PRODUCT DATA

Sound Intensity Calibrator — Type 4297

Sound Intensity Calibrator Type 4297 is used for on site Sound Pressure Calibration and Pressure-Residual Intensity Index Verification.

The most important and unique feature is that there is no longer any need to dismantle the sound intensity probe for calibration.

The calibrator is optimised for use with the 2260E Investigator™ sound intensity system for phase enhancement, but it can also be used with sound intensity analysis systems based on PULSE™.

Type 4297 is a complete sound intensity calibrator in one compact, portable unit with built-in sound sources. The acoustic feedback system automatically adjusts for variations in atmospheric pressure. Fulfils IEC 61043.

4297

Brüel & Kjær

USES

❍ Measurement and verification of pressure-residual intensity index

❍ Sound pressure calibration at 251.2 Hz (Type 1 IEC 60942)

FEATURES

❍ No need to dismantle the probe when calibrating

❍ Optimised for use with Type 2260E Investigator™ Sound Intensity System for phase enhancement

❍ A complete sound intensity calibrator in one unit

❍ Built-in sound source for sound pressure calibrations with acoustic feedback system to automatically adjust for variations in atmospheric pressure

❍ Built-in broad-band sound source for pressure-residual intensity index measurements

Introduction

Fig. 1
Type 4297 Sound Intensity Calibrator with a sound intensity probe in place for calibration

Sound Intensity Calibrator Type 4297 enables instruments which measure sound intensity to be accurately calibrated.

Type 4297 is intended for use with Bruël & Kjær Sound Intensity Probes Types 3583, 3584, 3595 (or earlier Types 3545 or 3548) with a Sound Intensity Microphone Pair Type 4197 (or earlier Type 4181). The microphones must be used with ¼″ preamplifiers.

The Sound Intensity Calibrator can be used for calibration of sound pressure sensitivity. To do this, the microphones are both positioned in the calibration chamber. There is no need to dismantle the probe and both microphones are exposed to exactly the same sound pressure (amplitude and phase).

The broad-band sound source is provided for measurement of the pressure-residual intensity index spectrum. This is used to assess the accuracy of sound intensity measurements.

A calibration chart is supplied which states the levels that should be detected during calibration.

A barometer is not needed because an accurate feedback system holds the sound pressure level at a constant value.

Calibration Procedure

Calibration of an intensity measuring instrument includes:

❍ sound pressure calibration of the individual microphone channels
❍ measurement of the pressure-residual intensity index spectrum of the system

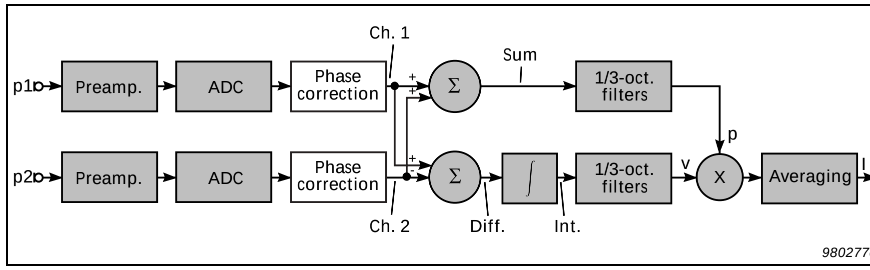


Fig. 2
Simplified block diagram of an intensity measuring instrument. The signals from two pressure microphones, p1 and p2, are used to determine the pressure midpoint of the probe axis, p, and the particle velocity along the probe axis, V. Multiplying p and V gives the intensity reading I. Δr is the microphone spacing and ρ is the density of the air

Sound Pressure Calibration

With the arrangement shown on the front cover, the sound source produces the same sound pressure level at each microphone. The microphone channels are calibrated against this known sound pressure level.

Pressure-Residual Intensity Index Measurement

The inset on the next page shows how small differences in the phase responses of the microphones and input channels result in the detection of “residual intensity”. Residual intensity is a parameter that should be taken into account when interpreting measured intensity data. The pressure residual intensity spectrum is not fixed; it is “tied” to, and rises and falls with, the measured sound pressure level.

Fig. 1 shows an arrangement for measuring the pressure-residual intensity index. The probe is placed in the Type 4297. Both microphones are exposed to the same sound pressure and same phase, and therefore any intensity detected is residual intensity.

It can be shown that, for a given measurement system and frequency, the difference between measured sound pressure level and detected residual intensity level will be a constant. This constant difference is called the pressure-residual intensity index.

The pressure-residual intensity index spectrum can be measured in the frequency range 40 Hz to 3 kHz with the spacer positioned as shown in Fig. 1 by subtracting the detected intensity spectrum from the sound pressure spectrum. An example is shown in Fig. 3.

In order to measure the pressure-residual intensity index spectrum in the frequency range 40 Hz to 6.3 kHz, remove the spacer and measure with the same arrangement. An example is shown in Fig. 4.

Residual Intensity Level

If a pressure-residual intensity index spectrum is to be used to assess the accuracy of sound intensity measurements, then the mean sound pressure spectrum in the field must also be measured. The residual intensity level is then quickly established by subtracting the pressure-residual intensity index spectrum from the measured mean sound pressure spectrum.

Fig. 3
*Typical intensity and sound pressure levels measured **with** spacers using the arrangement shown in Fig. 1. The pressure-residual intensity index spectrum is characteristic of the measurement system and is obtained by subtracting the intensity spectrum from the pressure spectrum*

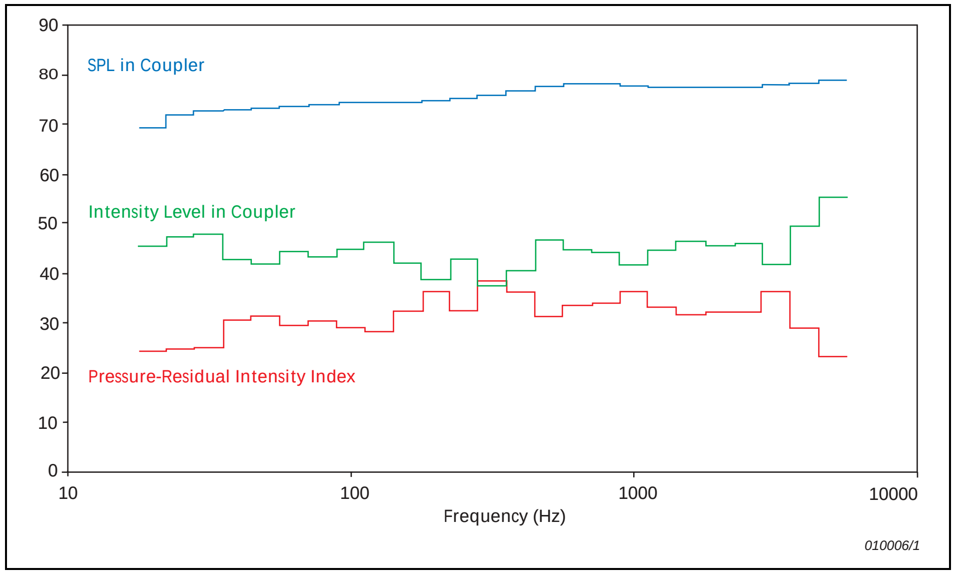
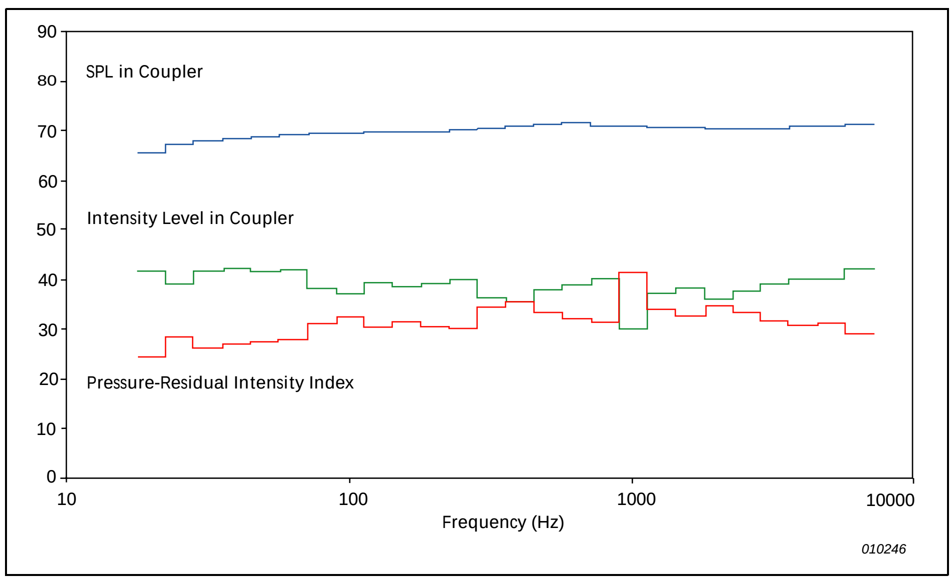


Fig. 4
*Typical intensity and sound pressure levels measured **without** spacer*



The residual intensity level is then compared to the measured sound intensity level. It can be shown that, for a certain frequency, the residual intensity level must be at least 7 dB lower to ensure a measurement error of less than 1 dB.

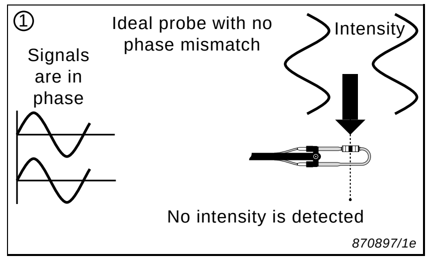
The residual intensity level shown in Fig. 3 is dependent on the sound pressure measured in the field and should not be confused with the intensity level which is measured with the arrangement shown in Fig. 2

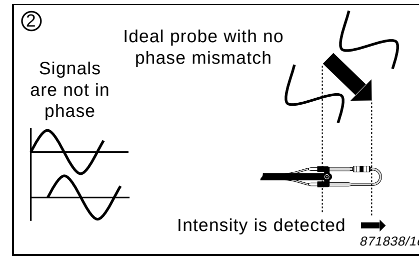
Microphones and Vent Sensitivity

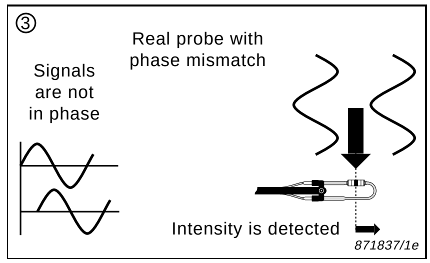
Type 4297 has been designed to work with Microphone Pair Types 4197 and 4181, which have an extremely low sensitivity to sound pressure at the equalisation vents due to their patented acoustical filters. When microphones are inserted into the coupler, their diaphragms are exposed to the sound pressure in the coupler but their pressure-equalization vents are not. Type 4297 cannot be used to measure the pressure-residual intensity index with conventional microphone pairs as they have vent sensitivities several orders of magnitude higher than that of Type 4197.

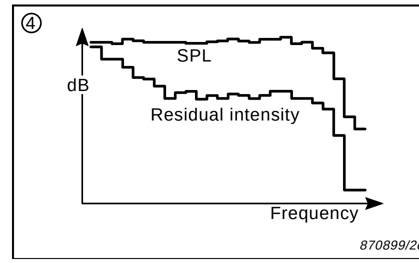
Residual Intensity

1. A sound wave is incident on a probe axis at 90°. There is no flow of acoustic energy along the probe axis. The signals from the microphones are in phase and no intensity is detected.
2. If a sound wave is incident at an angle other than 90°, then acoustic energy flows along the probe axis. The microphone signals are out of phase and intensity is detected.
3. In practice, if a sound wave is incident at 90°, then small differences between the phase responses of the microphones cause a small phase difference between the microphone signals. There now *appears* to be a flow of acoustic energy along the probe axis.
4. It is this *apparent* flow of acoustic energy that is detected and called "residual intensity".









Even under controlled laboratory conditions, it is very difficult to create a free-field situation where the angle between the propagation of the sound wave and the probe axis is exactly 90 degrees (as shown in boxes 1 and 3). However, for practical applications this situation can easily be simulated using the set-up shown in Fig. 1.

Compliance with Standards

	CE-mark indicates compliance with: EMC Directive. C-Tick mark indicates compliance with the EMC requirements of Australia and New Zealand
Safety	EN 61010–1 and IEC 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use. UL 3111–1: Standard for Safety – Electrical measuring and test equipment
EMC Emission	EN/IEC 61000–6–3: Generic standards. Emission for residential, commercial and light-industrial environments EN/IEC 61000–6–4: Generic standards. Emission 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
EMC Immunity	EN/IEC 61000–6–1: Generic standards. Immunity for residentail, commercail and light-industrial environments EN/IEC 61000–6–4: Generic standards. Immunity for industrial environments EN/IEC 61326–1: Electrical equipment for measurment, control and laboratory use – EMC requirments EN/IEC 60942: Sound Calibrators – Amendment 1
Temperature	IEC 60068–2–1 & IEC 60068–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature: –10 to +50°C (14 to 122°F) Storage Temperature: –25 to +70°C (–13 to 158°F) IEC 60068–2–14: Change of Temperature: –10 to +50°C (2 cycles, 1°C/min.)
Humidity	IEC 60068–2–3: Damp Heat: 90% RH (non-condensing at 40°C (104°F))

Specifications – Sound Intensity Calibrator Type 4297

Note: All specifications are for a probe with a spacer unless otherwise stated

POWER SUPPLY
2 × 1.5 V Alkaline Battery, type LR6 (QB 0013)
Lifetime: 8 hours continuous
External DC Power Supply Voltage: Regulated or smoothed 10 – 14 V, max. 100 mV ripple
Power: 3.5 W
Current: 300 mA
Inrush Current: 1000 mA
Socket: 5.5 mm diameter, 2 mm Pin (Positive)

SIGNAL LEVELS OBTAINED IN INTENSITY CALIBRATOR
Reference conditions according to IEC 60942
Ambient Static Pressure: 101.3 kPa
Ambient Temperature: 23° C
Relative Humidity: 50%

INDIVIDUAL CALIBRATION ACCURACY
Sound Pressure Level for Sine Output 251.2 Hz ± 0.1%
At Reference Conditions
94 ± 0.08 dB re 20 μPa

NOMINAL SOUND PRESSURE LEVEL
94 ± 0.2 dB re 20 μPa

Stabilisation Time: 5 s
Temperature Coefficient: < ± 0.002 dB/°C
Humidity Coefficient: Negligible
Total Harmonic Distortion: <2%

SOUND PRESSURE LEVELS MEASURED WITH SPACER
(Pink noise: all levels measured in 1/3-octaves):
251.2 Hz: 80 dB ± 2.0 dB SPL
20 Hz to 10 kHz: ± 3.0 dB re level at 251.2 Hz
Linear: 94 dB ± 3 dB
Fulfils IEC 60942, 1997 Class 1

PRESSURE-RESIDUAL INTENSITY INDEX OF SOUND FIELD
(Pink noise: all levels measured in 1/3-octaves):
Measured <u>with</u> 12 mm spacer: >24 dB from 40 Hz to 3 kHz
Fulfils IEC 61043, 1993 Class 1
Measured <u>without</u> spacer: >24 dB from 40 Hz to 6.3 kHz

DIMENSIONS AND WEIGHT (CASE)
Height: 6 cm (2.4")
Width: 5.5 cm (2.17")
Depth: 17 cm (6.7")
Weight: 730 gm (1 lb. 10 oz.)

ELECTRICAL SPECIFICATIONS
AC Input Sensitivity: 15.4 Pa/V with spacer
Max Input Voltage: 70 mV RMS
Input Impedance: >18 kΩ (f <10 kHz)

NOTE: All values are typical at 23°C, unless measurement uncertainty or tolerance field is specified. All uncertainty values are specified at 2σ (i.e. expanded uncertainty using a coverage factor of 2)

Ordering Information

Type 4297	Sound Intensity Calibrator
Includes the following accessories:	
2 × QB 0013	1.5V Alkaline Battery, type LR6
BC 0276	Calibration Chart
KE 1003	Etui
DH 0732	Wrist Strap

Optional Accessories

A0 0440	BNC to LEMO Cable
ZG 0386	EU Power Supply
ZG 0387	UK Power Supply
ZG 0388	US Power Supply
DH 0713	Harness
4297 CAI	Accredited Initial Calibration Pressure-Residual Intensity Index Verification of Types 2260, 3595 and 4297
4297 CAF	Accredited Calibration Pressure-Residual Intensity Index Verification of Types 2260, 3595 and 4297
4297 TCF	Conformance Test of Type 4297

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