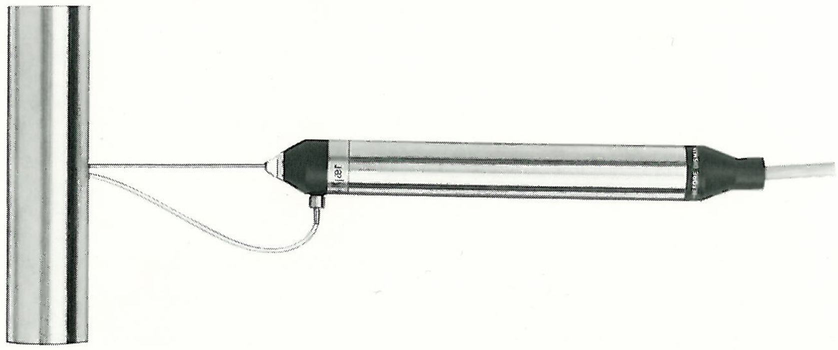
4182

Instruction Manual

Probe Microphone Type 4182



A microphone designed for sound pressure measurements in places where normal microphones cannot be used. It features a smooth frequency response over a wide frequency range, a very high acoustic orifice impedance and a built-in preamplifier allowing direct connection to Brüel & Kjær measuring amplifiers and frequency analyzers. Each probe microphone is delivered together with an individual calibration chart of sensitivity and frequency response.

Brüel & Kjær

SAFETY CONSIDERATIONS

Probe Microphone Type 4182 is neither intended nor approved for measurements on the human body.

SERVICE WARNING

The probe microphone contains no user-serviceable parts. It should be opened and serviced by qualified service personnel only.

2. ACCESSORIES

2.1. GENERAL

Various accessories are supplied with the probe microphone. Some of these are used to adapt the probe microphone to measurement requirements, the others are used in calibration measurements. The complete set is shown in Fig. 2.1 and the application of each item is described below.

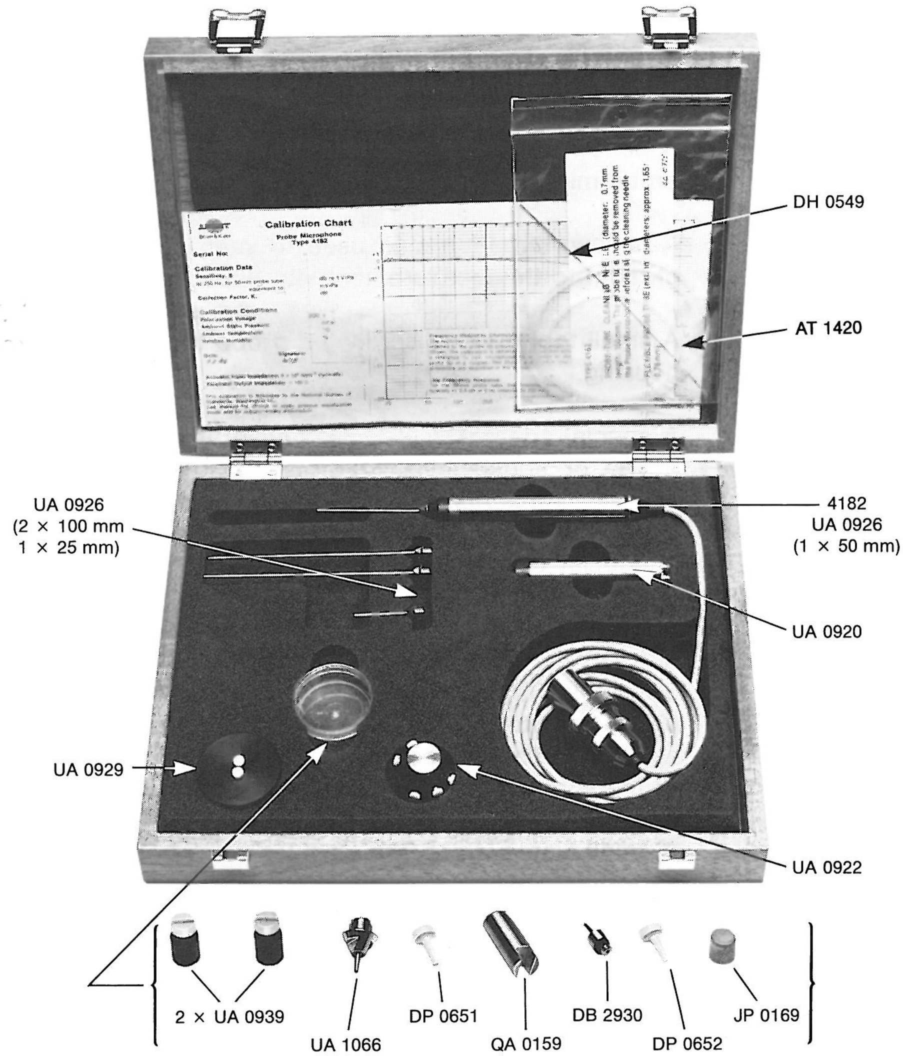


Fig. 2.1. The probe microphone is supplied in a box complete with the various measurement and calibration accessories shown

2.2. APPLICATIONS

Stiff Probe Tube Set (UA 0926): A set of narrow, stiff tubes which guide the sound pressure waves from the measurement site to the microphone diaphragm. The tubes can be screwed directly onto the front end of the probe microphone housing. A set of 4 is supplied, in lengths of 25 mm, 50 mm, and 100 mm (2 of these). All 4 tubes are matched to the 1,5 m waveguide tube located inside the housing.

Flexible Probe Tube (AT 1420): A 1,5 m length of narrow, flexible tube, which can be easily cut to a suitable length. It has two applications: (1) For measurements in awkward locations, it guides the sound pressure waves from the measurement site to the microphone diaphragm when attached to the front end of the probe microphone housing by means of the connecting stud. (2) For measurements involving a static pressure difference, it vents the microphone to the measurement site when attached by the vent stud to the vent hole on the probe microphone housing.

Cleaning Needle (DH 0549): A long, thin needle which can be pushed through the stiff probe tubes to remove dirt. The probe tube must be removed from the probe microphone before the needle is inserted.

Connecting Stud (UA 0166): A hollow, threaded stud used to connect a flexible probe tube to the probe microphone vent.

Vent Stud (DB 2930): A hollow, threaded stud used to vent the rear of the microphone diaphragm to the measurement site through a flexible tube.

Wrench (QA 0159): A small tool used to screw the probe tubes onto the probe microphone housing.

Pistonphone Adaptor (UA 0929): A special adaptor used during calibration measurements with a pistonphone or sound level calibrator. This adaptor replaces the standard adaptor of the pistonphone or sound level calibrator.

Calibration Coupler (UA 0922): A special coupler used during frequency response verification of the probe microphone. It has holes for a 1/2″ transmitter microphone and a 1/4″ reference microphone, and for stiff and flexible probe tubes.

Sealing Plugs (DP 0651, DP 0652): Small, black, rubber push-in plugs used to seal any holes in the pistonphone adaptor or calibration coupler which are not used during a measurement. There are two sizes, corresponding to the outer diameters of the stiff and flexible probe tubes.

Calibration Stop (UA 0939): A small clamp which can be fixed to a probe tube during calibration or frequency response verification of the probe microphone. It ensures that the tip of the probe tube is precisely located inside the pistonphone adaptor or calibration coupler.

Transmitter Adaptor (UA 0920): An adaptor which screws onto a 1/2″ microphone and permits the microphone to be used as a sound source for frequency response verification of the probe microphone.

Short-circuit Plug (JP 0169): A screw-on metal plug used to short circuit the DC terminal of the transmitter adaptor.

3. OPERATION

3.1. THE PROBE TUBES

3.1.1. Interchanging the Stiff Probe Tubes

Each stiff probe tube has a threaded stud at one end, used to attach it to the front end of the probe microphone housing. To screw a probe tube onto the housing, apply gentle finger pressure to Wrench QA 0159 as illustrated in Fig. 3.1. The gentle torque prevents the metal stud from damaging the plastic housing.

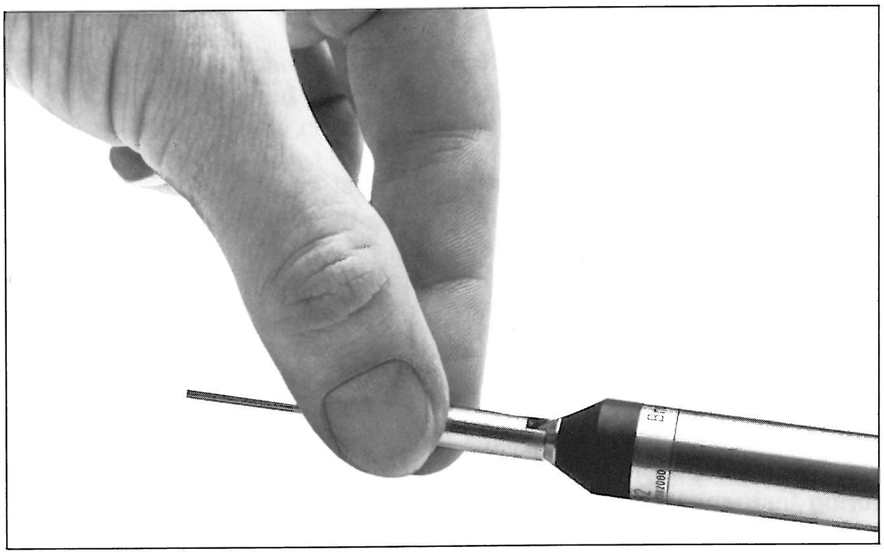


Fig. 3.1. To screw on a probe tube, use the wrench QA 0159 as shown

3.1.2. Cleaning the Stiff Probe Tubes

Remove the probe tube from the probe microphone housing and push the close-fitting cleaning needle through the probe tube.

Warning! Always remove the probe tube from the probe microphone before you insert the cleaning needle. This prevents dirt from entering the narrow channel inside the probe microphone and avoids the possibility of damaging the microphone diaphragm.

3.1.3. Bending a Stiff Probe Tube

Some awkward measurement locations may be most easily accessed with a suitably bent probe tube. The most important consideration during bending is to prevent the

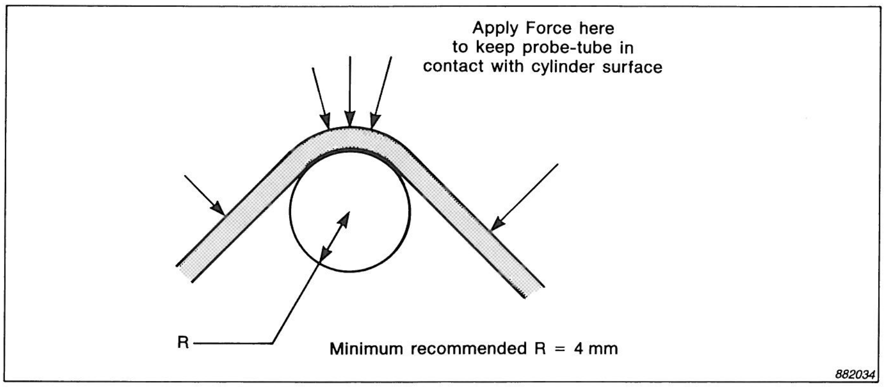


Fig. 3.2. To prevent the inner cross-section of the probe tube from collapsing during bending, ensure that it maintains contact with the cylindrical surface by pressing as shown

cross-section of the probe tube from collapsing. This is achieved by pressing the probe tube against a cylindrical surface, as shown in Fig. 3.2, and ensuring that the tube maintains contact with the surface throughout the operation. The smallest possible bend-radius is approximately 4 mm.

3.1.4. Use of a Flexible Probe Tube

Some measurement locations may be most easily accessed with a flexible probe tube. The 1,5 m length supplied can be cut to the desired length. To attach a flexible probe tube to the probe microphone housing, fit it to the connecting Stud ~~DB 2930~~ and screw the stud gently onto the housing as described in section 3.1.1. UA1066

3.2. CONNECTION TO MEASUREMENT INSTRUMENTATION

The probe microphone contains a microphone preamplifier which is similar to the Brüel & Kjær Type 2633, and which can be connected directly to all Brüel & Kjær measuring instruments and analyzers that have a standard 7-pin preamplifier input. The pin configuration of the 7-pin plug is shown in Fig. 3.3.

The built-in microphone is similar to the Brüel & Kjær Condenser Microphone Type 4135 and requires a polarization voltage of 200 V.

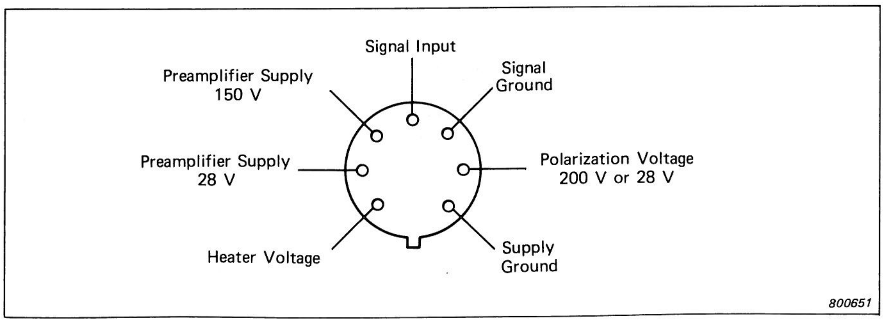


Fig. 3.3. The pin configuration for the standard 7-pin output plug of the probe microphone

3.3. CALIBRATION

3.3.1. General

The frequency response and sensitivity of the Type 4182 depend on the selected type and length of probe tube. Three methods of testing the sensitivity are described: sensitivity calibration; frequency response calibration with a reference microphone; and frequency response test without a reference microphone.

The sensitivity test is an absolute method which uses a calibrated sound source to give the sensitivity at one frequency. The calibrated sound source is either a pistonphone (250 Hz) or a sound level calibrator (1000 Hz).

The two frequency response tests are relative methods. The test with a reference microphone is the most accurate of the two but it requires more instrumentation. Typical results of frequency response tests for various lengths of stiff and flexible probe tubes are shown in section 4.2.1.

3.3.2. Sensitivity Calibration at 250 Hz or 1000 Hz

1. Fit the pistonphone Adaptor UA 0929 to Pistonphone Type 4228 (or previous Type 4220) or to Sound Level Calibrator Type 4230. The volume correction is 0 dB (ΔL_v = 0 dB) for the combination of UA 0929 and the pistonphone, and also for Type 4230.

2. Clamp the Calibration Stop UA 0939 to the probe tube, 5 mm from the tip.

   Warning! The calibration stop must be used to prevent damage to the diaphragm of the Type 4230.

   The Wrench QA 0159 can be used to set the correct distance as shown in Fig. 3.4.

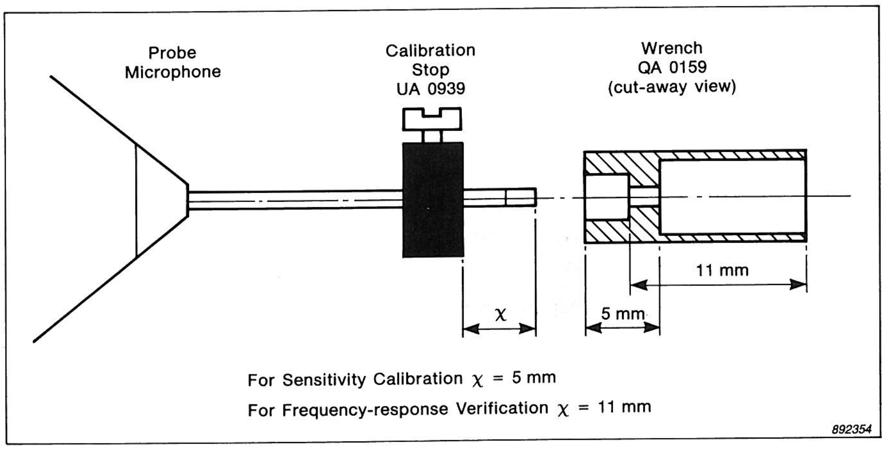


Fig. 3.4. Wrench QA 0159 can be used to set the correct distance between the calibration stop and the probe tip

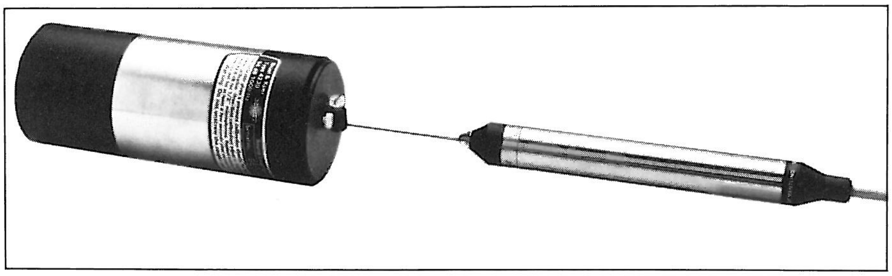


Fig. 3.5. The probe tip inserted through the hole in the pistonphone adaptor. ***Warning!*** *The calibration stop must be used to prevent damage to the diaphragm of the Type 4230*

3. Insert the tip of the probe tube through the appropriate hole in the pistonphone adaptor so that the calibration stop touches the outer surface of the pistonphone adaptor, see Fig. 3.5. The large hole is for the flexible tube and the small hole for the stiff tube.

4. Seal the un-used hole with the appropriate Sealing Plug DP 0651 or DP 0652. The two sizes of sealing plug correspond to the two sizes of hole.

5. Set the polarization voltage to 200 V and connect the probe microphone output to the preamplifier input of the measuring instrument.

6. Switch on the pistonphone or calibrator and perform the calibration.

3.3.3. Frequency Response Calibration – With a Reference Microphone

A transmitter microphone is used to produce a sound pressure at the tip of the probe microphone, inside the calibration coupler. This sound-pressure input is sensed by a reference microphone located very close to the tip of the probe microphone. A dual-channel signal analyzer measures the sound pressure input and voltage output and subsequently the frequency response of the probe microphone.

The measurement set-up is shown in Fig. 3.6 and Fig. 3.7, and the measurement procedure is as follows:

1. Screw the reference microphone onto the Microphone Preamplifier Type 2633. The recommended reference microphone is Brüel & Kjær Condenser Microphone Type 4136, which is not included.

2. Remove the protection grid from the reference microphone and screw this microphone carefully into the calibration coupler.

3. Screw the transmitter microphone onto the Transmitter Socket UA 0920. Press this assembly firmly into the Calibration Coupler UA 0922 until it meets the shoulder and rotate it slightly to ensure a good fit. The recommended transmitter microphone is the Brüel & Kjær Prepolarized Condenser Microphone Type 4129, which is not included.

4. Screw the Short-circuit Plug JP 0169 onto the DC terminal of the transmitter socket to ensure that the signal to the microphone has no DC offset. Connect the AC terminal of the transmitter socket to a random noise source of about 10 V RMS.

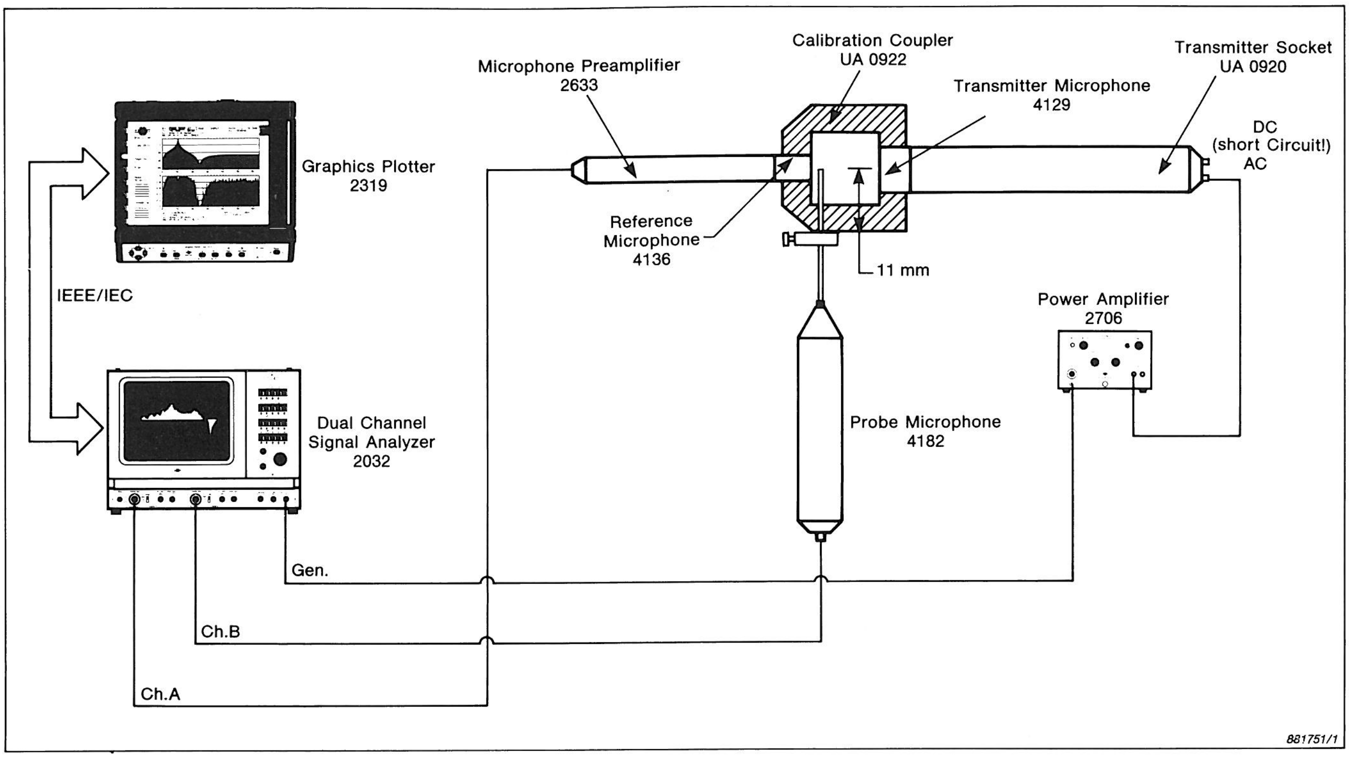


Fig. 3.6. The recommended measurement set-up for frequency response verification. If a reference microphone is not used, the relevant hole in the coupler should be sealed with the plug provided and the generator output connected to channel A of the analyzer

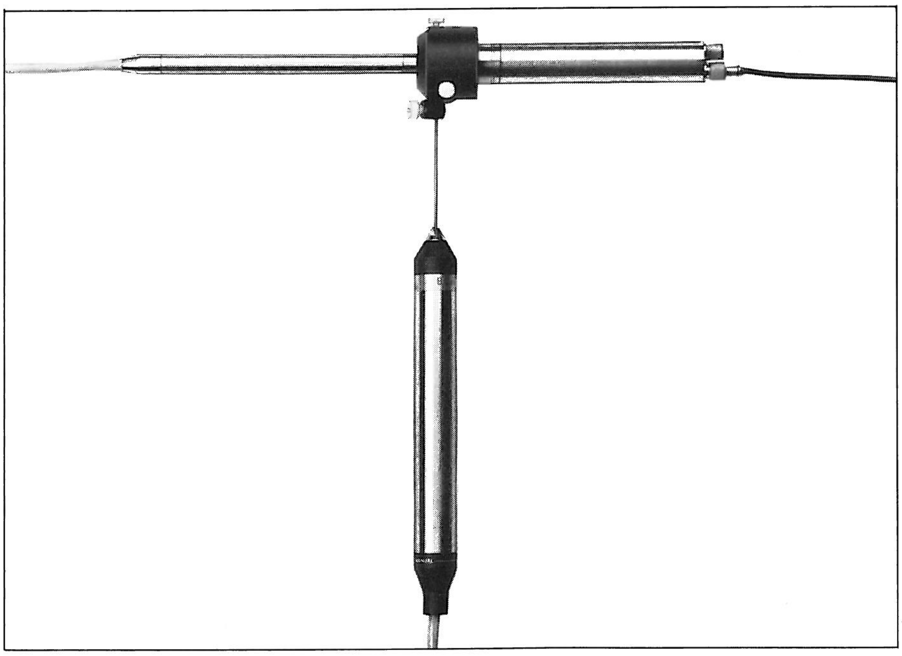


Fig. 3.7. Calibration Coupler UA 0922 with reference microphone (left), transmitter microphone (right) and probe microphone (bottom)

5. Set the polarization voltage for the reference microphone to 200 V and connect the preamplifier output of this microphone to channel A of the dual-channel signal analyzer.

6. Fit the selected probe tube to the probe microphone. To position a stiff tube correctly, clamp the Calibration Stop UA 0939 to the tube, 11 mm from the tip (the Wrench QA 0159 can be used to set the correct distance as shown in Fig. 3.4). To position a flexible tube, mark it with a pen.

7. Insert the tip of the probe tube through the appropriate hole in the coupler so that the calibration stop touches the outer surface of the coupler. To select the appropriate hole, see section 5.1.

8. Set the polarization voltage for the probe microphone to 200 V and connect the probe microphone output to channel B of the dual-channel signal analyzer.

9. Measure the frequency response on the signal analyzer.

Since the probe tip must not touch the diaphragm of the reference microphone, the centre line of the probe tube is located 1,2 mm away from the diaphragm. The resulting error in the measured frequency response increases as frequency increases. The correction curve is shown in Fig. 3.8. The true frequency response is found by adding the correction curve to the measured frequency response curve.

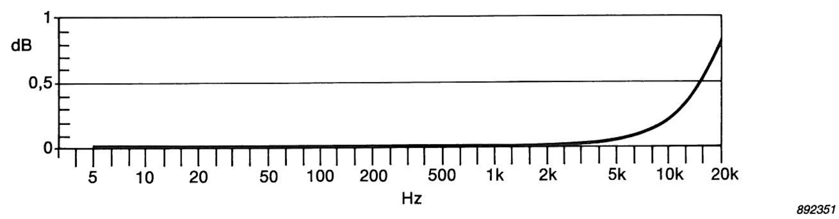


Fig. 3.8. The correction curve for the error in the measured frequency response due to the 1,2 mm distance between the reference microphone and the probe tip. This curve should be added to the measured frequency response curve

3.3.4. Frequency Response Test – Without Reference Microphone

This calibration method can be used, without a reference microphone, to check the frequency response of the Type 4182 in a limited frequency range and with reduced accuracy (typically ±1 dB). The method considers that the sound pressure in the coupler is proportional to the voltage supplied to the transmitter microphone. This is the case in the range from 200 Hz to 5 kHz.

The output from the generator – instead of the output from the reference microphone – is connected to channel A of the analyzer.

The diagram in Fig. 3.6 and photograph in Fig. 3.7 illustrate the measurement set-up for a frequency response test with a reference microphone. If the reference microphone is removed and its orifice in the coupler is sealed as described below, the measurement set-up becomes the one used for a frequency response test without a reference microphone. The measurement procedure for this test is as follows:

1. Screw the transmitter microphone onto the Transmitter Socket UA 0920. Press this assembly firmly into the Calibration Coupler UA 0922 until it meets the shoulder and rotate it slightly to ensure a good fit. The recommended transmitter microphone is the Brüel & Kjær Condenser Microphone Type 4129, which is not included.

2. Screw the Short-circuit Plug JP 0169 onto the DC terminal of the transmitter socket to ensure that the signal to the microphone has no DC offset. Connect the AC terminal of the transmitter socket to a random noise source of about 10 V RMS.

3. Seal the reference-microphone hole in the calibration coupler by screwing in the Knurled Plug YS 0665.

4. Fit the selected probe tube to the probe microphone. To position a stiff tube correctly, clamp the Calibration Stop UA 0939 to the tube, 11 mm from the tip (the Wrench QA 0159 can be used to set the correct distance as shown in Fig. 3.4). To position a flexible tube, mark it with a pen.

5. Insert the tip of the probe tube through the appropriate hole in the coupler so that the calibration stop touches the outer surface of the coupler. To select the appropriate hole, see section 5.1.

6. Set the polarization voltage to 200 V and connect the probe microphone output to channel B of the dual channel signal analyzer.

7. Measure the frequency response on the signal analyzer.

3.3.5. Frequency Response

A typical frequency response for a Type 4182 Probe Microphone with a 50 mm stiff probe tube attached is shown in Fig. 3.9.

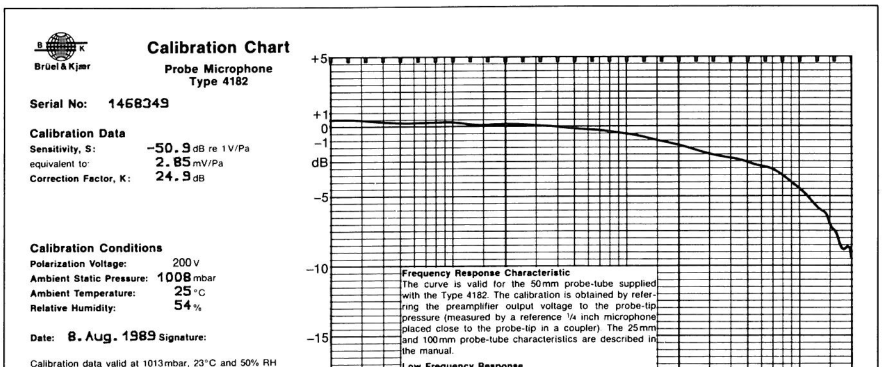


Fig. 3.9. A typical frequency response curve for the probe microphone, measured with a 50 mm stiff probe tube attached

3.4. MEASURING SOUND PRESSURE

WARNING! NOT APPROVED FOR HUMAN BODY MEASUREMENTS
Probe Microphone Type 4182 is neither intended nor approved for measurements on the human body.

3.4.1. General

For most measurements at room temperature and atmospheric pressure, the measurement procedure is simple: Attach a suitable probe tube to the probe microphone. Set the polarization voltage to 200 V. Connect the output plug of the probe microphone to the preamplifier input socket of the measuring instrument and place the probe tip in the required measurement position.

3.4.2. Temperature Limits of the Complete Probe Microphone

The probe microphone can operate when exposed to temperatures ranging from −10°C to +50°C. Its frequency response varies slightly within this temperature range, as illustrated in Fig. 4.10. Brüel & Kjær used the calibration procedure of section 4.2.6 to obtain these curves.

3.4.3. Temperature Limits of Probe Tip

With the 100 mm probe tube attached, the probe microphone can operate with the probe tip exposed to temperatures up to 700°C. The change in frequency response with temperature is shown in Fig. 4.8. Brüel & Kjær used the calibration procedure described in section 4.2.5 to produce these curves.

When the probe tube is exposed to high temperatures, no part of the microphone body should exceed 50°C.

3.4.4. Equalizing Static Pressures

When the static pressures at the probe microphone housing and the probe tip are different, such as for measurements in exhaust pipes, the static pressure behind the microphone diaphragm might need to be equalized with the static pressure at the probe tip. This prevents static deflection of the diaphragm and subsequent change in microphone sensitivity (1% sensitivity change for 300 Pa static pressure differential).

The back of the microphone diaphragm is normally vented to the ambient atmosphere through a threaded hole at the front of the probe housing. When the pressure difference becomes too high, venting to the measurement site is possible with the venting stud and the flexible tube connected as shown in Fig. 3.10.

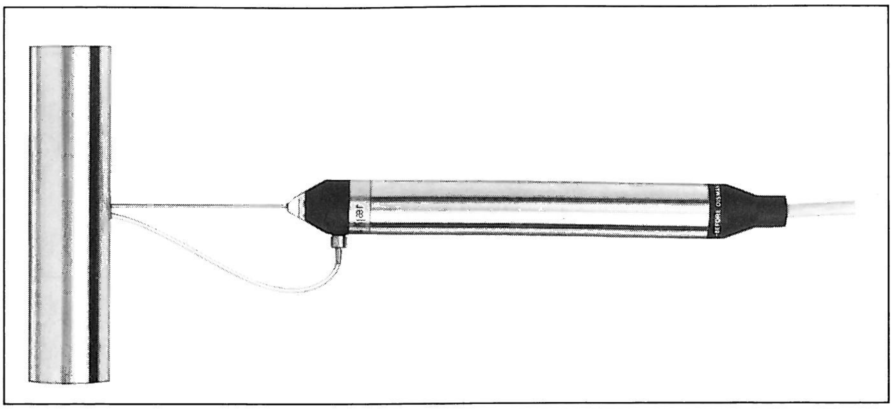


Fig. 3.10. The back of the microphone diaphragm can be vented to the probe tip by connecting the venting stud and flexible tube as shown

4. DESCRIPTION

4.1. CONSTRUCTION

4.1.1. General

The simplified drawing in Fig. 4.1 shows the main parts of the probe microphone. From left to right it shows the probe tube, the probe top and the probe housing. The probe top houses a condenser microphone. The cavity located in front of the microphone diaphragm connects the probe tube with a 1,5m long tube of the same diameter, which is closed at the opposite end. The tube is coiled to form a cylinder which surrounds the preamplifier housing.

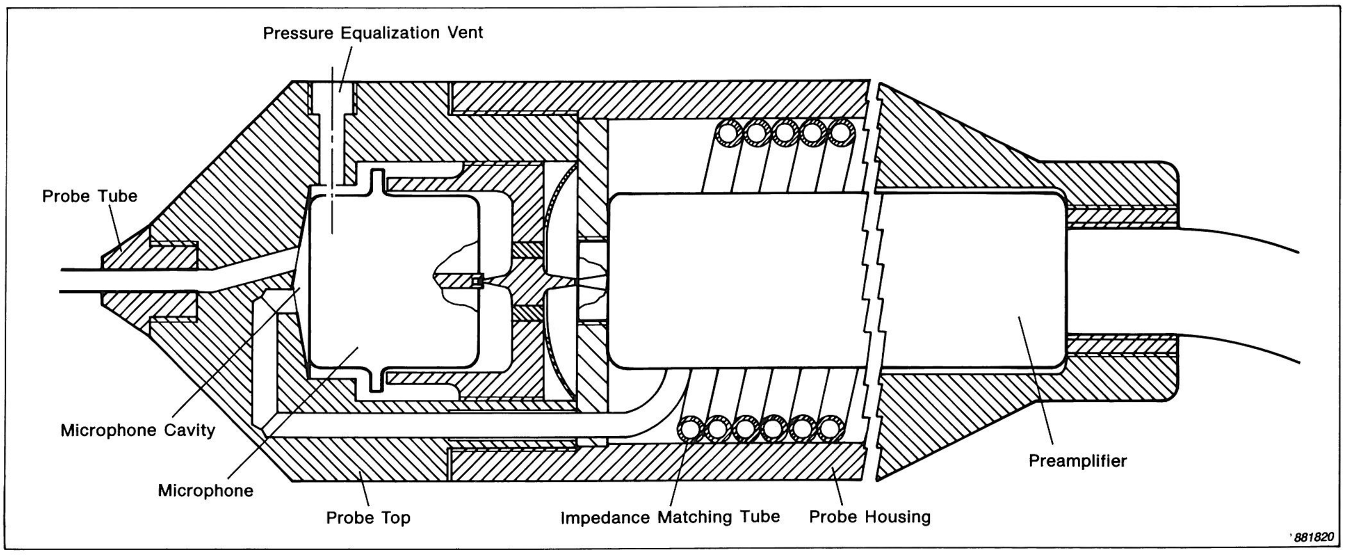


Fig. 4.1. The basic features of the probe microphone

4.1.2. Principle of Operation

The sound waves are guided from the probe inlet, through the probe tube to the cavity in front of the microphone diaphragm and further on into the tube which forms the wave guide. The wave guide terminates the probe tube with its characteristic impedance to minimize standing waves. Since the cavity is also designed to act as a matching element of the tube system, the probe microphone has a smooth frequency response. Reflections from the closed end of the wave guide are very weak due to the damping of the tube. The principle of operation is shown by the electro-acoustic circuit diagram in Fig. 4.2.

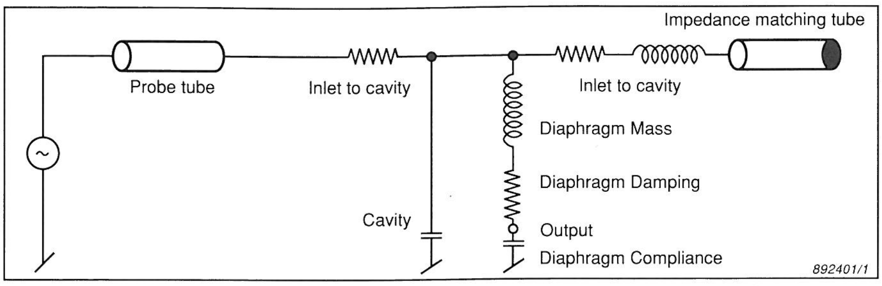


Fig. 4.2. Electro-acoustic circuit diagram illustrating the operating principle of the probe microphone

As the probe tube system is closed at the remote end, no gas flows through, even if measurements are made at places where the pressure differs from the ambient pressure. The Type 4182 is optimised for operation in air.

4.2. CHARACTERISTICS

4.2.1. Frequency Response

The frequency response depends on the probe tube selected for the application. The most well-defined frequency responses are obtained with the stiff tubes, but for some measurements the flexible tubes are better suited. The factory calibration is valid for the 50 mm stiff tube, see Fig. 3.9. Typical frequency characteristics for the 25 mm, 50 mm and 100 mm stiff tubes supplied with the probe microphone are shown in Fig. 4.3. Corresponding frequency characteristics for 50 mm and 100 mm flexible tubes are shown in Fig. 4.4. These are less smooth because the difference between the diameters of the flexible probe tube and the internal tube of the Type 4182 causes an impedance mismatch. Individual frequency characteristics for stiff and flexible tubes of any length can be found with the help of the Calibration Coupler UA 0922 and the accessories of the Type 4182. Various methods are described in chapter 3. The damping of narrow tubes increases with frequency, and is proportional to tube length. Therefore the frequency characteristics of long tubes roll off more steeply at high frequencies.

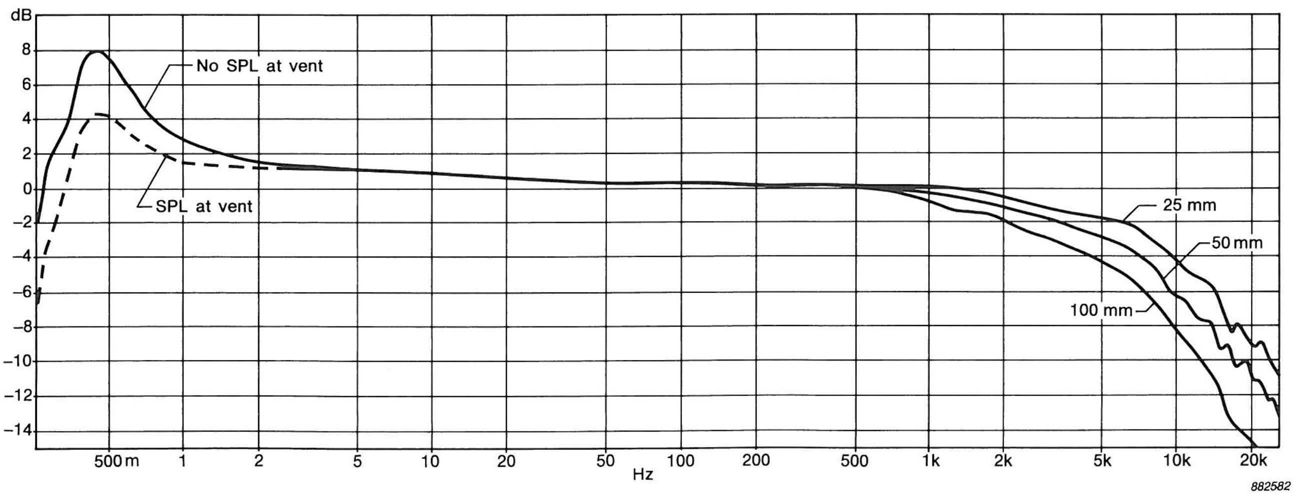


Fig. 4.3. Typical frequency responses of the probe microphone, measured with 25 mm, 50 mm and 100 mm lengths of stiff probe tubes attached

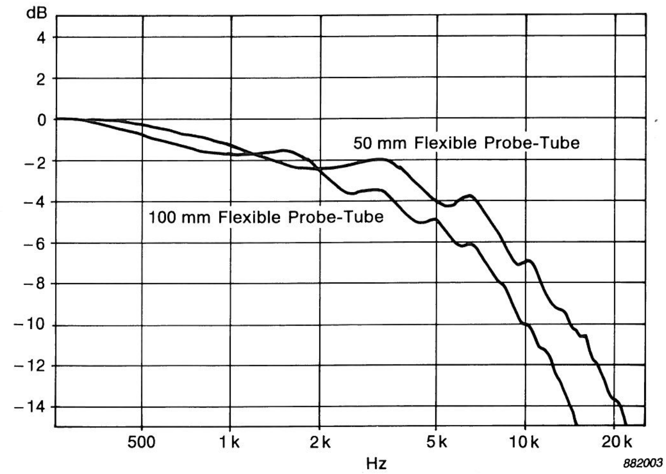


Fig. 4.4. Typical frequency responses of the probe microphone, measured with 50mm and 100mm lengths of flexible probe tube attached

4.2.2. Phase Response

A typical phase response curve for a probe microphone with a 50mm stiff probe tube attached is shown in Fig. 4.5. The measurement incorporated a time delay of 0,183ms, which corresponds to a distance of 63mm, which is the effective length from the probe tip to the microphone diaphragm.

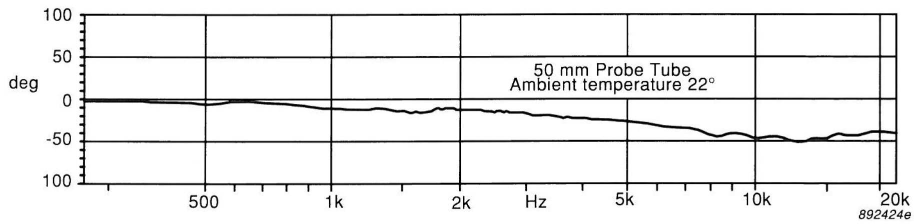


Fig. 4.5. A typical phase response of the probe microphone, measured with a 50mm probe tube attached

4.2.3. Inherent Noise

A typical inherent-noise spectrum measured in 1/3-octave bands is shown in Fig. 4.6. The corresponding wide-band noise level is equivalent to a sound pressure level of 44dB linear-weighted or 38,5dB A-weighted (reference 20 μPa).

4.2.4. Probe Tip Impedance

The probe microphone has a high acoustic impedance and can therefore be used for measurements in small cavities. In general it does not significantly load the cavities under investigation. In the frequency range above 50Hz and for volumes greater than 1 cm^3 the influence of loading is negligible.

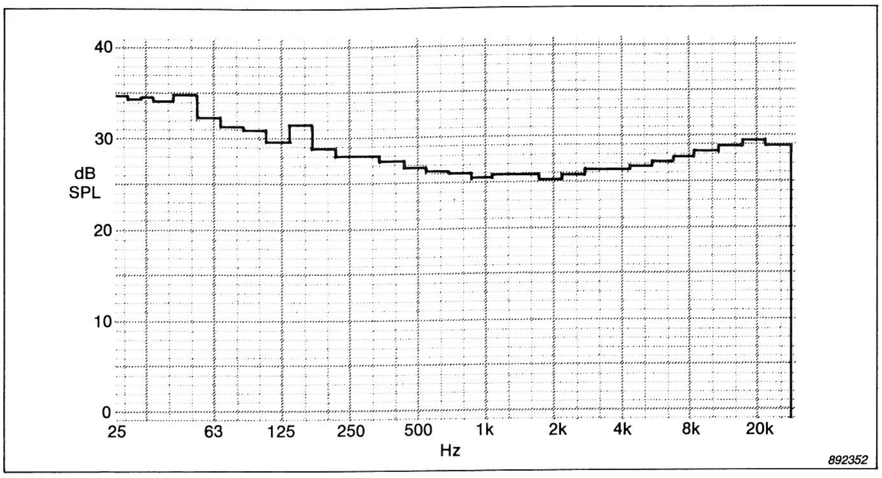


Fig. 4.6. A typical inherent noise spectrum for the probe microphone, measured using 1/3-octave bandwidth

4.2.5. Effect of Probe Tip Temperature on Frequency Response

The probe microphone can operate with a part of the probe tube exposed to temperatures up to 700°C. The sensitivity changes as a function of temperature and depends on the length of the heated part of the tube. Some sensitivity changes (reference 23°C), measured using the set-up shown in Fig. 4.7, are shown as a function of frequency in Fig. 4.8. Half of the 100 mm probe tube was heated to the indicated temperatures.

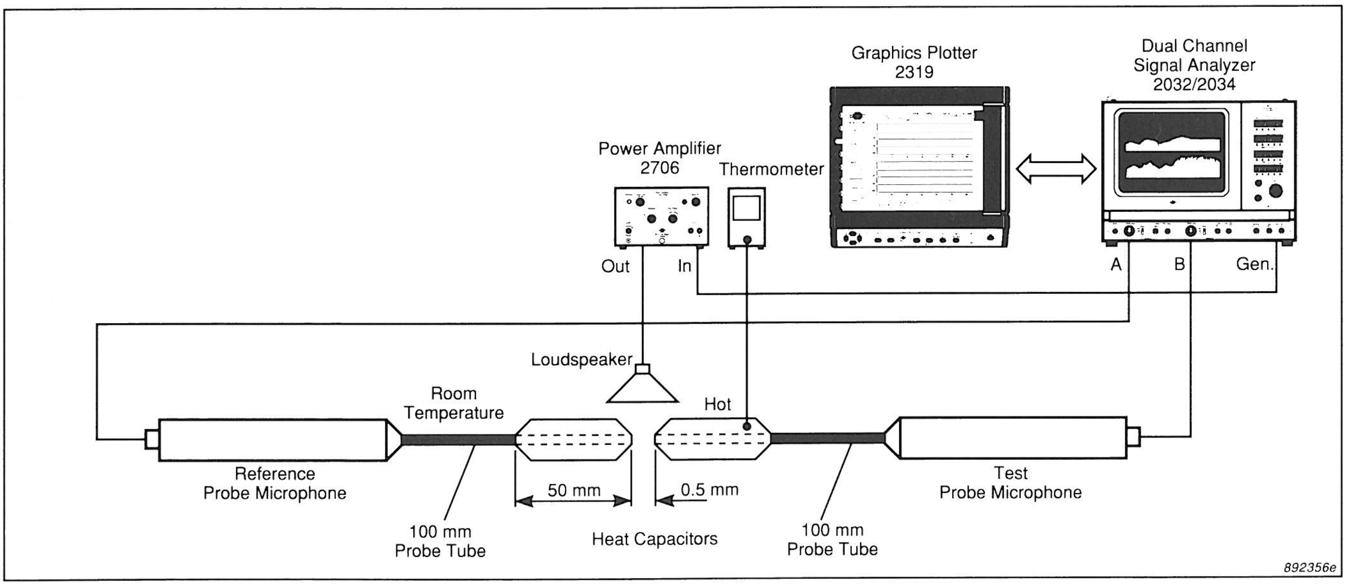


Fig. 4.7. The recommended set-up for measurement of the effect of high probe-tip temperature on the frequency response of the probe microphone

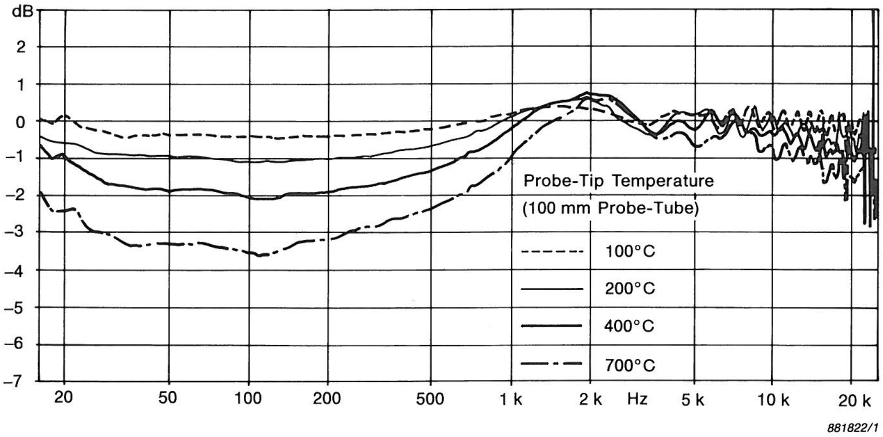


Fig. 4.8. Typical measurement results showing the effect of high probe-tip temperature on the frequency response of the probe microphone

The following is a brief description of the measurement procedure. The reference microphone was connected to channel A and the test microphone to channel B of the dual-channel signal analyzer. With both probe tips at room temperature, the frequency response function was measured and stored in memory. The temperature of the test probe tip was increased and the new frequency response function was measured. The equalize function of the analyzer was used to divide the new measurement by the stored measurement. The displayed result is the sensitivity change of the test microphone due to the temperature increase.

4.2.6. Effect of Temperature on the Complete Probe

The Type 4182 can operate with the entire microphone exposed to temperatures within the range from −10°C to +50°C. The changes in sensitivity with temperature, measured using the set-up shown in Fig. 4.9, are shown in Fig. 4.10. The results are valid for the 50 mm stiff tube and the reference temperature is 25°C.

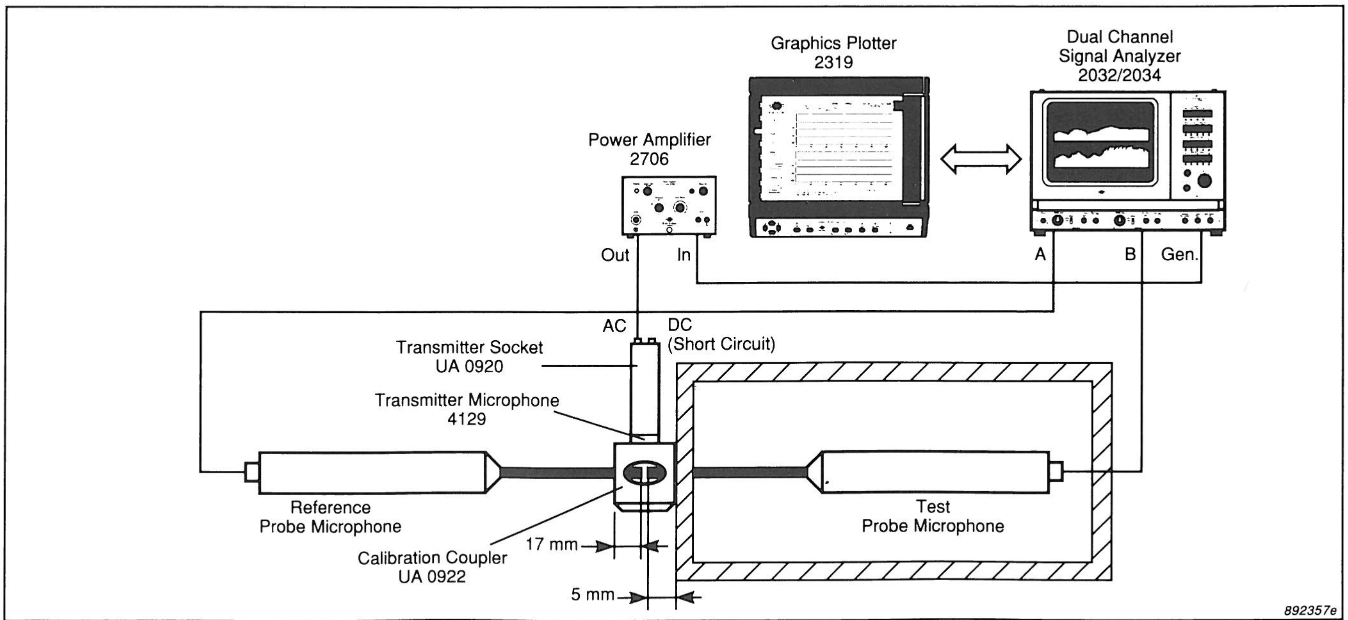


Fig. 4.9. The recommended set-up for measurement of the effect of probe-housing temperature on the frequency response of the probe microphone

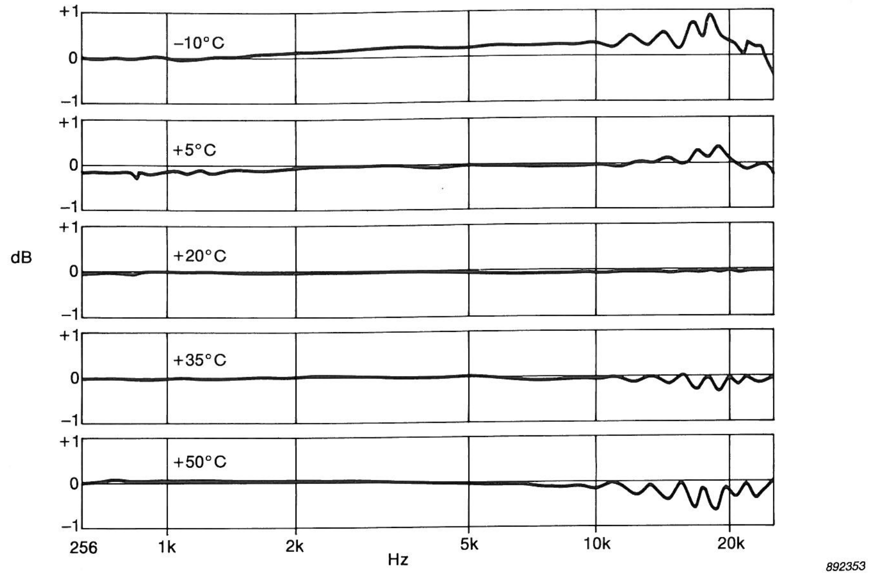


Fig. 4.10. Typical measurement results showing the effect of probe-housing temperature on the frequency response of the probe microphone

The measurement procedure is the same as in section 4.2.5 except in this case the temperature of the entire probe microphone is changed, instead of the tip alone.

5. APPENDIX

5.1. USE OF CALIBRATION COUPLER UA 0922

Calibration Coupler UA 0922 has five different holes for the probe tubes, a socket for the transmitter microphone, and another socket for a reference microphone. The following list, together with Fig. 5.1, describes which holes must be used for various calibration options.

① Frequency response; stiff probe-tube only; with reference microphone

② Frequency response; flexible probe-tube only; without reference microphone

③ Phase calibration; use hole ① also; stiff or flexible probe-tubes; with reference microphone (same as hole ①)

④ Frequency response; stiff probe-tube only; without reference microphone

⑤ Frequency response; flexible probe-tube only; with reference microphone

⑥ Threaded socket for reference microphone Type 4136

⑦ Push-in socket for transmitter microphone Type 4129

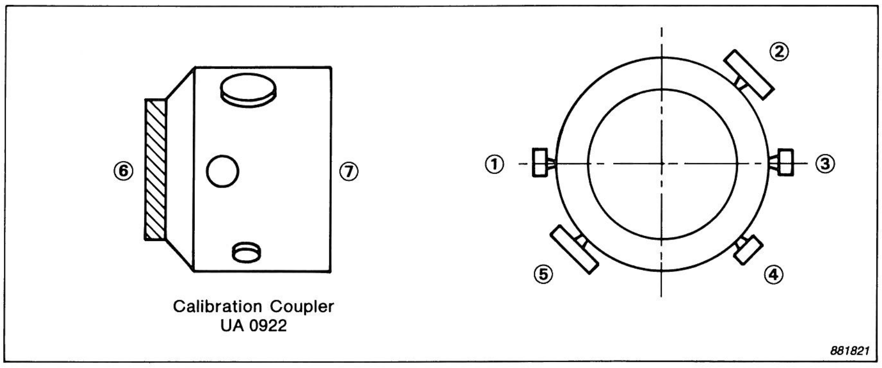


Fig. 5.1. Calibration Coupler UA 0922

5.2. A CONDENSER MICROPHONE AS A SOUND SOURCE

In the procedures described for frequency response calibration, a condenser microphone is used as a sound source. The formula given below can be used to approximate the sound pressure produced in a cavity whose dimensions are significantly less than the wavelength.

$$p = \frac{M_p e C \gamma p_a}{V}$$

where:

p = sound pressure developed in the cavity

M_p = open-circuit pressure sensitivity – quoted on the microphone calibration chart

e = voltage applied to the transmitter microphone

C = polarized capacitance of transmitter microphone – quoted on the microphone calibration chart

γ = ratio of specific heats $\frac{C_p}{C_v} = 1{,}4$

p_a = static pressure in coupler cavity—assume this is the ambient pressure

V = effective volume = 1 cm^3 (volume of coupler = 0,75 cm^3 and volume due to transmitter microphone = 0,25 cm^3)

Brüel & Kjær Technical Review No. 3, 1977, give further details concerning "Microphones used as Sound Sources".