

# Product Data

## Two-microphone Impedance Measurement Tube — Type 4206

### USES:

- Measurement of:
  - acoustic absorption coefficient
  - acoustic reflection coefficient
  - normalized impedance
- Measurements on complex or composite materials
- Measurements on orientation-sensitive materials
- Simulation of measurements on hanging ceilings

### FEATURES:

- Quick measurements over a large frequency range
- Software-controlled measurements, data management and hard copy facilities
- Low-frequency tube: 50 Hz to 1.6 kHz
- High-frequency tube: 500 Hz to 6.4 kHz
- Horizontal mounting of orientation-sensitive materials
- Wall mountable

Two-microphone Impedance Measurement Tube Type 4206 is used in measuring the acoustic absorption coefficient, acoustic reflection coefficient and normalized impedance of small test samples in the frequency range from 50 Hz to 6.4 kHz. The impedance measurement tube is supplied with two specially designed  $\frac{1}{4}$ " Microphones Type 4187 with preamplifiers, and Application Software BZ 5050 and BZ 5051.

Application Software BZ 5051 contains pre-programmed autosequences which control measurement and calibration procedures, post-processing, data file management and hard copy facilities for a measurement set-up controlled by a Brüel & Kjær Multichannel Analysis System Type 3550.

Application Software BZ 5050 contains software for use with an IBM-compatible PC, and allows the PC to act as system controller for a measurement set-up using either Type 3550 or Brüel & Kjær Dual Channel Signal Analyzers Type 2032 or 2034 (earlier types).



### Description

Type 4206 consists of:

- a large (low-frequency) measurement tube which has a frequency-weighting unit and sound source mounted at one end, and three couplers for mounting microphones flush with the inside of the tube
- a small (high-frequency) measurement tube which has two microphone couplers and is mounted directly onto the open end of the large measurement tube
- a large and a small sample holder, each with an acoustically hard backplate attached to a sliding piston
- two large extension tubes which can be fitted between the measurement tube and sample holder to increase the length of either of the measurement set-ups.

These components can be assembled into standard large and small tube set-ups into which the test samples are mounted. The effective length of each set-up can be changed by fitting one or both extension tubes and by changing the position of the sliding piston inside the sample holder.

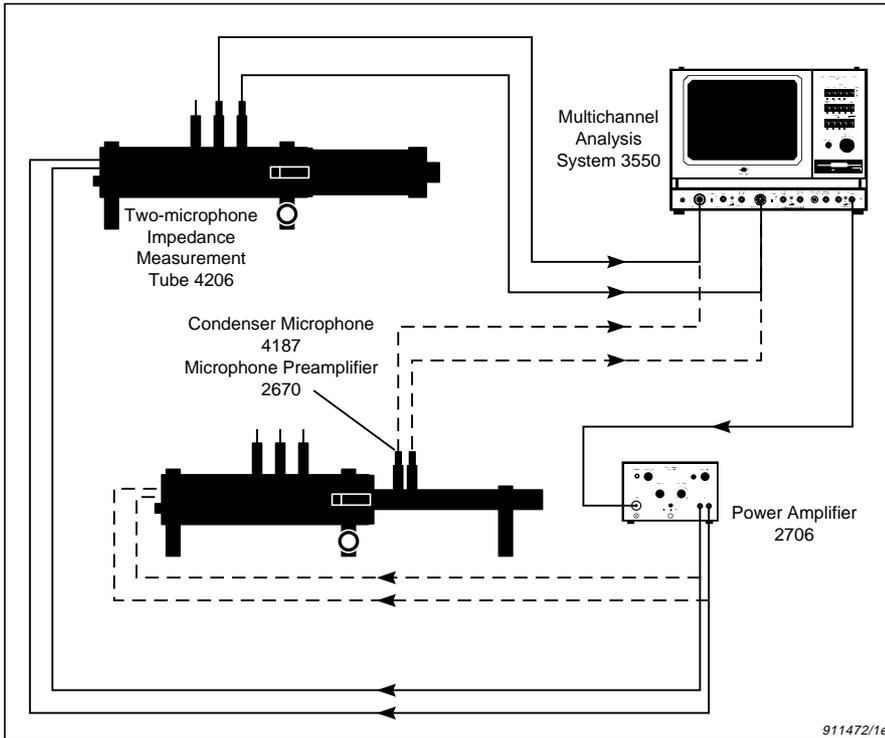


Fig.1 Large and small tube measurement set-ups using Type 3550 as controller

Three types of weighting are selectable with the large tube's frequency weighting unit:

- high-pass, for high frequency measurements in the small tube
- linear, for measurements in the large tub
- low-pass for extra measurement accuracy below 100 Hz.

Measurements inside the tube are made with two  $\frac{1}{4}$ " Condenser Microphones Type 4187 which are supplied with Type 4206, and which are specially designed to reduce errors due to pressure leakage at high frequencies.

## Calibration Procedure

Before measurements can be made using a particular tube set-up, a quick and easy calibration procedure must be used to ensure that the measurements are not affected by phase or amplitude mismatch between the two measurement channels. The measurements involved in this procedure are made by the system controller (either Type 3550 or PC) and you only need to switch the positions of the two microphones for the calibration to be completed.

## Type 3550-controlled Measurement Set-up

A measurement set-up using Type 3550 with Application Software BZ 5051 as system controller is shown in Fig.1. The large tube set-up is for measurements in the range 50 Hz to 1.6 kHz, and the small tube set-up is for measurements in the range 500 Hz to 6.4 kHz

Once the tube set-up is calibrated, the test sample is mounted and a measurement can be made. The analyzer generates a random signal which is then amplified (by, for example, Power Amplifier Type 2706), frequency weighted by the frequency-weighting unit in the large tube, and then applied to the sound source. The analyzer then measures the response of the two microphones and calculates the  $H_1$  frequency response function between the two microphone channels. From this frequency response function, all other test sample data is calculated.

For each measurement made on a sample, the following data can be calculated and displayed by the analyzer in the frequency range of interest: acoustic absorption coefficient (magnitude only), acoustic reflection coefficient, normalized impedance, frequency response function or calibration result, each displayed as magnitude, phase, real or imaginary part, or as a Nyquist plot (real versus imaginary) or Nichols plot (phase versus amplitude).

Data can be stored on disk and then recalled for future processing, or transferred to a PC as a screen picture. Hard copies can be made on graphics printers in B & K, HP, IBM, Epson and ASCII formats, and on graphics plotters in HPGL format.

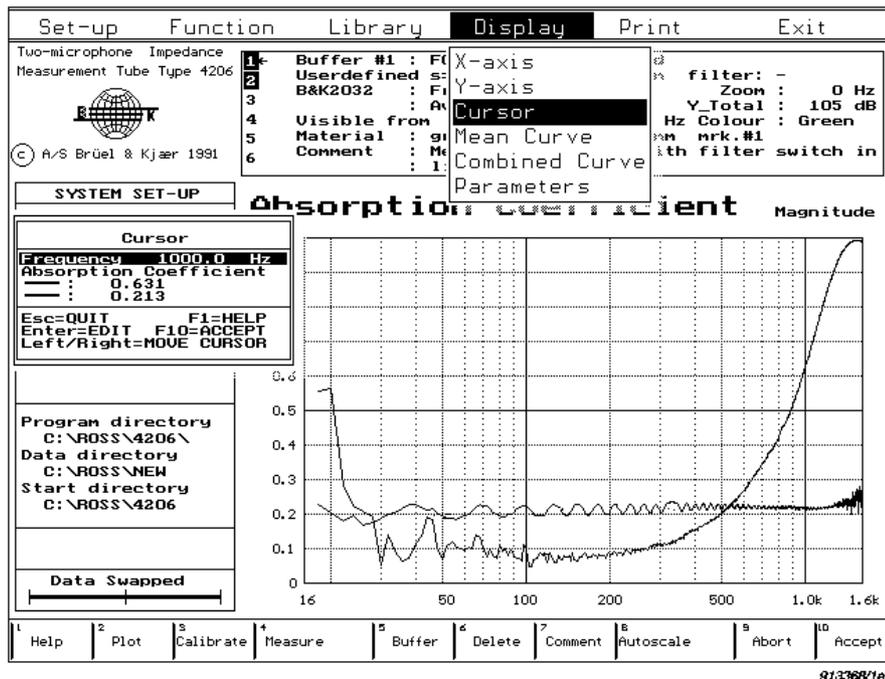


Fig.2 Application Software BZ 5050, showing the display options that are selectable for PC-controlled measurement set-ups

## PC-controlled Set-ups

The Type 3550 measurement set-up can also be controlled by a PC, using the IEEE-488 interface and Application Software BZ5050 (see Fig.2). Similar measurement set-ups using Brüel & Kjær Dual Channel Signal Analyzers Type 2032 and 2034 (earlier types) can also be controlled by a PC using the same software.

The measurement facilities offered by these PC-controlled set-ups are the same as for the Type 3550-controlled set-ups, but additional post-processing options are available including: combination of measurement data in overlapping frequency ranges, simultaneous graphical display of up to six sets of measurement data,

averaging of up to 10 sets of measurement data, and data file management on hard or floppy disk.

Hard copies can be made in graphical or tabular form in HP, IBM, Epson or ASCII formats, and plots can be made on Brüel & Kjær Graphics Plotter Type 2319 and other HPGL plotters. Measurement data can be saved as HPGL files and later imported into PC word processing programs, or saved as comma- and " " delimited files which can be read into spreadsheets.

## Applications

Type 4206 can be used to measure acoustic properties of almost any test

sample, including composite materials (e.g. ceiling tiles), and irregular materials (e.g. fissured acoustic tiling). The piston backplate onto which test samples are mounted inside the sample holders can be withdrawn to produce an air gap behind the test sample. This can be used, for example, to simulate measurements on hanging ceilings.

Type 4206 can also be mounted vertically to make measurements on orientation-sensitive samples (e.g. granular materials) which must be mounted horizontally.

All measurements using Type 4206 are made over all frequencies in a chosen frequency range simultaneously, and in a fraction of the time taken by traditional standing wave methods.

## Specifications 4206

### FREQUENCY RANGE:

**Large Tube:** 50 Hz to 1.6 kHz  
**Small Tube:** 500 Hz to 6.4 kHz

### ZERO ABSORPTION:

(calculated in  $1/3$ -octave bands)  
**50 Hz to 4 kHz:** <4%  
**5 kHz to 6.3 kHz:** <10%

### TUBE DIMENSIONS:

	Diameter [mm] (in)	Length [mm] (in)
Small Meas. Tube	29 (1.1)	200 (7.9)
Large Meas. Tube	100 (3.9)	440 (17.4)
Small Sample Holder	29 (1.1)	200 (7.9)
Large Sample Holder	100 (3.9)	200 (7.9)
Small Ext. Tubes	29 (1.1)	200 (7.9)
Large Ext. Tubes	100 (3.9)	200 (7.9)

### ASSEMBLED SET-UP DIMENSIONS:

**Large Tube (length)\*:** 700 mm (27.7")  
**Small Tube (length)\*:** 850 mm (33.6")  
**Total Width:** 140 mm (5.5")  
**Total Height:** 240 mm (9.5")

### $1/4$ " CONDENSER MICROPHONE CARTRIDGE TYPE 4187:

To optimize the measurement accuracy of Type 4206, the microphones have a non-removable protection grid which forms an airtight front cavity. This gives a coupling between Type 4206 and the microphones that is well-defined with respect to phase

\* Add 200 mm for each extension tube used

### COMPLIANCE WITH STANDARDS:

<b>CE</b>	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.
<b>Safety</b>	EN 61010-1 (1993): Safety requirements for electrical equipment for measurement, control and laboratory use.
<b>EMC Emission</b>	EN 50081-1 (1992): Generic emission standard. Part 1: Residential, commercial and light industry. EN 50081-2 (1993): Generic emission standard. Part 2: Industrial environment. CISPR 22 (1993): Limits and methods of radio disturbance characteristics of information technology equipment. Class B Limits. FCC Class B limits.
<b>EMC Immunity</b>	EN 50082-1 (1992): Generic immunity standard. Part 1: Residential, commercial and light industry. EN 50082-2 (1995): Generic immunity standard. Part 2: Industrial environment. <b>Note:</b> The above is guaranteed using accessories listed in this Product Data sheet only.
<b>Temperature</b>	IEC 68-2-1 & IEC 68-2-2: Environmental Testing. Cold and Dry Heat. Operating Temperature: +5 to +40 °C Storage Temperature: -25 to +70 °C
<b>Humidity</b>	IEC 68-2-3: 90% RH (non-condensing at 40°C)
<b>Mechanical</b>	Non-operating: IEC 68-2-6: Vibration: 0.3 mm, 20 m/s <sup>2</sup> , 10-500 Hz IEC 68-2-27: Shock: 1000 m/s <sup>2</sup> IEC 68-2-29: Bump: 1000 bumps at 250 m/s <sup>2</sup>
<b>Reliability</b>	MIL-HDBK 217 F, GB (Part-stress): MTBF >10000 hours
<b>Other</b>	ASTM E 1050-90 (1990)

# Specifications 4206 (cont.)

**Open-circuit Sensitivity (250 Hz):** 4 mV/Pa  
(-48 ± 3 dB re 1 V/Pa)  
**Capacitance (250 Hz):** 6.4 pF, typical  
**Frequency Response Characteristic (Flush Mounted) ± 1 dB:** 1 Hz to 8 kHz  
**Polarization Voltage:** 200 V

#### LOUDSPEAKER:

**Max. Average Power:** 10 W at 20°C (68°F)  
**Max. Pulsed Power:** 50 W for 2 s (limited by protection circuit)  
**Impedance:** 4 Ω  
**Diameter:** 80 mm (3.2")

**WEIGHT (with accessories):**  
12 kg (26.5 lb.)

#### TYPE 3550-CONTROLLED SYSTEM:

Measurements and calculations controlled by autosequences contained in Application Software BZ 5051 allowing measurement and display of acoustic properties in the chosen frequency range

**Hard Copy Facilities:** Hard copies can be made on graphics printers in B & K, HP, IBM, Epson and ASCII formats. Plots on Graphics Plotter Type 2319 and other HPGL plotters

#### PC-CONTROLLED SYSTEM:

PC acts as system controller. Application Software BZ 5050 allows measurement and display of acoustic properties in the chosen frequency range, combination of data in overlapping fre-

quency ranges, simultaneous graphical display of up to six sets of measurement data, averaging of up to 10 sets of measurement data, data file management

**Computer Requirements:** IBM-PS2, IBM-AT or compatible with EGA/VGA Graphics (maths coprocessor recommended)

**Compatible Analyzers:** Dual Channel Signal Analyzers types 2032 and 2034 (earlier types) and Multichannel Analysis System Type 3550

**Interface:** IEC/IEEE-488

**Hard Copy Facilities:** Screen dump or in tabular format in HP, IBM, Epson and ASCII formats. Plots on Graphics Plotter Type 2319 and other HPGL plotters

## Ordering Information

**Type 4206:** Two-microphone Impedance Measurement Tube

**Includes the following accessories:**  
2 × Type 4187: 1/4" Condenser Microphone Cartridge

2 × Type 2670: 1/4" Pre-amplifier  
AF 9111: Cable Labels, "A"  
AF 9112: Cable Labels, "B"  
BC 0200: Calibration Chart  
BZ 5050: PC Software (1 disk)  
BZ 5051: Autosequence software for Type 3550 (1 disk)

2 × DB 3259: Swivel Nut  
2 × DB 3260: Large Extension Tube  
DH 0615: Sample Holder Foot  
3 × DP 0821: Dummy Microphone  
DS 0864: Large Calibration Sample  
DS 0865: Small Calibration Sample  
UA 1117: Large Measurement Tube

UA 1118: Small Measurement Tube  
UA 1119: Large Sample Holder  
UA 1120: Small Sample Holder  
2 × UA 1168: Small Extension Tube  
2 × ZG 0350: LEMO to Brüel & Kjær 7-pin Adaptor

#### Required Accessories

##### ANALYZER:

One of the following:

**Type 3550:** Multichannel Analysis System (dual-channel configuration) with

**Type 3106:** Generator and Sampling Module

Type 2032: Dual Channel Signal Analyzer

Type 2034\*: Dual Channel Signal Analyzer

#### Optional Accessories

**AMPLIFICATION OF GENERATOR SIGNAL:**  
**Type 2706:** Power Amplifier

##### CABLES:

**AO 0019:** B & K to B & K Coaxial Cable (3 m)

**AO 0127:** B & K to BNC Coaxial Cable (1.2 m)

**AO 0264:** IEC/IEEE Interface Cable

**AO 0265:** IEEE/IEEE Interface Cable

##### FOR PRINTING MEASUREMENT DATA:

**Type 2319:** Graphics Plotter

\* Earlier models

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