110 Parkway Drive, Truro Heights
Nova Scotia, Canada, B6L 1NB
support@oceansonics.com
www.OceanSonics.com

Pistonphone User Guide

Version 1.0

OCEAN SONICS
Giving Our Oceans A Voice

Table of Contents

1 Field Calibrator Overview

1.1 What is a field calibrator?

Field calibrators like the GRAS 42AA, 42AC, or 42AG are calibrated measurement tools for verifying the proper functionality of microphones or hydrophones. They provide an excellent option for verifying proper hydrophone operation while in the field. Calibrators allow a user to take a measurement of the hydrophone's sensitivity at one fixed frequency. This is typically 250 Hz, though the 42AG calibrator allows the user to select 250 Hz or 1000 Hz.

1.2 How do they work?

Pistonphones like the 42AA or 42AC work by using a reciprocating piston to create a known pressure variation inside a volume of air. The piston has a fixed displacement so the volume of air surrounding the device under test must be precisely known to know the expected pressure amplitude. Pistonphones come with couplers that are matched to the dimensions of the hydrophones they are used to calibrate. Where pistonphones are dependent on the air volume inside them to function properly different couplers had different correction factors that must be added to the nominal pressure value to find the expected value that the hydrophone should read.

The 42AG calibrator works slightly differently than pistonphones, it uses a speaker cone and calibrated microphone to create a constant sound pressure level regardless of the air volume. This makes it slightly easier to use because it is not necessary to add correction factors to the pistonphone sound level to get the expected output value.

1.3 42AG Overview

Below shows an overview of the controls and features of the 42AG field calibrator. The battery compartment on the back holds 2 AAA batteries. When in use, the light above the Sound Level toggle button will display red initially and then turn green once the target pressure level is achieved. The 42AG calibrator displays the units in dB re 20 µPa which is standard for in-air sound level measurements. The two sound level options and their equivalent sound levels in water (where a reference of 1 µPa is used) are:

- 94 dB re 20 µPa *which is equivalent to* 120 dB re 1 µPa
- 114 dB re 20 µPa *which is equivalent to* 140 dB re 1 µPa

The values re 1 µPa will be the expected output values from the hydrophone or Lucy.

1. Power button
2. Show temperature, ambient pressure, rel. humidity
3. Toggle frequency
4. Calibration port
5. Toggle sound level
6. Screen

2 How to do a Field Calibration

Doing a field calibration with an Ocean Sonics hydrophone is relatively straightforward. Field calibrations are not intended to replace or precisely replicate lab or manufacturer calibrations. They are intended to be used to confirm the functionality of the hydrophone and detect the types of large offsets that may come with a damaged instrument. This guide will be focused on the 42AG calibrator because it is more user-friendly and is our preferred field calibrator. This guide assumes the user has an understanding of operating an icListen hydrophone and the Lucy2 software.

2.1 Setting up for a Pistonphone Calibration

The setup for a pistonphone calibration is easy. The required equipment list is as follows:

- 42AG calibrator
- Coupler appropriate for hydrophone under test

- Soft foam pad for placing devices (20 x 40 cm)
- icListen hydrophone
- icListen test cable (or extension cable and LaunchBox)
- Computer

The measurements should be done in a location away from loud noises or vibrations if possible. The ambient sound levels at the calibration frequency can be checked on the web interface or with Lucy to confirm they are not too high. They should be 20-30 dB or more below the 140 dB re 1 µPa generated by the instrument.

3 Conducting a Pistonphone Calibration

The following steps outline the process of conducting a pistonphone calibration.

1. Prepare a space to conduct the testing and place the foam on the bench surface.
2. Before starting the test, the o-ring near the mouth of the coupler should be checked for grease. If it is not already lubricated, a small quantity of Molykote 44 may be applied to the o-ring to help create a seal and allow for easier insertion of the hydrophone.
3. Before connecting the hydrophone adapter, the default adapter must be removed and replaced with the adapter appropriate for your hydrophone. Ensure that the o-ring in the adapter port is lubricated.

4. The coupler should be placed in the receiving port of the calibrator (or screwed on in the case of a 42AA/AC pistonphone).
5. Plug the hydrophone into the test cable and the ethernet port/computer/launchbox and power it on.
6. With the hydrophone on, insert it into the coupler mouth and carefully place the calibrator and hydrophone onto the foam. Depending on the coupler and hydrophone that are being tested, the tip may not fully insert into the coupler. With a properly greased o-ring and hydrophone should slide in easily and stop which it reaches the end. Do not force it. **Be sure that the cable will not pull the hydrophone askew or off the foam.**

7. Connect to the hydrophone using the computer and set it to measure FFT data at 8000 kSps (3200 Hz bandwidth).
8. Turn on the calibrator. The calibrator should be set to 250 Hz and 114 dB re 20 µPa.
9. From here, the test may be done a few different ways
    a. Simply view the live data display on the web browser. Set the step size to 3 dB and increase the reference level until the peak is in view. The value on the screen should be within 1-2 dB of the nominal value.
    b. Set up Lucy2 to stream FFT data from the hydrophone. As for the web browser, estimate from the screen the peak value at 250 Hz. Lucy2 allows the user to place the cursor at the peak to read the value more easily.
    c. Record FFT data on the hydrophone or stream it to the computer using Lucy2. The value may then be read from the FFT file directly and the file may be saved for better traceability.
10. Recording the FFT data has the added value of creating more traceable measurements. When viewing the FFT data it may be slightly more accurate to add the adjacent values above and below the peak to the peak value. This allows for accounting for some of the spectral spreading that occurs when the FFT is performed. Be sure to add the values in linear units and then recompute the value in decibels. An example of that is shown below:

$$SL_{3points} = 20 * log10\left(\sqrt{\left(10^{\frac{SL_{250Hz}}{20}}\right)^2 + \left(10^{\frac{SL_{-1}}{20}}\right)^2 + \left(10^{\frac{SL_{+1}}{20}}\right)^2}\right)$$

    a. When Viewing the FFT files, it is important to add the µPa reference value shown in the file header data to the tabulated values.
11. Whichever method you use, you will now have a value in dB re 1 µPa. If you would like to calculate the low frequency sensitivity of the hydrophone, you can use the below formula:

$$RVS_{meas} = SL_{meas} - RVS_{nom} + SL_{nom}$$

Where:
RVS_{meas} – Measured sensitivity level (Receive Voltage Sensitivity)
SL_{meas} – Measured sound level
RVS_{nom} – The nominal sensitivity level stated on the calibration sheet
SL_{nom} – The nominal sound level of the calibrator (either 120 or 140 dB)

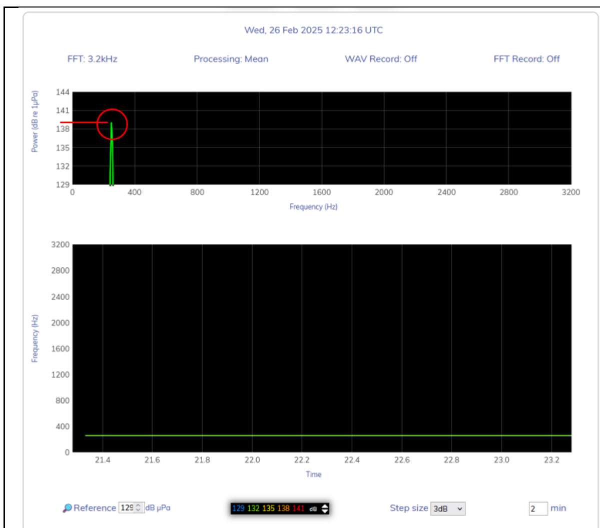
3.1 WAV File Processing

The previously mentioned methods all use the FFT data generated either by the hydrophone or the Lucy software. This is convenient for quickly checking the functionality of the hydrophones but introduces two sources in inaccuracy into the calculation. One is the spectral leakage of the FFT windowing function, and the other is the rounding of the FFT output to whole numbers in the saved files. The spectral leakage is the reason adding the adjacent bins may better estimate the precise pressure value. Processing the original WAV files can produce more accurate values but would generally not be necessary to confirm functionality in a field test.

4 Examples of Pistonphone Measurements

Below are examples of measurements taken using the different methods described above.

Viewing the sound level value in the web interface



The image to the left shows the data screen on the hydrophone web interface. With the frequency range set to 3200 Hz and the step size at 3 dB, the reference level is adjusted to bring the peak due to the tone at 250 Hz into view. As can be seen, the peak appears to be at 139 dB. The expected value is 140 dB so this result would indicate a functional hydrophone.

Calculating the sound level from an FFT file

Setup:			
dB Ref re 1	-120		
dB Ref re 1	90		
Sample Ra	8000		
FFT Size	1024		
Bin Width	7.8125		
Window F	Hann		
Overlap [%	50		
Power Cal	Mean		
Accumula	4		
Accel(x,y,z	30	1011	15
Magnetom	2023	-178	-1283

234.38	242.19	250	257.81	265.63
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
16	42	50	46	21
15	42	50	46	21
16	42	50	46	21
16	42	50	46	21

Shown at right are portions of a saved FFT file recorded through Lucy. They can also be logged on the hydrophone and then downloaded. To compute the pressure level, add the value at 250 Hz to the pressure reference level. 90 dB and 50 dB in this case gives 140 dB.

Viewing the sound level value in Lucy

Below shows the displayed sound level in Lucy2. Note that you can select an area of the FFT or waterfall display to zoom in on it. Also, hovering the mouse over a portion of the display will show the frequency and amplitude level at that position. In this case, the peak at 250 Hz is viewed and appears to have a sound level of 139.9 dB.