-O-TEC



Description of Device Tested: A hard clear acrylic personally moulded variable attenuation earplug. The earpieces are connected (corded) via a black plastic cord and the right and left earpiece are fitted with red and blue marker respectively. These device were set to 30 (dB) of attenuation.



This hearing protector device has been tested mechanically, and its sound attenuation was measured in accordance with Australian and New Zealand Standard AS/NZS 1270-2002.

Mean Reference Thresholds re 20uPa						
125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
32.5	24.9	11.9	11.5	8.9	6.5	11.6

Real-ear attenuation values (dB) at designated octave frequencies							
Subject ID	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
S1	22	20	23	28	34	38	41
S2	26	28	25	27	34	36	49
S3	19	23	32	34	32	30	38
S4	27	28	28	29	34	31	40
S5	25	23	24	24	31	38	38
S6	24	27	29	36	38	34	37
S7	26	30	35	36	35	39	53
S8	23	23	27	30	32	37	38
S9	18	22	24	25	33	34	46
S10	27	23	30	32	32	32	47
S11	24	23	31	33	30	40	42
S12	21	28	31	27	33	35	47
S13	22	23	31	30	36	38	49
S14	20	21	25	26	36	34	38
S15	28	26	29	32	34	39	45
S16	27	27	29	29	35	35	42
S17	27	29	32	37	30	37	41
S18	28	25	29	34	38	39	43
S19	29	25	37	37	38	41	50
S20	25	29	26	37	38	39	45
S21	24	26	25	26	36	40	30
S22	22	25	27	28	32	33	47
Mean	24.1	25.0	28.4	30.6	34.0	36.2	42.9
Standard Deviation	3.2	2.9	3.6	4.3	2.5	3.0	5.3
Mean minus SD	20.9	22.1	24.8	26.3	31.5	33.2	37.6

SLC₈₀ Rating	29	Mass varies from 6 to 12 grams
	CLASS 5	
	Clamping Force N/A	
Newtons		



Signatory: **Dated:**
 (Gordon Jarvis, NAL Research, Acoustic Test Facility)

Test Certificate – Variphone Earplug set at 25 dB

*This Certificate details the results of Hearing Protector testing carried out by
The National Acoustic Laboratories*

NAL Certificate No: 010407C **Test Series:** 153
Device Tested: Variphone - Variable Personally Moulded Earplugs - Set to 25 (dB)
Manufactured By: Variphone Hearing Protector

Date Tested: 2nd- 10th April 2007

Test Commissioned By: EAR-O-TEC



Description of Device Tested: A hard clear acrylic personally moulded variable attenuation earplug. The earpieces are connected (corded) via a black plastic cord and the right and left earpiece are fitted with red and blue marker, respectively. These devices were set to 25 (dB) of attenuation.

This hearing protector device has been tested mechanically, and its sound attenuation was measured in accordance with Australian and New Zealand Standard AS/NZS 1270-2002.



Mean Reference Thresholds re 20uPa						
125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
32.5	24.9	11.9	11.5	8.9	6.5	11.6

Subject ID	Real-ear attenuation values (dB) at designated octave frequencies						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
S1	19	19	21	26	32	33	41
S2	16	21	19	27	29	31	47
S3	13	16	22	29	30	26	37
S4	18	19	21	22	34	27	36
S5	20	19	23	22	28	37	39
S6	14	18	20	27	32	26	35
S7	13	20	21	26	34	38	45
S8	16	20	23	25	31	30	34
S9	12	14	20	24	27	29	45
S10	21	15	25	25	31	29	49
S11	17	18	25	29	29	32	44
S12	14	18	23	22	31	30	48
S13	13	15	27	25	33	33	38
S14	12	15	20	20	36	28	35
S15	16	16	20	25	28	31	44
S16	21	21	26	27	32	32	37
S17	15	18	21	28	29	33	36
S18	20	17	20	28	35	35	42
S19	22	19	31	33	39	35	43
S20	17	21	21	27	38	32	49
S21	20	22	19	23	33	34	30
S22	15	20	26	22	29	32	43
Mean	16.5	18.1	22.2	25.4	31.7	31.4	40.6
Standard Deviation	3.2	2.4	2.9	3.1	3.2	3.1	5.4
Mean minus SD	13.3	15.7	19.3	22.3	28.5	28.3	35.2

SLC₈₀ Rating	25	Mass varies from 6 to 12 grams
CLASS	4	
Clamping Force	N/A	
		Newtons



Signatory: **Dated:**
 (Gordon Jarvis, NAL Research, Acoustic Test Facility)

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Test Certificate – Variphone Earplug set at 20 dB

*This Certificate details the results of Hearing Protector testing carried out by
The National Acoustic Laboratories*

NAL Certificate No: 010407D **Test Series:** 153
Device Tested: Variphone - Variable Personally Moulded Earplugs - Set to 20 (dB)
Manufactured By: Variphone Hearing Protector
Date Tested: 2nd- 10th April 2007
Test Commissioned By: EAR-O-TEC



Description of Device Tested: A hard clear acrylic personally moulded variable attenuation earplug. The earpieces are connected (corded) via a black plastic cord and the right and left earpiece are fitted with red and blue marker, respectively. These devices were set to 20 (dB) of attenuation.



This hearing protector device has been tested mechanically, and its sound attenuation was measured in accordance with Australian and New Zealand Standard AS/NZS 1270-2002.

Mean Reference Thresholds re 20uPa						
125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
32.5	24.9	11.9	11.5	8.9	6.5	11.6

Subject ID	Real-ear attenuation values (dB) at designated octave frequencies						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
S1	14	16	15	25	31	34	42
S2	12	15	14	22	29	31	43
S3	10	12	18	22	28	37	32
S4	7	8	15	21	25	23	38
S5	12	13	16	22	32	29	37
S6	12	15	18	19	26	33	33
S7	6	11	15	24	31	22	33
S8	9	21	21	30	31	30	44
S9	11	12	16	22	26	25	42
S10	12	11	16	21	26	27	43
S11	6	9	18	26	27	29	42
S12	6	14	18	19	28	27	47
S13	5	6	23	21	34	31	34
S14	7	9	15	20	34	27	35
S15	10	8	15	21	26	28	44
S16	15	15	21	25	30	32	32
S17	7	12	20	26	27	32	33
S18	8	10	15	23	32	33	38
S19	11	16	15	26	36	28	47
S20	7	11	12	18	31	28	33
S21	9	13	18	21	28	30	46
Mean	9.4	12.2	16.7	22.5	29.2	29.3	38.8
Standard Deviation	2.8	3.4	2.6	2.9	3.1	3.6	5.3
Mean minus SD	6.6	8.8	14.1	19.6	26.1	25.7	33.5



SLC₈₀ Rating	21	Mass varies from 6 to 12 grams
CLASS	3	
Clamping Force	N/A	
		Newtons

Signatory: **Dated:**
 (Gordon Jarvis, NAL Research, Acoustic Test Facility)

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Summary

The device was tested for both mechanical and attenuation characteristics in accordance with AS/NZS 1270:2002 Acoustics – Hearing Protectors.

Table 6: Test Result Summary

Device	Type	Test Certificate Number	SLC ₈₀ Rating	Class
HP1	Variphone Earplug adjusted to maximum attenuation (34 dB)	010407A	33	5
	Variphone Earplug adjusted to 30 dB	010407B	29	5
	Variphone Earplug adjusted to 25 dB	010407C	25	4
	Variphone Earplug adjusted to 20 dB	010407D	21	3

All the devices were examined and prepared for testing in accordance with Section 3 of AS/NZS 1270-2002. All the earplugs were subjected to dry heat test.

Twenty-two samples of the Variphone Earplug was supplied for testing. Mechanical and attenuation tests were performed on the three samples.

None of the devices showed any evidence of mechanical failure before during and after testing.

AS/NZS1270: 2002 specifies a minimum of sixteen test subjects for testing earmuffs and twenty subjects required for testing earplugs.

Twenty-two test subjects were selected in conformance with AS/NZS1270: 2002 (ten male and twelve female subjects).

Testing was carried out from the 2nd to 10th April 2007 the results of both the mechanical and attenuation tests are presented on pages 12, 13, 14 and 15 of this report

7

References

1. *Attenuation and Use of Hearing Protectors*. Eighth Edition, National Acoustic Laboratories 1994.
2. *Australian and New Zealand Standard AS/NZS 1269:1998 Occupational Noise Management*. Standards Australia, Sydney.
3. *Australian and New Zealand Standard AS/NZS 1270:2002, Acoustics – Hearing Protectors*. Standards Australia, Sydney.