PRODUCT DATA

Impedance Tube Kit (50 Hz – 6.4 kHz) Type 4206
Impedance Tube Kit (100 Hz – 3.2 kHz) Type 4206-A
Transmission Loss Tube Kit (50 Hz – 6.4 kHz) Type 4206-T

Brüel & Kjær offers a complete range of tubes for acoustic material testing measurements such as acoustic impedance and admittance, as well as the coefficients for sound absorption, reflection and transmission loss.



Uses and Features

Uses

		Type 4206	Type 4206-A	Type 4206-T
Frequency Range	50 Hz – 1.6 kHz	•		•
	100 Hz – 3.2 kHz		•	
	500 Hz – 6.4 kHz	•		•
Parameters	Acoustic impedance	•	•	•
	Acoustic admittance	•	•	•
	Reflection coefficient	•	•	•
	Sound absorption coefficient	•	•	•
	Transmission loss coefficient			•

Features

- Measurements based on the two-microphone transfer-function method according to ISO 10534–2 and ASTM E1050–08 international standards for absorption coefficient and ASTM E2611–09 for transmission loss
- Horizontal mounting of orientation-sensitive materials; simulation of measurements on hanging ceilings
- Wall mountable
- Part of a complete acoustic material testing system featuring Brüel & Kjær's PULSE™ system
- Determination of noise reduction coefficient (ASTM C423–99a) from sound absorption coefficients at 250, 500, 1000 and 2000 Hz (Type 4206-A)

Applications

Standard	Tube Kit	Frequency Range
ISO 10534–2	Type 4206	50 – 6400 Hz
ASTM E1050–08	Type 4206	50 – 6400 Hz
ASTM E1050–08	Type 4206-A	100 – 3200 Hz
ASTM E2611–09	Type 4206-T	50 – 6400 Hz

- Characterisation of an acoustic material's properties
- Testing specified material characteristics
- Determining input data for acoustical modelling
- For research purposes

Benefits

- Normal incidence parameters are determined
- Fast and accurate measurements
- Large frequency range achieved using tubes of various diameters and microphone spacings
- Use of small samples
- Easy to assemble and disassemble

Why Test Materials?

With today's growing focus on noise-control issues and the emergence of sound quality as an important aspect of product design, acoustic material testing is becoming increasingly relevant to engineers, designers and manufacturers from a broad range of industries. For example, it is crucial to predict the impact of using specific noise-control materials at an early stage in the development of equipment or a machine. Simulation software can help make the prediction if the acoustic characteristics of the materials have been accurately specified.

Acoustic material testing is the process by which acoustic characteristics of materials are determined in terms of absorption, reflection, impedance, admittance and transmission loss.

Many different methods can be used to determine the acoustic properties of materials. These methods mainly involve exposure to known sound fields and measuring the effect of the material's presence on the sound field, and in order to ensure accuracy and repeatability, there is a range of standards covering material testing that prescribes well-defined acoustical conditions and special instrumentation.

Impedance Tubes

The Two-microphone Transfer-function Method

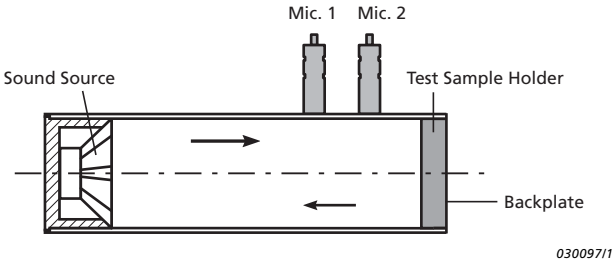


Fig. 1
Schematic diagram of the impedance tube for the two-microphone transfer-function method

A sound source (loudspeaker) is mounted at one end of the impedance tube, and a sample of the material is placed at the other end (see Fig. 1). The loudspeaker generates broadband, stationary random sound waves, which propagate as plane waves in the tube, hit the sample and reflect. The propagation, contact and reflection result in a standing-wave interference pattern due to the superposition of forward- and backward-travelling waves inside the tube. By measuring the sound pressure at two fixed locations and calculating the complex transfer function using a two-channel digital frequency analyzer, it is possible to determine the sound absorption and complex reflection coefficients and the normal acoustic impedance of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions.

This method is described in both ISO 10534–2 and ASTM E1050–08.

Impedance Tube Kit (50 Hz – 6.4 kHz) Type 4206

Type 4206 consists of:
- a 100 mm diameter tube (large tube)
- a 29 mm diameter tube (small tube)
- sample holders (29 and 100 mm)
- extension tubes (29 and 100 mm)L

Components can be assembled into two different setups:
- a large-tube setup to measure parameters in the frequency range from 50 Hz to 1.6 kHz
- a small-tube setup to measure parameters in the frequency range from 500 Hz to 6.4 kHz

The large tube has a loudspeaker at one end, and a frequency-weighting unit is also provided. The following three types of weighting are selectable:
- high-pass – for high-frequency measurements in the small tube
- linear – for measurements in the large tube
- low-pass – for extra measurement accuracy below 100 Hz

Fig. 2 *Type 4206 setups: Left, large tube setup; Right, small tube setup*





In the large-tube setup, the large sample holder is mounted directly to the open end of the large tube (Fig. 2, left). The large tube has three couplers for mounting microphones flush with the inside of the tube. Flush mounting couples the microphone to the sound field in the tube and prevents leakage that would cause measurement errors.

In the small-tube setup, the small tube is mounted to the open end of the large tube (with the loudspeaker), and the small sample holder in the small tube (Fig. 2, right). The small tube has two couplers.

The effective length of each configuration can be changed by fitting one or two extension tubes and by changing the position of the sliding piston inside the sample holder.

Measurements are made with two ¼″ Condenser Microphones Type 4187, which are supplied with Type 4206 and are specially designed to reduce errors due to pressure leakage at high frequencies.

Impedance Tube Kit (100 Hz – 3.2 kHz) Type 4206-A

Type 4206-A consists of:

- a 100 mm diameter tube (large tube)
- a 63.5 mm diameter tube (medium tube)
- a sample holder (63.5 mm)

Type 4206-A is specifically designed to cover the frequency range from 100 Hz to 3.2 kHz. This allows the comparison of data measured using the tube with data measured using the reverberation room method of ASTM C423-99a.

Fig. 3
Type 4206-A, medium-tube setup



In the medium-tube setup, the medium tube is mounted on the open end of the large tube (with the loudspeaker), and the medium sample holder in the medium tube (Fig. 3). The medium tube has three couplers for mounting microphones flush with the inside of the tube. Flush mounting couples the microphone to the sound field in the tube and prevents leakage that would cause measurement errors.

The effective length of the configuration can be changed by changing the position of the sliding piston inside the sample holder.

Measurements are made with two ¼″ Condenser Microphones Type 4187, which are supplied with Type 4206-A and are specially designed to reduce errors due to pressure leakage at high frequencies.

Applications for Types 4206 and 4206-A

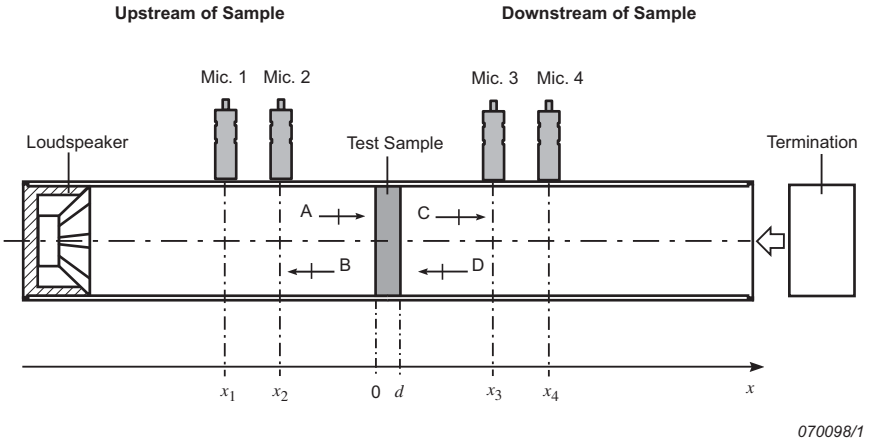
Types 4206 and 4206-A can be used to measure the acoustic properties of small test samples, including composite materials (for example, ceiling tiles) and irregular materials (for example, fissured acoustic tiling). The piston backplate, onto which test samples are mounted inside the sample holders, can be withdrawn in order to produce an air gap behind the test sample. This can be used to simulate measurements on hanging ceilings. In addition, both Impedance Tube Kits can be mounted vertically in order to make measurements on orientation-sensitive samples, which must be mounted horizontally (for example, granular materials).

Transmission Loss Tube

The Four-microphone Transfer-function Method

A sound source (loudspeaker) is mounted at one end of the impedance tube, and a sample of the material is placed in a holder (Fig. 4). The loudspeaker generates broadband, stationary random sound waves that propagate as plane waves. The plane waves hit the sample in the holder with part of the waves reflected back into the source tube, part absorbed by the material and part passing through the material to the receiving tube. The portion of the plane waves that pass through the material then encounter the end of the receiving tube where some of the waves are reflected and some exit the tube. By measuring the sound pressure at four fixed locations (two in the source tube and two in the receiving tube) and calculating the complex transfer function using a four-channel digital frequency analyzer, it is possible to determine the transmission loss of the material. The usable frequency range depends on the diameter of the tube and the spacing between the microphone positions.

Fig. 4
Schematic diagram of the transmission loss tube for four-microphone transfer-function method



The method is described in ASTM E2611−09.

Transmission Loss Tube Kit (50 Hz – 6.4 kHz) Type 4206-T

Type 4206-T consists of:

- two 100 mm diameter tubes (large tubes)
- two 29 mm diameter tubes (small tubes)
- sample holders (29 and 100 mm)
- extension tubes (29 and 100 mm)

Components can be assembled into two different setups:

- a large-tube setup to measure in the frequency range from 50 Hz to 1.6 kHz (Fig. 5, left)
- a small-tube setup to measure in the frequency range from 500 Hz to 6.4 kHz (Fig. 5, right)

Fig. 5 *Type 4206-T setups: Left, large tube setup; Right, small tube setup*





Measurements are made with four ¼″ Condenser Microphones Type 4187, which are supplied with Type 4206-T and are specially designed to reduce errors due to pressure leakage at high frequencies.

Applications

The measurement of a material's transmission loss is of interest for noise control using a barrier. This is important where a noise source can be separated from the listener by an obstruction, for example, in an automobile, where the dashboard acts as a barrier between the engine and passenger compartments, or in buildings, where a wall or door separates a noise source from a listener.

Techniques exist for measuring the performance of a complete component (dashboard, door, etc.) using a source and a receiving room or using a reverberation room, but the procedures take a long time to set up and produce results. Also, measurements of a complete component are a function of the component's materials, the geometry of the component and its boundary conditions and would be very sensitive to the fixing method.

It is desirable to measure directly the transmission loss of components' materials for use in:

- comparison of different materials for specific applications
- analytical models used in the design of materials and components
- performance verification of materials before they are manufactured into components

Transmission Loss Tube Kit Type 4206-T is useful for the direct measurement of a material's transmission loss.

Sample Positioning Tool for Type 4206-T: UA-1720

Because of the cylindrical form of the transmission loss tube, thin or curved samples can be difficult to hold in position. Also, especially when measuring porous, elastic materials, it is important to know and be able to reproduce the sample's position in the tube. Sample Positioning Tool UA-1720 overcomes these problems by supporting the sample within the tube and fixing it at a known position.

UA-1720 comprises:

- four sample holder rings, two with a 100 mm and two with a 29 mm outer diameter for the large and small tubes, respectively. Each of these rings has 1 mm of rubber to ensure that it remains in position when pushed into the tube
- a 30 cm sample positioning rod with scales for large and small tubes
- large and small circular discs that screw onto one end of the positioning rod and are used to push the sample holder rings into position
- large and small semicircular positioning rod guides that rest on the end of the transmission loss tube, support the positioning rod and allow you to read the position from the scale

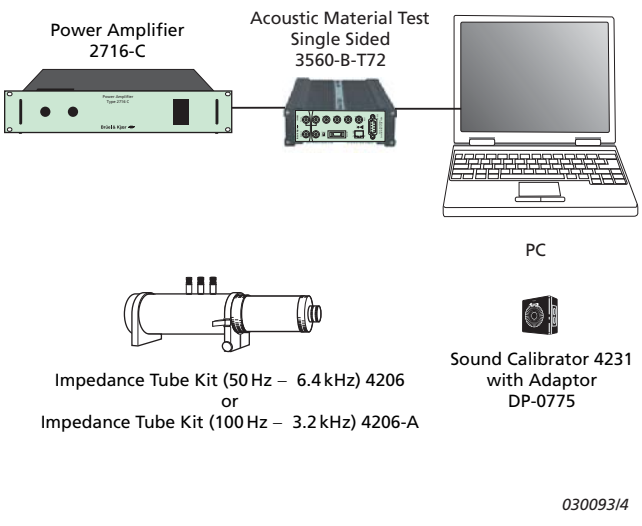
The sample should be cut approximately 0.4% smaller that the inside diameter of the tube to allow it to fall slowly into position.

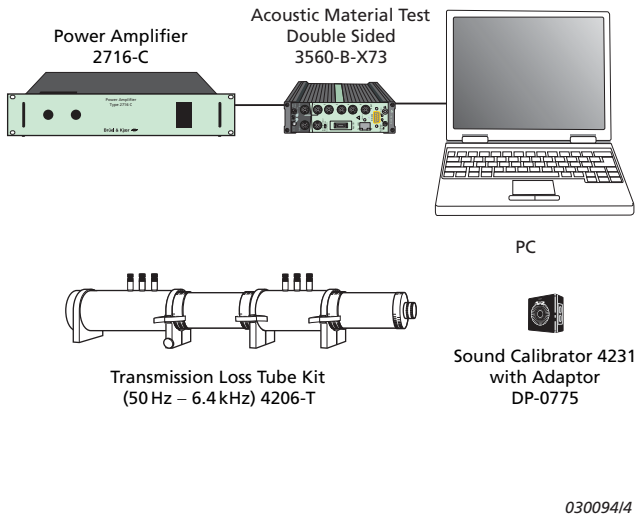
To use UA-1720:

1. Screw the appropriate circular disc onto the end of the positioning rod using the end with the small scale for the small disc or large scale for the large disc.
2. Push the first sample holder ring to the end of the sample holder.
3. Insert the sample and the second sample holder ring.
4. Using the semicircular plate as a guide, push the second sample holder ring in until the reading on the positioning rod's scale is equal to the thickness of the sample.

Complete Solutions from Brüel & Kjær

Fig. 6 *Setups for PULSE: Left, impedance-tube setup; Right, transmission loss setup*





Compliance with Standards

CE C-tick	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.
Safety	EN/IEC 61010–1 and ANSI/UL 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN/IEC 61000–6–3: Generic emission standard for residential, commercial and light industrial environments. EN/IEC 61000–6–4: Generic emission standard for 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. This ISM device complies with Canadian ICES–001 (interference causing equipment standard).
EMC Immunity	EN/IEC 61000–6–1: Generic standards – Immunity for residential, commercial and light industrial environments. EN/IEC 61000–6–2: Generic standards – Immunity for industrial environments. EN/IEC 61326: Electrical equipment for measurement, control and laboratory use – EMC requirements. **Note:** The above is only guaranteed using accessories listed in this Product Data sheet.
Temperature	IEC 60068–2–1 & IEC 60068–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: +5 to +40°C (41 to 104°F) Storage Temperature: –25 to +70°C (–13 to 158°F)
Humidity	IEC 60068–2–78: 90% RH (non-condensing at 40°C)
Mechanical	Non-operating: IEC 60068–2–6: Vibration: 0.3 mm, 20 m/s^2, 10–500 Hz IEC 60068–2–27: Shock: 1000 m/s^2 IEC 60068–2–29: Bump: 1000 bumps at 250 m/s^2
Other	ASTM E1050–08, ASTM C423–99a, ISO 10534–2, ASTM E2611–09

Specifications – Types 4206, 4206-A and 4206-T

FREQUENCY RANGE
Small Tube: 500 Hz to 6.4 kHz
Medium Tube: 100 Hz to 3.2 kHz
Large Tube: 50 Hz to 1.6 kHz

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

TUBE DIMENSIONS

	Inner Diameter mm (in)	Max. Sample Length mm (in)
Small Meas. Tube	29 (1.1)	200 (7.9)
Medium Meas. Tube	63.5 (2.5)	200 (7.9)
Large Meas. Tube	100 (3.9)	440 (17.4)
Small Sample Holder	29 (1.1)	200 (7.9)
Medium Sample Holder	63.5 (2.5)	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)
Small TL Tube	29 (1.1)	190 (7.4)
Large TL Tube	100 (3.9)	260 (10.2)
Small TL Sample Holder	29 (1.1)	65 (2.9)
Large TL Sample Holder	100 (3.9)	150 (5.9)

ASSEMBLED SETUP DIMENSIONS
Small Tube (length)*: 1050 mm (41.3″)
Medium Tube (length): 910 mm (36″)
Large Tube (length)*: 900 mm (35.4″)
TL Small Tube (length): 1280 mm (50.4″)
TL Large Tube (length): 1370 mm (53.9″)
Total Width: 140 mm (5.5″)
Total Height: 240 mm (9.5″)

¼″ CONDENSER MICROPHONE TYPE 4187
To optimise the measurement accuracy of Type 4206, the microphones have a non-removable protection grid that forms an airtight front cavity. This gives a coupling between Type 4206 and the microphones that is well-defined with respect to phase
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.)

* Add 200 mm for each extension tube used

Ordering Information

Type 4206 **Impedance Tube Kit** (50 Hz – 6.4 kHz)
Includes the following accessories:
- 2 × Type 4187: ¼″ Pressure-field Microphone
- 2 × Type 2670: ¼″ Preamplifier
- UA-1117: Large Measurement Tube
- UA-1118: Small Measurement Tube
- UA-1119: Large Sample Holder
- UA-1120: Small Sample Holder
- DS-0864: Large Calibration Sample
- DS-0865: Small Calibration Sample
- 2 × DB-3260: Large Extension Tube
- 2 × UA-1168: Small Extension Tube
- 3 × DP-0821: Dummy Microphone

Type 4206-A **Impedance Tube Kit** (100 Hz – 3.2 kHz)
Includes the following accessories:
- 2 × Type 4187: ¼″ Pressure-field Microphone
- 2 × Type 2670: ¼″ Preamplifier
- UA-1117: Large Measurement Tube
- UA-2033: Medium Measurement Tube with Sample Holder
- DS-1046: Medium Calibration Sample
- 4 × DP-0821: Dummy Microphone

Type 4206-T **Transmission Loss Tube Kit** (50 Hz – 6.4 kHz)
Includes the following accessories:
- 4 × Type 4187: ¼″ Pressure-field Microphone
- 4 × Type 2670: ¼″ Preamplifier
- UA-1117: Large Measurement Tube
- UA-1118: Small Measurement Tube
- UA-1630: Transmission Loss Measurement Tubes
- UA-1119: Large Sample Holder
- UA-1120: Small Sample Holder
- 3 × DS-0864: Large Calibration Sample
- 3 × DS-0865: Small Calibration Sample
- 2 × DB-3260: Large Extension Tube
- 2 × UA-1168: Small Extension Tube
- 3 × DP-0821: Dummy Microphone

Optional Accessories

Type 2716-C	Power Amplifier (includes Input and Output Cables WL-1324 and WL-1325)
WB-3540	Power Supplier for WB-3541
WB-3541	Power Amplifier
Type 4231	Sound Calibrator
DP-0775	Adaptor for ¼″ Microphones (for Type 4231)
UA-2033	Medium Measurement Tube with Sample Holder (for Type 4206)
UA-1720:	Sample Positioning Tool for Type 4206-T

Optional Systems

Type 3560-B-T72 Acoustic Material Test – Single-sided
Includes the following:
- Type 7770-N2: PULSE FFT Analysis
- Type 7758: PULSE Material Testing
- Type 3560-B-030: 5-channel PULSE Data Acquisition Unit with Generator and LEMO connectors

Type 3560-B-X72 Acoustic Material Test – Single-sided
Includes the following:
- Type 7770-N2: PULSE FFT Analysis
- Type 7758: PULSE Material Testing
- Type 3560-B-130: 5/1-ch Input/Output PULSE Data Acquisition Unit (Dyn-X) with Generator and LEMO connectors

Type 3560-B-T73 Acoustic Material Test – Double-sided
Includes the following:
- Type 7700-N4: PULSE FFT & CPB Analysis
- Type 7758: PULSE Material Testing
- Type 3560-B-030: 5-channel PULSE Data Acquisition Unit with Generator and LEMO connectors

Type 3560-B-X73 Acoustic Material Test – Double-sided
Includes the following:
- Type 7700-N4: PULSE FFT & CPB Analysis
- Type 7758: PULSE Material Testing
- Type 3560-B-130: 5/1-ch Input/Output PULSE Data Acquisition Unit (Dyn-X) with Generator and LEMO connectors

Services

Factory calibration is included with delivery of Types 4206, 4206-A and 4206-T

OPTIONAL SERVICES

4206-CFF	Impedance Measurement Tube, Factory Standard Calibration with Calibration Chart – annual
4206-EW1	Extended Warranty – one year extension
4206-TCF	Conformance Test with Certificate – factory test with statement that the instrument operates to specifications

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