PRODUCT DATA

Laboratory Standard Microphone Cartridge Types 4160 and 4180

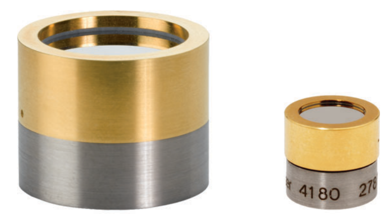
Types 4160 and 4180 are high quality condenser microphone cartridges intended for use as laboratory standard microphones and in laboratory coupler applications where high accuracy and long-term stability are essential.

Type 4160 is a 1" laboratory standard microphone for use in the medium and low frequency ranges.

Type 4180 is a ½" laboratory standard microphone for extended frequency calibrations.

Both microphones are designed for coupler applications and can be used with couplers filled with gases other than air as they feature very low gas leakage from the front cavity.

Both microphones are externally polarized and operate on a polarization voltage of +200 V. They are individually calibrated and pressure calibration data is provided with each microphone.



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Uses and Features

Uses
- Laboratory standard microphones
- Pressure and free-field reciprocity calibration
- Coupler measurements
- Constitute sound pressure references with a primary (reciprocity) calibration

Features
- Well-defined integral front cavities for coupler calibrations
- Low hydrogen leakage from front cavity
- Well-defined operating characteristics
- Flat pressure frequency responses up to:
  – 8kHz for Type 4160
  – 20 kHz for Type 4180
- Artificially aged for long-term stability
- Low sensitivity to environmental changes
- Standards:
  – IEC 61094-1, ANSI S1.15-1 (Type 4160: LS1P, Type 4180: LS2aP): Specifications for laboratory standard microphones
  – IEC 61094-2, ANSI S1.15-2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique
  – IEC 61094-3: Primary method for free-field calibration of laboratory standard microphones by the reciprocity technique

Brüel & Kjær

Laboratory Standards

Types 4160 and 4180 are both high-stability condenser microphone cartridges which find application as laboratory standards and in coupler measurements.

Type 4160 is a 1″ laboratory standard microphone for measurement in the medium and low frequency ranges. Type 4180 is a ½″ laboratory standard microphone for measurements at higher frequencies and at higher sound pressure levels.

Types 4160 and 4180 are delivered in storage boxes with individual calibration charts.

Description

The design and construction of Types 4160 and 4180 ensure high-quality laboratory microphones which are extremely reliable with respect to environmental factors and have excellent long-term stability. Types 4160 and 4180 have well-defined front volumes to facilitate accurate mounting of calibration couplers. For example, a feature of the front cavity of Type 4180 is its shallow depth, only 0.5 mm.

Frequency Response

Since Types 4160 and 4180 are designed mainly for use in pressure calibrations, they have flat pressure response curves as can be seen in Fig. 1. Type 4160 has a flat response up to 8 kHz and Type 4180 exhibits a flat response up to 20 kHz. Measurements can be made at higher frequencies, up to 20 kHz for Type 4160, and up to 40 kHz for Type 4180, but with reduced sensitivity.

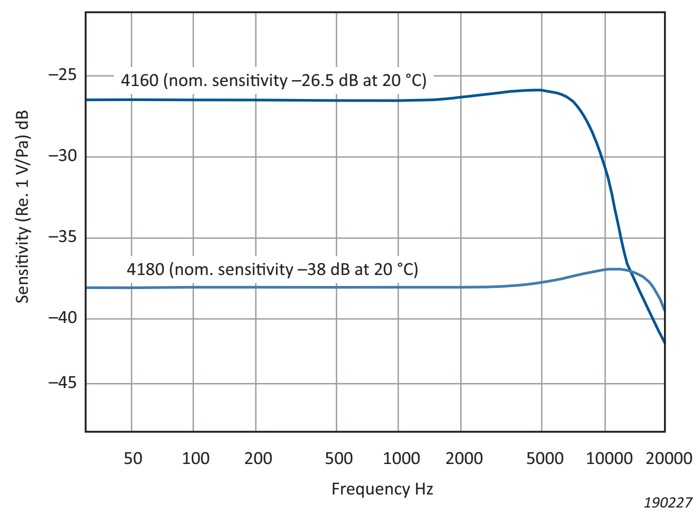


Fig. 1
Typical pressure frequency responses for Types 4160 and 4180

Lower-limiting Frequency

The pressure frequency response of Types 4160 and 4180 are not limited in the lower frequencies, since by the definition of pressure response, the vent is not exposed to the sound field. However, when the microphones are used in measurements where the pressure equalization vent is exposed to the sound, for example in a free field, the sensitivity at low frequencies decreases. The lower frequency limit (–3 dB), which is determined by the resistance of the pressure equalization vent, lies between 1 and 2 Hz for Type 4160 and between 1 and 3 Hz for Type 4180.

Free-field Measurements

Type 4180 may find application in free-field and diffuse-field measurements. It disturbs the sound field less than a 1″ microphone and is less sensitive to angle of incidence.

Dynamic Range

The lower limit of the dynamic range for a condenser microphone system is determined by the diaphragm thermal noise and by the electronic noise in the preamplifier. For Type 4160 connected to Preamplifier Type 2673, the dynamic range is from 11 dB(A) to 146 dB (3% distortion). Type 4180, when operated with the same preamplifier, has a dynamic range from 21 dB(A) to 160 dB (3% distortion).

Preamplifiers

Brüel & Kjær Preamplifier Types 2673 and 2669 may be used with Types 4160 and 4180. For fitting these preamplifiers to Type 4160, an adaptor (UA-1434) is required. Preamplifier Type 2673 has provision for microphone calibration using the insert-voltage technique.

Environmental Stability

Short-term environmental factors such as temperature and pressure have only a slight effect on the sensitivities of the microphones.

The diaphragm tension and the critical spacing between the diaphragm and backplate are stabilized against the effects of thermal expansion by close thermal matching of the materials of construction. The small, reversible sensitivity variation in regards to temperature is shown in Fig. 2. Although the temperature effect is predictable and small, it is recommended that laboratory standard microphones be kept within a narrow temperature range.

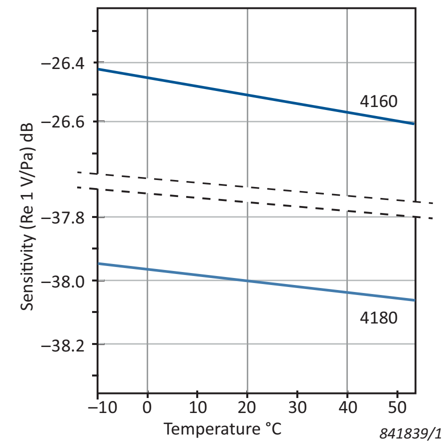


Fig. 2
Effect of temperature on microphone sensitivity (250 Hz)

Changes in barometric pressure produce a change in air stiffness. Most of the microphone stiffness, however, is due to mechanical stiffness and the effect of small changes in atmospheric pressure is consequently minimized, see Fig. 3.

In the absence of condensation, variations in relative humidity will have only a small effect on the microphone sensitivities due to a small variation in cavity air stiffness. For the full range of humidity, this effect is typically negligible.

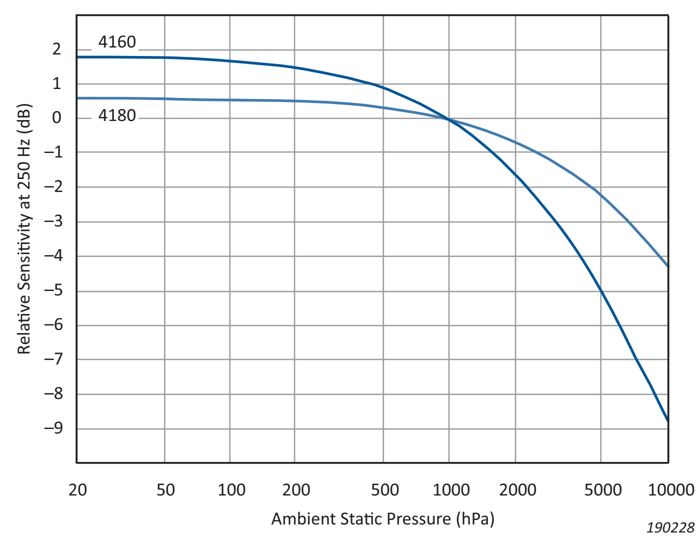


Fig. 3
Effect of ambient pressure on microphone sensitivity (250 Hz)

Long-term Stability

It is essential that a laboratory standard microphone is extremely stable over long periods of time. Changes of sensitivity with time could occur due to relaxation of the diaphragm tension or due to changes in the distance between the diaphragm and the backplate.

The excellent stability of Types 4160 and 4180 is the result of careful design and years of practical experience. Each diaphragm is microscopically inspected to detect any imperfections which could affect the performance or endanger long-term stability. Artificial ageing at high temperatures after the final tensioning of the diaphragm causes the microphone to settle into a state of very high operating stability.

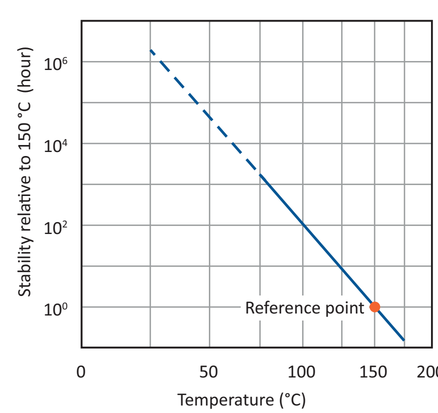


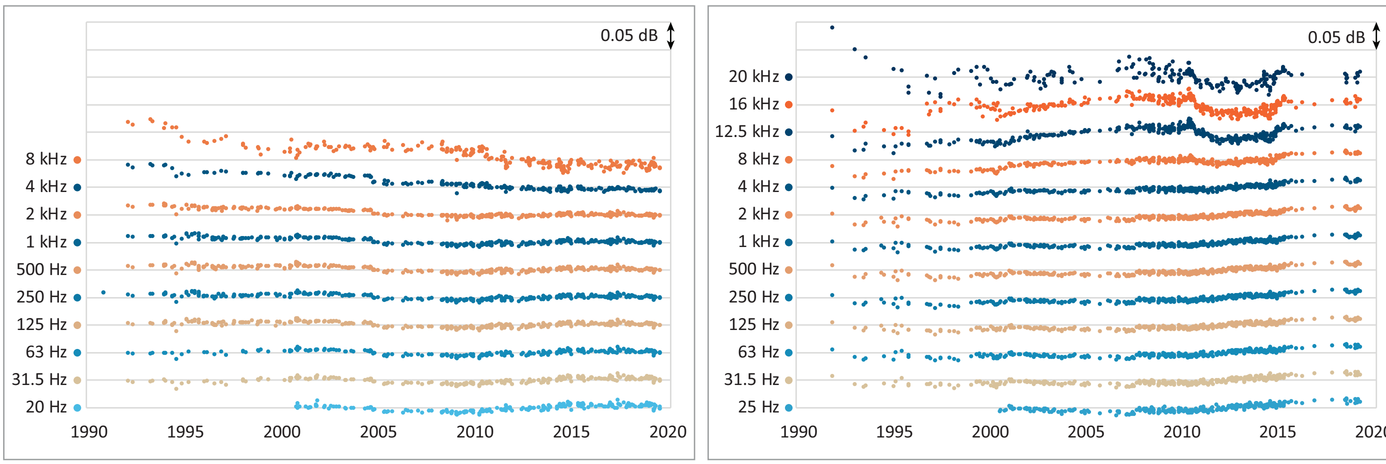
Fig. 4
Relative stability of diaphragm tension as a function of temperature

The predicted long-term stability of these microphones is a change of less than 1 dB over several hundred years, when operated at room temperature. This figure has been arrived at by extrapolation from measurements of diaphragm stability carried out at elevated temperatures, see Fig. 4. The predicted long-term stabilities have been supported by actual measurements made on primary standard microphones over the years at Brüel & Kjær laboratories; see Fig. 5.

Estimating Long-term Stability

The long-term stability estimates for Types 4160 and 4180 are less than 1 dB in 400 to 1000 years. Such figures are difficult to verify experimentally, as annual changes in sensitivity are very small compared to uncertainty of measurement. However, some samples have been used in reference laboratories for many years. The graph below shows the results of sensitivity measurements that have been carried out over more than 25 years in a reference laboratory. The results shown in the graph are consistent with the predicted long-term stability for these microphones.

***Fig. 5** Stability plots for Type 4160 (**left**) and Type 4180 (**right**) at different frequencies over 25 years*



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Coupler Measurements

The coupler mounting surfaces of Types 4160 and 4180 are designed so that the total effective diaphragm area faces exactly into the coupler. Using a coupler of diameter equal to the diaphragm diameter, optimal conditions exist for the propagation of plane waves, and the excitation of transverse waves at higher frequencies is repressed.

Hydrogen Leakage

For some applications, measurements are made with a coupler filled with a gas other than air, such as hydrogen. It is important that the leakage of gas from the cavity is low so that the useful measurement time can be extended. Special consideration has been given to the hydrogen leakage in the design of Types 4160 and 4180. The hydrogen leakages of Types 4160 and 4180 are very low and enable adequate measurement times.

Calibration

For accurate and convenient calibration of laboratory standard microphones, Brüel & Kjær Reciprocity Calibration Apparatus Type 5998 can be used.

Calibration Services

Microphone calibration services are available for Types 4160 and 4180 through the Danish Primary Laboratory of Acoustics at Brüel & Kjær (BKSV-DPLA), a designated institute participating in the CIPM MRA.

	4160	4180
General		
Open Circuit Sensitivity* (250 Hz)	−27 dB ±1 dB re 1 V/Pa, 44.7 mV/Pa	−38 dB ±1.5 dB re 1 V/Pa, 12.5 mV/Pa
Polarisation Voltage	+200 volts	+200 volts
Frequency Response* (pressure)	**up to 8 kHz:** ±1 dB (ref. to 250 Hz)	**up to 10 kHz:** ±1 dB (ref. to 250 Hz) **up to 20 kHz:** ±1.5 dB (ref. to 250 Hz)
Pressure Equalization System	Back vented	Side vented
Lower Limiting Frequency* (–3 dB)	1 to 2 Hz (vent exposed to sound)	1 to 3 Hz (vent exposed to sound)
Pressure Equalization Time Constant (range)	0.16 to 0.08 s	0.16 to 0.053 s
Diaphragm Resonance Frequency (90° phase shift)	8.5 kHz (typical)	23 kHz (typical)
Insulation Resistance (at 85% RH)	$>10^{15}$ Ω	$>10^{15}$ Ω
Polarized Capacity (250 Hz)*	55 ± 3 pF	17.5 pF (typical)
Cartridge Thermal Noise	0.6×10^{-6} Pa/√Hz, 9.5 dB(A), 10 dB(Lin)	1.3×10^{-6} Pa/√Hz, 18 dB(A), 21.5 dB(Lin)
Upper Limit of Dynamic Range (<3% distortion)	146 dB SPL (at 100 Hz, load: <0.5 pF)	160 dB SPL (at 100 Hz, load: <0.5 pF)
Safety Limit	160 dB (peak)	174 dB (peak)
Equivalent Air Volume (of diaphragm, 250 Hz)	148 ± 30 mm^3	9.3 mm^3 (typical)
Environmental		
Operating Temperature Range†	up to 50 °C	up to 50 °C
Temperature Coefficient (250 Hz, –10 to +50 °C)	−0.003 dB/K (typical)	−0.002 dB/K (typical)
Pressure Coefficient (250 Hz)	−0.0155 dB/kPa (typical)	−0.0058 dB/kPa (typical)
Humidity Coefficient (250 Hz)	Negligible	
Vibration Sensitivity **(for axial acceleration at frequencies <1 kHz)**	45×10^{-3} Pa/ms^{-2}, 67 dB at 1 ms^{-2}	36×10^{-3} Pa/ms^{-2}, 65 dB at 1 ms^{-2}
Magnetic Field Sensitivity (80 A/m, 50 Hz field)	4 to 24 dB, typical 18 dB SPL	6 to 34 dB, typical 20 dB SPL
Long-term Stability (at 20 °C)	>1000 years/dB	>400 years/dB
Hydrogen Leakage of Front Cavity	Δf_0 < 0.05%/min in 20 cm^3 coupler without buffers	Δf_0 < 0.3%/min in 3 cm^3 coupler without buffers
Physical		
Diameter	23.77 mm	**Front:** 13.2 mm **Back:** 12.7 mm
Height	19 mm	12 mm
Front Cavity Diameter	18.6 mm (average)	9.3 mm
Front Cavity Depth	1.95 mm	0.5 mm
Thread for Preamplifier Mounting	23.11 mm–60 UNS	11.7 mm–60 UNS

* Individually calibrated
† For use as a laboratory standard microphone, keep at a constant temperature

Note: Specifications valid at 23 °C, 1013 mbar and 50% RH unless otherwise specified

COMPLIANCE WITH STANDARDS

China RoHS mark indicates compliance with administrative measures on the control of pollution caused by electronic information products according to the Ministry of Information Industries of the People's Republic of China

WEEE mark indicates compliance with the EU WEEE Directive

Type 4160 1″ Laboratory Standard Microphone Cartridge
Type 4180 ½″ Laboratory Standard Microphone Cartridge

Optional Accessories

ACCESSORIES FOR TYPE 4160

Type 2669	½″ Preamplifier
Type 2673	½″ Preamplifier
UA-1434	Adaptor, 1″ microphone to ½″ preamplifier
DZ-9025	Dust Cap
Type 4228	Pistonphone
Type 5998	Reciprocity Calibration System

ACCESSORIES FOR TYPE 4180

Type 2669	½″ Preamplifier
Type 2673	½″ Preamplifier
DZ-9314	Dust Cap
Type 4228	Pistonphone
Type 5998	Reciprocity Calibration System

Calibration Services

PRIMARY CALIBRATION SERVICES

Primary calibration services are performed at the Danish Primary Laboratory of Acoustics at Brüel & Kjær (BKSV-DPLA)

Item No.	Calibration Frequency Series*	Calibration Specification
ET 2012	A	125, 250, 500, 1000, 2000 Hz
ET 2013	B	Octave frequencies between 31.5 Hz and the highest frequency stated for the type of microphone
ET 2014	C	Same as series B but with 1/3-octave frequencies above 1 kHz
ET 2014-W-002	E	1/3-octave from 10 Hz to 20 kHz
ET 2030	F	1/12-octave from 20 Hz to 25 kHz
ET 2015	D	Individual selected frequency. Only in addition to series A, B, C, E and F
ET 2016	Length of front cavity	This type of calibration is necessary to perform the above calibrations within the specified uncertainties. It does not need to be performed as frequently as sensitivity calibrations. The proposed interval is 5 years

* The generally applied calibration frequencies are nominal frequencies. The exact frequencies are in accordance with ISO 266 and equal to $10^{n/10}$ Hz, where *n* is an integer.

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