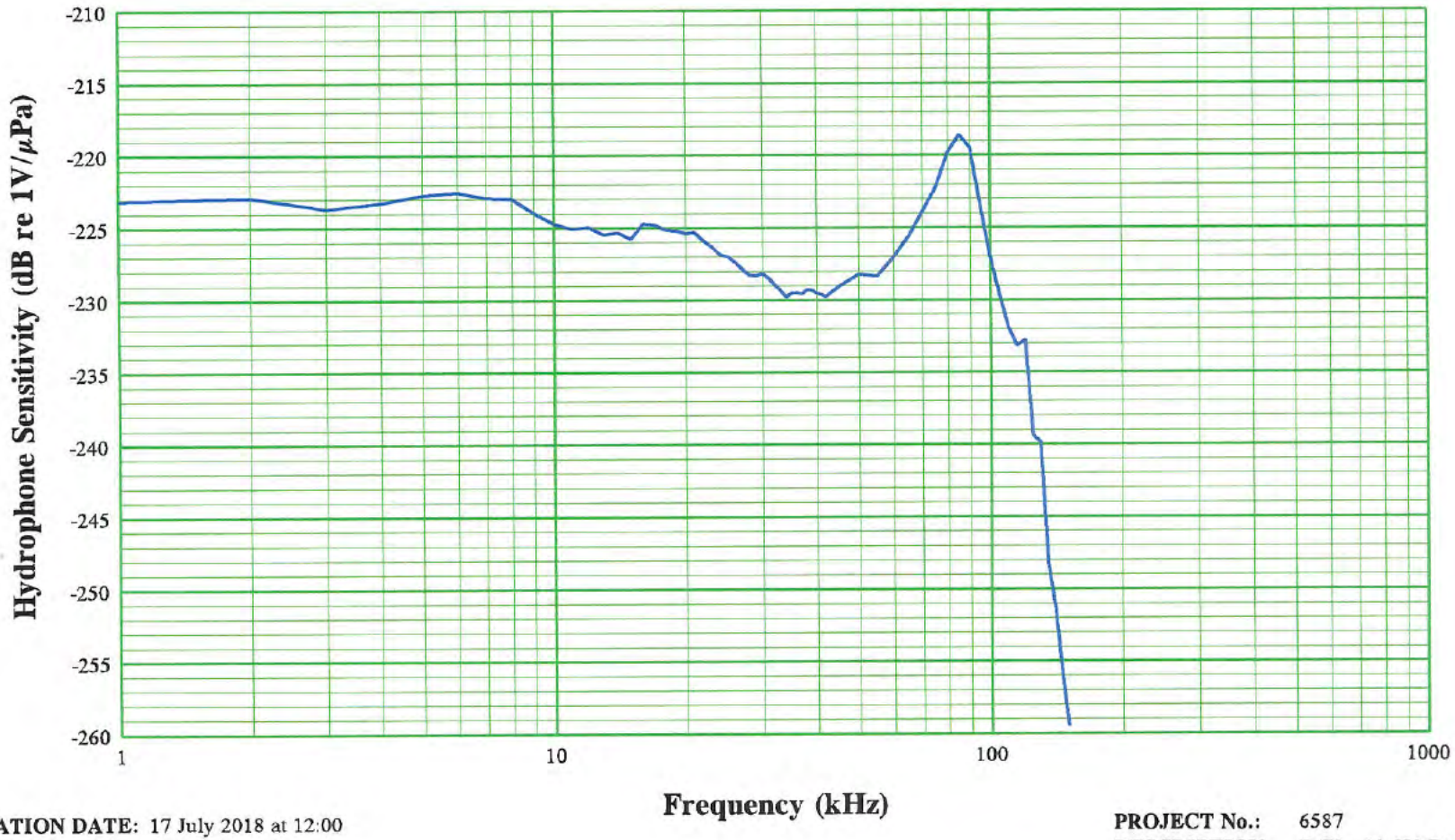
NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



CALIBRATION DATE: 17 July 2018 at 12:00
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: [Re da cte dl]
REMARKS: Set to -20 gain and no filters
0 to -20dB gain pre amp and H0 box

PROJECT No.: 6587
DESCRIPTION: D/70 with H0 Box
TEST SPEC:
WATER TEMP: 22°C (±0.5)
CABLE: 15m

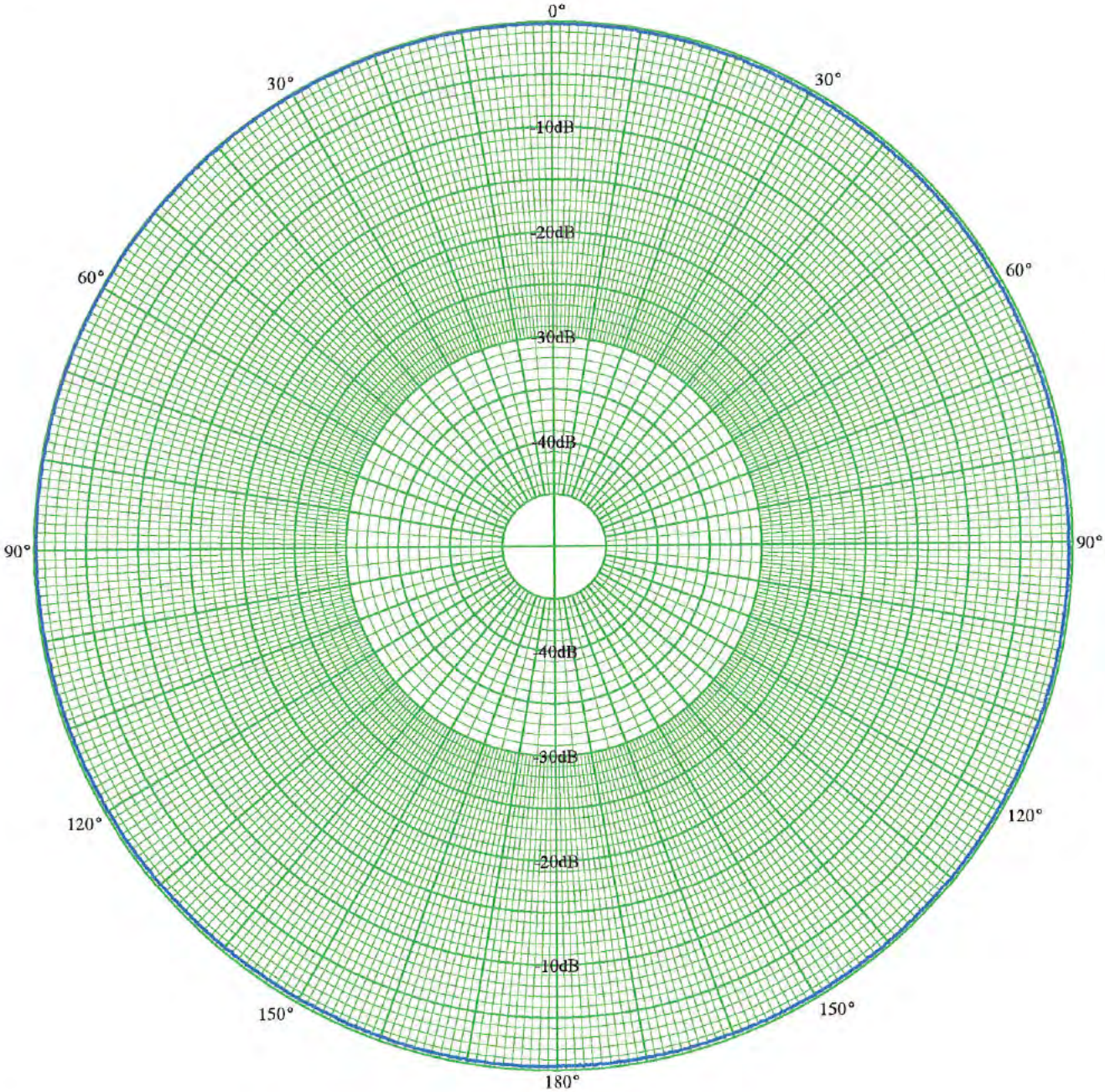
Ref:-M_D70(H0):12:01:07

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 17 July 2018 at 10:59
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: [Redacted]

PROJECT NO.: 6587
DESCRIPTION: D/70 with H0 Box
TEST SPECIFICATION:
WATER TEMPERATURE: 22°C



FREQUENCY: 10 kHz
0° ALIGNMENT: MECHANICAL
ROTATION: 360°

3dB BEAMWIDTH: N/A
OVERALL VARIATION: .5dB
SMOOTHING APPLIED: None

REMARKS: Set to -20 gain and no filters
0 to -20dB gain pre amp and H0 box

Ref:-D70(H0):10:59:41

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

TEST CERTIFICATE

PROJECT REF:	6587
SERIAL NUMBER:	None
TRANSDUCER TYPE:	D70(Ambient)
DESCRIPTION:	D/70 with HSS Box
TEST SPECIFICATION:	Test Instructions
ISSUE DATE:	18 July 2018

Ref Projector:	D/11_18684	**Ref Projector:**	D/26_22769
Ref Projector:	D/70_34376	**Ref Projector:**	D/140_29373

TABULATED RESULTS	**(3 pages)**
HYDROPHONE SENSITIVITY GRAPH	**(2 pages)**
POLAR PLOT	**(1 page)**

[Redacted]

[Redacted]

Customer:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire

[Redacted]

Eco Fish Global Ltd
Aberdeen Harbour
Expansion Project
St Fitting Road
Nigg Bay
AB11 8TN

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

PROJECT No.: 6587
DESCRIPTION: D/70 with HSS Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 3m cable

REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
1.000	-134.0	±1.5
2.000	-133.3	±1.0
3.000	-132.2	±1.0
4.000	-133.2	±1.0
5.000	-132.0	±1.0
6.000	-132.7	±1.0
7.000	-134.3	±1.0
8.000	-135.7	±1.0
9.000	-136.0	±1.0
10.000	-134.7	±1.0
11.000	-133.8	±1.0
12.000	-133.8	±1.0
13.000	-133.5	±1.0
14.000	-134.0	±1.0
15.000	-134.0	±1.0
16.000	-134.5	±1.0
17.000	-134.6	±1.0
18.000	-135.5	±1.0
19.000	-135.5	±1.0
20.000	-136.1	±1.0
21.000	-136.4	±1.0
22.000	-137.4	±1.0
23.000	-137.1	±1.0
24.000	-137.7	±1.0
25.000	-137.8	±1.0
26.000	-138.0	±1.0
27.000	-137.5	±1.0
28.000	-137.2	±1.0
29.000	-135.9	±1.0
30.000	-136.3	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

PROJECT No.: 6587
DESCRIPTION: D/70 with HSS Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 3m cable

REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
31.000	-136.8	±1.0
32.000	-136.9	±1.0
33.000	-137.5	±1.0
34.000	-137.6	±1.0
35.000	-138.0	±1.0
36.000	-138.1	±1.0
37.000	-138.2	±1.0
38.000	-138.5	±1.0
39.000	-138.5	±1.0
40.000	-138.7	±1.0
41.000	-138.6	±1.0
42.000	-138.4	±1.0
43.000	-137.8	±1.0
44.000	-137.5	±1.0
45.000	-137.6	±1.0
50.000	-136.6	±1.0
55.000	-137.5	±1.0
60.000	-137.4	±1.0
65.000	-136.2	±1.0
70.000	-134.0	±1.0
75.000	-132.2	±1.0
80.000	-129.8	±1.0
85.000	-128.7	±1.0
90.000	-129.1	±1.0
95.000	-134.2	±1.0
100.000	-137.9	±1.0
105.000	-140.7	±1.0
110.000	-142.1	±1.0
115.000	-142.6	±1.0
120.000	-144.5	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

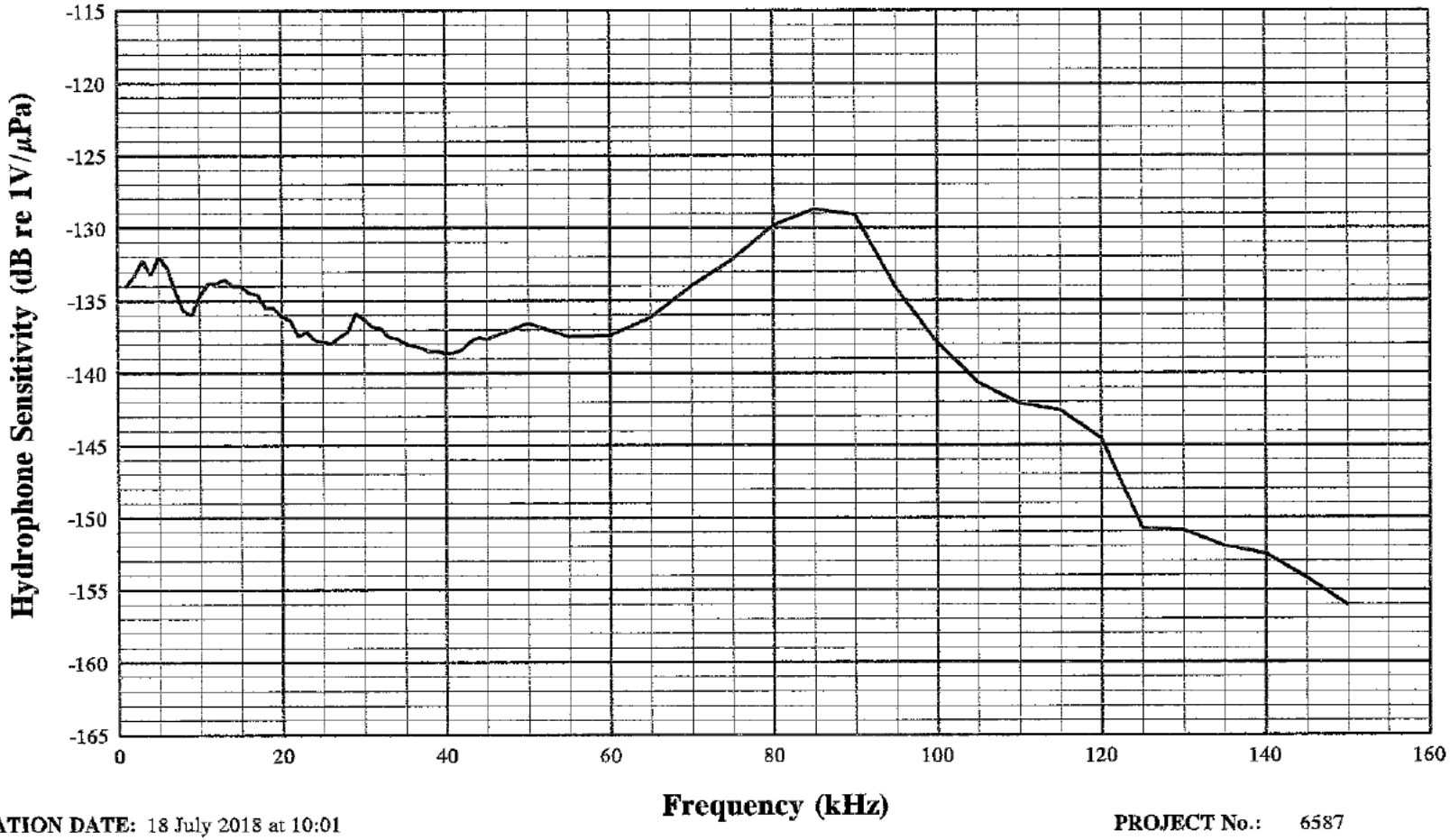
PROJECT No.: 6587
DESCRIPTION: D/70 with HSS Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 3m cable

REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
125.000	-150.8	±1.0
130.000	-150.9	±1.0
135.000	-152.0	±1.0
140.000	-152.5	±1.0
145.000	-154.2	±1.0
150.000	-156.1	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



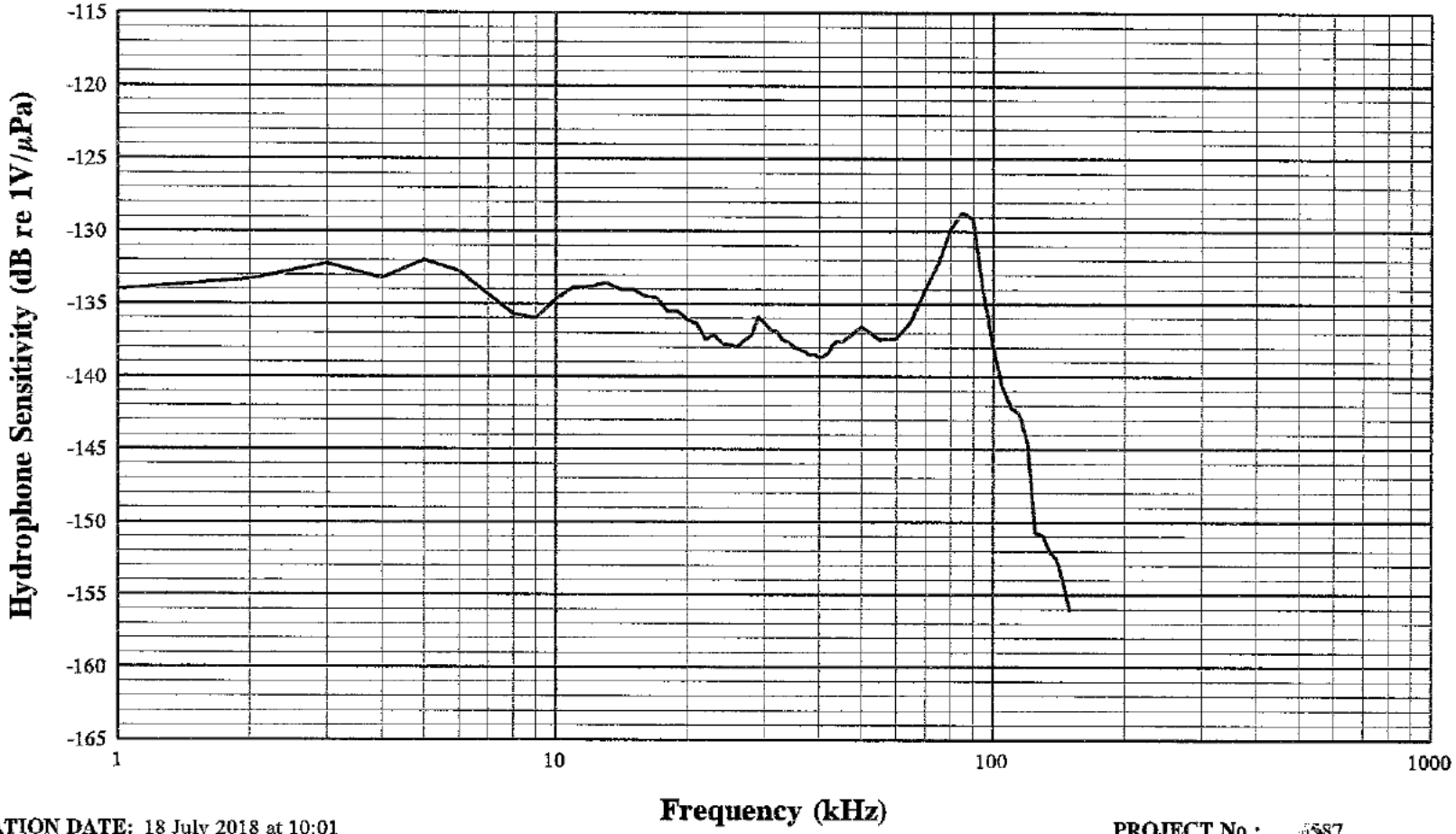
CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: [Re
ted
dac
REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

PROJECT No.: 6587
DESCRIPTION: D/70 with HSS Box
TEST SPEC: Test Instructions
WATER TEMP: 22°C (±0.5)
CABLE: 3m cable

Ref:-M_D70(HSS_AMB):10:04:29

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



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SERIAL NUMBER: None
CALIBRATED BY: [illegible]
REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

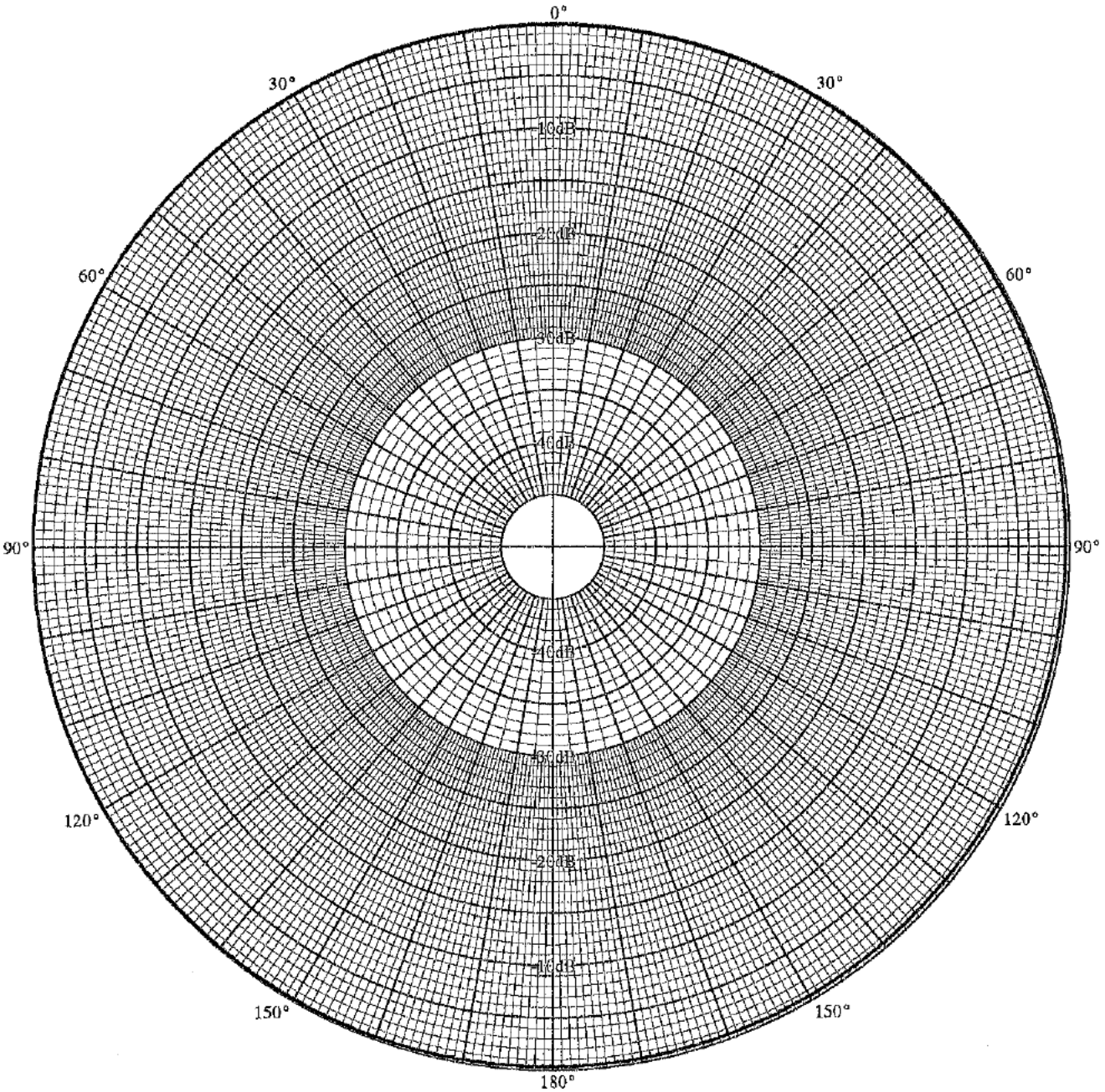
PROJECT No.: [illegible]87
DESCRIPTION: D70 with HSS Box
TEST SPEC: Test Instructions
WATER TEMP: 22°C (±0.5)
CABLE: 3m cable

Ref:-M_D70(HSS_AMB):10:05:02

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE:	18 July 2018 at 11:57	**PROJECT NO.:**	6587
TRANSDUCER TYPE:	D70(Ambient)	**DESCRIPTION:**	D/70 with HSS Box
SERIAL NUMBER:	None	**TEST SPECIFICATION:**	Test Instructions
CALIBRATED BY:	[Redacted]	**WATER TEMPERATURE:**	22°C



FREQUENCY:	10 kHz	**3dB BEAMWIDTH:**	N/A
0° ALIGNMENT:	MECHANICAL	**OVERALL VARIATION:**	.6dB
ROTATION:	360°	**SMOOTHING APPLIED:**	None

REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

Ref:-PH@10_D70(HSS_AMB)a:11:57:56

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

TEST CERTIFICATE

PROJECT REF:	6587
SERIAL NUMBER:	None
TRANSDUCER TYPE:	TC4032-1 Reson
DESCRIPTION:	Teledyne Reson + H4B Box
TEST SPECIFICATION:	Test Instructions
ISSUE DATE:	18 July 2018

Ref Projector:	D/11_18684	**Ref Projector:**	D/26_22769
Ref Projector:	D/70_34376	**Ref Projector:**	D/140_29373

TABULATED RESULTS	**(3 pages)**
HYDROPHONE SENSITIVITY GRAPH	**(2 pages)**
POLAR PLOT	**(1 page)**

[Redacted]

[Redacted]

Customer:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire

[Redacted]

Eco Fish Global Ltd
Aberdeen Harbour
Expansion Project
St Fitting Road
Nigg Bay
AB11 8TN

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

PROJECT No.: 6587
DESCRIPTION: Teledyne Reson + H4B Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 10m cable

REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
1.000	-164.8	±1.5
2.000	-165.5	±1.0
3.000	-164.9	±1.0
4.000	-165.3	±1.0
5.000	-165.4	±1.0
6.000	-165.8	±1.0
7.000	-166.1	±1.0
8.000	-166.0	±1.0
9.000	-165.8	±1.0
10.000	-165.7	±1.0
11.000	-165.6	±1.0
12.000	-165.4	±1.0
13.000	-166.1	±1.0
14.000	-166.3	±1.0
15.000	-166.3	±1.0
16.000	-165.8	±1.0
17.000	-165.8	±1.0
18.000	-166.1	±1.0
19.000	-165.9	±1.0
20.000	-165.7	±1.0
21.000	-165.7	±1.0
22.000	-166.3	±1.0
23.000	-165.9	±1.0
24.000	-165.7	±1.0
25.000	-165.5	±1.0
26.000	-165.4	±1.0
27.000	-165.1	±1.0
28.000	-165.1	±1.0
29.000	-165.5	±1.0
30.000	-165.5	±1.0

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

PROJECT No.: 6587
DESCRIPTION: Teledyne Reson + H4B Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 10m cable

REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/µPa)	UNCERTAINTY (dB)
31.000	-165.4	±1.0
32.000	-165.0	±1.0
33.000	-165.1	±1.0
34.000	-165.3	±1.0
35.000	-165.5	±1.0
36.000	-165.5	±1.0
37.000	-165.3	±1.0
38.000	-165.2	±1.0
39.000	-165.1	±1.0
40.000	-164.8	±1.0
41.000	-164.7	±1.0
42.000	-164.8	±1.0
43.000	-164.8	±1.0
44.000	-164.8	±1.0
45.000	-164.8	±1.0
50.000	-163.8	±1.0
55.000	-163.2	±1.0
60.000	-163.5	±1.0
65.000	-164.0	±1.0
70.000	-164.3	±1.0
75.000	-165.3	±1.0
80.000	-166.1	±1.0
85.000	-167.1	±1.0
90.000	-167.4	±1.0
95.000	-168.3	±1.0
100.000	-169.5	±1.0
105.000	-170.5	±1.0
110.000	-171.8	±1.0
115.000	-173.3	±1.0
120.000	-174.7	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: [Redacted]

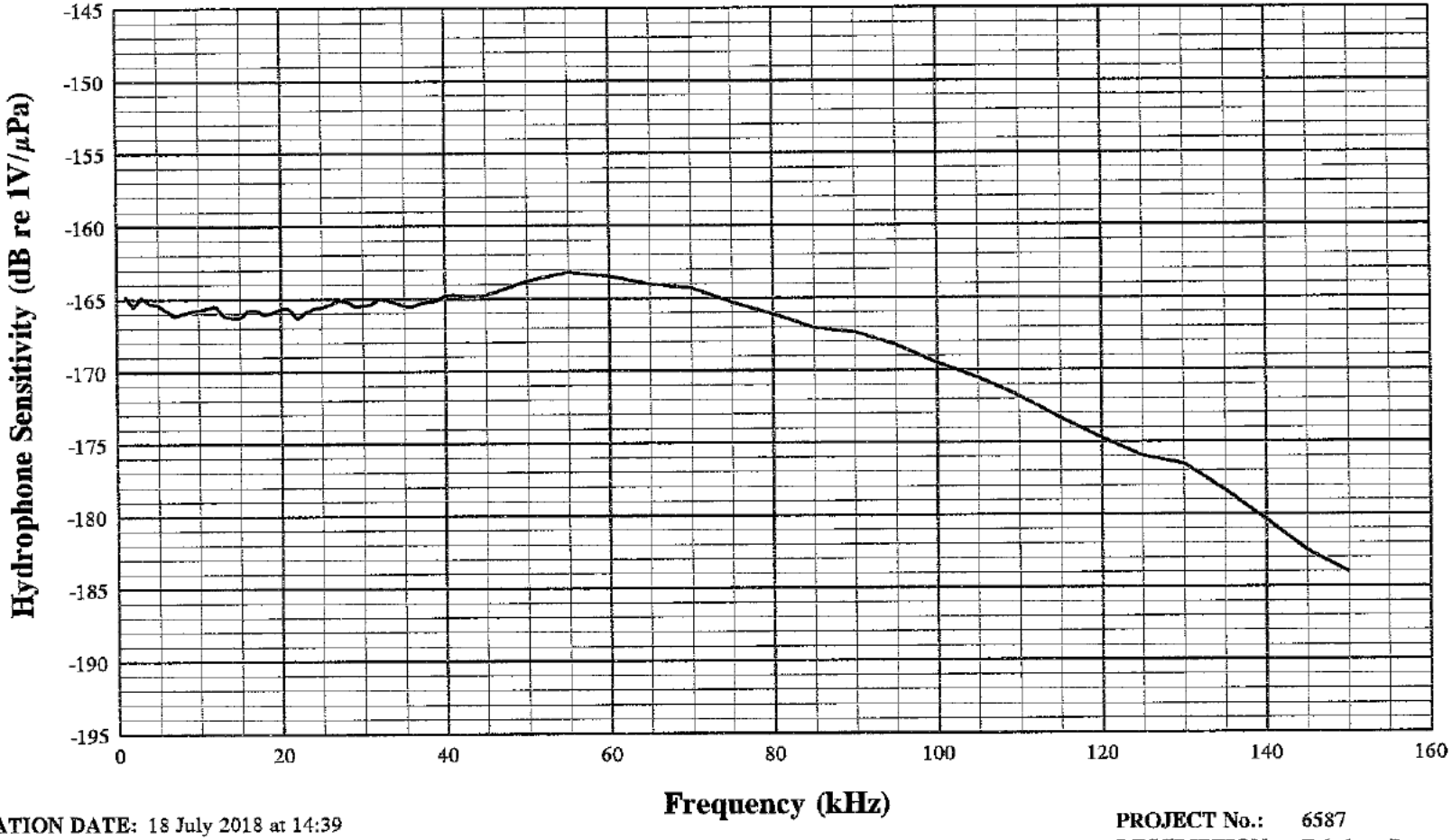
PROJECT No.: 6587
DESCRIPTION: Teledyne Reson + H4B Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 10m cable

REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
125.000	-176.0	±1.0
130.000	-176.5	±1.0
135.000	-178.3	±1.0
140.000	-180.4	±1.0
145.000	-182.5	±1.0
150.000	-184.0	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



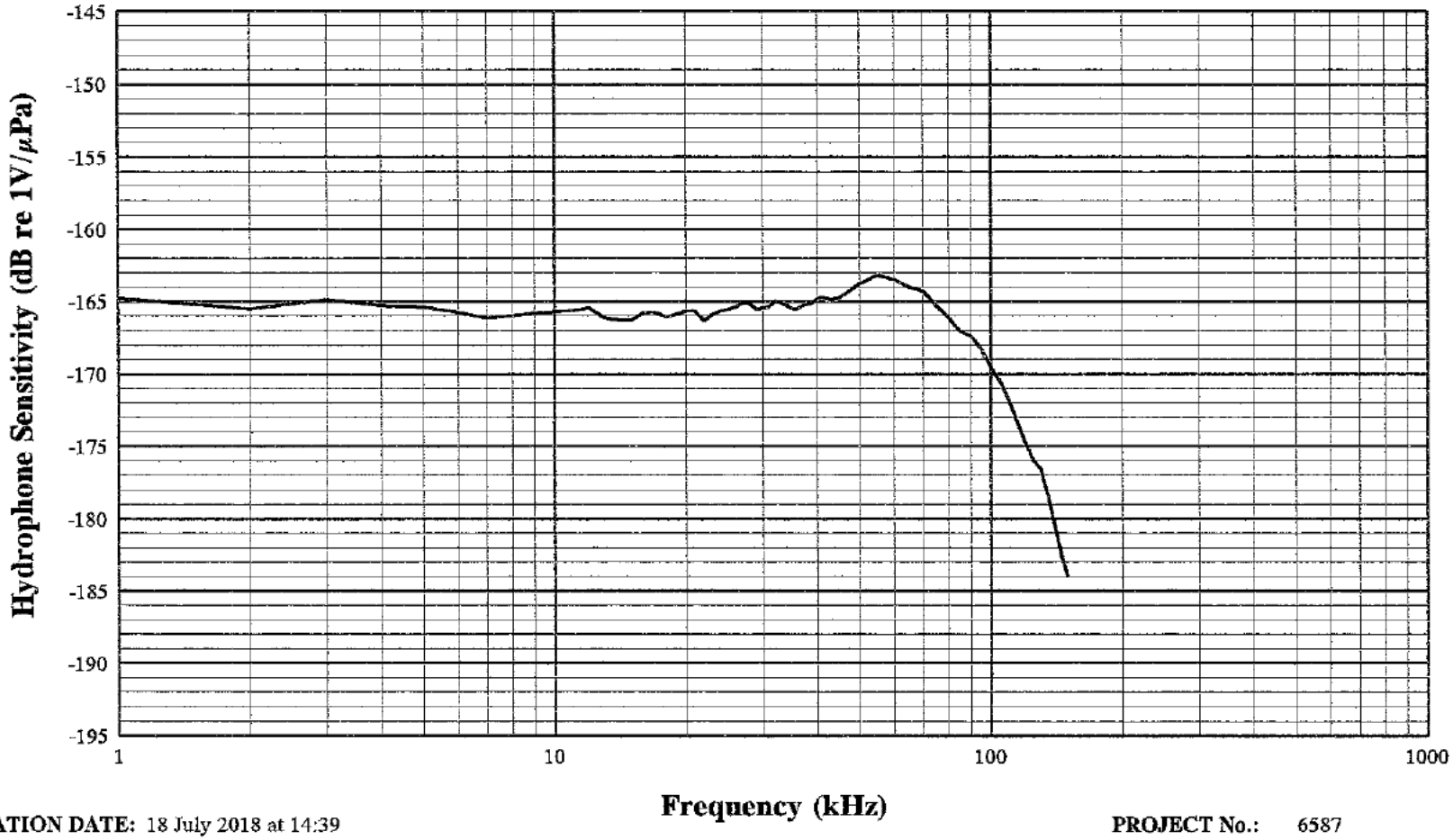
CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: [illegible]
REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

PROJECT No.: 6587
DESCRIPTION: Teledyne Reson + H4B Box
TEST SPEC: Test Instructions
WATER TEMP: 22°C (±0.5)
CABLE: 10m cable

Ref:-M_Reson(H4B):14:41:33

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: [illegible]
REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

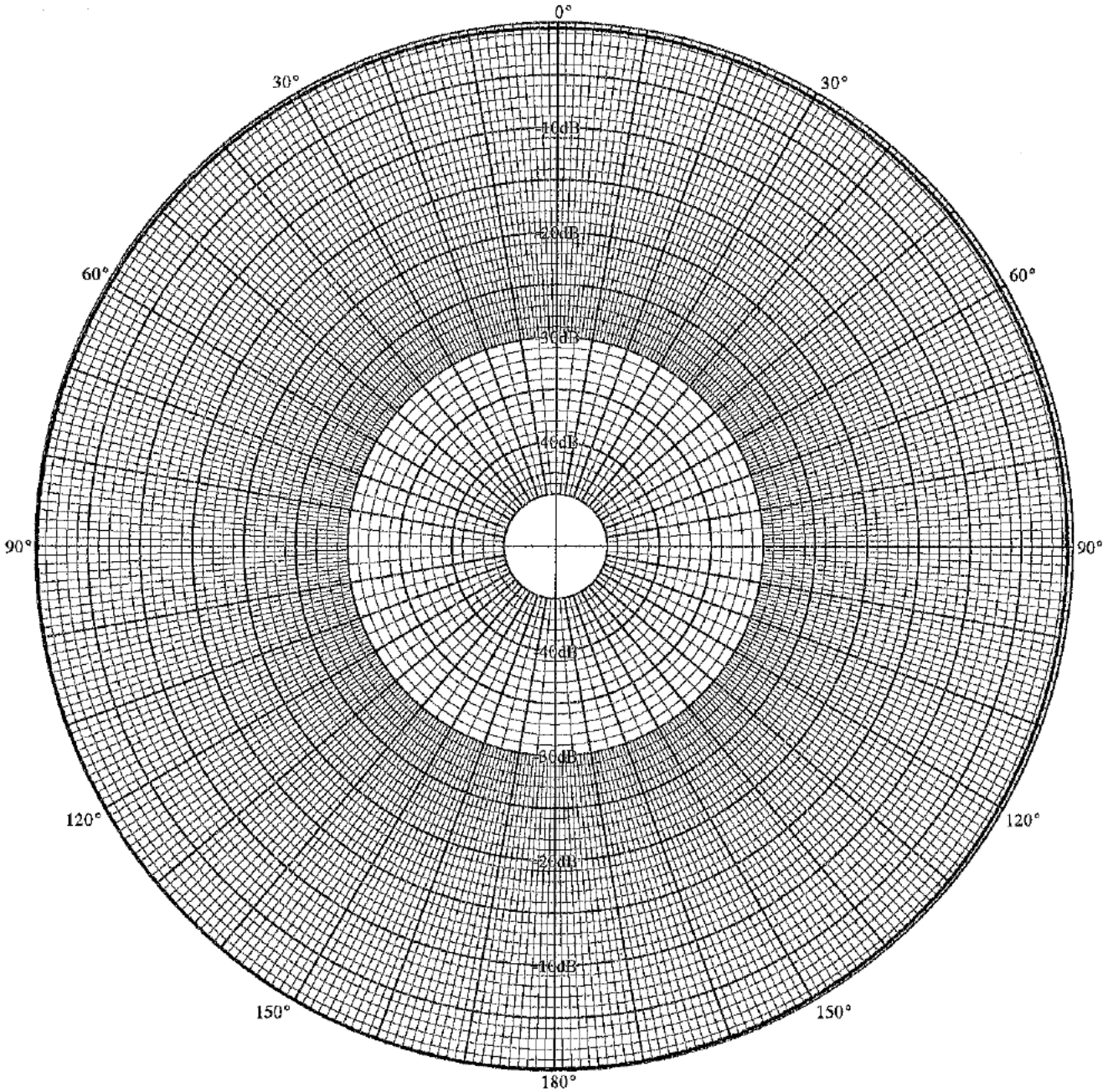
PROJECT No.: 6587
DESCRIPTION: Teledyne Reson + H4B Box
TEST SPEC: Test Instructions
WATER TEMP: 22°C (±0.5)
CABLE: 10m cable

Ref:-M_Reson(H4B):14:41:21

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE:	18 July 2018 at 13:42	**PROJECT NO.:**	6587
TRANSDUCER TYPE:	TC4032-1 Reson	**DESCRIPTION:**	Teledyne Reson + H4B Box
SERIAL NUMBER:	None	**TEST SPECIFICATION:**	Test Instructions
CALIBRATED BY:	[Redacted]	**WATER TEMPERATURE:**	22°C



FREQUENCY:	10 kHz	**3dB BEAMWIDTH:**	N/A
0° ALIGNMENT:	MECHANICAL	**OVERALL VARIATION:**	.7dB
ROTATION:	360°	**SMOOTHING APPLIED:**	None

REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

Ref:-PH@10_Reson_H4B:13:43:04

APPENDIX C – OPERATIONAL PROCEDURES + HYDROPHONE RECORDING FORMS

Chickerell Bioacoustics H10
Neptune D/70 (H0)
RESON (TC4032-1) (H4B)

Chickerell BioAcoustics

The H10 hydrophone

Operating instructions

[Redacted]

SECOND DRAFT

CBA11X/18 iss. 1.2
July 2018

Changes

1.0 First draft

1.1 Measurement section expanded

SECOND DRAFT

Contents

SECOND DRAFT

Introduction

H10 system is a dual role hydrophone and terminal unit system intended to allow measurements of high level pulses from explosives or pile driving and also to monitor for cetacean sounds during the pre-activity watch period. The hydrophone system is designed for deployment from a boat but can be used from a quayside or other platforms with suitable modification to the deployment system.

The hydrophone unit is a 10mm ceramic ball unit with integral preamplifier. The dry end terminal unit provides preset gain and drivers for a recorder, laptop and headphones. The whole system is powered from an external 12 Volt battery.

Wet end

The wet end consists of a 10 mm ball hydrophone together with an integral preamplifier with switchable gain. Information on the hydrophone is contained in Appendix A.

The unit assembly is shown in Figure 1 and the electrical diagram is shown in Figure 2.

Figure 1. H10 hydrophone assembly

Figure 2 Hydrophone block diagram

The gain is switched by reversing the power supply polarity to the wet end. The two selectable gains are -20 dB and +26 dB. The low gain setting is used to record the very loud sounds from activities such as explosives or impact pile driving. The high gain setting is used to monitor for cetacean sounds. A small hydrophone has a high resonant frequency (~140 kHz), which optimises the detection of cetacean clicks, but it also has very low sensitivity optimising its use to measure very high-level sounds. The penalty of using a small hydrophone is that the dynamic range at lower frequencies is reduced reducing its usefulness for measuring ambient noise and low frequency cetacean sounds.

If the high gain is selected when the high-level sound appears there is a potential for damage to occur to the sensitive electronics used in the preamplifier. This is prevented by using protection

diodes. However, it should be noted that these diodes will introduce distortion at high signal levels in the high gain position. In the low gain position there is no protection and the unit must not be used with sound levels that may exceed +260 dB re 1uPa.

In the low gain setting the estimated gain factors are:

Gain of hydrophone -206 dB re 1 Volt/uPa

Gain of preamplifier -20 dB

Giving a Calibration factor of -226 dB re 1 Volt/uPa

The highest output signal level from the preamplifier is 20 Volts peak, a level of +23 dB re 1 Volt. This means the maximum input signal level the wet-end unit can pass without clipping is 249 dB re 1 uPa.

In the high gain setting the estimated gain factors are:

Gain of hydrophone -206 dB re 1 Volt/uPa

Gain of preamplifier +26 dB

Giving a calibration factor of -180 dB re 1µPa/V.

The highest signal level that the system can handle when set to high gain is then 203 dB re 1 uPa.

The output noise spectrum is shown in Figure 3. Over the range 1-20 kHz the noise spectral level is 4.5 nV in a 1 Hz bandwidth.

Figure 3 – Noise spectrum

Dry end

The dry end terminal unit (TU) is housed in a grey polycarbonate box as shown in Figures 4 and 5.

Figure 4: Front panel of H10 terminal unit

Figure 5: Rear panel of H10 terminal unit

The TU provides all necessary gain and filter stages and click processing. A block diagram is shown in Figure 6.

Figure 6 Block diagram of dry-end

The input stage is a high-speed differential amplifier with gain that can be set to 0/+10/+20dB. When the system is used in the low-gain mode the input stage gain should be set to 0 dB but when used in the high-gain mode it should be set to +20 dB. The +10 dB setting can be used in the high-gain mode when there are high levels of ambient noise or in the low-gain mode when the sound source level is lower.

A variable gain amplifier follows the input stage and allows additional gains of 0/10/20/30 dB.

Two click detectors are provided for use in the high-gain mode. CD1 is a general purpose click detector which can detect clicks from all odontocete species. CD2 is highly optimised to detect harbour-porpoise clicks.

Outputs are provided for a recorder (1/4" jack), laptop PC (3.5mm jack), signal monitors (SMB coax) and headphones (3.5mm jack on front panel). The recorder output can have a calibration signal injected by pressing the red button on the front panel. There is an internal attenuator on the recorder output set by links to be 0/-10/-20 dB depending on the recorder in use. The default link setting is -10 dB and this is required by most recorders.

A suitable audio recorder with at least one channel is needed. The TU provides stereo outputs on the ¼" jack socket with raw audio on one channel and either CD1 or CD2 on the other channel. .

A calibration signal can be injected at the output to the recorder by pressing the red button marked 'Cal'. Pressing this button produces a 700 Hz tone at 200 mV RMS level into the recorder.

The unit is powered by an external 12 Volt battery. The unit will work over the range 9-18 Volts. An internal DC-DC convertor gives stable +/-12 Volts to power the electronics and the hydrophone preamplifier.

Using the H10 system

Purpose

The H10 system is designed to fulfil two requirements when monitoring high level sound. During the pre-watch it will be switched to high gain mode to monitor for cetacean calls and clicks and then just before the high level sound starts the unit is switched to low gain to allow a clean recording of the sound pulse. When the high level of sound finishes, the unit is switched back to high gain to again monitor for cetacean calls.

Warning: Use of this unit close to an extremely loud sound source e.g. large explosive charges, may result in damage to the electronic units.

Hydrophone deployment

The hydrophone should be deployed either at the same depth as the sound source or mid-water as appropriate for the measurements being made. Fishing floats may be placed along the cable to adjust the deployment depth and decouple the hydrophone from boat noise. The unit may also be deployed vertically by removing the floats and deploying over the side of a boat or from a quayside.

Be careful that the hydrophone is deployed in such a way that there is no danger of entanglement either with the deploying boat's propeller or with the sound source being measured. Remember that for safety reasons the deploying boat may need to get underway very quickly.

Making recordings

A suitable recorder should be connected to the TU box via the ¼" jack on the rear panel. Do not use any of the other available sockets for the recorder. The level on this jack is lower than the other outputs to meet the required signal level at the recorder input. This output also has the calibration tone injected. The 'Line Input' socket on the recorder should be used. If the recorder does not have a 'Line Input' then use the 'Mic Input' socket and ensure that any preset gain settings in the recorder

are the lowest possible. If required, ensure the recorder input selector is set to 'Line' on the recorder menu.

The recorder sampling rate should be set to 48 kHz with 24 bit sampling as the default setting. Other settings may be used as required by the measurements being made. This setting is normally found within the recorder menu structure under 'Input Settings'. Also make sure that any optional high-pass or low-pass filters within the recorder are de-selected. Also ensure that optional 48V power to the input socket is turned off.

Power

The H10 unit requires a 12 Volt battery for power. The input voltage must be in the range 9-18 Volts. Car batteries or dry lead-acid batteries are suitable.

Ensure the whole dry-end assembly is housed in a manner that prevents it being affected by seawater, spray or rain. The unit is mostly protected to IP66 but because of the jack sockets it should be treated as if the protection level is IP54.

Listening for marine mammal calls

In this mode the hydrophone gain switch should be set to high gain (+26 dB). The input stage gain should be set to +20 dB and the main gain switch set to get a reasonable sound level in the recorder and headphones.

Because of the low sensitivity of the hydrophone cable microphony is a potential problem and every care must be taken when deploying the H10 unit to ensure that the cable cannot rub on the deploying platform.

The operator should use headphones to monitor the raw audio in one ear to hear whistle calls and the click detector in the other ear to hear echolocation clicks. The front panel switch allows either the selection of the general click detector or a click detector optimised for harbour porpoise clicks. In addition, there is a PC output socket which provides raw audio and general click detector signals to be passed to a PC sound card and then displayed using ISHMAEL or PAMGARD software.

Two recorder stereo output sockets are provided. Both sockets carry the raw audio signal on one channel but the other channel is the general click detector on the 'Recorder 1' socket and the harbour porpoise detector on the 'Recorder 2' socket.

Making a loud sound measurement

In this mode the hydrophone gain switch should be set to low gain (-20 dB) and the input gain set to 0 dB. The main gain switch should initially be set to 0 dB but may need to be increased depending on the intensity of the sound.

To make a measurement the following sequence should be followed:

Switch on all equipment. Set the input gain to +20 dB and tap the hydrophone and listen for the sound through the headphones. This should be audible at all settings of the gain switch on the TU. Repeat while listening via the recorder output with the recorder in record standby mode. Check the sampling rate on the recorder and ensure that all optional filters are turned off. Return the input gain switch to 0 dB.

Deploy the hydrophone unit as required by the measurements. Note that with the very low gain settings it will not be possible to hear water noise. As a confidence check the gain can be changed to hydrophone gain high and input stage gain +20 dB at which settings sea noise should be audible. Return the gain settings to the lowest gains.

The use of high-quality sound-excluding headphones is strongly recommended to allow monitoring of the underwater sounds without being distracted by local boat noise or wind noise.

Make a note of at least the following:

- Hydrophone depth
- Hydrophone, input and TU gain setting
- Recorder input gain setting (This may need to be an approximate setting)

I use a standard log form an example of which is shown in Appendix B.

When ready to start a recording press 'Record' on the recorder. Ensure the recorder display counter is incrementing. The recording level meter should show no bars or only the lowest bar.

Note that for impact piling the sound will be a short transient and many of the commercial audio recorder meters will not fully respond in time so may under-indicate the sound level. There is an ISO Standard for the response characteristics of level meters and this is optimised for indicating speech levels. Most newer recorders also have either a peak indicating system or an overload indication, or both. It is better to use these rather than the main level indication.

Now press the calibration button for 2-3 seconds. The tone should be heard via the recorder but not via the headphones plugged into the terminal unit.

Run the recorder for as long as is needed to make the measurement. For piling this should ideally include the start-up sequence, a long sample of the piling and the stopping sequence. During the recording, monitor the level to make sure the recorder is not being overloaded. DO NOT CHANGE THE GAIN while making the recording unless it is ABSOLUTELY necessary. If it should be necessary then once the new gain has been set press the calibrate buttons again for 2-3 seconds. Ensure that a note is made in the log that the gain was changed and the old and new settings.

Before stopping the recording press the calibrate buttons again for 2-3 seconds. Then make a note of the full file name used by the recorder and the stop time.

For explosives work the same basic routine should be used but it is very important to check for overload of the recorder. You will only get the one loud bang so careful attention must be paid to the level meter. If the meter only moves up a bar or two then increase the TU gain by 10 dB before the next blast.

Filling in the Recording Form

Appendix B shows the suggested Recording Form for each recording made using H10. It is important to fill this in as completely as possible to aid the later analysis. Remember the person doing the analysis is NOT the person making the recording, the only communication between the two is this form. It is better to put too much information on the form than too little!

The Location entry is in two parts. Please enter the lat/long as ‘degrees minutes.decimal minutes e.g 57 34.123N 2 54.876W. Using NGR is not ideal as there are errors mapping NGR back to lat/long when plotting on a nautical chart. All GPS units will give the location as Lat/Long. The other part of the location entry should be a sketch showing where the hydrophone is relative to the sound source.

In the ‘Tidal information’ area please enter rising, falling, high or low and spring or neap. If the direction and speed are known please enter that as well.

In the ‘Weather information’ section enter sunny or cloudy, rain or fine, wind speed/direction.

In the ‘Hydrophone deployment method’ section enter how the hydrophone is deployed be it from a boat or quayside.

With H10 there are two gains to be recorded. The hydrophone gain is set by the ‘H/p gain’ switch and can take the values -20 or +26 dB. The terminal unit gain is set by the rotary switch on the front panel of the terminal unit.

The Recorder information can all be obtained from the ‘Menu’ option in the recorder.

Please enter the time at which the recorder was started and the time when it was stopped. The ‘File name’ should be the filename used by the recorder which is shown on the recorder screen. Do not invent your own filename as the analyser needs to relate the log sheet to a file.

Please note the words at the bottom of the form. Use the reverse to record times and events that may happen during a recording. Anything that could affect the recording should be noted e.g passing ships, construction events, gain changes, cal button pressed etc.

Appendix A. H10 hydrophone information

The H10 hydrophone is a spherical ball of ceramic which is omni-directional up the resonant frequency. It was manufactured by Graseby Instruments who are no longer active in the hydrophone market but its general characteristics are very similar to the Neptune D/140 hydrophone. The resonant frequency was measured as 139 kHz.

More information on the Neptune hydrophone is available from the Neptune website: http://www.neptune-sonar.co.uk/product-category/standard-transducer-products/projectors/spherical-projectors/

For the purposes of this document the sensitivity is assumed to be -206 dB re 1V/µof the hydrophone Pa.

Appendix B Recording Form

H10 Hydrophone recording form Date:

Location: Lat (dd mm.ddd): Long(ddd mm.ddd):

Purpose of recording:

Sound source:

Tidal information:

Weather information:

Hydrophone deployment method:

Hydrophone depth(m): Water depth (m):

TU gain: Hydrophone gain:

Recorder model:

Input gain setting: Sample rate: No of bits:

Recording start time: End time: File name:

Please use the reverse of this form to record relevant events during the recording such as cal tones, gain changes or ship movements.

Chickerell BioAcoustics

The H0 hydrophone

Operating instructions

[Redacted]

CBA114/17 iss. 2
January 2018

Introduction

H0 is a low gain hydrophone system primarily intended for use close-in to a loud underwater sound source. The aim is to be able to record the waveform in the near field while using H4B to record the far field signal.

The hydrophone unit uses a very low gain, high dynamic range preamplifier. The dry end terminal unit provides preset gain and drivers for a recorder, laptop and headphones. The whole system is powered from an external 12 Volt battery.

Wet end

The wet end is designated P67 and uses a Neptune D/70 ball hydrophone (See Appendix A). The integral preamplifier input stage has a gain of -20 dB or 0dB selectable by reversing the power supply to the preamplifier. The differential line driver has a gain of 6 db. The hydrophone has a nominal sensitivity of -198dB re 1V/µPa, i.e. a Sound Pressure Level (SPL) of +198dB at the hydrophone would produce 1 Volt RMS output from the hydrophone. When the gain is set to 0dB the maximum signal at the preamplifier output before clipping is 6 Volts RMS corresponding to an SPL on the hydrophone of 207.6dB re 1uPa.

If the input stage is set to a gain of -20 dB the overall wet-end gain is -14 dB and the maximum SPL it will be able to handle is 227.6 dB re 1 uPa. The 20dB attenuation occurs before the first active stage to maximise dynamic range and this is achieved by using a compensated resistive divider.

The estimated calibration factors for the wet end system are:

Gain set to 0dB:	-192 dB re 1V/uPa
Gain set to -20 dB:	-212 dB re 1V/uPa

Dry end

The dry end terminal unit (TU) is housed in a grey polycarbonate box as shown in Figures 1 and 2.

Figure 1. H0 Terminal Unit, front view

Figure 2. H0 Terminal Unit, rear view

The TU provides all necessary gain and filter stages. The input stage is a high-speed differential amplifier with the gain set by internal link to be 0/+10/+20dB. For normal use the link should be set to 0dB.

Outputs are provided for a recorder (1/4" jack), laptop PC (3.5mm jack), signal monitor (SMB coax) and headphones (3.5mm jack on front panel). The recorder output can have a calibration signal injected by pressing the red button on the front panel. There is an internal attenuator on the recorder output set by link to be 0/-10/-20 dB. The default link setting is -10 dB and this is required by most recorders.

A suitable audio recorder with at least one channel is needed. The TU provides stereo outputs on the ¼" jack socket with identical signals on both channels.

The unit is powered by an external 12 Volt battery. The unit will work over the range 9-18 Volts. An internal DC-DC convertor gives stable +/-12 Volts to power the electronics and the hydrophone preamplifier.

Using the H0 system

Purpose

The H0 system is designed to allow close-in monitoring of very loud sound sources such as impact pile-driving. It can also be used to monitor explosive sources and sonar transmissions. Because of the very low overall gain the unit is unsuitable for more general acoustic monitoring.

Hydrophone deployment

The hydrophone should be deployed either at the same depth as the sound source or mid-water as appropriate for the measurements being made. The gain is so low that no special noise reduction measures are needed. Ensure that the hydrophone is deployed in such a way that there is no danger of entanglement either with the deploying boat's propeller or with the sound source being measured. Remember that for safety reasons the boat may need to get underway very quickly.

Making recordings

A suitable recorder should be connected to the TU box via the ¼" jack on the rear panel. Do not use any of the other available sockets. The level on this jack is lower than the other outputs to allow for the expected signal level at the recorder input. This output also has the calibration tone injected.

The ‘Line Input’ socket on the recorder should be used. If the recorder does not have a ‘Line Input’ then use the ‘Mic Input’ socket and ensure that any preset gain settings in the recorder are the lowest possible. Ensure the input selector is set to ‘Line’ on the recorder menu.

The recorder sampling rate should be set to 48 kHz with 24 bit sampling as the default setting. Other settings may be used as required by the measurements being made. This setting is normally found within the recorder menu structure under ‘Input Settings’. Also make sure that any optional high-pass or low-pass filters within the recorder are de-selected.

Power

The H0 unit requires a 12 Volt battery for power. The input voltage must be in the range 9-18 Volts. Car batteries or dry lead-acid batteries are suitable.

Ensure the whole dry-end assembly is housed in a manner that prevents it being affected by seawater, spray or rain.

Making a measurement

To make a measurement the following sequence should be followed:

Switch on all equipment. Tap the hydrophone and listen for the sound through the headphones. You may need to set the TU gain to 0dB to hear this sound. Repeat while listening via the recorder output. Check the sampling rate on the recorder and ensure that all optional filters are turned off.

Deploy the hydrophone unit

Listen to the underwater sound using headphones. It is unlikely that background noise will be heard unless the TU gain is set to 0 dB. Move the headphones to the recorder and press ‘Record Pause’. The underwater sounds should be heard again, possibly at a different level.

If the pile driver is operating it should be possible to hear the impacts through the hydrophone. Note that although the same sound will travel through the air, the water path will be slightly faster so the two sounds with separate in time. The use of high-quality sound-excluding headphones is strongly recommended to allow monitoring of the underwater sounds.

Make a note of the following:

- Range to noise source
- Hydrophone depth
- TU gain setting
- Recorder input gain setting (This may need to be an approximate setting)

I use a standard log form an example of which is shown in Appendix B.

When ready to start a recording, make sure the TU gain is set to the -20 dB setting, then press ‘Record’ on the recorder. Ensure the recorder display counter is incrementing. If the recorder level indication is low increase the TU gain to 0 dB. The peak signal level should not be hitting the maximum level on the recorder display. The steady level between pulses may be very low. It is good

practice to keep the recorder 'Record Level' control in the 50-100% region. It should never be set below 25% as this will reduce the available dynamic range in the recording. If the indicated level on the recorder is too high then reduce the TU gain. If the TU gain is already on -20 dB then the sound level is too high for the hydrophone and the only option is to move the hydrophone away from the sound source.

Note that for impact piling the sound will be a short transient and many of the recorder meters will not fully respond in time so may under-indicate the sound level. There is an ISO Standard for the response characteristics of level meters and this is optimised for indicating speech levels. Most newer recorders also have either a peak indicating system or an overload indication, or both. It is better to use these rather than the main level indication.

Now press the calibration button for 2-3 seconds. Note that this tone will only be heard via the recorder. It will not be heard on headphones plugged into the H0 box.

Run the recorder for as long as is needed to make the measurement. This should ideally include the start-up sequence, a long sample of the piling and the stopping sequence.

DO NOT CHANGE THE GAIN while making the recording unless it is absolutely necessary. If it should be necessary then once the new gain has been set press the calibrate button for 2-3 seconds. Ensure that a note is made in the log that the gain was changed and the old and new settings.

Before stopping the recording press the calibrate button again for 2-3 seconds.

Personal safety

When making measurements close in to a very loud sound source such as impact pile driving the sound level in air will exceed the level likely to cause damage to hearing. While ear-defenders can be worn it is useful to be able to monitor the underwater signal by using headphones plugged into H0 box. The majority of normal headphones do not provide the same degree of attenuation compared with ear defenders. It is very important to use headphones with the best noise attenuation possible.

Appendix A. Neptune D/70 ball hydrophone information

Spherical Transducers **MODEL D/70**

- OMNI-DIRECTIONAL RESPONSE
- LOW NOISE PERFORMANCE
- ACOUSTIC REFERENCE STANDARD
- BROADBAND OPERATION
- AIR GUN & BOOMER MONITOR
- MARINE MAMMAL AUDIO SENSOR

With a combination of broadband frequency response, omni-directional beam pattern and high sensitivity the D/70 has become the most popular hydrophones in the Neptune range of 'D' type spherical transducers.

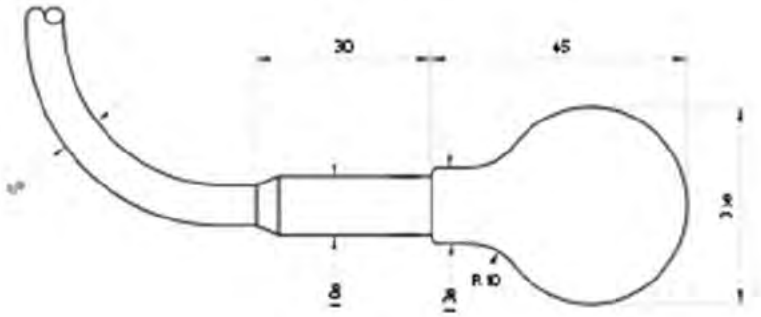
The all moulded construction and inherent strength of the PZT ceramic sphere achieves a robust, light weight, corrosion free design making it the ideal choice as a monitor hydrophone for air gun, boomer and other environments where high levels of shock are experienced.

Electrical connection to the transducer is by a low noise coaxial cable. The extruded polyurethane outer jacket of the cable enables the design engineer to build the transducer into customised equipment packages and readily obtain a waterproof seal by simple moulding techniques.

The D/70 is available with or without acoustic calibration. All calibrations are traceable to National Standards.

This product is stocked by our world-wide distributor

GSE Rentals Ltd, Aberdeen
[Redacted]



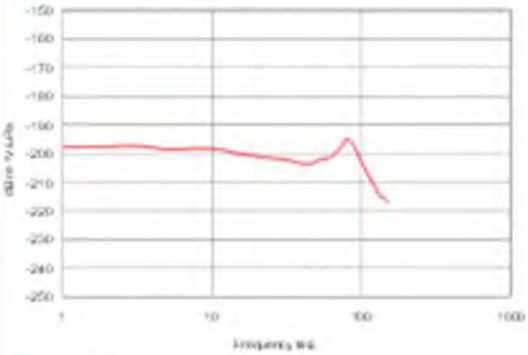
All dimensions in mm

MODEL D/70

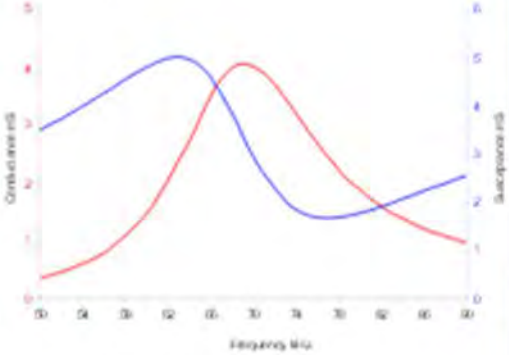
Spherical Transducers

Technical Specification	
Resonant Frequency	70 kHz (Nominal)
Beam Pattern	Omni ± 1 dB up to 80 kHz
Receive Sensitivity	See Graph
Transmit Sensitivity	See Graph
Capacitance at 1 kHz	9300 pF
Input Power	190 Watts around resonance
Operating Depth	1500 Metres
Operating Temperature	-5 to +40 °C
Storage Temperature	-40 to +80 °C
Cable Type	Polyurethane Ø6mm Low Noise Coaxial
Cable Length	10 metres standard Additional lengths supplied to order

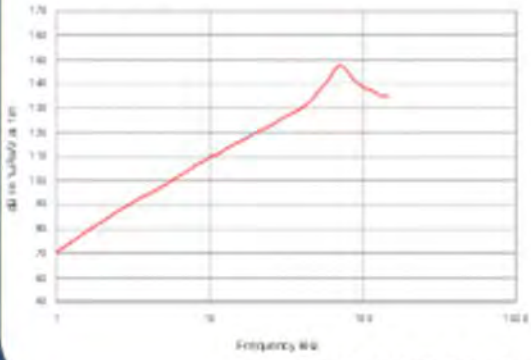
Receive Graph



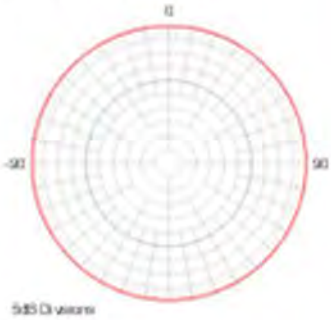
Admittance Plot



Transmit Graph



Beam Pattern at 70 kHz



Data illustrated is taken from actual in-water measurements

Appendix B Recording Form

H0 Hydrophone recording form

Date: Time(GMT):

Location:

Purpose of recording:

Sound source:

Tidal information:

Weather information:

Hydrophone deployment method:

Hydrophone gain: TU gain:

Recorder model:

Input gain setting: Sample rate: No of bits:

Recording start time: End time: File name:

Please use the reverse of this form to record events during the recording such as cal tones, gain changes or ship movements.

Chickerell BioAcoustics

The H4b hydrophone

Operating instructions

[Redacted]

CBA115/18 iss. 2
Febuary 2018

Introduction

H4b is a hydrophone and terminal unit system primarily intended for characterising underwater ambient noise and low level sound from a variety of sources. The hydrophone system is designed for deployment from a boat but can be used from a quayside with suitable modification to the deployment system.

The hydrophone unit is a calibrated Reson unit with integral preamplifier. The dry end terminal unit provides preset gain and drivers for a recorder, laptop and headphones. The whole system is powered from an external 12 Volt battery.

Wet end

The wet end is a calibrated Reson TC4032 hydrophone. Appendix A is an abbreviated version of the datasheet for this device. The hydrophone and preamplifier have a nominal sensitivity of -164dB re 1V/µPa when used in differential output mode, i.e. a Sound Pressure Level (SPL) of +164dB re 1µPa at the hydrophone would produce 1 Volt RMS output from the hydrophone. The first resonance is at 55 kHz giving a flat response (+/-2 dB) to 40 KHz but is usable to 120 kHz. The maximum output level is 6 V RMS in differential mode and the unit will overload at an SPL of 179.5 dB re 1 µPa.

The unit assembly is shown in Figure 1 and the electrical diagram is shown in Figure 2.

Figure 1. Reson TC4032 hydrophone assembly

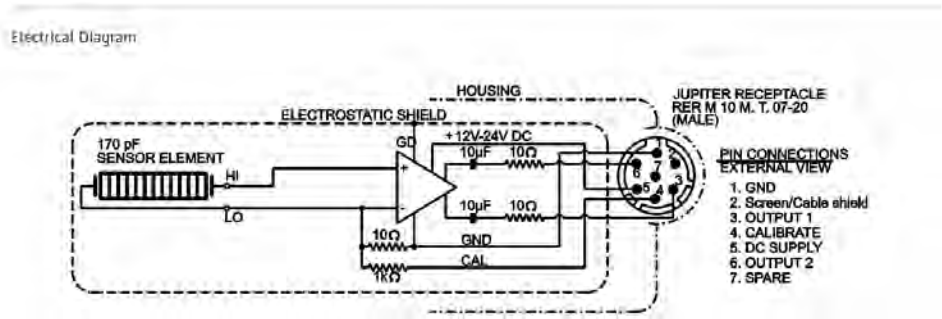


Figure 2. Electrical diagram of the Reson TC4032 hydrophone assembly

The TC4032 includes a tone injection facility whereby a tone can be injected in series with the ceramic element. This can be used to give confidence that the whole processing chain is functional.

The estimated calibration factor for the wet end system is 164 dB re 1µPa/V.

For deployment from a boat a number of fishing floats are tied to the cable at approximately 0.3 metre intervals to provide distributed buoyancy. This disconnects the hydrophone from vibration in the hull of the deploying vessel.

Dry end

The dry end terminal unit (TU) is housed in a grey polycarbonate box as shown in Figures 3 and 4.

Figure 3. Front of H4b Terminal Unit

Figure 4. Rear of H4b Terminal Unit

The TU provides all necessary gain and filter stages. The input stage is a high-speed differential amplifier with the gain set by internal link to be 0/+10/+20dB. For normal use the link should be set to 10dB. Note that this additional 10 dB gain will reduce the overload threshold for the system from the 179.5 dB re 1µPa at the hydrophone output to 169.5 dB re 1µPa.

A front panel switch allows the operator to select an additional gain of 0/10/20 dB.

Outputs are provided for a recorder (1/4” jack), laptop PC (3.5mm jack), signal monitor (SMB coax) and headphones (3.5mm jack on front panel). The recorder output can have a calibration signal injected by pressing the red button on the front panel. There is an internal attenuator on the

recorder output set by link to be 0/-10/-20 dB. The default link setting is -10 dB and this is required by most recorders.

A suitable audio recorder with at least one channel is needed. The TU provides stereo outputs on the ¼" jack socket with identical signals on both channels.

A calibration signal can be injected either at the hydrophone by pressing the red button marked 'H/P' or at the output to the recorder by pressing the red button marked 'Intl'. Pressing the 'Intl' button produces a 700 Hz tone at 200 mV RMS level into the recorder. During use, both buttons should be pushed sequentially with 'H/P' first then 'Intl'. Do not push both buttons together.

The unit is powered by an external 12 Volt battery. The unit will work over the range 9-18 Volts. An internal DC-DC convertor gives stable +/-12 Volts to power the electronics and the hydrophone preamplifier.

Using the H4b system

Purpose

The H4b system is designed to allow the characterisation of underwater ambient noise and to monitor low level sound from a variety of sources. At high sound levels the H0 system should be used. H4b can also be used to monitor higher level sound sources such as impact pile driving, explosive sources and sonar transmissions at longer ranges where the sound level has dropped below 170 dB re 1 µPa. Use of this unit close to a very loud sound source may result in damage to the electronic units.

Hydrophone deployment

The hydrophone should be deployed either at the same depth as the sound source or mid-water as appropriate for the measurements being made. The fishing floats may be moved along the cable to adjust the deployment depth. The unit may also be deployed vertically by removing the floats and deploying over the side of a boat or from a quayside.

Be careful that the hydrophone is deployed in such a way that there is no danger of entanglement either with the deploying boat's propeller or with the sound source being measured. Remember that for safety reasons the deploying boat may need to get underway very quickly.

Making recordings

A suitable recorder should be connected to the TU box via the ¼" jack on the rear panel. Do not use any of the other available sockets for the recorder. The level on this jack is lower than the other outputs to meet the required signal level at the recorder input. This output also has the calibration tone injected. The 'Line Input' socket on the recorder should be used. If the recorder does not have a 'Line Input' then use the 'Mic Input' socket and ensure that any preset gain settings in the recorder are the lowest possible. Ensure the recorder input selector is set to 'Line' on the recorder menu.

The recorder sampling rate should be set to 48 kHz with 24 bit sampling as the default setting. Other settings may be used as required by the measurements being made. This setting is normally found

within the recorder menu structure under 'Input Settings'. Also make sure that any optional high-pass or low-pass filters within the recorder are de-selected.

Power

The H4b unit requires a 12 Volt battery for power. The input voltage must be in the range 9-18 Volts. Car batteries or dry lead-acid batteries are suitable.

Ensure the whole dry-end assembly is housed in a manner that prevents it being affected by seawater, spray or rain. The unit is mostly protected to IP67 but because of the jack sockets should be treated as if the protection level is IP54.

Making a measurement

To make a measurement the following sequence should be followed:

Switch on all equipment. Tap the hydrophone and listen for the sound through the headphones. This should be audible at all settings of the gain switch on the TU. Repeat while listening via the recorder output. Check the sampling rate on the recorder and ensure that all optional filters are turned off.

Deploy the hydrophone unit as required by the measurements.

Listen to the underwater sound using headphones. Set the TU gain switch and headphone volume control to give a reasonable level. Move the headphones to the recorder and press 'Record Pause'. The underwater sounds should be heard again, possibly at a different level. Adjust the TU gain switch and recorder input gain so that the recorder level indicator is twitching at around -10 dB. This will be correct for most measurements. If monitoring a loud impulsive source such as pile driving it may be necessary to set the level based on no overload of the recorder (see below).

The use of high-quality sound-excluding headphones is strongly recommended to allow monitoring of the underwater sounds without being distracted by local boat noise or wind noise.

Make a note of at least the following:

- Hydrophone depth
- TU gain setting
- Recorder input gain setting (This may need to be an approximate setting)

I use a standard log form an example of which is shown in Appendix B.

When ready to start a recording press 'Record' on the recorder. Ensure the recorder display counter is incrementing. The peak signal level should not be hitting the maximum level on the recorder display. If it is then reduce either the TU gain or the recorder input level. It is good practice to keep the recorder 'Record Level' control in the 50-100% region. It should never be set below 25% as this will reduce the available dynamic range in the recording. If the indicated level on the recorder is too high then reduce the TU gain. If the TU gain is already on 0 dB then the sound level is too high for the hydrophone and the only option is to move the hydrophone away from the sound source.

Note that for impact piling the sound will be a short transient and many of the commercial audio recorder meters will not fully respond in time so may under-indicate the sound level. There is an ISO Standard for the response characteristics of level meters and this is optimised for indicating speech levels. Most newer recorders also have either a peak indicating system or an overload indication, or both. It is better to use these rather than the main level indication.

Now press the two calibration buttons for 2-3 seconds each. Press the 'H/P' button first, then the 'Intl' button. Both tones should be heard via the recorder but only the 'H/P' tone via the headphones plugged into the TU.

Run the recorder for as long as is needed to make the measurement. For piling this should ideally include the start-up sequence, a long sample of the piling and the stopping sequence. During the recording monitor the level to make sure the recorder is not being overloaded. DO NOT CHANGE THE GAIN while making the recording unless it is absolutely necessary. If it should be necessary then once the new gain has been set press the calibrate buttons again for 2-3 seconds. Ensure that a note is made in the log that the gain was changed and the old and new settings.

Before stopping the recording press the calibrate buttons again for 2-3 seconds. Then make a note of the file name used by the recorder and the stop time.

Filling in the Recording Form

Appendix B shows the suggested Recording Form for each recording made using H4b. It is important to fill this in as completely as possible to aid the later analysis. Remember the person doing the analysis is NOT the person making the recording, the only communication between the two is this form. It is better to put too much information on the form than too little!

The Location entry is in two parts. Please enter the lat/long as 'degrees minutes.decimal minutes e.g 57 34.123N 2 54.876W. Using NGR is not ideal as there are errors mapping NGR back to lat/long when plotting on a nautical chart. All GPS units will give the location as Lat/Long. The other part of the location entry should be a sketch showing where the hydrophone is relative to the sound source.

In the 'Tidal information' area please enter rising, falling, high or low and spring or neap. If the direction and speed are known please enter that as well.

In the 'Weather information' section enter sunny or cloudy, rain or fine, wind speed/direction.

In the 'Hydrophone deployment method' section enter how the hydrophone is deployed be it from a boat or quayside.

The Recorder information can all be obtained from the 'Menu' option in the recorder.

Please enter the time at which the recorder was started and the time when it was stopped. The 'File name' should be the filename used by the recorder which is shown on the recorder screen. Do not invent your own filename as the analyser needs to relate the log sheet to a file.

Please note the words at the bottom of the form. Use the reverse to record times and events that may happen during a recording. Anything that could affect the recording should be noted e.g passing ships, construction events, gain changes, cal button pressed etc.

Appendix A. Reson TC4032 hydrophone information leaflet

Teledyne RESON

Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

The TC4032 general purpose hydrophone offers a high sensitivity, low noise and a flat frequency response over a wide frequency range. The high sensitivity and acoustic characteristics makes TC4032 capable of producing absolute sound measurements and detecting even very weak signals at levels below “Sea State 0”. The TC4032 incorporates an electrostatically shielded highly sensitive piezoelectric element connected to an integral low-noise 10dB preamplifier. The TC4032 preamplifier is capable of driving long cables of more than 1.000 meters, and the preamplifier features an insert calibration facility. Per default the amplifier is provided with differential output. The differential output is an advantage where long cables are used in an electrically noisy environment. For use in single ended mode: Use positive output pin together with GND.

Technical Specification

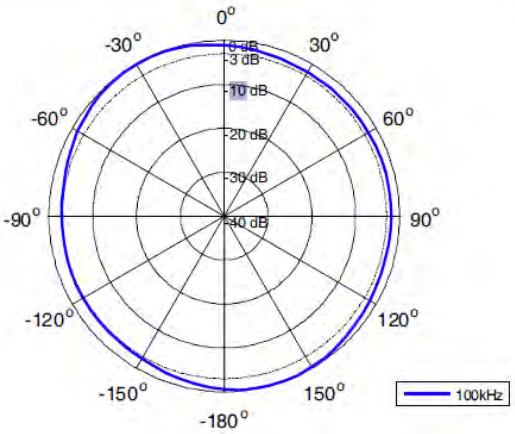
Usable Frequency range:	5Hz to120kHz
Linear Frequency range:	15Hz to 40kHz ±2dB
	10Hz to 80kHz ±2.5dB
Receiving Sensitivity:	-170dB re 1V/ µPa (-164dB with differential output)
Horizontal directivity:	Omnidirectional ±2dB at 100kHz
Vertical directivity:	270° ±2dB at 15kHz
Operating depth:	600m
Survival depth:	700m
Operating temperature range:	-2°C to +55°C
Storage temperature range:	-30°C to +70°C
Weight (in air):	720g without cable
Max. output voltage:	≥3.5Vrms (at 12VDC)
Preamplifier gain:	10dB
Supply voltage:	12 to 24VDC
High pass filter:	7Hz -3dB
Quiescent supply current:	≤19mA at 12VDC
	≤22mA at 24VDC
Encapsulating material:	Special formulated NBR*
Housing material:	Alu Bronze
	AlCu10Ni5Fe4

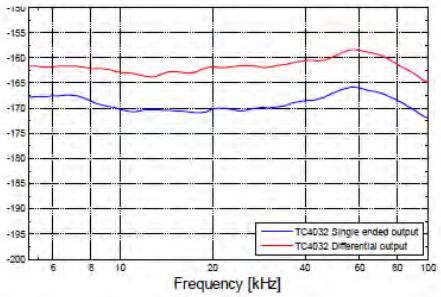
***NBR means Nitrile Rubber**
The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and will be destroyed by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), nitro hydrocarbons (nitrobenzene, aniline), phosphate ester hydraulic fluids, Ketones (MEK, acetone), Ozone and automotive brake fluid.

Documentation:

Individually calibration curves: 250 kHz
Sensitivity at ref.: frequencies: 250 kHz
Receiving sensitivity: At 5 kHz to 100 kHz

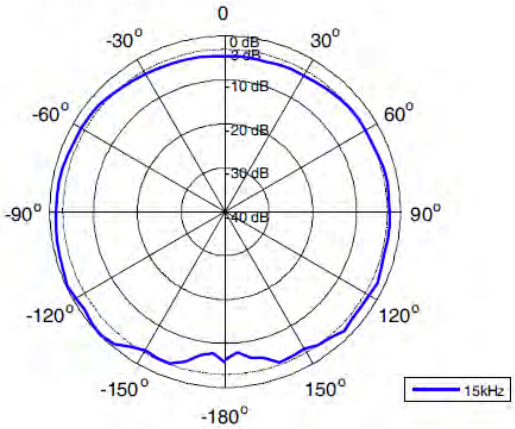
Vertical directivity: At 15 kHz
Horizontal directivity: At 100 kHz



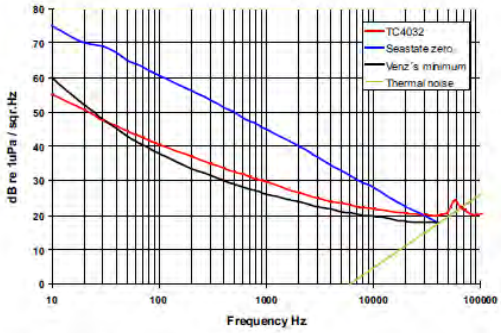


The OCR curve shown above is for single output

Vertical directivity pattern

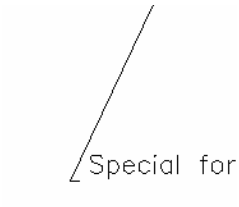


Typical equivalent noise pressure curve



Valid for all versions of TC4032

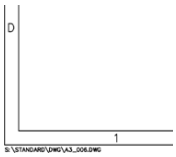
Outline dimensions



Electrical diagram

Insert voltage calibration

The TC4032 preamplifier contains an insert calibration circuit. This allows for electrical calibration of the hydrophone. The calibration method is not an absolute calibration but, it provides a reliable method for testing of the hydrophone, especially for hydrophones in fixed remote installations. The insert sine signal simulates the output signal from the sensor element. To perform an insert calibration, use an appropriate function generator. The applied calibration signal must not exceed 10 Vrms. A higher voltage may damage the calibration resistor. 2 Vrms will be appropriate for insert calibration. The attenuation of the calibration signal is 30dB for short cables. Apply the signal to the calibrate input, connector contact 4. = green wire of cable. Connect generator ground to sine generator ground, and measure the signal on hydrophone output.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Appendix B Recording Form

H4b Hydrophone recording form

Date:

Location: Lat (dd mm.ddd): Long(ddd mm.ddd):

Purpose of recording:

Sound source:

Tidal information:

Weather information:

Hydrophone deployment method:

Hydrophone depth(m): Water depth (m):

TU gain switch:

Recorder model:

Input gain setting: Sample rate: No of bits:

Recording start time: End time: File name:

Please use the reverse of this form to record relevant events during the recording such as cal tones, gain changes or ship movements.

APPENDIX D – EXPLANATION FROM PETER WARD, ACOUSTIC NOISE SPECIALIST, ON RMS VERSUS PEAK SOUND LEVELS

The acoustic thresholds used in the AHEP Environmental Statement Underwater Noise Modelling Study (Appendix 13-B) Study and subsequently in the Additional Environmental Information Report refer to a behavioural impact threshold of 170 dB re 1 uPa (rms). This threshold level comes from work published by Southall et al (2007) and used widely by the international community over the last decade.

This threshold uses rms metrics while impulsive type noises are best measured using peak level metrics. It is necessary therefore to convert the rms threshold to a peak level equivalent; however, there is not a universally agreed procedure for doing this beyond stating that:
dB rms = dB peak - N
where N is a number between 2 and 20.

The reason for the range of values given to the conversion factor is down to the shape of the sound wave when considered in the time domain. A realistic conversion factor can only be determined through a rigorous analysis of the acoustic data acquired during blasting. An estimate may nevertheless be gained by examining the published literature on this subject.

Peak SPLs may be converted to equivalent RMS following consideration of the nature of the signal in the time-domain. For a sinusoidal signal, the relationship between peak level signal and the RMS equivalent is given by peak level – 3dB. Impulsive signals such as those from a seismic airgun or a explosive detonation are not sinusoidal in shape so this conversion is not valid. Furthermore, during propagation the outgoing signal stretches out in time (see e.g. Urick 1983) and this is attributed to the sound travelling along multiple paths and each arriving at a given location at a slightly different time. As a result, the difference between peak level and RMS varies with distance. Various studies (1,2,3) suggest a range of values between 2 dB and 20 dB. The lower the conversion factor, the greater the overestimation of RMS SPL. For the purpose of the analysis undertaken in the Underwater Noise study and subsequent Clarification Note, a value of N=13 dB was used for the conversion.

The 170 dB re 1uPa (rms) threshold corresponds therefore to an equivalent level of 183 dB re 1uPa (peak).

From the Blast Propagation Modelling undertaken and discussed in the Clarification Note, it was found that the above-mentioned acoustic impact, given by the equivalent threshold of 183 dB re 1 uPa (peak), is met at a distance around 400 m from the blast site.

It is recommended that the 170 dB re 1 uPa rms (183 dB re 1 uPa peak equivalent) threshold is measured immediately adjacent to the bubble curtain on the seaward side. (In practice, it is suggested that the measurement station be no closer than approximately 50 m to the bubble curtain in order to prevent the survey vessel from interfering with the bubble curtain and its associated infrastructure.)

Comparison may be drawn with the acoustic threshold levels adopted by the German state authority (BSH) in connection with the pile-driving during the installation of the foundations for offshore windfarms. The limiting values are (i) Sound Exposure Level (SEL) = 160 dB re 1 uPa2.sec; and (ii) Sound Pressure Level (SPL) = 190 dB re 1 uPa peak; at a distance of no greater than 750 m from the construction site (4). It is worth noting that the BSH thresholds do not allow for marine mammals having different hearing sensitivity whereas, by contrast, the Southall et al thresholds do. In addition, the Southall et al behavioural threshold is 7 dB lower than the BSH threshold therefore the Southall et al impact may be considered precautionary.

References
1. Madsen P.T., (2005), “Marine mammals and noise: Problems with root mean square sound pressure levels for transients”, J. Acoust. Soc. Am. 117(6), 2005).
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3. McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys – a study of environmental implications. APPEA Journal 2000:692-708.
4. BSH (2013), Standard - Investigation of the Impacts of Offshore Wind Turbines on Marine Environment (StUK4).