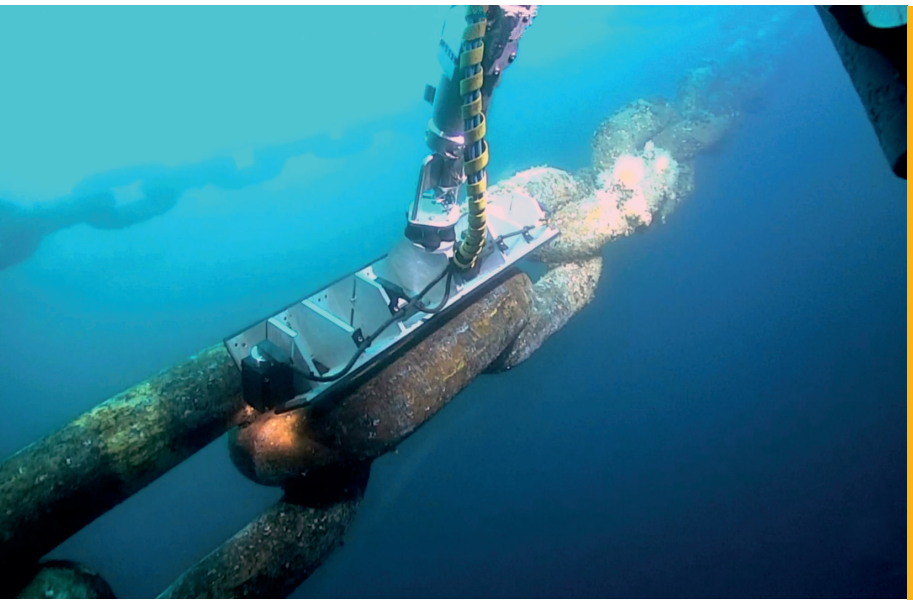
Mooring Chain Measurement

Frequently asked questions



Our chain measurement technologies include the following:

- **Optical Chain Measurement System (CMS) –** the most efficient and accurate tool on the market for measuring critical chain dimensions, with reproducibility to allow confident tracking of corrosion and wear rates.
- **Subsea Caliper –** versatile, and accurate digital caliper for Class-approved service or basic rental.
- **3D Photogrammetry –** the most detailed method of chain measurement, ideal for chains at or near end of life, or with anomalies requiring detailed engineering analysis.

Why is chain measurement important?

Mooring chains are designed with specific corrosion allowances to account for corrosion and wear throughout their service life. Design corrosion allowances are generally 0.2-0.4mm per year, but often higher in tropical waters. This amounts to 4-8mm total corrosion allowance for a typical FPSO mooring system with a 20-year design life. Monitoring chain diameter is a de facto performance standard for every mooring system and the accuracy and precision of measurement tools is critical when corrosion allowances are so minute.

When chains corrode and wear beyond the applicable tolerance, they may no longer meet their basic strength requirements[1] and require replacement. Chain link strength is more sensitive to wear and corrosion in certain areas than in others, so corrosion allowances may be consumed in some areas without chain link strength being significantly impacted.

Chain link intergrip wear (Noble Denton)

Which areas on a chain are most likely to see degradation?

Corrosion can happen anywhere on the surface of the link, but wear is generally isolated to the intergrip (double diameter) area. Corrosion rates used in the mooring design are in fact combined corrosion and wear rates, applying primarily to the intergrip area where diameter reduction is reasonably proportional to strength reduction.

Which areas on a chain are most sensitive to corrosion and wear?

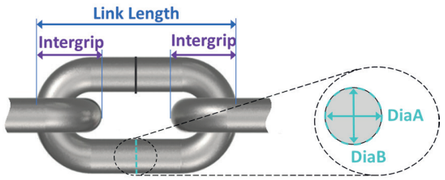
There is considerable variation in tensile stress based on the geometry of the chain link. Maximum tension is developed at the crown of the link, then followed by the inner shoulder area.

As chain links wear and corrode at the intergrip area, tensile stress increases at the crown until a crack initiates. This is the most likely area for failure, therefore intergrip diameter measurement (in the plane of intergrip wear) is the most crucial measurement for tracking and managing the residual strength of mooring chains.

Idealized chain link showing stress profile

Which areas do you assess during a chain measurement survey?

Regular measurement of intergrip and sidebar diameter is the best way to confirm adherence to design corrosion and wear rates, as required by Class and industry best practice.



Intergrip measurements are taken in the axial direction, across the wear plane. Due to the chain manufacturing process, the axial diameter is always smaller than the perpendicular diameter, often by as much as 5%, so perpendicular diameter isn't a critical measurement until intergrip corrosion/wear allowance is consumed.

Sidebar diameter measurements are used to track bulk corrosion rate, independent of wear. The sidebar area is easily accessible for measurement, and the rate of corrosion is usually representative of the chain link as a whole. Sidebar diameters should be measured in the plane of the link (IP) and out of plane (OP) so that cross-sectional area can be approximated. The weld area should be avoided as diameter can be 10-15% higher than the nominal rate in this area.

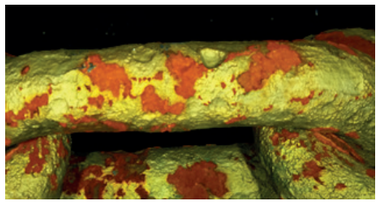
Older inspection codes require link length measurements to identify link elongation. For permanent mooring systems designed to 100-year return periods and modern safety factors, link elongation is not a typical concern.

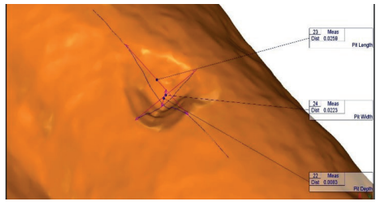
When is 3D Modelling/photogrammetry recommended instead of point-to-point measurement?

We recommend 3D modelling in cases of:

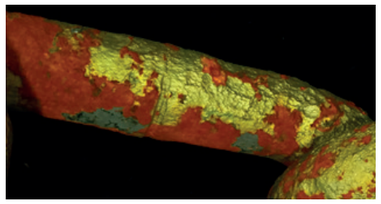
- Abnormal corrosion or wear,
- Restricted access, such as links at fairleads or in hawse tubes, or
- Chain dimensions nearing or below basic chain size, requiring strength analysis including FEA.

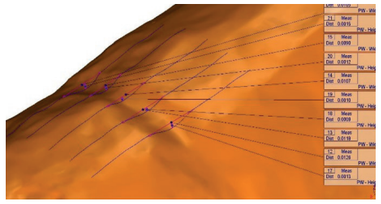
Abnormal corrosion and wear may be in the form of:



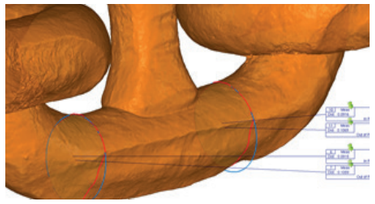


Significant pitting corrosion anywhere on the chain, but particularly large or sharp-edged pits in areas of high tensile stress.





Grooves caused by preferential corrosion in the flash butt weld area, particularly on inside of the chain link.



Severe sidebar corrosion, common at the touchdown zone in tropical environments with microbiologically-influenced corrosion.

The corrosion profile is in a low-stress area of the chain, but loss of significant cross-section will induce higher tensile loads along the inner sidebar.

Chain measurement | FAQ

What are the advantages of our Chain Measurement System?

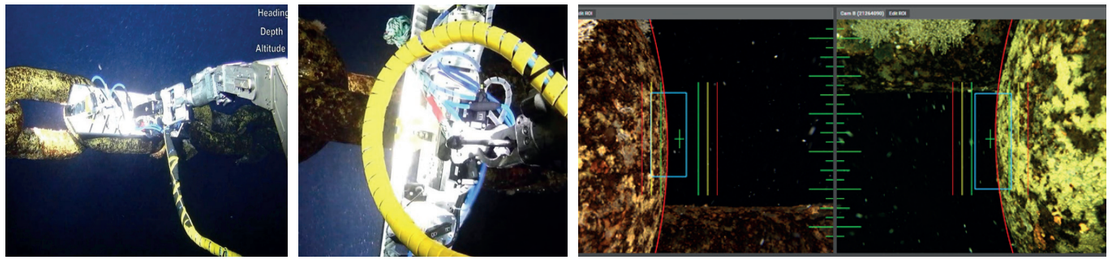
Ashtead Technology's Chain Measurement System (CMS) is a ROV-deployed optical caliper using HD cameras and machine vision to measure critical chain link dimensions with real time results, ensuring chain corrosion and wear rates are within expected tolerances.

Optical Chain Measurement System (CMS)

The optical CMS can collect intergrip length, sidebar diameters, and link length measurements all in a single ROV dive. With over 25 years of commercial use and continuous improvement, the CMS is considered the most reliable and repeatable method of monitoring mooring chain integrity offering a reduction in measurement time by a least 50%.

Ashtead Technology's optical CMS provides:

- Measurement of all critical dimensions in a single ROV dive (no need to reconfigure the tool between intergrip and sidebar diameter measurements)
- Accuracy of +/- 0.5mm and high degree of repeatability (precision)
- Data collection time as little as seconds per chain link with real-time results
- Able to be deployed under conditions of high chain movement
- Capable of measuring chain inclination simultaneously for verifying mooring tension and load sharing between lines



Optical Chain Measurement System (CMS) positioned for intergrip diameter/link length (left), sidebar diameter (centre), and data recording/GUI for intergrip measurement (right).

Mooring chains can also be measured using a variety of equipment, including mechanical calipers, optical calipers, and using 3D modelling/photogrammetry.

Mechanical Measurement

Ashtead Technology's (mechanical) Subsea Caliper used for intergrip and sidebar diameter measurement

Mechanical calipers can produce measurements to +/-1mm on chain links and other mooring components, i.e. shackles, H-links.

Measurement accuracy depends on precision placement which can be affected by ROV pilot experience, or chain motion.

Mild caliper misalignment can significantly reduce the precision and reproducibility of measurements, which is critical when tracking wear rates of 0.2-0.4mm/year.

Data collection time is also longer than using the optical CMS which can increase vessel costs.

3D Modelling using Photogrammetry

3D Modelling photogrammetry: data collection (left), and processing 3D model (right)

3D Modelling using Photogrammetry can provide comprehensive results and is best suited where abnormal corrosion is observed, or when a more detailed strength assessment required. It is not the most efficient method for point to point measurement.

1. Photogrammetry needs additional time for chain cleaning and data collection, which can increase vessel time.
2. Onshore data processing is needed after the offshore campaign to deliver accurate measurements
3. There is no opportunity for further sampling if anomalous measurements are identified.

What is the recommended schedule for chain measurement activities?

Class societies require mooring chains to be measured at five-year intervals for renewal surveys. However, better practice is to perform measurement during 2.5-yearly intermediate surveys or annually on select lines, such that each mooring line is surveyed on a five-year rolling schedule. In some cases, focusing on just one line per bundle can be acceptable if all mooring lines in the group have similar dynamics, degradation, and robust safety factors.

Key takeaways regarding mooring inspection quality and efficiency?

To maximise inspection quality, efficiency and cost, Ashtead Technology[2] recommends:

- Trained mooring inspectors for general visual and close visual inspection (GVI, CVI) who have the competence and experience to identify critical defects needing attention
- Point-to-point chain measurement for tracking corrosion/wear rates against design case assumptions, using our optical chain measurement (CMS) technology for optimal accuracy and efficiency.
- Employ 3D Modelling and Photogrammetry where abnormal corrosion is observed, or when detailed strength assessment required.

1 For detailed dialogue on the relation between chain corrosion/wear and strength, see OTC-27549-MS Strength Assessment of Degraded Mooring Chains, authored by ExxonMobil.

2 Ashtead Technology Ltd., through acquisition of mooring inspection specialist Welaptega Marine Limited, has over 25-years of experience developing and operating ROV-based technology in every major offshore energy region worldwide. Ashtead Technology has performed more than 200 in-situ chain measurement projects and contributed to JIPs and standards development with CSA/ISO and API.