

# PRODUCT DATA

## Head and Torso Simulators — Types 4128-C and 4128-D Handset Positioner for HATS — Type 4606

### **Head and Torso Simulator (HATS)**

*Head and Torso Simulators Types 4128-C and D are mannequins with built-in mouth simulators and calibrated ear simulators (according to IEC 60318–4/ITU-T Rec. P.57 Type 3.3) that provide realistic reproduction of the acoustic properties of an average adult human head and torso. They are ideal for performing in-situ electroacoustic tests on, for example, telephone handsets (including mobile and cordless), headsets, audio conference devices, microphones, headphones, hearing aids and hearing protectors.*

### **Handset Positioner for HATS**

*Handset Positioner Type 4606, with pressure/force and position read-outs, allows accurate, repeatable mounting of telephone handsets on HATS in both standardised and user-defined positions. This makes HATS into a state-of-the-art telephone test rig for measurement according to ITU-T recommendations.*



## Uses and Features

### Uses

#### **HATS Type 4128-C**

- Testing of headphones
- Evaluation of close-talking/noise-cancelling microphones
- Measurements on telephone headsets and hands-free communication devices
- Measurements on mobile and domestic telephones
- In-situ/insertion measurements on hearing aids
- Testing of hearing protectors

#### **HATS Type 4128-D, additional uses**\*

- Accurate, repeatable positioning of telephone handsets on HATS for electroacoustic measurements
- Testing of almost all telephone handset designs
- Measurements in standardised positions according to the ITU-T Rec. P.64

\* Also Type 4128-C with Handset Positioner Type 4606

### Features

- Mannequin provides accurate acoustic representation of the average human adult
- Complies with the acoustic requirements of ITU-T Rec. P.58, IEC 60318–7<sup>†</sup> and ANSI S3.36-1985
- Highly representative ITU-T Rec. P.58-based mouth simulator
- Highly representative IEC 60318–4<sup>‡</sup>/ITU-T Rec. P.57 Type 3.3 based calibrated ear simulator
- Includes pinnae complying with ITU-T Rec. P.57. A set of harder pinnae is available
- Adjustable neck angle to permit realistic posture
- Individual calibration data supplied
- Adaptable for a wide variety of telephone handset types (with Type 4606)
- Simple to configure for standardised or user-defined mounting positions (with Type 4606)
- Graduated adjustment in three planes about the Ear Reference Point (with Type 4606)
- Spring-loaded mounting of the handset against the ear with adjustable pressure force (with Type 4606)
- Positioning on both ears simulating left- and right-handed users (with Types 4606 and 4159-C)

<sup>†</sup> IEC 60318–7 formerly known as IEC 60959

<sup>‡</sup> IEC 60318–4 formerly known as IEC 60711

## Introduction

Head and Torso Simulator (HATS) Type 4128-C consists of a head mounted on a torso, representing the international average dimensions of a human adult. In airborne acoustic measurements it provides the correct simulation of the acoustic field around a human head and torso. You can use HATS free standing, fitted on a tripod, or on a turntable using a tripod mounting adaptor. HATS includes a mouth simulator and Right Ear Simulator Type 4158-C. Left Ear Simulator Type 4159-C is available for binaural measurements. HATS has an adjustable neck that allows you to position the head in a realistic posture for different positions of the torso. This is useful in real-life simulations, for example measurements in car seats.

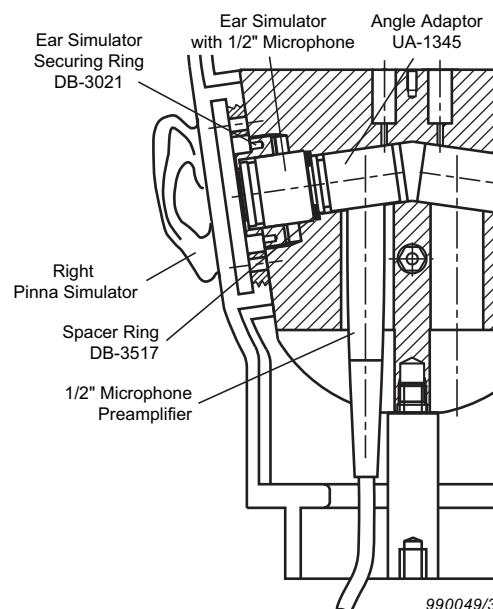
Handset Positioner Type 4606 is included with Type 4128-D and is separately available as an accessory to Type 4128-C. Otherwise the two HATS versions are identical.

All Head and Torso Simulators are delivered with an individual calibration.

## Description

**Fig. 1**  
Cross-section of the  
right ear with Ear  
Simulator Type 4158-C  
fitted

### The Ear Simulator



Each ear simulator consists of a removable silicon-rubber pinna joined to an ear canal. The ear canal ends in an occluded ear simulator, which simulates the inner part of the ear canal according to the IEC 60318-4 standard. The ear simulator contains a 1/2" microphone and is connected to a microphone preamplifier with an adaptor. The ear simulator complies with ITU-T Rec. P.57 and ANSI S3.25.

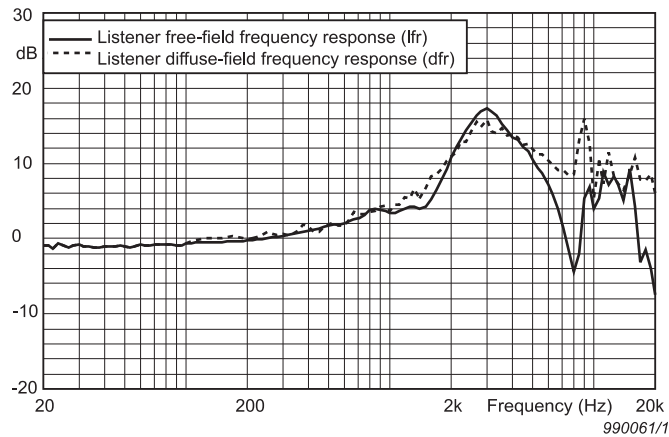
Type 4158-C is the right ear simulator of Type 4128-C. Left Ear Simulator Type 4159-C is also available for binaural measurements\*. Types 4158-C and 4159-C are each delivered with a calibration chart specific to their ear simulator and standard pinna. Sound Calibrator Type 4231 and Pistonphone Type 4228 are suitable calibrators for these ear simulators.

Each ear simulator is delivered with a pinna corresponding to the that specified in ITU-T Rec. P.57 (hardness 35 on the Shore-OO scale). This allows measurements on, for example, handsets using a realistic application force and obtaining a close simulation of an average human acoustic impedance presented to the handset. The pinna enables realistic deformation levels for measuring in open, semi-

sealed or sealed conditions due to its specially designed human-like shape and stiffness. Another somewhat harder pinna (optional accessory) can be used when the pinna hardness matters less and conformance with P.57 recommendations is not required. This pinna's hardness is Shore-OO 55 and is more durable than the softer pinna.

\* Type 4159-C can be fitted to Head and Torso Simulators with serial number 1947214 or higher (from February 1997).  
Type 4159-C cannot be retrofitted to earlier HATS units due to a re-design required for EMC conformance.

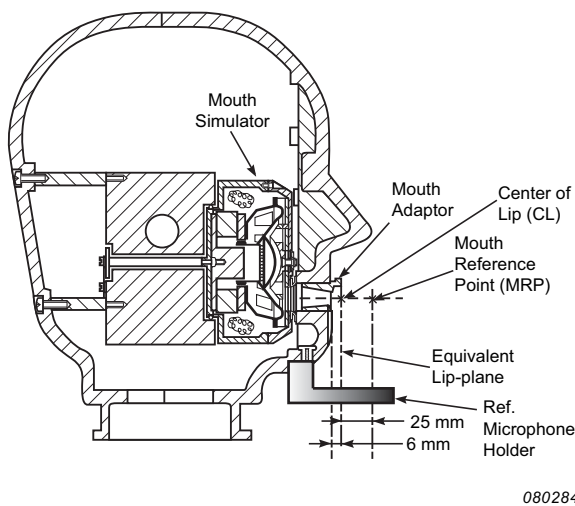
**Fig. 2**  
Typical Listener free-field and diffuse-field frequency responses of Type 4128-C



The combined influence of the torso, head, pinna and ear-canal on airborne sound signals can be quantified by the acoustic free-field transfer function (the frequency response from free-field to the eardrum). This is called the Listener free-field frequency response (lfr) or Head Related Transfer Function (HRTF) in telecommunications work, and the Mannequin frequency response in technical audiology. The typical Listener free-field response of Type 4128-C for sound incident at 0° (that is, coming from the front) is shown in Fig.2 (lfr). The Listener diffuse-field frequency response (dfr) is also shown. The frequency response data are provided on a CD with Type 4128-C.

**Fig. 3**  
Reference points of the HATS mouth simulator

### The Mouth Simulator



The HATS mouth simulator has a high-compliance loudspeaker that gives powerful low-frequency response and low distortion. The acoustic transmission path from the loudspeaker to the mouth opening ensures an easily equalised frequency response of the sound pressure level in front of the mouth. The equivalent lip plane containing the ITU-T Center of Lip (CL) is 6 mm in front of the mouth opening. The usual calibration position is at the ITU-T Mouth Reference Point (MRP), 25 mm in front of this plane. A holder is supplied with Type 4128-C that will hold a ¼" reference microphone at precisely the correct distance for calibration at the MRP. This holder can also hold a microphone right at the opening of the mouth if you want to monitor or equalize the sound pressure at this point.

The mouth simulator produces a sound-pressure distribution around the opening of the mouth simulating that of a median adult human mouth, corresponding to the figures given in ITU-T Rec. P.58. An individual equalisation procedure ensures a flat frequency response, enabling the mouth simulator to follow the frequency range of human subjects. Type 4128-C has the closest and most accurate human-matched Behind-the-lips-plane representation ideal for testing microphones in devices which pick up the sound between the mouth and ear, for example Bluetooth headsets, modern mobile phones and professional theatre microphones.

\* Celmer, Robert D., Beers, C., Miller-Klein, E., "Behind the Lip-Plane Acoustic Radiation Study of Human Subjects and Head & Torso Simulators", Audio Engineering Society 121st Conference, October, 2006.

## Handset Positioner Type 4606

**Fig. 4**  
*Handset Positioner for  
HATS Type 4606*

Brüel & Kjær has developed a handset positioner specifically for use with HATS. Handset Positioner for HATS Type 4606 (see Fig. 4), accurately and repeatably positions telephone handsets on the HATS for electroacoustic measurements. Type 4128-D includes Type 4606, which is also available separately as an accessory (upgrade) for Type 4128-C. The device screws directly into the top of the HATS and securely holds and positions mobile, cordless or conventional handsets. The handset mounts in the handset cradle, which is a multi-adjustable fixture capable of firmly holding practically any type of handset.



**Fig. 5**  
*Alignment of receiver  
of mobile phone in  
cradle*

An alignment jig is supplied (see Fig. 5) that allows you to position the handset within the cradle, setting up the handset's ear reference point (ERP) and the ear-cap plane. When the handset and cradle are mounted on the handset positioner, the ERP of the handset then corresponds to the nominal ERP of the HATS pinna. All the important fixing and positioning adjustments are accomplished via precision mechanisms equipped with graduated markings so that any position or adjustment is repeatable by simply setting all of the positioning parameters to the appropriate values. To this end, Brüel & Kjær supplies a table for noting down these parameters. Once the cradle is mounted on the handset positioner, it can be adjusted in three different planes about the ERP, and the corresponding angles can be read off graduated markings. Additional cradles are available as accessories.



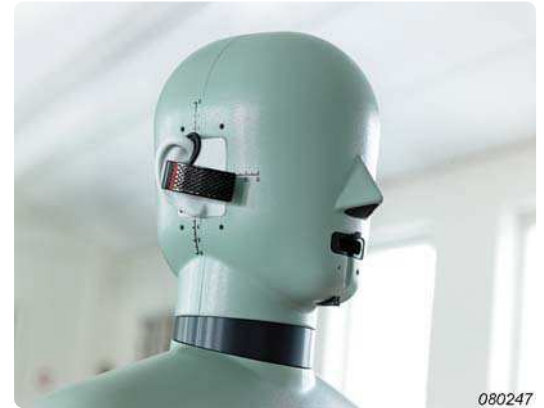
The handset can be pressed against the HATS pinna with adjustable force (0 – 18 N) by the handset positioner. This is done using a screw adjustment that allows you to set the force via a scale graduated in newtons. The resulting deflection of the pinna and the movement of the handset ERP occur along the axis formed by the nominal ERPs of the left and right HATS pinnae. The deflection can be read off the handset positioner, which is graduated in millimetres.

Type 4606 is also easy to set up for standardised measurements. A standardised position, the "HATS position" as defined in ITU-T Rec. P.64, is clearly marked on the handset positioner. This standardised position takes into account the anatomy of the average human head. For exploring the effect of asymmetric transducers and simulating left- and right-handed users, it is possible to perform measurements on both ears. This is simply done by turning the transverse part of the handset alignment tool by 180°, with all graduations of the adjustment screws being repeated for the left-hand position. A built-in quick release mechanism makes the cradle quickly dismountable, making it easy to change the handset or to change between measurements on the left and right ear.

For users of the table-top Telephone Test Head Type 4602-B, when it is fitted with the HATS positioning jig, it corresponds directly to the HATS position of Type 4606.

### Headset Measurements

The ear simulator in Type 4128-C allows accurate measurements to be made on the receiver part of a wireless or corded communications headset. The characteristics of the transmitting part can be measured thanks to the mouth simulator. Having both a mouth- and an ear simulator, Type 4128-C can also be used for sidetone measurements.



### Headphone Measurements

You can use Type 4128-C to determine a variety of headphone characteristics in situ. The influence of the pinnae is taken into account and the ear simulators provide the correct acoustic loading, so realistic evaluation of open, closed and insert headphones can be made. Simulated insertion responses are measured referring to either the equivalent free-field or diffuse-field response. Type 4128-C can also be used to determine the left/right tracking of headphones and their background noise insertion loss.



### Hearing Aid Measurements

Both in-the-ear and behind-the-ear hearing aids can be evaluated with Type 4128-C. Two ear mould simulators are supplied with Type 4128-C for testing hearing aids where individually made ear moulds are normally used. The mouth simulator in Type 4128-C is useful for developing multi-microphone noise-cancelling hearing aids. Simulated insertion gain, simulated directional responses and in-situ maximum output can be measured using HATS, as described in IEC Publication 60118-8, "Methods of Measurement of Performance Characteristics of Hearing Aids under Simulated In-situ Working Conditions".



### Vehicles

The sound field in cars and other small enclosures is influenced to a great extent by the physical presence of people in the enclosures. Type 4128-C greatly simplifies representative acoustical measurements under these conditions, enabling more realistic evaluation of vehicle audio systems and mobile telephones, and the effectiveness of measures taken for noise control.





## Microphone and Hands-free Communication Measurements

When measuring on microphones, Type 4128-C can closely simulate the interaction between the mouth, head, body and microphone. Its mouth simulator is an ideal sound source for the research, development and evaluation of a variety of microphones. In particular, you should use Type 4128-C with close-talking, noise-cancelling and Lavalier types, in which the characteristics of the human voice must be reproduced accurately and the acoustic influence of the head and body is important. Likewise, the quality of hands-free applications such as video conference and laptop VoIP call technologies can be measured intensively for codec optimisation, sidetone tracking, noise cancellation, etc. Type 4128-C enables full duplex operation (simultaneous receive and transmit) for simulation of real-life communication situations.



## Helmets/Masks

Previously, evaluation and testing of integrated helmet systems, for example communications equipment in crash helmets and gas masks, have been difficult to do realistically. With Type 4128-C, such systems can be thoroughly and realistically investigated with respect to both signals and noise. The mouth simulator of Type 4128-C replicates the sound field generated by the human mouth even with respect to the frequency-dependent motion of the acoustic-centre in the frequency range important for high-end, noise-cancelling microphones.

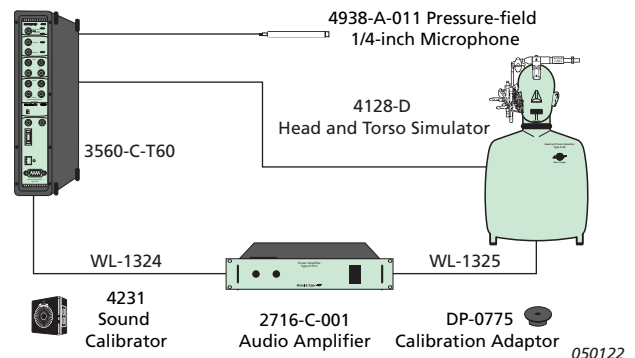


## Hearing Protector Measurements

Evaluating hearing protectors is straightforward using HATS instead of human subjects. The most important characteristic for hearing protectors is airborne insertion loss. This is found by measuring the free-field response of Type 4128-C with and without the hearing protectors in place and comparing the results. Type 4128-C can be placed in situ, so the actual noise sources for which the hearing protector is designed can be used in tests. The effectiveness of hearing protectors on noise from different angles is also easy to investigate.

## Telephone Measurements

HATS can be used as a representative mannequin for in-situ evaluation of telephone equipment including handset telephones, hands-free telephones, and group audio terminals or headsets. With both ear simulator and mouth simulator, you can investigate receive, transmit, acoustic sidetone and background noise characteristics for the full range of audio terminal devices. Full duplex operation is possible.



Measurements are made using the dedicated Telephone Test System Type 6712 or with general purpose PULSE Electroacoustics software. Several configurations of the latter are available; for up-to-date descriptions please see our website.

**Fig. 6**  
Sample setup for  
telephone testing



## Earphone Measurements

**Fig. 7**  
Stereo earphone  
mounted in HATS  
pinnae

The artificial pinnae of the ear simulators enable mounting and testing of small in-the-ear earphones supplied with modern portable players, telephones, etc.



## Compliance with Standards – Types 4128-C and 4128-D

 	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive. C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand
<b>Safety</b>	EN/IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use. ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
<b>EMC Emission</b>	EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments. CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device.
<b>EMC Immunity</b>	EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. <b>Note:</b> The above is only guaranteed using accessories listed in this Product Data sheet.
<b>Temperature</b>	IEC 60068–2–1 and IEC 60068–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –5°C to +40°C (+23°F to +104°F) Storage Temperature: –25°C to +70°C (–13°F to +158°F)
<b>Humidity</b>	IEC 60068–2–78: Damp Heat: 90% RH (non-condensing at 40 °C (104 °F))
<b>Mechanical</b>	Non-operating: IEC 60068–2–6: Vibration: 0.3 mm, 20 m/s <sup>2</sup> , 10–500 Hz IEC 60068–2–27: Shock: 1000 m/s <sup>2</sup> IEC 60068–2–29: Bump: 1000 bumps at 250 m/s <sup>2</sup>

## Specifications – Head and Torso Simulators Types 4128-C and 4128-D

### LISTENER FREQUENCY RESPONSE

Conforms to ITU-T Rec. P.58 for measurements on telecommunications devices and to IEC 60318–7 and ANSI S3.36–1985 for measurements on air conducting hearing aids

### EAR SIMULATOR

IEC 60318–4/ITU-T Rec. P.57 Type 3.3-based calibrated ear simulator complying with ITU-T Rec. P.57, IEC 60318–4 and ANSI S3.25 standards. Output from the ear simulator is via a 7-core 3 m cable (2.3 m from the bottom of the torso) terminated with a Lemo (1B) plug. For connection to a preamplifier input socket of Brüel & Kjær Power Supplies, Analyzers, etc., a Lemo-to-Brüel & Kjær adaptor is supplied  
**Typical Sensitivity:** 12.6 mV/Pa (–38 dB re 1 V/Pa) at 250 Hz  
**3% Distortion Level:** 162 dB re 20 µPa at eardrum position

### LEFT EAR TO RIGHT EAR TRACKING

±1 dB up to 5 kHz, ±3 dB up to 8 kHz (measured using the same ear simulator)

### PINNA SIMULATORS

Dimensions similar to those specified in ITU-T Rec. P.58, IEC 60318–7 and ANSI S3.36. Minor adjustments in the dimensional details have been

made which enable Type 4128-C to conform with the acoustic specifications of these documents in the frequency range 100 Hz to 8 kHz. Types 4158-C and 4159-C are supplied with calibrated pinna simulators. An additional pair of uncalibrated hard pinna simulators are available as accessories

### MOUTH SIMULATOR

Input to mouth simulator via 0.75 m cables (0.2 m from the bottom of the torso) terminated with banana-sockets

**Sound Pressure Distribution:** conforms to ITU-T Rec. P.58

**Mouth Opening:** W × H: 30 × 11 mm (1.18 × 0.43")

**Equivalent Lip Plane Position, CL:** 6 mm in front of the sound radiation opening

**Mouth Reference Point, MRP:** 25 mm in front of mouth CL

**Continuous Output Level at MRP:**

Min. 110 dB SPL, 200 Hz to 2 kHz

Min. 100 dB SPL, 100 Hz to 8 kHz


**Typical Sensitivity at 1 kHz:** 80 dB SPL 2 V/500 mm

**Distortion (Harmonic Components up to 8 kHz) at 94 dB SPL:**

<2%, 200 Hz to 250 Hz; <1% >250 Hz

**Max. Average Input Power:** 10 W max. continuous average power (at 20°C (68°F))

**Max. Pulsed Input Power:** 50 W for 2 seconds

 **CAUTION:** If the mouth simulator is excited with pulses of more than 50 W, damage may occur before the protection circuit reacts  
**Loudspeaker Impedance:** 4 Ω

**DIMENSIONS AND WEIGHT**

The main dimensions comply with the dimensional requirements of ITU-T Rec. P.58 and the reports from IEC 60318–7 and ANSI S3.36-1985

**Total Height, Head and Torso:** 695 mm (27.4")

**Torso:** Height: 460 mm (18"), Width: 410 mm (16"), Depth: 183 mm (7.2")  
External Neck Diameter: 112 mm (4.4")

**Head Angles:** Vertical or tilted 17° forwards

**Weight:** 9 kg (19.8 lb.)

**Specifications Type 4606**

**SPEAKING POSITION**

**Standardised position:** HATS position as defined in ITU-T Rec. P.64

∠A = 21.2°, ∠B = 12.9°, ∠C = 2.3°

**Variable positions:**

∠A can be adjusted from +15° to +35°

∠B can be adjusted from +30° to –10°

∠C can be adjusted from +20° to –20°

**Angle resolution:** 0.5°

**Precision:** Once mounted the handset Ear Reference Position ERP can be positioned within 1 mm relative to the nominal ERP of the HATS pinna

**HANDSET THICKNESS**

**Min:** ≥ 0 mm

**Max:** 44 mm

**HANDSET WIDTH**

**Min:** 26 mm

**Max:** 66 mm

**OFFSET ADJUSTMENT**

For asymmetrical handset the offset perpendicular to the handset can be adjusted in the range +/- half the handset width minus 8 mm

**END STOP ADJUSTMENT**

The End Stop can be adjusted from 8 to 36 mm (0 mm is located at the Ear Reference point, ERP of the handset)

**APPLIED EAR FORCE**

The force that a handset exerts against the HATS pinna can be adjusted from 0 to 18 N

**WEIGHT**

**Handset Positioner (incl. cradle, excl. handset):** 1.4 kg

**Alignment Jig (excl. cradle):** 2.4 kg

**Ordering Information**

- Type 4128-C-001 Head and Torso Simulator with Right Ear Simulator and Mouth Simulator  
Type 4128-C-002 Head and Torso Simulator with Right Ear Simulator, Left Ear Simulator and Mouth Simulator  
Type 4128-D-001 Type 4128-C-001 with Type 4606  
Type 4128-D-002 Type 4128-C-002 with Type 4606

Type	4128-C-001	4128-C-002	4128-D-001	4128-D-002
	includes			
Right Ear Simulator Type 4158-C	.	.	.	.
Left Ear Simulator Type 4159-C		.		.
Mouth Simulator	.	.	.	.
Handset Positioner Type 4606			.	.

All above include the following accessories:

- BC-5000-C: Calibration CD
- DZ-9769: Right Pinna – soft (Shore-OO 35)
- DZ-9770: Left Pinna – soft (Shore-OO 35)
- DB-2902: Ear Mould Simulator – short
- UC-0199: Ear Mould Simulator – long
- UA-1546: Adaptor for Calibration
- QA-0167: Ear Mounting Tool
- QA-0223: Preamplifier Mounting Tool
- UA-1043: Support Feet
- UA-2127: Ref. Microphone Holder
- UC-5290: Adaptor for Tripod

**Optional Accessories**

- Type 4606 Handset Positioner for HATS (included in Types 4128-D-001 and 4128-D-002)  
Type 4159-C Left Ear Simulator (included in Types 4128-C-002 and 4128-D-002)  
Type 4231 Sound Calibrator  
Type 4938 ¼" Pressure-field Microphone  
Type 2670 ¼" Microphone Preamplifier  
UA-1587 Centering Fork for Extraordinary Wide Handsets (for Type 4606)  
UA-1642 Deep Cradle (for Type 4606)  
UC-5345 Torso with adjustable neck ring – Upgrade  
DZ-9771 Right Pinna – hard (Shore-OO 55)  
DZ-9772 Left Pinna – hard (Shore-OO 55)  
AO-0419 Microphone Cable  
UA-1522 Tripod  
WE-0195 Flight case  
ZG-0350 Lemo-to-Brüel & Kjær Adaptor  
AO-0414 Extension Cable

**Services**

- 4128-CFF Factory Standard Calibration  
4128-EW1 4128-C Head and Torso Simulator. Extended Warranty, one year extension  
4606-TCF Conformance Test (Mounting and Testing of Type 4606 on Type 4128-C)

