13 Requirements for anchoring and positioning

13.1 General

NOTE 1 Basic requirements for planning, design, documentation, execution and control are stipulated in clauses 5-9.

Aquaculture farms shall have systems to keep the installation in position at all times.

For aquaculture farms with positioning systems other than an anchoring system, the same or a higher safety level than that achieved through this document shall be documented.

The anchoring system shall not impact on the rest of the aquaculture farm in such a way as to increase the danger of fish escape. Amongst other things, this includes maintaining the aquaculture farm in the correct position without exceeding the resistance of main components and extra equipment.

Anchor lines can for example consist of structural parts such as chains, fibre ropes, fibre straps, wires and relevant connections thereof. In order to achieve the desired properties in the system (e.g. elasticity and position), point weights (e.g. plumbs) or buoyancy (e.g. buoys) may be used.

13.2 General requirements for the design of anchoring

During the design of the anchoring system, consideration shall be given to bottom topography, environmental conditions and bottom conditions at the site, as well as load-giving components in the floating aquaculture farm's configuration.

The following minimum requirements shall be satisfied:

a) The forces from the anchoring shall not lead to exceedance of the resistance of the aquaculture farm's main components.

b) The components of the anchoring system shall be dimensioned based on the load effects obtained from the calculations.

c) The anchoring shall be designed so that it is adapted to the bottom type and bottom topography. This means among other things that it shall not be exposed to abrasion against rocks, stones or other hard objects on the bottom.

d) There shall be no contact between anchor lines which can lead to wear between lines and other components in the aquaculture farm.

e) The anchoring system shall be designed to take into account access and possible anchoring of vessels.

f) If vessels or other floating structures shall use parts of the anchoring in order to moor adjacent to the aquaculture farm, this possibility shall be documented through analyses or tests, and any limitations shall be stated.

g) Relevant serviceability limit and ultimate limit states shall be taken into account in the design of the anchoring system.

h) The anchoring shall have sufficiently robustness in relation to identified accidental situations.

i) The holding power of drag anchors shall exceed the design load from the anchor line.

j) The anchoring shall be accessible for inspection and condition monitoring. This does not apply to parts of the anchoring that are to be buried.

k) Relevant properties of structural parts of the anchoring shall be documented.

13.3 Requirements for structural parts of anchoring

13.3.1 Material factor

For parts where the material factor is not stated in Table 11, the manufacturer or supplier shall state the product's material factor. It shall be documented that the safety level in this document has been fulfilled.

13.3.2 Chains

13.3.2.1 General

The choice of chain shall be based on the characteristics that the chain shall have in the aquaculture farm.

Characteristics can be resistance, weight, elasticity, ductility, corrosion protection and fatigue properties.

Relevant characteristics shall be documented.

The chain shall have an average breaking stress of less than or equal to 700 MPa and an internal link length

not exceeding 6,58 x the chain diameter.

NOTE When chains are used for bottom attachment, where the self-weight of the chain is significant, both stud link chain and

studless chain can be used. At other points in the anchoring, it can be appropriate to use lighter chains with other

characteristics, such as a higher tensile strength and corrosion protection.

The risk of hydrogen embrittlement shall be assessed and documented.

13.3.2.2 Marking, testing and documentation

13.3.2.2.1 Marking

All chains shall be marked so as to facilitate traceability every two metres, with the exception of bottom chains, which shall be marked at least every five metres.

The marking shall at least identify the manufacturer and ID number of the chain.

13.3.2.2.2 Testing

To ensure that the requirements for the mechanical properties of the chain are met, type tests of each dimension of the chain shall be performed. Type tests shall consist of at least 3 fatigue tests and 3 destructive tensile tests. For fatigue tests, the number of load cycles (n) shall be at least 200 000. These tests shall substantiate that the fatigue resistance of the chain in seawater satisfies the S-N curve methodology described in 13.3.2.4.

In order to verify the mechanical properties and weld quality of the product, 3 destructive tensile tests and 3 hardness measurements of the chain for each dimension and batch shall

be performed, where a batch is the quantity of chain produced with a tracking to not more than a melt batch from the steelworks.

All chains shall be test-loaded during execution in order to detect any welding and/or material faults. The test loading shall be performed as a tensile test where a test load of up to at least 45 % of the chain's resistance is applied.

NOTE An excessively high test load can damage the chain.

Any corrosion protection shall be documented through the statement of type and thickness.

13.3.2.3 Documentation

All chains shall be supplied with a certificate which facilitates traceability. The certificate shall provide at least:

— information identifying the chain, such as the chain type, dimensions, materials, treatment,

consignment, etc.;

— information on the testing performed and the test consignment;

— results of test loading;

— weight (mass) per metre in air and weight per metre in water;

— manufacturer's test load (MPF);

— minimum breaking load (MBL);

— declaration by a representative of the manufacturer or supplier (authorised);

— place and date.

In addition, the manufacturer or supplier shall at least be able to present documentation of the following upon request:

— chemical analysis and mechanical testing of the basic material, including test results;

— testing performed on the chain and the test consignment (underlying documentation);

— fatigue properties, elasticity, yield strength and ductility.

13.3.2.4 Corrosion

The anticipated corrosion over the design working life shall be taken into account and included in connection with resistance estimation and fatigue calculation.

Corrosion protection can for example be carried out in the form of galvanization, the application of a coating or the use of a corrosion allowance.

If a corrosion allowance is used, this shall be taken into account during the design process. If a corrosion allowance is used on chains in the splash zone, a corrosion allowance in a diameter of 0,4 mm/year shall be used.

If corrosion protection is used, the lifetime of the protection shall be taken into account.

For other chains, a corrosion allowance of 0,2 mm/year shall be used.

13.3.2.5 Fatigue

A fatigue analysis shall be carried out for steel chains.

Fatigue of chains shall be calculated in accordance with S-N curve methodology, with the number of cycles to failure in accordance with:

log n s = log a − mlog s

where

n(*s*) is the number of cycles to failure;

s is the stress range/double amplitude (MPa);

a is a material parameter;

m is a material parameter.

No fatigue limit shall be assumed, and the value of *m* shall be 3,0.

The following values shall be used for *a*:

— studless chain: *a* = 6 × 1010;

— stud link chain: *a* = 1,2 × 1011.

Half of the expected corrosion shall be assumed in the calculations.

The fatigue life of a chain shall be equal to or longer than the design working life specified in the product documentation. If the lifetime of a chain based on fatigue calculations for relevant environmental loads is shorter than the design working life according to the product documentation, the design working life of the chain shall be set as equal to the calculated fatigue life.

13.3.3 Fibre ropes and fibre straps

13.3.3.1 General

The choice of fibre ropes and straps shall be based on the characteristics that they shall have in the aquaculture farm.

Characteristics such as resistance, weight, elasticity, elongation, UV protection, fatigue properties and lifetime shall at least be documented.

In the case of the splicing of fibre ropes, it shall be ensured that the size of the eye is sufficiently large to avoid problems associated with local bending of the fibre rope.

During the design process, it shall be taken into account that fibre ropes shall not come into contact with the seabed after installation.

If the fibre rope shall be stored on the seabed during installation, a protective cover shall be used.

In the event of a danger of overtrawling or similar, the fibre rope should also be protected by a suitable cover.

Rope (3- or 4-strand) and/or hawsers (braided) of various fibres may be used for anchoring.

These shall satisfy the requirements of NS-EN ISO 9554, NS-EN ISO 10572, NS-EN ISO 1346, NS-EN ISO 1140, NS-EN ISO 1141 or NS-EN ISO 10556 for fibre rope, mixed polyolefin, polypropylene (PP), nylon (PA), polyester and polyester/polyolefin respectively.

Fibre straps shall satisfy the requirements of EN 1492 (all parts). Other types of fibre straps may be used, provided that they fulfil the requirements of corresponding standards.

13.3.3.2 Marking, testing and documentation

All fibre ropes shall be tested, documented and marked as specified in NS-EN ISO 9554 and supplied with a certificate in accordance with the same standard.

In the case of fibre rope, tests shall be performed in accordance with NS-EN ISO 2307. In the case of fibre straps, testing shall be carried out in accordance with EN 1492 (all parts), and requirements related to reporting shall be in accordance with NS-EN ISO 2307.

Fibre rope shall be supplied with a self declaration from the manufacturer or supplier, which specifies the technical characteristics of the product (see certificate type 3.1 in accordance with EN 10204).

The self declaration shall contain at least the following:

— information that identifies type, material, treatment, consignment, etc.:

— how the rope is protected against UV radiation;

— reference to information on documentation of the product and test results in accordance with NSEN ISO 2307;

— declaration by a responsible representative of the manufacturer or supplier;

— place and date.

In addition, the product shall be supplied with the following documentation:

— weight (mass) per metre in air and weight per metre in water;

— loading and unloading curve within the working area of the rope or strap to MBL;

— MBL.

13.3.4 Steel wires

13.3.4.1 General

The choice of wires shall be based on requirements for the characteristics of the wire in the aquaculture farm. The characteristics can be resistance, minimum bending radius, weight, corrosion protection and fatigue.

Relevant characteristics of the wire shall be documented.

Weight (mass) in air and weight per metre in water shall be specified.

13.3.4.2 Marking, testing and documentation

Steel wires shall be marked, tested and documented in accordance with recognised methods for this type of component.

13.3.4.3 Compression and slack

Anchoring systems using steel wires should be designed in such a way that no compression occurs in steel wires.

13.3.4.4 Bending of wires

It shall be ensured that wires are not bent more than the minimum allowable bending radius during temporary phases or in connection with installation and operation activities.

Products shall be selected where the minimum bending radius is specified.

13.3.4.5 End termination

It shall be ensured that end termination is carried out in such a way that it is stronger than the wire itself and has an adequate design working life.

13.3.4.6 Damage to wires

Anchoring systems with wires shall be handled and operated so that protective covers and wires are not damaged.

Damaged cables shall be repaired or replaced.

13.3.4.7 Fatigue

A fatigue analysis shall be carried out for steel chains. The fatigue of chains shall be calculated in accordance with S-N curve methodology, with the number of cycles to failure, *n (s)*:

$$\log n\ s = \log a - m \log s$$

where

$n(s)$ is the number of cycles to failure;

s is the stress range/double amplitude (MPa)

m is a material parameter

a is a material parameter

13.3.5 Joints in anchoring systems

13.3.5.1 General

This subclause contains requirements for components that have a connecting function in the anchoring system.

13.3.5.2 Shackles

The choice of shackles shall be based on requirements for the characteristics of the shackles in the aquaculture farm. The characteristics of the shackles include for example MBL, corrosion, fatigue and resistance to wear.

It shall be ensured that selected shackles cannot end up across, if this would affect the properties of the shackles.

Shackles used for anchoring shall be tested and marked in accordance with EN 13889. Shackles that are only used for aquaculture farms may be marked with the minimum breaking load (MBL) instead of the maximum allowable working load (WLL).

The testing shall be documented through a type 3.1 certificate in accordance with NS-EN 10204.

Shackle bolts shall be provided with double securing at all times. The double securing shall be made from a material that is corrosion-resistant in the relevant environments. The double securing shall not contribute to increased corrosion of other shackle parts.

NOTE Double securing can for example be in the form of nuts and cotter pin or nuts and chemical thread lock.

Cotter pins shall be made from a corrosion-resistant material/surface coating and shall not contribute to increased corrosion of other shackle parts.

13.3.5.3 Thimbles

Any thimbles that are used shall be designed for the design load in the anchor line.

13.3.5.4 Connecting elements

Where several anchor lines connect at a single point, the connecting point shall have technical characteristics that meet the functional requirements for the anchoring.

It is permissible to use connecting elements of different layout designs and which are made from different materials, provided that sufficient resistance and lifetime can be documented for the intended use in the anchoring system. This also entails requirements for the documentation of three-dimensional resistance.

Connecting elements should be dimensioned so that they can be lifted. Resistance and limitation as regards lifting shall be specified.

Resistance shall be calculated for possible failure sections, connecting elements made from metal shall be dimensioned in accordance with relevant material standards.

If there are probable failure sections that can result in more anchor lines becoming detached from the connecting point, this shall be documented.

For connecting elements made from materials other than steel, material factors for known materials shall be used (see 13.3.1).

Wear and corrosion linked to the specific solutions shall be specifically assessed.

For connecting elements, at least MBL, yield strength, tensile strength, elasticity, corrosion protection, fatigue and resistance to wear shall be documented.

13.3.6 Buoys

Buoys shall be dimensioned to withstand the maximum pressure from submersion and waves at the design load on the anchor lines. Buoys and attachments shall be dimensioned to withstand the loads from submersion, wave and current loads, icing, drift ice, flotsam and boats.

It shall be documented through testing that no structural failure or reduction in buoyancy will occur when the buoy is subjected to 1,3 times the specified compressive resistance for at least 20 minutes.

Buoys shall be dimensioned for lifting operations and resistance, and limitations on this shall be specified.

If buoys are used in lifting operations, the buoys shall be approved as lifting equipment, and they shall thus be certified and recertified in the same way as other lifting equipment. Buoys,

including connections, used in lifting operations, shall also be designed as lifting equipment in accordance with NS-EN 1677 (all parts).

The movement characteristics of buoys shall be assessed, and the lifetime of buoys and attachments shall be documented based on an assessment of the load effect of the anchoring with buoys.

In addition, it shall be documented that the buoy is dimensioned for the dynamic loads that occur when exposed to waves and the line to the buoy alternates between slack and taut. Fatigue and wear shall be assessed during the design process.

It shall be documented that steel details are protected against corrosion during the design working life of the buoy.

13.3.7 Point weights and buoyancy in the anchor line

If point weights (e.g. plumbs) or buoyancy (e.g. buoys) are used along the anchor line to achieve the desired characteristics of the anchor lines (e.g. elasticity and position), this shall be included in the design, and local details shall be documented.

The point weights or buoys shall be attached to the anchor line in such a way that they cannot damage the line or pull the line so far down that wear can occur against the bottom.

13.3.8 Bottom attachments

13.3.8.1 General

The choice of bottom attachments shall be based on thorough survey of the bottom conditions at the site in accordance with the site survey (see clause 8).

13.3.8.2 Drag anchors

Steel drag anchors shall be dimensioned in accordance with NS-EN 1993-1-1.

Drag anchors shall be marked with the maximum holding force for which the anchor is approved.

Drag anchors shall be dimensioned so that the maximum specified holding force against the bottom is reached before the first yield occurs in the anchor.

The allowable load on drag anchors for different angles of attack shall be specified.

Consideration shall be given to the fact that drag anchors can be subject to uneven loading on the plate.

The user handbook for the drag anchors shall specify the seabed types for which they are suitable.

Anchors shall be documented through self declaration by the manufacturer or supplier, which shall specify the technical characteristics of the product and include at least a type 3.1 certificate in accordance with NS-EN 10204.

13.3.8.3 Rock bolts

Rock bolts shall be dimensioned for the design load from the anchor line using a material factor for anchor lines (see 13.3.1). The characteristics of the rock bolts include, for example, resistance, lifetime, corrosion and resistance to wear, and shall be documented.

Rock bolts shall be quench hardened and protected against corrosion.

The bolts shall be marked with the depth to which they shall be inserted into rock.

Rock bolts shall be documented through self declaration by the manufacturer or supplier, which shall specify the technical characteristics of the product (at least a type 3.1 certificate in accordance with NSEN 10204).

The MBL of the rock bolt shall be stated in the documentation.

Shackles and rock bolts that are connected to each other shall have dimensions that are adapted to each other, in order to prevent any increase in the risk of damage and fish escape.

13.3.8.4 Other types of bottom attachments

Other types of bottom attachments such as suction anchors, gravitational anchors, piles and spikes shall be dimensioned according to recognised methods based on design loads from the anchor line.

13.4 General requirements for anchoring analyses

13.4.1 General

The purpose of an anchoring analysis is to obtain load effects in the anchoring system and loads on the floating aquaculture farm.

The anchoring analysis shall also calculate global displacements of the various main components, see clause 7 and 9.4.2.

An anchoring analysis shall take into account possible configurations of the aquaculture farm while in operation.

An anchoring analysis shall be representative of the anchoring laid out.

The anchoring analysis shall be carried out in accordance with the requirements given in clause 9.

13.4.2 Requirements for documentation of the anchoring analysis

Documentation of the anchoring analysis shall include descriptions of the anchoring and components thereof, so that the party responsible for laying out the anchoring has sufficient information to lay out the anchoring in accordance with the assumptions in the analysis.

The anchoring analysis can assess tolerances linked to installation and specify acceptance criteria for laying out.

Calculation methods relevant to the structure concerned shall be used, and assessments shall be documented.

Documentation of the anchoring system shall provide a description that is sufficient to enable the anchoring to be judged and recalculated without any need to obtain other documentation.

This means among other things:

a) documentation of the equilibrium position (without environmental loads), including with pretensioning of all lines;

b) specification of each anchor line. At least specifications shall be provided of components such as bottom attachments, fibre ropes, chains, thimbles, shackles and any other components used for anchoring purposes. For all lines, key data shall be provided for each

component, such as resistance requirements with respect to failure, dimensions, elasticity and weight in water where relevant;

c) the position of each component of the anchor lines, as well as the coordinates of bottom attachments and attachment points on the aquaculture farm;

d) fundamental assembly drawing of the floating aquaculture farm, with laying patterns, attachment points, indication of line lengths and length/depth ratios of depth-dependent line lengths;

e) functional requirements that shall be met, with associated limit states, such as whether wellboats shall be able to moor to the floating aquaculture farm;

f) documentation of the degree of utilisation of components throughout the anchoring system in ultimate limit states, including fatigue and accidental situations;

g) documentation of the maximum forces at the end points of anchor lines attached to the aquaculture farm and bottom attachments;

h) documentation of a completed conformity assessment for the anchoring laid out.

13.5 Requirements for laying out and re-examination

13.5.1 General

Anchoring shall be laid out in such a way that none of the anchoring components are damaged during the laying-out process.

The holding force of the bottom attachments shall be controlled and documented through the application of a tensile load of at least 50 % of the design load of the line. The tensile load shall be held for at least 15 minutes.

The testing of holding power may be derogated from if a documented geotechnical investigation has been carried out which include a documentation of the resistance of the bottom attachment.

Following tensile testing, anchor lines shall be adjusted so that the level of pre-tensioning falls within the tolerances specified in the anchoring analysis.

NOTE Direct measurement of the pre-tensioning can be inaccurate as mean environmental loads will affect the estimate.

The grout used for the installation of bolts (e.g. rock bolts) shall be suitable for the environment in which it is used.

Further inspection and/or testing shall take place according to a fixed schedule, which includes time intervals for inspection and testing, based on the suppliers' user handbooks. The user handbook shall also include a list of events which shall trigger an increase in inspection and testing, as well as a plan for the (periodic) replacement of parts.

13.5.2 Laying out report

Following the laying out of anchoring, the way in which the anchoring was laid out shall be documented.

The report shall form the basis for determining whether or not a new analysisshall be carried out in order to establish conformity between the laid-out aquaculture farm and the anchoring analysis.

The report shall contain at least the following:

— time of laying out;

— specifications of each component in the anchoring, including bottom attachment, line type, thimbles, shackles and other equipment;

— specifications that include the component's location, weight, length (rope, wire and chain) and reference to product certificate;

— coordinates for laid-out bottom attachments/shore attachment and the method used for this;

—deviations from the anchoring analysis (other bottom attachments, lengths, location, pre-tensioning, etc.);

— documented holding force during physical testing of all bottom attachments in accordance with 13.5.1;

— map;

— design working life for all parts.

13.5.3 Anchoring inspection

After the anchoring has been laid out, the entire anchoring system shall be inspected.

A report on the anchoring inspection shall cover at least the following:

— time of inspection;

— horizontal direction of the line;

— coordinates for laid-out bottom attachments/shore attachments and the method used for this;

— documentation that the bottom attachment has been installed in accordance with the user handbook;

— an assessment of wear on inspected anchoring to the bottom, other lines and nets;

— other factors that can lead to wear;

— deviations from the laying out report.