Revision 7 - 9/8/2018

ABERDEEN HARBOUR EXPANSION PROJECT (AHEP)
UNDERWATER NOISE + PASSIVE ACOUSTIC MONITORING PROCEDURE
AUGUST 2018

1.1 Introduction

This method statement has been prepared to outline the background for blasting and bubble curtain mitigation and detail the proposed effectiveness testing, reporting, compliance and predicted model validation, instrumentation and approach, measurements and data analysis and reporting. It should be read in conjunction with the Drilling & Blasting Methodology-Environmental Controls Marine Mammals

1.2 Background (Blasting and Bubble Curtain)

1.2.1 Blasting

Explosives will be used below the seabed to fracture rock to allow the backhoe dredger to remove it for reuse. When blasting occurs, the following conditions will be adhered to:

- Blasting is restricted to daylight hours unless during exceptional circumstances.
- A maximum of two blasts a day.
- A process to record and report, in writing to the licensing authority, within 48 hours, instances where blasting has occurred, out with daylight hours, due to exceptional circumstances.
- The minimum amount of blasting will be undertaken using 20kg charge weights.
- No blasting allowed on a Sunday.
- No blasting during periods of extreme bad weather i.e. high wind/wave conditions. The drill and blast rig is limited to about 0.5m wave height, thus there will be no blasting if these conditions prevail. Blasting will not take place in a Beaufort Sea State greater than 3 (unless agreed otherwise with MS-LOT) due to the efficacy of the MMO and PAM mitigation measures. The bubble curtain supplier has confirmed that wind and wave height has no impact on the performance of the curtain.

Blasting in the northern area will be scheduled so that it is undertaken behind a partially constructed breakwater, so that there is no 'direct line of site' between the blasting and open water, as displayed in Figure 1.1. Blasting will also occur behind a double bubble curtain, which will be located in two different layouts to attenuate any blasting noise reaching 'open water,'. One layout stretches from the south of Nigg Bay to North Breakwater and the other from the southern shore of Nigg Bay, southwards, which will form an arc around the South Breakwater trench areas. This complies with the Construction Marine Licence 05965/16/0 conditions.

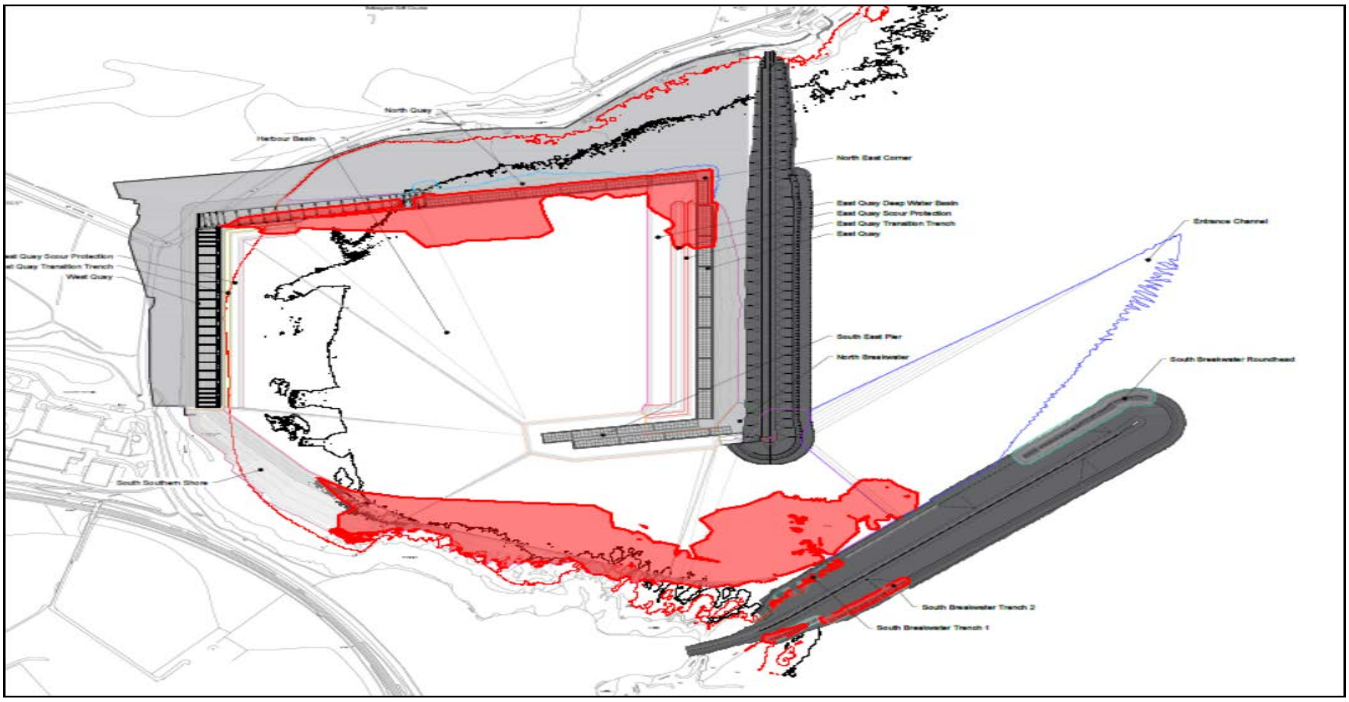

Figure 1.1 - Rock Blasting Zones - North and South

1.2.2 Bubble Curtain

The purpose of a bubble curtain is to attenuate the propagation of underwater sound arising from a high-intensity noise source such as an explosion. The curtain is formed from a collection of air bubbles. Each air bubble forms an impedance contrast in the water from, which the sound is reflected, while an ensemble of bubbles act as a series of high impedance scatterers. The curtain therefore presents a loss-inducing boundary between the sound source and the remaining water column. Note there are two separate hoses creating two walls of bubbles.

A perforated hose is laid on the seabed adjacent to the project area. Air is pumped through the hose which subsequently leaks through the holes thus producing bubbles which rise to the surface of the sea. As the bubbles rise, the surrounding hydrostatic pressure falls, the bubbles grow in size and also tend to fuse together leading to the formation of a curtain of bubbles.

1.2.3 Deployment Procedure - Double Bubble Curtain (DBC)

An area in the South Compound has been allocated as the location of the Double Bubble Curtain (DBC) compressor storage area. This area will contain 10 PTS 1600cfm compressors complete with two manifolds and compressor hoses which will provide compressed air to the Double Bubble Curtain Hoses (DBCH).

DUK have procured 2 x 850m bubble curtain hoses from Hydrotechnik, Lubeck. The hoses will run from the compressor area in the South Compound to approximately CH300 on the North Break Water and also to the South covering the South Breakwater areas, detailed in Figure 1.2 below.

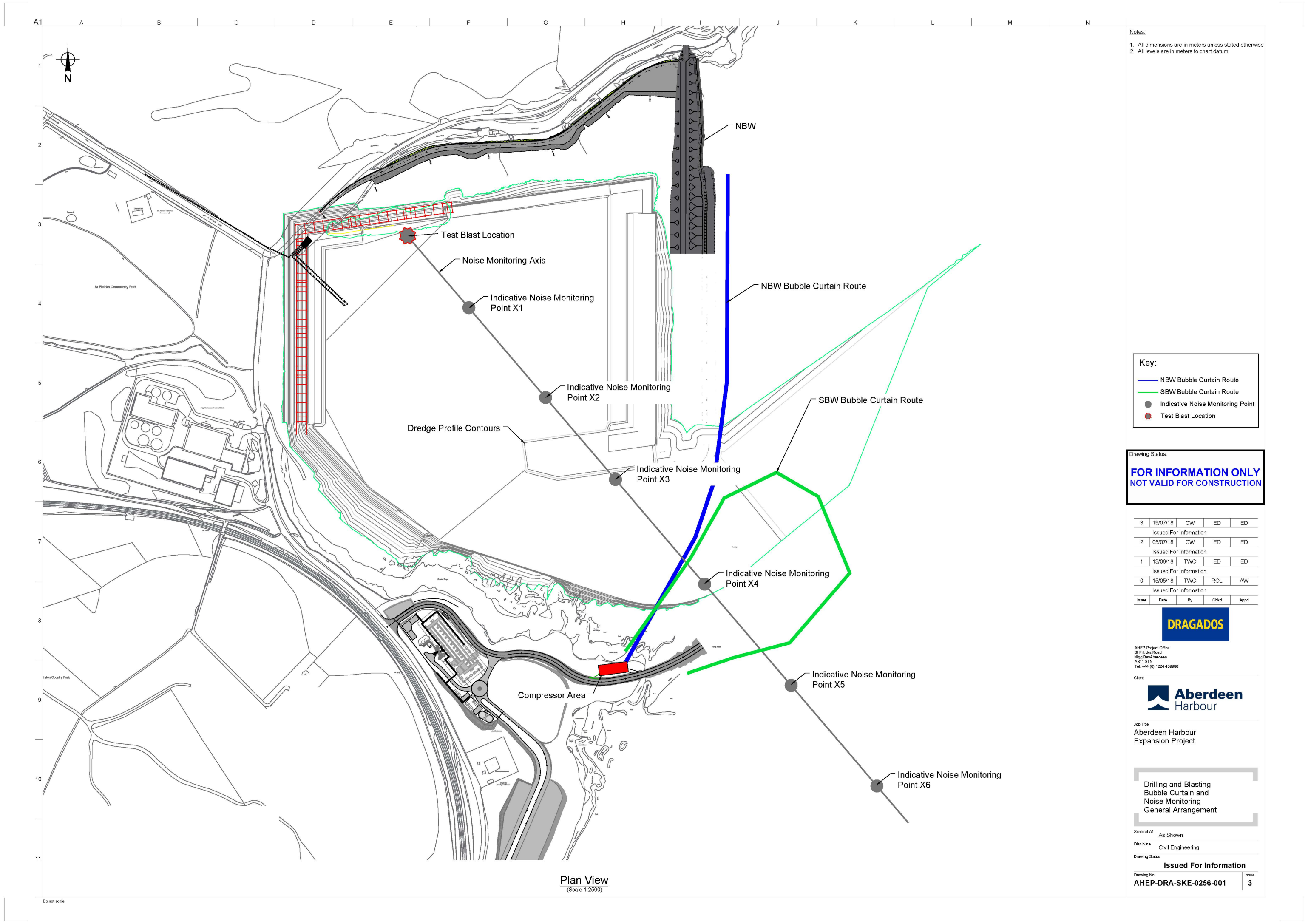

Figure 1.2 - Layout Location of Bubble Curtain

The small red area in Figure 1.2 is the Compressor storage area. The blue line illustrates the layout for the hose running from the Compressor area to the North Breakwater and the green line depicts the route of the hose when blasting is to occur in the South Break Water area.

It should be noted that both configurations will make use of a double bubble curtain and each will be separated by approx. 15m. This separation is determined by the average depth of water along the transect of the DBC

Based on the AHEP programme, early blasting operations will focus on the NE area of Nigg Bay. As such, test blasting will be carried out in this area, behind the partially completed breakwater and double bubble curtain. During the test blasting, underwater noise will be measured along a transect that has a direct line of sight to the blasting location, i.e. it is not impeded by the partially constructed northern breakwater.

The majority of blasting in the northern breakwater area will occur behind the blue line double bubble curtain (from Compressor area to the North Breakwater), and then the green line bubble curtain, as the works progress to the far eastern end of the southern rock blasting zone. The southern breakwater area requires considerable dredging of overburden before any blasting of any description can occur. It should also be noted that the blasting of the southern trench areas is at a depth - 17mCD and this in itself would act as a attenuation factor.

1.3 Bubble Curtain Effectiveness Tests (within combined PAM mitigation)

1.3.1 Acoustic Modelling & Locations

The indicative points for testing the bubble curtain effectiveness are presented in Figure 1.2 above. These include x3 UWN testing points inside the DBC (X1-X3) and x3 UWN testing points outside the DBC (X4-X6).

Previous experience of making acoustic recordings at sea indicates that successive measurements of sound pressure level at the same location are, more than likely, going to yield different sound pressure levels. The difference between each measurement is attributed to natural variation in the environment which subsequently affects acoustic propagation. Measurements made over a number of distances will give a sense of the variation likely to arise. Measurements made at just one location will not provide any indication of the inherent variability. Three measurements are considered an adequate number to provide a sense of the variability in sound pressure level.

1.3.2 Combined PAM and UWN Monitoring (PAM boat coverage and UWN testing points)

Two boats will be used during the DBC effective tests and the initial blast tests.

As described in Section 1.6.2, the hydrophones are capable of detecting harbour porpoise at a range of 300-400m and bottlenose dolphin at 1,000m. The locations of the two boat-based PAM hydrophones are designed to cover the necessary 1km mitigation for both species when blasting occurs in the north of the bay – this is shown on. Figure 1.3. An additional figure showing the hydrophone set-up for blasting in the south of the bay will be provided to MS-LOT for approval at least 2 weeks prior to blasting taking place in the south of the bay.

The PAM hydrophones will be deployed for one hour prior to a blast. Once there have been no marine mammals in the mitigation zone for a period of 30 minutes before the blast time, the PAM operator will give the 'green light' to the blast operator, who will detonate the blast. Immediately prior to the blast, the two monitoring vessels will move to the UWN monitoring locations (i.e. X1-6 as shown on Figure 1.2 and Figure 1.3), in accordance with the schedule set out in Table 1.

Blasting will not take place in a Beaufort Sea State greater than 3 (unless agreed otherwise with MS-LOT) due to the efficacy of the MMO and PAM mitigation measures.

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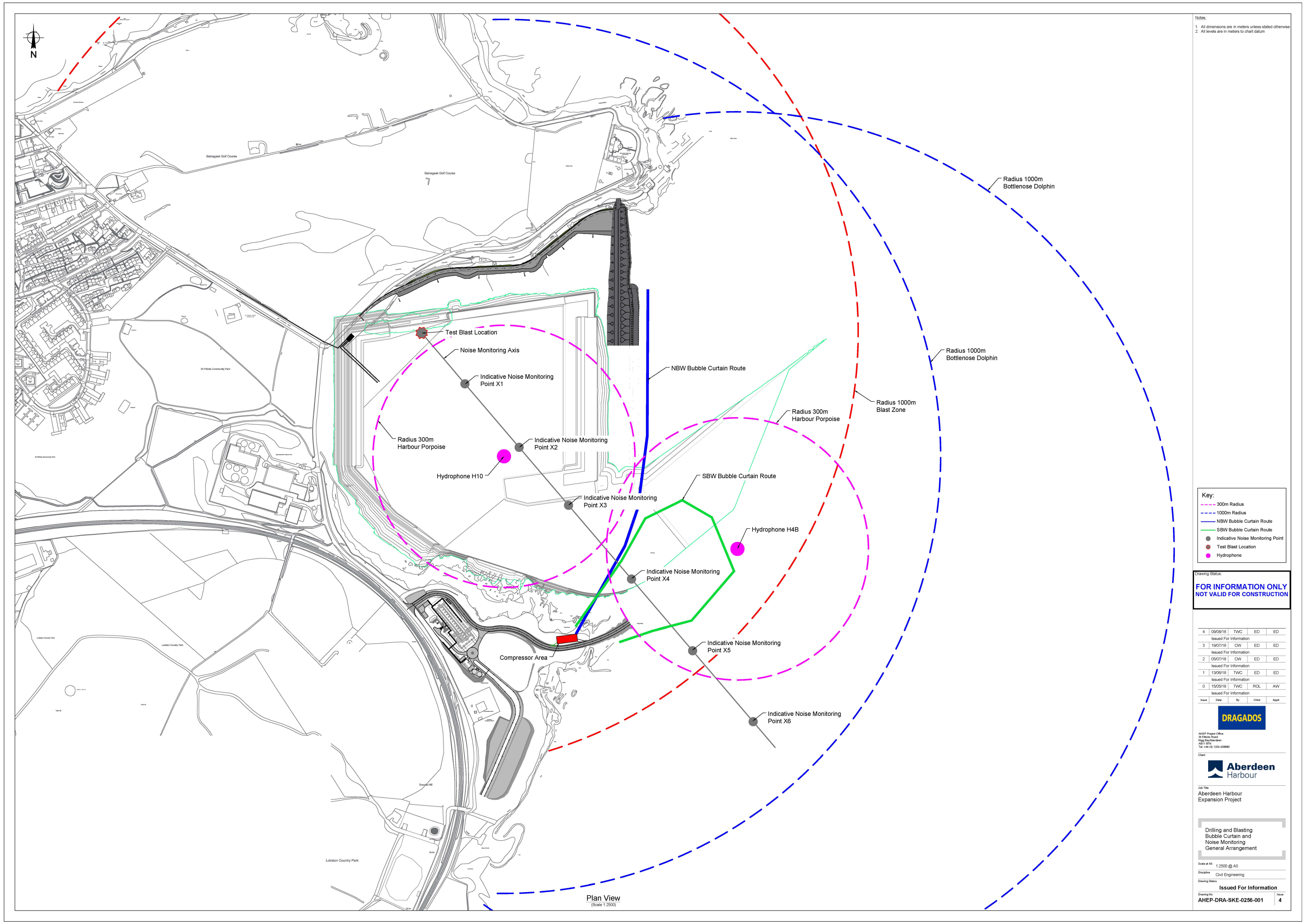

Figure 1.3 - PAM and Bubble Curtain Effectiveness Tests

The total number of test blasting days, boats, PAM mitigation zones and stations, UWN testing points and DBC interactions are summarised and ordered in Table 1. The first blast on day 1 will be a reduced charge size of 10 kg and all other blasts will be 20kg. If adverse effects on marine mammals are observed by the MMOs, MS-LOT will be notified immediately.

Table 1 – PAM and UWN Monitoring (summary and order of zones, points and testing)

Day	Boat A	Mitigation Zone	UWN Testing Point	Boat B	Mitigation Zone	UWN Testing Point	Bubble Curtain Effect
Day 1	Blast 1	A (x4 stations)	X1	Blast 1	B (x4 stations)	X4	Yes
	Blast 2	A (x4 stations)	X1	Blast 2	B (x4 stations)	X5	Yes
Day 2	Blast 1	A (x4 stations)	X1	Blast 1	B (x4 stations)	X6	Yes
	Blast 2	A (x4 stations)	X2	Blast 2	B (x4 stations)	X4	Yes
Day 3	Blast 1	A (x4 stations)	X2	Blast 1	B (x4 stations)	X5	Yes
	Blast 2	A (x4 stations)	X2	Blast 2	B (x4 stations)	X6	Yes
Day 4	Blast 1	A (x4 stations)	X3	Blast 1	B (x4 stations)	X4	Yes
	Blast 2	A (x4 stations)	X3	Blast 2	B (x4 stations)	X5	Yes
Day 5	Blast 1	A (x4 stations)	X3	Blast 1	B (x4 stations)	X6	Yes
	Blast 2	A (x4 stations)	X1	Blast 2	B (x4 stations)	X4	Yes
Day 6	Blast 1	A (x4 stations)	X1	Blast 1	B (x4 stations)	X5	Yes
	Blast 2	A (x4 stations)	X1	Blast 2	B (x4 stations)	X6	Yes

Note: the first blast on Day 1 will be 10kg. All other blasts will be 20 kg.

1.4 Procedures - Bubble Curtain Effectiveness (6 days of test blasting)

The following procedures will be followed for the UWN monitoring and testing of the DBC:

1.4.1 Setup (Test Blasting)

- Indicative locations between the blast site and the bubble curtain have been identified for monitoring (X1 to X2 and X3 from Boat A). The exact locations of the monitoring points will be determined and recorded using a boat-based GPS at the time of measurement.
- An estimation of the likely sound levels in the water on the inside of the bubble curtain (X1, X2 and X3) will be made. There is the possibility that if the hydrophone is placed too close to the blast site, the outgoing pressure wave is of such a magnitude that it will be saturated resulting in time-domain waveforms being clipped. If necessary, a consideration will be made to revising the location or else altering gain settings or swapping out the hydrophone for one of a different sensitivity e.g. D/70 (**H0**) (-20) for **H10** (-40). **H10** (-40) for example has been designed, built and tested to cope with a peak amplitude of up to 240dB.
- Indicative locations on the seaward side of the bubble curtain for the second recording location have been identified also. It is proposed to monitor underwater noise levels mid water at a range of distances from the point of the blast (X4, X5 and X6), approximately 1000m, 1250m and 1500m.
- Neither temperature nor tidal state are model dependencies for the blast propagation model used for the AHEP Environmental Statement (Technical Appendix 13-B), i.e. there is no allowance for such fluctuations in sound speed in the model. Regardless, sea temperature does not fluctuate sufficiently day-to-day to an extent that would affect noise propagation. In relation to tidal state, over the six days of test blasting, noise measurements will be taken at varying states of the tidal cycle, including at high tide when sound propagation is likely to be greater.
- For monitoring and testing specially-designed/calibrated hydrophones (engineered by Chickerell Bioacoustics), terminal/processing units (engineered by Chickerell Bioacoustics) and manual PCM audio recorders will be used to listen/record animal detections and then process and record the proposed explosives work. The PCM audio recorders will record files in .wav file format and the internal SD cards will be examined using CoolEdit (to quality check the data + extract sequences for further analysis) then MATLAB (to perform measurements on the data). In this work a mix of bespoke hydrophone configurations will be used and deployed from x2 boats (blast and seaward sides).
- For near field sounds (inside the DBC) the Chickerell Bioacoustics **H10** (-40), or the Neptune D70 **H0** (-20) will be used (as required). For far field sounds (outside the DBC) the Teledyne Reson TC4032-1 **H4B** will be used. For any ambient sounds the Neptune D70 **H4** will be used.
- Refer to Appendix A and B for specification sheets and testing/calibration certificates for each of these

hydrophones. Also note H10 does not have a specification sheet as it was designed and built in-house.

- Refer to Appendix C for copies of full operational procedures documents, also for the hydrophone recording forms that will be completed in full for each measurement taken.

1.4.2 Implementation (Test Blasting)

- For this work the hydrophones will be deployed at the same depth as the sound source or mid water (as appropriate) for the measurements being made. The units will be deployed vertically over the side of each boat (as required). Heavy lead weights will be fixed to each cable to ensure they are held vertically (always) in the strong tidal cycles / currents. They will also be deployed in such a way that there will be no danger of entanglement either with the deploying boat's propeller, other structures, or seabed.
- For safety reasons the deployments will also configured to allow for boat mobilisation and / or quick recovery. During blasting operations and during recording events the boat engines will be switched off (where possible) to avoid contamination of the sound recordings with engine noise.
- The Blast Contractor will activate the initial test blasts (using a 20kg charge weight apart from the first blast which will be 10 kg) for a period of 6 days, with 2 blasts per day, i.e. approximately 2 measurements will be made from each of the locations X1 – X6, and 24 measurements in total. If the acoustic technician feels the data gathered is insufficient further tests may need to be carried out; however, additional blasting past day 6 will not be carried out without the agreement of MS-LOT.
- Recordings will be made when the bubble curtain is on. Once the blast has taken place and the acoustic technicians have collected high quality data, the curtain will be turned off and each boat will bring the hydrophones aboard.
- The procedure will then be repeated at the remaining locations during the 6 days of test blasting.
- During implementation each acoustic technician will check the hydrophone output using the PCM recorder playback function and if required the CoolEdit software (quality check the data + extract sequences for further analysis).

- If the test blast noise exceeds the 170dB dB re 1uPA rms (183 dB re 1 uPa peak equivalent)[1] at a distance of 400 m from the blast site (or the calculated equivalent using a using a propagation loss model), which is the level predicted by the underwater noise modelling undertaken for the AHEP Environmental Statement,, the test blasting will stop and MS-LOT will be notified as per the Drilling & Blasting Methodology- Environmental Controls Marine Mammals. The blasting and monitoring will be revaluated.

1.4.3 Verify Modelling Outputs (Test blasting)

- As the key purpose of the test blasting is to verify the modelling outputs undertaken for the AHEP Environmental Statement, in terms of predicted noise levels at varying distances, it is not necessary to use smaller charge sizes during the testing phase, although the first blast on day 1 will be of a reduced size of 10 kg.
- It is not necessary for all locations to be tested for each blast; only that for each blast, a sound measurement is taken within and outwith the bubble curtain. The level of resource and effort required to achieve simultaneous monitoring (i.e. 6 boats, crews and hydrophones) would be significant.

1.5 Procedures – Ongoing Blasting Monitoring

1.5.1 Combined PAM and UWN Monitoring Points

After the test blasting phase, during the on-going blasting PAM monitoring will continue in accordance with the procedure set out above unless agreed otherwise with MS-LOT.

After the test blasting, ad-hoc UWN measurements will be taken at various locations and the main objective will be to record the wider construction noises (i.e. dredging, rock placement, drilling, rotary piling, blasting, passing ships, and ambient conditions if available).

The indicative PAM listening stations are fixed, however the UWN points are likely to change as construction progresses and as blasting moves from north to south for example.

[1] See Appendix D for further description of rms versus peak sound levels

Also, it is considered that as the project progresses, and the northern breakwater extends further from north to south, that the harbour entrance and channel out to open water will be the main focus point for PAM mitigation and control.

PAM will be used prior to marine drilling if activities are to commence during the hours of darkness. If drilling is continuing from daylight hours, without a break, then there should be no need to use PAM. If measurements of noise generated from drilling occur at a level unlikely to cause significant disturbance, it may be possible to reduce this mitigation. This data will be provided in the UWN Monthly reports.

Note no Rotary Piling will take place in the marine environment.

1.5.2 Setup (On-going blasting)

- UWN monitoring will be undertaken at various locations in the inner harbour and outer bay.
- The main objective is to record general construction noises and ambient conditions (if available).
- The measurement points are likely to change as the construction programme progresses.
- For monitoring and testing specially-designed/calibrated hydrophones (engineered by Chickerell Bioacoustics), terminal/processing units (engineered by Chickerell Bioacoustics) and manual PCM audio recorders will be used to listen/record animal detections and then process and record the construction noises (inc. explosives work). The PCM audio recorders will record files in .wav file format and the internal SD cards will be examined using CoolEdit (to quality check the data + extract sequences for further analysis) then MATLAB (to perform measurements on the data). In this work a mix of bespoke hydrophone configurations will be used and deployed from a single boat (blast and seaward sides).
- For near field sounds (50-100m closest) the Chickerell Bioacoustics **H10** (-40), or the Neptune D70 **H0** (-20) will be used (as required). For far field sounds (100-500m furthest) the Teledyne Reson TC4032-1 **H4B** will be used. For any ambient recordings the Neptune D70 **H4** will be used.
- Refer to Appendix A and B for specification sheets and testing/calibration certificates for each of these hydrophones. Also note H10 does not have a specification sheet as it was designed and built in-house.
- Refer to Appendix C for copies of our full operational procedures documents, also for the hydrophone recording forms that will be completed in full for each measurement taken.

1.5.3 Implementation (On-going blasting)

- For this work the hydrophones will be deployed at the same depth as the sound source or mid water (as appropriate) for the measurements being made. The units will be deployed vertically over the side of each boat (as required). Heavy lead weights will be fixed to each cable to ensure they are held vertically (always) in the strong tidal cycles / currents. They will also be deployed in such a way that there will be no danger of entanglement either with the deploying boat's propeller, other structures, or seabed.
- For safety reasons the deployments will also configured to allow for boat mobilisation and / or quick recovery. During blasting operations and during recording events the boat engines will be switched off (where possible) to avoid contamination of the sound recordings with engine noise.
- A wide range of construction noises will be recorded and detailed notes will be taken (inc. blasting)
- For general construction noises the recordings will be made when the bubble curtain is off (to avoid interference). When the acoustic technicians have collected high quality data, the curtain will be turned back on and each boat will bring the hydrophones aboard.
  During implementation each acoustic technician will check the hydrophone output using the PCM recorder playback function and if required the CoolEdit software (quality check the data + extract sequences for further analysis).

1.6 Instrumentation (UWN and PAM combined, switchable gains & single unit systems)

This section describes the equipment that will be used for each of the key UWN scopes of work, and includes Low and High level Sound Sources and existing acoustic environment noise and detection of marine mammals.

Refer to Appendix A and B for specification sheets and testing/calibration certificates for each hydrophone that forms our overall system. Also note H10 does not have a specification sheet as it was designed and built in-house.

1.6.1 Far-Field (Low-Level) Underwater Sound Sources + Detections (H4B)

The calibrated Teledyne RESON Hydrophone (TC4032-1) (**H4B**) (cabled by Chickerell Bioacoustics) with integral preamplifier (IP) and terminal unit (TU) will be used to characterise underwater ambient noise and low-level sounds from a variety of sources. This hydrophone system has been designed for deployment from a boat but can be used from a structure with suitable modification to the deployment system. The dry end TU will provide pre-set gain and drivers for a recorder, laptop and headphones. The whole system will be powered from an external 12 Volt battery.

Wet End

The wet end will be the calibrated TC4032 (**H4B**) hydrophone. This hydrophone and preamplifier has 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 1.4 and the electrical diagram is shown in Figure 1.5.

Figure 1.4. RESON TC4032-1 Hydrophone Assembly

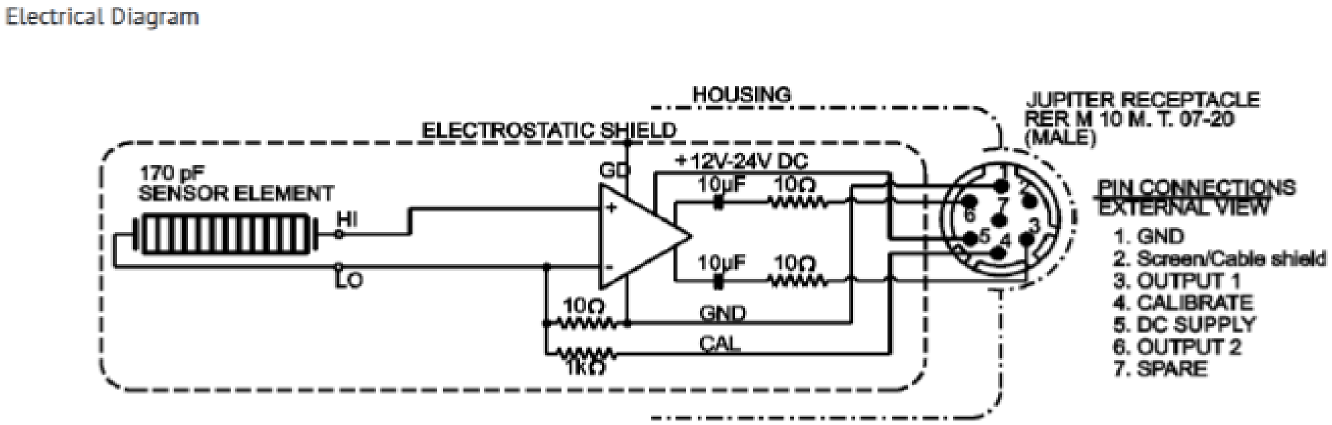

Figure 1.5. Electrical Diagram of the RESON TC4032 hydrophone assembly

The TC4032 (H4B) includes a tone injection facility whereby a tone is injected in series with the ceramic element. This will be used to give confidence that the whole processing chain is functional.

The estimated calibration factor for the TC4032 (**H4B**) wet end system is 164 dB re 1µPa/V.

This hydrophone has been fully tested and calibrated by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

Dry End
The dry end TU (engineered by Chickerell Bioacoustics) will be housed in a grey polycarbonate box, as shown in Figures 1.6 and 1.7.

Figure 1.6. Front of Terminal Unit

Figure 1.7. Rear of Terminal Unit

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

This TU has been fully tested and used during the calibrations by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

1.6.2 Near-Field (Loud) Underwater Sound Sources + Detections
Calibrated Chickerell Bioacoustics (**H10**) and Neptune D/70 (**H0**) ball hydrophones (housed and cabled by Chickerell Bioacoustics) with an IP and TU (engineered by Chickerell Bioacoustics) will be used to characterise loud underwater sounds (close-in to source). The aim of using these hydrophones will be to record the waveform in the near field, while using the TC4032-1 to record the far field signal.

It should also be noted that the near-field hydrophone unit (**H10**) has been designed/optimised for monitoring the explosives work / loud sound levels and can measure sound levels up to 240 dB re 1uPa. It uses an omni-directional ball hydrophone with characteristics similar to a Neptune D/140. By changing one switch setting it can also be switched to a high gain mode and is capable of picking up echolocation click from harbour porpoise and other odontocetes. The electronics have a flat response from 100 Hz to over 200 kHz, so the overall system response is determined solely by the hydrophone. With a resonance at 140 kHz it is optimised to pick up the clicks from harbour porpoise.

These hydrophone units will use very low gain settings and high dynamic range preamplifiers. The dry end TU will provide pre-set gain and drivers for the acoustic recorder, laptop and headphones. The whole system will be powered from an external 12 Volt battery.

Wet End

The wet ends have designated P67 and will use Chickerell Bioacoustics (**H10**) and Neptune (**H0**) ball hydrophones. The IP input stage will have gain settings of -40dB, -20 dB,0dB and +26dB selectable by switching the power supply to the preamplifier. The differential line driver will have a gain of 6 db.

The D/70 (**H0**) 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 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 D/70 (**H0**) wet end system are:
Gain set to 0dB: -192 dB re 1V/uPa
Gain set to -20 dB: -212 dB re 1V/uPa

In the low gain setting for **H10** 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 for **H10** 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. Over the range 1-20 kHz the noise spectral level is 4.5 nV in a 1 Hz bandwidth.

These hydrophones have been fully tested and calibrated by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

The calibration results also show that all hydrophones are in line with previous work, well within any experimental design errors, are capable of detecting the target species (inc. harbour porpoise and bottlenose dolphin) and are suitable for mitigating and then measuring the blasting and construction works proposed and ongoing.

Dry End

The dry end TU (engineered by Chickerell Bioacoustics) will be housed in a grey polycarbonate box as shown in Figures 1.8 and 1.9.

Figure 1.8. Front of Terminal Unit


Figure 1.9. Rear of Terminal Unit

For H0 the TU will provide all necessary gain and filter stages. The input stage will be a high-speed differential amplifier with the gain set by internal link to be 0, -20dB. For normal use the link will be set to 0dB.

For H10 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.

These TUs have been fully tested and used during the calibrations by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

1.6.3 Existing Acoustic Environment
The calibrated Neptune D/70 (**Ambient**) ball hydrophone or Teledyne RESON Hydrophone (TC4032-1) (**H4B**) (housed and cabled by Chickerell Bioacoustics) with an IP and TU (housed in a waterproof box and engineered by Chickerell Bioacoustics) will be used to characterise the existing acoustic environment. Monitoring will be 1 or 2 times a month. A report will be completed each month of the findings and issued to SNH/MS-LOT & WDC. as detailed in Table 3 section 1.12.

The hydrophone will be deployed off a suitable structure and/or platform and/or directly from the PAM/UWN monitoring boat. If from a structure and/or platform a long rod will be used to hold it off any structure. If from the boat it will be deployed from a stationary/anchored boat (with engine and echosounder off) and power be provided by a 12 Volt battery.

All data will be recorded using a Wildlife Acoustic Recorder (SM2) or PCM Recorder and a series of SD cards. Measurements will be taken at these points to ensure all noise sources are captured at various times during a 24 hr period.

The D70 (**Ambient**) unit assembly (excluding the Wildlife Acoustic Recorder (SM2) is shown in Figure 1.10.

These hydrophones have been fully tested and calibrated by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

Also the proposed TUs (described as H4B, HSS and/or Ambient) have also been fully tested and used during the calibrations by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

Figure 1.10. Typical Assembly (Structure/Platform/Boat Deployed)

The calibration results also show that all hydrophones are in line with previous work, well within any experimental design errors, are capable of detecting the target species (inc. harbour porpoise and bottlenose dolphin) and are suitable for mitigating and then measuring the blasting and construction works proposed and ongoing.

1.6.4 Acoustic Recorders and Sampling Frequencies

For the boat and land-based work suitable PCM acoustic recorders will be connected to the TU boxes via the 1/4" jacks on the rear panels. The 'Line Input' sockets on the recorders will be used and the recorder inputs will be set to 'Line' on the recorder menus. The recorder sampling rates will be set to 48 kHz with 24-bit sampling as the default settings. The optional high-pass or low-pass filters within the recorders will also be de-selected.

The acoustic recorders to be used are illustrated in Figure 1.11.

Figure 1.11. PCM Acoustic Recorder Recorders

We record the linear time series after signal amplification and some limited filtering. A recording of say 10 seconds sampled at 96 kHz will provide 960,000 samples. MATLAB is then used to handle this data and this works using matrices. It should also be noted that spectral processing is not overly useful with short duration impulses such as explosives.

1.7 Animal Detections, Vessel(s) and Performance

1.7.1 Animal Detections, Click Detectors and Predicting Ranges
Any animals observed / detected during the noise testing and monitoring will be noted and logged. A click detector will also form part of the hydrophone deployments and where possible this will be correlated to any noises recorded during the underwater noise surveys.

It is expected that a detection ranges between 300 and 400m would be achievable for harbour porpoise (especially with the H10 configuration.

For cetacean detection, the terminal/processing units to be used in this work will include echolocation click detectors. These will be optimised to detect clicks from cetaceans, which will translate the sounds down to the bandwidth that can be sampled at 48 kHz. This technique has been successfully used on other Ecofish Global (EFG) projects and has detected clicks from a variety of species.

1.7.2 Vessel, Navigation and Plotting
DUK will provide spec of x2 boats and navigation etc (Clachan Marine). x2 boats will be required for the PAM and Bubble Curtain Effectiveness Tests. Once the blast testing scope of works is complete, x1 boat will be required for ongoing PAM (daily) and UWN (monthly).

1.7.3 Mitigation and Control
The outlined PAM system and vessels will be used, as well as x2 MMOs, situated on each headland for blasting operations to ensure the 1km mitigation zone is clear of harbour porpoise, dolphins and other marine mammals, prior to start-up of the operations.

PAM will provide information on available tonal calls/vocalising marine mammals within the mitigation zone that are not visible to MMOs. The boat-based PAM configurations will cover the 1km mitigation zone (direct line of sight) for blasting, as a minimum. The MMO watches will encompass a radius from their location on the Headlands.

All hydrophones and Tus proposed have been fully tested and calibrated by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

The calibration results also show that all hydrophones and terminal units are in line with previous work, well within any experimental design errors, are capable of detecting the target species (inc. harbour porpoise and bottlenose dolphin) and are suitable for mitigating and then measuring the blasting and construction works proposed and ongoing.

1.7.4 - Previous Work and Performance
It should also be noted that these systems have been used extensively elsewhere and both the D/70 and TC4032-1 hydrophones have repeatedly detected echolocation clicks from bottlenose dolphins and common dolphins in previous deployments (areas dominated by these species).

On the Nigg South Quayside Project (Global Energy) in 2014, EFG had hundreds, possibly thousands of detections over a 12-month period (inc. bottlenose dolphin, grey seal, harbour porpoise and minke whale). EFG also reported UWN monitoring results to MS-LOT on a monthly basis and completed this work order successfully. The data that was obtained during this work is considered to be one of the largest datasets for UWN in shallow estuarine coastal waters in the world. This data was also submitted as a pack to MS-LOT and uploaded to the National Archive for Underwater Acoustics at the time.

An example of species that were observed, detected and mapped for movement and distribution during this work is presented in Figures 1.12 to 1.15.

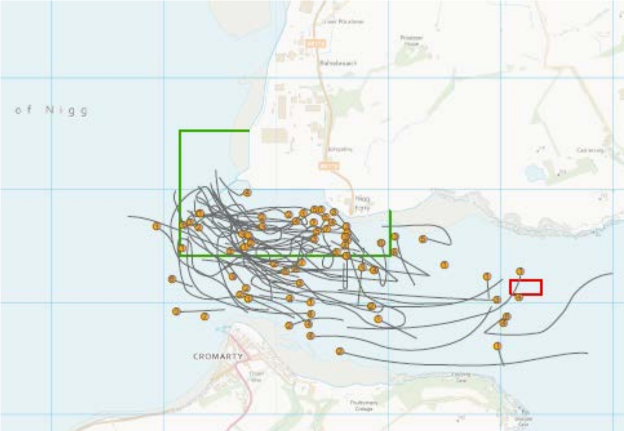

Figure 1.12 - Bottlenose Dolphin

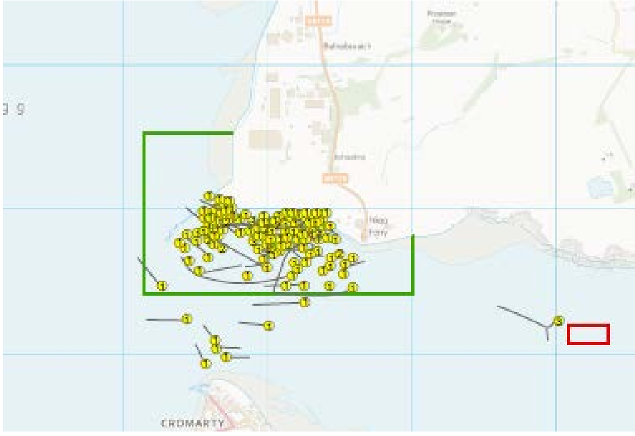

Figure 1.34 - Grey Seal

Figure 1.14 - Harbour Porpoise

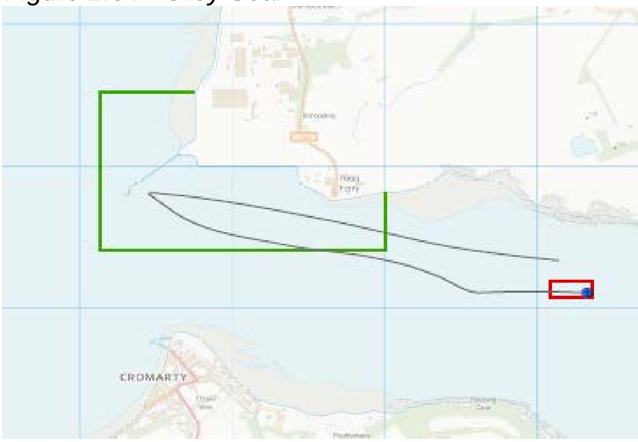

Figure 1.15 - Minke Whale

For further details on this project see http://www.ecofishglobal.co.uk/project/eiamitigation-nigg-south-quayside/

More recently (2017 into 2018) EFG carried out underwater noise monitoring during piling works at the Kyleakin Feed Mill on the Isle of Skye. The new Kyleakin Feed Mill is situated off the A87 across the Skye Bridge (in the old quarry at Kyleakin). The scope of the marine works included demolition (of the existing pier reinforced concrete deck), steel sheet piling (vibro and impact), dredging (platform, barge, excavators and dumpers), caisson foundations, infill works, associated concrete slabs, drainage works, services and electrical works.

Data collected was then analysed by our marine bio-acousticians who could provide a fascinating insight into the levels of underwater noise generated and also the ambient noise associated with this complex site (including passing ships, animal noises (notably bottlenose dolphin) etc.

For further details on this project see http://www.ecofishglobal.co.uk/project/underwater-noise-monitoring-kyleakin/

1.8 Measurements, Data Analysis and Quality Assurance

The level of noise in the water can vary over a very wide range. The level of noise will be described using Sound Pressure Level (SPL) and the usual units are micro Pascals. Because of the very large range it is normal to use a logarithmic ratio of level expressed in decibels (dB). The level in dB is given by:

$$\mathrm{SPL}(\mathrm{dB}) = 20 \times \mathrm{Log}_{10}\left(\frac{\mathrm{Pressure}}{\mathrm{Reference}}\right)$$

In underwater acoustics the reference pressure is always 1 μPa so SPL is expressed as dB re 1μPa.

Typical wideband SPL's vary from around 60 dB re 1µPa in very quiet conditions, up to >220 dB re 1µPa close to an impact pile driver (a range of 180 dB). Most measuring systems are limited to a dynamic range of around 90 dB, so it is necessary to use a range of hydrophones when characterising underwater sound sources.

EFG have a range of measuring hydrophones available to characterise sound sources and a few of the have already been covered above. Within this section the methodology employed to analyse the collected acoustic data is detailed.

1.8.1 Far-Field (Low-Level) Underwater Sound Sources

Characterising low level sound sources requires a hydrophone with moderate gain and good noise performance. For these measurements the calibrated TC4032-1 (**H4B**) hydrophone configuration will be used. Calibration tones will be injected at the start of a recording to overcome the lack of calibration in the PCM acoustic recorders.

When analysing each recording the calibration tones will be identified and measured by the analysis system, so that absolute levels could be assigned to the measured data.

Data recorded will be archived onto a large networked hard disk for further analysis. CoolEdit software will then be used to carry out quality checks and to determine which sections of the data were suitable for further analysis. If necessary sections of the data will be extracted into smaller files to speed up the analysis.

The chosen data will then be passed to the MATLAB processing software, where routines will be specially written for this work, and data processed (as required) for each task.

1.8.2 Near-Field (Loud) Underwater Sound Sources

The processing of the recorded data will be the same as for the low-level sound sources. With CoolEdit being used to quality check the data and extract sequences for more detailed analysis and then MATLAB used to perform measurements on the data.

1.8.3 Existing Acoustic Environment

Acoustic environments can be characterised in two ways. Spot measurements can be made using the D/70 (**Ambient**) or TC4032-1 (**H4B**) configuration (as described above). However, it is also useful to make longer term measurements to allow a more detailed characterisation of the acoustic environment. Such measurements usually last for days rather than minutes and EFG routinely employ the fixed Neptune D/70 (**Ambient**) configuration to carry out this task (from suitable structure, platform or boat).

Individual files are inspected using the CoolEdit software and interesting sounds identified and extracted for further analysis by the MATLAB software. Specific MATLAB routines are used to display interesting events, e.g. passing ships, and to display the whole recording sequence as a spectrogram and a variability plot.

1.8.4 Animal Detections

Any animals observed / detected during the noise monitoring will be noted and logged. A click detector will also form part of the static hydrophone deployment and where possible these will be correlated to any noises recorded during the underwater noise surveys.

The PAM system (using a Neptune D/70 ball hydrophone) will be deployed and connected to terminal/processing units (engineered and preamplified by Chickerell Bioacoustics), then connected to a PC (laptop) with ISHMAEL bioacoustic analysis software installed and displaying sound waveforms and spectrograms. This configuration will have recording capability for real-time sound input, acoustic localisation, beamforming, automatic call recognition, and a sound annotation facility.

1.8.5 Testing and Calibration Certifications

All hydrophones and TUs proposed have been fully tested and calibrated by Neptune Sonar (July 2018). Refer to Appendix B for testing/calibration certificates.

This testing facility operates to the standards set by the National Physics Laboratory (NPL), and all work was done under a controlled testing facility.

The calibration results also show that all hydrophones and terminal units are in line with previous work, well within any experimental design errors, are capable of detecting the target species (inc. harbour porpoise and bottlenose dolphin) and are suitable for mitigating and then measuring the blasting and construction works proposed and ongoing.

1.8.6 Personnel and Quality Assurance

The Lead PAM Operator will remain in constant communication with the acoustic technicians, MMOs and the blasting manager. The Lead PAM Operator will be responsible for mitigation control across the site and will instruct the blast manager to delay operations until the acoustic/PAM/MMO mitigation team is satisfied that all marine mammals are out of the mitigation zone and that mitigation protocols have been adhered to. All start and stop times will be recorded, as well as, operational and technical down time.

During the blast efficiency testing acoustic technicians from x2 boats will provide PAM (pre-charge) and record underwater noise (during blasting events). The Lead PAM Operator will be stationed on one of these boats and/or within the shoreline PAMBASE.

The Lead PAM Operator will be experienced and dedicated to the task of operating the specific PAM equipment.

The Lead Bioacousician will also be present on site at the start of equipment testing and will ensure quality assurance, proper set up and will troubleshoot any technical glitches or queries that may arise (pre monitoring and testing).

1.9 Reporting, Compliance and Predicted Model Validation (UWN)

Underwater noise monitoring reports will be produced when underwater noise monitoring is ongoing and will contain the following information:

- Frequency representation in third octave bands (frequency domain - PSD distribution with variability).
- Temporal variance in frequency content (time domain - spectrogram).
- Received levels at recording location.
- Estimated source level of activity (detail method of calculation).
- Log of recordings together with ancillary data (including weather).

UWN monitoring data will be provided to MS-LOT and SNH daily during the test blasting. In addition, a report illustrating the underwater noise levels at agreed distances from the source, MMO and PAM records, and the location and depth of test blasts, will be submitted within 2 working days after the 6 days of test blasting have occurred.

Within the first 2 days of test blasting activities a site visit will be held for MS, SNH and WDC to demonstrate the marine mammal mitigation and measuring systems deployed at AHEP (PAM, DBC, MMOs etc.).

Unless otherwise approved by MS-LOT, no more than 20kg charges will be used. Once blasting has commenced and underwater noise monitoring data is available, on the sound levels generated by blasting behind a bubble curtain, DUK may seek to amend the charge size in consultation with MS-LOT, SNH and WDC.

Staged reports will be prepared and submitted for; (1) bubble curtain effectiveness tests; and (2) UWN monitoring (interim/monthly); and (3) UWN monitoring (final).

The final report will consider the predicted noise levels described in the AHEP Environmental Statement and further information submitted in support of the HRO and ML applications. The report will describe/compare any differences between the predicted noise levels and those recorded. It will also detail any lessons learnt for future applications.

1.10 Reporting and Compliance (MMO/PAM)

For each of the activities listed above, a record of activity including watches prior to activities commencing, marine mammals observed, delays to operations commencing and any post-operation sightings will be completed. All data will be recorded on standard JNCC template sheets for all “Effort” “Operations” and “Sightings”.

As per the Dredging Marine Licence, Marine Mammal Observer logs will be submitted to MS and JNCC as required. Logs will also be submitted to SNH and WDC as required.

Whilst activities are ongoing on site, with the potential to create underwater noise likely to disturb marine mammals, DUK are required to produce a monthly report on the mitigation measures deployed, marine mammal monitoring undertaken, and noise measurements collected, as well as a forward look to activities planned in the next month and any specific mitigations proposed. This report will include an Action Log to detail any problems encountered or issues to be raised with the regulator and provided to Marine Scotland, SNH and other interested parties. The report will also detail any exceptional circumstances where blasting has occurred, out with daylight hours, although any specific incidences will be reported to MS-LOT within 48 hours.

Reports will include:

- Completed Marine Mammal Reporting Forms;
- Date and location of the operations;
- A record of all mitigation deployed, including details of the duration of the MMO/PAM search and any occasions when activity was delayed or stopped due to presence of marine mammals;
- Details of watches made for marine mammals, including details of any sightings, details of the PAM equipment and detections, details of the sea state during the MMO and PAM mitigation period, and details of the activity during the watches;
- Any instances of ‘false negative’ readings of marine mammals, determined by analysis of the simultaneous detections made by MMOs and PAM recorders at different distances.
- Details of any problems encountered including instances of non-compliance with the agreed MMMP; and
- Any recommendations for amendment of the MMMP.

1.11 UK Noise Registry

The UK Marine Noise Registry (MNR) is a database that records the spatial and temporal distribution of impulsive noise generating activities in UK seas in order that they can be analysed to determine whether they may potentially compromise the achievement of Good Environmental Status (GES) under the Marine Strategy Framework Directive. The MNR was developed, and is maintained, JNCC on behalf of Defra and the Devolved Administrations (DAs).

DUK are required to submit data to the UK Noise Registry on planned activities and once activities are undertaken records of the actual activity. DUK must complete and submit a Close-out Report for the licensable marine activities that produced loud, low to medium frequency (10Hz-10kHz) impulsive noise in the online MNR at 6-month intervals during the validity of the licence and no later than 12 weeks from the completion of the licensable marine activity.

In line with the MNR guidance ‘noisy’ underwater activities recorded in the MNR are likely to be explosive use and any impact piling (although the latter is not planned).

Information required to be recorded in the MNR when explosives are used is listed in Table 2.

Table 2: Information required in the Marine Noise Registry

Proposed activity form	Close-out report

• Earliest start date (DD/MM/YYYY)
• Latest end date (DD/MM/YYYY)
• Expected duration of activity
  o Location
  o Latitude/longitude point (decimal degrees)
  o Latitude/longitude polygon (decimal degrees)
  o Quadrant/block
• Source properties:
  o SPL, dB re 1μPa (peak) @1m SEL, dB re 1μPa2 s (per pulse) @1m
  o Piling: maximum hammer energy (KJ)
  o Explosives: mass of TNT equivalent (kg)
	• Source properties:
	  o SPL, dB re 1μPa (peak) @1m
	  o SEL, dB re 1μPa2 s (per pulse) @1m
	  o Piling: maximum hammer energy (KJ)
	  o Explosives: mass of TNT equivalent (kg)
	• Actual location of activity
	  o Latitude/longitude point (decimal degrees)
	  o Quadrant/Block
	• Actual dates on which activity took place in correspondence with the location

1.12 Reporting Schedule

The reporting schedule provided by DUK is presented in Table 3 below. This covers document names, purpose, content, timescale, frequency, consultee, approval levels and response turnaround durations.

Table 3: Reporting schedule

Document Name	Purpose	Content	Timetable	Frequency	Consultee	Approval required or Information	Response Required & Timescale
Underwater Noise Test & Bubble Curtain Validation	Validation of Model and DBC effectiveness.	Results of 6 days of testing	After 6 days of testing	1 report of 6 days	SNH/MS-LOT/WDC	Yes	1-2 days
Increase In Blast size	Rationale for increase in Blast Size	Results from Blast Testing	6-8 days after initial tests	1 report after 6 -8 days	SNH/MS-LOT/WDC	Yes	1-2 days
Monthly Operational Blast Reports	Monthly Blast Noise Reports	Details of blasting &any issues	End of each month	1 report per month	SNH/MS-LOT/WDC	For Information	No
Ad hoc Noise Monitoring	Ambient Noise activities carried out.	Details and results of all noise generated in that month	End of each Month	1report per month	SNH/MS-LOT/WDC	For Information	No
MMO Reports (Monthly)	Details of all MMO activities	Details of all MMO observations/date/time/mitigations	End of each month	1 report per month	SNH/MS-LOT/WDC/JNCC	For Information	No
Marine Noise Registry Notification	Details of Commenceme nt of noisy activities	Details of proposed noisy activity	7 days before start of blasting	Start of blasting	UK Noise registry	For information	No
Marine Noise Registry Close Out Report	Noise registry Close Out Report	Sources of noise/dates/times	End of Blasting	6 month intervals	UK Noise registry	For information	No

APPENDIX A - SPECIFICATION SHEETS

Chickerell Bioacoustics H10
Neptune D/70 (H0 + H4)
RESON (TC4032-1) (H4B)

Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

TC4032

- **Low noise performance**
- **High sensitivity**
- **Wide frequency range**
- **Flat frequency response**
- **Long term stability**
- **Individually calibrated**

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.
Versions with different filter characteristics are available: 4032-1 5Hz to 120 kHz, 4032-2 1Hz to 120 kHz and 4032-5 100Hz to 120 kHz.

TECHNICAL SPECIFICATIONS	
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
Preamplifi er gain:	10dB
Max. output voltage:	3.5Vrms at 12VDC
Supply voltage:	12 to 24VDC
High pass fi lter:	7Hz -3dB
Quiescent supply current:	≤19mA at 12VDC ≤22mA at 24VDC
Encapsulating material:	Special formulated NBR
Housing material:	Alu Bronze AlCu10Ni5Fe4

TELEDYNE RESON
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Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

NBR means Nitrile Rubber

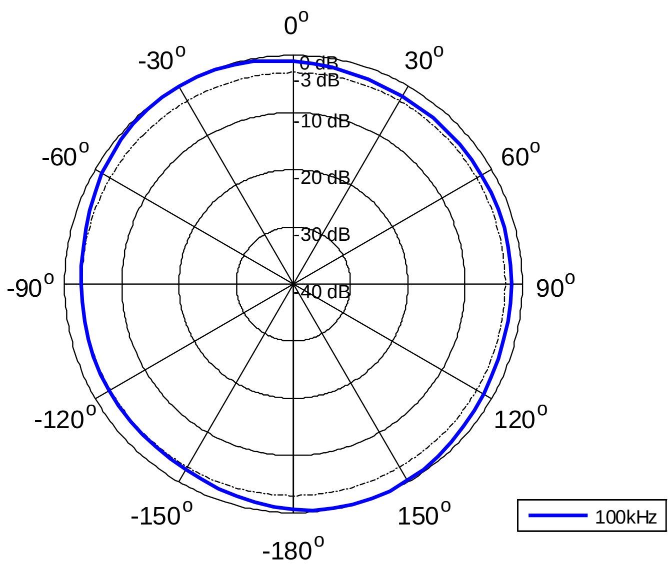
The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and will be destroyed by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), nitro hydrocarbons (nitrobenzene,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

Documentation:

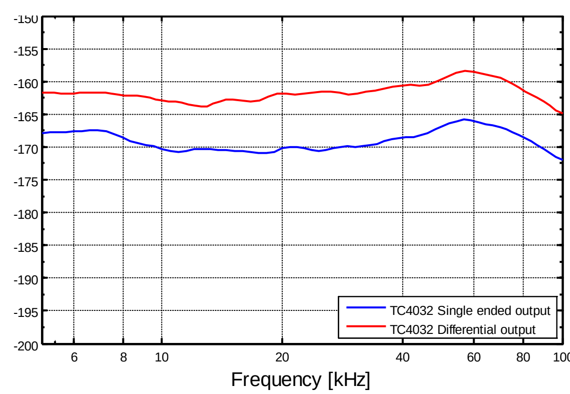
Individually calibration curves: 250 kHz
Sensitivity at ref.: frequencies: 250 kHz
Receiving sensitivity: At 5 kHz to 100 kHz

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

Horizontal directivity pattern

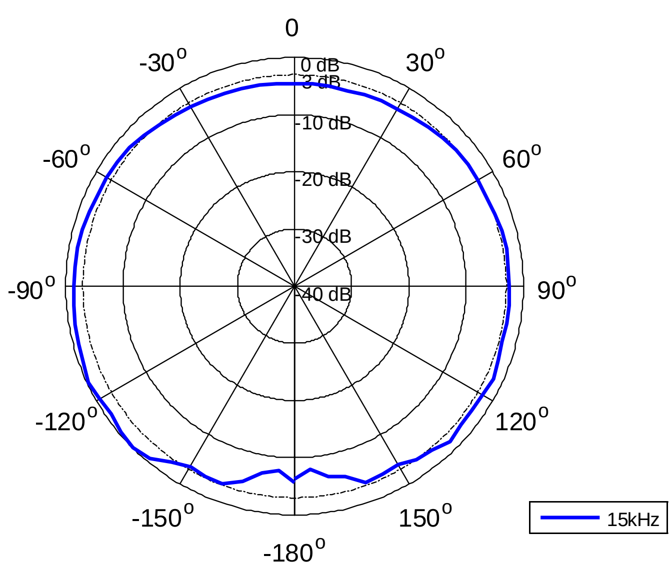


Receiving Sensitivity [dB re 1V/µPa @ 1m]

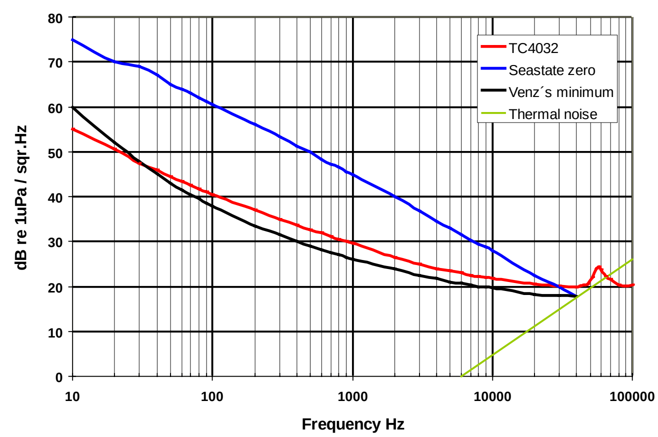


The OCR curve shown above is for single output

Vertical directivity pattern



Typical equivalent noise pressure curve



Valid for all versions of TC4032

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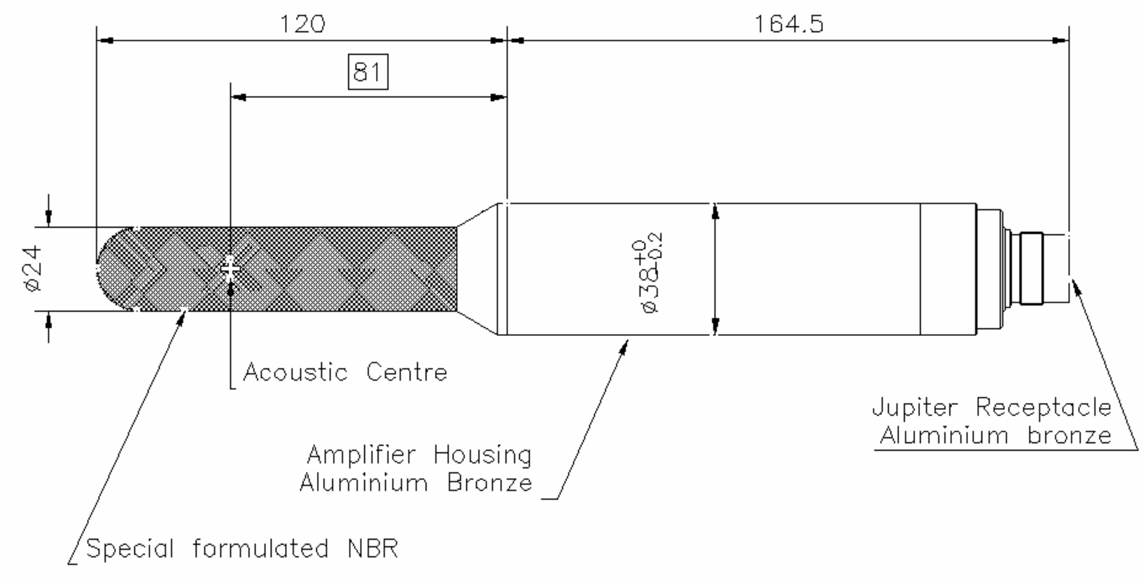
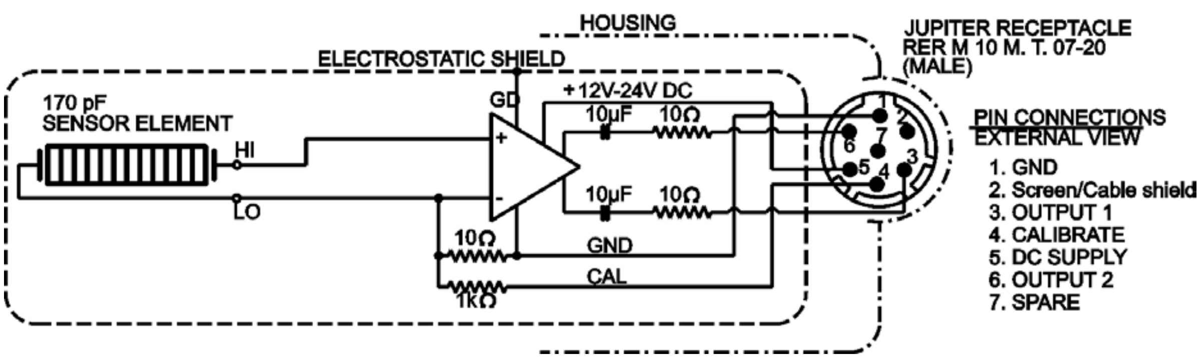
Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

Outline Dimensions



Electrical Diagram



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 (3) together with GND.

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.

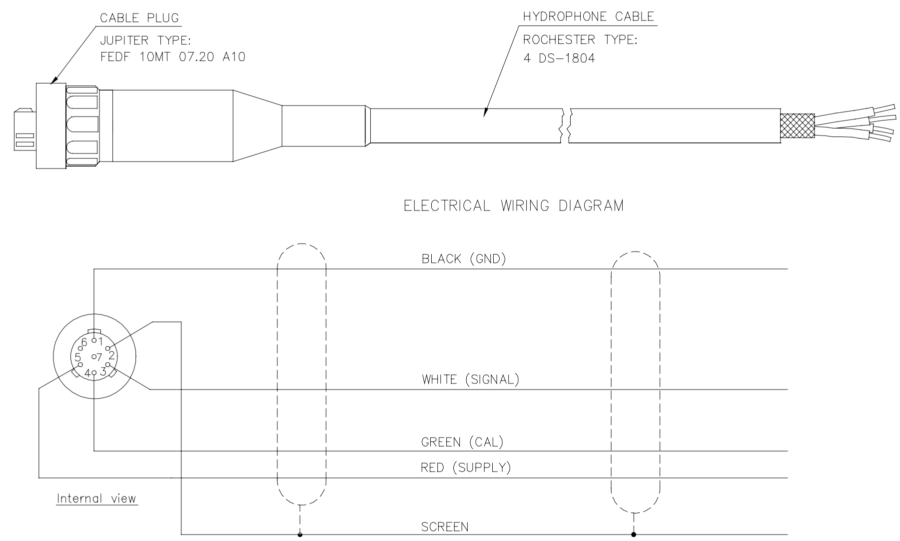
Apply the signal to the calibrate input, connector contact 4. = green wire of cable. Connect generator ground to sine generator ground, and measure the signal on hydrophone output.

Hydrophone TC4032

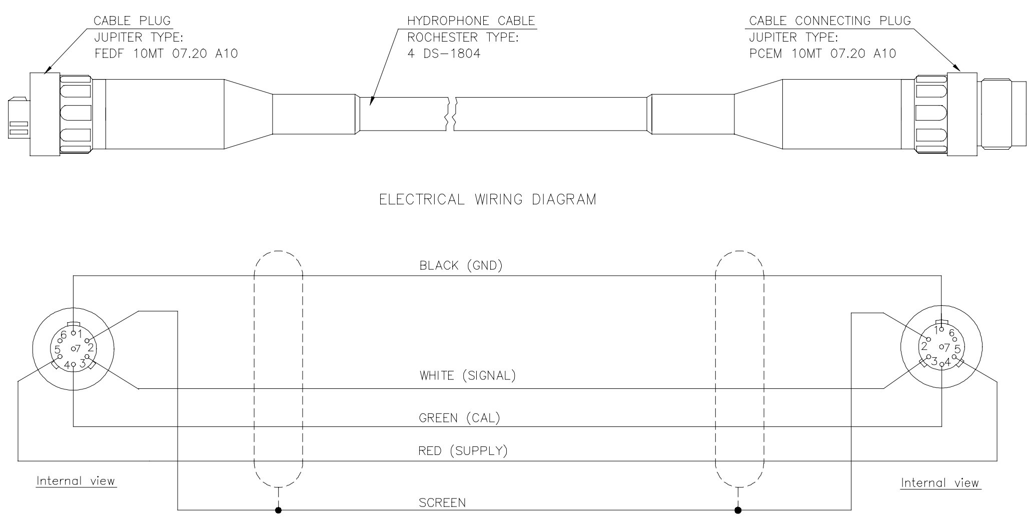
Low Noise Sea-State Zero Hydrophone

Accessories

TL8058
Std.: 10m extension
Weight in ait 1700g
Only for single ended use
Opt.: Different length on request

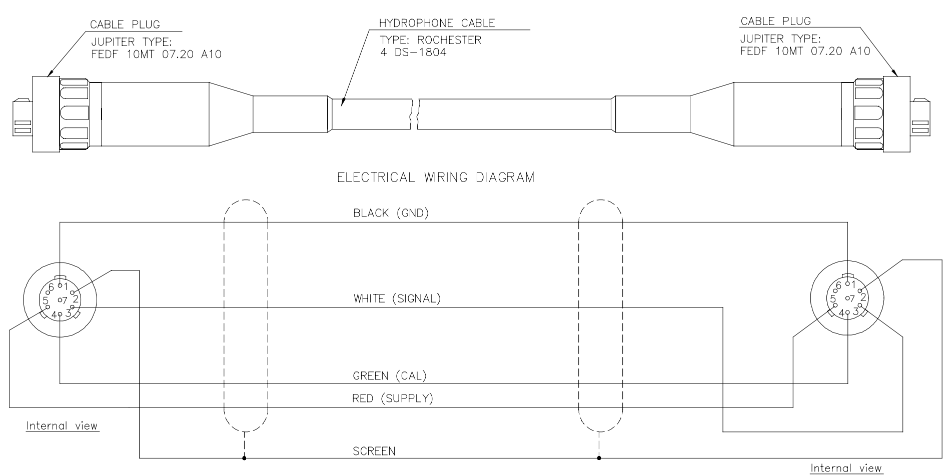


TL8059
Std.: 10m extension
Weight in ait 1800g
Only for single ended use
Opt.: Different length on request



TL8086
Std.: 10m extension
Weight in air 1800g
Only for single ended use
Opt.: Different length on request

Use cable TL8086 to connect
directly to EC6070 or EC6073



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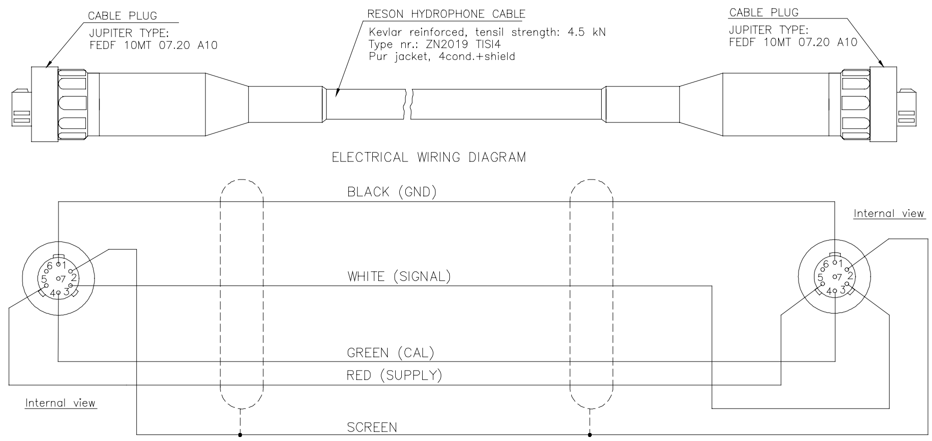
Hydrophone TC4032

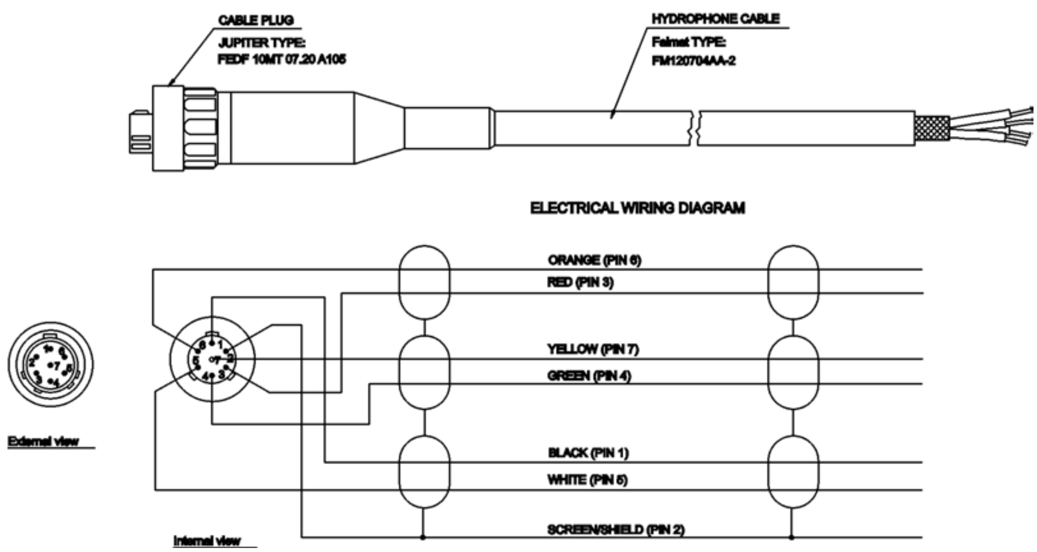
Low Noise Sea-State Zero Hydrophone

Accessories

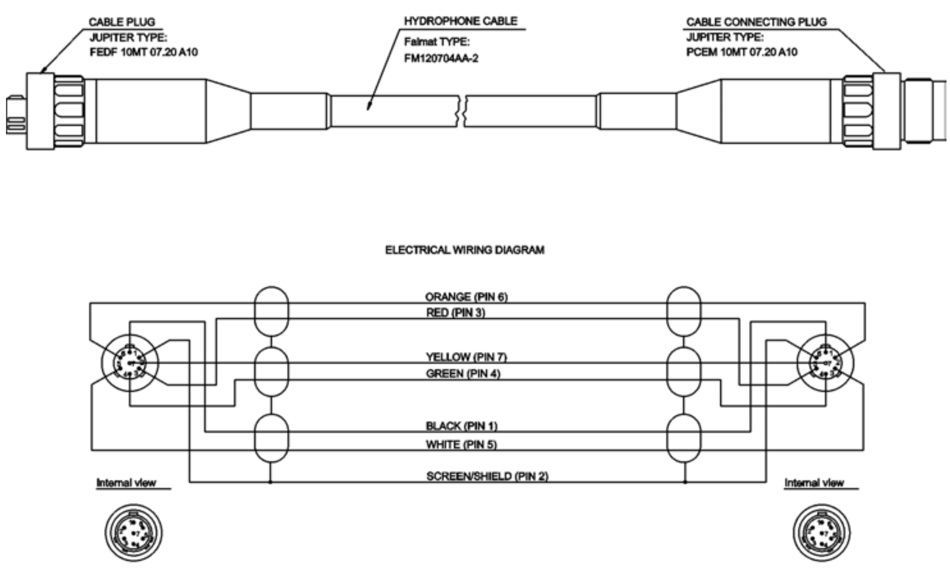
TL8091
Std.: 10m extension
Weight in ait 1400g
Only for single ended use
Opt.: Different length on request



TL8140
For differential and
single ended use



TL8142
For differential and
single ended use



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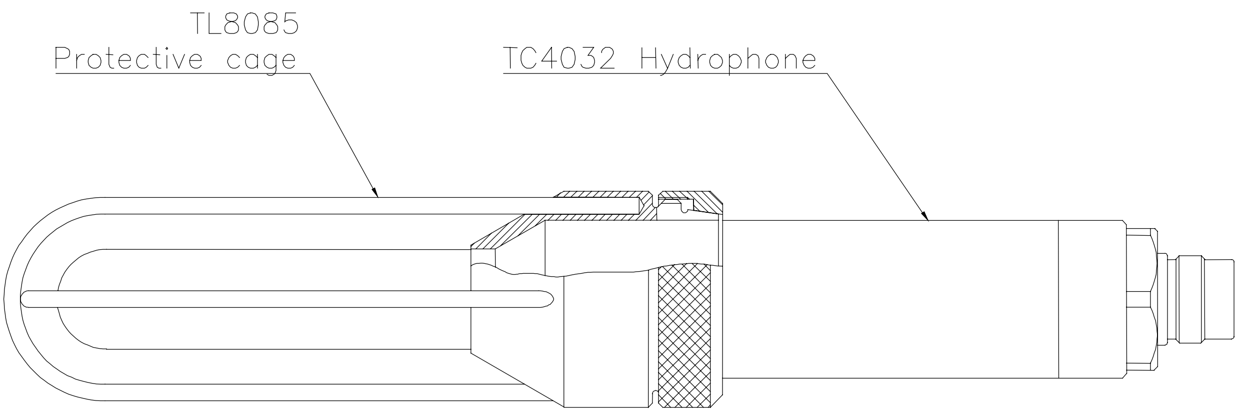
Hydrophone TC4032

Low Noise Sea-State Zero Hydrophone

Accessories

TL8085



For information on export control regulations on this product, please refer to **www.reson.com**

Version: B110 091103 / US

Teledyne RESON A/S
Denmark
Tel: +45 4738 0022
reson@teledyne-reson.com

Teledyne RESON Inc.
U.S.A.
Tel: +1 805 964-6260
sales@teledyne-reson.com

Teledyne RESON LTD.
Scotland U.K.
Tel: +44 1224 709 900
sales@reson.co.uk

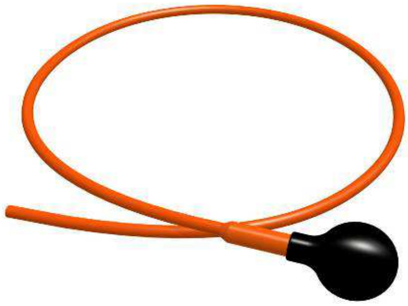
Teledyne RESON B.V.
The Netherlands
Tel: +31 (0) 10 245 1500
info@reson.nl

Teledyne RESON Pte. Ltd.
Singapore
Tel: +65 6725 9851
singapore@teledyne-reson.com

Teledyne RESON Shanghai Office
Shanghai
Tel: +86 21 6473 5403
shanghai@teledyne-reson.com

TELEDYNE RESON
Everywhereyoulook™

- 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.

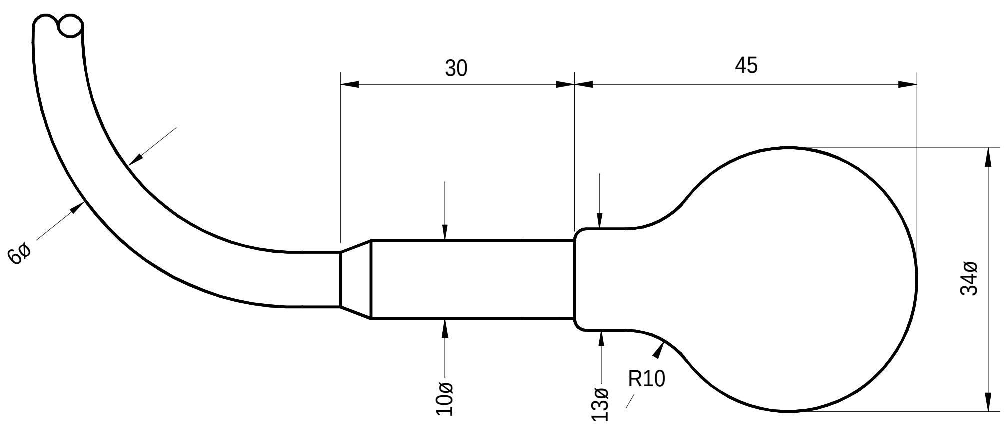
The all moulded construction and inherent strength of the PZT ceramic sphere achieves a robust, light weight, corrosion free design making it the ideal choice as a monitor hydrophone for air gun, boomer and other environments where high levels of shock are experienced.

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.

<u>This product is stocked by our world-wide distributor</u>

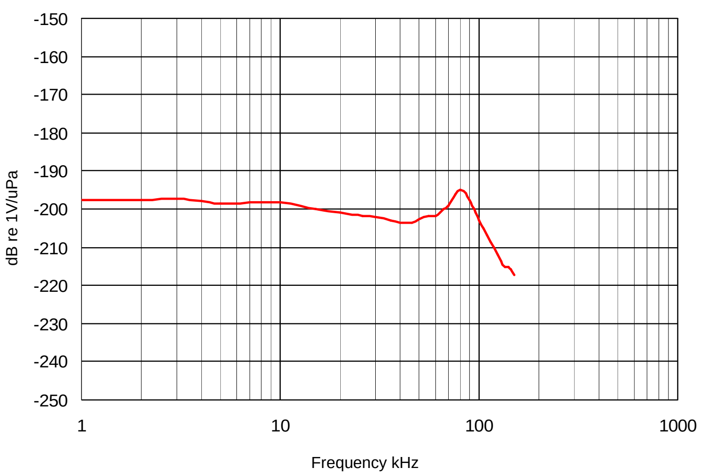
GSE Rentals Ltd, Aberdeen
Tel: +44 (0) 1224 771247
Fax: +44 (0) 1224 723116
E Mail: info@gserentals.co.uk



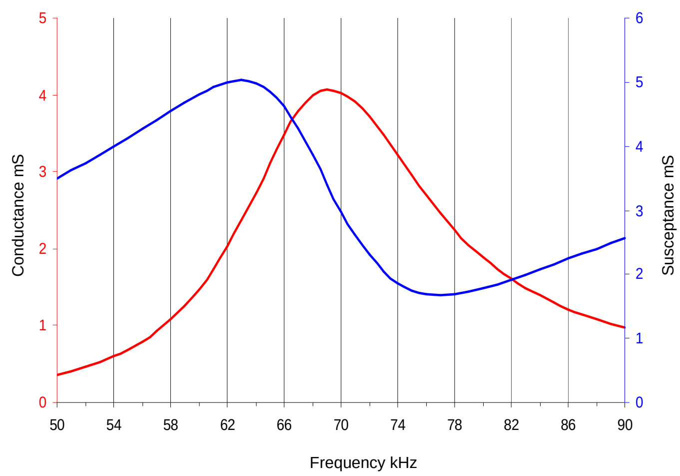
All dimensions in mm

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

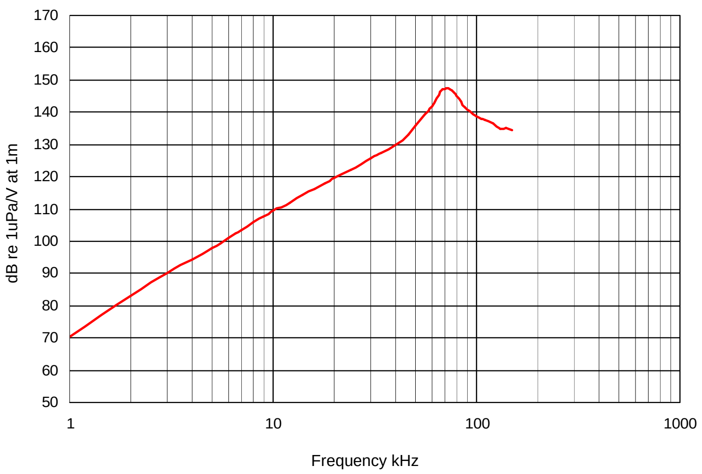
Receive Graph



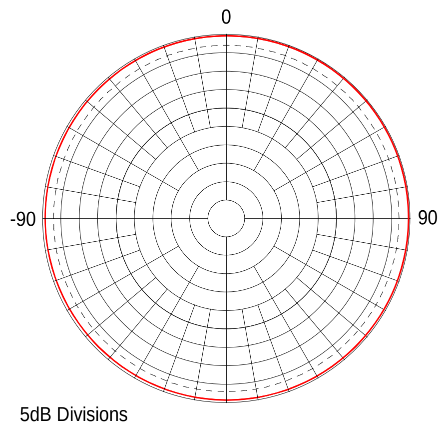
Admittance Plot



Transmit Graph



Beam Pattern at 70 kHz



Data illustrated is taken from actual in-water measurements

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] Engineer

[redacted].........

[redacted]. Griffiths

[redacted]

N. P. Dearing

Issued by:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire
TEL: +44(0) 1262 490234
FAX: +44(0) 1262 490485
Email: info@neptune-sonar.co.uk

Customer:

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: I. Bayles

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: I. Bayles

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

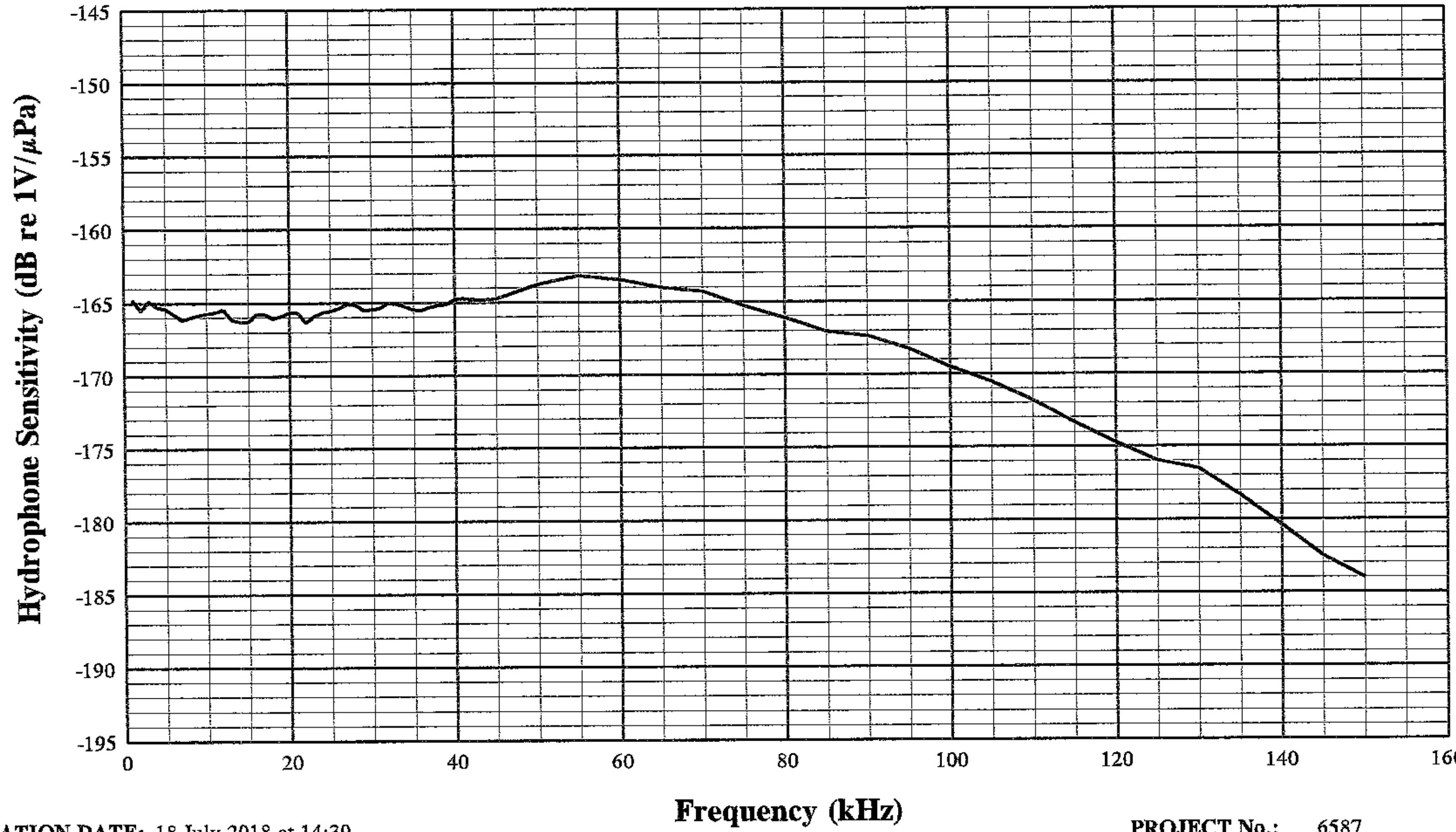
CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

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



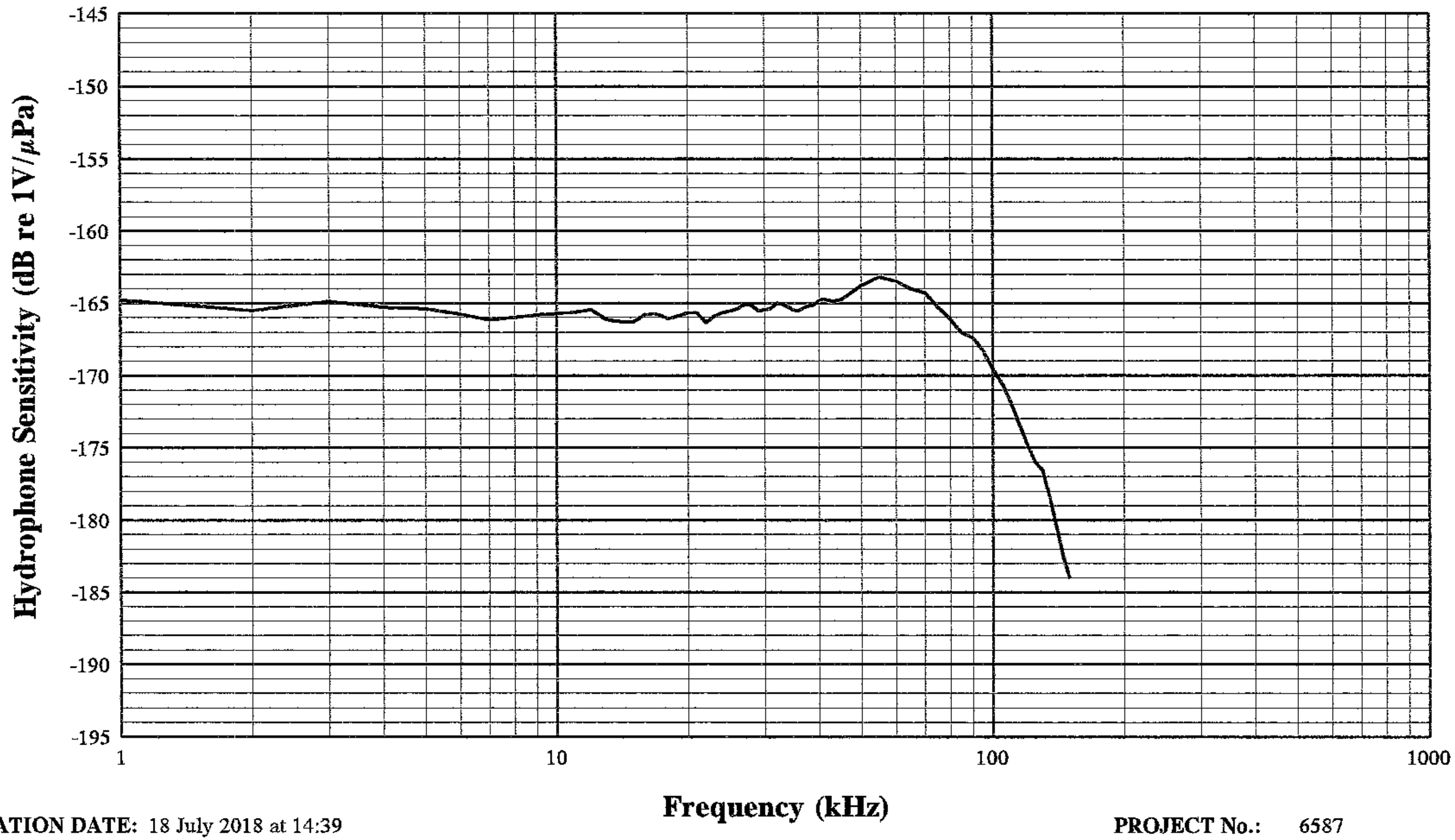
CALIBRATION DATE:	18 July 2018 at 14:39
TRANSDUCER TYPE:	TC4032-1 Reson
SERIAL NUMBER:	None
CALIBRATED BY:	I. Bayles
REMARKS:	10dB Pre-amp and H4B Box. Tested on lowest gain settings with no filters selected

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



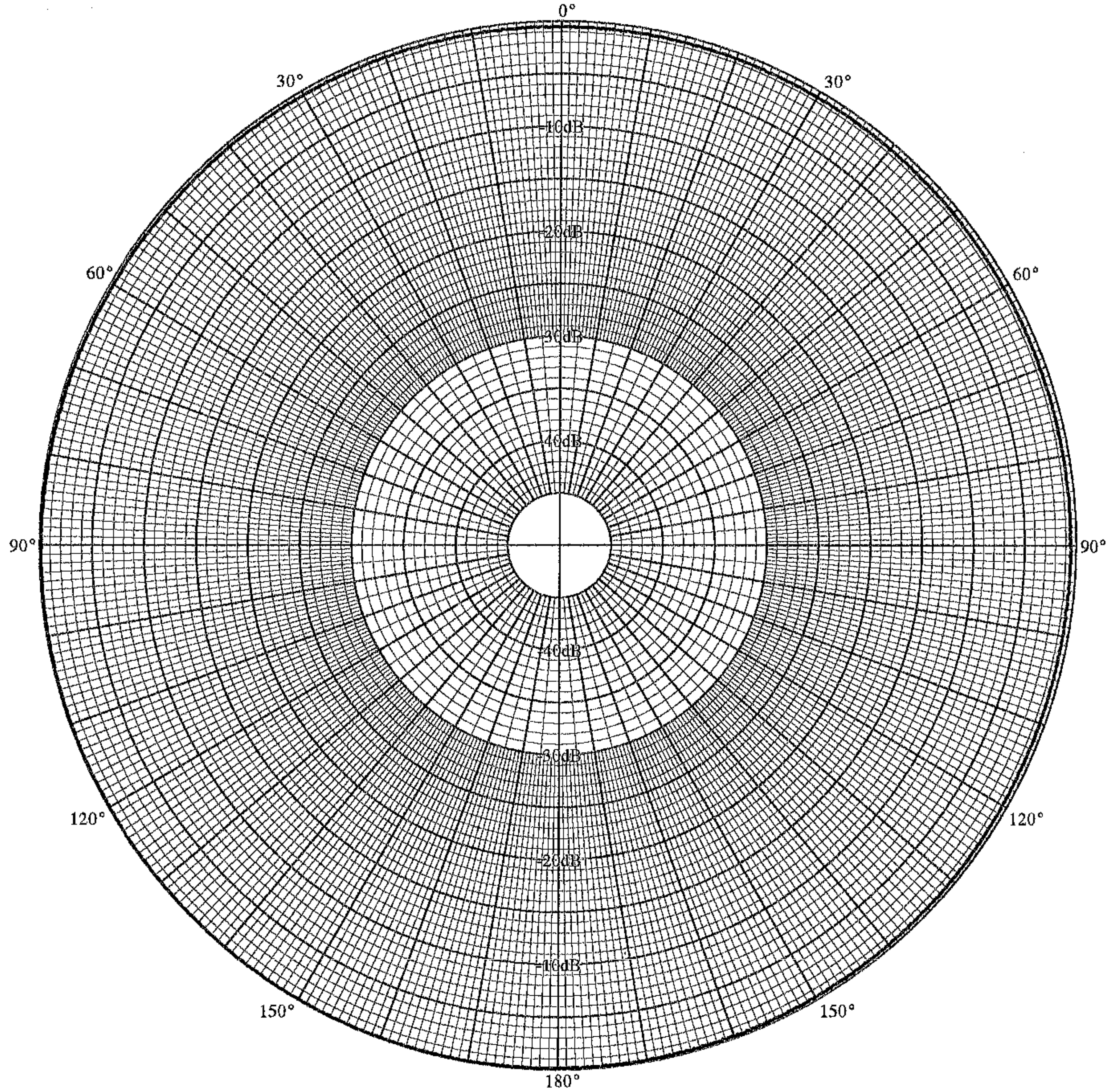
CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles
REMARKS: 10dB Pre-amp and H4B Box.
Tested on lowest gain settings with no filters selected

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:	I. Bayles	**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 B - CALIBRATION CERTIFICATES

Chickerell Bioacoustics H10
Neptune D/70 (H0 + H4)
RESON (TC4032-1) (H4B)

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

TEST CERTIFICATE

PROJECT REF:	6587
SERIAL NUMBER:	None
TRANSDUCER TYPE:	H10 (C B)
DESCRIPTION:	H10 + H10 Box
TEST SPECIFICATION:	Test Instructions
ISSUE DATE:	19 July 2018

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

[redacted] Engineer

[redacted].....

[redacted] I. Griffiths

[redacted]

N. P. Dearing

Issued by:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire
TEL: +44(0) 1262 490234
FAX: +44(0) 1262 490485
Email: info@neptune-sonar.co.uk

Customer:

Eco Fish Global Ltd
Aberdeen Harbour
Expansion Project
St Fittings 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: 19 July 2018 at 9:25
TRANSDUCER TYPE: H10 (C B)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

PROJECT No.: 6587
DESCRIPTION: H10 + H10 Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 15m cable

REMARKS: +26dB to -20db switchable pre amp
Tested with H10TU set to -20dB

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
1.000	-221.4	±1.5
2.000	-221.2	±1.0
3.000	-223.1	±1.0
4.000	-221.2	±1.0
5.000	-220.3	±1.0
6.000	-221.3	±1.0
7.000	-220.9	±1.0
8.000	-221.1	±1.0
9.000	-221.3	±1.0
10.000	-221.8	±1.0
11.000	-222.1	±1.0
12.000	-221.7	±1.0
13.000	-221.9	±1.0
14.000	-221.5	±1.0
15.000	-221.6	±1.0
16.000	-221.1	±1.0
17.000	-221.7	±1.0
18.000	-222.3	±1.0
19.000	-221.9	±1.0
20.000	-222.1	±1.0
21.000	-222.3	±1.0
22.000	-223.0	±1.0
23.000	-223.1	±1.0
24.000	-223.5	±1.0
25.000	-223.6	±1.0
26.000	-223.6	±1.0
27.000	-223.3	±1.0
28.000	-223.4	±1.0
29.000	-223.4	±1.0
30.000	-223.2	±1.0

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 19 July 2018 at 9:25
TRANSDUCER TYPE: H10 (C B)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

PROJECT No.: 6587
DESCRIPTION: H10 + H10 Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 15m cable

REMARKS: +26dB to -20db switchable pre amp
Tested with H10TU set to -20dB

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
31.000	-223.2	±1.0
32.000	-223.0	±1.0
33.000	-223.0	±1.0
34.000	-223.2	±1.0
35.000	-223.3	±1.0
36.000	-223.4	±1.0
37.000	-223.8	±1.0
38.000	-224.5	±1.0
39.000	-225.0	±1.0
40.000	-225.0	±1.0
41.000	-225.0	±1.0
42.000	-225.0	±1.0
43.000	-225.2	±1.0
44.000	-225.4	±1.0
45.000	-225.4	±1.0
50.000	-225.9	±1.0
55.000	-226.6	±1.0
60.000	-227.3	±1.0
65.000	-229.0	±1.0
70.000	-227.9	±1.0
75.000	-229.3	±1.0
80.000	-229.1	±1.0
85.000	-227.9	±1.0
90.000	-226.3	±1.0
95.000	-225.2	±1.0
100.000	-225.5	±1.0
105.000	-225.8	±1.0
110.000	-226.2	±1.0
115.000	-226.4	±1.0
120.000	-226.0	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

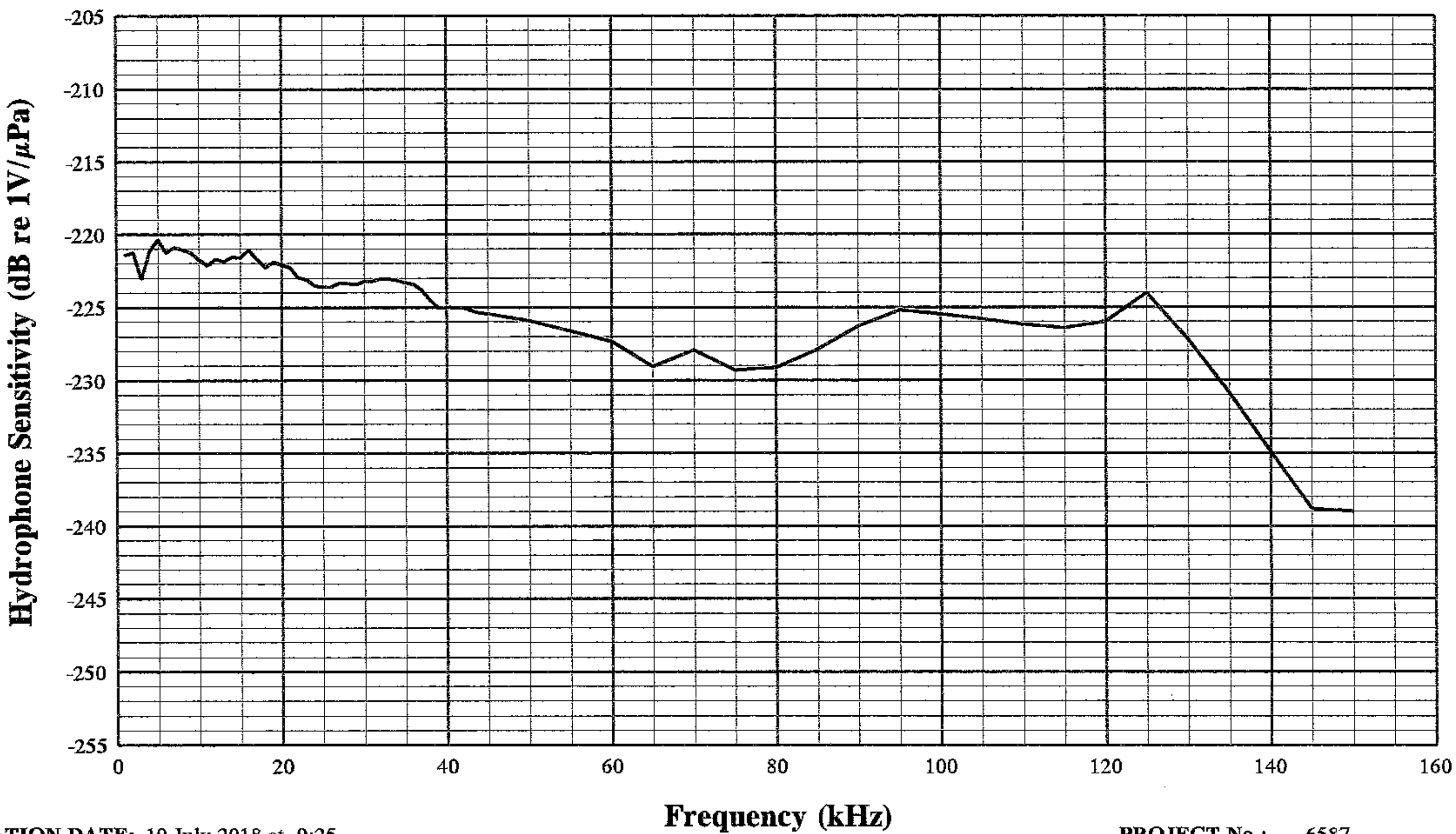
CALIBRATION DATE: 19 July 2018 at 9:25
TRANSDUCER TYPE: H10 (C B)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

PROJECT No.: 6587
DESCRIPTION: H10 + H10 Box
TEST SPECIFICATION: Test Instructions
WATER TEMPERATURE: 22°C (±0.5)
CABLE: 15m cable

REMARKS: +26dB to -20db switchable pre amp
Tested with H10TU set to -20dB

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
125.000	-224.0	±1.0
130.000	-227.2	±1.0
135.000	-230.8	±1.0
140.000	-234.9	±1.0
145.000	-238.8	±1.0
150.000	-239.0	±1.0

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY



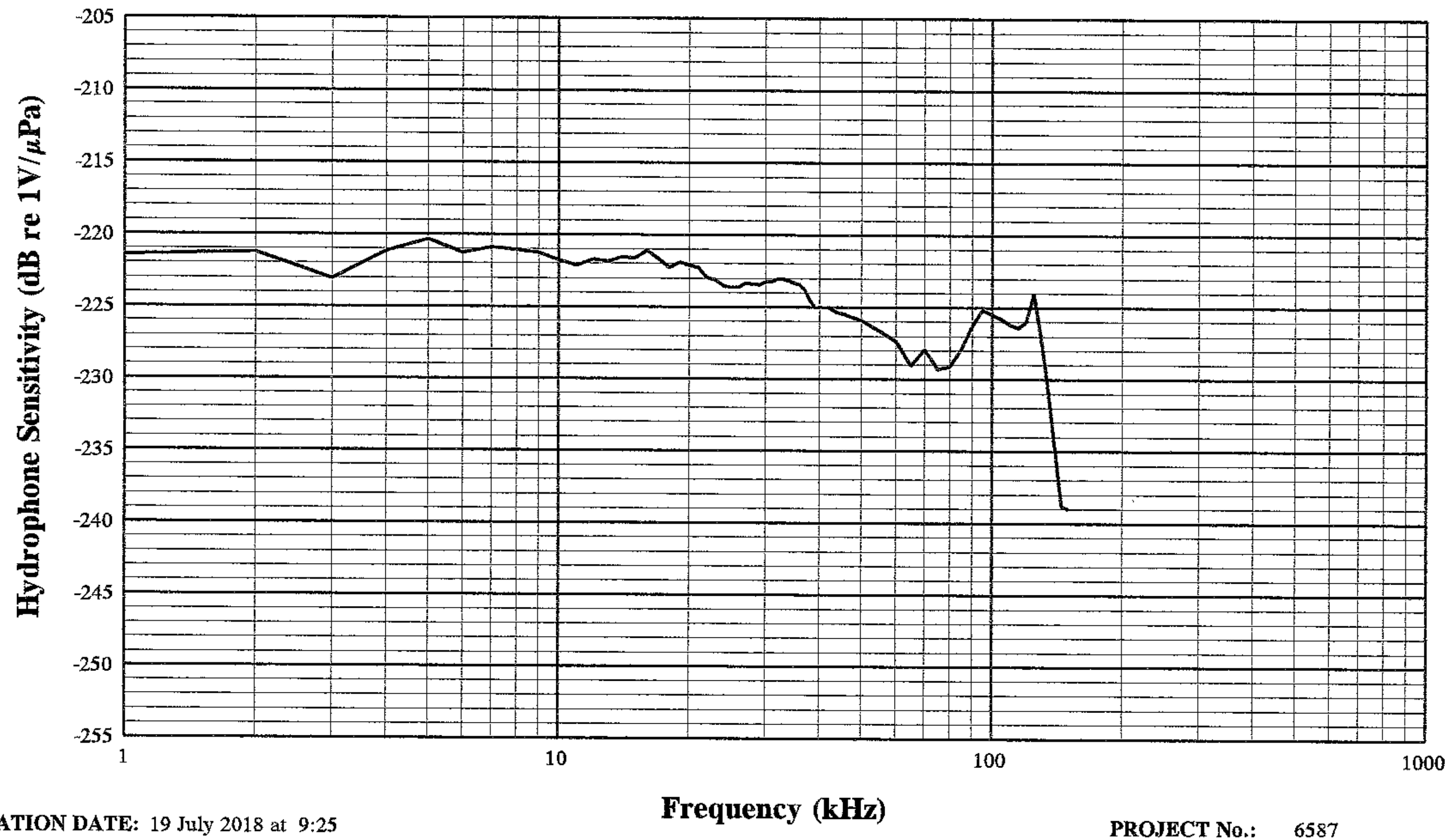
CALIBRATION DATE: 19 July 2018 at 9:25
TRANSDUCER TYPE: H10 (C B)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles
REMARKS: +26dB to -20db switchable pre amp
Tested with H10TU set to -20dB

PROJECT No.: 6587
DESCRIPTION: H10 + H10 Box
TEST SPEC: Test Instructions
WATER TEMP: 22°C (±0.5)
CABLE: 15m cable

Ref:-M_H10(H10TU):12:27:41

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY



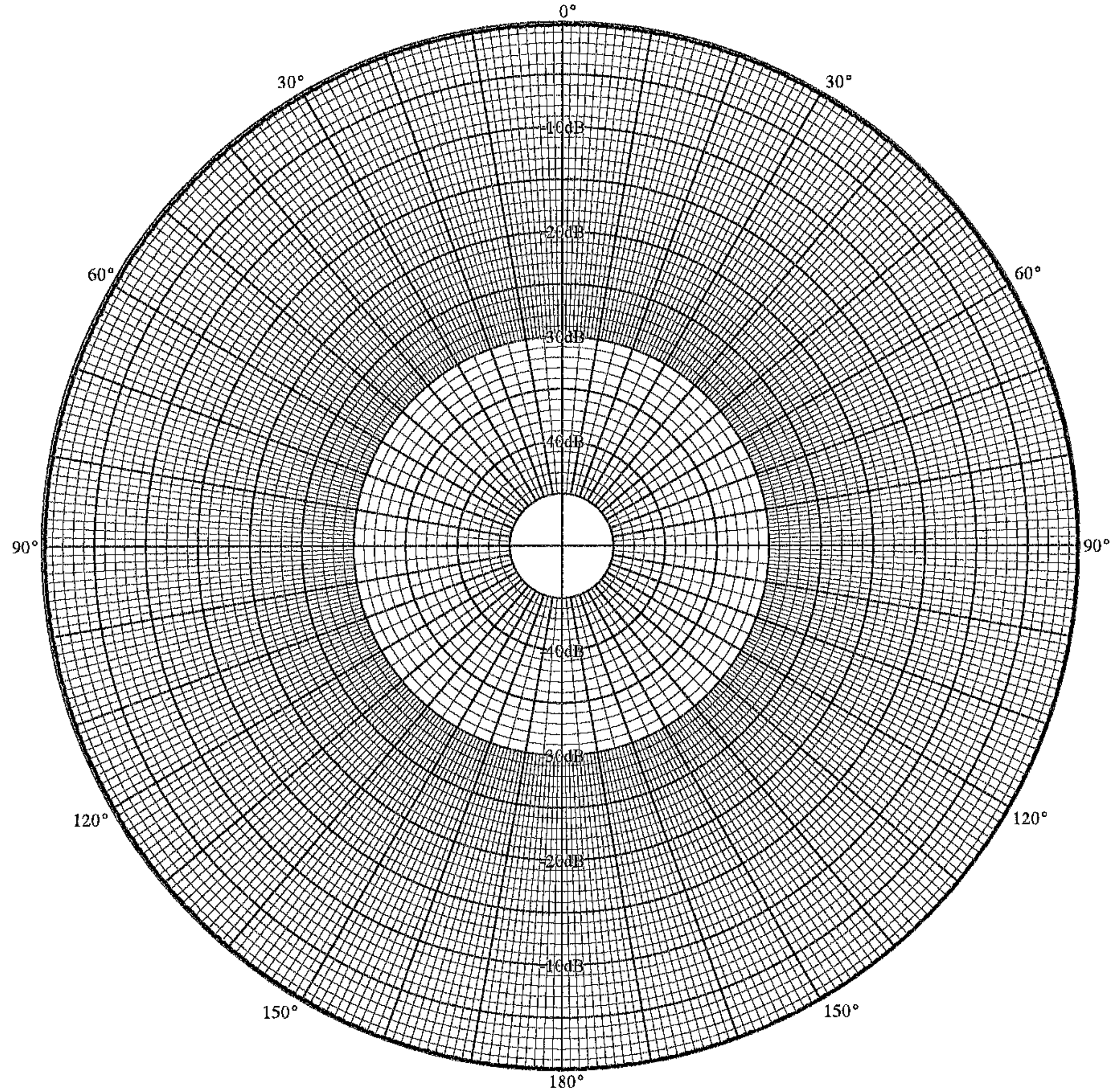
CALIBRATION DATE:	19 July 2018 at 9:25
TRANSDUCER TYPE:	H10 (C B)
SERIAL NUMBER:	None
CALIBRATED BY:	I. Bayles
REMARKS:	+26dB to -20db switchable pre amp Tested with H10TU set to -20dB

PROJECT No.:	6587
DESCRIPTION:	H10 + H10 Box
TEST SPEC:	Test Instructions
WATER TEMP:	22°C (±0.5)
CABLE:	15m cable

Ref:-M_H10(H10TU):12:27:51

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE:	19 July 2018 at 8:37	**PROJECT NO.:**	6587
TRANSDUCER TYPE:	H10 (C B)	**DESCRIPTION:**	H10 + H10 Box
SERIAL NUMBER:	None	**TEST SPECIFICATION:**	Test Instructions
CALIBRATED BY:	I. Bayles	**WATER TEMPERATURE:**	22°C



FREQUENCY:	10 kHz	**3dB BEAMWIDTH:**	N/A
0° ALIGNMENT:	MECHANICAL	**OVERALL VARIATION:**	.4dB
ROTATION:	360°	**SMOOTHING APPLIED:**	None

REMARKS: +26dB to -20db switchable pre amp
Tested with H10TU set to -20dB

Ref:-PH@10_H10(H10TU):12:26:42

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

TEST CERTIFICATE

PROJECT REF:	6587
SERIAL NUMBER:	None
TRANSDUCER TYPE:	D70(H0)
DESCRIPTION:	D/70 with H0 Box
TEST SPECIFICATION:	Test Instructions
ISSUE DATE:	17 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]gineer

[redacted]........

[redacted]. Griffiths

[redacted]

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire
TEL: +44(0) 1262 490234
FAX: +44(0) 1262 490485
Email: info@neptune-sonar.co.uk

[redacted]

[redacted] N. P. Dearing

Customer:

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: 17 July 2018 at 12:00
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: I. Bayles

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

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

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/µPa)	UNCERTAINTY (dB)
1.000	-223.1	±1.5
2.000	-222.9	±1.0
3.000	-223.7	±1.0
4.000	-223.3	±1.0
5.000	-222.7	±1.0
6.000	-222.5	±1.0
7.000	-222.9	±1.0
8.000	-223.0	±1.0
9.000	-224.0	±1.0
10.000	-224.7	±1.0
11.000	-225.1	±1.0
12.000	-224.9	±1.0
13.000	-225.4	±1.0
14.000	-225.3	±1.0
15.000	-225.8	±1.0
16.000	-224.7	±1.0
17.000	-224.8	±1.0
18.000	-225.1	±1.0
19.000	-225.2	±1.0
20.000	-225.4	±1.0
21.000	-225.3	±1.0
22.000	-225.9	±1.0
23.000	-226.3	±1.0
24.000	-226.8	±1.0
25.000	-227.0	±1.0
26.000	-227.4	±1.0
27.000	-227.9	±1.0
28.000	-228.2	±1.0
29.000	-228.3	±1.0
30.000	-228.1	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 17 July 2018 at 12:00
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: I. Bayles

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

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

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/µPa)	UNCERTAINTY (dB)
31.000	-228.5	±1.0
32.000	-228.9	±1.0
33.000	-229.3	±1.0
34.000	-229.8	±1.0
35.000	-229.5	±1.0
36.000	-229.5	±1.0
37.000	-229.6	±1.0
38.000	-229.2	±1.0
39.000	-229.3	±1.0
40.000	-229.5	±1.0
41.000	-229.6	±1.0
42.000	-229.8	±1.0
43.000	-229.5	±1.0
44.000	-229.3	±1.0
45.000	-229.0	±1.0
50.000	-228.2	±1.0
55.000	-228.3	±1.0
60.000	-227.0	±1.0
65.000	-225.6	±1.0
70.000	-223.9	±1.0
75.000	-222.3	±1.0
80.000	-219.8	±1.0
85.000	-218.6	±1.0
90.000	-219.5	±1.0
95.000	-223.5	±1.0
100.000	-227.0	±1.0
105.000	-229.7	±1.0
110.000	-231.9	±1.0
115.000	-233.2	±1.0
120.000	-232.8	±1.0

NEPTUNE SONAR LTD

ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 17 July 2018 at 12:00
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: I. Bayles

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

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

FREQUENCY (kHz) (±0.005%)	HYDROPHONE SENSITIVITY (dBre1V/μPa)	UNCERTAINTY (dB)
125.000	-239.4	±1.0
130.000	-239.8	±1.0
135.000	-248.3	±1.0
140.000	-251.2	±1.0
145.000	-255.7	±1.0
150.000	-259.5	±1.0

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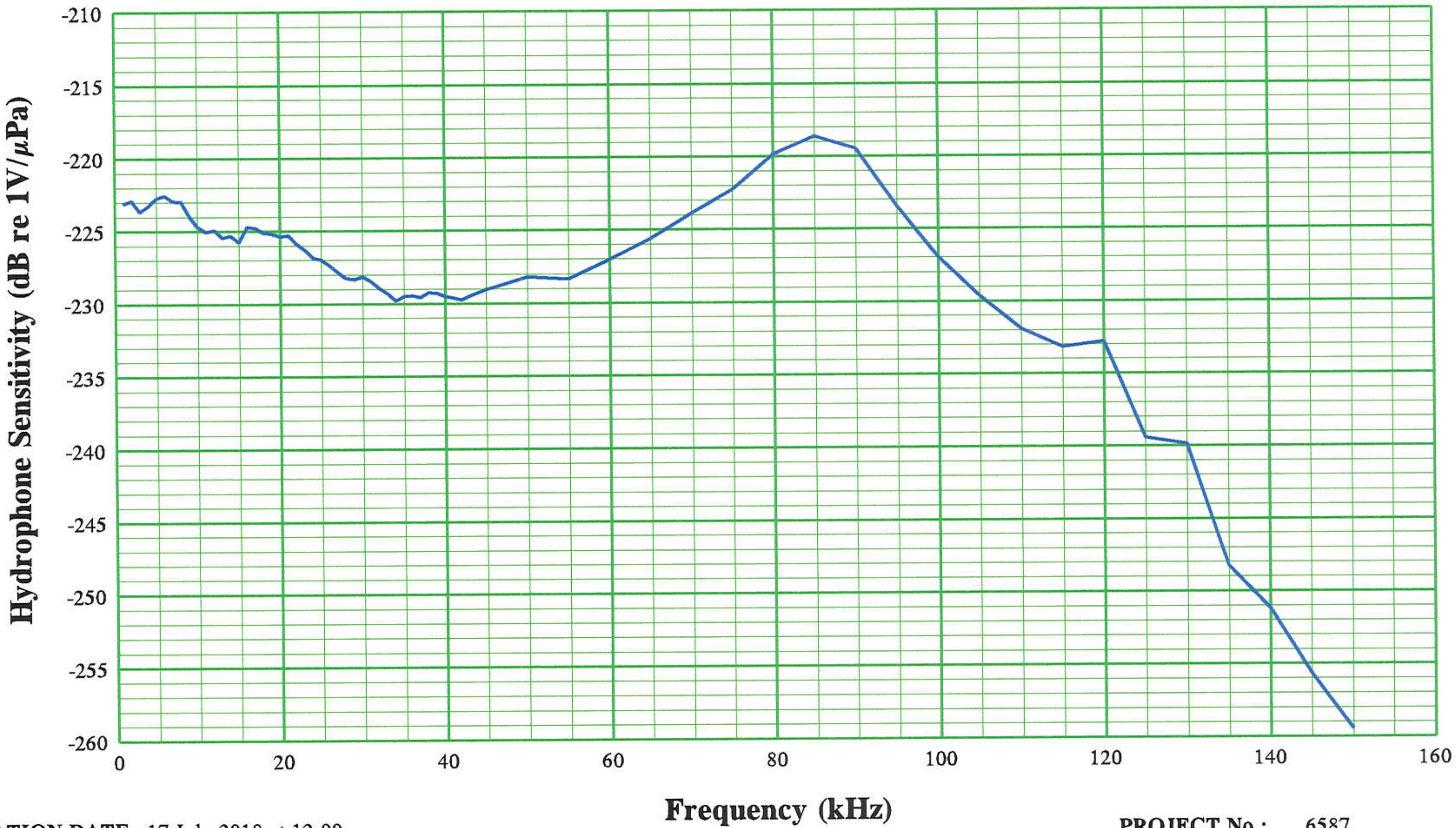
ACOUSTIC CALIBRATION LABORATORY



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TRANSDUCER TYPE:	D70(H0)		**DESCRIPTION:**	D/70 with H0 Box
SERIAL NUMBER:			**TEST SPEC:**	
CALIBRATED BY:	I. Bayles		**WATER TEMP:**	22°C (±0.5)
REMARKS:	Set to -20 gain and no filters 0 to -20dB gain pre amp and H0 box		**CABLE:**	15m

Ref:-M_D70(H0):12:01:29

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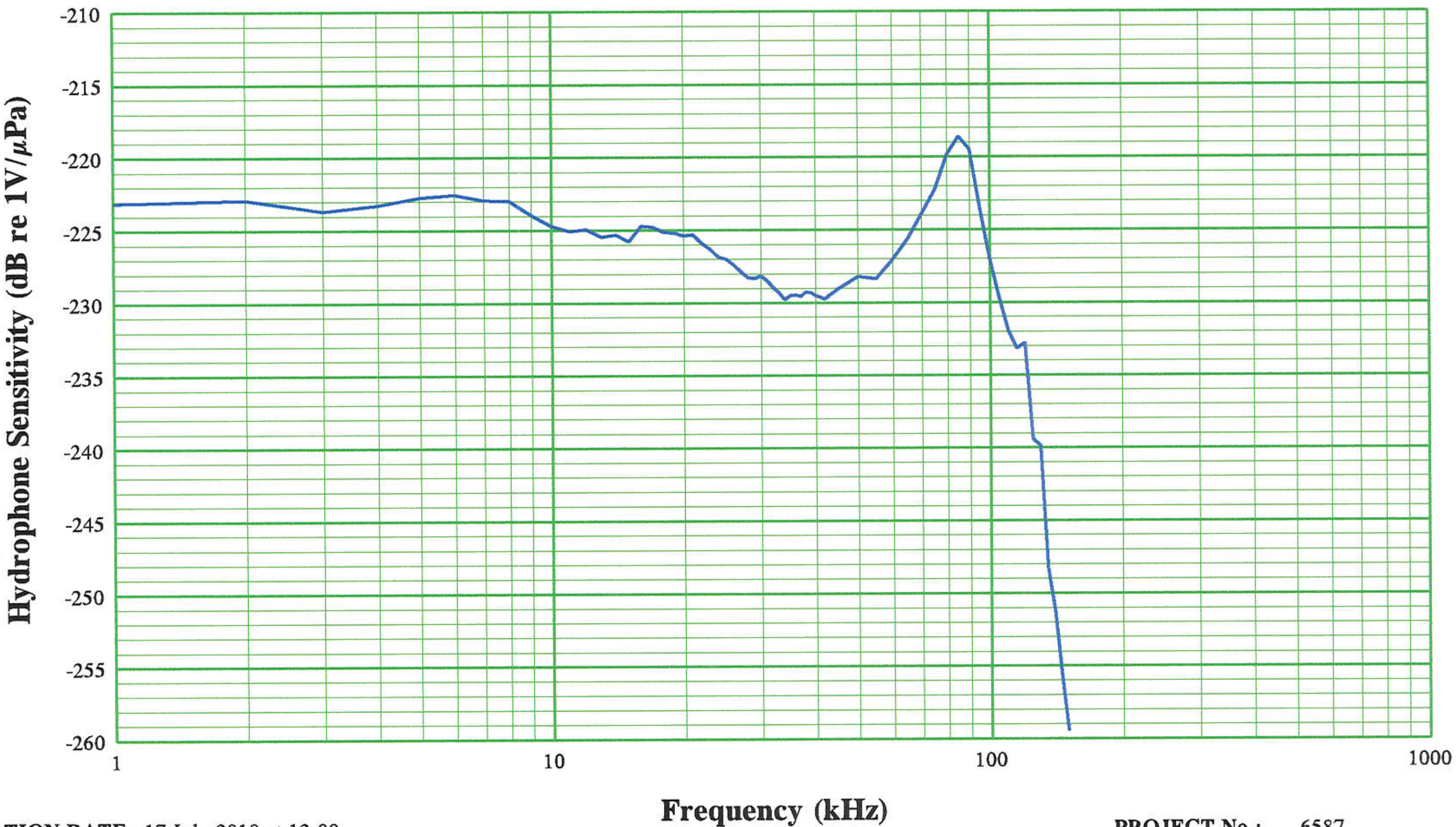
ACOUSTIC CALIBRATION LABORATORY



CALIBRATION DATE:	17 July 2018 at 12:00
TRANSDUCER TYPE:	D70(H0)
SERIAL NUMBER:	
CALIBRATED BY:	I. Bayles
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

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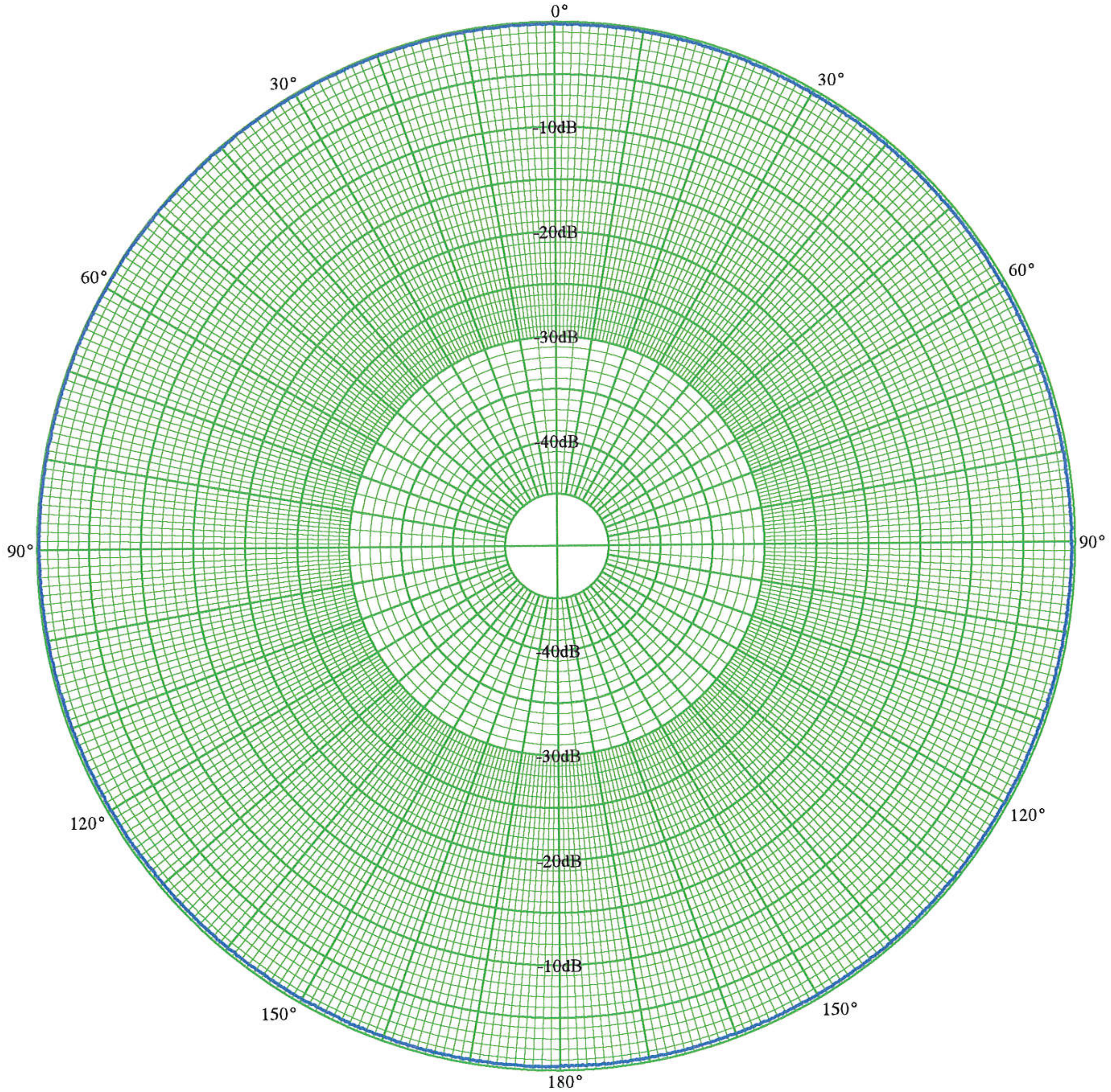
ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 17 July 2018 at 10:59
TRANSDUCER TYPE: D70(H0)
SERIAL NUMBER:
CALIBRATED BY: I. Bayles

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)**

Calibration Engineer

[redacted]......

[redacted] **I. Griffiths**

Quality Executive

[redacted]

N. P. Dearing

Issued by:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire
TEL: +44(0) 1262 490234
FAX: +44(0) 1262 490485
Email: info@neptune-sonar.co.uk

Customer:

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%

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ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

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: I. Bayles

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: I. Bayles

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

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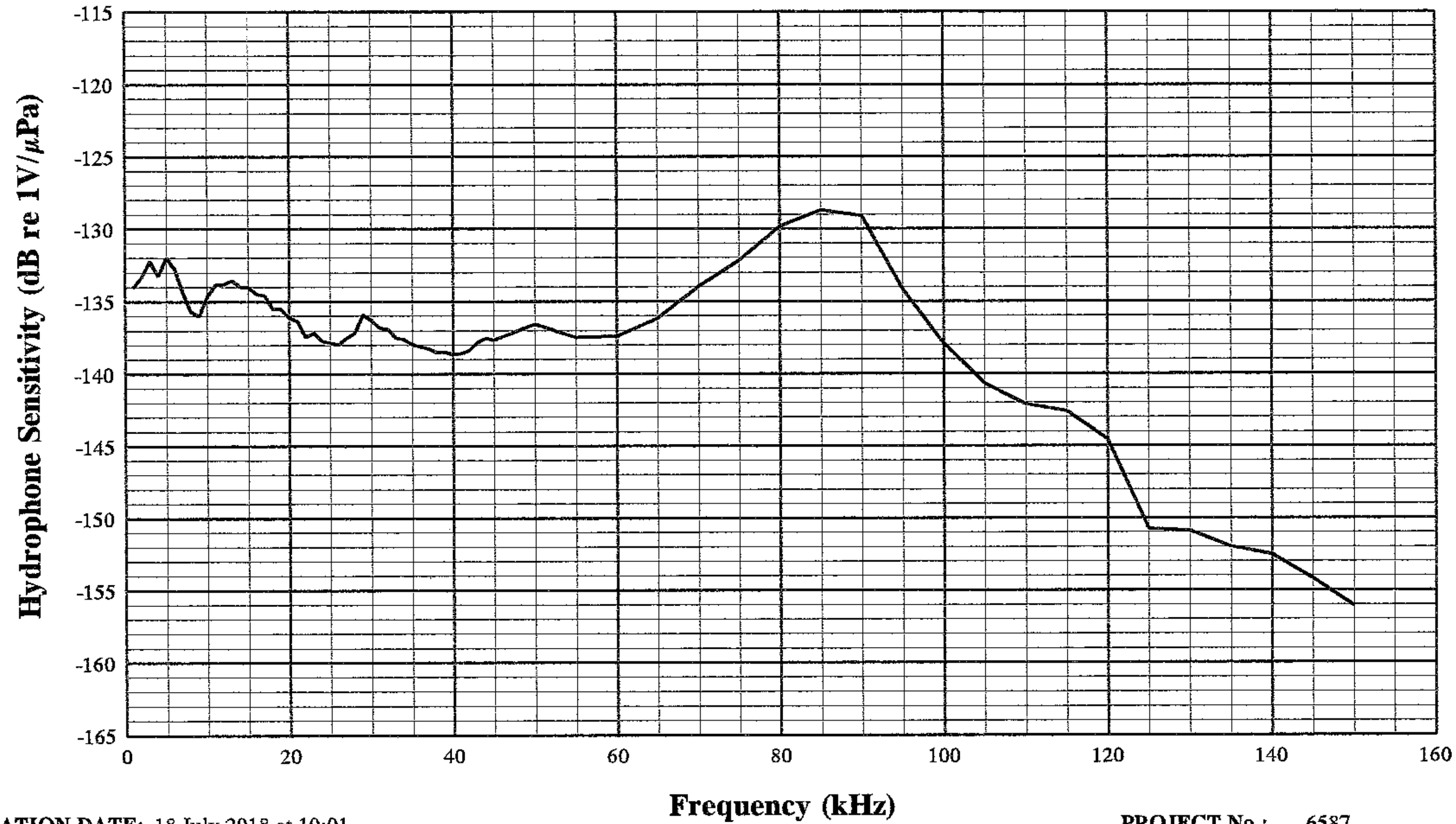
ACOUSTIC CALIBRATION LABORATORY



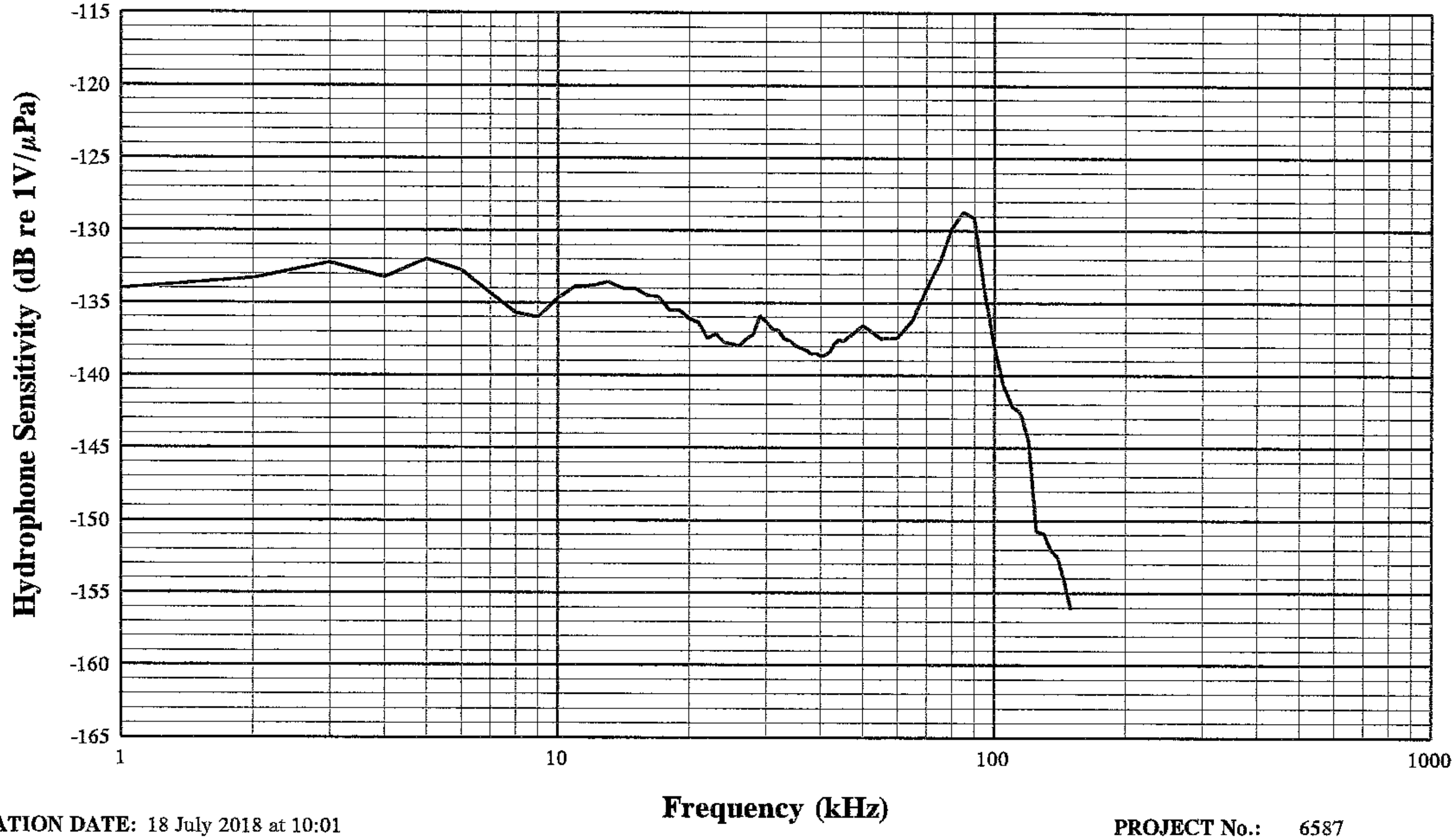
CALIBRATION DATE: 18 July 2018 at 10:01
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles
REMARKS: 36dB Pre-amp and HSS Box. Tested with 20m cable
Tested on lowest gain settings with no filters selected

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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TRANSDUCER TYPE:	D70(Ambient)
SERIAL NUMBER:	None
CALIBRATED BY:	I. Bayles
REMARKS:	36dB Pre-amp and HSS Box. Tested with 20m cable Tested on lowest gain settings with no filters selected

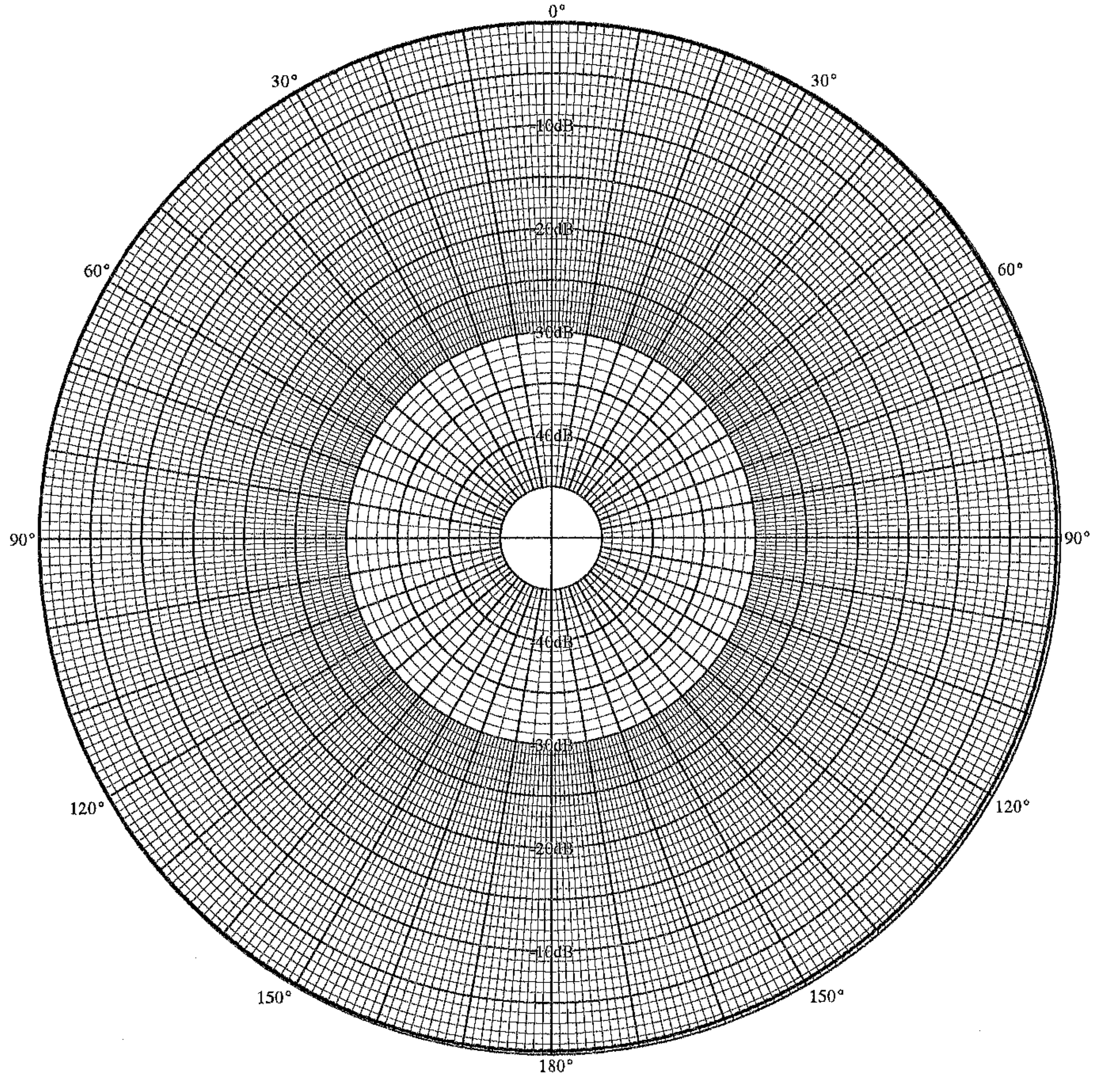
PROJECT No.:	6587
DESCRIPTION:	D/70 with HSS Box
TEST SPEC:	Test Instructions
WATER TEMP:	22°C (±0.5)
CABLE:	3m cable

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

NEPTUNE SONAR LTD
ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 11:57
TRANSDUCER TYPE: D70(Ambient)
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

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



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

3dB BEAMWIDTH: N/A
OVERALL VARIATION: .6dB
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] Engineer

[redacted].........

[redacted] I. Griffiths

[redacted]

N. P. Dearing

Issued by:

Neptune Sonar Ltd
Kelk Lake
Kelk
Driffield
East Yorkshire
TEL: +44(0) 1262 490234
FAX: +44(0) 1262 490485
Email: info@neptune-sonar.co.uk

Customer:

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%

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ACOUSTIC CALIBRATION LABORATORY

CALIBRATION DATE: 18 July 2018 at 14:39
TRANSDUCER TYPE: TC4032-1 Reson
SERIAL NUMBER: None
CALIBRATED BY: I. Bayles

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: I. Bayles

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: I. Bayles

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

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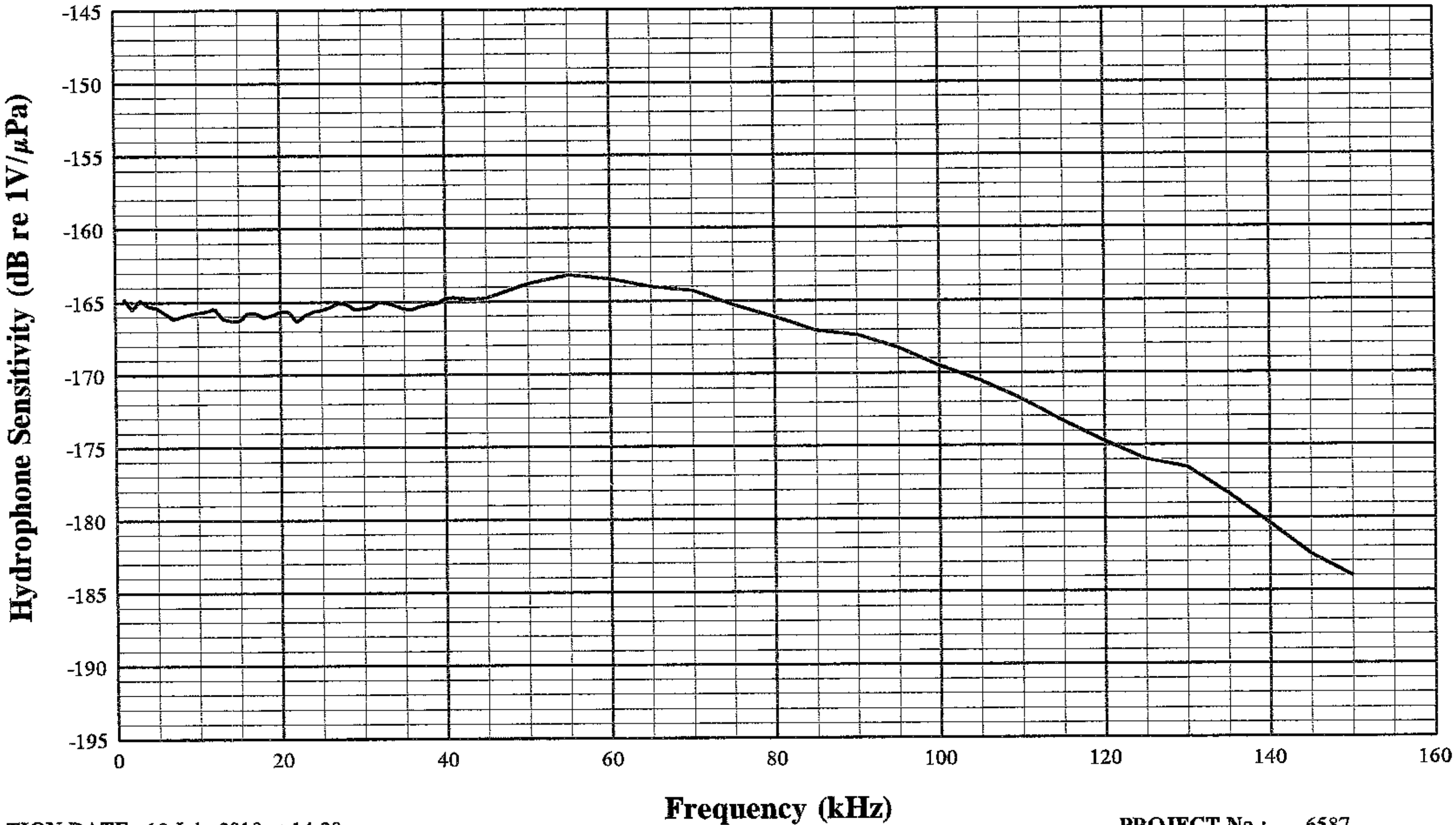
ACOUSTIC CALIBRATION LABORATORY



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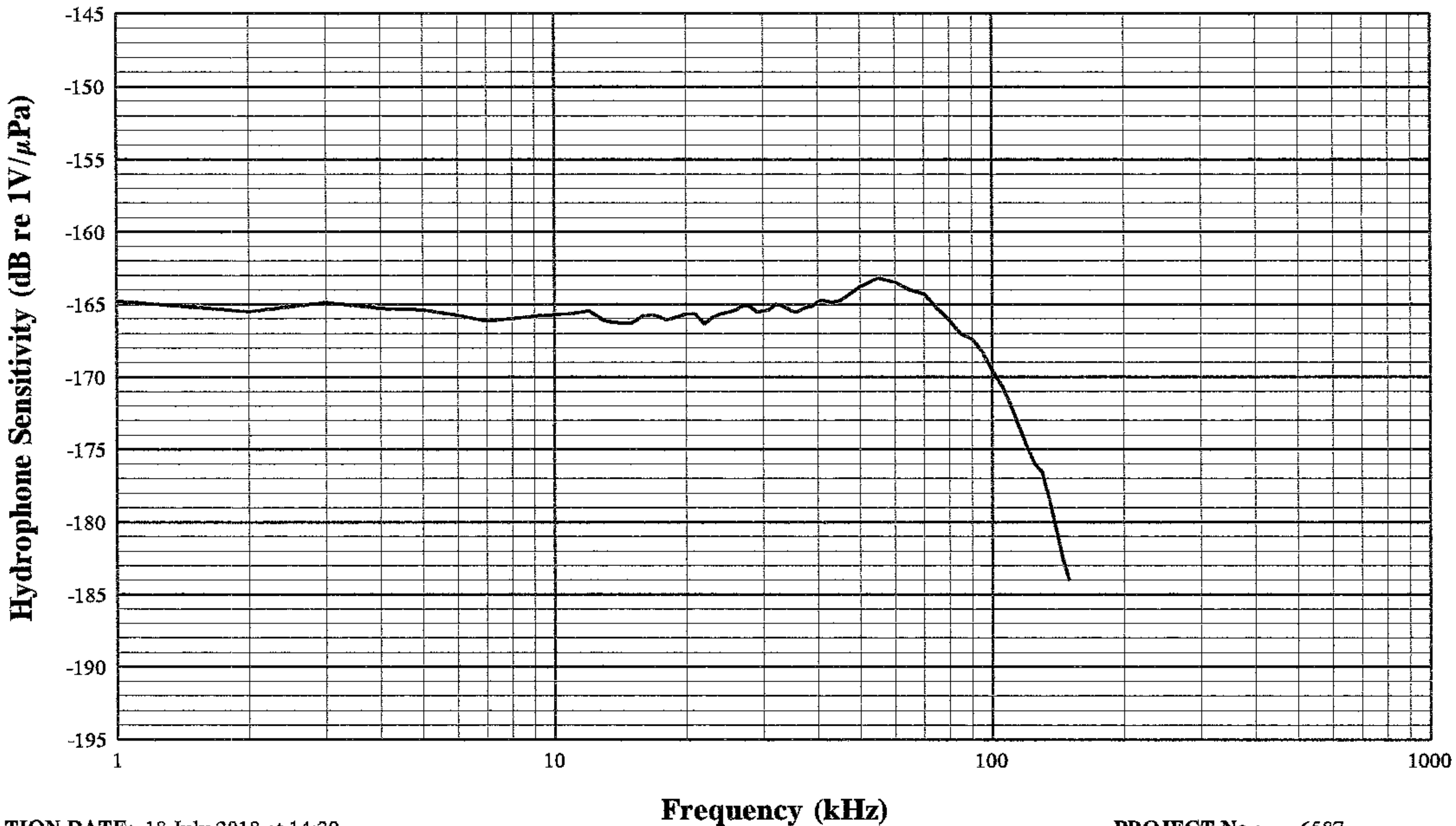
TRANSDUCER TYPE:	TC4032-1 Reson
SERIAL NUMBER:	None
CALIBRATED BY:	I. Bayles
REMARKS:	10dB Pre-amp and H4B Box. Tested on lowest gain settings with no filters selected

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

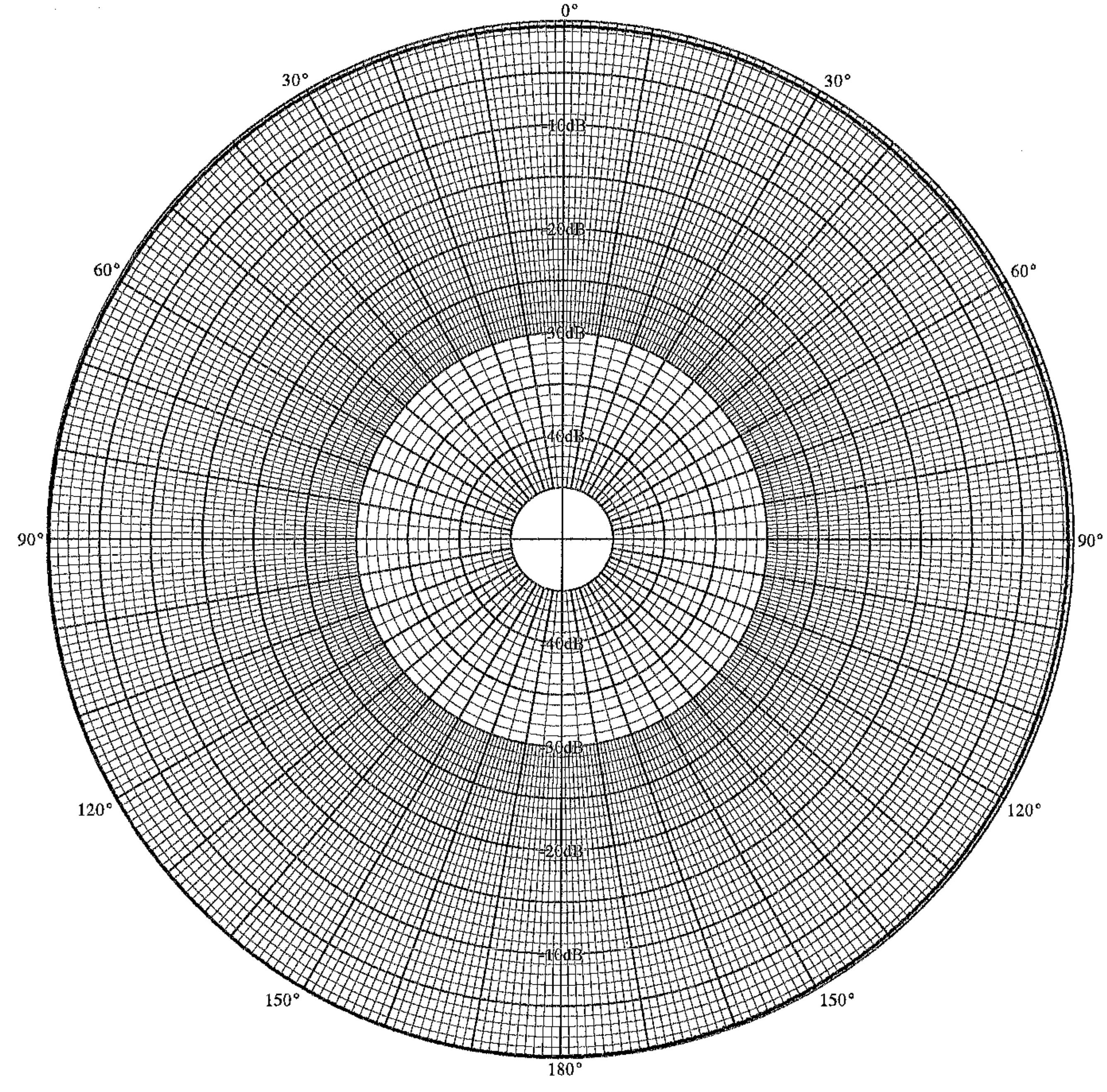


CALIBRATION DATE:	18 July 2018 at 14:39	**PROJECT No.:**	6587
TRANSDUCER TYPE:	TC4032-1 Reson	**DESCRIPTION:**	Teledyne Reson + H4B Box
SERIAL NUMBER:	None	**TEST SPEC:**	Test Instructions
CALIBRATED BY:	I. Bayles	**WATER TEMP:**	22°C (±0.5)
REMARKS:	10dB Pre-amp and H4B Box. Tested on lowest gain settings with no filters selected	**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:	I. Bayles	**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

Ed Harland

CBA11X/18 iss. 1.2
July 2018

Changes

1.0 First draft

1.1 Measurement section expanded

Contents

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

Ed Harland

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.

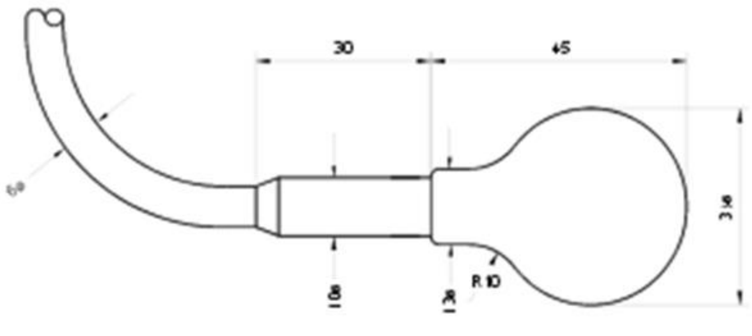
The all moulded construction and inherent strength of the PZT ceramic sphere achieves a robust, light weight, corrosion free design making it the ideal choice as a monitor hydrophone for air gun, boomer and other environments where high levels of shock are experienced.

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.

<u>This product is stocked by our world-wide distributor</u>

GSE Rentals Ltd, Aberdeen
Tel: +44 (0) 1224 771247
Fax: +44 (0) 1224 723116
E Mail: info@gserentals.co.uk



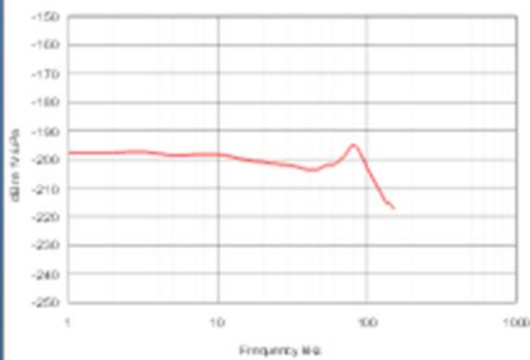
All dimensions in mm

MODEL D/70

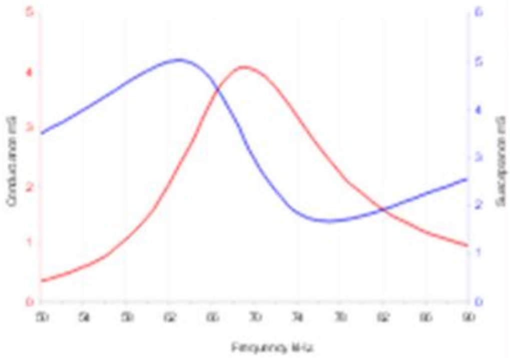
Spherical Transducers

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

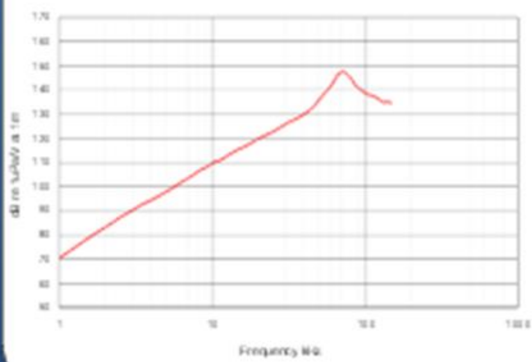
Receive Graph



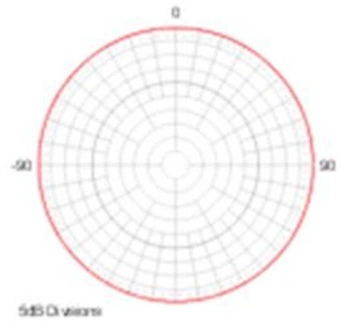
Admittance Plot



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

Ed Harland

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

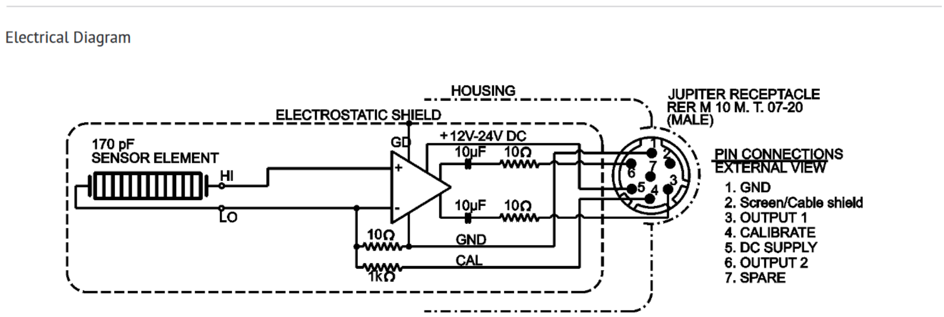


Figure 2. Electrical diagram of the Reson TC4032 hydrophone assembly

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

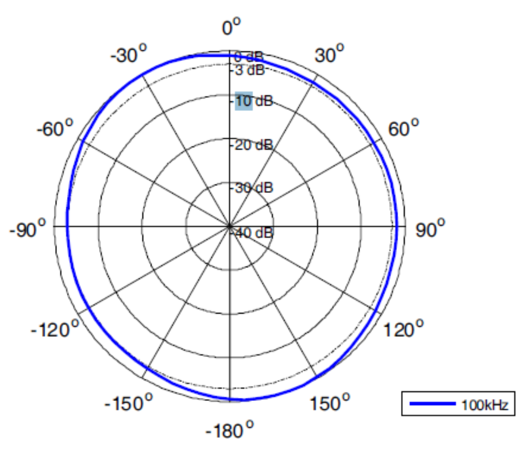
Usable Frequency range:	5Hz to120kHz
Linear Frequency range:	15Hz to 40kHz ±2dB 10Hz to 80kHz ±2.5dB
Receiving Sensitivity:	-170dB re 1V/ µPa (-164dB with differential output)
Horizontal directivity:	Omnidirectional ±2dB at 100kHz
Vertical directivity:	270° ±2dB at 15kHz
Operating depth:	600m
Survival 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

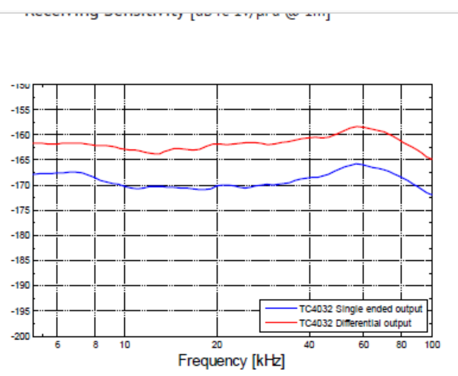
***NBR means Nitrile Rubber**
The NBR rubber is first of all resistant to sea and fresh water but also resistant to oil. It is limited resistant to petrol, limited resistant to most acids and will be destroyed by base, strong acids, halogenated hydrocarbons (carbon tetrachloride, trichloroethylene), 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

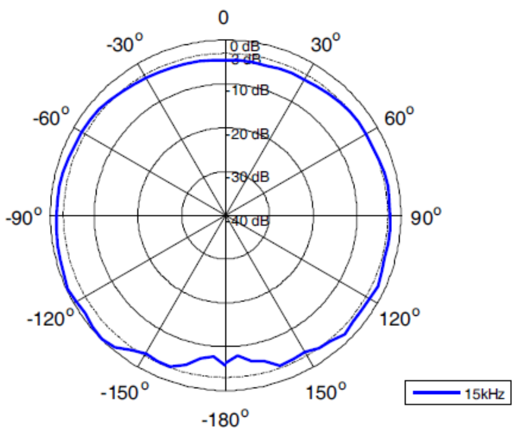
Vertical directivity: At 15 kHz
Horizontal directivity: At 100 kHz



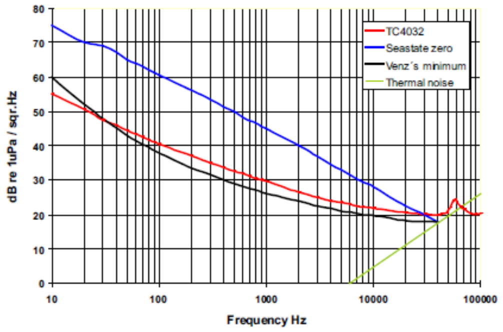


The OCR curve shown above is for single output

Vertical directivity pattern

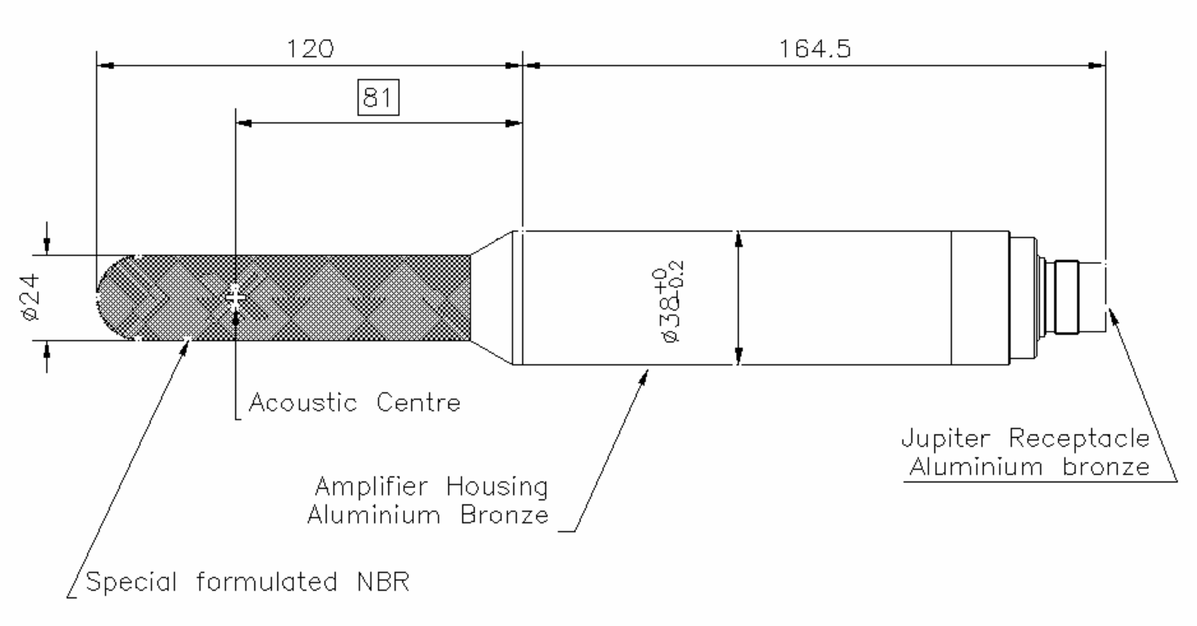


Typical equivalent noise pressure curve

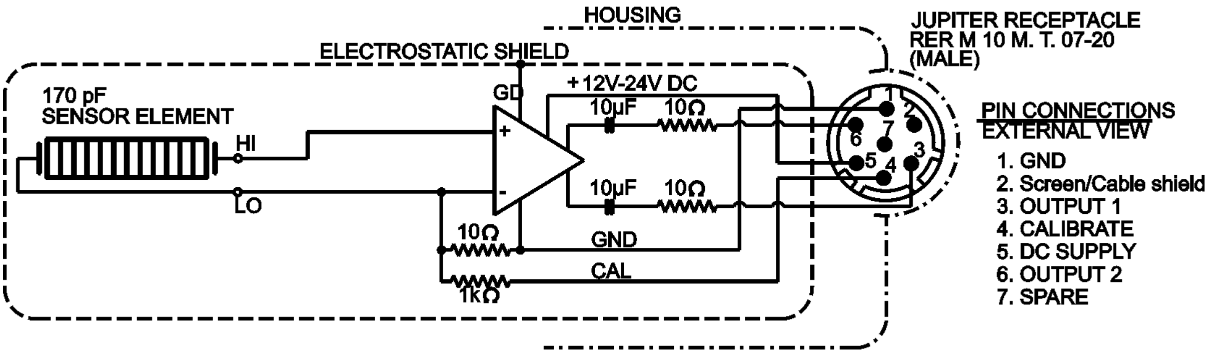


Valid for all versions of TC4032

Outline dimensions

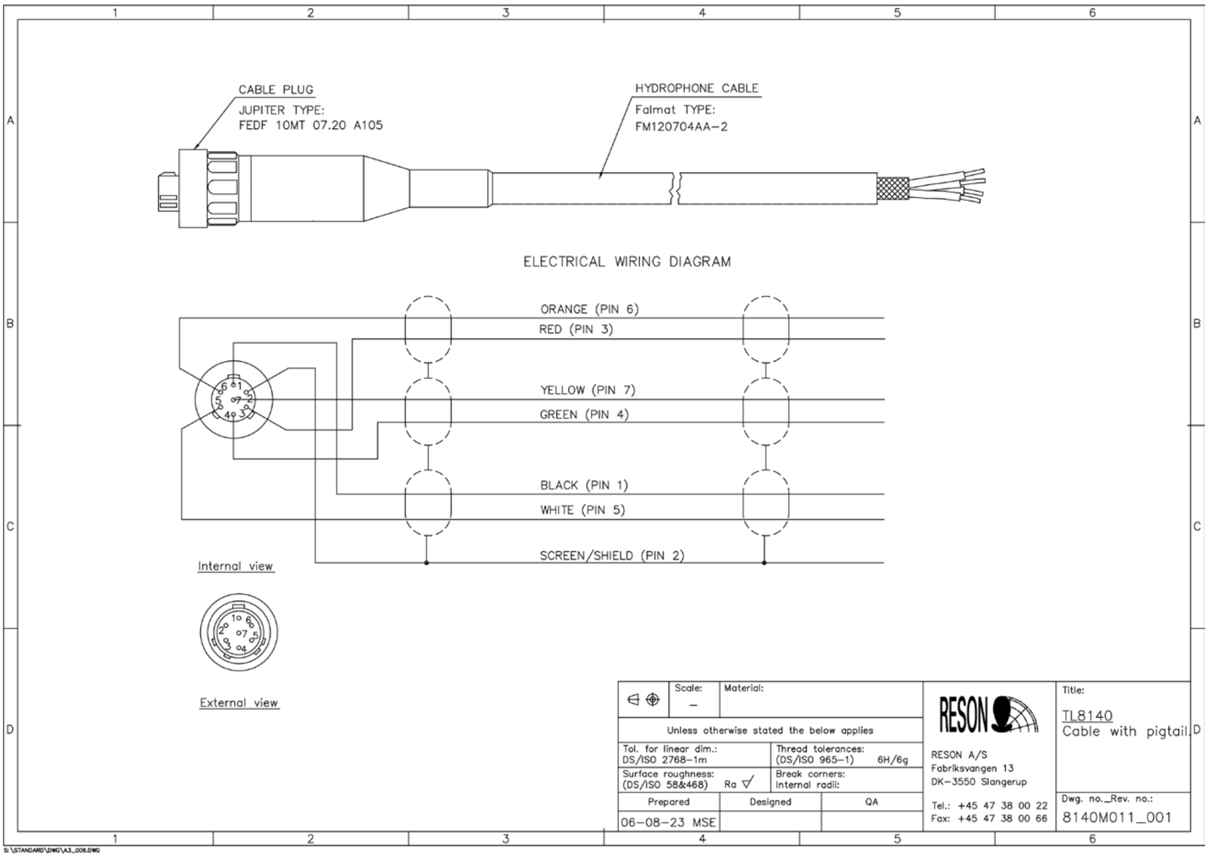


Electrical diagram



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.


CABLE PLUG
JUPITER TYPE:
FEDF 10MT 07.20 A105
HYDROPHONE CABLE
Falmat TYPE:
FM120704AA-2
ELECTRICAL WIRING DIAGRAM
ORANGE (PIN 6)
RED (PIN 3)
YELLOW (PIN 7)
GREEN (PIN 4)
BLACK (PIN 1)
WHITE (PIN 5)
SCREEN/SHIELD (PIN 2)
Internal view
External view
Scale:
Material:
Unless otherwise stated the below applies
Tol. for linear dim.: DS/ISO 2768-1m
Thread tolerances: (DS/ISO 965-1) 6H/6g
Surface roughness: (DS/ISO 58&468) Ra
Break corners: Internal radii:
Prepared
Designed
QA
06-08-23 MSE
RESON
RESON A/S
Fabriksvangen 13
DK-3550 Slangerup
Tel.: +45 47 38 00 22
Fax: +45 47 38 00 66
Title:
TL8140
Cable with pigtail.
Dwg. no._Rev. no.:
8140M011_001
S:\STANDARD\DWG\A3_006.DWG

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

EcoFish GLOBAL

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).
2. Greene Jnr C.R.,"Physical acoustics measurements". In: W.J. Richardson (ed.) Northstar Marine Mammal Monitoring Program 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. LGL Rep 2121-2, LGL Ltd, Canada and Greeneridge Sciences Inc. USA for BP (Alaska) Inc. and Nat. Mar. Fish Serv. Alaska. 245 pp.
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).