PRECISION ACOUSTICS

0.2 mm needle hydrophone (NH0200)

The 0.2 mm needle hydrophone is one of a range of needle hydrophones manufactured by Precision Acoustics Ltd. It is designed to be used in conjunction with a submersible preamplifier and DC coupler with power supply to form a hydrophone system. Whenever properties are reported in this data sheet they refer to those of a hydrophone system incorporating a 0.2 mm needle hydrophone, preamplifier and DC coupler.

The size of the active element of a hydrophone affects many properties including sensitivity, frequency response, directional response, dynamic range and noise equivalent pressure. This technical data sheet is prepared in compliance with IEC 62127 – part 3 [3] and provides a detailed specification of a 0.2 mm needle hydrophone system.

The 0.2 mm needle hydrophone is a popular general purpose measurement device offering a good compromise between sensitivity and directivity for a wide range of applications at frequencies from 1.0 MHz to 40 MHz.

PRODUCT DESCRIPTION

The 0.2 mm needle hydrophone is a general-purpose hydrophone that provides a good compromise between sensitivity, frequency response, directional response, dynamic range and noise equivalent pressure for measurements in the 1 MHz to 40 MHz range. The large active area enables signals ≈ 1 kPa to be measured. However larger sensor areas result in a more directional response pattern particularly at higher frequencies.

Specification

Model Number	NH0200	
Sensor element dimensions	Diameter: Thickness:	0.2 mm 9 µm
Hydrophone dimensions	See Figure 1	
Weight of hydrophone	1.26 g	
Transduction method	Piezoelectric conversion	
Sensor material	Polyvinylidene Fluoride (PVDF)	
Mean sensitivity in the range 2 MHz to 12 MHz	55 mV/MPa (additional data below)	
Hydrophone frequency band	0.1 MHz to 40 MHz	
Measurement uncertainty	0.1 MHz to 1 MHz: 1 MHz to 8 MHz: 9 MHz to 20 MHz: 21 MHz to 30 MHz: 31 MHz to 40 MHz:	9 % 8 % 11 % 12 % 15 %
Output impedance of hydrophone system	50 Ω	
Orientation during use	Needle tip pointing directly towards the acoustic source (see Figure 4)	

Dimensions

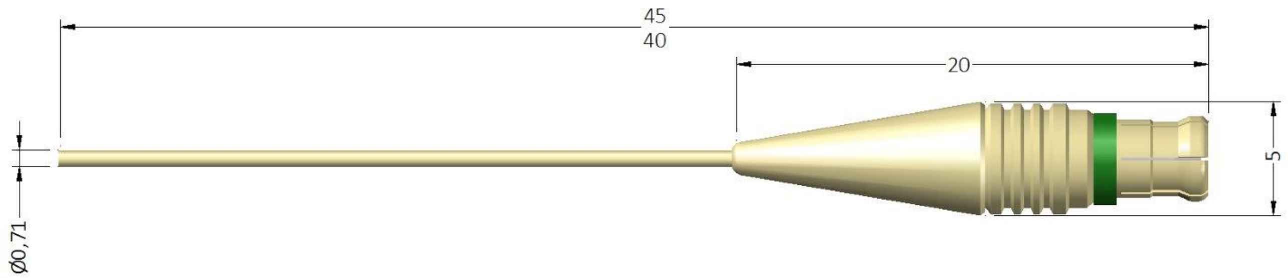

Figure 1 - Dimensioned drawing of 0.2 mm needle hydrophone (NH0200)

SENSITIVITY AND FREQUENCY RESPONSE

All probe type hydrophones have a frequency response that is a function of frequency. The theoretical basis of this response is well understood and described elsewhere [1]. Figure 2 and Figure 3 show the typical end-of-cable loaded sensitivity for the needle hydrophone used in conjunction with its appropriate pre-amplifier, when loaded by 50 Ω. The data sets displayed in these figures were both acquired by the National Physical Laboratory, London (NPL).

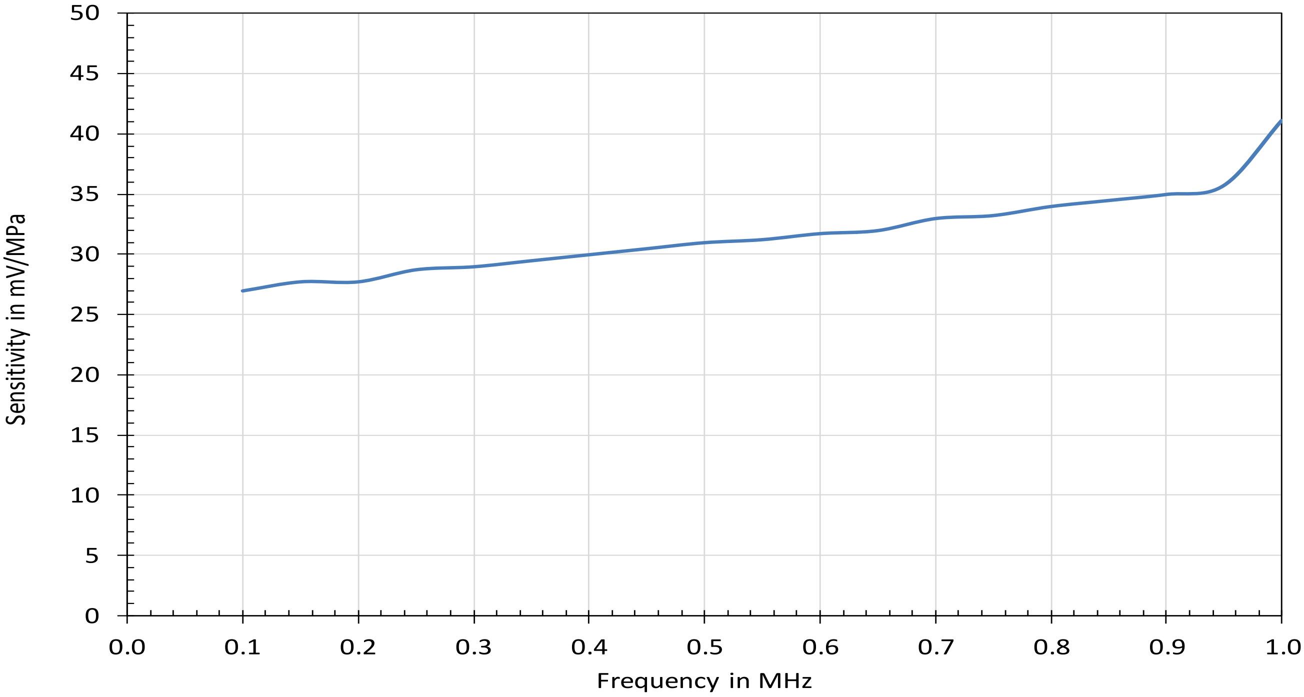

Figure 2 - Typical frequency response of a 0.2 mm needle hydrophone in the range 100 kHz to 1.0 MHz

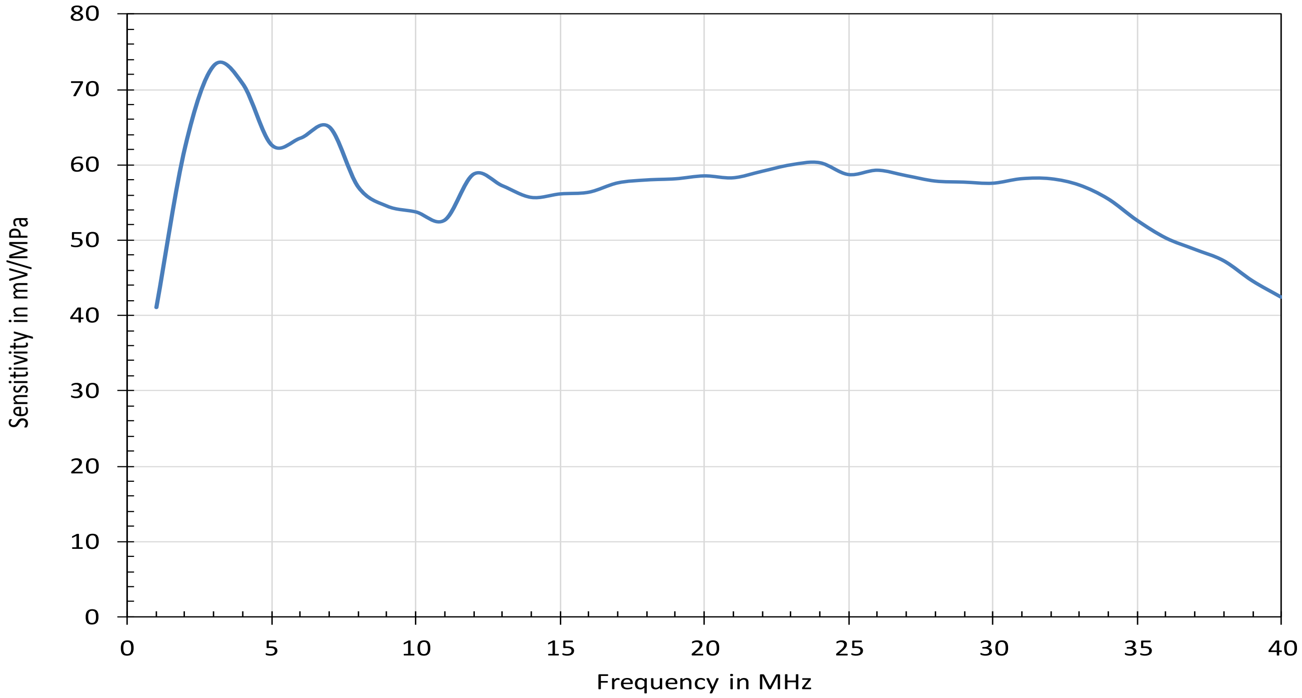

Figure 3 - Typical frequency response of a 0.2 mm needle hydrophone in the range 1.0 MHz to 40 MHz

Needle hydrophones used to make absolute measures of acoustic pressure should be calibrated at least once every 12 months. The hydrophone should be checked against a reference source on a monthly basis so that variations in sensitivity are identified sooner than the annual calibration interval.

The measurement uncertainty for the frequency response measurement was determined in accordance with the methods established in [2]. One of the main uncertainty contributions is that due to the calibration of the reference hydrophone used in the calibration, which itself is traceable to national primary standards.

DIRECTIONAL RESPONSE

The directional response of the hydrophone was established using the same nonlinear field as that used in the determination of the frequency response. The hydrophone was placed in a mounting fixture that permitted the precise position of the active element to be adjusted. The hydrophone's tip was then adjusted so that there was less than 100 ns temporal shift of the recorded waveform when it was rotated in the field. This alignment ensured that the hydrophone was not displaced during rotation and therefore that any variations in received signal were due only to the directional response of the hydrophone. By recording the waveform generated by the hydrophone as a function of angle, the directional response at a range of frequencies could be established. The directional response of the 0.2 mm needle hydrophone at 1 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz, 25 MHz, 30 MHz and 40 MHz has been plotted in Figure 5.

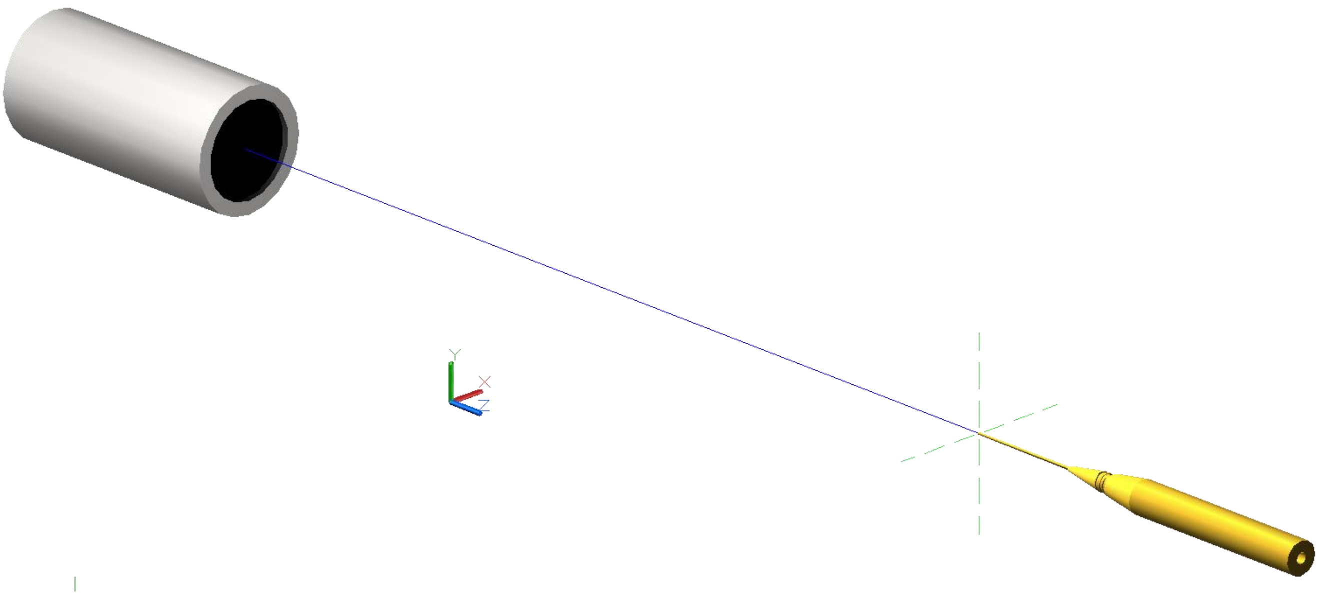

Figure 4 - Orientation of needle hydrophone during use

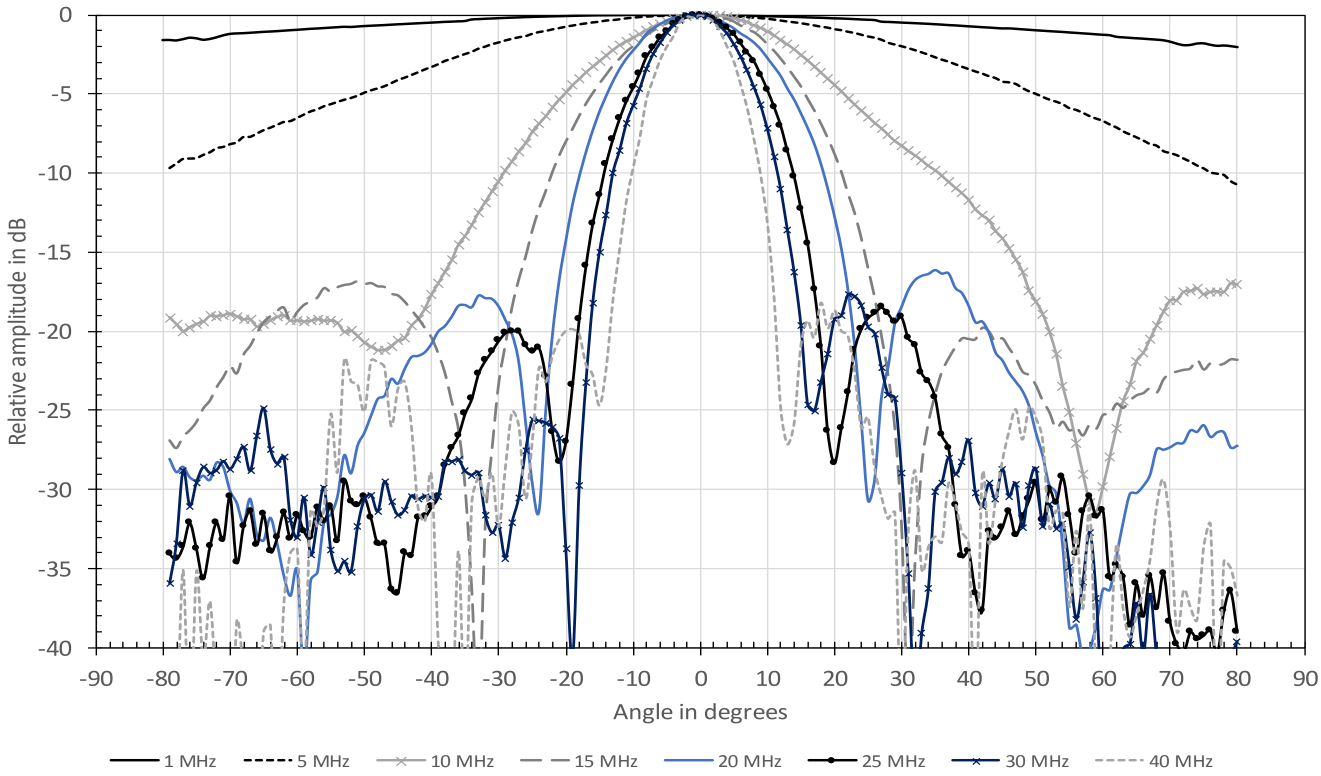

Figure 5 - Directional response of 0.2 mm needle hydrophone

Effective radius

The effective radius of the hydrophone was calculated from the angles at which the –3 dB and –6 dB points of a directional response curve occur in accordance with the methods described in [3] and the mean effective radius is shown in Figure 6. However, the IEC method fails at lower frequencies for this hydrophone because the directional response stays above -6dB level at frequencies below 5 MHz.

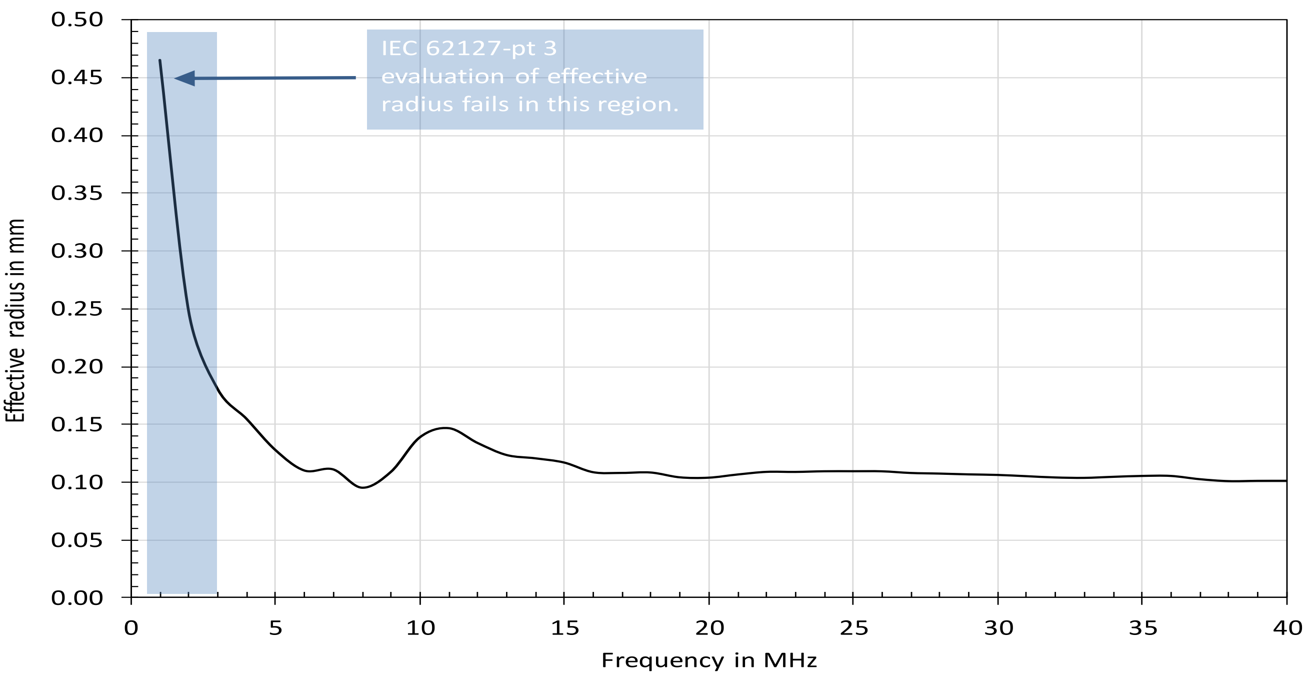

Figure 6 - Effective radius of 0.2 mm needle hydrophone

DYNAMIC RANGE, LINEARITY AND ELECTROMAGNETIC INTERFERENCE

Lower dynamic limit

The noise floor of the hydrophone assembly limits the measurement of small acoustic signals. The noise level of the pre-amplifier is approximately 60 µV rms over a 100 MHz bandwidth. If the hydrophone sensitivity is assumed to be 55 m V/MPa, the noise level stated leads to a noise equivalent pressure for the 0.2 mm needle hydrophone

$$\frac{60\ \mu V}{55\ mV\ /\ MPa} = 1.1\ kPa$$

The data acquisition system being used to record the waveforms produced by the hydrophone can also limit the minimum recordable signal. For example, an oscilloscope that is limited to a maximum resolution of 0.5 mV will only be able to display signals of amplitude 0.5 mV / 55 mV/MPa = 10 kPa or greater.

$$\frac{0.5\ mV}{55\ mV\ /\ MPa} = 9\ kPa$$

Upper dynamic limit

Concerning the pressure threshold above which mechanical damage occurs to the hydrophone: this hydrophone has been designed for use in fields up to 10 MPa. Although hydrophones of this type have been used for ultrasonic fields that exceed 50 MPa, there is an elevated risk of damage. The supplier's advice should be sought if the hydrophone is to be used in fields containing acoustic pressure levels beyond 10 MPa.

Concerning the pressure beyond which amplifier saturation occurs: the pre-amplifier that is used with this hydrophone can start to exhibit nonlinearities when its output voltage exceeds a 700 mV peak to peak. Taking into account the typical 0.2 mm needle hydrophone sensitivity, this corresponds to a pressure of

$$\frac{700\ mV}{55\ mV\ \ /\ MPa} = 12.7\ MPa$$

However, as discussed above, measurement of pressures at this level could lead to hydrophone damage and thus supplier's advice should be sought.

ELECTRIC OUTPUT CHARACTERISTICS

No representative data are available here as this has not been determined for the hydrophone described here.

ENVIRONMENTAL ASPECTS

Temperature variation

This needle hydrophone can be used for measurement over an operating temperature range of 5 °C to 50 °C, and can be stored over the range 5 °C to 50 °C. Exposure to temperatures above 60 °C has the potential to cause irreversible damage to the hydrophone.

This hydrophone assembly has been calibrated at a temperature between 19 °C and 25 °C. The sensitivity of the hydrophone will be a function of temperature and an increase in the sensitivity of 0.6 % per degree temperature rise should be expected.

Water quality

The hydrophone assembly has been designed for complete immersion in water and can easily withstand the hydrostatic pressure caused by 2 m of water. Although the hydrophone assembly can be used for prolonged periods (>48 h) of immersion, the hydrophone should be withdrawn from water and allowed to dry whenever it is not in use.

There are no specific operating requirements in terms of water quality for use of this hydrophone. However, hydrophone measurements standards such as the [4] [5] may have specific requirements for water quality.

Prolonged immersion in water that has not been deionized (e.g. tap water) can lead to a build-up of deposits on the hydrophone tip. Calcium carbonate deposits can be a particular problem in "hard" water areas and will lead to a loss of sensitivity of the hydrophone.

Other liquid media

Although designed for operation in water, the hydrophone assembly can be used in many other liquid media. It should be noted, however, that the calibration of this hydrophone was undertaken in water. Other materials present different acoustic impedance loads on the hydrophone active element and this is likely to affect the sensitivity of the hydrophone. Certain liquids should be avoided due to their chemically aggressive nature. Examples of materials that should be avoided are:

- concentrated acids (e.g. nitric acid, sulphuric acid);
- concentrated alkalis (e.g. sodium hydroxide);
- strong organic solvents [e.g. many aldehydes, many ketones, Dimethyl Chloride (DMC), dimethylformamide (DMF)].

As supplied, the only materials of the hydrophone assembly that are exposed to the surrounding liquid are gold, stainless steel, polytetrafluoroethylene (PTFE), brass and the polyvinyl chloride (PVC) cladding on the pre-amplifier cable. However, if the outer gold electrode on the hydrophone becomes damaged, the PVDF and a rigid casting resin might also become exposed.