NORTEK MANUALS

Operational Guidelines

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1 Introduction

These guidelines give an overview of considerations that should be made before making a deployment, focusing on the practical aspects. To help you ensure a successful deployment, these guidelines can be used to identify the most appropriate deployment method, choose the right instrument, prepare and carry out the deployment as well as the necessary maintenance of an instrument.

For a theoretical background on the measurement principles used by our instruments, please refer to the Principles of Operation - Currents and Principles of Operation - Waves manuals.

Most information found here is general and relevant for all different types of current meters and profilers, with the main focus being the Signature series and Generation 2 Aquadopps and AWACs.

Nortek online

At our website, www.nortekgroup.com, you will find technical support, user manuals, FAQs, and the latest software and firmware. General information, technical notes, and user experience can also be found here.

Your feedback is appreciated

If you find errors, omissions or sections poorly explained, please do not hesitate to contact us. We appreciate your comments and your fellow users will as well.

Contact Information

We recommend first contacting your local sales representative before the Nortek main office. If you need more information, support or other assistance, you are always welcome to contact us or any of our subsidiaries by email, phone or fax.
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Version/revision	Date	Comments
Version 2025.1	05 / 2025	First release
Version 2025.2	07 / 2025	Addition of checklist in Appendix, information regarding RTC battery
Version 2025.3	08 / 2025	Additional information regarding magnetic declination

2 Initial deployment planning

When starting the deployment planning process, the first step is to understand exactly what one aims at studying. Why are you interested in a specific location and what is the data you aim to collect? Are you interested in waves or currents? Will one depth level be sufficient or is a velocity profile of the water column required? In most cases your deployment site is predetermined either by oceanographic features you aim at studying, a man-made channel or harbor that requires monitoring or the site of a future aquaculture or wind farm. In some cases you may deploy your instrument on already existing structures but in most scenarios the sensor will be deployed on its own, either in a mooring line, on a surface buoy, or a bottom frame.

In any of these deployment scenarios, a thorough understanding of the local bathymetry and prevailing current systems is essential for ensuring accurate data collection and operational safety. We strongly recommend the following preparatory steps:

- Consult detailed nautical charts and bathymetric maps to understand depth variations, underwater features, and bottom types in your deployment area. These resources can help in selecting optimal deployment locations and avoiding unsuitable or hazardous zones. Public repositories, hydrographic agencies, and marine research institutions often provide such data, which may offer insights into both large-scale and localized seafloor characteristics.

- Identify potential environmental hazards or operational challenges, such as strong tidal currents, seafloor instability, or regions with high biological activity that may interfere with equipment deployment or data quality.

- If your instrument will be deployed near the surface or in shallow waters, it is critical to map out local shipping lanes. Proximity to vessel traffic increases the risk of equipment damage or loss due to entanglement, collision, or retrieval by mistake.

- Investigate the nature and intensity of fishing activities in the vicinity of your deployment site. This includes understanding the type of fishing gear that is used (e.g., trawling, longlines, nets), the frequency of activity, and common vessel routes. Fishing gear can pose a significant threat to deployed instruments, especially if the installation is not clearly marked or are difficult to detect by fishermen.

If the deployment is intended to span an extended period of time, it is equally important to account for seasonal variations in oceanographic and environmental conditions. If the instrument is located in an area with seasonal sea ice, a surface signature (buoy) is usually not recommended.

3 Choosing the right instrument

Once you have a good understanding of the deployment environment, it is important to choose the right instrument for the job. Consider whether the instrument is suitable for the intended measurement, including the correct range, cell size and blanking distance.
Take into consideration if the data is required in real time or will it be sufficient to retrieve the data after the instrument has been recovered.

Nortek instruments are specifically engineered to measure two key oceanographic parameters: currents and waves. The most suitable instrument for your needs will depend on your deployment location and specific research objectives. To ensure you select the optimal configuration, we recommend contacting your local Nortek representative for personalized guidance. For a comprehensive overview of the capabilities and limitations of each instrument, please refer to the technical specifications available on the respective product pages on our website.

4 Deployment configuration

The primary goal of any instrument deployment is to keep the mooring at the chosen location and to make as accurate measurements as possible. The success of a deployment depends both on the ability to estimate the range of conditions that the deployment site may be exposed to and to design a structure that will survive those conditions. The most important environmental conditions are wind, waves, currents and tides. In addition, the pressure constraints, fouling and corrosion are aspects that will influence the deployment to a certain degree.

It is wise to think through all aspects affecting the deployment and to have a clear target for the deployment. What do you want to measure, and for how long? At which location, and how will the surrounding environment influence the measurements? The different seasons of the year may also present different limitations and challenges.

The deployment site should be carefully assessed. There are a number of aspects to consider regarding the deployment site that might play a role when it comes to successful data collection. To mention a few:

- An idea about the bathymetry of the area and the bottom conditions may avoid failure during deployment. Burial of the instrument in sandy areas is of course something that should be avoided.
- The salinity (and temperature, but this is measured directly) affects the speed of sound, and knowing the salinity level ahead of the data collection may save time when post-processing the data. For more information about how salinity affects the speed of sound, and how this affect your measurements, please refer to the Principles of Operation - Currents.
- The scattering level is usually not a problem, but should be considered in areas with few particles in the water (e.g. the area between 1000 m below the surface and 100 m above the bottom is challenging from a Signal-to-Noise Ratio (SNR) point of view).
- If the instrument is located in an area with seasonal sea ice, a surface signature (buoy) is usually not recommended.
- If there are any other human activities at the site, e.g. trawling, this can be disruptive and even destructive for the measurements.
- The choice of mooring line, flotation and anchor should depend on the type of mooring and environment in which it is deployed.

4.1 Forces acting on a deployment

When designing a mooring system, it is crucial to achieve the right balance between the various forces acting on the deployment. Properly accounting for these forces ensures stability, minimizes unwanted movement, and enhances the accuracy of measurements.

Forces in the vertical direction include:
- Buoyancy (mass x gravitation), which is positive upwards (buoy) and negative downwards (anchor).
- Tension from above.
- Tension from below.
- Drag from any vertical current.

Forces in the horizontal direction:
- Angled tension from above.
- Angled tension from below.
- Drag from any horizontal velocity.

4.1.1 Buoyancy

Positive buoyancy comes from objects that have an upward directed force when submerged, that is, objects that have a density that is lower than the water around it. Negative buoyancy represents a downward force. To determine the buoyancy of an object, knowledge about the mass and the volume of the object is essential. Remember that the actual buoyancy is the mass of the seawater the object displaces minus the mass of the object (Archimedes' Law). It is of primary interest to keep a mooring as vertical as possible; therefore, sufficient buoyancy is essential, at the same time as the handling of the deployment is not affected (e.g. not too heavy).

The apparent immersed weight of an object in water can be calculated using (1):

$$\text{Apparent immersed weight} = \text{weight of object} - \text{weight of displaced fluid} \tag{1}$$

The weight of the displaced fluid is constant and dependent on the volume of the object. The weight of the object may change, if, for example, the batteries are exchanged. For further details and example calculations, please see this FAQ.

Detailed buoyancy data is available in the general assembly drawings, which can be found on the product page on our website. Due to the variety of battery combinations available, we only specify the weight of the instrument itself. To determine the total instrument weight with additional batteries, simply add the weight of the chosen battery option. For specific battery weight information, refer to our website under Spare Parts.

4.1.2 Tension

The tension in a mooring line is the result of both static and dynamic loads. Depending on the buoyancy and environmental forces acting on the system, this tension can pull downward, upward, or at an angle, but it never exerts a pushing force, as a mooring line cannot support compression.

Static load
The static component of mooring line tension is determined by:

- The weight of the mooring line itself, including the material and any coatings or sheathing that may add mass.
- The weight of the instrument attached to the mooring.
- The weight of other immersed components, such as floats, anchors, connectors, shackles, and additional sensors.
- The buoyancy force exerted by any flotation devices or positively buoyant components in the system, which counteract the downward weight.

This static component represents the baseline, steady-state force acting on the mooring system when it is at rest in the water.

Dynamic load
The dynamic component of the tension arises due to external forces that cause movement in the system. These forces include:

- Wave action: Vertical displacement due to waves induces cyclic forces on the mooring line, creating fluctuating tension.
- Currents: Horizontal water movement drags the mooring and attached components, leading to additional stress on the line.
- Platform motion (if applicable): If the mooring is attached to a floating platform or buoy, its movement introduces additional fluctuations in tension.
- Drag forces: These forces occur when water moves past the mooring line and its payload, generating resistance proportional to the instantaneous velocity of the system. (Explained further in the next section.)
- Inertial forces: Changes in velocity (acceleration or deceleration) create additional forces on the mooring system. These inertia forces depend on the mass of the mooring line and attached components, making heavier deployments more susceptible to dynamic loading.

Implications for mooring design
Understanding the balance between static and dynamic loads is crucial for designing a stable and durable mooring system. Overestimating static load may lead to unnecessarily large and heavy components, making deployment and maintenance difficult. Underestimating dynamic forces can lead to mooring failure due to excessive stress cycles, fatigue, or line breakage.

4.1.3 Drag

The drag force, also known as hydrodynamic resistance, is a resistive force that opposes the motion of an object moving through a fluid. The magnitude of the drag force depends on the size and shape of the object, as well as the velocity of the surrounding currents or wind. When an object moves through a fluid, it experiences resistance due to both viscous effects and pressure effects. These two components act simultaneously, and their relative influence depends on the nature of the flow around the object. If the flow around the object is laminar, the drag is primarily caused by shear stresses, meaning that friction between the fluid and the object's surface dominates. In contrast, when the flow becomes turbulent, pressure differences between the upstream and downstream sides of the object contribute significantly to the overall drag force. The combination of fluid velocity and the object's shape may result in a wake forming behind the object. This wake leads to pressure drag, which arises due to the difference in pressure across the object's front and rear surfaces.

Drag force calculation
Most drag force data are obtained empirically through direct measurements. However, for an approximate estimation, the drag force can be calculated using (2).

$$F = \frac{1}{2} C_D \rho A V^2 \tag{2}$$

F (N) is the drag force
ρ (kg m^{-3}) is the mass density of the fluid
A (m^2) is the cross-sectional area of the object
V (m/s) is the relative velocity
C_D is the drag coefficient, a dimensionless parameter that depends on the object's shape

The drag coefficient, C_D, can be further refined based on the flow conditions and body orientation. It can be calculated using (3).

$$C_D = \frac{2F}{\rho A V^2} = f(Re, \alpha) \tag{3}$$

α is the angle between the flow direction and the specified body axis (no tilt: α = 0)
Re is the dimensionless Reynolds number, which is a dimensionless quantity that characterizes the type of flow around the object defined by (4).

$$Re = V \frac{d}{v} \tag{4}$$

d (m) is the characteristic length scale of the object
v (m^2 s^{-1}) is the fluid's kinematic viscosity

The Reynolds number can be used to distinguish between different flow regimes. When *Re* is small (typically *Re*<1), viscosity dominates, leading to laminar flow around the object. In contrast, at higher Reynolds numbers (*Re*>1000), the flow becomes turbulent, characterized by chaotic fluid motion and vortex formation. While these threshold values are approximate, they serve as a general guideline: turbulence is typically associated with Reynolds numbers significantly greater than unity. In turbulent conditions, vortex shedding may occur, causing additional unsteady forces on the mooring system.

Effects of drag on mooring systems

Drag forces impact mooring systems in two primary ways: mooring excursions and mooring inclination. When a mooring experiences significant drag, it can be displaced horizontally from its intended position, leading to errors in current measurements. This occurs because the mooring takes time to reach equilibrium after experiencing a shift in current conditions, during which the velocity measured by the instrument may not accurately represent the true current. Additionally, exposure to drag forces can cause the instrument to move deeper in the water column, altering the intended measurement location. This effect, known as drag-down, results in changes to parameters such as pitch, velocity, and pressure, which may become apparent in the recorded data. Excessive inclination can introduce measurement errors due to sensor tilt and distort the collected data.

Beyond the steady drag force, moored instruments may also experience fluctuating lift and drag forces due to vortex shedding. These oscillatory forces can further contribute to unwanted motion, increasing uncertainty in data collection. In order to predict changes in the excursion and inclination when designing a deployment, drag forces must be calculated for the expected current conditions.

These can also be used to predict errors in the data, since a certain amount of movement cannot be avoided.

4.1.4 Natural frequency of subsurface buoys

Each subsurface buoy exhibits a unique dynamic response, influenced by its design and the environmental forces acting upon it. When an instrument is mounted on a subsurface buoy, the buoy's motion can introduce velocity artifacts in the collected data, potentially contaminating measurements. The characteristic response of the buoy is determined by several key design parameters, including mass, buoyancy, drag, and mooring line length.
By analyzing the forces acting on the buoy and considering a nominal displacement from equilibrium, the system can be modeled using a linearized differential equation of motion. (5) provides a first-order estimation of the buoy's natural frequency ω_n.

$$\omega_n = \sqrt{\frac{R}{ML}} \quad (5)$$

with:

$$R = F_B g \quad (6)$$

- L is the mooring line length
- R is the cable tension of the mooring (restoring force)
- F_B is the buoyancy force in mass units [kg]
- M is the total mass of the buoy and any attached instruments

(7) describes the moorings oscillation period T.

$$T = \frac{2\pi}{\omega_n} \quad (7)$$

The motion of a subsurface buoy resembles an inverted pendulum. When displaced from equilibrium, the mooring system oscillates back and forth at its natural frequency, creating an apparent velocity in the velocity measurement cells. This movement can introduce false velocity readings, affecting directional accuracy and increasing uncertainty in wave measurements.

One of the most likely explanations for measurement errors at certain frequencies is that the buoy is responding to wave energy at other frequencies, leading to unexpected displacements. During periods of low wave energy, wave orbital velocities have lower amplitudes, making measurements more susceptible to noise and false velocity signals. To ensure accurate data collection, it is essential to understand the expected motion of the subsurface buoy and design the system so that its natural frequency does not overlap with dominant wave frequencies. If the natural frequency of the buoy coincides with wave frequencies of interest, measurement errors may occur due to resonance effects. One of the most effective ways to adjust the natural frequency is by modifying the mooring line length (L). Since increasing L lowers the natural frequency and decreasing L raises it, adjusting the line length can help shift the buoy's response frequency away from the dominant wave energy band. Additionally, modifying the buoyancy and total mass of the system can further fine-tune the buoy’s response characteristics.

4.1.5 Damping factor

The damping factor (ξ) can be calculated to make an indication of the potential for resonant behavior at the system natural frequency. It is a key parameter in evaluating how the mooring system will respond to external forces, such as wave energy. The damping factor ξ is defined by (8).

$$\xi = \frac{D}{2M}\sqrt{\frac{ML}{R}} \qquad (8)$$

- *D* is a coefficient defined by the buoy drag coefficient, cross sectional area and water density
- *M* is the total mass of the buoy and any attached instrument
- *R* is the reserve buoyancy
- *L* is the mooring line length

The damping factor classifies system behavior into two main regimes:

Over damped Systems (ξ>1)
In an over damped system, the mooring returns to its equilibrium position without oscillation or overshoot. No free oscillations occur, even at the system's natural frequency. This is the preferred condition for mooring design, as it minimizes unwanted movement that could contaminate velocity measurements.

Under damped Systems (ξ<1)
An under damped system is capable of oscillations, meaning that when disturbed, it may sway back and forth multiple times before settling. If the external forcing—such as wave energy—matches the system's natural frequency, resonant motions can develop. This resonance can cause persistent artificial velocity signals, leading to errors in current measurements and increased directional uncertainty.

By ensuring an over damped design, the mooring system can effectively resist resonant motion, reduce measurement artifacts, and improve the overall accuracy of velocity data collection.

4.1.6 Mooring vibrations

High-frequency mooring vibrations caused by vortices shedding occur when ocean currents flow past mooring structures such as surface and subsurface buoys, mooring lines, risers, and other submerged components. As the current moves around these structures, it generates alternating vortices that create pressure fluctuations perpendicular to the flow direction. If the mooring structures are not rigidly mounted, they can be highly sensitive to excitation from vortex shedding, especially when the shedding frequency matches the structure's natural resonance frequency. This results in resonant vibrations that are primarily transverse to the flow direction. These vortex-induced motions not only cause oscillations but also increase the overall drag force acting on the mooring. The combination of increased drag and continuous movement can significantly affect data collection, causing greater mooring offsets, higher mooring line tensions, and oscillations in tension forces, which in turn contribute to fatigue damage over time.

Excessive mooring vibration can adversely affect the data; vibration introduces spurious velocities and interferes with the proper operation of the tilt sensor. The impact of mooring oscillations must be carefully considered. A general solution to improve on data quality is to design a more stable deployment by considering the components that generate mooring vibrations. The addition of aerodynamic devices may partly prevent and partly reduce the strength of vortex induced vibrations. It may be possible to detect intervals of excessive vibration by closely analyzing velocity and tilt data.

Unusual oscillations in the data may indicate periods of strong vortex-induced motion. For more precise vibration measurements, the use of an accelerometer can provide detailed insights into the extent and frequency of mooring oscillations, allowing for more targeted mitigation strategies.

4.2 Mounting alternatives

Most Nortek products can be used in either stand-alone or online mode. In stand-alone mode, data are collected to the internal recorder and power comes from internal or external batteries. In online mode, data are transmitted to shore in such a way that the measurements are continuously available.

4.2.1 Surface buoy

Surface buoys are frequently chosen for data collection programs that require multiple measurement parameters or real-time current profiling. Surface buoy-mounted ADCPs can be deployed in two primary configurations: self-contained mode or as an integrated component of the buoy system. The integrated setup is generally preferred, as it allows for power supply from the buoy, facilitates real-time data transmission, and provides remote access through satellite or other communication networks. For details on instrument integration, please see the Integrator's Manual specific to your sensor.

Tilt is a critical factor that must be considered when working with surface buoys. If the instrument is likely to experience significant inclination, bin mapping adjustments are necessary to correct for potential distortions in the data. Additionally, excessive tilt can interfere with the ADCPs compass readings. To address this, an attitude and heading reference system (AHRS) can be integrated with instruments from the Signature series, either within the ADCP itself or as a separate component on the buoy. Next to a magnetometer and an accelerometer, the AHRS is also equipped with a gyroscope. The combination of all three sensors allows for a compensation of motion on a moving system which is particularly valuable to increase single ping precision. For further details on the AHRS, please see this FAQ.

4.2.1.1 Hazards and challenges

Before deploying an ADCP on a surface buoy, several factors should be carefully evaluated. Since the buoy is floating on the sea surface it is endangered by vessel traffic and fishing operations, which could strike the buoy and thereby disrupt or damage the instrument. Additionally, surface buoys are susceptible to unintended interactions, such as vessels tying up to them or acts of vandalism. These incidents can impact the buoy’s stability, compromise data quality, and even result in loss of power or communication capabilities.

Another persistent challenge in buoy-mounted deployments is the presence of air bubbles near the ADCP transducer. These bubbles originate from wave action, surface turbulence, or trapped air pockets released by the buoy itself. In high sea states, bubble formation intensifies, and the instrument’s profiling range can be substantially reduced. Compounding this issue, waves sloshing against the buoy or support frame can generate broadband structural noise, further degrading the signal-to-noise ratio (SNR).

To address this, several strategies are used:

- Suspending the ADCP below the buoy on a rigid pole, frame, or cage structure to place it beneath the bubble-rich surface layer
- Designing the buoy to minimize turbulence, using hull shapes or baffling to reduce bubble generation

Despite these measures, some performance degradation during rough conditions is inevitable and instruments deployed at the sea surface will always have a reduced range compared to a upward looking orientation!

4.2.1.2 Integrated deployment

Deploying an acoustic instrument as an integrated component of a buoy system requires careful planning and rigorous assessment of potential electromagnetic interference (EMI). Interference from electrical noise can significantly degrade both recorded and transmitted data, particularly in environments where multiple electronic systems are operating concurrently. It can manifest in the data as an overall elevated noise floor or periodically raised return signal strength. We recommend testing the assembled system before deployment to investigate potential interference sources.

Electrical noise may originate from:
- The buoy's on-board power supply
- DC/DC converters
- Other operational sensors or electronic equipment installed on the buoy

These sources can introduce noise that overlaps with the acoustic instrument's operational frequency range, especially when power supplies use switching regulators or are poorly filtered. Different instrument models operate at different frequencies, and therefore be susceptible to different types of noise. For instance, a buoy system optimized for a Signature 55 may experience different interference characteristics when swapped with a Signature 1000.

To minimize interference and ensure high-quality data collection:

- Power Supply Compatibility: Always verify that any external power supply (other than the one delivered with the instrument) has a switching frequency that lies outside the acoustic sensor's operational bandwidth.
- Measurement Timing: If multiple acoustic instruments or sensors are deployed on the same buoy, their acoustic signals can interfere with one another. Staggering their measurement intervals—so they do not ping simultaneously—can reduce cross-talk and improve overall data quality.(See also: Acoustic interference between multiple instruments)
- Shielding and Grounding: Proper cable shielding and grounding practices can help reduce EMI transmission paths and protect signal integrity. Ensure that the grounding plate is in contact with seawater.

Note: When working with Gen2 instruments or the Signature series, a spectrum analyzer test can be carried out, to identify individual noise sources and systematically remove them.

Electrical noise sources will impact instrument operating at different frequencies to a variable extent. Therefore a renewed noise test will be necessary, if switching the instrument.

4.2.2 In-line mooring

Two general in-line mooring methods are presented, referred to as an L-mooring and an I-mooring.

The L-mooring, illustrated in Figure 1, is a deployment setup that is suitable for shallow water moorings. The advantage of the L-shape is that the instrument is protected from the winds, waves and currents that the surface buoy is exposed to. This will prevent waves and bad weather from influencing the data quality (depending on the distance from the surface of course). Having the hardware submerged and away from the most dynamical part of the water column leads to a considerable reduction in component fatigue due to surface-wave action. The surface buoy works as a signature of where the instrument is located, and as an aid in the retrieval of the system.

It is recommended to attach a subsurface buoy along the mooring line resting at the bottom. If something should happen with the surface buoy or the mooring line attached to the surface signature,the bottom line can be used as a backup for recovery. It is easier to catch the line if it is lifted off the bottom by the buoy compared to when it is resting along the bottom. Another improvement recommended is to add a subsurface buoy above the anchor to the left, as illustrated. This will prevent abrasion of the line during e.g. low tide. The magnitude of the buoyancy must be such that no part of the cable touches the ocean floor under slack conditions.

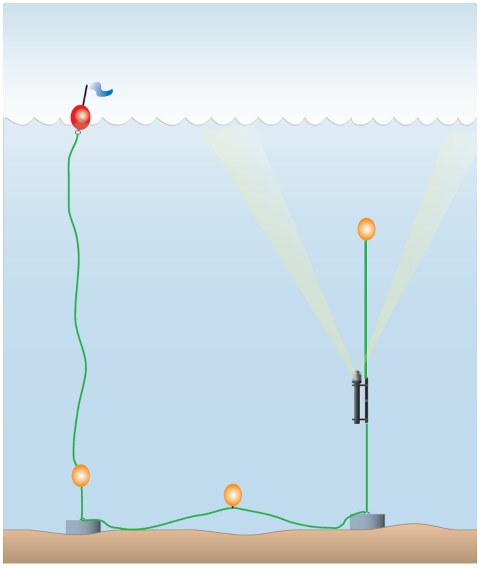


Figure 1: L-mooring

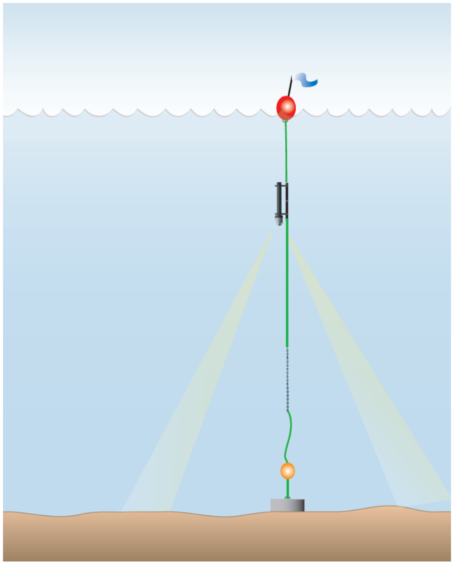


Figure 2: I-mooring

The bottom mounted surface penetrating I-mooring can be used at all depths. Figure 2 shows a typical I-mooring with the instrument pointing downward. An alternative is to mount the instrument looking up. The disadvantage of using a mooring type with the instrument directly connected to a surface buoy like this, is that the buoy is exposed to storms, waves, winds and strong surface currents. The motion transferred to the buoy by the environment makes this method tortuous, as this motion contaminates the instrument measurements. One must thus consider the effect of surface waves, ocean currents, bio-fouling and other factors that can vary with the time of year, location and regional climate and weather patterns. Storms, ships, ice, and vandalism can damage surface buoys. A good alternative is to use a subsurface float together with an acoustic release.

An I-mooring extending from the surface to the bottom must include a mooring line that has the ability to stretch, to compensate for the large vertical excursions that the buoy may experience during the change of tides and with passing waves and swells. It has the advantage of reducing the buoy watch circle (the freedom of movement of a buoy, defined by the mooring length) and sensor motion, and it is relatively easy to deploy. The disadvantage is that the wave action and high static tension under severe current conditions cause high dynamic loading. The latter can be reduced by replacing a part of the mooring line with a slack part, as the figure above illustrates, referred to as a semi-taut mooring. The disadvantage then is that the motion of the buoy and the sensor may become considerable, thus introducing errors in the measured velocity. In the above illustration, a chain (working as a dead weight anchor) is added right above the slack part to reduce excessive motion. In addition, it is a good idea to include a subsurface buoy along the slack line, to prevent the slack part to be exposed to rubbing against the anchor and bottom during e.g. low tide.

A I-mooring is recommended where there is minimal variance of water level, low currents and small waves. The dynamic loading requires use of a larger size anchor than semi-taut mooring. The L-mooring enables more buoy movement than the I-mooring, but it absorbs better the energy that might disrupt the performance of the I-mooring.

It is possible to attach several instruments along the same mooring line. The vertical distance between each instrument attached (and the along beam range of each instrument) must determine if the instruments should transmit signals out of step with each other, to avoid interference. (For details see the Acoustic interference chapter) To ensure vertical orientation for each instrument along the line, you should include a subsurface float above each instrument.
These floats as well as other elements on the mooring line should be placed at a sufficient distance from the instrument, so that it does not interfere with the beams. (See the Physical beam interference chapter)

The design of the mooring must focus on minimizing the motion of the instrument and disturbance in the flow, so that the sensor does not sample in its own turbulent wake, as this may generate significant errors in the data. When working with an in-line instrument like an Aquadopp, it is useful to deploy the sensor using a Aquafin, which will maintain a constant upstream orientation.

4.2.3 Subsurface buoy

The type of subsurface buoy illustrated in Figure 3 is designed to allow the instrument to make velocity profiles unobstructed by the mooring hardware. One of the advantages is, that the buoy is located away from surface forcing, thus it is not subject to surface excitation. The disadvantage is that if the currents in the area are too strong, drag down of the mooring and unrecoverable high tilt may invalidate the measurements.

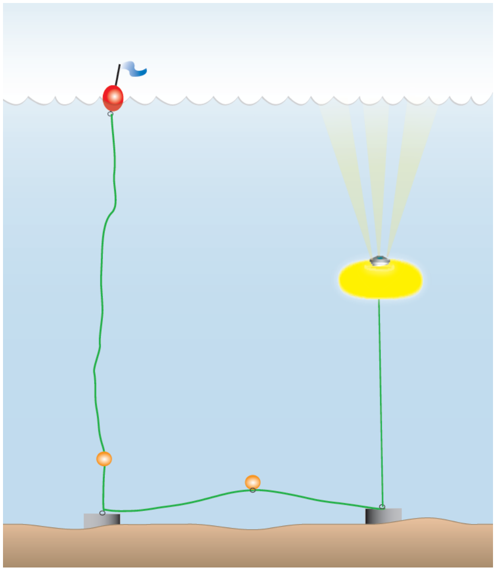


Figure 3: Subsurface buoy with instrument mounted inside

A deployment can be improved by adding a subsurface buoy right above the anchor to the left (figure above), to avoid rubbing, and a buoy along the line resting at the bottom, to make it possible to catch and retrieve the instrument in case of surface buoy loss or mooring line snap. The subsurface buoy may rotate under the influence of tides, waves and currents.If wave data is of interest, note that using a subsurface buoy for deploying requires that the instrument is capable of collecting data that can be used with SUV processing method. This is because of the movement of the instrument. For more information about the processing methods please refer to the Principles of Operation - Waves manual. Most wave processing methods are mathematically incapable of solving wave parameters if there is instrument movement and thus require that the instrument does not move or rotate during data collection. This problem is solved by utilizing the SUV processing method. This method requires AST and is therefore exclusive to the AWAC and Signature system.

As an alternative to the surface buoy, the instrumentation may be recovered by disconnecting the mooring line from the anchor by use of a pop-up buoy with an acoustic release mechanism. With a pop-up buoy, the surface buoy is no longer needed.

Using a subsurface buoy with a short mooring line to the bottom (corresponding to a bottom mount) is convenient in coastal areas with moving sand, waves or very soft bottom types, as this avoids burial. In regions with irregular / sloping bottoms, use of subsurface buoy facilitates vertical orientation of the instrument, as opposed to using bottom frames. Subsurface buoy moorings are also favorable at latitudes with seasonal ice, because the buoy allows continuous collection of data undisturbed of the sea ice.

When using a subsurface buoy it is important to understand how the natural frequency of the buoy may contaminate the data collection.

4.2.4 Bottom mount

The bottom frame is typically used in fixed deployment situations. The advantage of mounting the instrument at the bottom is the reduced chance of measurement errors due to instrument motion and movement from interaction with the surface (waves, wind), or motion transferred from the mooring line during in-line mounting. When using a bottom mount, the emitted beams are not in the risk of encountering any obstructions related to the deployment setup.

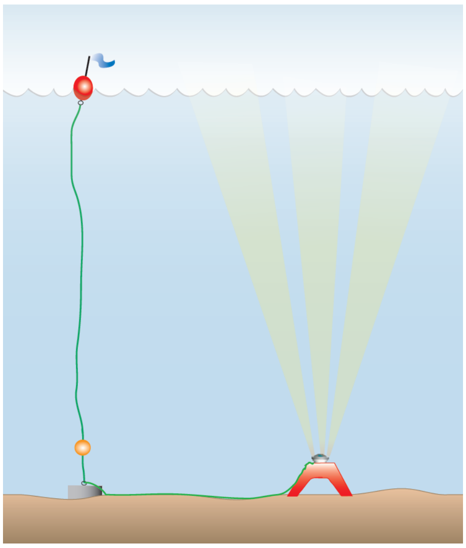


Figure 4: Bottom mounted instrument

If the deployment depth is shallow, the mounting frame may be exposed to strong forces due to the orbital currents that waves generate. The design of the frame should therefore be compact and heavy. This and other considerations regarding bottom frames are listed in the equipment chapter. Note that if your plan is to make measurements near the surface from a bottom mounted instrument, the tilt must be as small as possible. If the bottom is not level, it might the use of a gimbal could be beneficial, or use a subsurface buoy as mentioned in the previous section.

If measuring waves is the focus of a deployment, bottom mounted gauges work well in shallow water. However, in depths greater than a certain limit, bottom mounted wave gauges are not able to provide the directional resolution necessary for most research and commercial requirements. This limit is determined by the signals associated with orbital velocities and pressure attenuation, and the fact that they attenuate exponentially with depth. Read more about this in the Principles of Operation - Waves.

4.2.5 Online

4.2.5.1 Electrical noise

Deploying an acoustic instrument as an online system, which is supplying real-time data over a subsea cable, a rigorous assessment of potential electromagnetic interference is required. Interference from electrical noise can significantly degrade both recorded and transmitted data. It can manifest in the data as an overall elevated noise floor or periodically raised return signal strength.

Electrical noise may originate from:

- The power supply (For power supplies other than what is provided by Nortek)
- DC/DC converters
- Other operational sensors or electronic equipment installed in the vicinity of the instrument

These sources can introduce noise that overlaps with the acoustic instrument's operational frequency range, especially when power supplies use switching regulators or are poorly filtered.

To minimize interference and ensure high-quality data collection:

- Power Supply Compatibility: Always verify that any external power supply has a switching frequency that lies outside the acoustic sensor's operational bandwidth.
- Measurement Timing: If multiple acoustic instruments or sensors are deployed within a close range, their acoustic signals can interfere with one another. Staggering their measurement intervals—so they do not ping simultaneously—can reduce cross-talk and improve overall data quality.(See also: Acoustic interference between multiple instruments)
- Shielding and Grounding: Proper cable shielding and grounding practices can help reduce transmission paths and protect signal integrity.

4.2.5.2 Using long cables

Cables arguably provide the most reliable means of communication. When working over large distances, it is important to be aware of the following challenges as well as the precautions that can be taken to minimize them:

- **Maximum cable length**

RS232 data communication at 9600 baud can be used for cable lengths up to 50 meters, depending on environmental conditions. If a longer cable is required, we recommend switching to the RS422 communication protocol, as RS232 may be too slow and could result in data loss. For cable lengths exceeding 100 meters, the use of an interface box is strongly advised.

- **Voltage drop**

When supplying power to your instrument over a long cable, the voltage drop due to the cable's internal resistance must be taken into account. The extent of the voltage loss depends on the cable length, the instrument's current draw, and the specific resistance of the cable. For detailed information on how to calculate voltage drop in your system, please refer to the relevant FAQ. This calculation will help you determine the minimum power supply voltage required to operate the instrument reliably. It is essential to consider both the minimum operational voltage and the maximum voltage rating of the instrument—these values are available in the technical documentation on our website. A stable power supply is just as critical as correct voltage. An unstable supply can result in corrupted data or intermittent faults. In extreme cases, severe power surges in systems lacking an interface box or DC/DC converter can damage the electronics irreparably.

- **Multiple power supplies**

When multiple power sources are present, the instrument will draw current from the source with the highest voltage until the voltages equalize, after which it will draw from both. It is also possible to add backup batteries and memory to online systems. The battery ensures continued data collection if the main cable connection is interrupted, while additional memory allows for data to be stored locally without loss.

4.3 Equipment

Selecting the right equipment when designing a mooring system is essential for ensuring stability, durability, and accurate data collection. Each component—whether buoys, mooring lines, anchors, or shackles—must be carefully chosen based on environmental conditions, expected loads, and measurement objectives. Poorly selected equipment can lead to excessive mooring motion, increased drag, structural fatigue, and data contamination due to misalignment or interference.

4.3.1 Standard equipment

4.3.1.1 Surface buoy

Surface buoys serve multiple functions in mooring deployments, including acting as a base for surface instruments, retrieval floats, mounting platforms, buoyancy providers, or surface markers for telemetry systems. One of their primary roles is to provide sufficient buoyancy at the top of the mooring line to help maintain a near-vertical orientation of the mooring. A properly designed surface buoy ensures that the mooring system meets depth excursion and instrument inclination requirements, keeping instruments stable and at a consistent depth even through changing tidal conditions and wave action.

The shape and dimensions of the buoy should be carefully selected based on the specific deployment objectives and environmental conditions. In most cases, the buoy should minimize dynamic stress on the mooring line to prevent excessive motion that could degrade data quality or introduce mechanical strain. Since the buoy is subject to wave-induced motion, including heave and roll, efforts should be made to limit the degree of motion transferred to the mooring and instruments. Spherical buoys are commonly used due to their high strength-to-weight ratio, ease of construction, and widespread availability. For durability and reliability, it is recommended to use hard plastic buoys filled with either foam or air, rather than soft plastic air-filled buoys, which are more susceptible to puncturing and failure.

4.3.1.2 Subsurface buoy

A subsurface buoy plays a critical role in reducing wave-induced motion of the mooring line and helping to keep the mooring as vertical as possible. It also provides support for the weight of both the mooring line and the instrumentation, preventing excessive strain on individual components. Additionally, a subsurface buoy enhances backup recovery capabilities; if the mooring line or cable were to snap, the buoy's positive buoyancy allows the instrument to rise to the surface, facilitating retrieval. By positioning positive buoyancy above the anchor, the risk of entanglement and wear from contact with the seabed is minimized. This is particularly important in L-mooring configurations, where it is recommended to attach a buoy along the mooring line resting at the bottom. If a surface buoy is lost or the mooring line breaks, retrieval from the seabed becomes significantly easier when the mooring line is not fully settled on the ocean floor.

When using a subsurface buoy in the upper water column, it is essential to minimize its density, as its efficiency rapidly decreases with added weight. The floating material density must increase with depth to withstand the higher hydrodynamic pressure at greater depths. While pressure resistance is only a concern in deep-water deployments, selecting the correct buoy material is crucial. Synthetic foam is particularly well-suited for deep-sea moorings due to its high-pressure resistance and suitability for strong current regimes. To reduce drag, one large-diameter buoy is generally preferable over multiple smaller buoys. The buoyancy of the subsurface buoy significantly influences mooring system response, affecting stability, movement, and overall instrument performance.

In some deployments, instruments can be mounted directly within a subsurface buoy. When considering this approach, the shape of the buoy is an important factor:

- Ellipsoid-Shaped Buoys: These have lower drag than spherical buoys, making them a good option for calm environments or when instruments are deployed near the seabed. However, in high-current areas, ellipsoid buoys are not ideal, as strong currents can cause excessive tilting, increasing drag forces. Once the bottom of the buoy faces upstream, the drag contribution becomes severe, compromising stability.
- Streamlined Subsurface Buoy (SUBS): The torpedo-shaped SUBS buoy is designed for high-current regimes, providing greater stability and reducing mooring excursions and inclinations. Unlike ellipsoid buoys, the SUBS is more effective at maintaining a vertical instrument orientation, making it a preferred choice in dynamic ocean environments.

The ellipsoid buoy has a tendency to rotate more than the SUBS, but data from an experiment comparing the two buoys shows that the rotation is slow enough so that the compass is able to keep up with the rotation and provide accurate measurements. Conversely, the SUBS is more stable for the roll (side to side), but the pitch becomes larger during time of increased wave energy.

4.3.1.3 Mooring line

Choosing the appropriate mooring line is crucial for ensuring the stability and longevity of a deployment. Several factors must be considered, including load type, rope material, ease of handling, deployment duration, and the surrounding environment. Different rope materials offer unique properties such as strength, drag, stretch, endurance, weight, and buoyancy characteristics (floating vs. sinking). Understanding these factors allows for better mooring performance and reduced wear over time.

Drag considerations: deep vs. shallow water moorings
In deep-ocean moorings, drag on the mooring line is a significant factor across the entire length of the system. To minimize excessive drag, it is generally advisable to select a mooring line with the smallest diameter possible. The diameter of the line represents the largest portion of overall drag contributions due to its large cross-sectional area (*A* in Equation 2). For shallow water moorings, however, currents (V^2 in Equation 2) — such as tidal, wind-driven, and wave-induced flows — often exert a greater influence than the diameter of the mooring line. In these cases, the focus should be on managing the effects of these currents rather than solely minimizing the line's diameter. In rough sea conditions, a heavier sinker may be required to prevent the buoy from lifting the anchor.

Stretch and elasticity: managing mooring tension
The stretch characteristics of a mooring line play a critical role in determining the position of both the instruments and surface buoy at any given time. In deep-water moorings, maintaining a taut mooring line is essential to minimize movement caused by currents and waves. This is often achieved using elastic synthetic rope, which helps absorb energy from ocean motion and prevents the surface buoy from being pulled underwater during extreme conditions. However, the elasticity of synthetic ropes is non-linear and changes over time due to material fatigue. Additionally, in shallow-water deployments, elastic rope is generally not recommended due to the risk of abrasion from the seafloor. In this case, floats along the line can be used to keep the mooring off the bottom while maintaining stability. Note that synthetic ropes are made of viscoelastic materials, so their stiffness characteristics are not constant and vary with the duration of load application, the load magnitude and number of cycles. In general, synthetic mooring lines become stiffer after long use.

To maintain the strength and durability of the mooring line, it is important to avoid knots on the rope, as this reduces the breaking strength with up to 50%. Additionally it is recommended to use torque-balanced wire rope, which helps reduce rotation in the mooring line, preventing twisting and strain over time.

4.3.1.4 Anchor

The ability of an anchor to hold a position on the seafloor is dependent on several factors; the seabed type, the anchor material, shape and weight. A failure in anchor performance can have severe consequences for the deployment, leading to drift, instability, or even loss of the mooring system. The anchor must be sufficiently heavy to ensure that the mooring assembly sinks properly and remains in place on the seafloor. It must be capable of withstanding both vertical and horizontal forces exerted by ocean currents, waves, and tidal changes. If the anchor weight is too low, the mooring system may shift position during strong currents or high tides, compromising data accuracy and stability. However, the anchor size and weight should also be kept within reasonable limits to ensure practical deployment and retrieval. Site conditions play a crucial role in determining the necessary anchor weight.

The holding power of an anchor is influenced by the type of seabed it rests upon. In general:

- Soft, cohesive seabeds (e.g., mud or fine sand) provide higher horizontal friction, improving anchor stability.
- Hard seabeds (e.g., rock, gravel, or shell-covered areas) offer lower holding power, making anchoring more challenging.

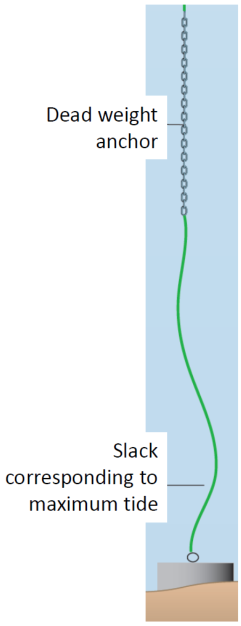


Figure 5: Illustration of the use of dead weight anchor

Anchor shape also affects performance. Certain designs enhance holding power by increasing seabed friction. If the seabed is too soft, the anchor may sink excessively, altering the mooring's intended configuration. In such cases, mud mats can be used to prevent excessive sinking and ensure that mooring components remain at their configured depth—especially crucial when using acoustic releases, which must remain suspended in the water column. Additionally, the density of the anchor material is critical, as materials experience a loss of weight when submerged. For example, the effective weight of concrete underwater is only 56% of its dry land weight. Due to this reduced buoyant weight, larger concrete anchors may be required to achieve the necessary holding power.

When using acoustic release systems, the anchor is often left behind on the seafloor. To minimize environmental impact, it is recommended to use anchors that can disintegrate over time, preventing long-term obstruction on the seabed. A disintegrating anchor also provides a secondary recovery mechanism—if the acoustic release fails, the system may eventually refloat as the anchor material degrades.

Dead weight anchor: The dead weight anchor (illustrated in Figure 5) is used to resist vertical pull of the system; some weight underneath the instrument will keep it from bouncing around in rough weather. A length of chain is recommended due to the reduced chance of sidelobe interference compared to when using weight with a larger surface area. Ballast underneath the surface buoy has the same effect, and the risk of entanglement of the mooring line is reduced. A length of chain placed above the anchor will reduce the tension the anchor experiences.

4.3.1.5 Selecting and managing metals

Choosing the right metals for a mooring system is essential for both structural integrity and the reliability of deployed instruments. Key considerations include corrosion prevention, material compatibility, mechanical strength, and avoiding magnetic interference. Addressing these effectively ensures the durability of your deployment and the accuracy of your measurements.

Shackles, swivels, and links serve a critical role in the structural integrity of a mooring system. They are used to connect various components of the mooring line and ensure that instruments remain securely in place throughout deployment. When selecting these connecting elements, the primary consideration must be their strength—each component must be able to withstand the maximum expected tension from the parts it joins. Always bear in mind: **a mooring is only as strong as its weakest link**. Swivels are commonly used to allow relative rotation between two connected components. This rotational freedom helps reduce torsional stress on the mooring line, which can otherwise build up over time due to ocean currents or instrument motion. Reducing torsion improves the longevity of the line and the reliability of the entire deployment.

Corrosion prevention and material compatibility

Corrosion poses a serious risk to the mooring system. Mixing different metals in the presence of an electrolyte like seawater can result in galvanic cells that accelerate the degradation of more reactive metals.

Best practices for corrosion mitigation:

- Avoid Mixing Metals: Use the same type of metal for connecting components whenever possible.
- Isolate Dissimilar Metals: Use nylon washers, plastic sheeting, rubber gaskets, or synthetic rope to physically separate different metals. Even inserting a small length of rope between metal components can provide effective electrical insulation.
- Apply Sacrificial Anodes: Attach zinc anodes to vulnerable components such as battery canisters. These anodes corrode preferentially, protecting the surrounding metal parts.
- Inspect Regularly: Periodically check for early signs of corrosion and replace compromised parts before failure occurs.
- Electrically Isolate Battery Canisters: Use non-conductive materials to prevent galvanic contact with other metals

Avoiding magnetic interference

Your instrument relies on magnetic sensors for orientation and positioning. The presence of magnetic metals in the rigging can interfere with these sensors, leading to inaccurate directional readings and compromised data quality. Be mindful of material selection when choosing clamps, shackles, and mounting structures near your instrument. Non-magnetic materials such as stainless steel or titanium are preferred over ferromagnetic metals like iron or standard carbon steel. Perform a thorough compass calibration after installing the instrument in its final configuration. Even if all precautions are taken, minor local disturbances can still affect the compass, making calibration essential. The correct steps for a successful compass calibration can be found here.

4.3.1.6 Bottom frame

When designing or selecting a bottom frame, you should consider a few things before you drop your gear in the water.

Stability. The frame should sit on the bottom and not move or rock back and forth. One common solution is to use a tripod leg configuration. Stability naturally improves with a larger frame "footprint" and a lower profile. The frame will normally have the battery canister on one of the legs. If possible, put the battery inside the leg, and not outside. Have an equal amount of weight on each side / leg; the frame might tip over if the weight is too little and / or uneven. Make sure that the weight is correct underwater.

Mobility. Clearly, the frame should not move while on the bottom. Movement can come from strong mean currents or wave generated currents. Wave generated currents can be particularly troublesome in shallow waters or environments where waves are large and long. The frame must also be firmly attached to the bottom if the bottom type is relatively soft. Note that shifting sediment or sand can undermine bottom fasteners.

Ease of deployment. This should be considered if the frame is to be deployed by divers or handled by a small boat. If a large amount of weight is used to eliminate mobility, it may not be manageable by a small boat or crew.

Orientation. The instrument should be placed vertically and in the case of the AWAC, with AST, a tilt less than 5 degrees should be the aim. For other instruments, the performance deteriorates quickly for tilts greater than 10 degrees. A gimbal is the best solution if you do not use divers to ensure the proper orientation of your frame / instrument.

Retrieval. This is perhaps more of a deployment consideration; however, some method should be kept in mind for a retrieval system that does not interfere with the instrument's performance. Surface buoys floating above the instrument can interfere with the acoustic beams; moreover, they may be dragged away or lost due to shipping traffic or curious mariners. Alternative methods of retrieval include acoustic releases (from bottom weight), pop up buoys with releases, drag lines and/or offset mooring systems.

Trawl resistance. Bottom fishing is perhaps one of the most challenging issues for bottom-mounted systems. Trawl resistant bottom frames are designed for protecting the instruments from trawler gear. The frames can reduce the risk of being impacted by trawlers, but the risk is not completely eliminated. A good alternative is the Miniaturized Trawl Resistant Bottom Mount (MTRBM) systems.

Multi-sensor mounting. Since Nortek instruments provide the possibility to integrate external sensors, this should be considered when deciding on a frame.

Ease of shipping. Some frames can be separated into sections for easy shipping. This of course reduces operational costs when testing is performed at different locations.

Corrosion resistance. All materials of the frame must be corrosion resistant. Materials such as fiberglass, stainless steel (316), aluminum, and plastic are good alternatives. You must always isolate any metal you use, and make sure not to mix metals to reduce the risk of corrosion.

Burial. This is also a challenging issue for bottom-mounted instruments. Low profile frames may not be the best alternative in locations with large sediment deposits or moving sand. Sometimes it is just a matter of time before the frame slowly sinks or sand builds up; in these situations, some users (of online systems only) have found sensors measuring distance from the instrument to the bottom useful. If mean currents and wave-induced currents are manageable at the bottom, a solution against burial is to mount the instrument on a subsurface buoy located just above the bottom.

Magnetic influence. Some materials can influence the magnetic field around the instrument, causing problems with the heading reading. A compass calibration should always be done before each deployment to account for any magnetic influences. Stay away from galvanized steel in particular, as this can have a very unstable effect on the magnetic field, so even with a compass calibration it may still for example change the magnetic effect of the battery discharging, introducing errors. Magnetic deviation in the instrument compass due to a magnetic source on the bottom frame should be taken into account by calibrating the compass attached to the frame before deployment.

4.3.2 Ancillary equipment

4.3.2.1 Pop-up buoy

The pop-up buoy is recommended when use of a surface buoy is impractical. Most of the pop-up buoy's life is spent submerged, secure from storms and surface traffic. It functions by attaching one end of a line to e.g. the bottom frame and the other end to the buoy. Upon receiving an acoustic command, the buoy rises to the surface and the line attached to the buoy can be used to pull up the equipment directly. The Spin buoy by Abyssus, the Fiobuoy by Fiomarine and the 875-PUB by Benthos are good alternatives. Make sure to obey the depth limitations specified by the manufacturer.

4.3.2.2 Acoustic release

An acoustic release system is deployed in-line on a mooring, close to the anchor. When activated from the surface unit, the release system disconnects from the anchor, and the mooring aided by its flotation elements, ascends to the surface for recovery. To ensure successful retrieval, it is essential that the mooring system has sufficient buoyancy to overcome the weight of the remaining submerged components. Buoyant elements should be strategically placed near the acoustic release and/or distributed along the mooring line. This ensures that once released, the mooring rises efficiently and reliably to the surface. If buoyancy is inadequate, the mooring may remain suspended in the water column or ascend too slowly, making it difficult or impossible to locate and retrieve.

It is recommended practice to utilize a pair of releases to provide redundancy. Ensure both units are independently addressable by the acoustic command system and conduct pre-deployment tests of each release on deck to confirm functionality.

4.3.2.3 Gimbal

When deploying instruments on uneven or sloped seafloors, maintaining proper orientation of the instrument head is essential for accurate data collection. In such cases, a gimbal mount is often used to ensure the transducer head remains upright regardless of minor variations in the seabed. The gimbal functions as a pivoting platform that uses gravity to self-level the instrument, keeping it aligned in the correct vertical orientation for reliable measurements. It must be properly balanced to function effectively. This means that a counterweight is required below the instrument, particularly for top-heavy sensors like the AWAC

It is equally important to ensure that there is enough vertical clearance beneath the gimbal. On uneven terrain or with seabed sediments that cause the frame to settle unevenly, the bottom of the gimbal assembly may come into contact with the seafloor. This contact can interfere with the gimbal's freedom of movement, potentially causing the instrument to tilt or become stuck in a non-upright position. In areas with strong bottom currents, a gimbal can become counterproductive. If the instrument is mounted in an open-bottom frame, water flow can enter from below and destabilize the gimbal mechanism. This can cause the instrument to oscillate, tilt, or behave erratically, negating the benefits of the self-leveling design and possibly leading to compromised data.

4.3.2.4 AquaFin / AquaClamp

Nortek's **AquaFin** optimizes the instrument's ability to measure without flow disturbance while simplifying in-line deployment and be utilized when working with an Aquadopp. The AquaFin shackles in-line and swivels the instrument so that its beams always face into undisturbed flow. The need for an Aquafin depends on the mooring construction, e.g. wether the instrument is suspended below a surface buoy or deployed above an anchor using floatation elements. The instrument's compass has no trouble compensating for the heading changes.

The **AquaClamp** is similar to the AquaFin in that it is used to mount an Aquadopp current meter or profiler on a mooring line. The AquaClamp mounts in-line in the mooring line, and it is used when clamping the instrument directly to the mooring line is not practical or desired. The AquaClamp provides a stable setup and will not rotate with the flow!

4.4 Interference

4.4.1 Acoustic interference between multiple instruments

To minimize the risk of interference between multiple instruments deployed in the same area, it is recommended to stagger your instruments. This can be achieved by setting a time interval between the starting times of the instruments, ensuring that they do not ping at the same time. Staggering the instruments in this way helps to reduce the likelihood of one instrument picking up the pings from another, leading to more accurate data collection. For further details on this topic, please see this FAQ.

4.4.2 Physical beam interference

Any physical obstructions within an instrument's acoustic beams can introduce visible data errors, potentially compromising measurement accuracy. Common sources of interference include nearby instruments, marine growth on the seabed, mooring components, or buoys. When an obstruction reflects part of the acoustic signal, it often appears in the data as a constant line at a speed different from the surrounding measurements. To minimize the risk of such errors, careful deployment planning is essential. Before deployment, assess the surrounding environment to identify potential obstructions and ensure that no part of the mooring rig interferes with the acoustic pings.

It is also important to consider that as an acoustic beam travels farther from the instrument, its width increases. This expansion is influenced by blanking distance, cell size, and beam geometry. As the beam grows wider, the chances of it encountering unintended obstructions increase, making it even more critical to ensure a clear measurement path. To be sure to avoid contamination of your signal by blockage, you should ensure that you have at least a **15 degree clearance to each side of the main beam**.

For further details on physical beam blockage, see this FAQ.

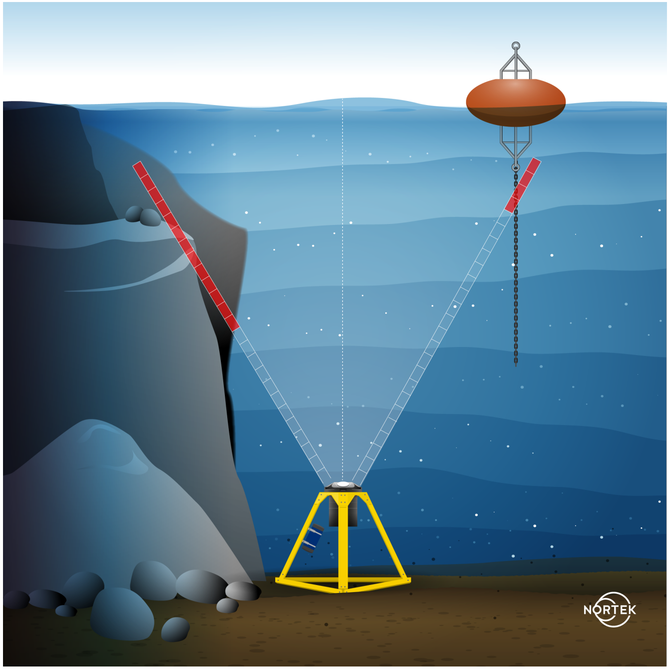


Figure 6: Example of deployment setup affected by obstructions. The cells marked in red will experience significant data loss

5 Preparation

After having chosen the best fitting deployment configuration and acquisition of necessary instruments it is necessary to develop a detailed mooring design to prepare for deployment and function test as well as configure the instrument.

This section covers:

✓ How to design a mooring and select the individual components
✓ A detailed description on how to set up your instrument initially and function test it before deployment
✓ How to test your construction and prepare for departure

5.1 Mooring diagram

All moorings exposed to high currents or significant wave motion require a thorough static analysis to assess how the mooring system will behave on the seabed. However, while static analysis provides insight into equilibrium conditions, it does not account for transient effects such as the increased loads during free fall or the long-term impact of high waves, which can contribute to fatigue failure over time. To fully understand these stresses, a dynamic analysis is necessary.
Dynamic analysis allows for a more detailed evaluation of mooring behavior under real-world conditions, helping to estimate critical factors such as the knockdown of instruments (actual deployment depth), the natural frequency of the mooring line, and the horizontal excursion caused by drag forces. These insights are essential for optimizing mooring configurations and ensuring long-term stability and reliability.

A variety of specialized mooring software tools are available to assist in conducting these analysis. These programs not only help in calculating forces and loads but also generate visual representations of mooring systems. Such diagrams are invaluable for identifying potential design issues, optimizing configurations, and effectively communicating the mooring setup to the crew and stakeholders.

Creating detailed mooring diagrams is a crucial step in the planning process. They help reveal potential complications such as incorrect weight-to-buoyancy ratios, metal-to-metal contact points that require isolation, or elements that could interfere with the magnetic field, affecting instruments like compasses or magnetometers. Additionally, clear and precise diagrams improve operational efficiency by making it easier for vessel crews to understand the rigging plan, reducing the risk of errors during deployment. These visuals can also enhance reports and presentations by providing a clear representation of the mooring system.

Investing time in proper analysis and visualization ensures safer, more efficient mooring deployments and helps mitigate risks associated with extreme environmental conditions.

5.2 Instrument configuration

This chapter outlines the essential steps required to prepare any instrument for deployment. It begins with instructions for establishing a connection, followed by guidance on performing a functionality test, compass check, and pressure calibration.
These procedures are critical to ensure reliable data acquisition and must be completed for both new and previously used instruments.

5.2.1 Intial startup

Always test the instrument before a deployment to verify that it works as expected. Additionally, always make sure you have the most recent software and firmware installed, which are always available on our website.

5.2.1.1 Power

The first step is to make sure the instrument has a source of power. Power will normally come from the internal battery pack or from the AC/DC converter that is delivered with most systems. Always perform a visual inspection of any used batteries to check for leaks or other signs of damage.

Internal batteries

The internal battery pack is located inside the pressure case for all instruments except AWACs. Internal batteries enable autonomous deployments of up to a year and also provide backup power in the event of failure of the external supply. Note that the battery pack inside the pressure case is disconnected when sent from Norway. Please refer to the Maintenance chapter for detailed information on how to connect or change a battery pack. It also ships with an external power supply, which we recommend you use for all but the final testing. If you leave the instrument collecting data, it will continue to run until the batteries are dead. Always make sure to stop data collection when testing is complete. Find more information about the Nortek Batteries at our Website.

Storage Guidelines:

- store batteries in cool (0°C - 20°C) and dry (relative humidity < 65%) environment
- keep them away from water, direct heat or sunlight to prevent degradation
- ensure that there are no opportunities for the battery terminals to short circuit

Lithium-Ion batteries are rechargeable and therefore usable for multiple deployments. As with other rechargeable batteries (e.g. a car battery), one has to keep in mind that their capacity will decrease over time. Its lifetime is considerable reduced when completely discharged. A storage charge of 15% - 45% is recommended, which should be checked regularly to prevent a complete discharge.

If using batteries that have been stored for an extensive period of time, it is recommended verify their initial charge by testing them using a Multimeter. To avoid starting a deployment with a partially charged battery, our Deployment Software will issue a Warning when clicking Deploy and the connected instrument is equipped with a battery whose charge is significantly lower than stated in the setup. The charge itself is not a reliable source of information regarding the remaining lifetime of a used or old battery. Specifically Lithium batteries tend to maintain a stable voltage for an extended period of time during their discharge cycle, before decreasing rapidly. Alkaline batteries show a roughly linear discharge curve as seen on the example of Figure 7. When planning on reusing batteries it is therefore recommended to take note of previous deployments and their energy usage. This will prevent the instrument from unexpectedly running out of power during the next deployment. The power usage for a given deployment configuration and length can be found in the deployment software.

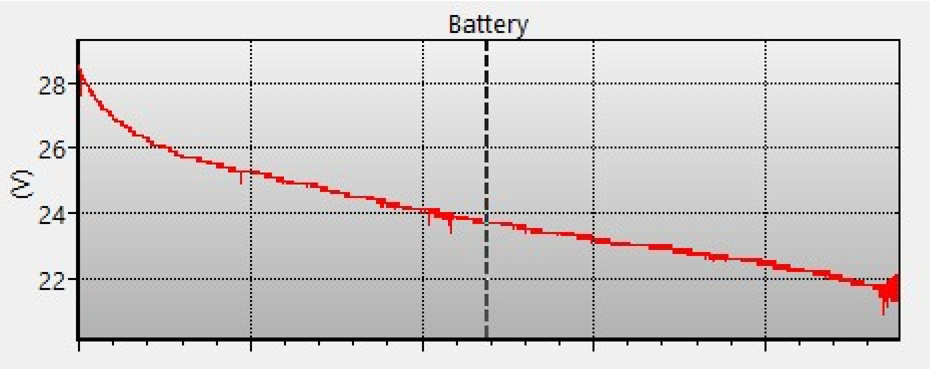


Figure 7: Example discharge curve of a Signature 500 equipped with a 27V / 540Wh Alkaline battery. The figure shows the voltage curve from the fully charged state of a new battery to insufficient power supply for the instrument.

External power

You may also supply power with the external supply that is delivered with the systems, or you can use your own external supply. If you use your own supply, be sure the voltage does not exceed the voltage input range available for you instrument.
Check the data sheet for your specific instrument for exact requirements. The instrument will always draw power from the source with the highest voltage. If you use an internal battery to backup data collection, an external supply can provide a higher voltage than the battery pack, which prevents the internal pack from discharging. Then, if external power fails, the internal battery pack takes over and sustains operation. The power and battery lines are diode protected, so you do not have to worry about wiring the instrument power backwards - this will not damage your instrument.
When connecting and powering both serial and ethernet at the same time, ethernet will always take priority. In such a setup, you will only be able to use Ethernet for communications and data output.

5.2.1.2 Establishing a connection

Find the instrument specific software on our software page and install it on your PC. Installing instrument software does not require a license key. Always confirm that your software and firmware version is up to date. The Deployment software has been designed to aid you in the planning, execution, recovery, data retrieval and conversion. A thorough description of the software and its features can be found in the software's help section. Communication to your instrument can be established using either a Ethernet or Serial connection. Serial communication is available for all our sensors whereas Ethernet can be used with instruments from the Signature series as well as Generation 2 AWACs.

Serial connection

Your instrument can communicate serially using either RS232 (8) or RS422 (9) communication protocol. Ensure that you are using the correct USB converter for the configured protocol on your specific instrument. Connect the serial cable to the converter, and insert it into the USB drive of the computer. For first time use, give the converter enough time to install its driver correctly. If the driver is not installed correctly, find the updated versions from our Software site. In the instrument software, choose the correct serial port to use. If you are unsure about which port number to use, check the Device Manager on your computer.

Figure 8: RS232 converter

Figure 9: RS422 converter

To establish a connection, it is necessary to set the correct baud rate. The standard and available rates for you instrument can be found in the technical specifications available on our website . A higher baud rate speeds up large file transfers and is appropriate when you have a short serial cable and a relatively noise-free environment.

Note: Generation 2 Aquadopps and the serial cable following the instrument can be used with both RS232 and RS422.

Changing communication protocol

For Generation 1 Aquadopps and AWACs the communication protocol is decided by the harness, and in order to change protocol the harness itself has to be replaced. For more information about this please contact your local Nortek representative. If your instrument has the option of Ethernet Communication (Signature or Generation 2 AWAC), you can change between the two available communication protocols (RS232 / RS422) using commands. To change the protocol from RS232 to RS422 follow these two steps:

1) Send the command `SETINST,RS=422` (similarily, if you want to change back to 232 you write `RS=232` instead).
2) Send the command `SAVE,INST`

Further details can be found in this FAQ.

Note: Should you be connected to the instrument through a serial cable (for example when working with a Gen2 Aquadopp), the then communication protocol can not be changed!

Changing baud rate:

The baud rate can either be changed using the **New Baud Rate** button in Nortek Deployment or by sending the command SETINST,BR=115200 through the terminal window. See the software for more details.

Ethernet connection

The Ethernet communication has been implemented by using a dedicated network processor, and needs to be powered by connecting a power supply to the external power breakout on the cable. Note that powering through the Ethernet cable will also power the rest of the electronics. The instruments should not be powered with power over ethernet (PoE), as this will potentially damage the instruments electronics.

DO NOT APPLY POWER TO THE ETHERNET CABLE BEFORE YOU HAVE CONNECTED THE CABLE TO THE INSTRUMENT

If you power the Ethernet cable before you connect it to the instrument, there is a risk that you will connect the cable incorrectly and apply power to the wrong lines. This will cause components on the board to burn out. If this occurs, you will see a loss of communication and you will need to return the instrument to Nortek for repair.

1. Connect the supplied test cable to the communication output on your instrument, then apply power to the breakout cable. The blue LED should be turned on shortly.
2. Use a direct connection or an Ethernet switch to connect the Ethernet connector to your computer.
3. If you use a computer Ethernet port that has status lights, verify that the link is active by looking for a solid green light on the port. If an Ethernet switch is used, the Ethernet port should also show an active Ethernet link.

The Discover configuration menu selection in our Deployment software provides a means to locate and configure the network information for instruments without having to know the IP address of the instrument. All instruments found on the network are displayed. If you use a static IP address you can input it directly and click Connect.

Only one person can be connected to an instrument at a time. If you try to establish connection with an occupied instrument, you will receive a notification.

5.2.1.3 Firmware upgrade

Nortek releases firmware updates multiple times per year. We are constantly improving our instruments functionality and components, so it is extremely important that the firmware on your instrument is kept up-to-date. Failing to keep the firmware updated may mean that your instrument will not work as intended. Updating the firmware will not affect your installed licenses. When you connect to an Instrument, the Deployment software will prompt you to update the firmware if a new version is available (when connected to the internet).

By the term firmware we are referring to the internal software of the instrument, as opposed to the instrument software running on a PC. When you purchase a brand new instrument, it has a firmware version matching the PC software, hence no firmware upgrade will be needed before you start using the instrument. However, new functionality (and in rare cases bug fixes) is likely to be offered in the future, requiring that the firmware is upgraded. New firmware is posted at the Nortek web, at https://www.nortekgroup.com/software. You will need to register to get access, but access is otherwise free of charge. **Transfer data that you would like to retain to your PC before you upgrade the firmware, as any data recorded on the instrument will be erased to avoid inconsistencies.**

To check for available updates when connected to our Deployment Software, click the **Check for updates** button. To upgrade firmware, upload a firmware file and then start the upgrade. Wait until the firmware upgrade is complete, this will be confirmed by the message "Your instrument was successfully upgraded!"

5.2.2 Functionality test

At this stage, it is assumed that a stable and reliable connection to the instrument has been successfully established. Before conducting any deployment tests, it is strongly recommended to perform a functionality test to verify that all instrument components are operating correctly. Ensure that your instrument is connected as outlined in the Establishing a connection section. The functionality test also assumes you are familiar with the Deployment Software.

Begin by creating a `.deploy` file, ideally configured to sample at the instrument's maximum rate. When doing so, select all default options except for the average interval and measurement interval—these should be set to their lowest common value. Next, setup up your instrument to show live data using the deployment configuration you created. You can confirm the instrument is sampling by checking the LED indicator, which will blink with each emitted ping.

Note: If the instrument is left collecting data while powered by internal batteries, it will continue until the batteries are depleted. Always stop data collection once testing is complete.

Sensor Checks

Temperature
Verify that the instrument's temperature reading is reasonable. After sufficient time to reach thermal equilibrium, the reading should be close to room temperature.

Pressure
The instrument measures absolute pressure in units of dBar, and below sea level the pressure readings will then include the water and atmospheric pressure. The atmospheric pressure usually fluctuates around 10.13 dBar, and 1 dBar is equivalent to the pressure change over 1m depth in fresh water (so at 1m depth the absolute pressure would be 11.13 dBar). During production, the pressure offset is set to 9.5 dBar to output the gauge pressure (pressure relative to the atmospheric pressure). The outcome is that when the instrument is in air, you will see a value of 0.2-0.7 dBar, depending on atmospheric conditions. Be aware, that the pressure sensor cannot output negative values.

Test the pressure sensor by submerging the instrument in water and look at the pressure readings. For example, if the instrument is placed at approximately 0.5 meters depth, the pressure reading should increase by the same amount.
An alternative way to test whether the sensor is functioning is by forming a seal around the sensor with your mouth and blowing to observe an increase in pressure. The location of the sensor is indicated in Figure 10.

Important: Always adjust the Pressure Offset according to local conditions before final deployment.

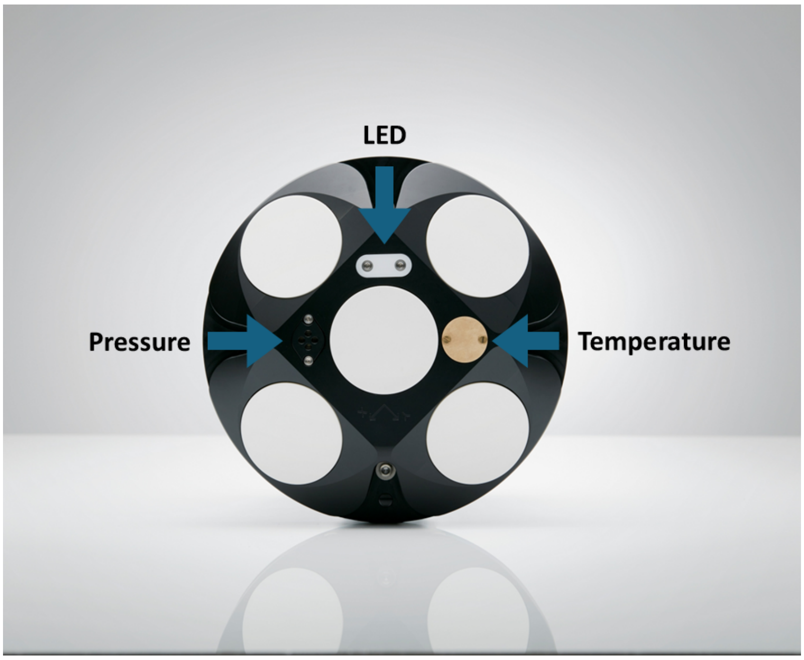


Figure 10: Demonstration of sensors on the instrument head on the example of a Signature 500.

Tilt

The tilt sensor is located on the electronic boards inside the housing. Tilt is given in pitch and roll values. Pitch indicates the rotation around the y-axis, while roll indicates the rotation around the x-axis. The x-axis is marked on the instrument head, and the y-axis follows the right hand rule. Ensure that the tilt values correspond with the instrument's orientation by following this procedure: (An example of the expected observations is shown in Figure 12.)

1. Hold the instrument as level as possible while aiming the X direction away from you. The values for "Pitch" and "Roll" should now be close to zero.
2. Tilt the instrument 10º to the **right**. The "**Roll**" value should read approximately 10.
3. Tilt the instrument 10º to the **left**. The "**Roll**" value should read approximately -10.
4. Tilt the instrument 10º **forwards**. The "**Pitch**" value should read approximately -10.
5. Tilt the instrument 10º **backwards**. The "**Pitch**" value should read approximately 10.
6. Turn the instrument **upside-down** while keeping the x-direction directed away from you. Repeat the previous steps and confirm that the values remain consistent

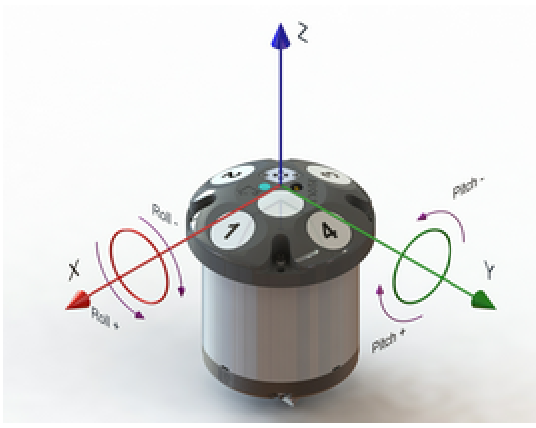


Figure 11: Definitions of beam number, pitch and roll on the example of a Signature

Note on AHRS: When using the standard magnetometer, the instrument will adjust automatically for its orientation and pitch and roll will be 0º and the accelerometer Z value should read -1 when pointing downward. Since the AHRS maintains its orientation, the instrument will observe a roll of 180º and pitch 0º when pointing directly downwards.

Compass

The compass, together with the tilt sensor, provides instrument heading value. The heading indicates which direction the x-direction is pointing towards.

Start by ensuring that the heading is close to zero when the x-direction is pointing towards North. Since the heading values range from 0 to 360 degrees, pointing the instrument towards North may also result in values close to 360. Check that the compass values correspond to the instrument's orientation while rotating it around its vertical axis. For example, pointing the x-direction towards East should result in a heading value of approximately 90 degrees etc.

Note that magnetic interference from nearby equipment or installations may affect the measurements so take this into consideration when evaluating the result. See the Compass Calibration section for more information.
See also "How To" videos on Nortek Support site.

Figure 12: Example timeseries of tilt (a) and heading (b) function test in Nortek Deployment

Beams

1. Noise floor

The instrument noise floor represent the internal noise of the instrument itself, and is a useful parameter for determining the effective measurement range. For more details about amplitude and its applications, please refer to the Principles of Operation - Currents.
The noise floor can be tested either by having the instrument ping in air or in water. For a precise noise floor measurement, submerge the instrument in water to ensure proper grounding. The noise floor can then be identified by analyzing the amplitude profile at a sufficient distance from the instrument, where the profile flattens out.
In air, the instrument will only measure noise, and the amplitude profile should appear as a flat line through the whole profile, representing the noise floor. However, since the instrument is designed to be grounded in water, measurements taken in air may be affected by surrounding noise sources. The first measurement cell is particularly prone to interference from the surroundings, so it is recommended to examine values further along the profile.

Refer to the final test checklist included with the instrument for the expected noise floor value for your specific instrument. Note that these values are obtained by testing in water at the factory and small variations can occur depending on the test environment.

2. Maximum amplitude
Test each beam's response by submerging the instrument in water and observe the amplitude in the first measurement cell. You should be seeing a significant increase in amplitude upon submersion. The maximum amplitude observed will depend on the conditions at your test site. You can use the maximum amplitude values found on the final test checklist as a reference for your specific instrument.

3. Correlation
While measuring in air, the correlation values will be low. When the instrument is submerged in water you should observe a significant increase. For more information about the correlation parameter, please refer to Principles of Operation - Currents.

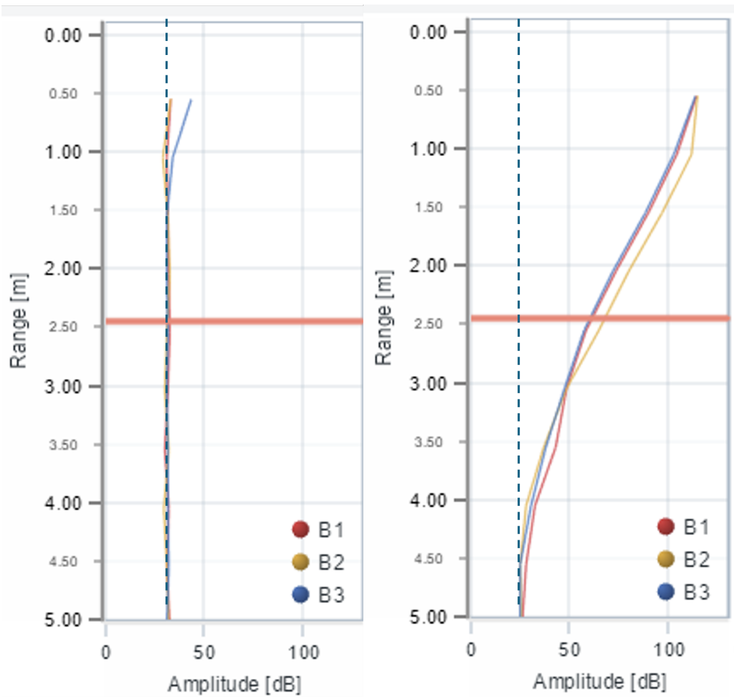


Figure 13: Example beam check carried out in Nortek Deployment. The left image is the amplitude in air whereas the right image shows the amplitude submerged in a water bucket. The dashed line indicates the instruments noise floor.

Recorder/Memory

1. Test the recorder by starting a Recorder Deployment.
2. Write a name for the file you will record internally and start deployment. A notification may appear warning the instrument is running off an external power supply, press Yes to continue.
3. A pop-up confirming your deployment will appear, press OK. You will be taken back to the Home screen while the instrument is deployed.
4. After a few minutes, stop the data collection by reconnecting to your instrument.
5. Find and retrieve the file you created under **Recorder Data Retrieval**.
6. Convert the raw data to ASCII by selecting **Data Conversion** and finding your downloaded file using the **Add file** feature. Specify the folder you want to save the converted file in and press **Start**.

7. Review the collected data with an ASCII test editor (i.e. Notepad).

Note:
- If you leave the instrument collecting data using the internal batteries it will run until depletion. Always make sure to stop data collection when testing is complete.
- We recommend starting new deployments with an empty memory. Before you erase the recorder, make sure that you have transferred all the data you want to retain and that the data is in good shape.

5.2.3 Compass calibration

When collecting current data in ENU coordinates it is crucial to have accurate values for the instrument orientation. In order for the instrument heading to be reported correctly a compass calibration is needed. Each compass has been calibrated at the factory to quantify the characteristic response of the individual components and of the system as a whole. When it leaves the factory, each system can measure its tilt and the direction of its magnetic field vector accurately, anywhere in the world. However, users disturb the magnetic field near the instrument when they deploy. Adding a battery pack and mounting the instrument with deployment hardware adds magnetic materials that change the magnetic field around the instrument. The compass calibration procedure quantifies this magnetic disturbance, which is then used to correct the obtained heading.
As a side note, the compass is not used when measuring velocity in XYZ or beam coordinates, but if you plan on using the compass heading at a later point (for instance to orient the XYZ velocities relative to the lake axes) it is probably worth calibrating the compass in advance.

5.2.3.1 Calibration setup

Compass calibration should be performed immediately before deployment, especially if new magnetic materials have been introduced near the instrument. This ensures that any local magnetic disturbances, particularly those rotating with the instrument, are accurately corrected. The calibration process involves a single, slow rotation of the instrument around its tilt axis, lasting at least 60 seconds. For the calibration to be effective, the compass and any nearby magnetic materials must remain fixed relative to each other throughout the procedure. When properly executed, this process can compensate for magnetic disturbances even greater than the Earth’s magnetic field.

It is essential that the compass calibration is performed using the same setup intended for deployment. This means that the battery must be inserted, and if a mooring frame is being used, the instrument should be mounted to it during calibration. This ensures that any magnetic influences introduced by the full deployment configuration are properly accounted for, resulting in a more accurate and reliable calibration. A steady rotation of the entire deployment setup can proof to be difficult for larger frames and instrument. Customers have been successful by mounting wheels on the mooring frame, suspending the setup from a tree or rotating the assembled buoy in water using a vessel from a considerable distance.

Avoiding magnetic interference
Be aware of any material that may be disrupting the magnetic field in the vicinity during calibration as this may skew the directionality of your data. This is likely to occur at magnetic fields stronger than 5 Gauss. Velocities with respect to X, Y and Z and according to each beam will be correct but North, East and Up may be incorrect. You should conduct this procedure outdoors, away from other possible magnetic elements.Remove any devices from the viscinity that could emit a magnetic signal like phones and laptops not required for the calibration. **If possible, do the final calibration before you board your vessel as ship decks tend to have non-uniform magnetic disturbances significant enough to disrupt the compass calibration process.** Do not subject any part of the

instrument, including batteries, to a magnetic field stronger than 20 Gauss. This may permanently damage the components and cause irreversible damage to the compass.

Identifying the instrument's z-axis

You can identify the instruments z-axis by first locating the arrow indicating beam 1 / the x-axis. Use the right-hand-rule to remember the notation conventions for vectors. Use the first (index) finger to point in the direction of positive X-axis and the second
(middle) finger to point in the direction of positive Y. The positive Z-axis will then be in the direction that the thumb points. A heading of 0° should therefore be observed, if if the instruments x-axis is pointing towards North, consequently a heading of 90° indicates the x-axis pointing towards East.
Use the pitch and roll output of the software to determine, weather the instrument's position is steady and horizontal.

5.2.3.2 Calibration procedure

Connect the instrument and select **Compass Calibration** in the Deployment Software suitable for your instrument. To find the correct software, follow the information on our software page. Within the calibration routine it is possible to record the calibration data to a .txt file. This can later be used to apply the same calibration to the same or another instrument.
The steps below apply both to instruments with a standard magnetometer and to those with the AHRS option. Should the procedure be unclear, consult this demonstration created by our support team: Compass Calibration.

1. Confirm that the frame (or similar) with the instrument, battery canister, and extra ballast, etc. to simulates the intended deployment setup as closely as possible.
2. Make sure the frame is level when calibrating the compass, and that it is possible to rotate the entire system 360° horizontally. Best calibration results can be achieved when suspending the frame in air or in a rotatable structure. If that is not possible, place the instrument setup on a flat surface. A hand-held calibration is not sufficiently stable.
3. Open the compass calibration function in the instrument software and start the calibration process
4. Rotate the entire system slowly around the Z-axis of the instrument. Note that when doing this in the field, you cannot expect to produce a perfect circle. However, we recommend you do this slowly, approximately 30 seconds per 360º, in an attempt to come as close to the ideal circle as possible. Press **Stop** once you have completed the rotation.
5. You need to decide whether the estimated maximum error is acceptable for your deployment. The quality indicator will turn green if the calibration is good. A yellow signal indicates adequate calibration whereas a red signal indicates a bad calibration.
6. To utilize the obtained offset, click **Update**. You will be prompted to confirm that the new values shall be transferred to the instrument to serve as the new compass setting.

Without selecting **Update**, the calibration results will not be applied and the instrument remains uncalibrated.

Quality of calibration

The estimated magnitude error [%] gives a rough estimate of the quality of calibration, where 3.5% correspond to around 2° of heading error.
This error is shown by the quality indicator:

- Green: 0% < x < 3.5% — Indicates the estimated magnitude error is acceptable.
- Yellow: 3.5% < x < 10% — Suggests a moderate level of error.

- Red: x > 10% or x < 0% — Indicates significant error or invalid measurements.

A good calibration will also have a relatively flat Corrected Normals graph as can be seen in the left element of Figure 14. The calibration seen in the example of the right is of low quality: The rotation was not carried out smoothly and with a constant velocity as can be seen by the fluctuations in the underlying blue curve in the top graph. Additionally the right calibration was carried out in the vicinity of a strong electromagnetic disturbance that did not rotate with the instrument, which deformed the ellipse.
Should the quality of the calibration not reach the required accuracy, repeat the calibration or consider changing to a location with reduced magnetic influence.

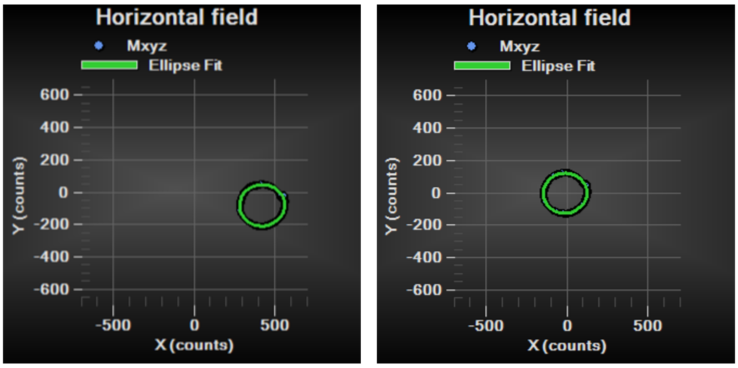


Figure 14: Example for a bad/red (top) and a good/green (bottom) compass calibration using the Signature Deployment Software

Typically, you will see offsets coming from these two sources:
Hard Iron (X/Y offset): This will cause a shift in the position of the ellipse away from the origin (0,0).
Soft Iron (Mx, My, Mz): This will deform the ellipse.

When you first run the calibration routine, you will typically see that the circle will be offset from original as can be seen in Figure 15.

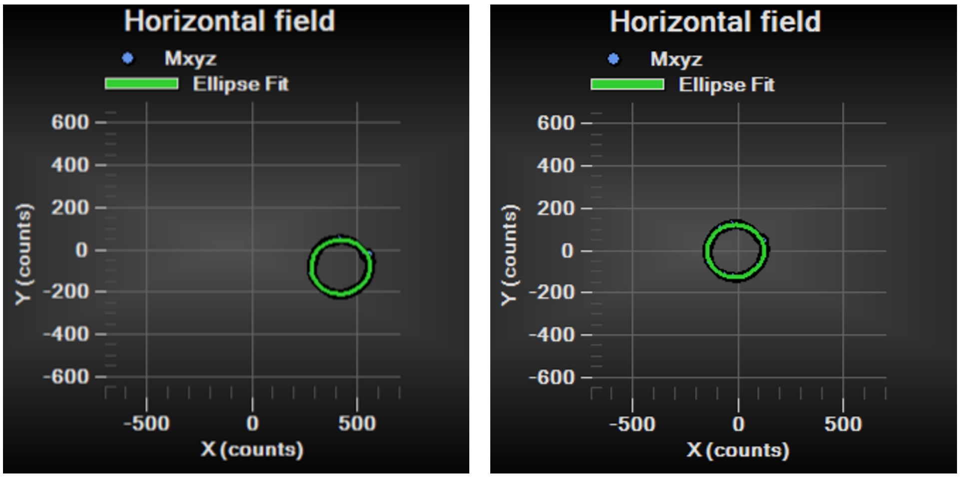


Figure 15: Compass calibration before (left) and after (right) the calibration has been applied. A hard iron offset has been removed.

After the instrument offsets have been updated the calibration can be confirmed by selecting **Verify** and re-executing the data collection and rotation and ensuring that the circle produced is centered on (0, 0, 0) (and that the corresponding offset corrections are close to 0). This step can be used to confirm, that the hard and soft iron influences have been compensated for.

Note: If batteries are replaced during deployment compass re-calibration should be performed since the magnetic signature of between battery packs are different and may change as it discharges.

5.2.3.3 Offset sources

The upper graph shown in our deployment software during compass calibration shows the output of the magnetometer in *counts*. If there are no magnetic distortions present, the output should show a perfect circle centered on (0,0). The radius of the circle represents the magnitude of the magnetic field at the calibration location. Typically, you will see deviations from a perfect circle centered on (0,0) coming from these two sources:

Hard Iron (X/Y offset [Counts]): This will cause a shift in the position of the ellipse away from the origin.
Hard iron or permanent magnet iron offsets are produced by materials that exhibit a constant, additive field to the earth's magnetic field, for example magnetized iron. Their offset is therefore constant and can be easily corrected for.

Soft Iron (Mx, My, Mz [Counts]): This will deform the ellipse.
Soft iron offsets can be described as deflections or alterations in the existing magnetic field, caused for example by metals like nickel and iron or alloys like kovar and steel.These are materials that can be magnetized quickly by an external field, but lose their polarization once the external source is removed. Calibrating for soft iron effects is more complex, as it involves not just offset corrections but also scaling and sometimes even more sophisticated transformations to correct for the non-uniform distortions across different orientations.

Note that you can only correct for hard iron sources, specifically those that remain fixed and rigid to the to the magnetometer as it rotates through space. Should you for example be calibrating your instrument in a frame next to a steel vessel, you will be able to remove the offset of the frame but not the vessel as it does not follow the rotation of the instrument.

5.2.3.4 Deployment in challenging conditions

Horizontal field strength in polar regions
The magnetometer captures the strength of the horizontal component of the magnetic field. Its strength decreases progressively towards the poles, which needs to be considered when measuring in Polar regions. You can find the strength of the horizontal field in your specific location on this map or NOAA's Magnetic Field Calculator. Magnetometer measurements at a location with a field intensity below 6000nT should be used with caution.
If the exact mounting position of the instrument is known, using the XYZ coordinate system is a good solution should the magnetic field intensity be to low.

Deployment next to large offset sources
When deploying the instrument next to a large offset source like a steel platform, its compass reading are not usable. Therefore it will be necessary to establish its orientation manually. Once the instrument is mounted, its true heading can be measured using some form of external source, preferably something that is not affected by the local magnetic field, such as a GPS compass. The difference between this value and what the instrument reports will be the bias (offset) introduced by the local magnetic interference and it will need to be added/subtracted from the reported estimates during post-processing.
This correction can only be used, if the instrument is deployed stationary, where a constant orientation of the instrument is guaranteed.

5.2.3.5 Magnetic declination

Magnetic declination is the angle between true north (geographic north) and magnetic north (the direction a compass points). This angle varies depending on your geographic location and can cause significant discrepancies in directional measurements. The compass calibration in your instrument does not automatically account for magnetic declination at the deployment site. This means that the orientation reported by the instrument may deviate from true north, especially in areas with strong declination. Since the ENU coordinate system (East-North-Up) uses true north as a reference, magnetometer readings must be corrected for the local declination during each deployment. To identify the local declination at your deployment site use tools like NOAA's Declination Calculator.

How to correct magnetic declination

You must apply the declination correction either before or after the deployment, using one of the following methods:

1. Pre-deployment correction

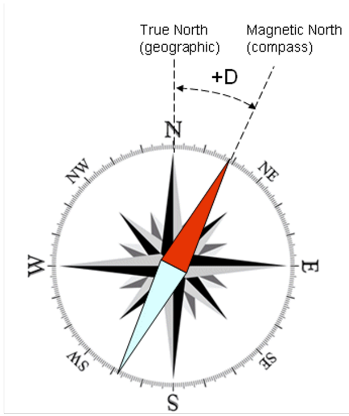
Use the relevant configuration commands (refer to the Integration Manuals) to save the declination value into the instrument before deploying it.

2. Post-processing correction

When processing the recorded data, our software tools offer a setting to apply the declination correction. You can enter the local declination value during this step.

- Eastern (positive) declination: Enter a positive value.
- Western (negative) declination: Enter a negative value.

Example: For a deployment in Oslofjord, where the local declination is +4.72°, you must enter 4.72 into the processing software or save it using commands.



Latitude:	59.9° N
Longitude:	10.5° E
Date	**Declination**
2024-11-20	4.72° E ± 0.45° changing by 0.22° E per year

Figure 16: Illustration of a positive/eastern declination in Oslo.

During post-processing, the entered declination value is automatically added to the magnetometer data, aligning the results with true north and ensuring compatibility with the ENU coordinate system. Utilize the help section in the software for detailed instructions. To access the correct data processing software for your instrument, please consult our software page.

5.2.3.6 Compass calibration in post-processing

A compass calibration can also be done in Ocean Contour for Signature instruments in post-processing, given that the instrument has turned 360 degrees either on its way down the water, during deployment or while the instrument is retrieved. The user can select a fitting time window where a full rotation has occurred and retrieve the compass offset from the raw magnetometer data. Should your Signature be deployed on a rotating system like a buoy, no compass calibration is needed before deployment, since a higher calibration quality can be achieved using the raw magnetometer data post-deployment. Alternatively the compass calibration procedure itself can be carried out after recovering the instrument. The offsets need to be recorded and then manually added during the post-processing.

For details on the procedure please refer to the help section in the Software.

5.2.4 Pressure offset

The instrument measures absolute pressure, and below sea level the pressure readings will then include the water and atmospheric pressure. To adjust for this, a pressure offset needs to be selected for offsetting absolute to relative pressure at the deployment site.

The atmospheric pressure usually fluctuates around 10.13 dBar, and 1 dBar is equivalent to the pressure change over 1m depth in fresh water (so at 1m depth the absolute pressure would be 11.13 dBar). The factory setting is 9.5 dBar. The outcome is that when the instrument is in air, you will see a value of 0.2-0.7 dBar, depending on atmospheric conditions. Be aware that the pressure sensor cannot output negative values. If the pressure sensor output '0' value, the pressure offset might be too high relative to the atmospheric pressure at site. The pressure sensor outputs the absolute pressure value in units of dBar.

How to adjust the pressure offset:
1. Obtain the local atmospheric pressure at the deployment site. This can be retrieved from weather services or websites (e.g. this Website)
2. Enter this value into the deployment software as the Pressure Offset.

Alternatively, you may choose the **"Set Zero Pressure**" option in the software. This sets the current pressure reading as the new baseline, effectively zeroing the offset to the current atmospheric conditions.
For a step-by-step guide, refer to the instructional video prepared by our support team.

Note:
The pressure offset can only be set to a constant. Should a more advanced correction using a atmospheric pressure time series be required, this will need to be done manually.

5.2.5 Erase recorder

We strongly recommend starting each new deployment with an empty recorder to ensure optimal performance and avoid data conflicts. Before erasing the recorder, verify that all important data has been successfully transferred and backed up. Once confirmed, proceed by selecting the Erase Recorder function.
Note: Erasing the recorder does not format the memory. Formatting is a separate function and must be performed explicitly if required. We recommend formatting the recorder regularly

Recorder wear may occur over time due to repeated write/erase cycles. Although the exact durability may vary slightly between instrument models, the recorder is typically rated for up to 10,000 files. This implies that if the recorder is erased before each deployment, the system can support approximately 10,000 deployments before the recorder needs replacement.

Important: If the SD card reaches full capacity during deployment, the instrument will stop saving data to memory. However, if serial output is enabled, it will continue to transmit real-time data even though recording to memory has stopped.

5.2.6 Deployment configuration

Once the setup of the instrument is complete, the deployment plan needs to be configured and uploaded to the instrument. Details on the configuration and use of our deployment software can be found in its Help section.

For the theoretical background on the measurement principles of our instrument please consult the Principles of Operation - Manuals. Should you be using Custom Commands to configure the ADCP, you will find a list of available options in the System Integration Manuals corresponding to your instrument.

Should you feel unsure about the your configuration, feel free to reach out to our support team for second opinion and advise on how to optimize your setup.

5.3 Test rig construction

Before heading to the deployment site, it is strongly recommended to assemble and test your full rig at your facility. This dry run allows you to verify that all components fit and function as intended, helping to catch any issues early—before you're in the field where changes can be more difficult or impossible to implement.

Key steps to follow:

- Assemble the complete rig, including the instrument, mooring frame, ropes, weights, and all fastening components.
- Test for physical interferences: Make adjustments to the positioning of the instrument to avoid contact or interference with bolts, shackles, weights, ropes, or locking mechanisms that may obstruct sensor function or cause turbulence during measurement.
- Secure all attachments: Ensure that the mooring components, especially the instrument mount and rope connections, are robust and tight. Loose fittings can lead to drifting or even loss of the instrument.
- Check for metal-induced magnetic interference: If metals are part of the setup, consider using isolation techniques or non-metallic spacers to minimize magnetic distortion, especially near the compass.
- Measure and count your ropes: Confirm that you have sufficient line length for the intended deployment depth, plus extra for redundancy or unforeseen needs.
- Document adjustments: If any part of the rig is modified during this test, update your deployment plan accordingly so the changes are accounted for later.

Tip: It’s always better to discover and resolve potential issues at this stage than at sea with limited equipment.

5.4 Packing

A well-prepared inventory is essential for a smooth and successful deployment. Based on your rig design, mooring setup, and instrument configuration, you should create a comprehensive **inventory list** that includes everything you need to bring on the vessel. This inventory should not only cover the primary components but also include spares, tools, consumables, and safety gear. Treat this as a critical planning step—any overlooked item can delay or jeopardize the deployment.

Plan for contingencies

Marine environments are unpredictable, and even with the best planning, issues can arise. Bring extra equipment to mitigate common problems:

- Extra shackles or clamps in case of loss overboard
- Additional rope in case the planned mooring depth changes
- Printed or digital copies of the instrument's manuals

6 Instrument maintenance

6.1 Post-deployment

Rinsing
Ensure all equipment is thoroughly washed after deployment in salt water and allowed to dry completely before storage. Pay special attention to the pressure sensor—it should be rinsed carefully. We recommend removing its cover to ensure that any trapped sediment is fully cleared.

Removal of Bio-fauling
We realize barnacles have to be removed mechanically, but we strongly advice against using sharp objects capable of harming the polyurethane surface. We also recommend staying away from strong organic solvents such as acetone. Instead place the instrument in a 50/50 vinegar and water solution and leave it for 24h hours. Was the instrument gently with a sponge in soap/water solution. Repeat this process until the barnacles are removed. Avoid scrubbing and high pressure washers

Visual inspection
After each deployment a visual inspection of the exterior and interior of the instruments should be carried out. Check the end bell for signs of corrosion. If used frequently, one should consider replacing the end bell after 5 years to mitigate the risk of leakage. If the instrument has been subjected to environmental conditions outside the specified design limits (refer to the Technical Specification for your instrument for the limits), mechanical tolerances of non-metal components may be affected.

Data
Retrieve the data using the appropriate deployment software.We recommend to store the data in two separate locations before erasing the recorder on the instrument.

(Optional) Function test
If the visual inspection or preliminary data analysis raises concerns about the instrument's performance, conducting a functional test is recommended to verify sensor operation.

Connector care
- Flush both halves of the connector set with compressed air and remove any dirt.
- Check that both connectors are dry. If not, let them air-dry.
- Inspect for damage, corrosion and cuts.
- Grease connectors before storage!
- Mate with a dummy plug.

Preparation for storage
Ensure that the instrument is completely dry before storing it. Disconnect the instrument from any source of power, including internal batteries while stored.

For prolonged storage at elevated temperatures close to the specified limit, or when temperature variation is uncertain, it is recommended that the screws securing the end cap be loosened in order to minimize the risk of any deformation due to temperature/stress over time (if your instrument has an accessible pressure case). A preventive maintenance routine should include regular cleaning of the instrument. Use a **mild** detergent and pay special attention to the transducers. Do not expose any part of the instrument to harsh chemicals. Check the pressure sensor and remove any dirt from the holes in the cap. Be careful when opening the pressure sensor cap as it is easy to dent the sensor.

NOTE: The Real Time clock (RTC) within the instrument requires power from its own internal battery. This battery can be depleted if the instrument is disconnected from power for an extended period of time. (4 weeks for the Gen1 Aquadopp, 1 year for the Gen1 AWAC, Signature and Gen2 instruments) We commend to place the instrument on external power for 24h before deployment to ensure that the RTC's internal battery is fully recharged.

6.2 Mechanical aspects and maintenance

Preventive maintenance is your primary tool to keep your instrument in shape and ready for action and deployment. We recommend a regularly scheduled procedure which will act as a preventative measure to ensure your instrument continues functioning as intended. The following sections can be used as a maintenance guideline for the components that may be exposed to wear and tear.

We recommend conducting a Functionality Test after the maintenance procedure has been finished, to ensure that the instruments functionality is as expected. For AD2CP instruments, we also recommend adding an entry in the internal log that is kept within the instrument. This can be helpful in assessing service intervals etc. The "Add Deployment Log Entry" box on the Logs tab in the web interface can be used for this. This log will also keep a record of things like formatting or erasing the recorder and firmware upgrades.

DO NOT EXPOSE THE ELECTRONICS

In general, there should be no reason to expose the instrument electronics. **Do not open the housing to expose the electronics unless instructed by Nortek.**

Only qualified personnel are allowed to perform corrective maintenance activities. Please contact Nortek for further assistance if in any doubt.

6.2.1 Changing a battery pack

These instructions apply both when installing a battery pack into a new instrument and when replacing the battery after a deployment.
When opening the instrument, great care should be taken to keep the sealing surfaces clean and protected from mechanical damage. Before opening, take note of the end cap orientation in respect to the housing. Ensure that the instrument is reassembled in the same configuration.

1. Detach any existing connections to the instrument.
2. Remove the end cap from the pressure case. This can be done by unscrewing the endbell (Gen2 Aquadopp) or removing bolts and washers connecting both parts (Signature, battery canister).
3. Carefully disconnect the Molex connector. Gently remove the battery without pulling on the cables.
4. Insert the new battery into the pressure case and connect it using the 2-pin harness connector.
5. Place a fresh desiccant bag in the pressure case, as humid air can condense enough water do damage the electrical circuitry.
6. Attach the remaining Molex connectors to the end cap. Ensure cables are arranged to avoid being pinched during reassembly.
7. **Confirm O-rings are free from dust/particles and not damaged. We recommend replacing and/or greasing them as described in the O-ring Care chapter.** This step is crucial, as it ensures that the instrument does not leak!
8. Align with the end cap with the pressure case in their original orientation. Reattach the end cap. See the chapter Securing Screws for details on correct tightening technique and necessary torque.

Functional checks

- Check the LED. It should be lit up for 5min after connecting a battery pack.

- Test the instrument by collecting data without using an external power source to ensure that the battery is properly connected. Make sure to stop data collection so that the instrument will power down after you are through testing it.

Battery disposal

If you have lithium batteries, keep in mind that you must be very careful and that disposal requires special precautions and/or procedures. Rules for disposal of batteries, especially lithium batteries, vary from country to country.

Additional resources

For visual guidelines on battery exchange, please see this video created by our support team!
Storage guidelines can be found in the chapter: Power.

6.2.2 Connector care

Nortek supplies two types of cables - Subconn and Impulse. Here, we have highlighted a set of instructions on how to take care of each connector type.

To identify which cable you have, there are two methods you can use. First, determine the instrument you are working with. All DVL's and Signatures use SubConn connectors, while AWAC, Vector, Aquadopp and Aquadopp Generation 2 use Impulse connectors. Secondly, you can identify the connector sleeve color. A red sleeve indicates a SubConn connector, while a black sleeve indicates an Impulse connector.

SubConn connector care

- Connectors must be greased with Molykote 44 Medium before every mating.
- A layer of grease corresponding to minimum 1/10 of socket depth should be applied to the female connector.
- The inner edge of all sockets should be completely covered, and a thin transparent layer of grease left visible on the face of the connector.
- After greasing, fully mate the male and female connector in order to secure optimal distribution of grease on the pins and in the sockets.
- To confirm that grease has been sufficiently applied, de-mate and check for grease on every male pin. Then re-mate the connector.

You can find further details in the SubConn supplier guide: SubConn® handling instructions

Impulse connector care

- Lubricate mating surfaces with 3M Silicone Lubricant equivalent. Connectors must be lubricated on a regular basis.
- Lubricate O-rings with Molykote 111 or equivalent. Replace o-rings when re-using connectors.
- Avoid nicks and cuts around contacts as these are the sealing surfaces.
- Do not pull on cable to disconnect.
- Avoid sharp bends at cable entry to connector.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods of time..
- Connectors should not be allowed to dry out. If this occurs soak in water before use.

You can find further details in the Impulse supplier guide: Impulse handling instructions

Greasing connectors with not recommended products or lubricants is discouraged because some grease can act as an electrical insulator, attract contaminants, chemically degrade connector materials, be difficult to remove, and interfere with sealing mechanisms. These issues can lead to poor electrical connections, equipment malfunction, and water damage. Instead, using manufacturer-recommended lubricants or sealants ensures proper connectivity and protection without these adverse effects.

When properly mated, the engaging nut on the cable plug will thread smoothly onto the receptacle shell until it rather abruptly reaches a point where it cannot be hand-tightened any further. At this point the mating surfaces of the plug and receptacle are in contact, and have formed a good seal. The amount of force required to tighten the engaging nut should stay the same throughout (up until the point where it cannot be further hand-tightened). Otherwise, the connectors are not mating properly and will not form a good seal.

6.2.3 Cable care

To keep your cables in good condition:

- Avoid nicks and cuts around contacts, as these are the sealing surfaces.
- Do not pull on the cable to disconnect connectors; pull the connector itself.
- Avoid sharp bends at cable entry to connector. It is important to check the bend radius for each cable to ensure adequate usage!
- Ensure that the cable is fixed to the mounting fixture to avoid mechanical stress to the connection.
- Elastomers can be seriously degraded if exposed to direct sunlight or high ozone levels for extended periods.

6.2.4 Replace desiccant bag

Humid air can condense enough water do damage the electrical circuitry. At least once a year, replace the desiccant located in the pressure case or the external battery canister. You may wish to replace the desiccant bag more regularly if the instrument is exposed to multiple significant changes in temperature (e.g. from a hot/humid surface environment to cool water). If the instrument is opened more regularly throughout the year, it is advised to replace the desiccant bag every time the case is open. Refer to the battery installation procedure for instructions on opening the pressure case.

6.2.5 O-ring care

O-rings are the critical component that keeps water out of the housing and thus the instrument dry. Watertight sealing of the instrument housing is provided by double O-rings on the head and end cap sub-assemblies. The outer O-ring forms the primary seal and the inner forms a secondary (or backup) seal. If the integrity of the O-rings are degraded the instrument should not be re-deployed. In this case, please contact us.

If the instrument has never been opened, O-ring inspection is not necessary. Should your instrument have been in use for more than 5 years, consider sending it in for a service at Nortek HQ. Further details on the service routine can be found under the following FAQ. However, when changing batteries, the O-rings on the endbell are exposed and we recommend to make a routine of inspection, maintenance and replacement of exposed O-rings.

- Check the O-rings and the O-ring grooves for grit, hair, lint, sand, or anything that could potentially breach the O-ring seal.
- After frequent deployments or if O-rings or groves appear dirty, remove O-rings and clean the grooves. To remove O-rings, use finger pressure or the rounded edge of a plastic card to lift the O-ring out of the grove. Caution! Never use a metal object to remove an O-ring. It may cause damage to the O-ring or the sealing surface.
- To check O-rings for damage, place the O-ring between the middle and index finger and thumb. Then pull the O-ring through your fingers, feeling for any debris or wear.
- If O-rings are dirty, it is best to replace them. Washing dirty O-rings with soap and water is not recommended. Soap breaks down the lubricants and will compromise the integrity of the seal.
- Properly greased O-rings will help maintain sealing integrity and minimize O-ring degradation. Use enough grease, for example Molykote 111, to lubricate the O-ring thoroughly, but not so much that it will attract additional debris.
- Clean the groove with a lint free swab or the folded edge of a paper towel.

NOTE: Do not open the transducer end on your instrument to check O-rings. Opening the whole instrument means exposing the electronics, and this shall not be done unless Nortek has approved and provided guidance on how to do it.

6.2.6 Securing screws

When installing end caps and sensor heads, care should be taken when tightening the screws. The following guidelines, incorporating best practices and specific torque recommendations, will assist you in achieving optimal results.

Preparation:

- Cleanliness: Ensure that all screws, threads, O-rings, and sealing surfaces are clean and free from contaminants. Even minor debris can compromise the seal and lead to leaks.
- Make sure to not squeeze the harness when reattaching the endbell.
- Spring Washers: Always use new spring washers during reassembly, as reused washers may not provide the necessary tension.

Thread Engagement

- Proper Alignment: When reinserting screws, ensure they align correctly with the threads. A recommended technique is to turn the screw slowly counterclockwise until you feel it "drop" into the first thread winding, then proceed to tighten clockwise. This method helps prevent cross-threading and ensures proper engagement.

Tightening Sequence

Cross-Pattern Approach: Adopt a cross-pattern (or star-pattern) tightening sequence to ensure even compression of the O-ring and to minimize mechanical stress:

- Slightly tighten one screw.
- Move to the screw directly opposite and tighten it slightly.
- Continue this pattern with the remaining pairs of opposing screws.
- Repeat the sequence, gradually increasing torque, until all screws are appropriately tightened.

This method promotes uniform O-ring compression and reduces the risk of leaks or damage.

Torque Specifications

- Torque Values: Applying the correct torque is essential to avoid over-compression of the O-ring and potential damage to the threads or housing. Refer to the following torque specifications for different screw sizes:

Screw size	Instrument	Torque	Turn past compression
#6-32 UNC	Aquadopp, Signature 1000, DVL 1000	70 N·cm / 6 In·lb	Approx. 1/4
#8-32 UNC	DVL 500 (Transducer head only)	160 N·cm / 14 In·lb	Approx. 1/4
#10-24 UNC	Signature 500, Signature 250	230 N·cm / 20 In·lb	Approx. 1/8
1/4"-20 UNC	Signature 100, Signature 55, Signature battery canister	500 N·cm / 45 In·lb	Approx. 1/6

Table 1: Screw fastening guidelines

- Manual Tightening: If a torque wrench is unavailable, tighten the screws until the spring washer is compressed, then apply the additional turn as specified above
- Caution Against Over-Tightening: Excessive torque can strip threads or damage the surrounding material. Tighten screws slowly and evenly, allowing the plastic to deform appropriately. A turning rate of approximately 5 degrees per second is recommended.

Post-Tightening Checks
- Visual Inspection: After tightening, inspect the assembly to ensure the end cap is seated correctly against its flange and that there is uniform compression of the O-ring.
- Functional Test: If possible, perform a pressure test to confirm the integrity of the seal before deploying the equipment.

Please refer to this video created by our support department for visual guidelines on how to open a close an ADCPs endbell.

Over-torquing has no positive effect and may damage the threads and/or area around the screw holes on the head and end cap. Keep in mind that ocean pressure holds the end cap tightly; all the screws have to do is to secure the end cap from falling out when the system is above water. **Most water leak damage can be traced back to O-rings in poor condition, damaged sealing surfaces or contaminants on O-rings and/or sealing surfaces.**

6.2.7 Biofouling

Marine growth (bio-fouling) is an important consideration for long-term mooring deployments. Over time, current profilers and other submerged instruments become coated with biological material, which can eventually block the transducers and reduce profiling range. To monitor fouling, track long-term trends in amplitude data. While short-term variations are influenced by factors like suspended sediments, zooplankton, and bubbles, biological growth—especially barnacles—introduces a slow downward trend. Profiling range gradually declines until signal strength becomes insufficient. With experience, you'll learn how long it takes before cleaning is necessary, allowing you to establish reliable maintenance intervals.

Initial Deployment vs. Post-Cleaning Factory-new instruments have smooth surfaces that resist fouling at first. After cleaning, rougher surfaces promote faster regrowth. Maintenance is typically required every 6–12 months, though this depends on factors such as:
- Water temperature and depth
- Geographic location
- Seasonal biological activity

Growth is fastest in warm, shallow waters and slowest in cold, deep environments.

When calculating forces on the mooring line, include the effects of marine growth by increasing estimates for weight, diameter, and drag of all components.

To prevent bio-fouling from impacting your data collection, there are two main methods that can be chosen:

Anti-fouling paints
- Can be used on transducers, but apply only a thin layer (~1 mm) to avoid impacting signal strength. Avoid chemically aggressive or particle-laden paints (e.g., containing metal flakes). Make sure that there are no air bubbles trapped between the paint and the face of the transducer.
- Ideal for deployments over an extended period of time (> 1 year)

- Do not paint anodes, grounding plates or pressure ports.
- Users have reported positive results from using paint by Jotun (Primer + Paint e.g. SeaMate M or SeaQuantum)

If in doubt if the layer was too thick, perform a function test before deployment.

Anti-fouling adhesive patches

- Supplied by Nortek. For further details, please contact your sales representative.
- Made of silicone resin, polyester film and acrylic adhesive.
- Durable and effective solution to double deployment time while reducing the environmental impact compared to paint.
- Intended for shorter deployments of 3-6 months.
- Ensure that no pressure/ temperature sensors are covered when applying!

7 Appendix

Deployment checklist

Sensor type: . . . .

Serial number: . . . .

Deployment Depth: . . . .

Mooring: . . . .

Location: . . . .

Instrument Configuration

- ☐ Use of recent software/ firmware
- ☐ Function Test
- ☐ Compass Calibration
- ☐ Pressure Offset applied
- ☐ Deployment Configuration saved
  Filename: . . . .
- ☐ Start Now/ Later
  Time: . . . .

Optional:

- ☐ Instrument start confirmed (LED/Sound)

Mooring Assembly

- ☐ Battery connected
- ☐ Desiccant bag is replaced
- ☐ Dummy Plugs installed
- ☐ Removal of protective caps
- ☐ Final Deployment Depth
  . . . .
- ☐ Instrument in water
  Time: . . . .

Notes:

. . . .

. . . .

. . . .

. . . .

Technician: . . . .

Date: . . . .

Recovery checklist

Sensor type: . . . .

Mooring: . . . .

Serial number: . . . .

Location: . . . .

Deployment Depth: . . . .

Recovery & Disassembly

- ☐ Instrument on deck
  Time: . . . .
- ☐ Rinse with freshwater
- ☐ Removal of Biofouling
- ☐ Deployment stopped
  Time: . . . .
- ☐ Visual inspection

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Preparation for storage

- ☐ Data recovery
  Filename: . . . .
- ☐ Connector Care (Greasing!)

Optional:

- ☐ Function test

Technician: . . . .

Date: . . . .

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