# Product Data

## Condenser Microphone Cartridges — Types 4160 and 4180

USES:

0 Laboratory standard microphones

0 Pressure and Free Field Reciprocity Calibrations

0 Coupler measurements

FEATURES:

0 Well defined integral front cavities for coupler calibrations

0 Low hydrogen leakage from front cavity

0 Well-defined operating characteristics

0 Flat Frequency Pressure Responses up to:
4160: 8kHz
4180: 20 kHz

0 Artificially aged for long term stability

0 Low sensitivity to environmental changes

0 Standards:
4160: ANSI S1.12-1967, ANSI S1.l0-1966 (and revisions), IEC 327 and 402, JIS C 5515, and IEC draft standard for 1 " laboratory standard microphones type LS1 P
4180: IEC draft standard for **1/2"** laboratory standard microphones type LS2aP

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

One-inch diameter Type 4160 has become established as a laboratory standard microphone for use in the medium and low frequency ranges.

Half-inch diameter Type 4180 has been developed as a laboratory standard microphone to meet the need 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 both feature very low gas leakage from the front cavity.

Both microphones are of the external polarization type and operate on a polarization voltage of +200 Volts. The microphones are individually calibrated and pressure calibration data are provided with each microphone.

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

Type 4160 has been used for some time in such applications and conforms to IEC 327 and 402, ANSI S1.12-1967 and ANSI Sl.lO-1966, JIS C 5515, and the current IEC draft standard for 1" laboratory standard microphones. It has become established as a high precision reference standard and is used in the medium frequency ranges and for measurements at low sound pressure levels.

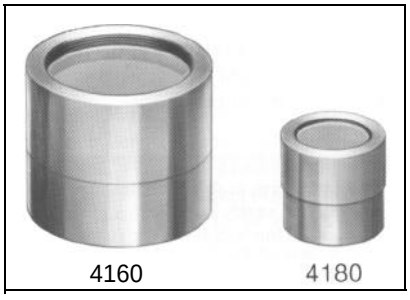
Type 4180 has been developed to meet a growing need for a laboratory standard 1/2" microphone which enables measurements at higher frequencies and at higher sound pressure levels.

Standard specifications for l/2" laboratory standard microphones are under consideration and the 4180 has been designed to comply with the most recent drafts of these standards.

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

## Description

The high standards of design and construction of both microphones ensure a high quality laboratory microphone which is extremely reliable with respect to environmental factors and has an excellent long-term stability. The construction of Types 4180 and 4160 is similar to that of other Brüel & Kjær condenser microphones but with the addition of well-defined front volumes to facilitate accurate mounting of calibration couplers. A feature of the front cavity of the 4180 is its shallow depth, only 0,5mm.




**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. The 4160 has a flat response up to 8kHz and the 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.

**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 de-

creases. The lower frequency limit (-3dB), which is determined by the resistance of the pressure equalization vent, lies between 1 and 2Hz for the 4160 and between 1 and 3Hz for the 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 the 4160 connected to Preamplifier Type 2645 the dynamic range is from lldB(A) to 146dB (3% distortion). The 4180 when operated with the same preamplifier has a dynamic range from 2ldB(A) to 160dB (3% distortion).

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

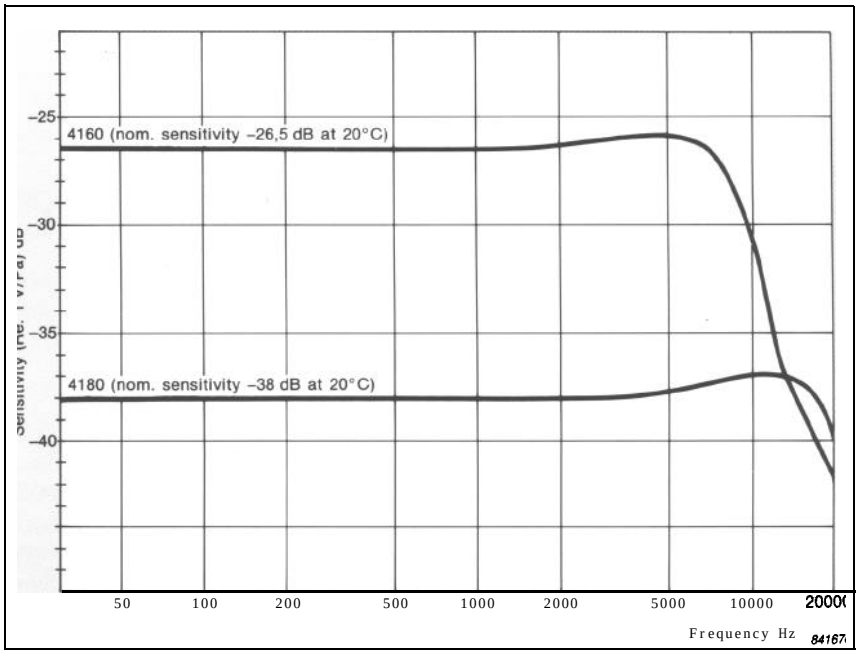



*Fig 1 Typical pressure frequency responses for Types 4160 and 4180*

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 with temperature is shown in Fig. 3. Although the temperature effect is predictable and small it is recommended that lab-

The long term stability estimates for Brüel & Kjær microphones are so high, namely less than 1 dB in 400 to 1000 years, that it is quite difficult to verify such a figure experimentally, as the annual change in sensitivity would not be detectable using current calibration methods. One can however rule out the possibility of large deviations from the predicted stability by direct measurement. The graph below shows the results of sensitivity measurements which have been carried out over a 23 year period on primary standard microphones at the Brüel & Kjær laboratory. The microphones in question are Briiel & Kjær 1" microphones. The graph shows that there has been no change in sensitivity over the measurement period, within the experimental errors. The decrease in scatter of results since 1977 can be attributed to new calibration apparatus and to a change in measurement procedure. These results are consistent with the predicted long term stability for these microphones.

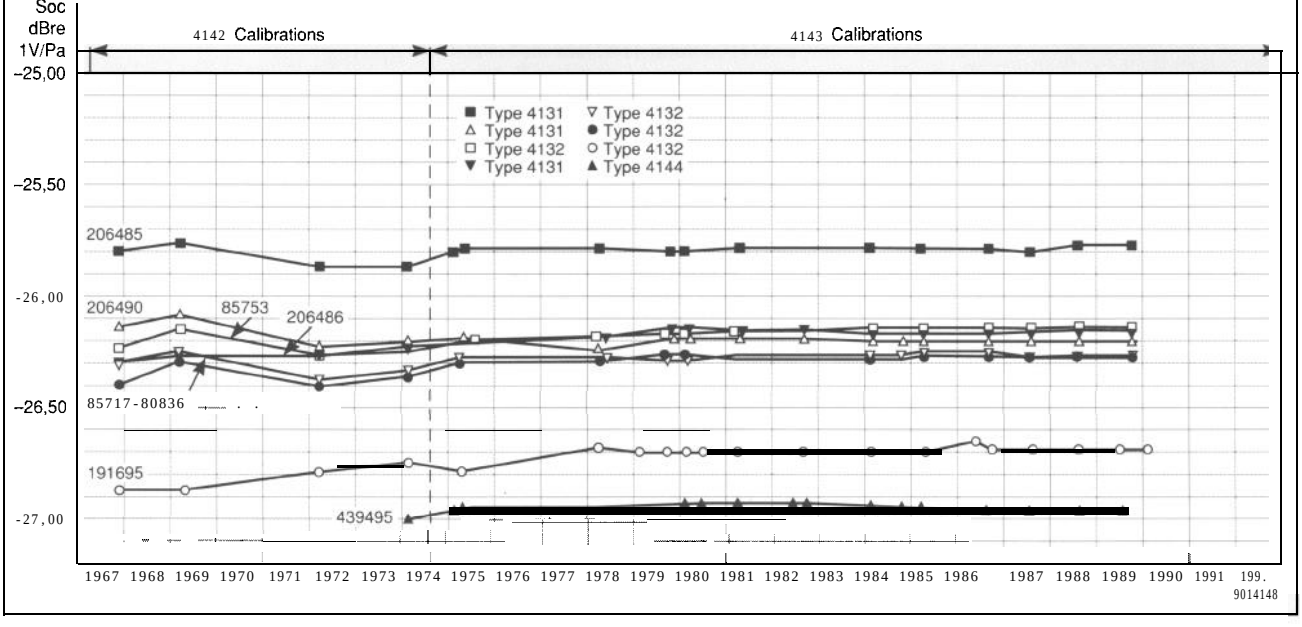



*Fig. 2. Measurements made on the sensitivities of one inch primary standard microphones at the* ***Brüel*** *& Kjær laboratory form 1967 to 1990. Microphone Type numbers are indicated beside each curve*

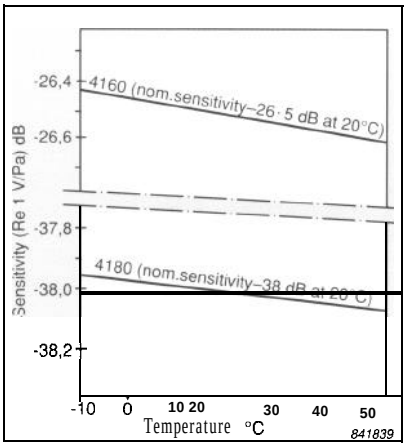



*Fig. 3. Effect of temperature on microphone sensitivity (25OHz)*

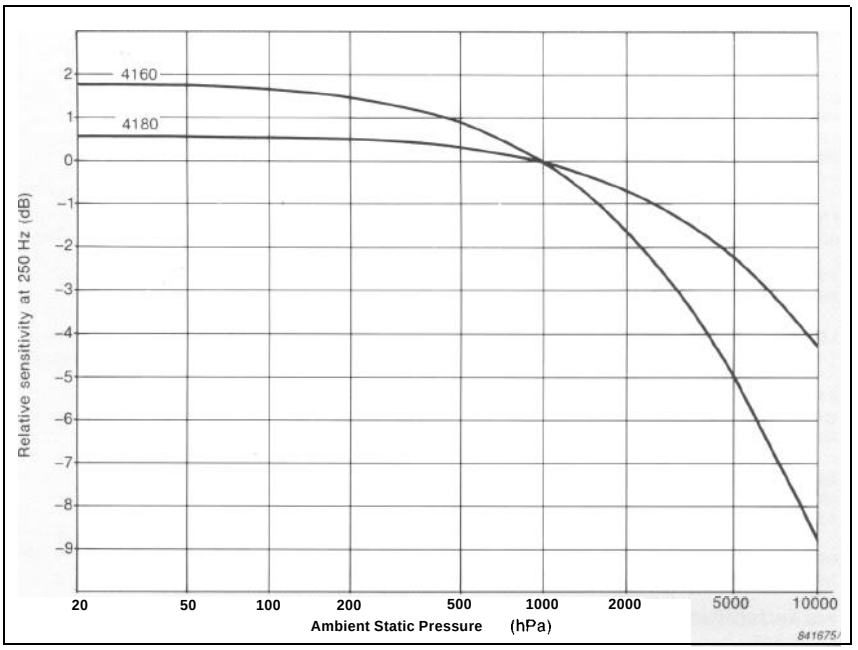



*Fig. 4. Effect of ambient pressure on microphone sensitiuity (25OHz)*

oratory standard microphones be kept within a narrow temperature range.

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. 4.

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 less than 0,0025dB for the 4160 and 0.OOO8dB for the 4180.

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 the 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 the 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.

The predicted long-term stability of these microphones is a change of less than 1dB in 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, Fig. 5. The predicted long-term stabilities have been supported by actual measurements made on primary standard microphones over the years at the Brüel & Kjær laboratories; see Fig. 2.

Coupler Measurements

The coupler mounting surfaces of the 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

Coupler measurements are often 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 question of hydrogen leakage in the design of the 4160 and 4180. The hydrogen leakages of the 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 4143 can be used. An adaptor ring UA 0825 is available which can be fitted to Brüel & Kjær l/2" microphone Types 4133, 4134, 4147 and 4149 to give them the same front geometry as the 4180. Adaptor ring DB 0111 is available for converting 1" microphone Types 4144 and 4145 to the same front geometry as the 4160.

Preamplifiers

Brüel & Kjær Preamplifiers Type 2645 and 2639 may be used with the 4160 and 4180 microphones. For fitting these Preamplifiers to Type 4160, an adaptor (UA 0786) is required. Type 2645 has provision for microphone calibration using the insert voltage technique.

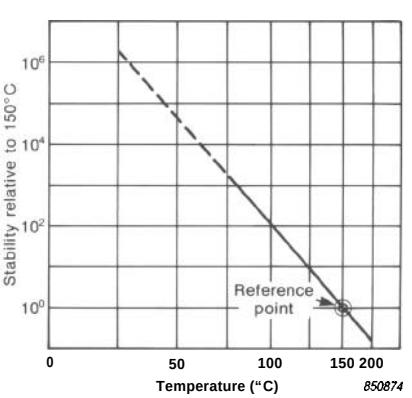



*Fig. 5. Relative stability of diaphragm tension as a function of temperature*

# Specifications 4160

**OPEN CIRCUIT SENSITIVITY* (250 Hz):**
-26,5 dB ± 1 dB re 1 V/Pa, 47mVIPa

**POLARIZATION VOLTAGE:**
+200 Volts

**FREQUENCY RESPONSE*** (pressure):
up to 8kHz: ± 1 dB (ref. to 250 Hz)

**PRESSURE EQUALIZATION SYSTEM:**
Back vented

**LOWER LIMITING FREQUENCY*** (-3dB):
1 Hz to 2 Hz (vent exposed to sound)

**PRESSURE EQUALIZATION TIME CONSTANT:**
Range: 0,16 to 0,08 s

**DIAPHRAGM RESONANCE FREQUENCY (90°** phase shift):
8,5 kHz (typ.)

**INSULATION RESISTANCE** (at 85% RH):
$> 10^{15}\ \Omega$

**POLARIZED CAPACITY' (250 Hz):**
55 ± 3 pF

**CARTRIDGE THERMAL NOISE:**
$0{,}6 \times 10^{-6}\ Pa/\sqrt{Hz}$
9,5 dB(A), 10 dB(lin)

**UPPER LIMIT OF DYNAMIC RANGE** (<3% distortion):
146 dB SPL (at 100 Hz, load: <0,5 pF)

SAFETY LIMIT:
160 dB (peak)

EQUIVALENT AIR VOLUME (of diaphragm, 250 Hz):
148 ± 30 $mm^3$

OPERATING TEMPERATURE RANGE:
up to 50°C (for use as a laboratory standard microphone keep at a constant temperature)

TEMPERATURE COEFFICIENT (250 Hz):
–0,003 dB/°C (typ.) for the range: -10 to +50°C

PRESSURE COEFFICIENT (250 Hz):
–0,0016 dB/hPa (typ.)

HUMIDITY COEFFICIENT (250 Hz):
0,0025 dB/100% RH (due to variation in air stiffness)

VIBRATION SENSITIVITY:
45 $\times 10^{-3}$ Pa/$ms^{-2}$, 67 dB at 1 $ms^{-2}$, for axial acceleration at frequencies <1 kHz

**MAGNETIC FIELD SENSITIVITY:**
4 to 24 dB, typ. 18 dB SPL for 80 A/m, 50 Hz field

**LONG-TERM STABILITY** (at 20°C):
> 1000 years/dB

**HYDROGEN LEAKAGE OF FRONT CAVITY:**
$\Delta f_0 < 0{,}05\%$/min in 20 $cm^3$ coupler without buffers

DIMENSIONS:
Diameter: 23,77 mm (with and without grid)
Height: 19,35 mm (with protection grid)
:19 mm (without protection grid)
Front Cavity Diameter: 18,6 mm (average)
Front Cavity Depth: 1,95 mm
Thread for preamplifier mounting:
23.1 l-60 UNS

ACCESSORIES AVAILABLE:
Reciprocity Calibration Apparatus Type 4143
Pistonphone ..... Type 4228
Preamplifier ..... Type 2645
Preamp. Adaptor ..... UA 0786
Preamplifier ..... Type 2639
Preamp. Adaptor ..... DB 0375
Coupler Adaptor Ring 1 ″ DB 01 11
Protection Grid ..... DD 0168

Above data valid at 23°C, 1013 hPa and 50% RH unless otherwise specified.

• Individually calibrated

# Specifications 4180

**OPEN CIRCUIT SENSITIVITY* (250 Hz):**
-38dB ±1,5 dB re 1 V/Pa, 12,5 mV/Pa

POLARIZATION VOLTAGE:
+200 Volts

FREQUENCY RESPONSE* (pressure):
up to 10 kHz: ±1 dB
up to 20 kHz: ±1,5 dB
(ref. to 250 Hz)

**PRESSURE EQUALIZATION SYSTEM:**
Side vented

LOWER LIMITING FREQUENCY* (-3dB):
1 Hz to 3 Hz (vent exposed to sound)

PRESSURE EQUALIZATION TIME CONSTANT:
Range: 0,16 to 0,053s

DIAPHRAGM RESONANCE FREQUENCY (90" phase shift):
23 kHz (typ.)

INSULATION RESISTANCE (at 85% RH):
$> 10^{15}\ \Omega$

POLARIZED CAPACITY' (250 Hz):
17.5 pF (typ.)

CARTRIDGE THERMAL NOISE:
$1{,}3 \times 10^{-6}\ Pa/\sqrt{Hz}$, 18 dB(A), 21,5 dB(lin)

**UPPER LIMIT OF DYNAMIC RANGE** (<3% distortion):
160dB SPL (at 100 Hz, load: <0,5 pF)

SAFETY LIMIT:
174 dB (peak)

**EQUIVALENT** AIR VOLUME (of diaphragm, 250 Hz):
9.3 $mm^3$ (typ.)

OPERATING TEMPERATURE RANGE:
up to 50°C (for use as a laboratory standard microphone keep at a constant temperature)

TEMPERATURE COEFFICIENT (250 Hz):
–0,002 dB/°C (typ.) for the range: -10 to +50°C

PRESSURE COEFFICIENT (250 Hz):
–0,0007 dB/hPa (typ.)

**HUMIDITY COEFFICIENT (250 Hz):**
0,0008 dB/100% RH (due to variation in air stiffness)

**VIBRATION SENSITIVITY:**
36 $\times 10^{-3}$ Pa/$ms^{-2}$, 65dB at 1 $ms^{-2}$, for axial acceleration at frequencies <1kHz

**MAGNETIC FIELD SENSITIVITY:**
6 to 34 dB, typ. 20 dB SPL for 80 A/m, 50 Hz field

LONG-TERM STABILITY (at 20°C):
> 400 years/dB

HYDROGEN LEAKAGE OF FRONT CAVITY:
$\Delta f_0 < 0{,}3\%$/min in 3 $cm^3$ coupler without buffers

DIMENSIONS:
Diameter (front): 13,2 mm
Diameter (back): 12,7 mm
Height: 12mm
Front Cavity Diameter: 9,3 mm
Front Cavity Depth: 0,5 mm
Thread for preamplifier mounting:
11,7-60 UNS

**ACCESSORIES AVAILABLE:**
Reciprocity Calibration Apparatus Type 4143
Pistonphone ..... Type 4228
Preamplifier ..... Type 2645
Preamplifier ..... Type 2639
Coupler Adaptor Ring ..... UA 0825
Dust Cap ..... DD 0371

Above data valid at 23°C, 1013hPa and 50% RH unless otherwise specified.

• Individually calibrated


**Brüel & Kjær**

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