Instruction Manual

45CB Acoustic Test Fixture According to ANSI S12.42

LI0052 – 19 February 2016

G.R.A.S. Sound & vibration

Revision History

Any feedback or questions about this document are welcome at **gras@gras.dk**.

Revision	Date	Description
1	14 February 2011	First preliminary version
2	31 March 2011	Second preliminary version
3	26 May 2011	First publication
4	9 May 2012	Revision. Specification of ear canal extension length. New pinnae with 3 bolts included in lists and instructions. Instructions for removal of insertion plugs and test of ear canal wear. Difference between measuring with 67SB Blast Probe and 45CB. Specification of diffuse field response.
5	19 February 2016	Included Items p. 6 corrected (->GR1482 Ear Canal Extension)

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Introduction

The Concept

The G.R.A.S. 45CB Acoustic Test Fixture according to ANSI S12.42 is developed to meet the need for a commercially available ATF suitable for tests of hearing protectors at very high noise levels.

The 45CB meets or exceeds the requirements as defined in the ANSI/ASA S12.42 standard: "*Methods for the Measurement of Insertion Loss of Hearing Protection Devices in Continuous or Impulsive Noise Using Microphone-in-Real Ear or Acoustic Test Fixture Procedures.*"

The sturdy 45CB is built to handle a wide range of noise levels—continuous and impulsive—for testing

- Active and passive earplugs
- Active and passive ear muffs
- Circumaural ear muffs integrated in work and safety helmets or designed for use under helmets

It is ideally suited for objective tests of the insertion loss of active and passive hearing protectors subjected to high-level continuous and impulsive noise.

The Design Parameters of the 45CB

It fulfills all the basic requirements of an acoustic test fixture for objective measurements of hearing protectors over a wide dynamic range.

- A self insertion loss greater than 70 dB over a wide frequency range allows for high-level testing of the attenuation of hearing protectors intended for use over a large dynamic range. For more information, see "Verifying the Self Insertion Loss of the 45CB" on page 29 and "Large Self Insertion Loss" on page 31.
- A peak dynamic level of 172 dB allows testing at levels that are realistic even for high impulsive noise environments. Levels of up to 190 dB can be measured /calculated accurately based on closed ear measurements combined with measurement of the transfer function of the open ear (TFOE). For more information, see "Measuring the IL Using Impulse Noise (Above 172 dB)" on page 21.
- The RA0045–S7 Ear Simulator with the built-in 40BP ¼˝ pressure microphone ensures a measurement system fast enough to correctly account for the impulse peaks produced by high-level noise sources, such as heavy industrial and agricultural equipment, guns, and explosive devices.

- The dimensions of the ear canal extensions (L: 14 mm, Ø7.5 mm as required by ANSI 12.42) make it possible to measure the insertion loss of insertion plugs under realistic conditions, that is, at the temperature they achieve when used by people.

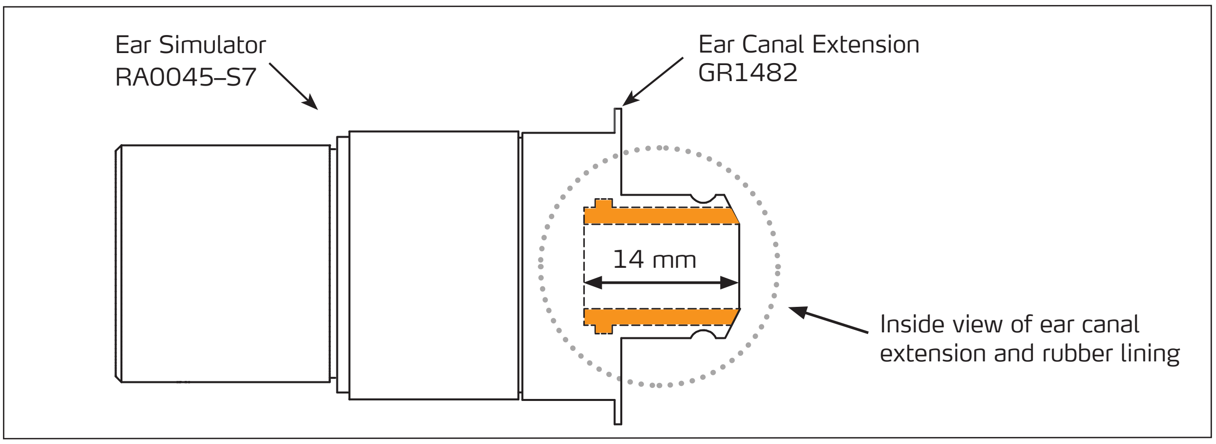

Fig. 1. *The length of the ear canal extension is 14 mm to accommodate insertion plugs.*

- The rubber coating of critical parts of the 45CB, which has the correct shore hardness (55 Shore 00), and a heating system with temperature control make it possible to measure the elastomeric materials of hearing protection devices at body temperature. For more information about the heating system, see "Operating the Temperature Control Unit" on page 11.

- The 45CB is a rugged design that is ideally suited for outdoor measurements.

Using This Manual

This manual describes the basic information you need to know for operating and maintaining the 45CB.

Additional information about the specifications, cleaning instructions, accessories, ordering information, and glossary, are also provided.

The 45CB Package and Accessories

The 45CB Acoustic Test Fixture, ANSI S12.42 is delivered as a pre-assembled package. The following table lists all the items delivered with the 45CB. The contents of the 45CB in its flight case are shown in Fig. 2.

The 45CB Package

Included Items	Part Number
Head assembly, including heating control panel, and connectors for couplers and heating elements	
Two ear simulators based on IEC 60318-4, including 40BP ¼" pressure microphone and GR1482 Ear Canal Extension	RA0045-S7
Two calibration plugs for self insertion loss verification	GR1407
Two ¼" LEMO preamplifiers, very short, with 7-pin LEMO connector and 40 cm lightweight cable	26AS-S3
Left pinna for 45CB, 55 Shore 00	KB0077
Right pinna for 45CB, 55 Shore 00	KB0078
Silicone grease	MI0016
20 mm test plug	GR1511
Hex key, 2.5 mm	YY0023
Flight case with removable wheels	KM0082
24 V DC mains adapter for heating elements	AB0016
Manual	LI0052

Fig. 2. *The 45CB in its flight case.*

Accessories

The following accessories are needed to operate the 45CB, but they are not included in the basic package. They must be ordered separately.

Accessory		Part Number
LEMO Blast Probe Microphone according to ANSI S12.42		67SB
Power module for 45CB:	2-Channel Power Module with gain, filters, and SysCheck generator	12AA
	2-Channel Power Module with Signal Conditioning and Computer Interface	12AQ
Power module for 67SB:	1-Channel Power Module with gain, filters, and SysCheck generator	12AK
Pistonphone:	Intelligent pistonphone	42AP
	Pistonphone	42AA
½” Calibration adapter for KEMAR pinnae		RA0157
3 m LEMO extension cable		AA0008
10 m LEMO extension cable		AA0009
30 m LEMO extension cable		AA0012
100 m LEMO extension cable		AA0014
2 m BNC – BNC		AA0034
3 m BNC – BNC		AA0035
5 m BNC – BNC		AA0036

Unpacking and Packing the 45CB

The 45CB weighs 14.75 kg, so you must take care when lifting it to avoid damaging it or hurting yourself. To make packing and unpacking easier, the 45CB is furnished with a strap around the neck. When lifting the 45 CB from its flight case (Fig. 2), you can use this strap and one of the handles to pry it loose from the protective foam of the flight case and lift it.

When placing the 45CB in the flight case, please ensure that the neck strap is properly placed so that it is accessible the next time you unpack the 45CB.

Getting Started

System Requirements and Setup Examples

The 45CB is pre-assembled and calibrated from the factory. To set up the 45CB for measurements, you must mount the pinnae, provide power for the heating elements, and power and polarization voltage for the ear simulators and the reference microphone. Fig. 3 and Fig. 4 show setups for impulse measurements using the 67SB Blast Probe According to ANSI 12.42 as the reference microphone. The two channels of the 45CB and the blast probe must be connected to a signal analyzer or a PC capable of signal analysis.

Setup with Analyzer with LEMO Inputs and Signal Conditioning

Fig. 3 shows a typical setup with an analyzer that provides signal conditioning. Power supply and polarization voltages are taken from the analyzer. To obtain the full available dynamic headroom, a supply voltage of ±60 V for the ear simulators is necessary. If a 120 V single-ended supply is used, the input to the analyzer must be AC-coupled.
The power for the heating system can be provided by the included mains adapter. For use in the field, you can use truck or car batteries. While the 45CB warms up (approximately 30 minutes), the power consumption is 2.5 A.

Note: The microphones of the ear simulators are polarized and the setup is therefore not CCP compatible.

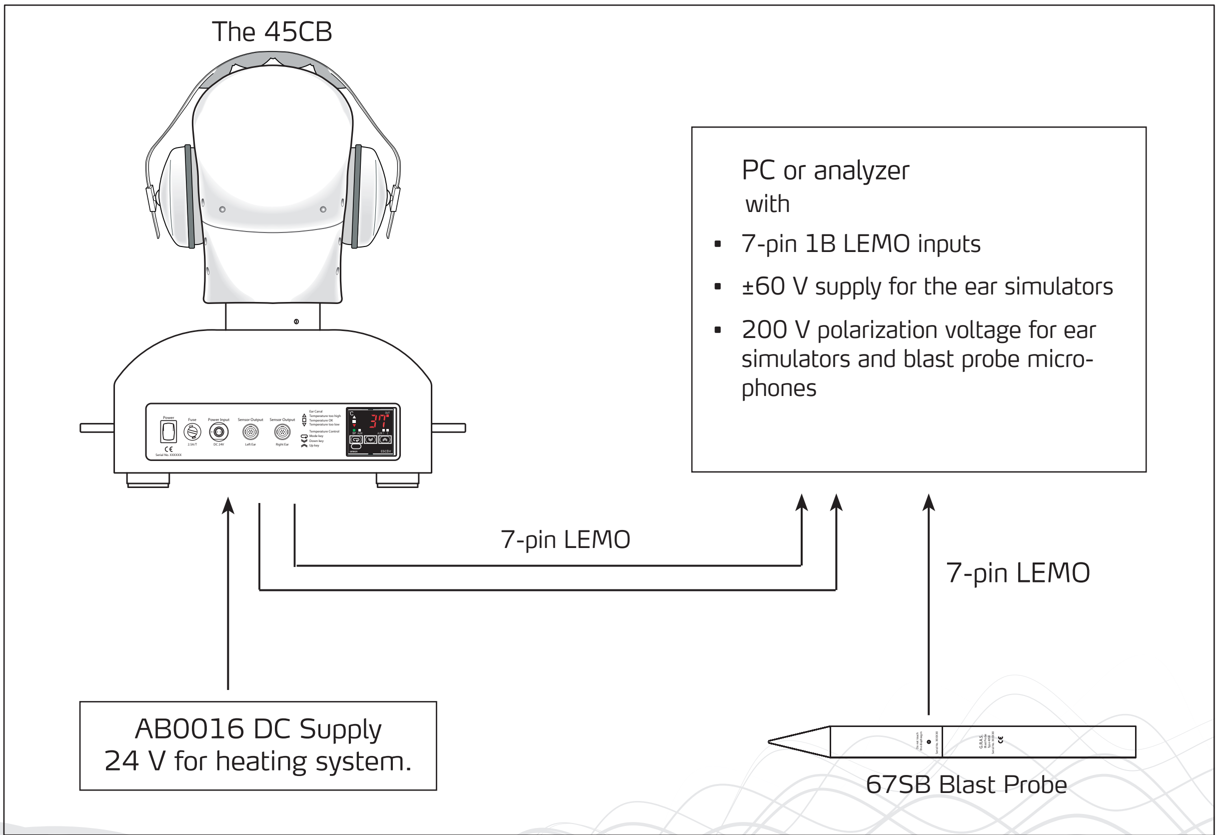

Fig. 3. *The 45CB connected to an analyzer that provides signal conditioning.*

Setup with Separate Power Modules

Fig. 4 shows a typical setup with separate power modules. Power supply and polarization voltages are provided by separate power modules. We recommend the 12AA Power Module because it provides overload indication and gain settings. To obtain the full available dynamic headroom, a supply voltage of ±60 V for the ear simulators is necessary. Alternatively, if a 120 V single-ended supply is used, the input of the analyzer must be AC-coupled.
The power for the heating system can be provided by the included mains adapter. For use in the field, you can use truck or car batteries. While the 45CB warms up (approximately 30 minutes) the power consumption is 2.5 A.

Note: The microphones of the ear simulators are polarized and the setup is therefore not CCP compatible.

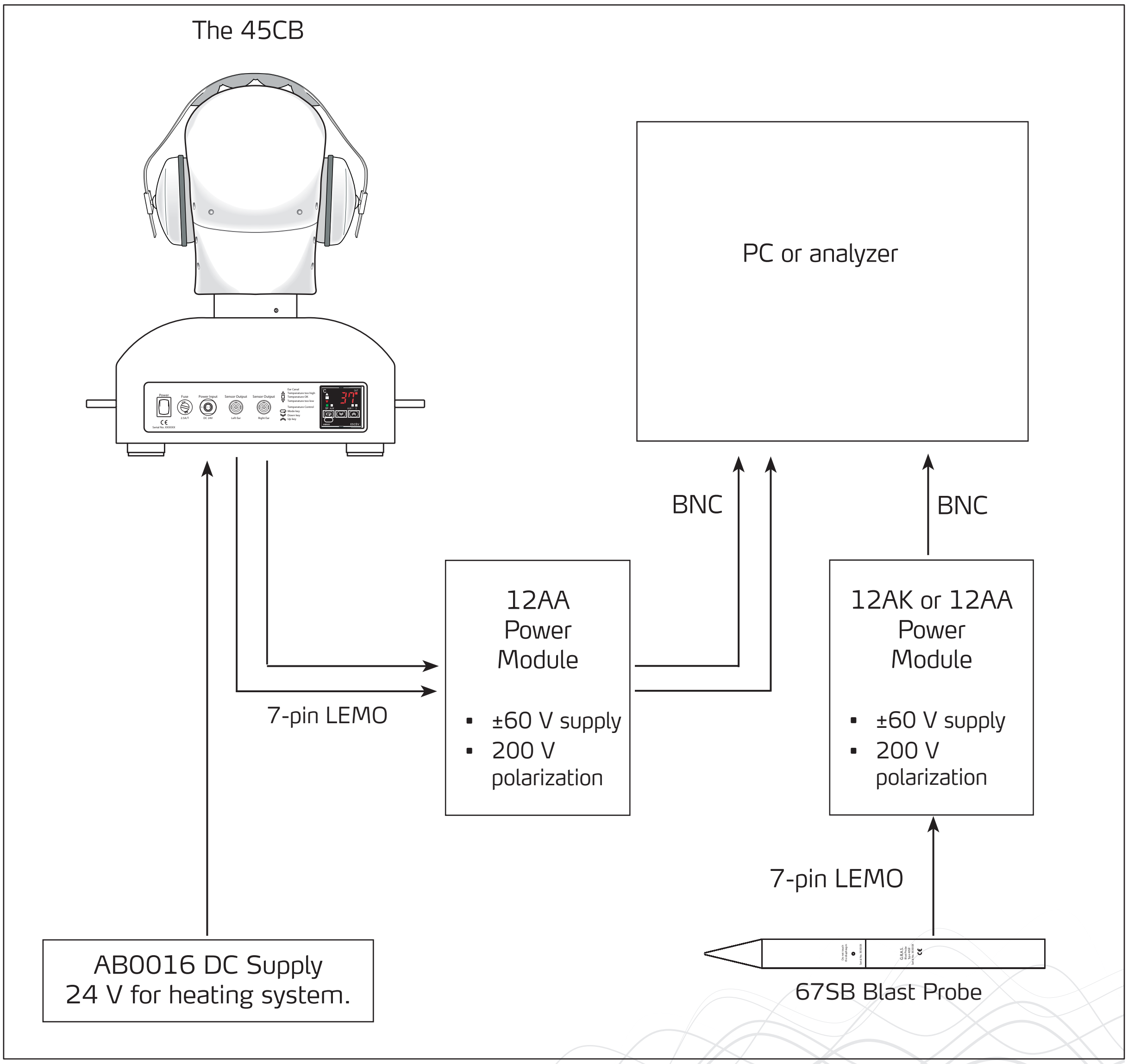

Fig. 4. *The 45CB connected to analyzer via separate power modules providing signal conditioning.*

Attaching and Removing the Pinnae

The 45CB is delivered without the pinnae attached to the head core fixture.

To attach the pinna to the head core fixture, you must align the pinna correctly and press it onto the 12 studs shown in Fig. 4.

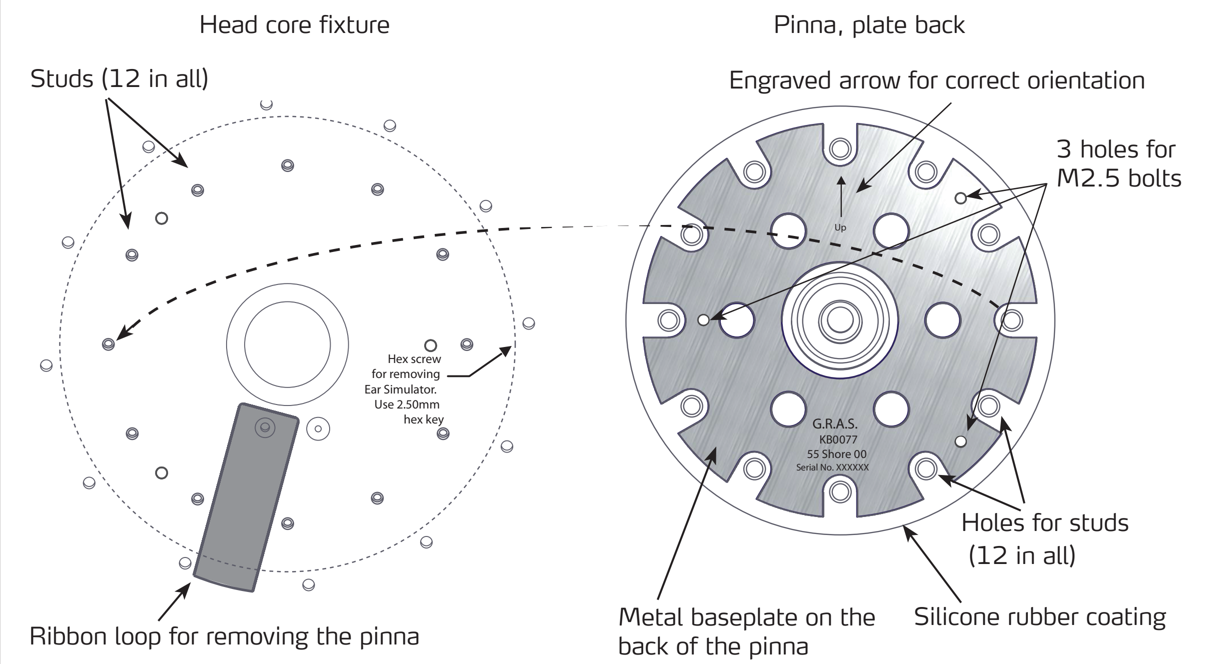

Fig. 5. *Attaching the pinna to the head fixture.*

Attaching the Pinna

1. Make sure the ribbon loop at the bottom of the head lies flat in the recess. (The ribbon loop is used for removing the pinna.)
2. Make sure that the engraved arrow on the pinna points upwards (Fig. 4).
3. Push the pinna gently, but firmly onto the 12 studs, starting at the top and working your way around the full circle. When finished, ensure that the pinna is flush with the head.
4. Fasten the three M2.5 bolts.

Removing the Pinna

1. Loosen the three M2.5 bolts and pull them out.
2. Pull the ribbon to loosen the pinna.
3. Pull the pinna gently off of the studs.

Important: Only use the ribbon loop shown in Fig. 5 to remove the pinna. Do not pull on the ear lobe on the pinna because this can gradually damage the ear lobe.

Operating the Temperature Control Unit

This section explains the temperature display and describes how to operate the heating unit. The 45CB is factory-preset to heating the flesh simulation parts to 37 °C.

The 45CB has a built-in temperature control unit. With this unit, you can heat the silicone rubber in the ear canal extension and on the pinnae to body temperature (37 °C or 98.6 °F) as required by ANSI S12.42.

The control unit heats the head using heating elements attached to the inner surface of the head and a thermocouple for monitoring the actual temperature. When the preset temperature is reached, the control unit maintains and monitors the temperature to make sure it remains at the desired level.

The purpose of a heating unit in the 45CB is to ensure that the silicone rubber parts of the 45CB and the elastomeric materials used in earplugs and earmuff cushions are not unduly influenced by too low a temperature. This is typically the case when the ambient room temperature is lower than the normal body temperature.

With the temperature control unit, you can

- Set the temperature
- Monitor the actual temperature
- Set alarm levels
- Set the unit to display temperature in Celsius (°C) or Fahrenheit (°F)

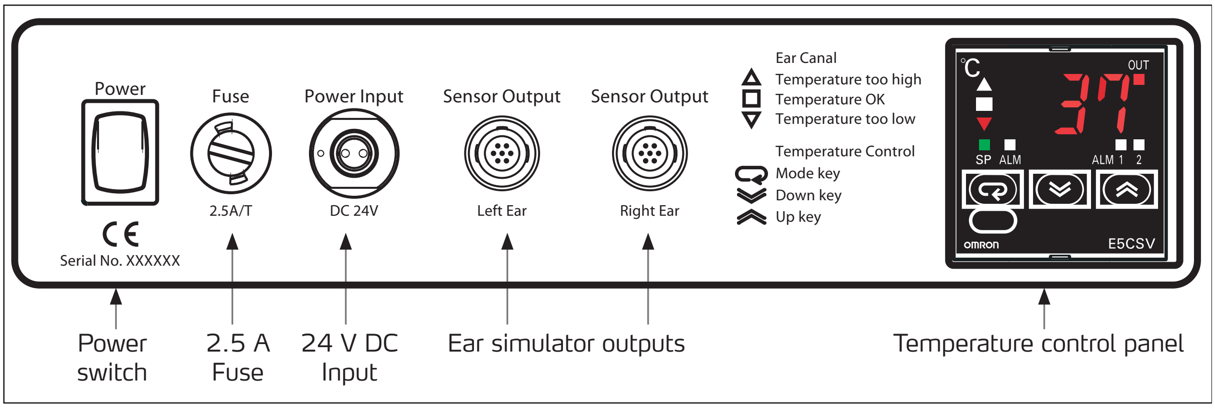

Fig. 6. *The control unit panel on the 45CB.*

This section describes how to use the heating unit in the 45CB. For a complete Omron E5CSV instruction manual, visit www.omron.com.

The control unit has a temperature range of 0 to 199.9 °C and an accuracy of ±1%.

Fig. 7 shows the various parts of the temperature control panel in the control unit.

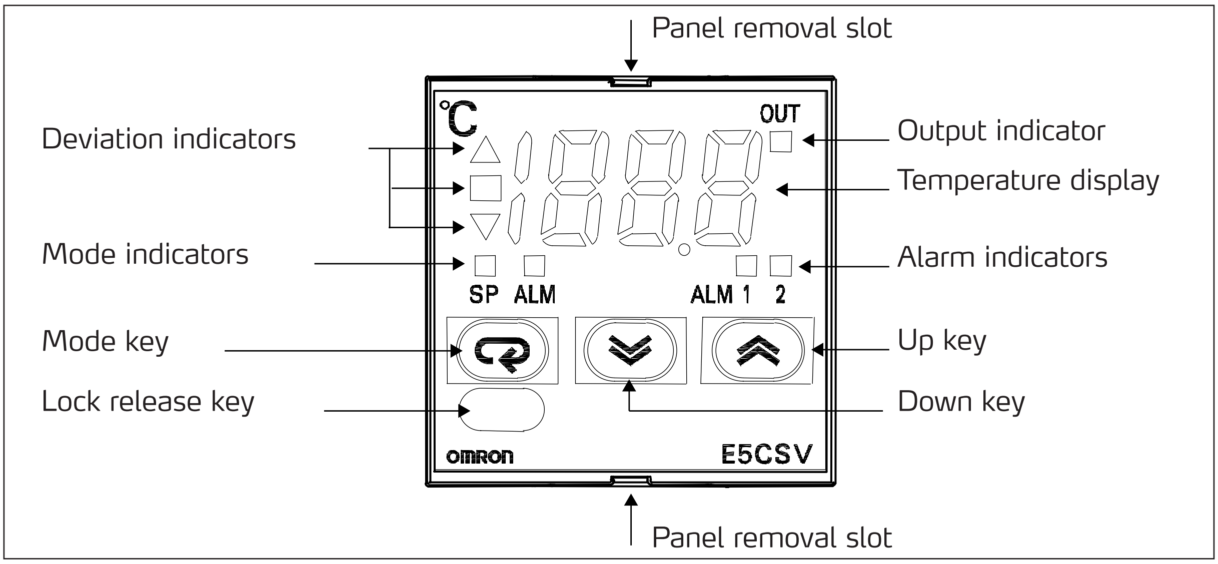

Fig. 7. *The display panel of the temperature control unit.*

The **Mode** key controls what is shown in the temperature display. Pressing the **Mode** key toggles between

- Actual temperature (Mode indicators not lit)
- Set temperature (SP Mode indicator lit)
- Alarm level (ALM Mode indicator lit).

The **Up** and **Down** keys are used to set the temperature in any of these modes.

The **Deviation** indicators show whether the actual temperature is above, equal to, or below the set temperature.

Use of the **Lock release key** is not necessary in this configuration of the 45CB. The **Output indicator** and **Alarm indicators** can be used for visual control.

Starting the Heating Control Unit

To start the unit, connect the power supply to the power input and switch on the power.

When you turn the control unit on, it shows the actual temperature of the test head.

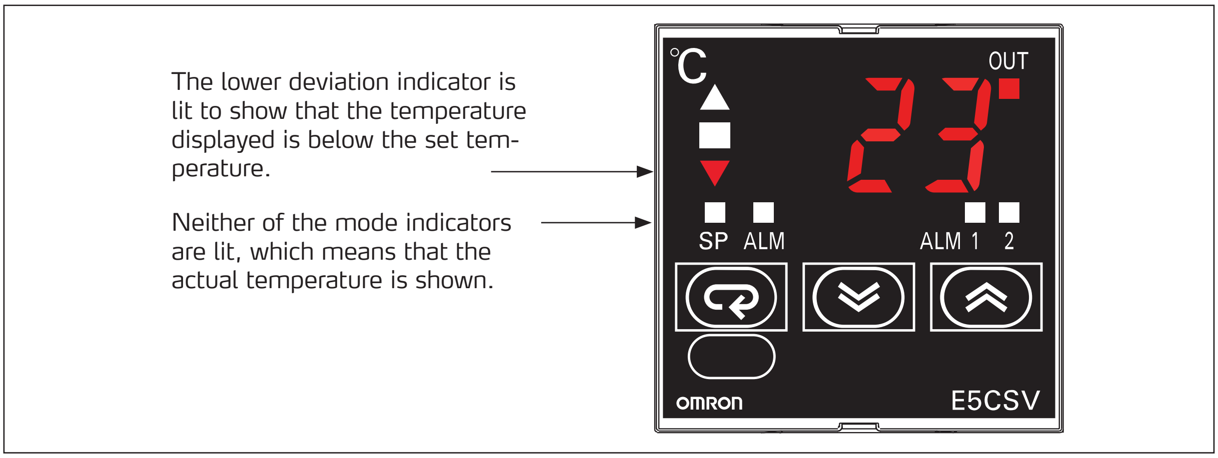

Fig. 8. *The temperature control unit showing the actual temperature.*

Note: The unit takes about 30 minutes to heat the head from 21 °C (normal ambient temperature) to the 37 °C (body temperature) required by ANSI S12.42.

Note: The control unit cannot provide cooling. For the control unit to maintain a temperature of 37 °C for the test head, the ambient temperature must be lower than the temperature setting on the control unit.

By default, the control unit shows the temperature in °C. For information about switching the display setting to °F, see “Switching the Display Settings Between Celsius and Fahrenheit” on page 14.

Setting the Temperature

To set the temperature, the control unit must be in SP mode (set point mode).

1. Press the **Mode** key to toggle to SP mode; the SP indicator light turns green.

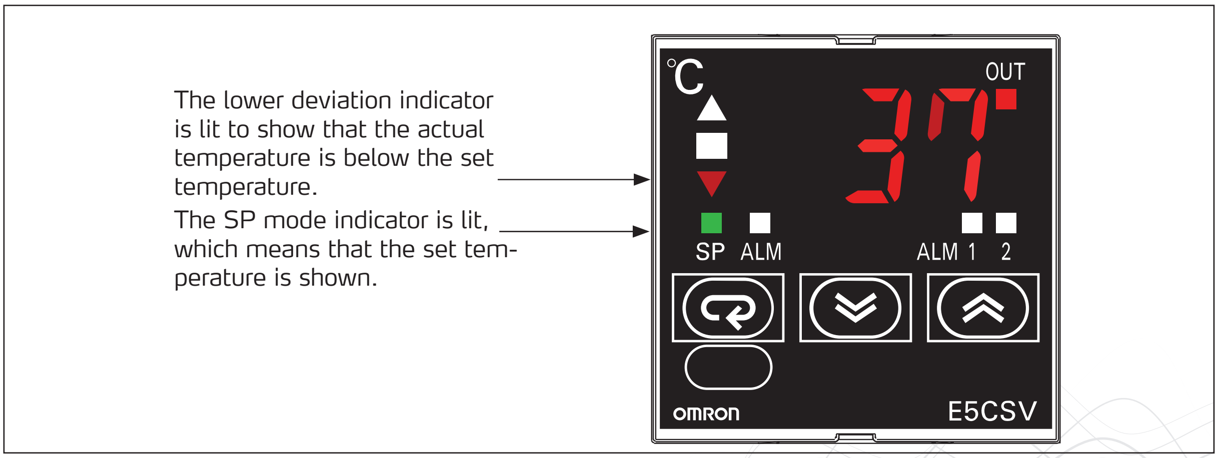

Fig. 9. *The temperature control unit in SP mode.*

2. Use the **Up** or **Down** key to change the numbers until you reach the desired temperature setting.

Fig. 9 shows an example where the set temperature is displayed, but the deviation indicator shows that the actual temperature of the head is lower.

Fig. 10 shows an example where the actual temperature of the head is equal to the preset temperature. You can begin testing in this state.

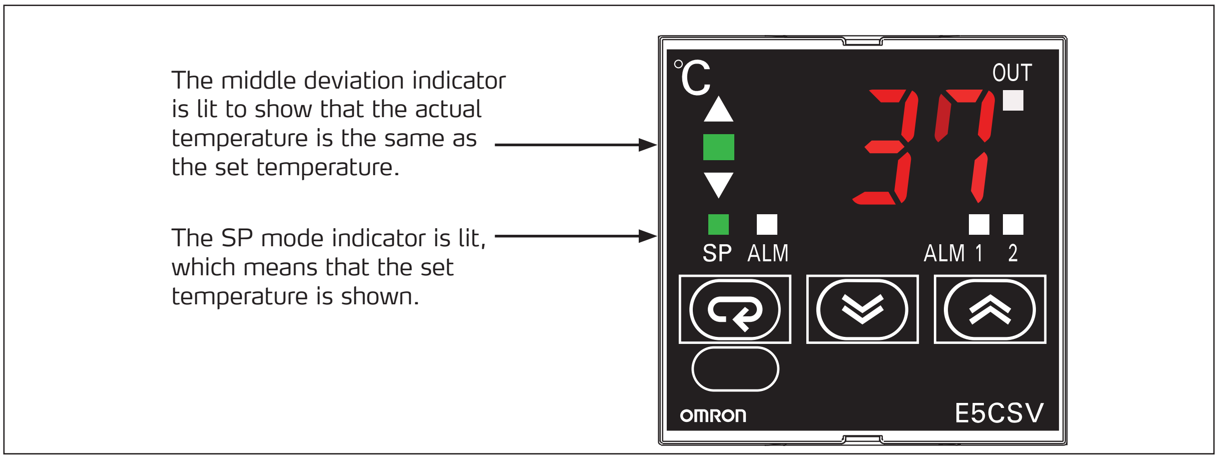

Fig. 10. *The temperature control unit in SP mode where the set temperature is reached.*

Setting the Alarm Level

The alarm settings in the 45CB can be set to alert you to specific temperature deviations in the silicone-rubber coated parts after the unit has reached the preset temperature. Deviation from the desired temperature will be shown on the display.

Switching the Display Settings Between Celsius and Fahrenheit

By default, the temperature control unit displays temperature in Celsius. You can change the settings on the unit to display Fahrenheit.

To change the settings for the temperature display,

1. Remove the front panel by inserting a 2 mm screwdriver in the two panel removal slots at the top and bottom and carefully pulling the panel out (arrow 2 in Fig. 10).

2. On the back side of the display panel, there is a switch group at the base. This is where you will find the Celsius/Fahrenheit switch (Fig. 10). By default, all these switches are pushed down in the off position. Switch number 6 at the far right controls the display of Celsius or Fahrenheit. In the down position, Celsius is displayed. To display Fahrenheit, push the number 6 switch up.

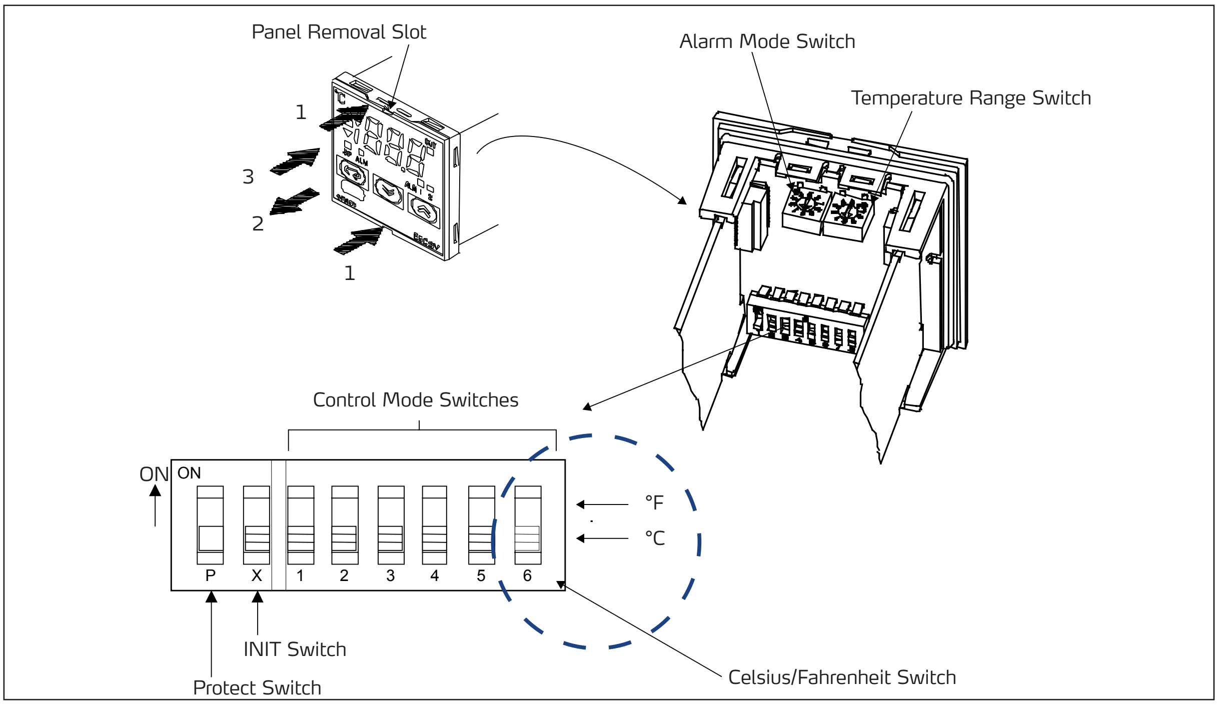

Fig. 11. *Removing the temperature display panel to access the control mode switches to change the setting between Celsius and Fahrenheit.*

Note: For quick temperature conversions regardless of switch setting, the formulas are

Fahrenheit to Celsius: [°F] = [°C] × 9/5 + 32
Celsius to Fahrenheit: [°C] = [°F] – 32 × 5/9

Measuring with the 45CB

Introduction

The 45CB is ideally suited for measurements of hearing protectors where human test subjects cannot be used, that is, when very high noise levels are used and when objective measurements are needed.

The 45CB is a rugged design intended for use in real-life measurement situations because it can withstand high temperatures and high humidity.

This makes the 45CB very versatile so it can be used for measurements with the actual types of noise and surroundings that the protectors under test are intended for.

- It can be used for outdoor measurements as well as other measurement situations approximating real-life conditions: at test sites, inside vehicles, in aircraft, etc.
- It can be used for measurements with continuous noise and impulsive noise and can therefore be used with any type of test signal or real-life noise source.

Continuous Noise Measurements

When continuous noise is used, broadband random noise is recommended as outlined in S12.42. The frequency range must be from 10 Hz to 10 kHz, rolling off at least 3 dB at 80 Hz and 12.5 Hz. Measurements can also be conducted using recorded signals of the type of noise that the hearing protectors are intended to protect against, for example vehicle noise and similar noise sources.

When measuring with continuous noise, a variety of G.R.A.S. free-field and random incident measurement microphones can be used as reference.

The choice will, of course, depend on the specific application in question. For more information, contact G.R.A.S. at gras@gras.dk.

Impulse Noise Measurements

The following is a block diagram of a typical measurement setup for impulse measurements.

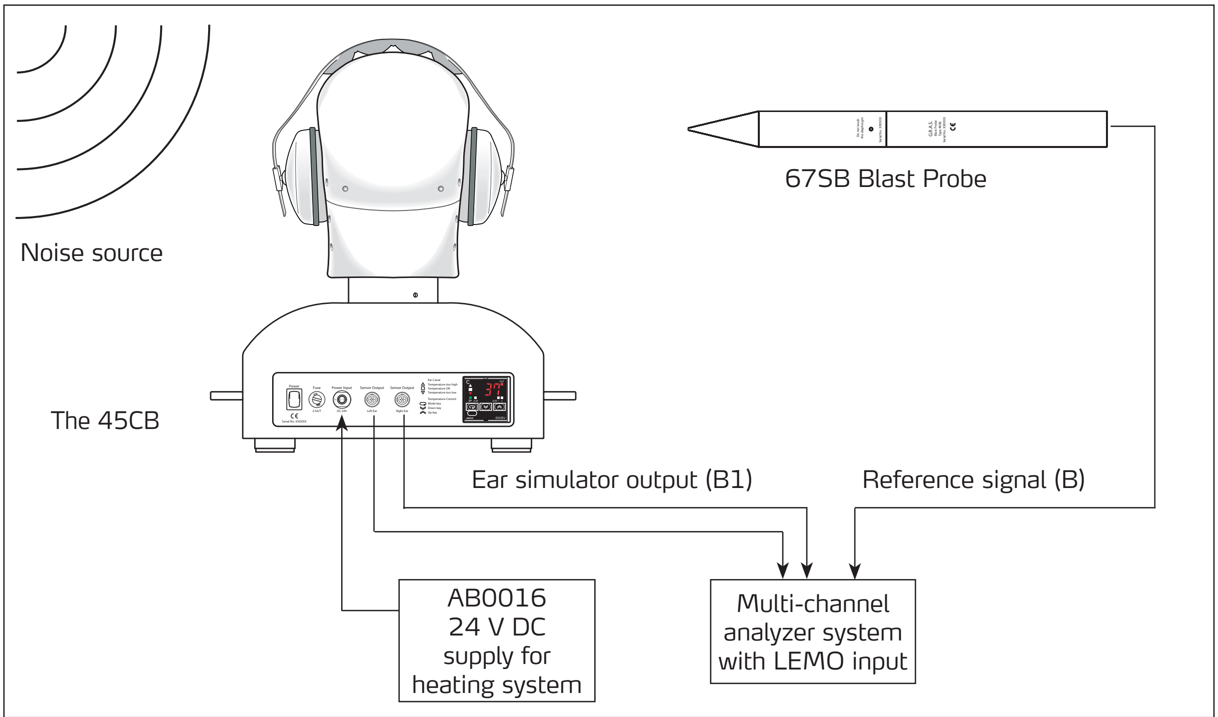

Fig. 12. *Block diagram of a typical setup for the 45CB with the blast probe 67SB providing the reference signal for an earmuff test on the 45CB.*

In the setup example,

- The 24 V DC supply delivers power for heating the silicone-rubber coated parts of the 45CB.
- The two output channels of the 45CB are connected to a multi-channel analyzer. Depending on the connectors used, you can connect the 45CB to a power module, which is then connected to the analyzer. We recommend the 12AQ Power Module in such a setup.
- The impulse for the measurements is generated by a blast tube or an explosive device. (This is indicated by “noise source” in Fig. 12).
- The reference signal is registered by the free-field blast probe. This is used for calculating the insertion loss of the earmuffs being measured.

Positioning the 45CB for Impulse Measurements

Because reflections influence the measurements, it is important that the components of the test setup are positioned correctly.

The first reflection must arrive at least 5 ms after the impulse peak or be 60 dB down compared to the impulse source arriving at the 45CB.

Fig. 13 shows a suggested guideline for a measurement setup. For more information about the correct configuration for a measurement setup, always refer to ANSI S12.42.

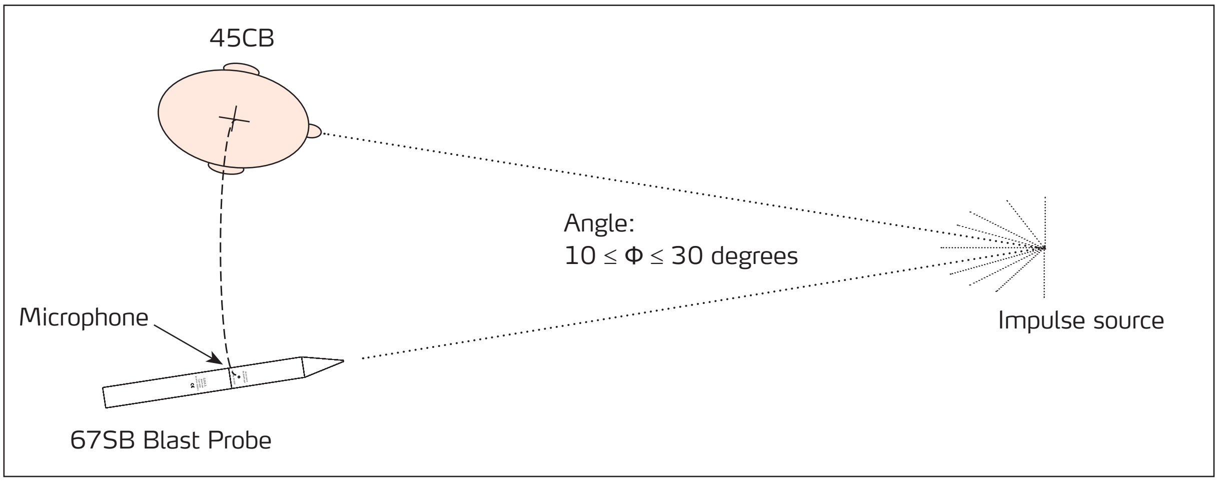

Fig. 13. *Guideline for test setup positioning for measuring an impulse noise.*

Key points to remember for this setup are

- The microphone (diaphragm) in the blast probe (67SB) must be placed at the same distance to the noise source as the ear entrance points (EEP) of the 45CB.
- Both the microphone diaphragm of the blast probe and the EEP of the 45CB must be at the same elevation from the ground.
- The 45CB must face the noise source with only ±3 degrees in deviation. Use the cross mark engraved on top of the head to ensure the correct orientation.
- Both channels of the 45CB should be measured at the same time.
- The level of the peak noise must be measured using a free field blast probe positioned at the same distance from the noise source as the 45CB.
- For more detailed instructions, see ANSI S12.42, section 10.3.3.

Note: The 45CB can also be used for outdoor measurements.

Requirements for the Impulse Noise

To measure the insertion loss of a hearing protector intended for protection against noise generated by blasts, gunfire, etc., you need to generate impulsive noise. You can use the method described in the Annex G, "*Procedure for generation of impulsive noise*" from ANSI S12.42. The impulse noise source can be provided either by a shock tube or an explosive device.

The key points of Annex G are

- The minimum permissible A-duration must be equal to or greater than 0.5 ms, and the maximum must be equal to or less than 2.0 ms. (This is why a shock tube or explosive discharge must be used.)
- The 45CB must be positioned in such a way that reflections from the ground and other surfaces do not interfere with the measurement.
- The peak pressure levels shall be in the range of 130–170 dB
  a) 130–134 dB
  b) 148–152 dB
  c) 166–170 dB

The following shows an example of a suitable impulse signal captured by the 45CB (black) and the 67SB blast probe (red).

Note: The signal measured by the 67SB blast probe will be up to 15 – 17 dB lower compared to the same signal when measured by the 45CB. This is due to the frequency dependent transfer function of the open ear, as shown in the plots starting with Fig. 28 on page 32.

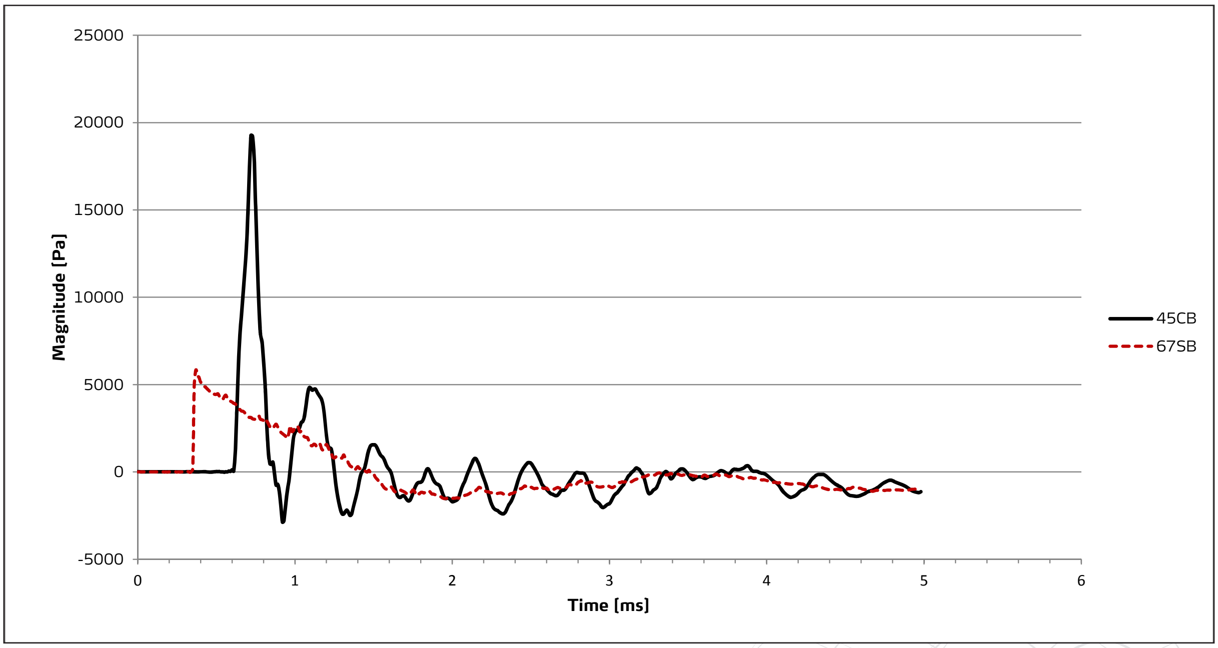

Fig. 14. *Impulse shown in time domain at 170 dB.*

The following table lists suggested amounts of explosives and distances. The table also shows the suggested distances for desired peak levels using blasting caps and C-4 RDX.

Important: Please note that these noise sources must be operated by certified professional experts because of the potential hazards involved in their use.

Reynolds RP 83 Blasting Caps		C-4 RDX		
L_{peak}	Distance	L_{peak}	Mass	Distance
130 dB	42 m	130 dB	7 g	200 m
140 dB	21 m	140 dB	7 g	65 m
150 dB	8 m	150 dB	7 g	26 m
160 dB	2.8 m	160 dB	17 g	11.6 m
		170 dB	35 g	6.5 m

Measuring the Insertion Loss of a Hearing Protector

This section describes how to verify the self insertion loss of the 45CB and how to measure the self insertion loss of hearing protection devices below and above 172 dB.

Measuring the IL Using Impulse Noise (Below 172 dB)

You can measure the third-octave band levels of noise in two conditions to measure the insertion loss (IL) of a hearing protector. The two conditions—open ear and closed ear—are both measured at the eardrum location.

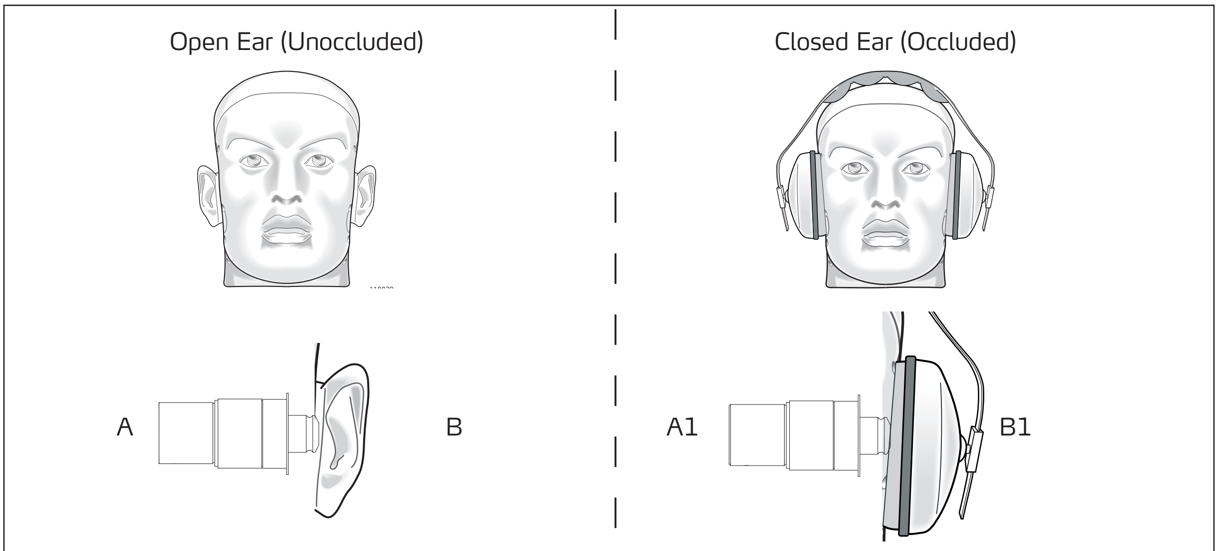

Fig. 15. *Measuring the insertion loss of a hearing protector using impulse noise below 172 dB.*

At levels within the dynamic range of the built-in microphone (that is, below 172 dB), you can determine the IL of a hearing protector by directly measuring and calculating the difference between the sound pressure at the microphone diaphragm with and without protection. The microphone diaphragm represents the eardrum.

The insertion loss (IL) is calculated as the difference between the spectra obtained without and with hearing protectors. The formula is

IL = A – A1

where

A is SPL at the eardrum (microphone diaphragm) without protection.

A1 is SPL at the eardrum (microphone diaphragm) with protection.

Measuring the IL Using Impulse Noise (Above 172 dB)

For very high-level impulse noise, the insertion loss can be calculated by measuring the difference between the noise spectrum obtained in the free field outside the hearing protector and the noise spectrum measured at the eardrum, that is, the measurement microphone in the ear simulator.

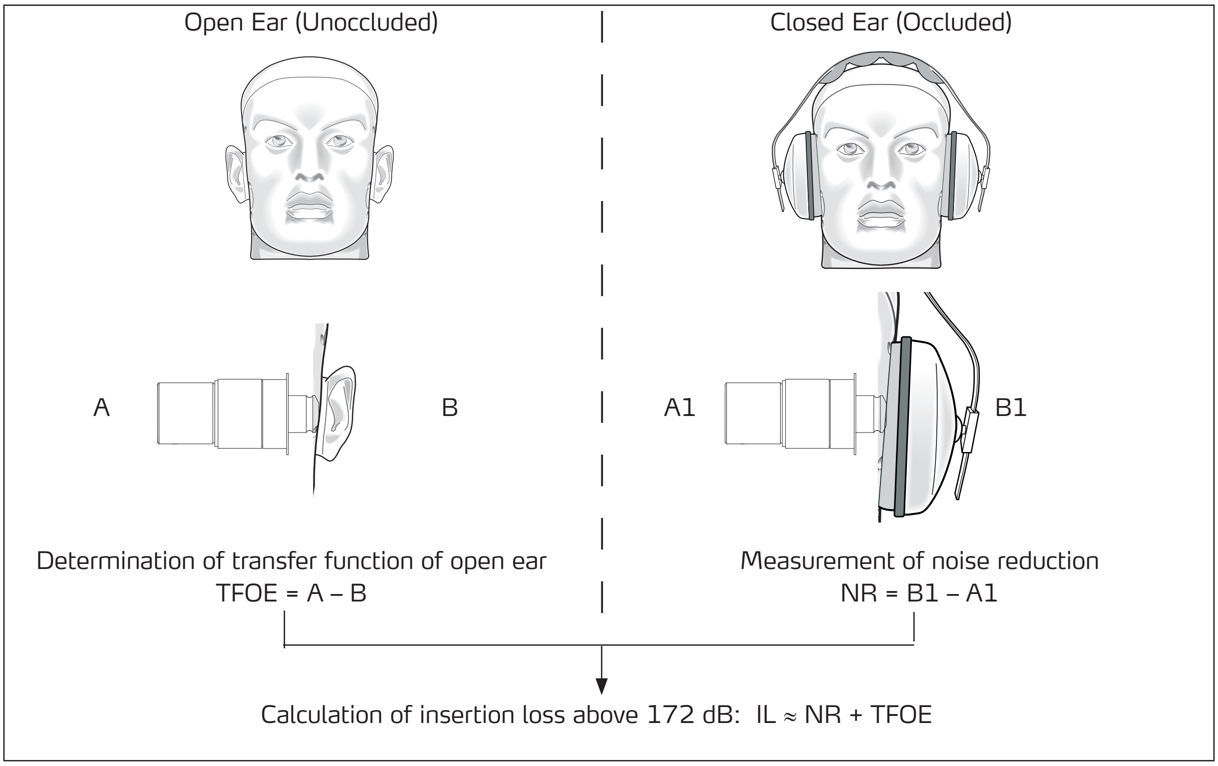

Fig. 16. *Calculating the insertion loss of a hearing protector at levels above 172 dB.*

The microphone in the Ear Simulator can handle a maximum SPL of 172 dB. This means that when evaluating the IL of hearing protectors above 172 dB, a direct comparison of SPL with open and occluded ears cannot be used as this would lead to overload at open ear condition. However, this limitation can be circumvented without compromising the validity of the measurement.

This requires that the Transfer Function of the Open Ear (TFOE)/(the open ear calibration waveform) of the 45CB is measured at a level below the upper dynamic limit of the microphone. The transfer function of the open ear is linear up to 190 dB and does not depend on the peak pressure or duration of the impulse. It closely resembles that of the human ear and, as a result, "hears" or loads a sound source in very much the same way. Because the transfer function can be assumed to be linear up to 190 dB, the TFOE can be measured at, for example, 170 dB and the result computed to correspond to the level used with occluded ears (for example, +20 dB corresponding to 190 dB).

The following steps are required for this type of measurement

1. **Determination of the Transfer Function of the Open Ear**.
   The TFOE must be measured at levels below the upper dynamic limit of the microphone. A number of impulse and continuous noise measurements are recommended. See the left half of Fig. 16.

2. **Measurement of the noise reduction of the hearing protectors above 172 dB.**
   With hearing protectors mounted on the 45CB, measurement of the noise reduction at levels up to approximately 190 dB can be performed. The presence of hearing protectors over the ear simulators will reduce the SPL picked up by the microphones to a level below the peak capacity of the microphone. See the right half of Fig. 16.

3. **Calculation of the IL of the hearing protectors.**
   The Insertion Loss can be calculated by combining the measurements obtained in steps 1 and 2. The formula for calculating the insertion loss is:

   $IL \approx NR + TFOE$

   where NR is noise reduction from step 2 and TFOE is transfer function open ear from step 2.

As mentioned, the TFOE can be measured using impulses at levels between 150 dB and 172 dB. Typical measurements of the TFOE of the 45CB are given in Fig. 28 and Fig. 30. However, to ensure precise results, you need to perform measurements on *your* specific sample of the 45CB. Several averaged measurements using impulse and/or continuous noise are needed.

Caution: Note that the calibration data of the Ear Simulators is not sufficient for this purpose. Measurement of the TFOE of your specific 45CB (= the completed assembly of ear simulator, ear canal extension, and pinnae) is required (see left part of Fig. 16).

An FFT Analyzer is needed for these calculations.

For more information, see ANSI S12.42, Section 11.3, *Computation of the peak insertion Loss*.

Maintenance

Calibration

The 45CB is calibrated in a controlled laboratory environment using traceable calibration equipment before leaving the factory. We recommend calibration prior to each use to ensure the accuracy of your measurements. We also recommend that you send the ear simulators for calibration once a year, either for a traceable calibration or an accredited calibration.

Calibration type	Order number
Traceable calibration	CA0013
Acredited calibration	CA1009

Important: You need to heat the 45CB to working temperature before calibrating. The mean temperature coefficient of the 40BP is 0.01 dB/°C.

Calibrating the RA0045-S7 Ear Simulator

Note: You need the Calibration Adapter RA0157 for this coupler (must be ordered separately).

Pistonphones 42AA or 42AP are suitable. This explanation uses the 42AP.

1. Before you begin to calibrate the coupler, you must remove the pinnae (see "Attaching and Removing the Pinna" on page 10).
2. Loosen the pistonphone's retention collar (Fig. 17).
3. Mount the Calibration Adapter RA0157 into the pistonphone (Fig. 18).

Fig. 17. *Loosen the retention collar on the pistonphone.*

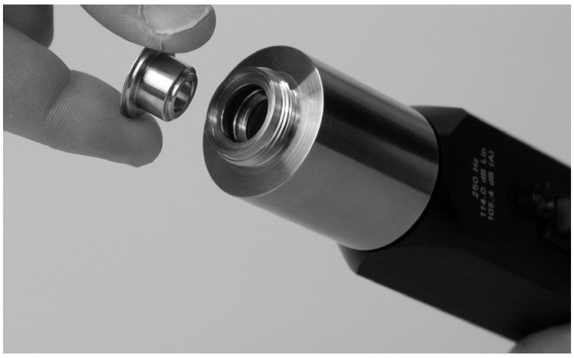

Fig. 18. *Mount the adapter RA0157 on the pistonphone.*

4. Turn on the pistonphone; check that the LED turns green.

5. Place the pistonphone carefully onto the ear canal (Fig. 19).

Fig. 19. *Place the pistonphone onto the ear canal.*

Note: Hold the pistonphone strictly horizontally.

For more information about using the pistonphones, see their respective instruction manual.

Correction Factors

The correction factor for the setup with the 42AP or 42AA pistonphone is –0.92 dB ±0.04.

This means that your analyzer should read: 114.00 dB – 0.92 dB = 113.08 dB ±0.04.

Removing and Mounting the Head

The 45CB is delivered fully assembled, except for the pinnae. You only need to disconnect the head from the shoulder assembly when changing the couplers in the head. When the head is removed from the base, you can access all the internal cables in the head. The Ear Simulator and heating elements are connected to the control panel via female connectors at the neck top plate as shown in Fig. 20.

Removing the Head from the Shoulder Assembly

1. Loosen the two 2.5 mm hex screws at the 30 and 90 degree marks on the neck and gently lift the head off the shoulder assembly.
   You may need to *gently* rock the head while lifting at the same time.

Caution: The cables are short and all connectors must be disconnected before the head can be set aside.

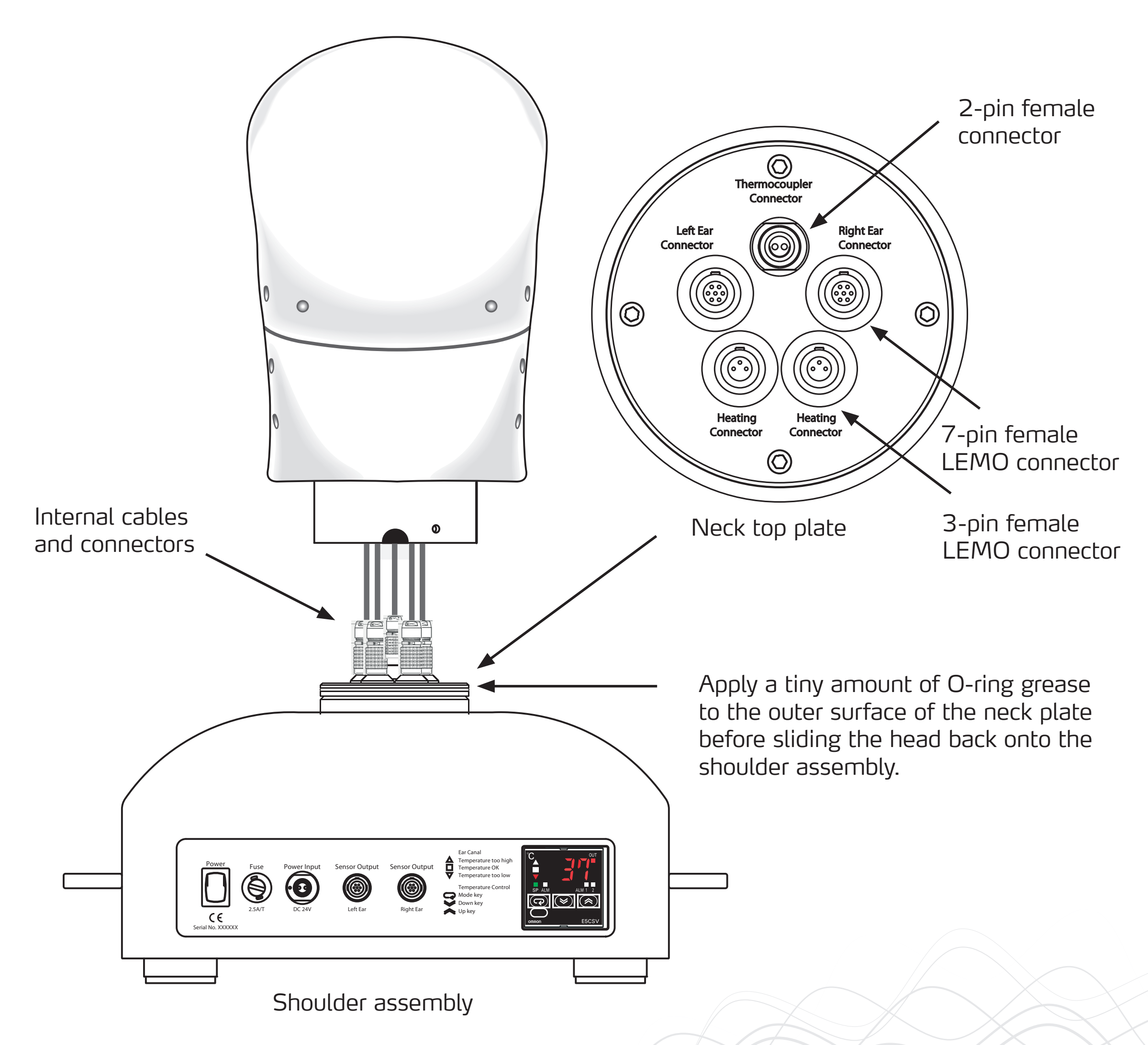

Fig. 20. *Internal shoulder to head connectors.*

2. Disconnect all 5 cable connectors from the neck top plate.

3. Place the head on a plane surface

Caution: Avoid placing the head on the cables. As shown in Fig. 21, the neck ring has a semi-circular opening intended for cables that do not need to remain inside the ring. When removing the head to dismount the ear simulators, keep the cables inside the ring so that they can come out with the couplers without strain.

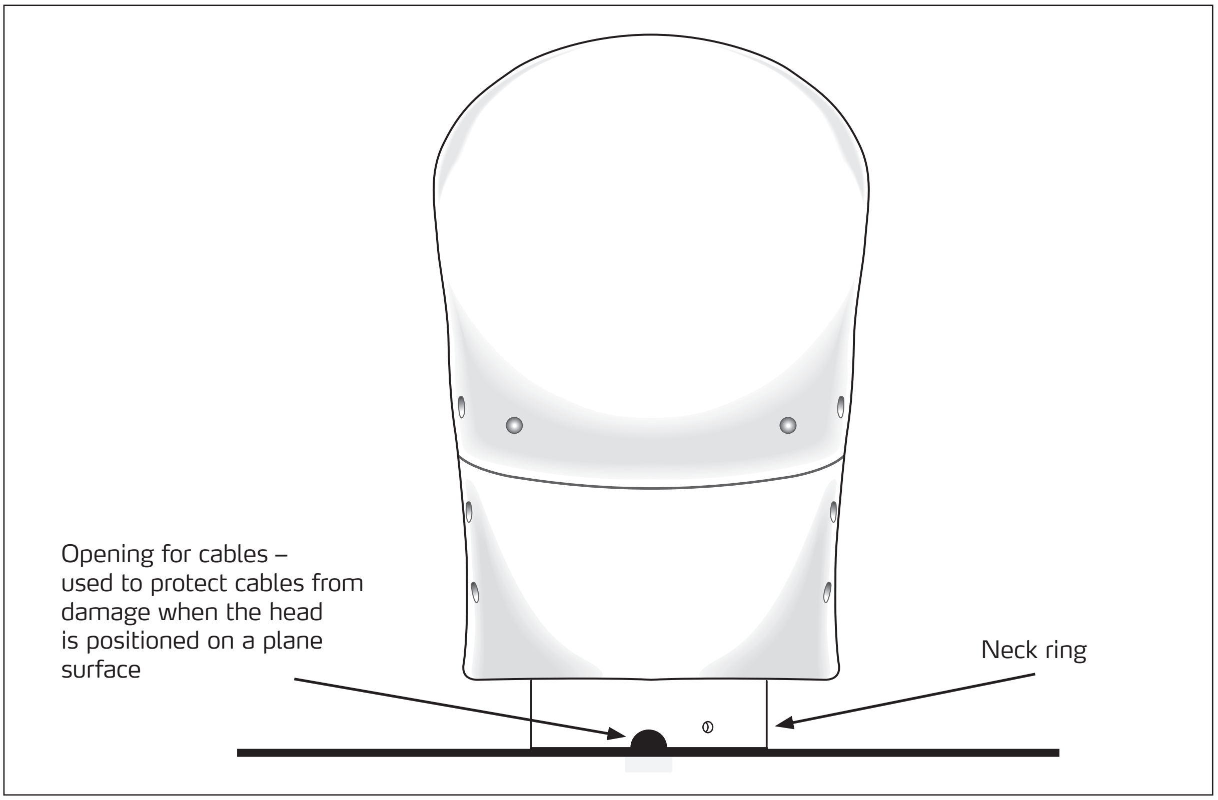

Fig. 21. *The semi-circular opening for cables at the rear of the neck ring.*

Removing the head and cables can be done by one person. However, because the head is heavy and the cables and connectors are sensitive to strain, it may be safer to assign two people to the task so that one person can hold the head above the shoulder assembly while the other disconnects the cables.

Mounting the Head onto the Shoulder Assembly

1. Before you mount the head on the shoulder assembly, connect all shoulder-to-head cables.

Note: Apply a tiny amount of O-ring grease to the outer surface of the neck plate before sliding the head back onto the shoulder assembly.

2. Make sure that the left and right sensors are connected correctly (right to right, left to left). Slide the head gently onto the shoulder.

3. Secure the assembly by fastening the two 2.5 mm hex screws in the collar.

Removing Insertion Plugs

When removing insertion plugs, pulling them out will also force the soft rubber around the ear entrance to move outwards, causing excessive wear.

To avoid this, keep the area behind the ear entrance depressed while pulling out the plug. Fig. 22 shows where to press while pulling.

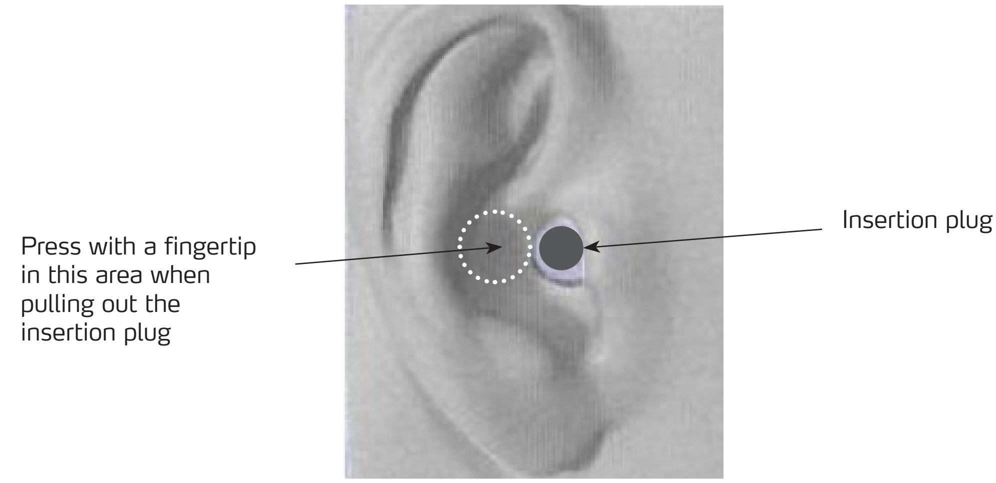

Fig. 22. *Removing an insertion plug.*

Checking the Ear Canal Extension for Wear

Every time an insertion plug is pulled out, the friction involved will cause wear to the rubber lining. As suggested in 6.7 of the ANSI S 12.42, check it periodically for deterioration that might affect insertion loss measurements. A 20 mm long cylindrical plug is part of the 45CB delivery for this purpose. Keeping a log of the PIL (Passive Insertion Loss) with this plug will give you a clear indication of the wear.

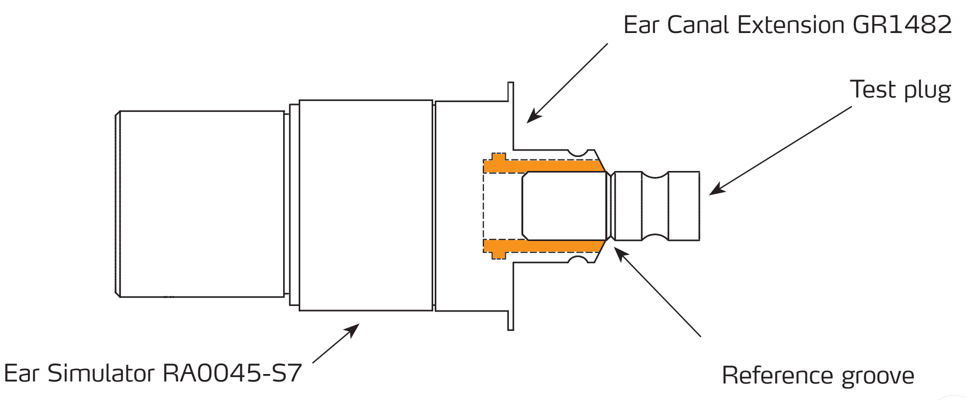

Fig. 23. *Plug for checking of wear to the rubber lining of the ear canal extension.*

Inserting and Removing the Ear Simulator/Ear Canal Extension Unit

The 45CB is delivered with the Ear Simulator and the Ear Canal Extension pre-assembled and in place, along with the preamplifiers and the cables. This section describes how to remove and insert these parts.

To remove the Ear Simulator/Ear Canal Extension:

1. If the pinna is in place, remove it by pulling the ribbon loop. See “Attaching and Removing the Pinnae” on page 10.
2. Loosen the 2.5 mm hex screw through the hole in the back of the head. (An arrow on the head indicates the location of this screw. See the left drawing in Fig. 5)
3. Gently pull out the coupler assembly.

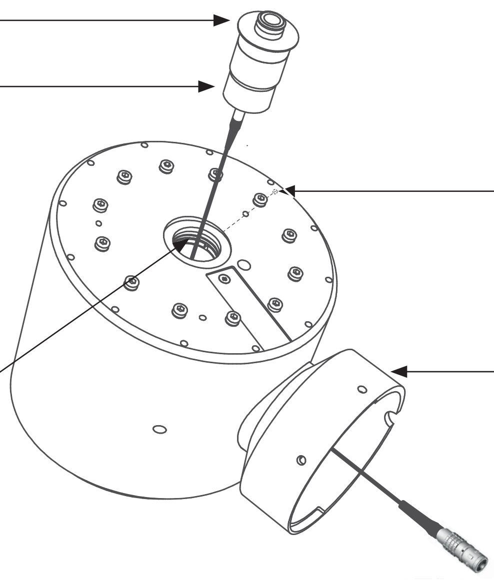

Fig. 24. *Removal and installation of the Ear Simulator and the Ear Canal Extension unit. The core head fixture is seen from below, without the head simulation parts and pinnae.*

To insert the Ear Simulator/Ear Canal Extension Unit:

1. Apply a small amount of grease (MI0016) to the O-ring in the 45CB to make a sealed fit (Fig. 24).
2. Gently push the assembled coupler unit (Ear Simulator RA0045–S7 and Ear Canal Extension GR1482) as far as it will go into the hole.
3. Secure the coupler by tightening the 2.5 mm hex screw at the back of the head.
4. Check that the coupler unit is properly secured by gently pulling it outward.

Verifying the Self Insertion Loss of the 45CB

This section describes how to verify the self insertion loss of the 45CB. To measure the self insertion loss of the 45CB, use the two calibration plugs that are delivered with the 45CB. The 45CB is delivered with the open Ear Canal Extensions GR1398 already in place. Replace these ear canal extensions with the calibration plugs to verify the 45CB's self insertion loss. The calibration plugs are similar to the ear canal extensions, but they are not open. Both the plugs and the ear canal extensions are thread-mounted onto the ear simulator.

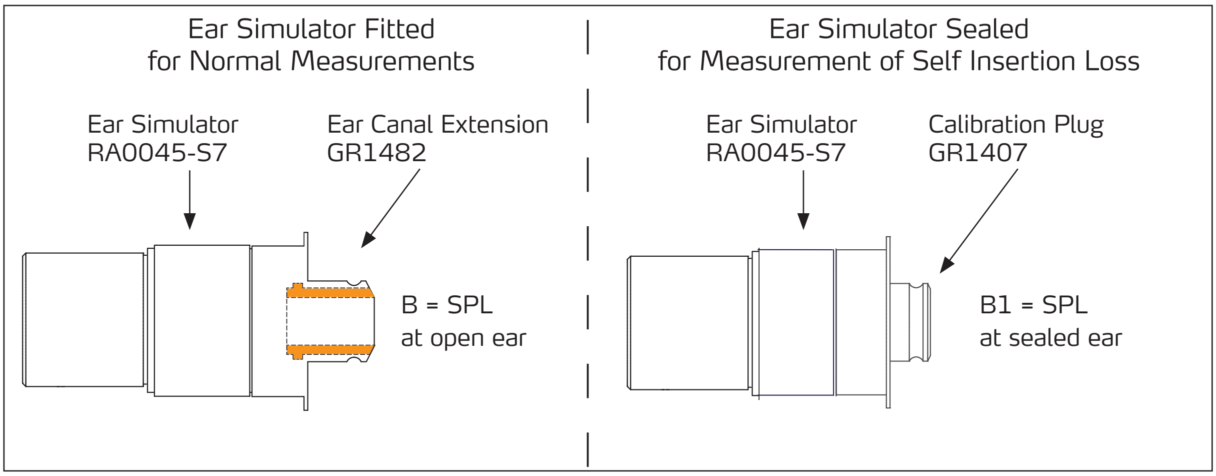

Fig. 25. *Fitting or sealing the ear simulator for verification of self insertion loss.*

To insert the plugs,

1. Remove the pinnae (see "Removing the Pinna" on page 10).
2. Loosen the hex screws securing the assembled couplers (see Fig. 24).
3. Pull out the coupler assembly.
4. Unscrew and remove the ear canal extension.
5. Insert the calibration plugs.
6. Do not attach the pinnae! This is part of the ANSI S12.42 requirement.
7. Prepare the measurement setup.
8. Use a test signal as described in Annex G of the ANSI Standard, that is, a shock tube or an explosive charge.

The formula for calculating the insertion loss (IL) is

IL = B – B1

where B is the sound pressure level (SPL) in the free field and B1 is the signal from the closed (occluded) ear on the 45CB.

Cleaning

You can clean the head, torso, and collar rings using a soft cloth, a drop of dishwashing liquid, and lukewarm water.

Never immerse any of the parts in water.

Technical Specifications

Typical Performance Data

This section includes typical measurements of the self insertion loss, transfer function of open ear, and frequency response.

Large Self Insertion Loss

The 45CB is designed to offer sufficient acoustic damping to allow measurements of the insertion loss of hearing protectors at very high levels of continuous and impulsive noise.

The self insertion loss is better than 70 dB over a wide frequency range.

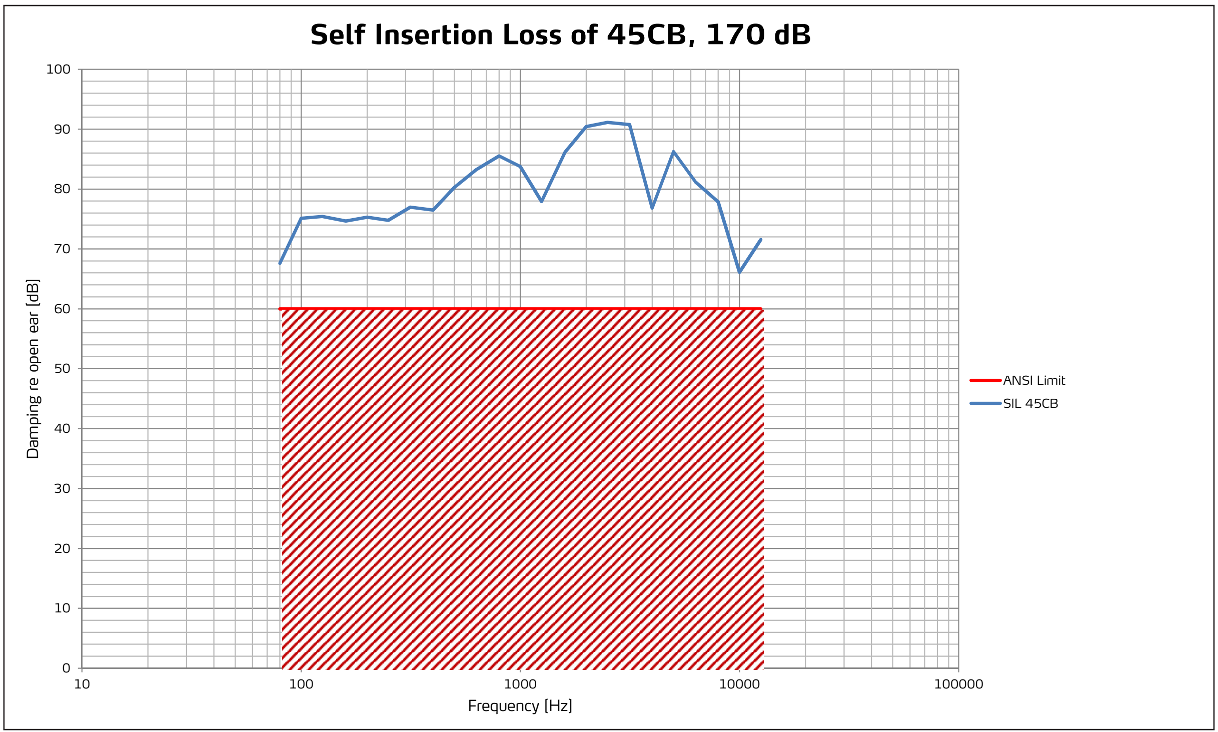

Fig. 26. *Typical self insertion loss of the 45CB at 170 dB in relation to the ANSI S12.42 requirement.*

Transfer Function of Open Ear (TFOE)

The ear simulators included in the 45CB have a transfer function that is very similar to that of the human ear. The diagrams in this section show typical measurements for grazing incidence and normal incidence for the 45CB measured with ear simulators, ear canal extensions and pinnae in place.

TFOE: Grazing Incidence

The **Grazing Incidence** TFOE for the 45CB at 170 dB is illustrated by Fig. 27 and Fig. 28. The 45CB is faces the sound source so the sound wave "grazes" the eardrum, or microphone diaphragm.

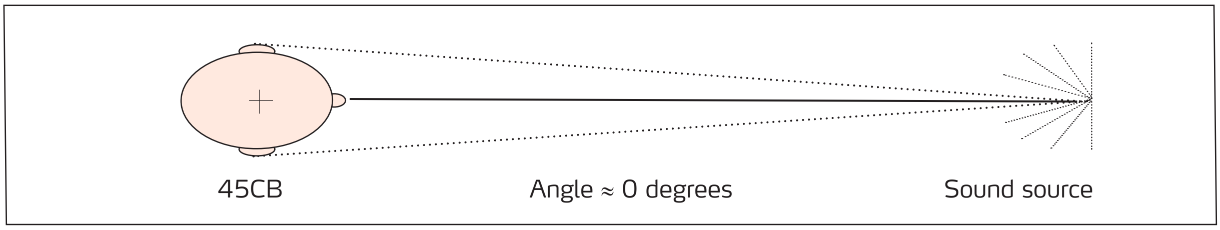

Fig. 27. *Top view of the 45CB positioned for measuring grazing incidence.*

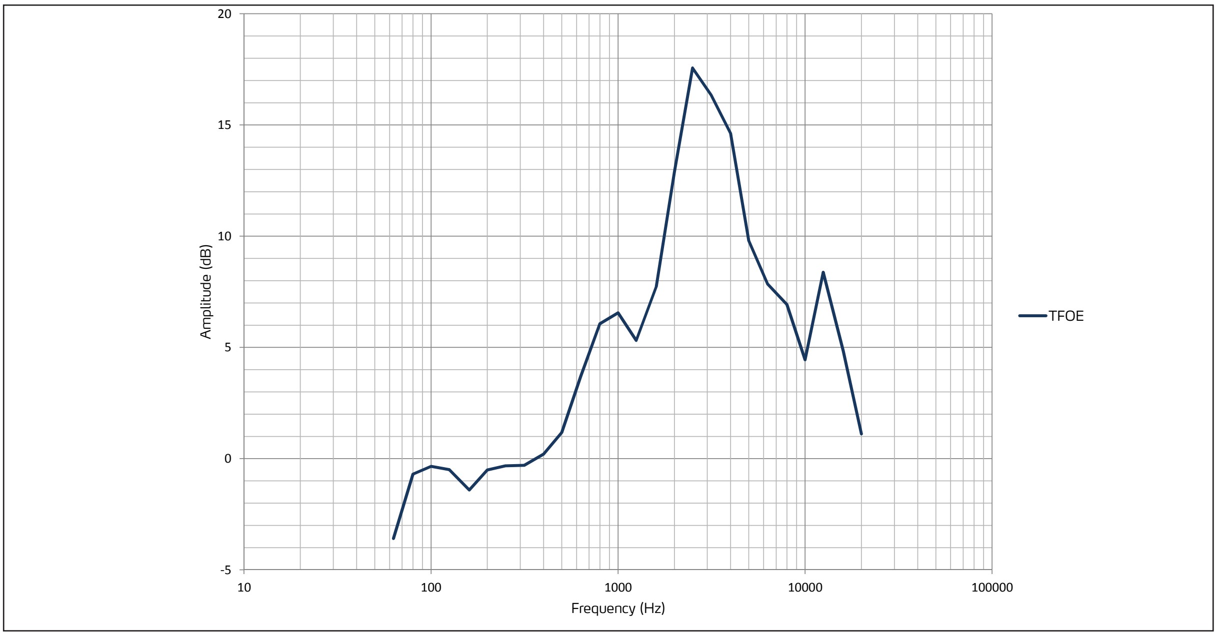

Fig. 28. *Typical transfer function of open ear at 170 dB for the 45CB, grazing Incidence.*

TFOE: Normal Incidence

- The **Normal Incidence** TFOE for the 45CB at 170 dB is illustrated by Fig. 29 and Fig. 30. The 45CB is at a 90° angle to the sound source so the sound wave reaches the microphone diaphragm directly.

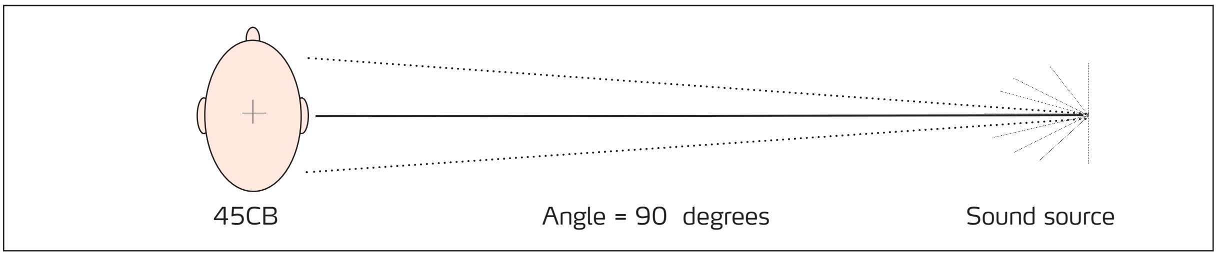

Fig. 29. *Top view of the 45CB positioned for measuring normal incidence.*

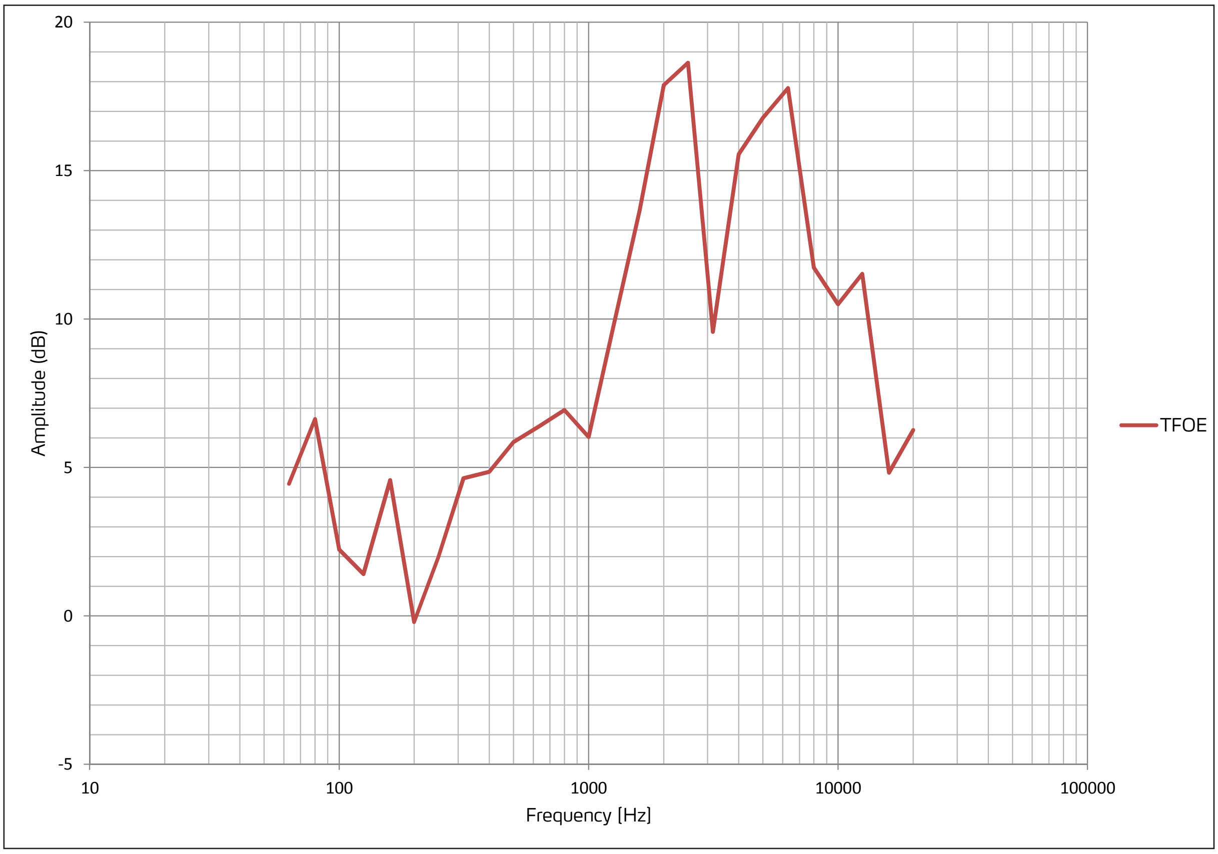

Fig. 30. *Typical transfer function of open ear at 170 dB for the 45CB, normal Incidence.*

TFOE: Diffuse Field Response

The 45CB transfer function of open ear in diffuse field is shown below.

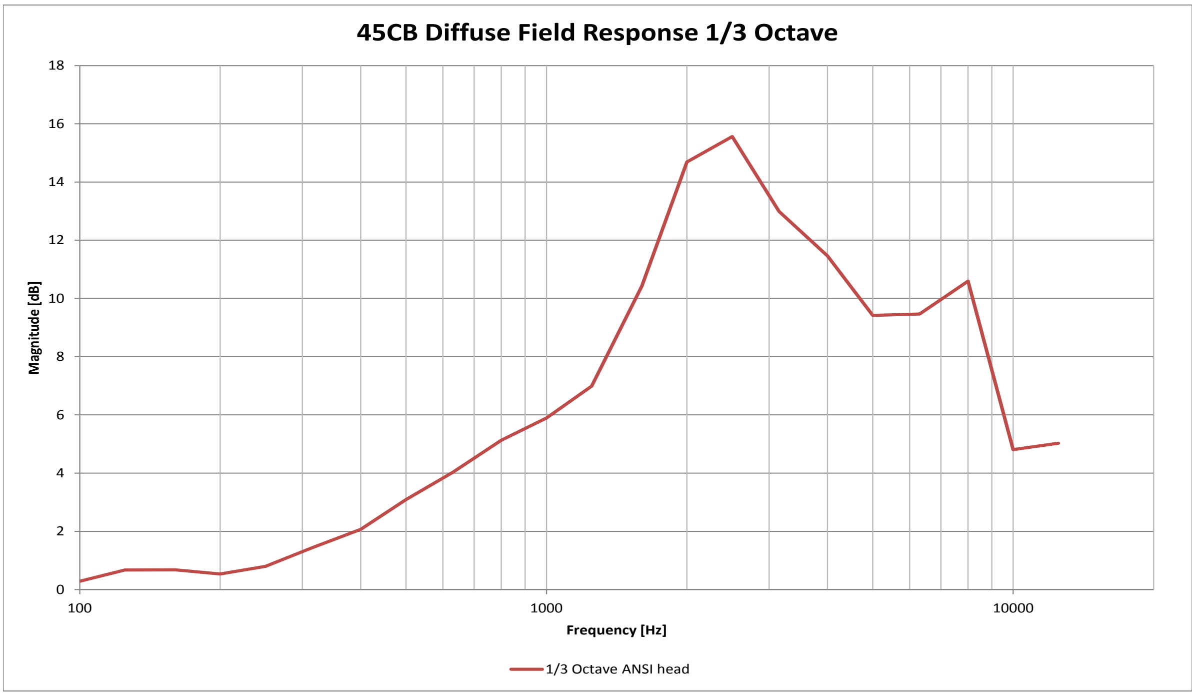

Fig. 32. *Typical transfer function of open ear in diffuse field.*

Ear Simulator Frequency Response

The acoustic input impedance of the RA0045-S7 closely resembles that of the human ear and, as a result, loads a sound source in very much the same way.

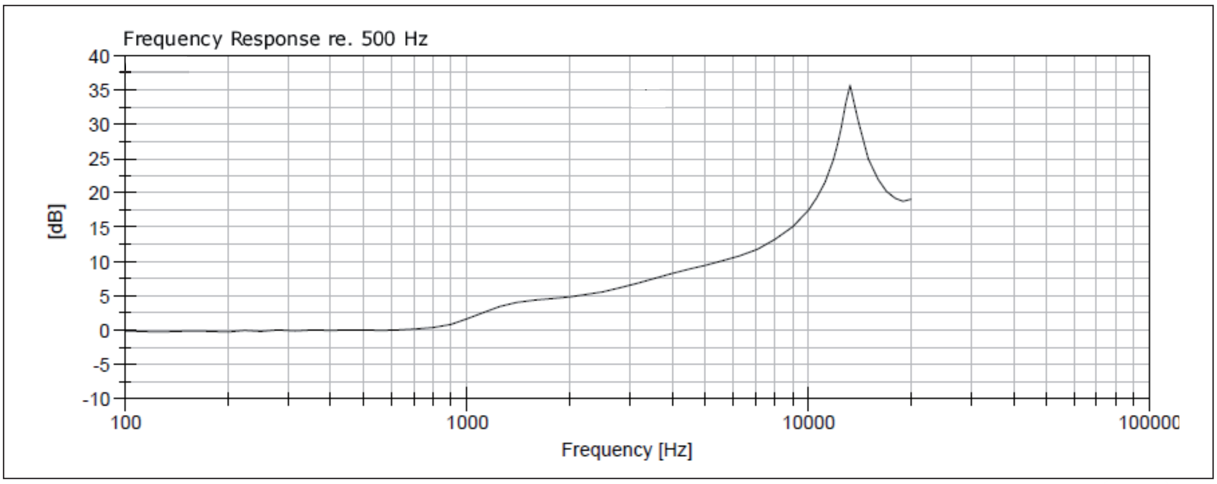

Fig. 31. *Typical ear simulator frequency response re 500 Hz for the RA0045-S7.*

Important: Do **not** remove the microphones and preamplifiers from the ear simulators because that will invalidate the factory calibration.

Dimensions and Data

Head Dimensions	
Width, from EEP to EEP (Ear Entrance Point)	138 mm
Height from center axis	137 mm
45CB Dimensions	
Width (from handle to handle)	364 mm
Height, total	400 mm
Depth	240 mm
Weight	14.75 kg
Mounting thread in base	5/8″
Self Insertion Loss	
Measured with closed ear simulators	
100 Hz – 8 kHz	>74 dB
80 Hz – 12.5 kHz	>65 dB
Ear Simulator Specifications	
Maximum level, open ear, 3% distortion	172 dB
Nominal sensitivity at 250 Hz	1.6 mV/Pa
Resonant frequency	13.5 kHz (±1 kHz)
Effective volume	1.26 cm^3 (± 0.04cm)
Sensor output	Two 7-pin female Lemo

Data were collected in a temperature of 23 °C (±3 °C) and in a relative humidity of 60 % ±20 %.

Power Supply	
Mains	110–230 V
Power Requirements	24 V DC / 2.5 A
Power Requirements for Heating Unit	
Socket	2 pin
Voltage	24 V DC
Power consumption	2.5 A
Ambient Operating Conditions	
Temperature	0 °C – 39 °C
Relative humidity (non-condensing)	0 % – 100 %

System Integration

The 45CB is assembled and tested by G.R.A.S. before leaving the factory. An individual test certificate is included with each 45CB.

Calibration

Before leaving the factory, all G.R.A.S. products are calibrated in a controlled laboratory environment using traceable calibration equipment. We recommend a yearly recalibration at minimum, depending on the use, measurement environment, and internal quality control programs.

We recommend calibration prior to each use to ensure the accuracy of your measurements.

Warranty

All G.R.A.S. products are made of high-quality materials that will ensure life-long stability and robustness. The 45CB is delivered with a 2-year warranty.

Damaged diaphragms in microphones can be replaced.

The warranty does not cover products that are damaged due to negligent use, an incorrect power supply, or an incorrect connection to the equipment.

Service and Repairs

All repairs are made at G.R.A.S. International Support Center located in Denmark. Our Support Center is equipped with the newest test equipment and staffed with dedicated and highly skilled engineers. Upon request, we make cost estimates based on fixed repair categories.

If a product covered by warranty is sent for service, it is repaired free of charge, unless the damage is the result of negligent use or other violations of the warranty. All repairs are delivered with a service report, as well as an updated calibration chart.

Ordering Information

The 45CB Acoustic Test Fixture according to ANSI S12.42 is delivered as a preassembled package. The following table lists all the items delivered with the 45CB.

Included Items	Part Number
Head assembly, including heating control panel, and connectors for couplers and heating elements	
Two ear simulators based on IEC 60318-4, including 40BP ¼" pressure microphone and GR1398 Ear Canal Extension	RA0045-S7
Two Calibration Plugs for self insertion loss verification	GR1407

Included Items	Part Number
Two ¼″ LEMO Preamplifiers, very short, with 7-pin LEMO connector and 40 cm lightweight cable	26AS-S3
Left pinna for 45CB, 55 Shore 00	KB0077
Right pinna for 45CB, 55 Shore 00	KB0078
20 mm test plug	GR1511
Silicone grease	MI0016
Hex key, 2.5 mm	YY0023
Flight case with removable wheels	KM0082
Power supply	AB0016
Manual	LI0052

Accessories

The following accessories are needed to operate the 45CB, but they are not included in the basic package. They must be ordered separately.

Accessory		Part Number
Blast Probe Microphone according to ANSI S12.42		67SB
Power module for 45CB:	2-Channel Power Module with gain, filters, and SysCheck generator	12AA
	2-Channel Power Module with Signal Conditioning and Computer Interface	12AQ
Power module for 67SB:	1-Channel Power Module with gain, filters, and SysCheck generator	12AK
Pistonphone:	Intelligent pistonphone	42AP
	Pistonphone	42AA
½″ Calibration adapter for KEMAR pinnae		RA0157
3 m LEMO extension cable		AA0008
10 m LEMO extension cable		AA0009
30 m LEMO extension cable		AA0012
100 m LEMO extension cable		AA0014
2 m BNC – BNC		AA0034
3 m BNC – BNC		AA0035
5 m BNC – BNC		AA0036

Glossary

The following is a list of the abbreviations used in this manual.

ATF	Acoustic test fixture
ANSI	American National Standards Institute
EEP	Ear entrance point
HPD	Hearing Protection Device
IL	Insertion loss
NR	Noise reduction
SPL	Sound pressure level
TFOE	Transfer function of the open ear

Manufactured to conform with:

CE marking directive: 93/68/EEC

WEEE directive: 2002/96/EC

RoHS directive: 2002/95/EC