APPENDIX 8 - AQ RING

8.1 General design of the AQ Ring

In the figure below, the AQ ring in the mooring system is connected to the grid mooring with anchoring lines, grid ropes, buoys and bridles. These are connected in a connection point with AQ Ring.

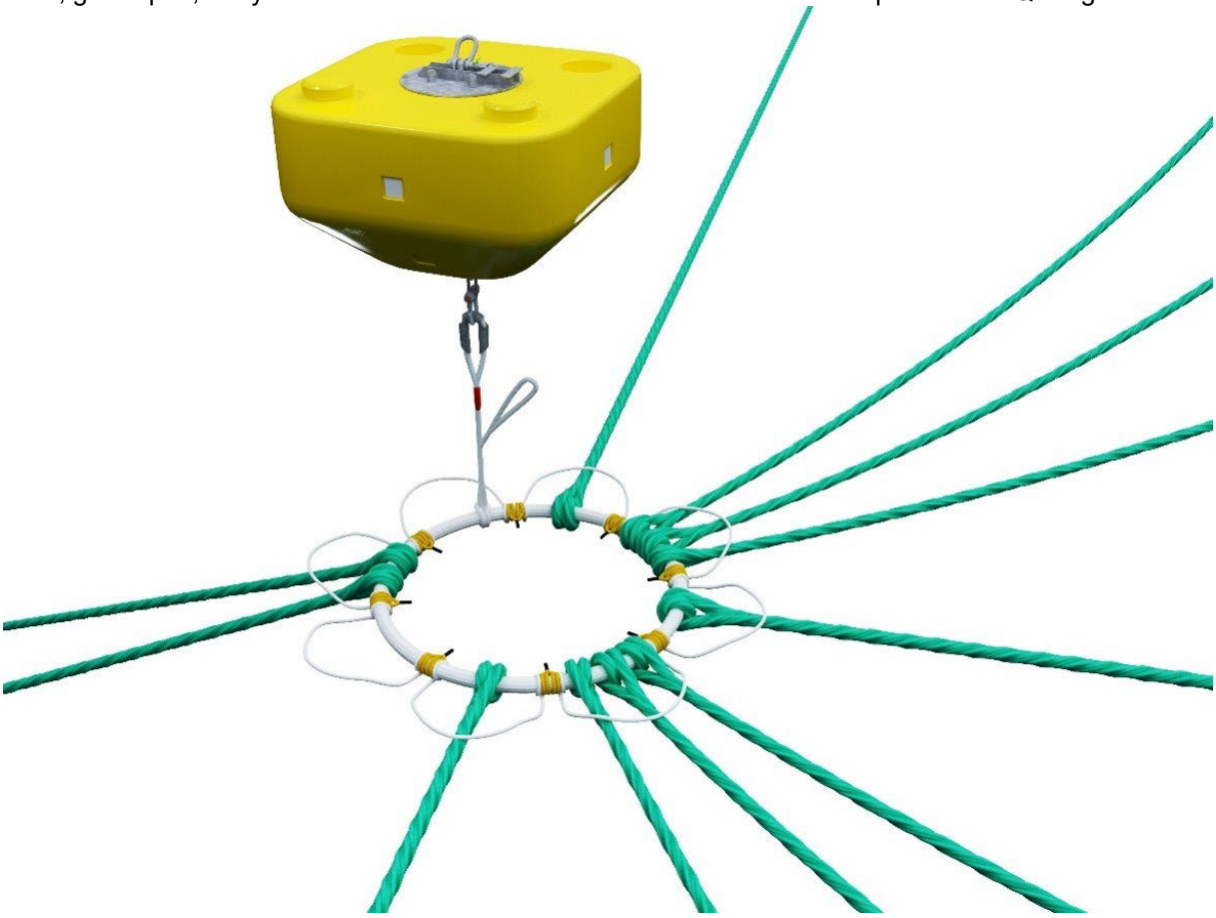

Figure 1 - A connection point with AQ Ring in a mooring system

The mooring system is pretensioned to avoid shock loads. Buoys are used for buoyancy to achieve this pretension. Therefore, the mooring system will work regardless of whether pens are installed or not. The design of the connection point is shown in figure 1 with approved fastening for buoy line, grid ropes, bridles and anchoring lines.

Please note: The grid is manufactured by ScaleAQ so the risk of deviations in the grid is unlikely.

Please note: The grid is packaged by ScaleAQ.

Please note: The AQ Ring with its circular shape is basically a grommet, i.e. a circle with long-spliced rope.

Please note: The buoy line is attached to the AQ ring using the cow hitch (throttling of the buoy line against AQ ring), see picture below. At the end, towards the buoy, there is a spliced eye with a tube thimble where shackles are used for connecting the buoy.

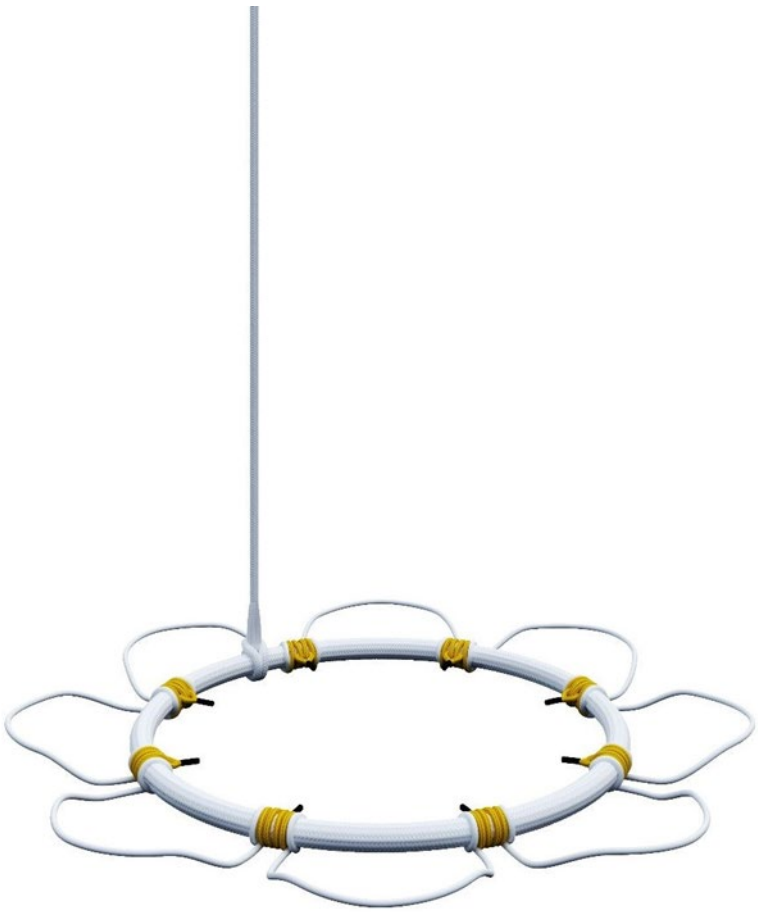

Figure 2 - Buoy line connected in the AQ Ring

8.2 Installation of anchoring lines, grid lines and bridles in AQ Ring

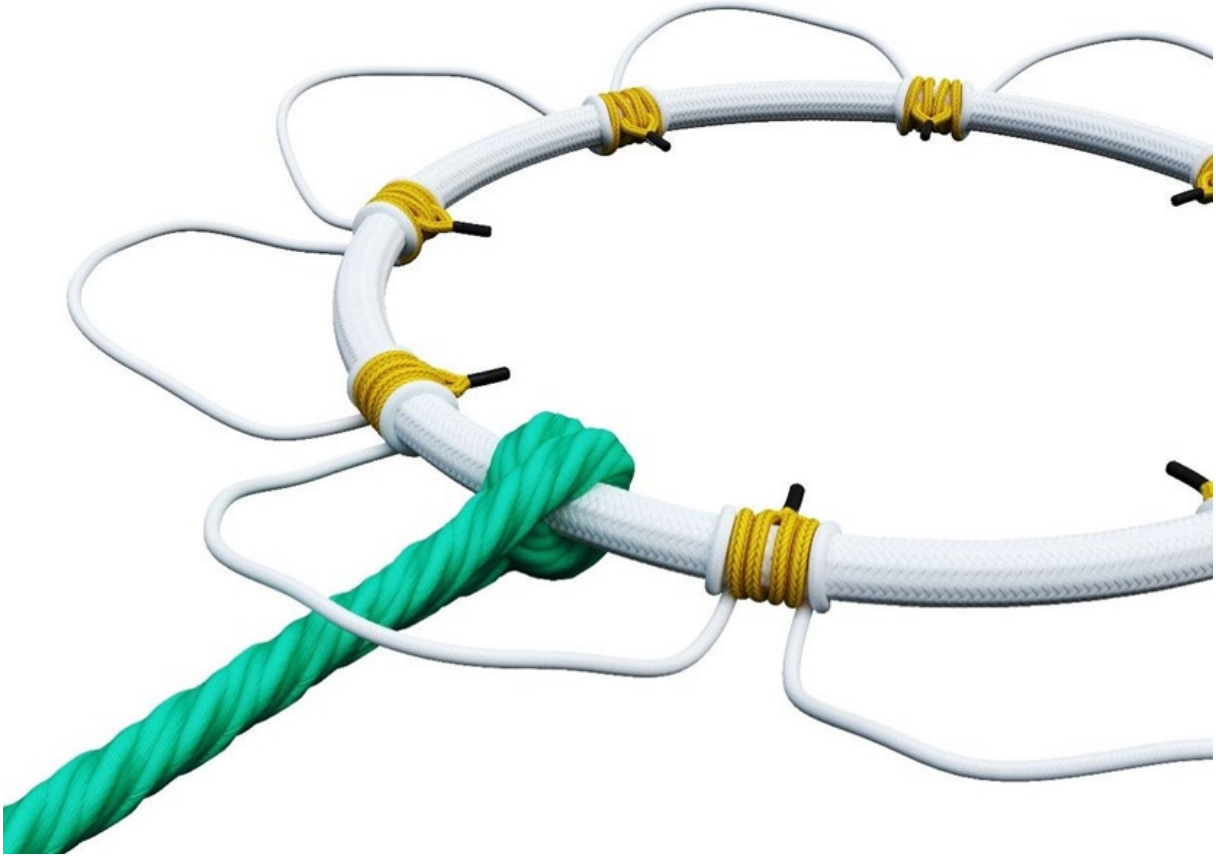

Figure 3 - Installation of anchoring lines, grid lines and bridles in AQ Ring

Installing anchoring lines, grid lines and bridles in AQ Ring is done by pulling the ropes twice around the AQ Ring and then splicing using 5 tucks. This fastening does not reduce the capacity of the rope. ScaleAQ must be contacted when using other methods for installing anchoring lines, grid lines and bridles to the AQ Ring. The breaking capacity of loops is tested to 28 tons lateral (horizontal) and 10 tons in lift (vertical).

On the incoming rope, a jacket (equivalent to the AQ Ring jacket) can also be used that is threaded over the rope before installing.

8.3 Maximum permissible loads

For the maximum permissible loads applied to the mooring components, the following is stated in the product certificate for ScaleAQ AQ Ring.

MBL Grommet: 270 tons

MBL 48mm Dextron 12 Plus: 170.3 tons

Maximum permissible dimensioning load incoming mooring lines: 136 tons

Capacity loops vertically/horizontally: 10 tons / 28 tons

The grommet MBL is similar to the breaking strength of the AQ ring when it is pulled from end to end by two opposite points.

The rope in the AQ Ring has MBL 170 tons. This gives the maximum design load equal to 170/2.5 = 68 tons with current factors according to NS9415:2021. The grommet strength is based on MBL = 170 tons and the grommet factor 1.5 will be ~170x1.5=255T. The grommet factor is empirically based equal to 1.5 for round slings and similar products.
MBL Grommet is tested to 270 tons, accordingly, the grommet factor is equal to 1.6 for this product.

When calculating in Aquasim and with simple load/response distributions, the incoming load F of the AQ Ring, when the rope ting is extended 180 degrees, will be distributed with 50% load T on the two sides that make up the AQ Ring in the stretched configuration, see figure 4. Accordingly, incoming loads are allowed 136T when calculating with material factor 2.5 according to NS9415:2021.

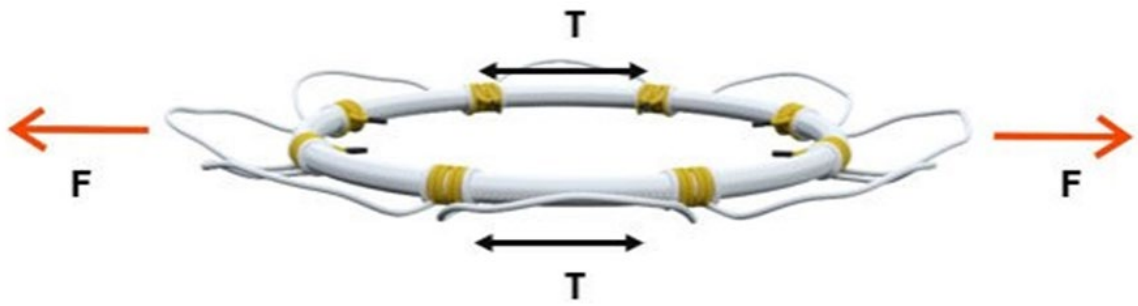

Figure 4 - AQ Ring capacity explanation

8.4 Redundancy

The main redundancy of the AQ Ring is in the jacket surrounding the Dextron 12 Plus rope. The mantle protects against chafing and is therefore an important barrier against any weakening of the AQ Ring properties and against damage to it. At the same time, the AQ ring is sectioned with loops outside, preventing concentration of loads.
The jacket reduces the likelihood of possible breakage in the AQ ring. Chapter 13.3.5.4 of NS9415:2021 with regard to the assessment of possible fractures is covered as a result of this design choice. The loss of several anchoring lines in such a scenario is therefore considered unlikely.

The protective jacket is made of Polyester and Dyneema and has been developed through extensive testing and testing on Messenger-lines and anchoring lines offshore since the 90s.

8.5 Use of the mooring component AQ Ring

The mooring component can be used in mooring systems for floating aquaculture facilities and/or feed barges. See NS 9415:2021 for definitions.

8.6 AQ Ring - Product information

Mooring systems supplied by ScaleAQ AS can be delivered with an AQ Ring as the connection point. Anchoring lines, grid ropes, bridles, and buoy lines are connected at this connection point by using approved connections.

- Estimated service life: 20 years
  - The estimated service life is long as the tensions in the ring are below the cut-off limits for fatigue, ref. NS9415.
- Wear limit: The jacket of the AQ Ring must be intact. In case of wear on the jacket and visible yellow rope, the AQ Ring must be replaced.

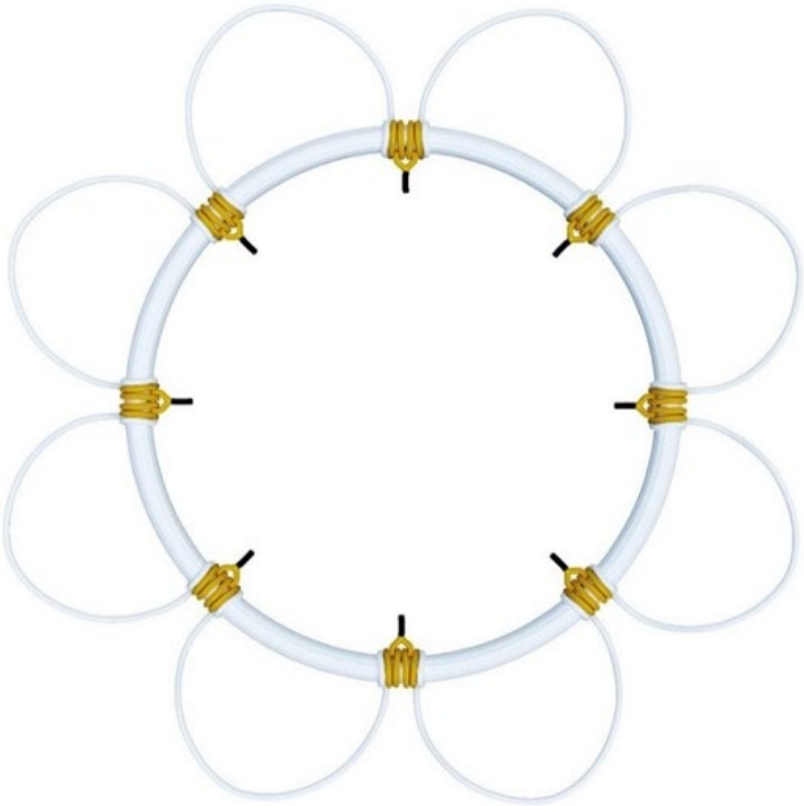

Figure 5 - AQ Ring

Item no.	Description	Contact diameter [mm]	Diameter [mm]	Weight [kg]	MBL, grommet [tons]
302526	AQ Ring	48	1400	16	270

Table 1 - AQ Ring

8.7 Buoy line - Product information

When using an AQ Ring as a connection point, the buoy line MUST be used, see figure 6 and table 2.

The buoy line is connected to the AQ Ring using a cow hitch where it is space. The buoy is connected to the buoy line with a mooring shackle.

- Estimated service life: 10 years
- Wear limit: The jacket of the buoy line must be intact. In case of wear on the jacket and visible yellow rope, the buoy line must be replaced.

Figure 6 - Buoy line for AQ Ring

Item no.	Description	Contact diameter [mm]	Length [m]	Weight [kg]	MBL [tons]
302738	Buoy line for AQ Ring, 8 meters	24	8	10	46.8
301397	Buoy line for AQ Ring, 10 meters	24	10	12	46.8

Table 2 - Buoy line for AQ Ring

8.7 Transport, packaging and assembly

Whole coils are wrapped with protective plastic from the manufacturer. The finished spliced and measured rope is wrapped with plastic and labelled. Coiled up on pallets.

It is important to ensure that no damage from contact with sharp edges or chafing occurs when packing ropes for transport. It is important to protect the rope from direct sunlight.

When unwinding the rope to splice grid ropes, bridles, and anchoring lines, it is important to ensure that this is done in a way that prevents the occurrence of kink on the rope. The correct method is described in the splicing procedure in ScaleAQ AS' quality system. This can be sent upon request.

The AQ Ring shall initially be stored on pallet and moved by truck as usual. The parts can also be moved by crane if lifting equipment approved for this purpose is used. It is important that the AQ Ring is not damaged during these operations. Check carefully for wear against the ground and wear against the lifting equipment itself.

There are no major requirements for storing synthetic fiber ropes. The rope is resistant to bacteria and mold and can be stored in a wet state. It is, however, important to protect it against direct sunlight and excessive heat. The best way to store the ropes is in a cold, dry, and well-ventilated environment.

8.8 Labeling at shipment
Prefabricated grid with AQ Ring is placed in a container or transport bag and labeled.

8.9 Lifting the AQ Ring
Lifting the AQ Ring must be done carefully, making sure that no sharp edges are in contact with the AQ Ring. Lifting by the loops in the AQ ring is **NOT** permitted.

8.10 AQ Ring – Complete grid
The AQ Ring grid consists of AQ Rings as connection points that are connected with product-certified rope. Preferably sinker rope.

The grid ropes are coiled one by one and wrapped in plastic.

8.11 Installation of AQ Ring in the mooring system
The assembly of a complete system will depend on the design of the site and the mooring system.

Before the AQ Ring grid is installed, it is important that the two anchoring lines in the main stretch at both ends, as well as the accompanying anchoring lines in the side stretches, are installed so there are four corners for easy fastening of the AQ ring grid.

One end of the grid is attached to a minimum of 2 anchoring lines in the main stretch and is carefully pulled out of the container with the installation vessel moving at a slow speed.

When the entire grid is pulled out, it is tightened up and fastened in the main stretch at the opposite end. Buoys can be connected continuously during deployment.

It is important that the main lines where you start installing the AQ Ring grid have as close as possible the correct planned length. This is to ensure correct positioning of the mooring system.

The anchoring lines in the main stretches to be installed on the part of the AQ Ring grid on the end may have some excess length, so they are easy to get a hold of. The anchoring lines against the side stretches are fastened last. After all anchor lines and buoys are installed, adjust, and tighten the grid until it is in the correct position and correctly pretensioned.

Bridles and pens are installed after the grid is fully adjusted. All connections to the AQ Ring must be made using methods approved by ScaleAQ.

8.12 Inspection and maintenance - inspection after the anchoring is laid out
All AQ rings with associated connections are visually inspected.

Inspect for wear damage to the AQ ring and rope that are connected to the ring. Inspect for damage on the jacket.

If any damage to AQ Ring is discovered, ScaleAQ must be notified.

Performed with ROV, diver or camera. The connection point can also be lifted with a crane.

8.13 Inspection and maintenance – Biennial inspection
All AQ Rings with associated connections are inspected closely visually.

Inspect for wear damage to the AQ Ring and rope that are connected to the ring. Inspect for damage on the jacket.

If damage to the AQ Ring is discovered, the supplier must be notified.

All connection points are lifted with a crane.

8.14 Traceability information

AQ Ring labeled with a Velcro jacket for each ring as shown below.

Batch format: 603910-1

A buoy line labeled with a Velcro mantle for each buoy line as shown below.

Batch format: 603910