Product Data

Sound Intensity Probe Sets — Types 3583, 3584
Sound Intensity Microphone Pairs — Types 4178, 4197
Dual Preamplifier — Type 2682

USES:

- ❍ Measurement of sound intensity using two-microphone technique, in accordance with IEC 1043 Class 1
- ❍ Sound power measurements in accordance with ISO 9614–1, ISO 9614–2, ECMA 160 and ANSI S 12–12

FEATURES:

- ❍ Microphone pairs matched for phase and amplitude response
- ❍ Individual calibration data
- ❍ $^{1}/_{3}$-octave centre frequency ranges:
  3583: 20 Hz to 10 kHz
  3584: 20 Hz to 6.3 kHz
- ❍ Minimal shadow and diffraction effects
- ❍ Well-defined acoustical microphone separation

The transducer is the first stage in many measurement chains. Its reliability determines the ultimate accuracy of the system. This is especially so for sound intensity measurements with a two-microphone technique where stringent requirements are placed on the phase and sensitivity matching between the probe microphones.

Types 3583 and 3584 are two-microphone probe sets for measuring sound intensity with Brüel & Kjær's range of sound intensity analyzers. These probe sets feature precision, phase and sensitivity matching between the probe microphones. All the probe sets are supplied with a 1/2″ Sound Intensity Microphone Pair Type 4197, enabling measurements between 1/3-octave centre frequencies of 20 Hz and 6.3 kHz. With 1/2″ microphones the probe sets comply with IEC 1043 Class 1. Type 3583 also includes a 1/4″ Microphone Pair Type 4178, extending the upper 1/3-octave centre frequency to 10 kHz. The Remote Control Unit ZB 0017 is part of Type 3584. Remote Control Unit ZH 0354 is available for Type 3583.

1/2″ Sound Intensity Microphone Pair Type 4197 features phase-corrector units which make precision low-frequency phase matching a practical possibility, leading to increased measurement range and accuracy. A phase-matching calibration chart is supplied with each microphone pair.

An assembled probe

970279e

970281e

Probe Set Type 3583 in carrying case

970282e

Probe Set Type 3584 in carrying case

Introduction

Measurement of sound intensity (sound power per unit area) is increasingly being used as a routine technique in a wide range of noise investigations. The method permits the determination of sound power from direct measurement of sound intensity, even in situations where pressure-based measurements would be impossible. Since the method does not require special acoustic environments such as reverberation and anechoic chambers, significant savings can also be made.

To measure sound intensity accurately using a two-microphone technique, you need a reliable sound intensity probe set containing a matched microphone pair to obtain information on both the instantaneous pressure and pressure gradient in the sound field. The microphones are separated by a fixed distance in the sound field, and the microphone signals are fed to a sound intensity processor which calculates the sound intensity. The sound intensity is calculated from the time average of the sound pressure multiplied by the particle velocity (calculated from the measured pressure gradient). Such a system measures the component of the sound intensity along the probe axis and also indicates the direction of energy flow.

Two sound intensity probe sets are available from Brüel & Kjær: Types 3583 and 3584. The characteristics of the probe sets and the sound intensity microphone pairs 4178, 4197 are described in this product data sheet. For further details of the sound intensity analyzers and information on which probe set is suitable for which analyzer, see the separate product data sheets for the analyzers.

Fig.1 A sound intensity probe consists of: Dual Preamplifier Type 2682, Sound Intensity Microphone Pairs Types 4197 and 4178 and spacers

Probe Description

The sound intensity probe sets are constructed in similar ways. They consist of a robust frame (see Fig. 1) which holds the microphone preamplifier(s) and matched microphones in the face-to-face configuration. The distance between the microphones is defined by solid plastic spacers which are held in place by threaded studs on the microphone grids. Sound is constrained to act on each microphone through a narrow slit between the spacer and the microphone grid. This arrangement gives well-defined acoustic separation of the microphones and minimizes shadow and reflection effects.

The probe sets are strong but lightweight and can be held using either a handle and extension rod, or with an analyzer remote control unit attached to the probe set. All the probe sets are supplied in attaché cases containing the microphone pairs, windscreens (spherical and ellipsoidal) and accessories. In addition Type 3584 is supplied with Remote Control Handle ZB 0017.

Sound Intensity Probe Sets

Both probe sets are supplied with 1/2″ Sound Intensity Microphone Pair Type 4197 for measurements in the low and medium frequency ranges. Type 3583 also includes 1/4″ Sound Intensity Microphone Pair Type 4178 for measurements in the medium and high frequency ranges (Fig. 1). These 1/4″ microphones are also available separately for use with the other probe sets. Both Type 4197 and 4178

Sound Intensity Microphone Pair Type 4197
Calibration Chart
Bruel & Kjær

Serial No: 2113339	Part 1	Part 2	
Open-circuit Sensitivity, S_0:	***-38.5***	***-38.5***	dB re 1V/Pa
Equivalent to:	*11.9*	*11.9*	mV/Pa
Uncertainty, 95 % confidence level		0.2	dB
Capacitance:	*19.6*	*19.8*	pF
Vent Sensitivity, 20 Hz: (re diaphragm sens.):	*-77.7*	*-73.2*	

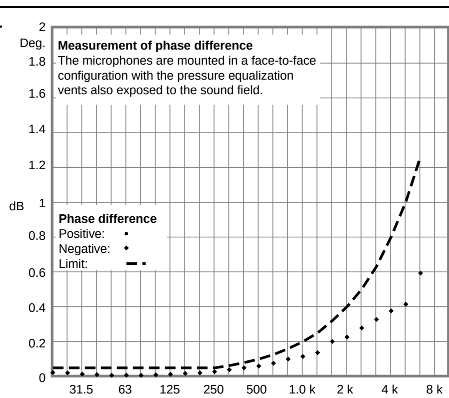
Valid At:

Temperature:	23	°C
Ambient Static Pressure:	101.3	kPa
Relative Humidity:	50	%
Frequency:	251.2	Hz
Polarization Voltage, external:	200	V

Sensitivity Traceable To:
DPLA: Danish Primary Laboratory of Acoustics
NIST: National Institute of Standards and Technology, USA

Environmental Calibration Conditions:
101.4 kPa 25 °C 30 % RH

Procedure: 704619 **Date:** 21. Apr. 1998 **Signature:**



Frequency Response (re 250Hz) :

1/3 Octave Centre Frequency	Part 1 Actuator Response	Part 1 Free Field Response 0 Sound Incidence	Part 2 Actuator Response	Part 2 Free Field Response 0 Sound Incidence
[Hz]	[dB]	[dB]	[dB]	[dB]
250	-0.00	-0.00	-0.00	0.00
-	-	-	-	-
1000	-0.09	0.01	-0.09	0.01
1250	-0.13	0.01	-0.13	0.01
1600	-0.20	0.01	-0.20	0.01
2000	-0.30	0.01	-0.31	-0.00
2500	-0.46	-0.00	-0.47	-0.02
3150	-0.69	-0.02	-0.72	-0.05
4000	-1.04	-0.01	-1.09	-0.06
5000	-1.54	0.01	-1.59	-0.05
6300	-2.39	-0.11	-2.45	-0.17
8000	-3.33	-0.01	-3.42	-0.09
10k	-4.62	0.18	-4.71	0.09

BC-0261-11

Fig.2 Calibration chart supplied with the 4197 microphone pair. The measured microphone phase matching and individual microphone free-field responses are given operate on a polarization voltage of 200 V.

The probe sets have cables terminated with a single 18-pin plug, and are specially designed for direct connection to dual-channel analyzers.

The useful free-field frequency range for the 3583, using the various microphone and spacer combinations, is from 1/3-octave centre frequencies of 20 Hz to 10 kHz. For Type 3584 the range is 20 Hz to 6.3 kHz. The actual frequency range in practice depends on the difference between the pressure and intensity levels, that is, Pressure-Intensity Index (see section on Frequency Range), which is dependent on the nature of the sound field and the phase response deviation between the probe and processor channels.

The IEC 1043 standard distinguishes between Probe, Processor and Instrument and classifies them according to the measurement accuracy achieved. There are two degrees of accuracy designated Class 1 and Class 2. The Brüel & Kjær probe set complies with IEC 1043 Class 1, which has the most stringent tolerance requirements. Note, however, that the IEC standard only specifies the frequency range from centre frequencies of 50 Hz to 6.3 kHz in 1/3-octave bands.

Microphone Pairs Types 4197 and 4178

Phase matching of the 4197 microphone pair is better than 0.05° between 20 Hz and 250 Hz, and is better than *f*/5000 degrees at higher frequencies, where *f* is the frequency. Such phase matching is possible as a result of the microphone phase-corrector units (patented) which are fitted to the 4197 microphones. The normalized microphone frequency responses differ by less than 0.2 dB up to 1 kHz and by less than 0.4 dB up to 7.1 kHz.

Type 4197 is supplied with 8.5 mm, 12 mm and 50 mm spacers. Calibration data provided (Fig. 2) include phase matching up to a 1/3-octave centre frequency of 6.3 kHz, microphone sensitivities at 250 Hz, and individual free-field frequency responses valid for the microphones with the 12 mm spacer in position.

Type 4178 consists of a pair of 1/4″ microphones, phase matched to better than 0.2° from 20 Hz to 1 kHz and sensitivity matched to better than 1 dB. The 4178 is supplied with 6 mm and 12 mm spacers, along with calibration charts giving the individually measured free-field frequency response for each microphone.

Fig. 3 Remote control units

The 1/4″ Type 4178 microphones can also be mounted in a side-by-side configuration using parts available separately. These include the side-by-side mounting clip DK 1002 to separate the microphones by a distance of 12 mm, two adaptors (2 × UA 0954) to provide well-defined microphone venting when using this configuration, and two Type 2670 preamplifiers which connect to the adaptors. Although this is not the optimum configuration for precision measurements, the more compact arrangement allows measurements to be made in more confined spaces and closer to surfaces.

Remote Control Unit

The different remote control units (Fig. 3) are intended for use with different analyzers, and information on which probe set is most suitable is included in the Product Data for these analyzers.

Remote Control Unit ZB 0017, supplied with the 3584, has "Start", "Autosequence", "Accept/Save" and "Input Autorange" controls, and also LEDs for overload, autosequence and averaging information, with directional information.

ZH 0354 is available separately for use with Type 3583 and is specifically designed for use with Dual Channel Real-time Frequency Analyzer Type 2133.

Frequency Range

The overall frequency ranges are shown in Fig. 4 for 1/2″ microphone pair Type 4197 with 8.5, 12 and 50 mm spacers. Note that the frequency range depends on the difference between the pressure level and the intensity level. In most field measurements, the sound intensity level is lower than the sound pressure level. The ability of a sound intensity instrument to measure intensity levels much lower than the pressure level depends on the probe and processor phase matching. The difference between pressure and in-

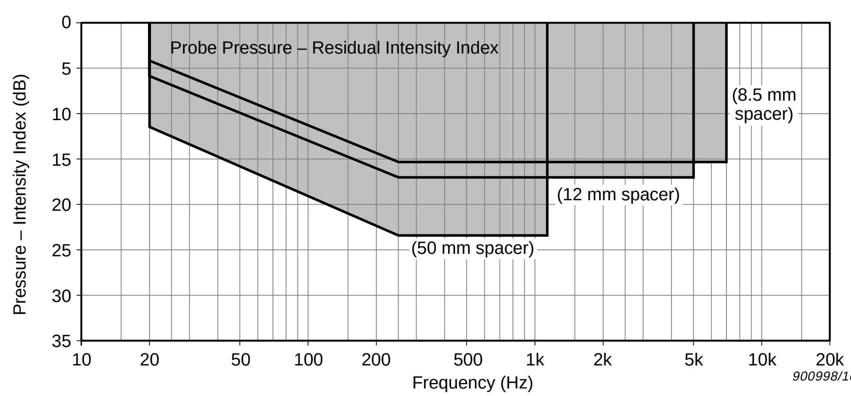


Fig. 4 Specified frequency and Pressure-Residual Intensity Index ranges for the probe (Pressure-Residual Intensity Index = Pressure Level – Intensity Level)

tensity levels is called the *Pressure-Intensity Index* which is denoted by δ_{pI} and is normally a positive quantity.

δ_{pI_0} is the Pressure-Residual Intensity Index of the measurement instrumentation (shown for the probe by the limits of the shaded area in Fig. 4). δ_{pI_0} is determined by the phase (mis)match of the system, and its effect on the accuracy of a measured sound intensity level is determined by the value chosen for the constant K. If K is 7 dB, then an accuracy of ±1 dB can be expected. If K is 10 dB as specified in ISO 9614, then the accuracy will be ±0.5 dB (the sign of this bias error depends on the sign of the system's phase mismatch). Measurements must be restricted to values of δ_{pI} given by:

$\delta_{pI} \le \delta_{pI_0} - K$

The Pressure-Residual Intensity Indices for the intensity probe set, shown in Fig. 4 (solid lines), are derived directly from the phase matching specifications.

The Pressure-Residual Intensity Index can be increased during processing by applying corrections for the phase difference. This phase difference compensation is a feature of several Brüel & Kjær analyzers.

As the static pressure equalization vent may cause problems, the IEC 1043 standard specifies that probes designed to operate at frequencies below 400 Hz must be tested in a plane standing wave field. The standing wave ratio must be 24 dB at a frequency between 125 and 400 Hz. Fig. 5 illustrates the performance of the Brüel & Kjær intensity probe for this test at 125 Hz.

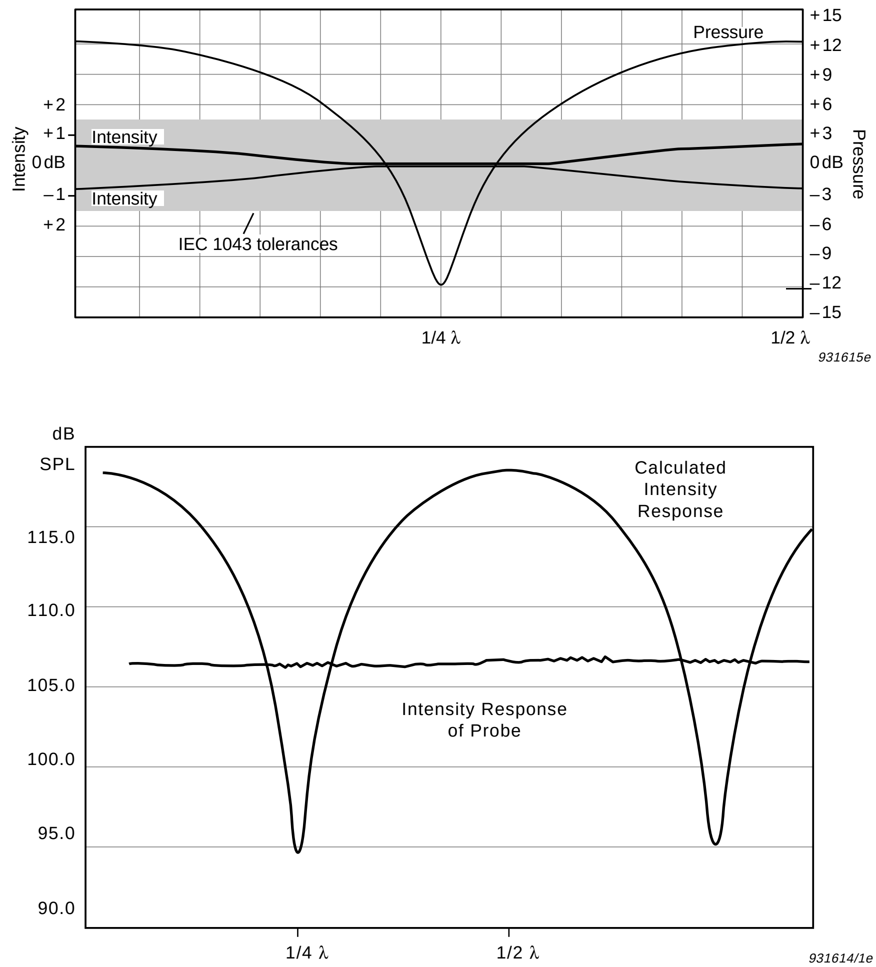


Fig. 5 The upper graph illustrates the calculated intensity response limits relative to a standing wave, for a probe consisting of Sound Intensity Microphone Pair Type 4197 and Dual Preamplifier Type 2682. The calculation is valid for the maximum phase deviation specified for the microphone and preamplifier pair and for field conditions according to IEC 1043 (50 mm spacer at 125 Hz and a standing wave ratio of 24 dB). In practice the intensity response of the probe is significantly better as shown in the typical measurement in the lower graph

High-Frequency Limit

The upper limit of the frequency range for a sound intensity probe set depends on the length of the microphone spacer. Approximating the

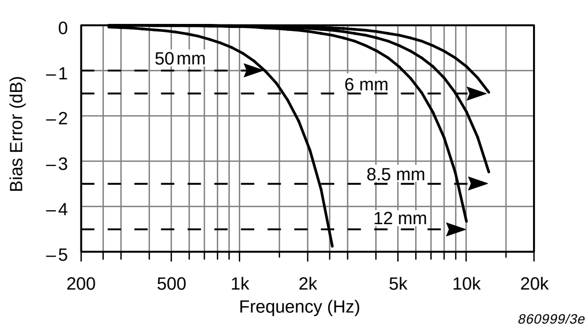


Fig. 6 High-frequency bias error in sound intensity measurements (for plane waves, 0° incidence). The upper frequency limits (–1 dB error) for the different spacers are indicated. 4197 microphones

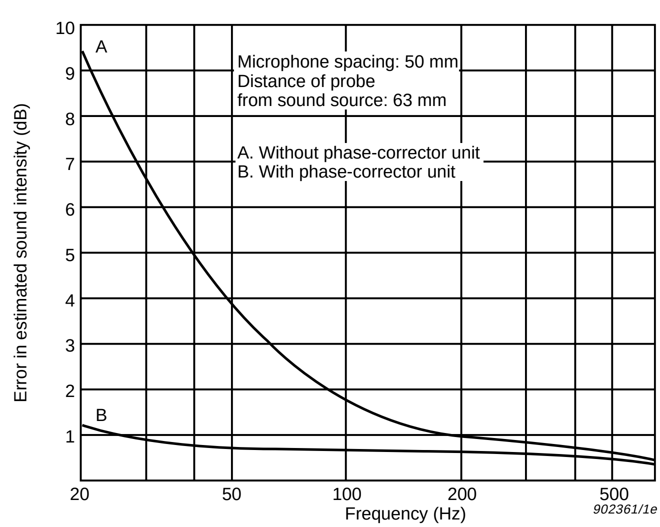


Fig. 7 The phase-corrector units fitted to the 4197 suppress vent sensitivity and result in more accurate near-field measurements

pressure gradient using two microphones separated by a short distance in the sound field leads to an underestimate of the sound intensity level, but the error is less than 1 dB as long as the distance between the microphones is less than one sixth of the wavelength. This means that for high-frequency measurements, a short spacer should be used. The bias error is plotted as a function of frequency for the different microphone spacers in Fig. 6. To keep this error to less than 1 dB, the appropriate spacer is chosen for the frequency range of interest. 50 mm, 12 mm and 8.5 mm spacers are used with 1/2″ microphones up to 1/3-octave centre frequencies of 1.25 kHz, 5 kHz and 6.3 kHz respectively; 12 mm and 6 mm spacers with 1/4″ microphones up to 1/3-octave centre frequencies of 5 kHz and 10 kHz respectively.

The Probe Sets in the Sound Field

It is important that a sound intensity probe set does not disturb the sound field which it is measuring. The face-to-face configuration and the optimized mechanical design of the Brüel & Kjær probe set means that the disturbance of the sound field is very small.

The spacers used to separate the microphone pairs in the sound field are designed to give acoustic separations of 6 mm, 8.5 mm, 12 mm and 50 mm; their physical lengths in fact differ slightly from these values. The effective acoustical separation of the microphones varies slightly as a function of frequency due to reflections. This effect is minimized by the solid spacers which separate the microphones, and the distance variation is less than 0.5 mm for the 12 mm spacer as shown in Fig. 8. The effect on the accuracy of the measured sound intensity is consequently very small.

The phase matching specified for the 4197 microphone pair is retained even in sound fields with very high pressure-level gradients, such as are found close to point sources. This is a benefit of the patented phase-corrector units which are fitted to these microphones. Ordinary condenser microphones can have their phase responses altered if there is a difference between the pressure level at the pressure equalization vent and that at the diaphragm. Type 4197 microphones are, however, essentially insensitive to sound at the vent and the accuracy of near-field measurements at low frequencies is consequently increased (Fig. 7).

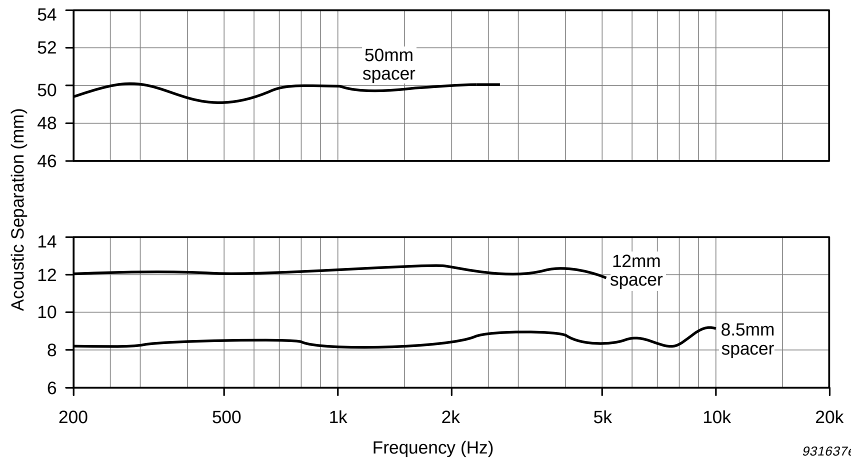


Fig. 8 Measurement of the variation of effective acoustical separation as a function of frequency for 4197 microphones with 50 mm, 12 mm and 8.5 mm spacers

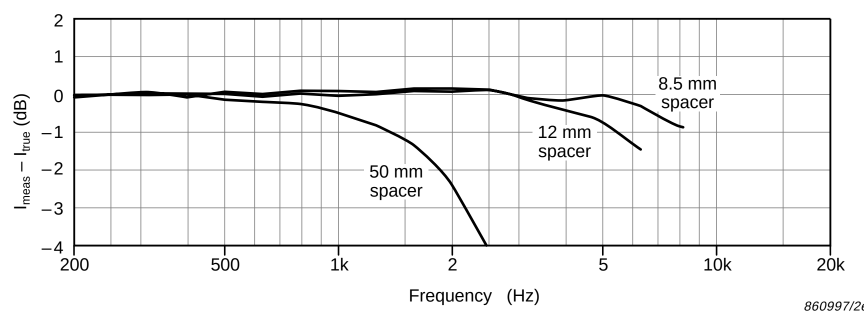


Fig. 9 Comparison measurement of the sound intensity measured using Microphone Pair Type 4197 with the actual sound intensity

Fig. 9 shows the difference between the true intensity and the measured intensity in a free field. The typical response shown in this graph includes all the possible sources of error: phase mismatch, free-field corrections, microphone distance variation and the high-frequency approximation error (the latter giving a −1 dB error at centre frequencies of 1.25 kHz, 5 kHz and 6.3 kHz respectively).

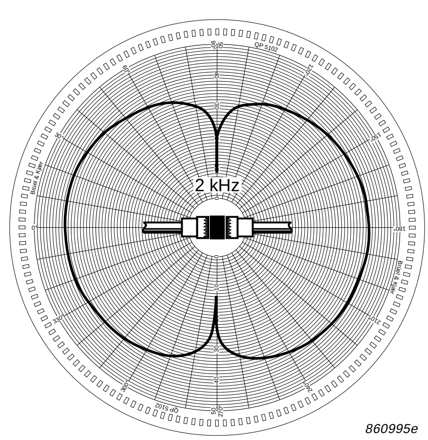


Fig. 10 Measured directional characteristics for a probe set fitted with 4197 microphones and a 12 mm spacer at 2 kHz

Directional Characteristics

Typical directional characteristics for a sound intensity probe/processor system are given in Fig. 10, which shows the measured intensity as a function

Fig. 11 The Sound Intensity Calibrator Type 3541 for both pressure and intensity calibration of sound intensity measuring systems

of angle of incidence. This figure-of-eight characteristic is due to the fact that a sound intensity system measures the component of the sound intensity along the probe axis, i.e. $I_{meas} = I\cos\theta$.

The minimum feature of the probe's characteristics can be used to help locate sound sources.

Calibration

Phase calibration of the 1/2″ microphone pair 4197 is done at Brüel & Kjær by subjecting the two microphones to the same sound signal in a pressure coupler. This individual phase calibration can be used to derive the actual Pressure-Residual Intensity Index for the microphone pair.

Complete calibration of sound intensity measurement systems containing a sound intensity probe set can be conveniently made using a Sound Intensity Calibrator Type 3541 (see Fig. 11). This permits simultaneous sensitivity adjustment of both channels of the processor (in both pressure, particle velocity or intensity modes) and allows determination of the Pressure-Residual Intensity Index of the probe and processor combinations which employ microphone pairs with phase-corrector units, that is, Type 4197 (or earlier Type 4183). Further details can be found in the separate Product Data for the Type 3541.

If only amplitude (pressure) calibration is required, the two channels can be calibrated separately using a Pistonphone Type 4228 or together using Sound Level Calibrator Type 4231 with Coupler DP 0888.

The Dual Preamplifier Type 2682 introduces a damping of 0.2 dB in channel B and 0.5 dB in channel A when using 1/2″ microphones, and 0.6 dB in channel B and 1.4 dB in channel A with 1/4″ microphones.

Ordering Information

Type 3583 Sound Intensity Probe Set
Includes the following accessories:
Type 4197: Sound Intensity Microphone Pair
Type 4178: Sound Intensity Microphone Pair
Type 2682: Dual Preamplifier
UA 0993: Telescopic Probe Stem
DH 0556: Handle
UA 0781: Ellipsoidal Windscreen
UA 0782: Spherical Windscreen
DZ 9814: Cable Reel
UA 0996: Mounting for Remote Control Unit ZH 0354
QA 0038: Allen Key

Type 3584 Sound Intensity Probe Set
Includes the following accessories:
Type 4197: Sound Intensity Microphone Pair
Type 2682: Dual Preamplifier
ZB 0017: Remote Control Handle
UA 0781: Ellipsoidal Windscreen
UA 0782: Spherical Windscreen
DZ 9814: Cable Reel
QA 0038: Allen Key

Accessories Required

Type 3583 requires either of the following:
AO 0324: 5 m Extension Cable
ZH 0354: Remote Control Unit for Type 2133

Optional Accessories

CALIBRATION EQUIPMENT:
Type 4228: Pistonphone
Type 4231: Sound Level Calibrator with Coupler DP 0888
Type 3541: Sound Intensity Calibrator (includes Type 4228)

MICROPHONES:
Type 4178: 1/4″ Sound Intensity Microphone Pair (with 6 and 12 mm spacers)

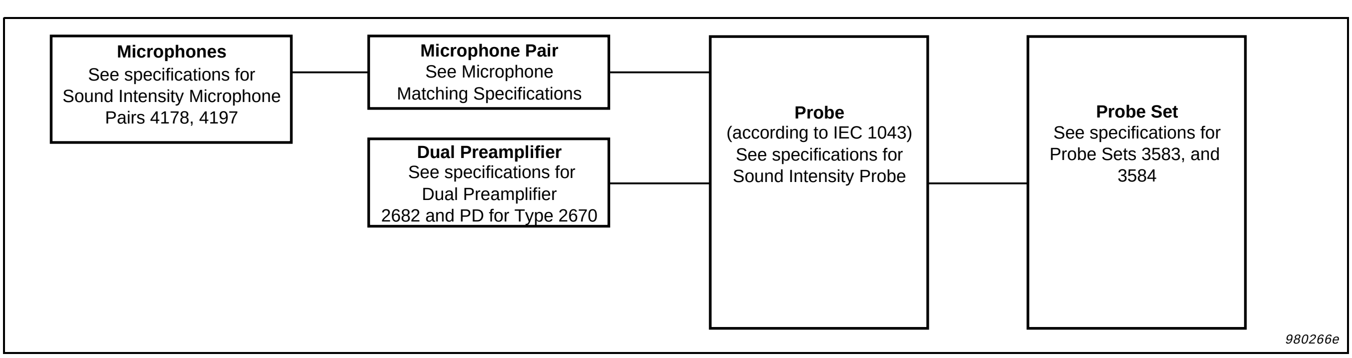
SPACERS:
For 1/4″ microphones Type 4178
UC 0196: 6 mm spacer
UC 0195: 12 mm spacer
For 1/2″ microphones Type 4197
UC 5349: 8.5 mm spacer
UC 5269: 12 mm spacer
UC 5270: 50 mm spacer

HANDLES:
For Type 3584
UA 0993: Telescopic Probe Stem
DH 0556: Handle

EXTENSION CABLES:
AO 0324: 5 m Single Cable Extension
AO 0325: 30 m Single Cable Extension
WH 0844: Branched cable (18-pin LEMO to two 7-pin Brüel & Kjær microphone plugs)
WL 1218: Branched cable (18-pin LEMO to two 7-pin LEMO)

SIDE-BY-SIDE ACCESSORIES:
2 × Type 2670: Preamplifier
2 × UA 0954: 1/4″ Venting Adaptor
DK 1002: Side-by-side Clip

Overview of Specifications



Specifications Sound Intensity Microphone Pairs 4178, 4197

Type		4178	4197
Diameter		1/4″	1/2″
Polarization voltage (V)		200	200
Open-circuit sensitivity	mv/Pa	4*	11.2*
	dB re 1 V/Pa	–48	–39
Free-field frequency response 0° incidence	±1 dB	6 Hz to 14 kHz*	5 Hz to 12.5 kHz*
	±2 dB	4 Hz to 100 kHz	0.3 Hz to 20 kHz
Resonance frequency		95 kHz	34 kHz
Lower limiting frequency	–3 dB	0.3 to 3 Hz	0.14 Hz
Vent sensitivity re diaphragm sensitivity	at 20 Hz	<–16 dB* (–6 dB/octave)	<–64 dB* (–18 dB/octave)
Polarized cartridge capacitance	at 250 Hz	6.4 pF*	19.5 pF*
Cartridge thermal noise		29.5 dB(A)	20.0 dB(A)
Upper limit of dynamic range	Distribution <3%, 100 Hz	164 dB SPL	162 dB SPL
Temperature coefficient	–10°C to +50°C, 250 Hz	–0.005 dB/°C	–0.002 dB/°C
Ambient pressure coefficient	at 250 Hz	–0.0007 dB/hPa	–0.0007 dB/hPa
Humidity coefficient	100% RH	<0.1 dB	<0.1 dB
Vibration sensitivity	at 1 m/s^2	59 dB SPL	65.5 dB SPL
Magnetic field sensitivity	50 Hz, 80 A/m	10 to 42 dB SPL	6 to 34 dB SPL
Thread for preamplifier mounting		5.7 — 60 UNS	5.7 — 60 UNS
Accessories included		6 mm spacer UC 0196 12 mm spacer UC 0195	8.5 mm spacer UC 5349 12 mm spacer UC 5269 50 mm spacer UC 5270

* Individually calibrated

Microphone Matching Specifications

Type		4178	4197
Phase response difference (absolute value) (1/3-octave centre frequencies)		<0.2°: 20 Hz to 1 kHz* Estimated: *f*[kHz]×0.2°: 1 kHz to 10 kHz	<0.05°: 20 Hz to 250 Hz* $< \frac{f[Hz]}{5000}$°: 250 Hz to 6.3 kHz*
Amplitude response difference	normalized at 200 Hz	<0.2 dB: 20 Hz to 2 kHz <0.3 dB: 2 Hz to 10 kHz	<0.2 dB: 20 Hz to 1 kHz <0.4 dB: 20 Hz to 7.1 kHz
Sensitivity difference	at 250 Hz	<1 dB	<1 dB
Polarized capacity difference		<0.3 pF	<1.0 pF

* Individually calibrated

Specifications Dual Preamplifier 2682

Phase matching		<0.015° at 50 Hz (20 pF mic. capacitance) *f*[kHz]×0.06°: 250 Hz to 10 kHz
Electrical noise re microphone sensitivity‡	1/4″ 6.4 pF dummy	39.2 dB SPL (A)
	1/2″ 19.5 pF dummy	19.4 dB SPL (A)
Input impedance		>15 GΩ‖0.25 pF
Other specifications		Refer to Product Data (BP 1584) for Type 2670

‡This corresponds to a total (Microphone + Preamplifier) noise floor of 39.3 dB SPL (A) and 22.7 dB SPL (A) respectively.
Note: All values are typical at 25°C (77°F), unless measurement uncertainty is specified. All uncertainty values are specified at 2σ (i.e., expanded uncertainty using a coverage factor of 2)

Specifications Sound Intensity Probe

Matched Sound Intensity Microphone Pairs*		½″ Type 4197
Intensity free-field frequency ranges (centre frequency –⅓-octave) with ½″ microphones Type 4197 (IEC 1043 Class 1)	8.5 mm spacer	250 Hz to 6.3 kHz (δ_{pI_0} > 15.3 dB)†
	12 mm spacer	250 Hz to 5.0 kHz (δ_{pI_0} > 16.8 dB)
	50 mm spacer	20 Hz to 1.25 kHz (δ_{pI_0} > 23 dB above 250 Hz)
Intensity free-field frequency ranges with ¼″ microphones Type 4178	6 mm spacer	max. 10.0 kHz
	12 mm spacer	max. 5.0 kHz

* See separate specifications
† Pressure-Residual Intensity Index

Specifications Probe Sets 3583 and 3584

Type		**3583**	**3584**
Remote Control Handle		(Remote Control Unit ZH 0354 available as option)	ZB 0017
	Functions	—	Start, Autosequence, Accept/Save, Input Autorange
	LEDs	—	Overload, Averaging, Direction, Autosequence
Dimensions	Length	Max. 730 mm (28.7 in)	425 mm (16.7 in)
	Width	43 mm (1.7 in)	
Weight	Incl. handle	0.45 kg (1 lb.)	0.35 kg (0.77 lb.)
	In case	4.5 kg (9.9 lb.)	4.8 kg (10.6 lb.)

Compliance with Standards

CE	CE-mark indicates compliance with: EMC Directive
Safety	EN 61010–1 and IEC 1010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN 50081–1: Generic emission standard. Part 1: Residential, commercial and light industry. EN 50081–2: Generic emission standard. Part 2: Industrial environment. CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Class B limits
EMC Immunity	EN 50082–1: Generic immunity standard. Part 1: Residential, commercial and light industry. EN 50082–2: Generic immunity standard. Part 2: Industrial environment. **Note:** The above is guaranteed using accessories listed in this Product Data sheet only.
Temperature	IEC 68–2–1 & IEC 68–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –10 to +50°C (+14 to +122°F) for operation within specifications Storage Temperature: –25 to +70°C (–13 to +158°F)
Humidity	IEC 68–2–3: 90% RH (non-condensing at 40°C (104°F))

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