# DHA-7
# Downhole Hydrophone Array

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# *Operation Manual*

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# 1 – Introduction

The DHA-7 Downhole Hydrophone Array (Figure 1) is designed for high-resolution seismic borehole imaging. It is ideal for shallow gas and mining investigations, earthquake engineering and foundation studies, and teaching and research. The array is suited for use in water-filled, cased and uncased, wide- to narrow-diameter boreholes.

The DHA-7 uses unique proprietary polymer hydrophones, which unlike ceramic hydrophones are non-shattering and require no export license when used in the downhole configuration. Polymer hydrophones provide superior performance and durability under the rigors of borehole applications with a stable signal response up to 10 kHz.

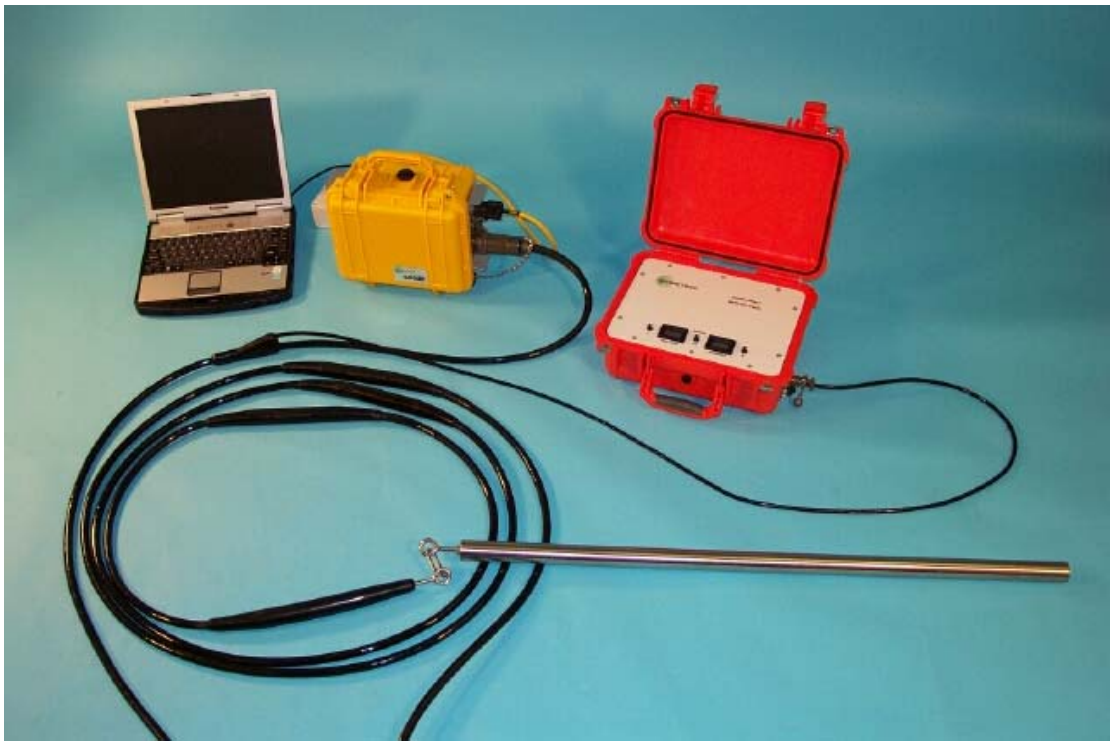

**Figure 1. DHA-7 Downhole Hydrophone Array connected to a Geode seismograph with laptop PC controller.**

This manual provides operating instructions, including description of the DHA-7 system components, setup, calibration, and warranty.

# 2 – System Components

The standard DHA-7 Downhole Hydrophone Array system includes the following items:

- Active section cable with integrated lead cable and tail eye bolt, wound on reel
- Tail weight (6-kg) with stainless steel shackle
- DHA-7/MicroEel Battery Pack
- Universal AC battery charger for the DHA-7/MicroEel Battery Pack
- CD with support documents (*.pdf) including the operations manual, connector wiring tables, and hydrophone calibration plots

## 2.1 Cable

The active section consists of a series of pods, the number equaling the number of channels ordered, either 12 or 24 as a standard; other channel counts are available through custom order. The largest channel number is always wired as the deepest hydrophone. Each pod contains one hydrophone and one preamplifier that are in-line molded to a multi-conductor cable with a polyurethane encasement (Figure 2). The cable itself is triple-sealed with an abrasion-resistant polyurethane jacket and contains a Kevlar center stress core. The available pod intervals range from 1 to 5 m in length; the interval can be as small as 0.5 m through custom order.

**Figure 2. Array cable with hydrophone element and preamplifier pod.**

The lead and active sections are one integrated piece, with no interconnection on the cable in between the two sections. The total maximum length, including the lead and the active section, is 400 m.

### *2.1.1 Hydrophones*

The array uses Geometrics' unique proprietary polymer hydrophones. The hydrophone incorporates design features offering superior performance compared to previous polymer hydrophone designs as well as the traditional PZT ceramic-type hydrophones. Specifically, it is non-shattering and incorporates an isolating platform, making it immune to cable-borne energy. In addition, other design aspects allow its response to acoustic pressure alone to dominate the output.

### *2.1.2 Hydrophone Preamplifiers*

The true differential preamplifier used with the hydrophone is of a single-pole low-cut and a single pole high-cut design. The low-cut frequency is determined by the $\frac{1}{2}\pi$ RC time constant which is related to the element capacitance and the input resistance of the preamplifier front-end. The preamplifier features exceptionally low noise. Nominal element capacitance is 5 nF at 22 degrees C. The design also provides full voltage regulation at each preamplifier. The voltage regulator isolates each channel from the other which is desired when all preamplifiers share a common power bus.

### *2.1.3 Lead Cable Connector Terminations*

The standard topside lead cable termination is a Y-type with one 61-socket connector (PT06J-24-61S) for analog output, and one 4-pin connector [PT06A-8-4P(SR)] for power connection to the DHA-7/MicroEel Battery Pack (Figure 3). As an option, the analog output termination may be ordered with a 27-socket connector (NK-27-21C) instead of the 61-socket connector. Adaptor cables are also available to connect to seismographs with other analog input connector types.

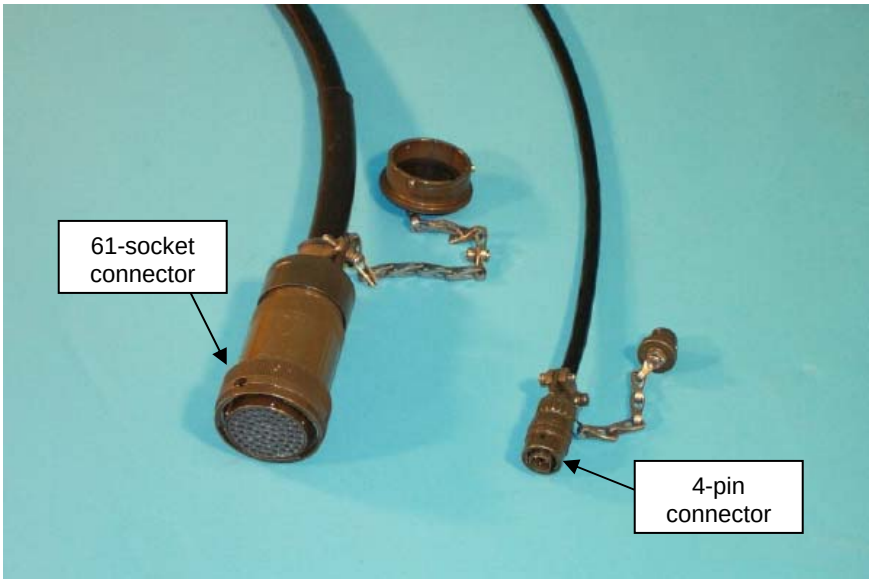


**Figure 3. Lead cable connector terminations (NK-27 termination not shown).**

### *2.1.4 Tail Weight*

The tail end of the active section includes about one meter of extra cable with an integrated stainless steel tail eye bolt used to receive the 6-kg stainless steel tail weight (Figure 4). The tail weight must be attached to the tail eye bolt with the supplied interconnecting stainless steel shackle. The use of other tail weights of a different configuration and/or weight is not recommended.

**Figure 4. Tail weight.**

### *2.1.5 Meter Marks*

The array cable may be ordered with meter marks as a custom option. The marks appear on the lead cable as slight bulb-outs with the measurement value indicated (Figure 5). Measurements start at the active section and span the length of the lead cable to the topside end. The in-line arrow indicates the decrement direction and the cross-line arrow indicates the exact position of the indicated measurement value.


**Figure 5. Meter mark.**

### *2.1.6 Cable Reel*

The array is shipped wound on a reel for storage, transport, and deployment. The reel is fully composed of certified (US-07OP HT) wood, to comply with international shipping regulations.

## 2.2 Power Supply and Requirements

The array is powered by the DHA-7/MicroEel Battery Pack. The battery pack is rechargeable using the included AC battery charger.

### *2.2.1 DHA-7/MicroEel Battery Pack*

The DHA-7/MicroEel Battery Pack (Figure 6) contains two 12V DC deep discharge (5 Amp-hour) sealed lead-acid batteries used in a ±12V DC differential power configuration. The array power lead is connected to the battery pack via the 4-socket connector located on the right-hand side of the battery pack. This connector is also used to connect the AC battery charger. Next to the connector is a grounding post (¼”-20 bolt and nut).

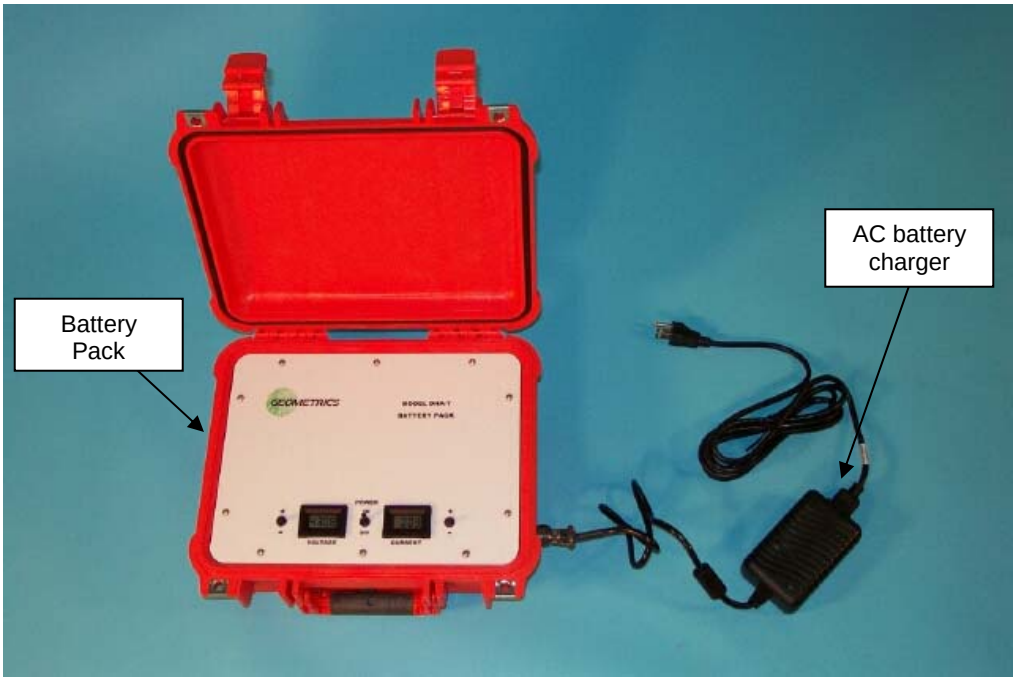


**Figure 6. DHA-7/MicroEel Battery Pack with AC battery charger.**

The battery pack front panel includes a Power ON/OFF switch, a VOLTAGE (Volts) meter, a CURRENT (Amps) meter with the associated +/- polarity switches for each respective meter (Figure 7). The metering provides a method of measuring the individual battery voltage and current being supplied to the array.


**Figure 7. Detail of DHA-7/MicroEel Battery Pack.**

The DHA-7 is designed to be powered by the DHA-7/MicroEel Battery Pack; use of another power source is not advised and could damage the array and void the warranty. In addition, under no circumstances should power to the array be shared with another instrument.

### *2.2.2 Power Consumption*

Each hydrophone preamplifier draws approximately ±10.8 mA per channel. Based on this draw, a 12-channel array has a total current of 130 mA, and a 24-channel array has a total current of 260 mA. The battery pack, with two 5 Amp-hour batteries, should have sufficient capacity to power the array for the desired length of time. If the batteries are fully charged, a 24-channel array can be powered continuously for approximately 19 hours (5 Amp-hours divided by 260 mA).

The actual operating time will vary depending on the state, temperature, and age of the batteries. The ideal battery operation temperature is between 41 to 77 degrees F (5 to 25

degrees C). Long-term exposure to temperatures above 106 degrees F (41 degrees C) can shorten the life of the batteries. As temperature decreases, the available battery capacity and performance are reduced; however, this is not a permanent condition and capacity will be recovered as temperature rises.

### *2.2.3 AC Battery Charger*

The AC Battery Charger is suitable for use anywhere in the world with a universal input from 90V AC to 264V AC. The output is 1.5 Amps constant current at 24V DC. Depending on the recharging mode of the charger and the state of the batteries, output levels will vary.

# 3 – System Set-up

## 3.1 Interconnections

The procedure for setting up the DHA-7, DHA-7/MicroEel Battery Pack, and seismograph interconnections is as follows.

1) With the battery pack power switch in the OFF position, connect the 4-pin power connector on the cable lead to the 4-socket power connector on the battery pack.

2) Move the battery pack power switch to the ON position. The CURRENT and VOLTAGE meters will turn on and indicate the status of the batteries.

   Toggle the +/- switch next to the CURRENT meter to measure battery draw for each polarity. Each current measurement should read approximately 130 mA for a 12-channel array and 260 mA for a 24-channel array.

   Next, toggle the +/- switch next to the VOLTAGE meter to measure battery potential for each polarity. The voltage should read from 11.8V DC to 13.4V DC for each battery. The array will operate with a minimum voltage of approximately 10.8V DC depending in the length of the cable lead. Recharge the battery pack (see Section 3.3) immediately when the minimum permissible voltage is reached.

3) Connect the analog output connector on the cable lead to the seismograph and check for incoming signal. It is also recommended that the seismograph gain be set to the lowest possible setting.

   For ideal testing conditions allowing optimal hydrophone response, it is recommended that the hydrophone section of each pod not be in direct contact with any solid surface, such as other parts of the cable.

## 3.2 Deployment

Tightly fasten the interconnecting stainless steel shackle between the tail eye bolt and the tail weight to avoid loss of the weight down the borehole.

Use of other tail weights of a different configuration and/or weight are not recommended.

Most arrays are easily deployed off the reel by hand or a small winch may be desired.

Avoid rubbing the cable jacket on sharp or rough edges, such as the top of the well casing.

## 3.3 Battery Charging

A new DHA-7/MicroEel Battery Pack should be charged for a minimum of 20 hours prior to use. In addition, the temperature when the charging occurs should be between 41 to 77 degrees F (5 to 25 degrees C). If charging takes place above 77 degrees F (25 degrees C), the time required for a full charge will increase and the potential recharge cycles will be reduced.

The procedure for charging the battery pack is as follows.

1) Plug the battery charger into an AC outlet and connect the 4-pin connector on the charger cable to the 4-socket connector on the battery pack. Open the battery pack enclosure vent located between the case latches to allow gas venting during the charge cycle.

2) Switch the battery pack power switch to the ON position (the power switch must be ON to charge the internal batteries from the external charger). The VOLTAGE and CURRENT meters will turn on and indicate the status of the batteries.

3) The charger changes the recharging mode based on the state of the batteries, as well, the values of the VOLTAGE and CURRENT meters will vary depending on the cycle mode of the charger. There is an LED on the charger to indicate charging status.

   A lit LED indicates that the charger has power and is properly functioning.

   An orange LED indicates that the charger is in charging mode with a constant current of approximately 1.5 Amps.

   A flashing LED indicates that the charger is in deep-discharge charging pulse mode and charging starts at 0.5V DC, giving pulse currents up to 5V DC. This has the effect of removing loose sulphation formed during the deep-discharge state of the batteries.

   A green LED indicates that the charger is in standby mode and the current slowly reduces to zero.

Recharge the battery pack after every 6 to 8 hours of use. It will not harmed if left on a continuous charge past the normal recharge time; however, continuous charging for extended periods of time will reduce the life of the batteries. Therefore, it is recommended that a continuous charge be limited to no more than 1 week.

The battery pack will lose capacity without use. A battery pack in storage must be recharged at least every 6 months or sulphation will reduce the storage capacity. Depending on the charging, depth of discharge, and use conditions, the expected number of recharge cycles is usually between 500 and 1000.

# 4 – Appendix

## 4.1 Connector Wiring

Wiring tables for the lead cable are included on the serialized CD included with each shipment. Channel 1 is always wired as the shallowest hydrophone.

Figure 8 shows the battery pack-to-array wiring.

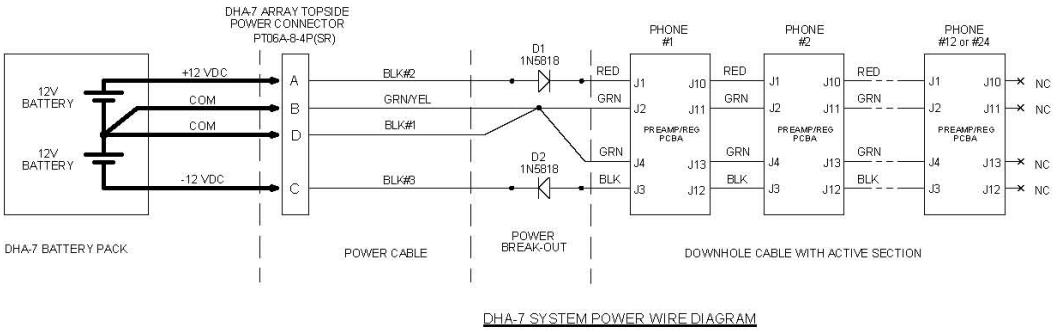


**Figure 8. DHA-7/MicroEel-D Battery Pack wiring.**

## 4.2 Calibration

All hydrophone channels of any given array have been low-frequency calibrated over a band from 0 to 200 Hz as a quality control measurement. The performance band defined by the low-cut of the polymer film capacitance and input resistance of 10 Hz, and a high-cut of 10 kHz has been demonstrated to be "predictably flat" over a entire band. Significant testing has demonstrated that the low frequency calibration of the hydrophone is 99.99% representative of the broadband response up to 10 kHz. This low frequency calibration is performed by the substitution method where a known calibrated reference is compared with the unknown hydrophone channel under calibration. The calibrated reference and the unknown are placed in a sealed chamber into which white noise is injected. A dual channel FFT analyzer is used to compare the response of the two and the resulting transfer function indicates the response in dB of the unknown in terms of sensitivity relative to 1V per µPa and phase.

All hydrophone channels in the array are guaranteed to be within a ± 1 dB relative span. The calibration plots for each hydrophone are provided on the serialized CD included with each shipment.

## 4.3 Specifications

| | | |
|---|---|---|
| ***Electrical*** | | |
| **Hydrophone** | Sensor type | Proprietary Polymer |
| | Sensors per group | One |
| | Frequency response | 10 Hz to 10,000 Hz ± 1.0 dB |
| | Capacitance | 5 nF at 22˚C |
| | Sensitivity | -196 dB re 1 Volt per 1 µPa |
| | Sensitivity with depth | < 1.0 dB over 400 m depth |
| | Sensitivity with acceleration | < -70 dB re 1 Volt per g |
| **Preamplifier** | Type | Ultra-low noise differential |
| | Gain | 6 dB |
| | Current | 11 mA per channel |
| | Power | ±12V DC DHA-7/MicroEel Battery Pack on surface |
| ***Physical*** | | |
| **Cable** | Type | Multi-conductor with polyurethane jacket |
| | Termination | Topside: Y-type with one 61-socket connector (or 27-socket connector) and one 4-pin connector<br>Tail: 1-m (3.28-ft) long with stainless steel swivel and 6-kg (13.2-lb) weight |
| | Maximum total length | 400 m (or 1,300 ft) (lead plus active section) |
| | Strength member | Kevlar center stress core |
| | Outside diameter | 13.5 mm (0.53 in) |
| | Weight | 12 channels: 0.12 kg/m (0.08 lbs/foot)<br>24 channels: 0.15 kg/m (0.10 lbs/foot) |
| | Bend radius | 12.7 cm (5 in) |
| | Working load | 273 kg (600 lbs) |
| | Breaking strength | 909 kg (2,000 lbs) |
| **Active section** | Channels | 12 or 24 standard; other counts available* |
| | Group Interval | 1 to 5 m (or 3 to 15 ft) standard; other intervals available with a minimum of 0.5 m (or 18 in)* |
| | Outside diameter (hydrophone) | 41.3 mm (1.63 in) |
| | Length (hydrophone) | 30.5 cm (12 in) |
| | Weight (hydrophone) | 0.16 kg (0.35 lbs) |
| | Bend radius | 22.9 cm (9 in) |
| ***Environmental*** | | |
| **Depth** | Operating maximum | 400 m (or 1,300 ft) |
| **Temperature** | Operating range | -10˚C to +70˚C |
| | Storage range | -40˚C to +70˚C |

*Please contact the factory to discuss your requirements. ~\DHA-7_v9a_ds.doc

## 4.4 Warranty and Service

Geometrics warrants the Model DHA-7 system for 3 months. Warranties commence on the date of shipment. If the equipment fails during the applicable warranty period, Geometrics will repair or replace the defective item at its factory in San Jose, California at no charge to the customer for parts and labor. The cost to ship the equipment to Geometrics' factory and back to the customer's site is for the customer's account. Repairs might be done at a local service center, if available, nearest customer location. Geometrics must be notified within 7 days of system failure for any warranty claim. Geometrics must establish to its satisfaction that failures have not been the result of abuse or improper deployment of the system. Warranties are void for damage caused by incorrectly applying power, including over-voltage and reverse voltage.

The limited warranty stated herein is in lieu of all other warranties expressed or implied (including the implied warranties of merchantability and fitness for a particular purpose) and of all other obligations or liability on the part of Geometrics, and Geometrics neither assumes nor authorizes any person to assume for it any other liability. Geometrics shall not be liable for special, incidental, or consequential damages of any nature (including, but not limited to lost revenue or profits) with respect to any merchandise or services sold, delivered or rendered hereunder.

Should the instrument or any part thereof need to be returned to the factory for servicing, please contact the Customer Service Department via email at support@geometrics.com or telephone at 408-954-0522. Be ready to provide the serial number and an explanation of the problem. You will be issued an RMA number and instructions for shipping the instrument.