VRYHOF

VRYHOF MANUAL

THE GUIDE TO ANCHORING

Vryhof Manual

the guide to anchoring

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General

General

A stone and something that looked like a rope. For millennia this was the typical anchor.

The use of the anchor changed with the requirements that shipping had over the centuries, more particular with the requirements of the Navies of this world in the late 1800, early 1900s. Their lumpy war ships required larger and heavier, mostly casted anchors.

The true revolution in anchor design came in the late 1960s with the first oil discoveries offshore, first to steady rigs and work vessels, two decades later to moor floating production units.

Established in 1972, Vryhof Anchors was amongst the first anchoring pioneers in an industry building on great technical achievement. Likewise Vryhof built on its experience developing anchors with staggering holding power and handling characteristics.

Vryhof became the world leader in its field working alongside leaders in engineering, manufacturing and installation of mooring systems for all kinds of floating structures. In doing so the company has secured numerous anchor and ancillary equipment patents.
The company understands the industry needs can not be met by the supply of standard hardware only. Their universal and tailored solutions are rooted in proven engineering and based on long practical experience. With their products, advice and this manual, it shares its knowledge with those who are daily faced with complex mooring situations.

This manual is intended as a means of reference for all who purchase, use, maintain, repair or are in any way involved with anchoring. Though written from one anchor designer's standpoint, the information provided is applicable to many types of anchors. Total objectivity is, of course, impossible.

It is hoped this manual will contribute to the work and success of all who work with anchors. They are the only fixed reference point for many of the floating structures on the world's often turbulent waters.

Mooring systems

Mooring systems have been around just as long as man has felt the need for anchoring a vessel at sea. These systems were used, and are still used, on ships and consist of one or more lines connected to the bow or stern of the ship. Generally the ships stayed moored for a short duration of time (days).

When the exploration and production of oil and gas started offshore, a need for more permanent mooring systems became apparent. Numerous different mooring systems have been developed over the years, of which a short selection is presented here.

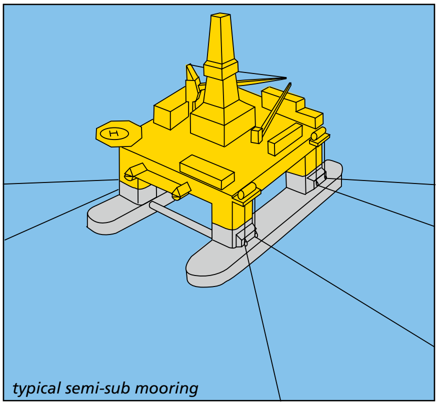
Semi-submersible drilling rig - generally a semi-submersible is moored using an eight point mooring. Two mooring lines come together at each of the columns of the semi-submersible.

CALM buoy - generally the buoy will be moored using four or more mooring lines at equally spaced angles. The mooring lines generally have a catenary shape. The vessel connects to the buoy with a single line and is free to weathervane around the buoy.

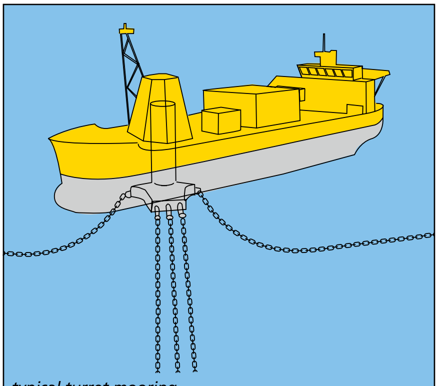
Spread mooring - generally used on FPSOs and FSOs in milder environments. The mooring lines are directly connected to the FPSO or FSO at both the stern and bow of the vessel.

Turret mooring - this type of mooring is generally used on FPSOs and FSOs in more harsh environments. Multiple mooring lines are used, which come together at the turntable built into the FPSO or FSO. The FPSO or FSO is able to rotate around the turret to obtain an optimal orientation relative to the prevailing weather conditions.

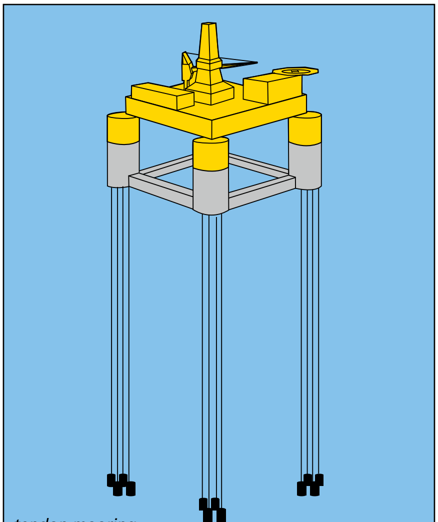
Tendon mooring - used in extreme deep water to semi-permanent moor production units, generally called Tension Leg Platforms, on suction or driven piles.



typical semi-sub mooring

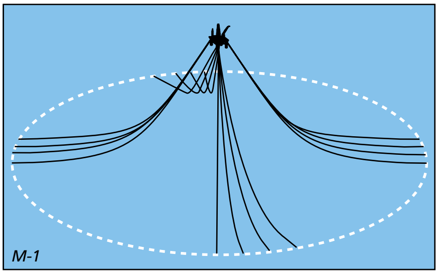


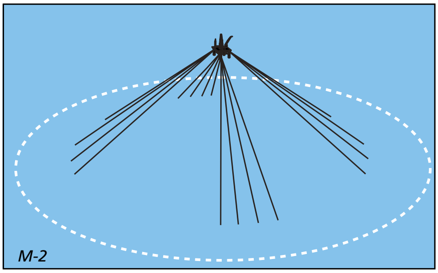
typical turret mooring

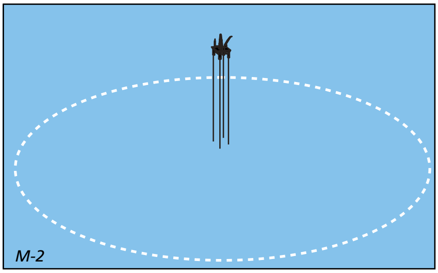


tendon mooring

Mooring systems







Catenary mooring

When oil and gas exploration and production was conducted in shallow to deep water, the most common mooring line configuration was the catenary mooring line consisting of chain or wire rope (fig. M-1). For exploration and production in deep to ultra-deep water, the weight of the mooring line starts to become a limiting factor in the design of the floater. To overcome this problem new solutions were developed consisting of synthetic ropes in the mooring line (less weight) and/or a taut leg mooring system.

Taut leg mooring

The major difference between a catenary mooring and a taut leg mooring is that where the catenary mooring arrives at the seabed horizontally, the taut leg mooring arrives at the seabed at an angle (fig. M-2). This means that in a taut leg mooring the anchor point has to be capable of resisting both horizontal and vertical forces, while in a catenary mooring the anchor point is only subjected to horizontal forces. In a catenary mooring, most of the restoring forces are generated by the weight of the mooring line. In a taut leg mooring, the restoring forces are generated by the elasticity of the mooring line.

An advantage of a taut leg mooring over the catenary mooring is that it has a smaller footprint, i.e. the mooring radius of the taut leg mooring will be smaller than for a catenary mooring for a similar application. This reduces the material quantity, cost and weight of the total mooring system.

Tendon / Tension Leg mooring

This mooring system was developed to moor extreme large production units in very deep water. More recently it is also applied to small TLP unit moorings. Generally suction anchors are applied, however with the availability of vertical loaded gravity installed anchors this system might become more popular for relatively small floating units that are unable to carry large weight from the deep water mooring system (fig. M-3).

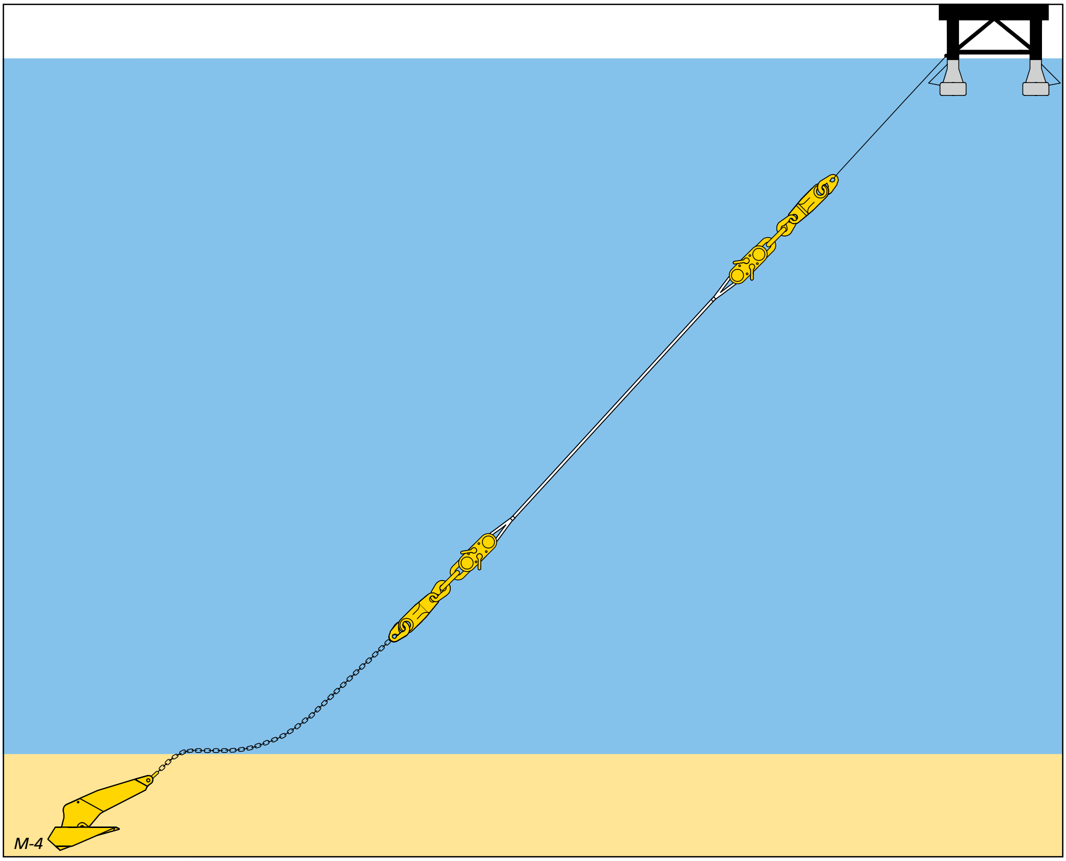
Mooring line components

The mooring line

A typical mooring system can be divided into three different main components:

- The mooring line
- The connectors
- The anchor point

Of each of these main components a large variety is in use, each to match project specifications for a certain application, capacity, its size or weight. In the overview that follows we describe the most commonly used components (fig. M-4).


M-4

Mooring line components

Mooring line

Chain

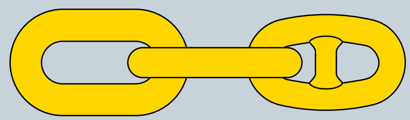
The most common product used for mooring lines is chain which is available in different diameters and grades. Two different designs of chain are used frequently, studlink and studless chain. The studlink chain is most commonly used for moorings that have to be reset numerous times during their lifetime, for instance on semi-submersibles, while studless chain is often used for permanent moorings (FPSOs, buoys, FSOs). A chain mooring line can be terminated in either a common link or an end link (fig. M-5).

Wire rope

When compared to chain, wire rope has a lower weight for the same breaking load and a higher elasticity. Common wire ropes used in offshore mooring lines are six strand and spiral strand. The wire rope is terminated with a socket -for instance open spelter, closed spelter, CR socket (chain rope)- for connection to the other components in the mooring system. Generally wire rope is more prone to damage and corrosion than chain (fig. M-6).

Synthetic fiber rope

The use of synthetic fiber ropes in the mooring line have become common practice in deep water mooring. Typical materials that can be used are polyester and high modulus polyethylene (Dyneema). The major advantages of synthetic fiber ropes are the light weight and elasticity of the material. The synthetic fiber rope is generally terminated with a special spool (thimble) and shackle for connection to the other components in the mooring system (fig. M-7).



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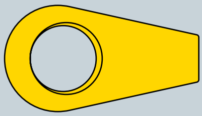
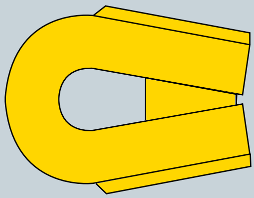


M-6

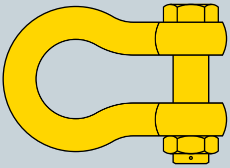


M-7

Connectors

Shackles

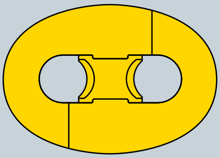
The shackle is a connector that is very common in the offshore industry. It consists of a bow, which is closed by a pin. Many different types of shackles are available. The shackle can be used in both temporary and permanent moorings (fig. M-8).



M-8

Connecting link Kenter type

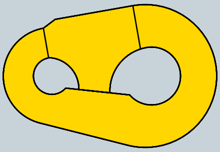
The connecting link Kenter type is most commonly used for the connection of two pieces of chain mooring line, where the terminations of the two pieces have the same dimensions. The connecting link Kenter type has the same outside length as a chain link of the same diameter. Generally connecting links Kenter type are not used in permanent mooring systems, as they have a shorter fatigue life than the chain (fig. M-9).



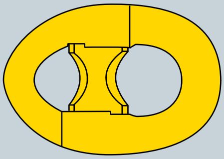
M-9

Connecting link pear shaped

The pear shaped connecting link is similar to the connecting link Kenter type, except that it is used for the connection of two pieces of mooring line with terminations that have different dimensions. Like the connecting link Kenter type, the pear shaped connecting links are not used in permanent mooring systems (fig. M-10). In Norway the Kenter and Pear link are replaced by the Trident anchor shackle (fig. M-11).



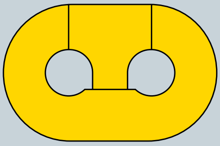
M-10



M-11

Connecting link C-type

Like the connecting link Kenter type, the connecting link C-type is used for the connection of two pieces of mooring line with terminations that have the same dimensions. The major difference between the Kenter type and the C-type is the way that the connector is opened and closed. This connector is generally not used in permanent moorings (fig. M-12).



M-12

Mooring line components

Swivels

A swivel is used in a mooring system, generally of a temporary type, to relieve the twist and torque that builds up in the mooring line. The swivel is often placed a few links from the anchor point, although it can also be placed between a section of chain and a section of wire rope. There are two basically different groups of chasers available.

A. Roller bearing swivel:
These are applied to anchor/chain connections and to connect ground chain and torgue neutral fiber rope. This type of swivel is ideally used to install and tension prelaid mooring systems.

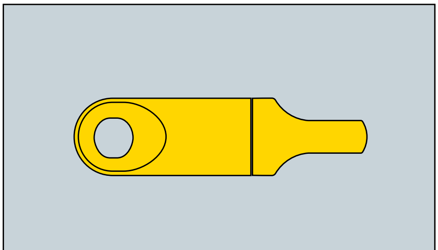
B. Slide bearing swivels:
These serve wire rope connections, both in buoy-off operations and complete mooring operations that involve wire connections.

Mooring swivels
A new generation mooring swivel can be supplied in either forged or cast versions. This swivel type is mostly applied to compensate for torque in chain/wire rope or rope connections (fig. M-13).

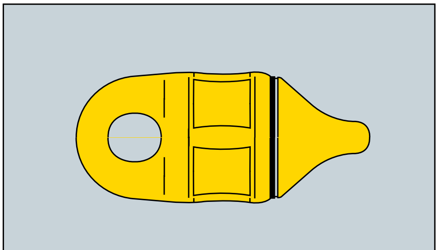
Anchor handling swivels

The anchoring swivel (fig. M-14) withstands the largest load impact during handling and serves all types of connections. The slim geometry allows the swivel to run through a fairlead, chaser ring or over an anchor handler stern roller under high load, without damage to the bearing system or any other swivel part.

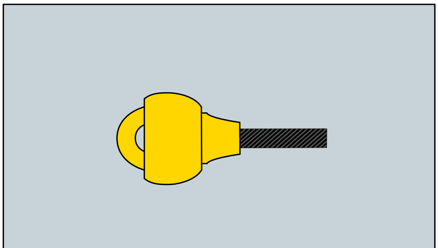
The ball anchoring swivel (fig. M-15) combines a wire socket, swivel and chain connector in one unit. The device absorbs the torque built up in the line. This is especially suited for use in a MODU anchoring line and runs through the fairlead.



M-13



M-14

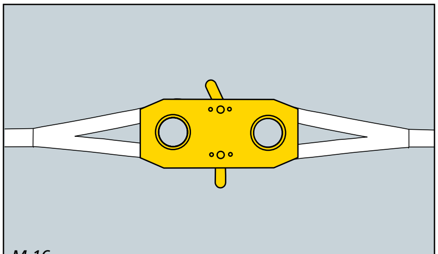


M-15

Mooring line components

M-Link synthetic rope connector

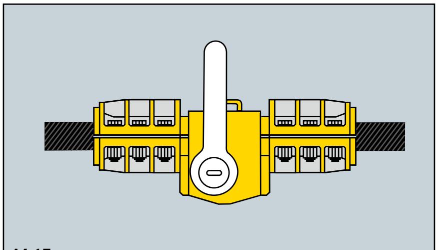
A new generation connector has been introduced to replace time costly handling of bulky synthetic rope thimbles. They serve to connect two lengths of synthetic rope in deep water mooring lines as well as to connect a buoy to a line without damaging the line (fig. M-16).



M-16

Wire clamp

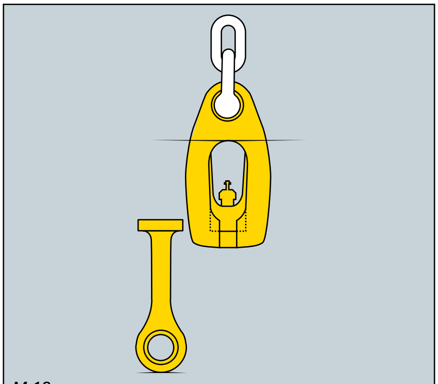
A new compact design wire clamp serves to add buoyancy bodies to a wire rope assuring loads are spread over a length of wire to prevent bending damage. The clamp can be adjusted to fit a large variety of wire rope diameters (fig. M-17).



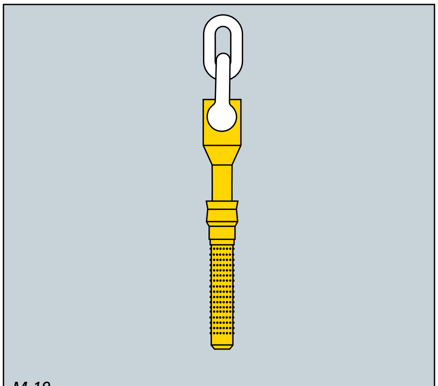
M-17

Subsea connector tools

With the increase of water depths in which floating units were moored it became a requirement to connect or disconnect mooring lines or their connecting components without the assistance of divers. A large variety of these tools exists, mostly purpose built. Some designs accommodate all end-connectors commonly used in any combination of chain, wire and synthetic mooring lines. They are either operated mechanically, hydraulically or deployed with assistance of an ROV unit (fig. M-18 & M-19).



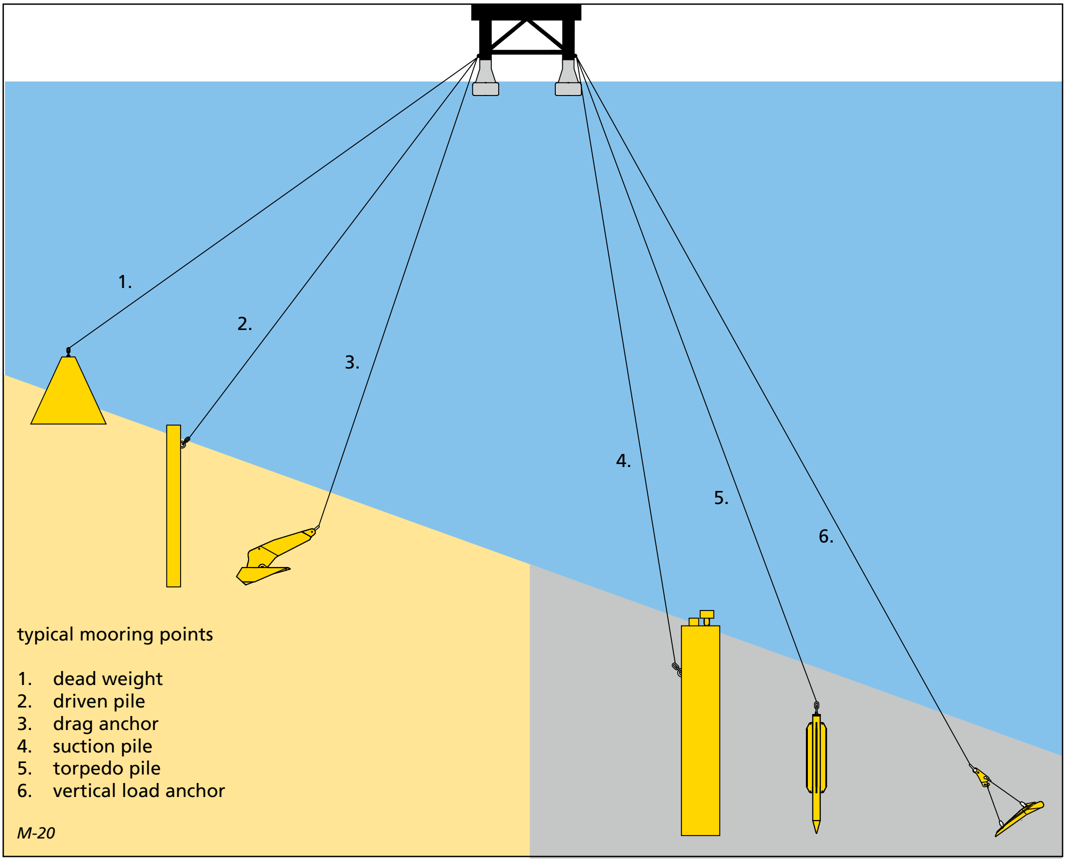
M-18



M-19

The anchoring point

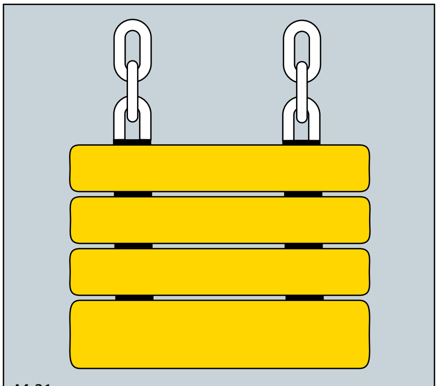
The basic choice of the type of anchoring point is mostly determined by a combination of the water depth in which it is to be applied, the condition of the soil and the load that the anchor point needs to withstand. With the increase of water depth, remoteness of the mooring location from shore, environmental conditions, sea and soil behaviour, the practicality of an anchor point or the cost of its transportation and installation become important selection criteria.
In the illustration below we show the most principle anchor point types ranged by water depth (shallow to ultra deep water) and soil type (hard to soft soil). In the following subject we describe each of the typical anchor points (fig. M-20).



M-20

Dead weight

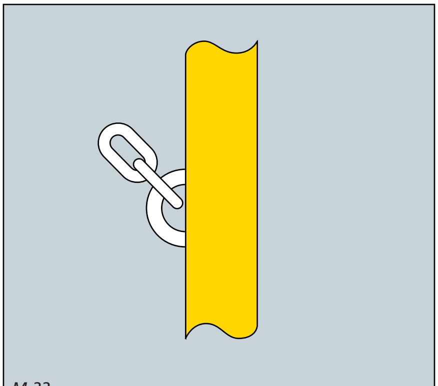
The dead weight is probably the oldest anchor in existence. The holding capacity is generated by the weight of the material used and partly by the friction between the dead weight and the seabed. Common materials in use today for dead weights are steel and concrete (fig. M-21).



M-21

Pile

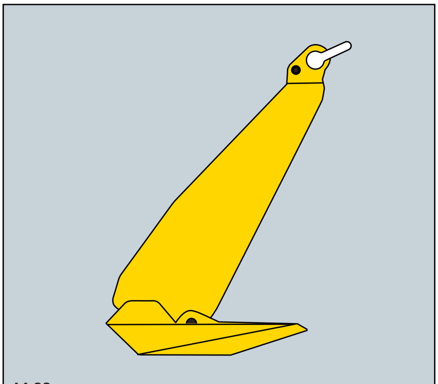
The pile is a hollow steel pipe that is installed into the seabed by means of a piling hammer or vibrator. The holding capacity of the pile is generated by a combination of the friction of the soil along the pile and lateral soil resistance. Generally the pile has to be installed at a great depth below the seabed to obtain the required holding capacity. The pile is capable of resisting both horizontal and vertical loads (fig. M-22).



M-22

Drag embedment anchor

This is the most popular type of anchoring point available today. The drag embedment anchor has been designed to penetrate into the seabed, either partly or fully. The holding capacity of the drag embedment anchor is generated by the resistance of the soil in front of the anchor. The drag embedment anchor is very well suited for resisting large horizontal loads, but not for large vertical loads although there are some drag embedment anchors available on the market today that can resist significant vertical loads (fig. M-23).

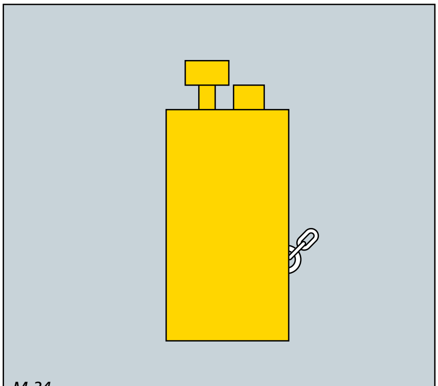


M-23

Mooring line components

Suction anchor

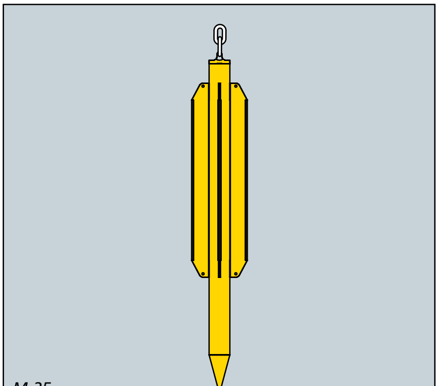
Like the pile, the suction anchor is a hollow steel pipe. But unlike the pile the suction anchor is closed at the top and generally has a much larger diameter than that of the pile. The suction anchor is forced into the seabed by means of a pump connected to the top of the pipe. When the water is pumped out of the suction anchor this creates a pressure difference between the outside of the pipe and the inside forcing the anchor into the seabed. After installation the pump is removed. The holding capacity of the suction anchor is generated by a combination of the friction of the soil along the suction anchor and lateral soil resistance. The suction anchor is capable of withstanding both horizontal and vertical loads (fig. M-24).



M-24

Gravity installed anchor

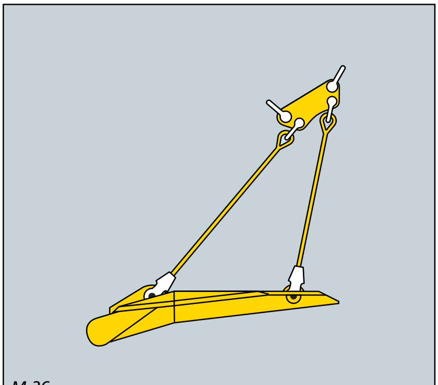
This anchor type is a hybrid system that combines significant vertical and horizontal load capacity. It installes itself due to its drop weigth and requires no external energy or mechanical handling. It is therefore ultimately suited for ultra deep water moorings (fig. M-25).



M-25

Vertical load anchor

The vertical load anchor is installed like a conventional drag embedment anchor, but penetrates much deeper. When the anchor mode is changed from the installation mode to the vertical (normal) loading mode, the anchor can withstand both horizontal and vertical loads. Although designed to suit deep water mooring application, its omnidirectional load capacity allows mooring objects in confined subsea infrastructures such as in vicinity of pipeline and cables (fig. M-26).



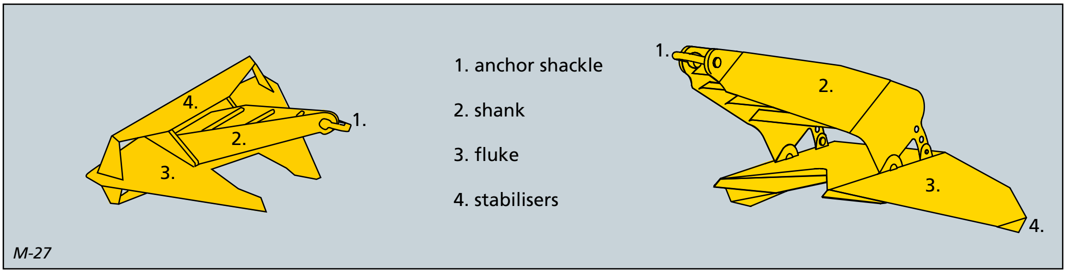
M-26

History of drag embedment anchors

History traces the use of anchors to China as far back as 2,000 BC, though it is quite probable that they were used prior to this. At that time the general tendency was to use large stones, baskets of stones, bags of sand or even logs of wood loaded with lead which were then fastened to lines. It was this weight as well as a certain degree of friction on the bottom which secured a vessel in position.

With the introduction of iron into anchor construction, teeth or flukes were built on the anchor, allowing penetration into the seabed, thus offering additional stability. Yet these primitive anchors were of poor construction and often broke under pressure. Curved arms were introduced in 1813, and from 1852, the so-called ‘Admiralty Anchor’ was used for ships of the Royal Navy. Another refinement in the 19th century was the elimination of the stock, the crosspiece at the top of an anchor which ensured that the positioning of the anchor would allow the flukes to penetrate the soil. A stockless anchor was invented in 1821 and became popular, primarily as a result of the ease of handling and stowing, qualities still valued today.

A large number of anchor types has been designed and commercialised over the years. Some have prospered, others not. The most recent designs are the results of vast experience and extensive testing, and are far more efficient than their historical predecessors. A short overview of the anchors in use today, is presented on the following pages.



Characteristics of anchor types

Based upon certain charateristics such as fluke area, shank, stabilisers, it is possible to classify the various anchor types.
To allow a rough comparison of anchor type efficiency, an indication (*) is provided for a 10 T anchor as (HOLDING CAPACITY = WEIGHT F EFFICIENCY).

Class A efficiency range *33 to 50
slender anchors with ultra-penetration.

Class B efficiency range *17 to 25
anchors with 'elbowed' shank, allowing for improved penetration.

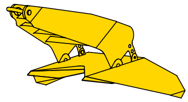
Class C efficiency range *14 to 26
anchors with open crown hinge near the centre of gravity and relatively short shank and stabilisers or built-in stabilisers.

Class D efficiency range *8 to 15
anchors with hinge and stabilisers at the rear and relatively long shanks and stabilisers.

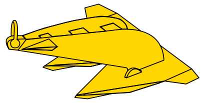
Class E efficiency range *8 to 11
anchors with very short, thick stabilisers; hinge at the rear and a relatively short, more or less square-shaped shank.

Class F efficiency range *4 to 6
anchors with square shank, no stock stabilisers. The stabilising resistance is built-in the crown.

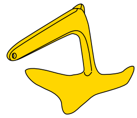
Class G efficiency range *<6
anchors with small fluke area and stabilisers at the front of the shank.



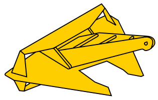
Class AA Efficiency well in excess of 50 Stevpris Mk6



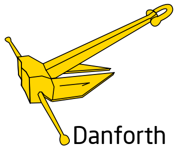
Class A Stevpris



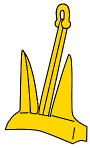
Class B Bruce SS



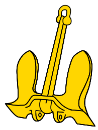
Class C Stevin Mk6



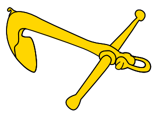
Class D Danforth



Class E AC14

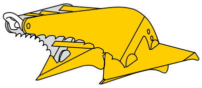


Class F US Navy Stockless



Class G Single Fluke Stock

Characteristics of anchor types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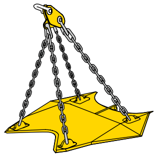
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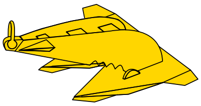
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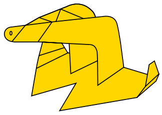
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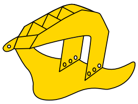
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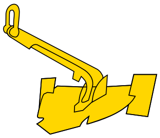
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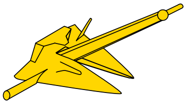
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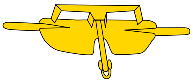
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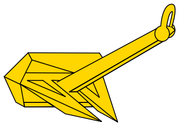
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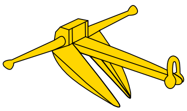
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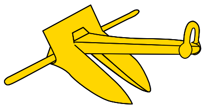
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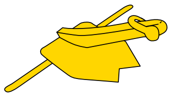
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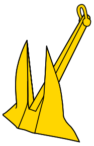
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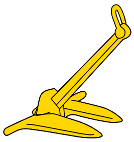
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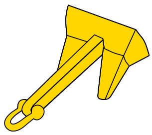
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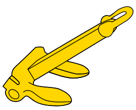
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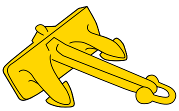
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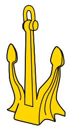
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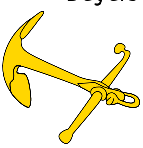
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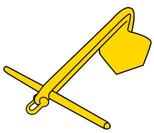
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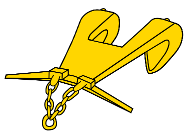
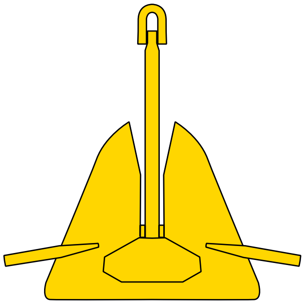

Mooring Anchor

History of Vryhof anchor designs

A brief chronological summary of the types of anchors Vryhof has designed for use in the offshore and dredging industries:

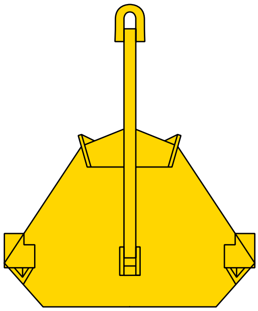
- 1972 - The **Stevin®** anchor: The original design. The wing was not yet enlarged. The anchor had a square shank. It is no longer manufactured.

Stevin



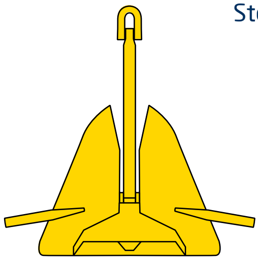
- 1974 - The **Hook®** anchor: originally designed for permanent moorings. This design was surpassed in 1980 by the Stevpris® design and is no longer manufactured.

Hook



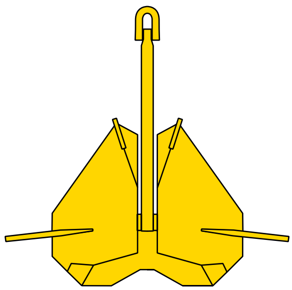
- 1977 - The **Stevin® Mk3** anchor: is the improved version of the original Stevin® anchor. It was equipped with an enlarged crown and fluke area and a streamlined shank for more efficient penetration. This anchor is still manufactured and in use in offshore and dredging activities. It has approvals from all the classification societies.

Stevin Mk3



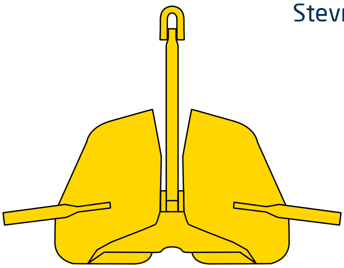
- 1978 - The **Stevfix®** anchor: this anchor was designed with special fluke points for harder soils and a larger fluke area than the Stevin®, but has been surpassed by the Stevpris® anchor. It is no longer manufactured.

Stevfix



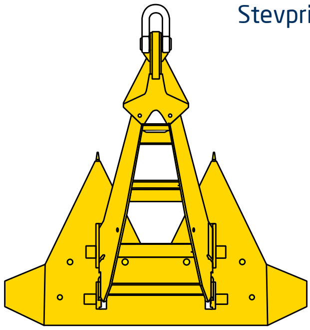
History of Vryhof anchor designs

- 1979 - The **Stevmud®** anchor: the Stevmud anchor is essentially the Stevin® anchor with a considerably enlarged fluke area. This anchor type was also surpassed by the Stevpris® anchor and is no longer manufactured.



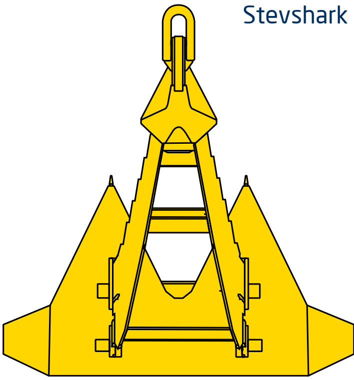
Stevmud

- 1980 - The introduction of the Stevpris® and Stevshark ® anchors. The **Stevpris®** anchor is a deep penetrating anchor with a plough shaped shank, surpassing the performance of all earlier designs in the Vryhof range, and incorporating the latest experience, research and knowledge of the anchor designer. The Stevshark® anchor is a specially reinforced Stevpris® anchor, equipped with a serrated shank and cutter-teeth for better penetration in hard soils, such as coral types or sandstone. The fluke points are specially reinforced to withstand high point loads.



Stevpris Mk5

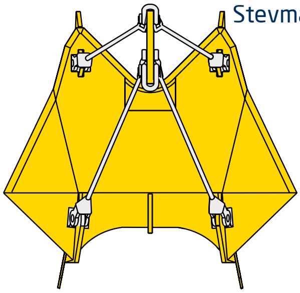
- 1990 - The **Stevpris® Mk5** anchor and **Stevshark® Mk5** anchor, improved versions of the original Stevpris® anchors and Stevshark® anchors were introduced. The Stevshark® anchor is an adapted version of the Stevpris® anchor. In extreme hard soils an anchor will not penetrate very deeply. Consequently the fluke tips and a small portion of the fluke need to withstand extreme high loads and bending forces for which the Stevshark® anchor has been strengthened in critical places. The Stevshark ® Mk5 anchor is based on the Stevpris® Mk5 anchor design and has been widely used for permanent and semi-permanent moorings as well as reaction anchor in the dredging and marine construction industries.



Stevshark Mk5

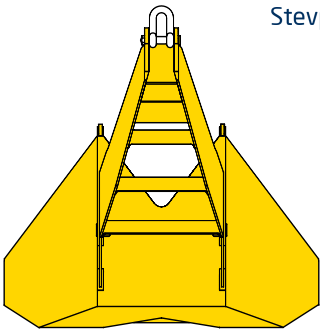
History of Vryhof anchor designs

- 1996 - Introduction of the **Stevmanta® VLA** (Vertical Load Anchor). Based on industry demand for an anchor that could withstand vertical loads, the Stevmanta® VLA was developed. The Stevmanta® VLA is a new design in which a traditionally rigid shank has been replaced by a system of wires connected to a plate. The anchor is designed to accept vertical (or normal) loads and is installed as a conventional drag embedment anchor with a horizontal load to the mudline to obtain the deepest penetration possible. By changing the point of pulling at the anchor, vertical (or normal) loading of the fluke is obtained thus mobilising the maximum possible soil resistance. As a VLA is deeply embedded and always loaded in a direction normal to the fluke, the load can be applied in any direction. Consequently the anchor is ideal for taut-leg mooring systems.



Stevmanta VLA

- 2004 - Introduction of the Stevpris® Mk6 anchor The **Stevpris® Mk6** anchor was developed on the experience of numerous anchor installations. It combines the geometry of the Stevmanta® anchor fluke design with an improved robust shank and shank head configuation which prevents interference with the chaser. The fluke shape minimizes soil disturbance and its large surface provides a more than 30% increase in holding power over that of the Stevpris® Mk5 anchor. The Stevpris® Mk6 anchor has considerable uplift capabilty so that it has also greater water depth tolerance in combination with suitability for a wide range of soil conditions. The Stevrpis® Mk6 anchor can be equipped with the Stevtrack® data acquisition system to monitor its position on the seabed and during penetration.



Stevpris Mk6

History of Vryhof anchor designs

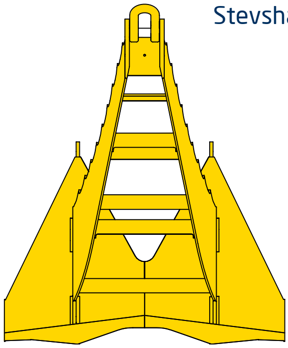
• 2014 - Introduction of the Stevshark® Mk6 anchor

The **Stevshark®** anchor is a strengthened version of the Stevpris® anchor design. It has a number of concrete differences all aimed to a higher structural strength and the ability to penetrate into hard soils.

- Strengthened fluke tips
- Cutter points on fluke tips (optional)
- Serrated shank leading edges
- Hollow fluke to allow ballasting (30% of the anchor weight)

Due to the structural additions the anchor weight is higher than a comparable Stevpris® anchor. Its dimensions are the same however.

Stevshark Mk6

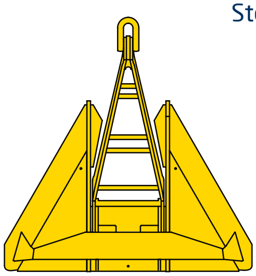


• 2015 - Introduction of the Stevin® Mk6 anchor

The **Stevin®** anchor is a hinged, drop-anchor that since its inception has been the work-anchor for a large variety of work vessels as it matches a very wide range of operational parameters and serves repetitive anchoring.

In the new Stevin® Mk6 design the massive single leg shank has been replaced by the proven Stevpris® Mk6 shank which serves hinging on the fluke that is based on the Stevpris® Mk6 geometry. The fluke angle can be fixed with a bolt in a 32^0, 41^0 and 50^0 angle. The Stevin® Mk6 anchor has increased structural strength and is now able to withstand side loads. Its stability in handling as well as during penetration has also improved. First full scale tests proved it builds it holding power swiftly and maintains this in the narrowest band width imaginable.

Stevin Mk6




VRYHOF ANCHORS HOLLAND
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EMAIL: VRYHOF@VRYHOF.COM
STEVPRIS MK6
SERIAL NO: 10.000

2

Theory

Criteria for anchor holding capacity

Anchor design used to be based solely on the practical experience of the anchor manufacturer. Nowadays, science has become a major factor in the design process, complementing the experience of the anchor manufacturer. Based on test results, both in the laboratory and in the field, a much better understanding of anchor behaviour has been achieved.

The performance of an anchor is influenced by many different factors, of which the following are only a few: fluke area and design, shank design, soil conditions, load conditions, type of mooring line.

This chapter presents a short overview of how these parameters influence the performance of the anchor. It is by no means complete, but it will give a better understanding of how an optimal anchor design can be achieved. In the last part of this chapter, a few relevant test results are presented.

The holding capacity of an anchor is governed by the following parameters:

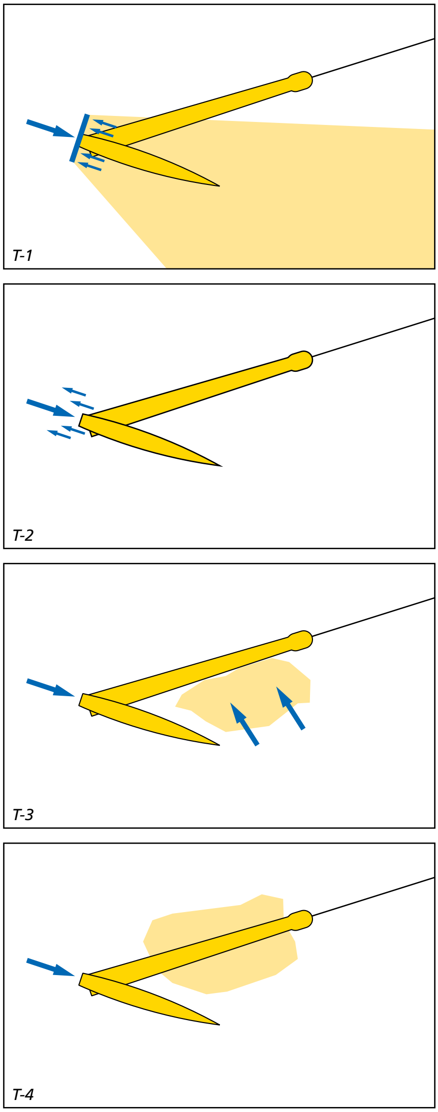
- The fluke area, which is limited by the strength of the anchor design.
- The penetration of the anchor. The penetration of the anchor is governed by the soil type (deep penetration in very soft clay and shallow penetration in sand), the anchor type (design), the type of mooring line that is used (chain or wire rope) and the applied load.

An increase in fluke area or an increase in the penetration depth of the anchor usually results in a higher holding capacity.

In the following paragraphs, the influences on the anchor penetration are further clarified.

Streamlining of the anchor

A streamlined anchor is very important for optimal penetration in the soil. As can be seen in fig. T-1 and fig. T-2, an anchor which has protruding parts will encounter much more soil resistance and consequently will not penetrate as deep as a more streamlined anchor with the same fluke area.



Criteria for anchor holding capacity

Shank shape

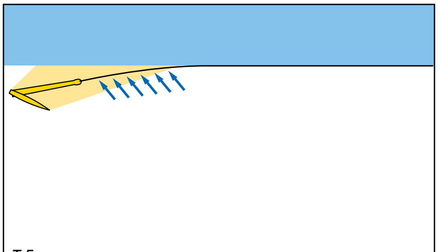
A square shank, which is common for most older type single shank anchors, will cause penetration resistance due to the fact that the soil cannot pass easily past the shank. A clod of soil will form underneath the shank, effectively increasing the resistance of the soil (fig. T-3). Bevelling the shank allows deeper penetration. When the single shank is replaced by a twin shank construction (for instance Stevpris, FFTS), usually two thin parallel steel plates, the soil can pass through and past the shank more easily, and consequently the twin shank anchor can penetrate deeper (fig. T-4).

Mooring line

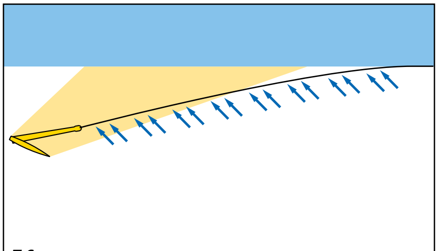
An anchor connected to a wire rope mooring line will penetrate deeper than the same anchor connected to a chain mooring line (fig. T-5 and fig. T-6). This is because of the higher lateral resistance (penetration resistance) along the chain mooring line. This effect is noticeable in all soil conditions, but especially in very soft clay where very deep penetration can be obtained. The holding capacity of a chain mooring line, due to friction in and on the seabed, is larger than the holding capacity of a wire rope mooring line.

When an anchor reaches its ultimate holding capacity, i.e. it will not resist any higher loads, at shallow penetration a wedge shaped piece of soil (in front and above the anchor) it will fail. The holding capacity of the anchor can then be described as a combination of the following parameters (fig. T-7 and fig. T-8):

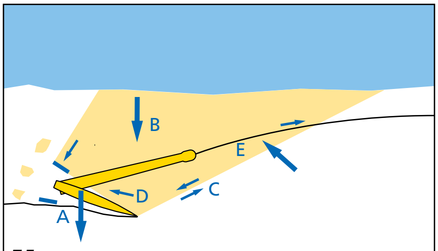
- The weight of the anchor (A).
- The weight of the soil in the failure wedge (B).
- The friction of the soil in the failure wedge along fracture lines (C).
- Friction between fluke surface and soil (fluke area) (D).
- The bearing capacity of shank and mooring line (E).
- The friction of the mooring line in and on the soil (E).



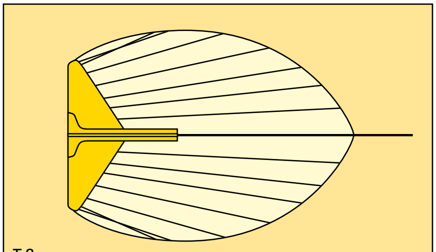
T-5



T-6



T-7



T-8

Criteria for good anchor design

Anchor parameters can be scaled from geometrically proportional anchors using the scale rules in table A.

There are several attributes of an anchor which are crucial in assuring its effective performance:

- The anchor must offer a high holding capacity; a result of the fluke area and shank design in combination with penetration and soil type.
- The design of the anchor should be such that the anchor is capable of being used successfully in practically all soil conditions encountered over the world, ranging from very soft clay to sand, corals and calcarenites.
- The fluke/shank angle of the anchor should be easily adjustable, allowing the anchor to be quickly deployed in different soil conditions.
- The design must be so conceived and produced that the high loads common in practice can be resisted.
- The anchor must be designed so that it can be easily handled, installed, retrieved and stored.
- The penetration of an anchor depends upon its shape and design. Obstructing parts on the anchor should be avoided as much as possible.
- The stability of an anchor encourages its penetration and, consequently, its holding capacity. Efficient stabilisers are an integral part of a good anchor design.
- The shank must permit passage of the soil.
- The surface area of an anchor fluke is limited by the required structural strength of the anchor.
- The anchor design must have optimal mechanical strength to fulfil requirements and stipulations of the classification societies.
- The anchor should be designed to ensure an optimum between structural strength of the anchor and holding capacity.
- The anchor should be streamlined for low penetration resistance.

Scale influence

	Model	Reality	Related to Weight
Length	L	n	$W^{1/3}$
Fluke area	A	n^2	$W^{2/3}$
Weight	W	n^3	W
Penetration	P	n	$W^{1/3}$
Moment	M	n^4	$W^{4/3}$
Moment of inertia	I	n^4	$W^{4/3}$
Section Modulus	S	n^3	W
Bending stress	M/S	$n^4/n^3=n$	$W^{1/3}$
Shear strength	F/A	$n^3/n^2=n$	$W^{1/3}$

table A

Aspects of soil mechanics in anchor design

Until the nineteen seventies anchor design was largely an empirical process. There was not much science involved, mainly experience. It is not easy, for instance, to calculate the Ultimate Holding Capacity (UHC) of an anchor from the commonly known soil mechanics formulas. The main problem is the prediction of the volume of soil mobilised by the anchor. To a large degree, it is this volume which determines the UHC. Detailed understanding of soil characteristics and behaviour is essential in the anchor design
process and of increasing benefit in handling at sea. It is this understanding which is the hallmark of a competent anchor designer and builder.

For anchor design and installation, the availability of good soil data is of utmost importance as the soil has great influence on anchor behaviour. The following are influenced by the soil conditions encountered:
Anchor type - some anchors are more suited for soft soil conditions (soft clay), while others are more suited for hard soils (sand and hard clays), although there are a number of anchor types on the market that are suited for most soil conditions encountered.
Holding capacity - in hard soil, like sand and clay, the maximum attainable ultimate holding capacity with a certain anchor type and size, is higher than the attainable ultimate holding capacity in very soft clay.
Penetration and drag - in very soft clay the anchor will penetrate deeper than in harder soil like sand. As a consequence, the drag length of the anchor will also be longer in very soft clay than in hard soil.
Retrieval forces - when an anchor is installed in very soft clay, the required retrieval forces will be higher than in hard soil, like sand. For example, in very soft clay the required retrieval force of an anchor can be equal to 80%-90% of the installation load, while in hard soil (sand) the retrieval force might only be 20%-30% of the installation load.

Soil classification

Soil strength is generally expressed in terms of the shear strength parameters of the soil. The soil type is classified mainly by grain size distribution.

Grain size	Soil description
< - 2 μm	Clay
2 - 6 μm	Fine Silt
6 - 20 μm	Medium Silt
20 - 60 μm	Coarse Silt
60 - 200 μm	Fine Sand
200 -600 μm	Medium Sand
0.6 - 2 mm	Coarse Sand
2 - 6 mm	Fine Gravel
6 - 20 mm	Medium Gravel
20 - 60 mm	Coarse Gravel
60 - 200 mm	Cobbles
> - 200 mm	Boulders

In general, the soil types encountered in anchor design are sand and clay (Grain diameter from 0.1 μm to 2 mm). However, mooring locations consisting of soils with grain sizes above 2 mm, such as gravel, cobbles, boulders, rock and such, also occur. Clay type soils are generally characterised by the undrained shear strength, the submerged unit weight, the water content and the plasticity parameters. The consistency of clays is related to the undrained shear strength. However, American (ASTM) and British (BS) standards do not use identical values (table B).

The undrained shear strength values S_u can be derived in the laboratory from unconfined unconsolidated tests (UU). On site the values can be estimated from the results of the Standard Penetration Test (SPT) or Cone Penetrometer Test (CPT). An approximate relation between shear strength and the test values are shown in table C.

Undrained Shear Strength (kPa)

Consistency of Clay	ASTM D-2488	BS CP-2004
Very soft	0 - 13	0 - 20
Soft	13 - 25	20 - 40
Firm	25 - 50	40 - 75
Stiff	50 - 100	75 - 150
Very stiff	100 - 200	150 - 300
Hard	200 - 400	300 - 600
Very hard	> 400	> 600

table B

S_u kPa	UU kPa	SPT N	CPT MPa
0 - 13	0 - 25	0 - 2	0.0 - 0.2
13 - 25	25 - 50	2 - 4	0.2 - 0.4
25 - 50	50 - 100	4 - 8	0.4 - 0.7
50 - 100	100 - 200	6 - 15	0.7 - 1.5
100 - 200	200 - 400	15 - 30	1.5 - 3.0
> 200	> 400	>-30	>3.0

table C

Soil classification

The mechanical resistance of sandy soils is predominantly characterised by the submerged unit weight and the angle of internal friction, φ. These parameters are established in the laboratory. An approxim-ate correlation between the angle φ and the relative density of fine to medium sand is given in table D.
The undrained shear strength of clayey soil can also be estimated based on manual tests.

- In soft clay the thumb will easily penetrate several inches, indicating an undrained shear strength smaller than 25 kPa.
- In firm (medium) clay the thumb will penetrate several inches with moderate effort, indicating an undrained shear strength between 25 kPa and 50 kPa.
- Stiff clay will be easily indented with the thumb but penetration will require great effort, indicating an undrained shear strength between 50 kPa and 100 kPa.
- Very stiff clay is easily indented with the thumbnail, indicating an undrained shear strength between 100 kPa and 200 kPa.
- Hard clay is indented with difficulty with the thumbnail, indicating an undrained shear strength larger than 200 kPa.

The rock strength can generally be described by its compressive strength (table E).

A classification system for soil based on the carbonate content and grain size of the soil (Clark and Walker), is shown on page 48 of this chapter.

Descriptive term	Relative Density	Angle φ	SPT N	CPT MPa
Very loose	< 0.15	< 30	0 - 4	0 - 5
Loose	0.15 - 0.35	30 - 32	4 - 10	5 - 10
Medium dense	0.35 - 0.65	32 - 35	10 - 30	10 - 15
Dense	0.65 - 0.85	35 - 38	30 - 50	15 - 20
Very dense	> 0.85	> 38	> 50	> 20

table D

Descriptive term	Compressive strength q_u [MPa]
Very weak	< 1.25
Weak	1.25 - 5
Moderately weak	5 - 12.5
Moderately strong	12.5 - 50
Strong	50 - 100
Very strong	100 - 200
Extremely strong	> 200

table E

Fluke/shank angle

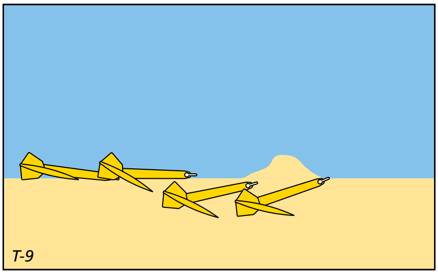
The penetration of an anchor into a certain soil type is greatly influenced by the selected fluke/shank angle. For hinging anchor types (Stevin, Danforth etc.) the fluke/shank angle is the angle between the anchor shackle, the hinge and the fluke tip. The method for measuring the fluke/shank angle for fixed shank anchors (Stevpris, FFTS, etc.) is not well defined. Often it is the angle between the anchor shackle, the rear of the fluke and the fluke tip, but not all anchor manufacturers use the same definition.

The recommended fluke/shank angles for different soil conditions are presented in table F.

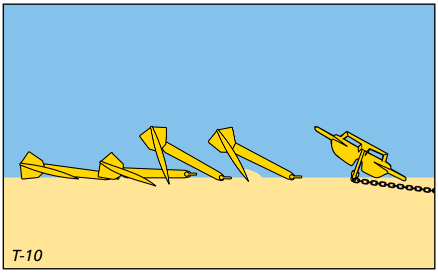
Some modern anchors, like the Stevpris Mk5, have an additional intermediate fluke/shank angle of 41°, which can be used in intermediate or more complex soil conditions. For instance at a location where the anchor has to pass through a layer of soft clay before penetrating into a layer of sand.
If an anchor is used with an incorrect fluke/shank angle, it will negatively influence performance. This is the case for all anchor types.

In hard soil, an anchor with a fluke/shank angle of 32° will give the highest holding power. If an anchor is used with the fluke/shank angle set at 50°, the anchor will fail to penetrate into the seabed and will begin to trip, fall aside and slide along the seabed (fig.T-9 and fig. T-10).

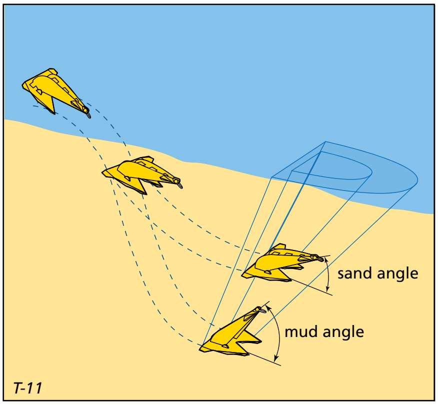
If an anchor is used in very soft clay (mud) with the fluke/shank angle set at 32°, the anchor will penetrate into the seabed, however the penetration will be less than when a fluke/shank angle of 50° is used. Consequently the holding capacity will be lower when the fluke/shank angle is set at 32° and the drag length longer (fig. T-11).



T-9



T-10



T-11

Soil type	Approximate fluke/shank angle
Very soft clay	50°
Medium clay	41°
Hard clay and sand	32°

table F

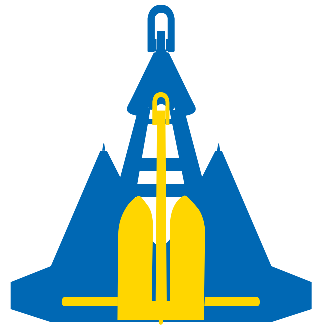
Fluke area

Because the fluke area of an anchor is of great influence on the holding capacity, it can be useful to compare the fluke area of different anchor types that are available on the market today. In general, it can be stated that two anchors of the same weight but of different type (for instance a Stevin anchor and a Stevpris Mk5 anchor), do not necessarily have the same fluke area. Consequently, two anchors of the same weight but different type, will have different holding capacities.

Some examples:

Fig. T-12 shows a Stevpris Mk5 anchor and a Moorfast anchor, both of identical weight. It demonstrates that in spite of being the same weight, the fluke areas differ substantially. The ultimate holding capacity of the Stevpris Mk5 anchor is 4 to 8.5 times higher than that of the same weight Moorfast anchor.

Fig. T-13 illustrates the difference in fluke area of the Stevpris Mk5 anchor in comparison with the Bruce FFTS Mk4 anchor, both of which have identical weight.



T-12

T-13

Strength of an anchor design

Anchors should be designed to withstand the loads applied on them in the different loading situations. Typical loading situations and areas of special attention for anchors are:

- During the proof loading of the anchors in the factory, after construction has been completed. On basis of the proof load results, the classification societies issue the approval certificate.

While embedded in the seabed

- Depending on the soil conditions, different loading situations can occur on the anchor. In sands and clays, the load tends to be spread equally over the anchor, which generally presents no problems. Retrieval is also very simple, without excessive loads placed on the anchor.
- In very hard soils, the anchor has to be able to withstand the load with only one or two of the fluke tips buried in the soil, as penetration in very hard soil conditions is generally shallow.
- In very soft clays (mud) penetration of the anchor is uncomplicated. However, recovery of the anchor can cause high loads, sometimes exceeding the load that was used to install the anchor.
- Sidewards forces on the top of (shallow) buried anchors can be so extreme that no anchor is capable of resisting them.

During anchor handling

- Care should be taken during the handling of the anchors, as the loads exerted by the winches, vessels and chain can sometimes exceed the structural strength of the anchor and cause damage. Anchor designers attempt to design the anchors for these high loads, however this is not always possible due to variations in the magnitude of the loads during handling operations.
- Large forces can be exerted on the anchor when high winch power is used, the anchor is caught on the anchor rack or caught behind the stern roller of the AHV.

Strength of an anchor design

- The use of an improper anchor/chaser combination. When a chaser is used that is either too small or too large, the chaser could jam on the shank of the anchor and cause damage.

In light of the points above, the Stevpris range of anchors are now more closely examined below.

Strength of the shank

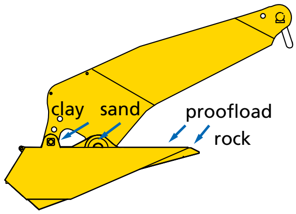
The prismatic shape of the Stevpris range of anchors not only ensures optimal penetration of the soil but also guarantees maximum strength. Although the Stevpris designs also have limitations, they are more able to withstand sideward forces on the shank, a frequent occurrence in practice. When using an anchor in very soft clay (mud), the bending moment on the shank is low during the installation and when the anchor is in the soil. However, during the breaking out of the anchor, high bending moments could be introduced in the shank due to the high retrieval forces required in very soft clay. In extremely sticky soils, the breaking out force of the anchor can rise to 80% or 90% of applied anchor load; in certain instances, it can even exceed 100%. To reduce these forces the breaking out procedure is undertaken at low speed to allow time for the anchor to break out.

Strength of the fluke

The strength of the fluke and especially the fluke points of an anchor are very important when working in extremely hard soils such as coral, limestone and other rock types. It is possible in such instances that the total holding capacity of the anchor will have to be sustained by the fluke points alone. This means the structure must be strong enough to withstand extreme bending forces. Loading in normal soil conditions is not usually a problem due to the fact that the load is equally spread over the fluke.

Strength of an anchor design

In fig. T-14, the different force points are shown for varying soil conditions. The location on the fluke where the proofload is applied, is also indicated.



T-14

Strength in extremely hard soils

In very hard soils such as calcarenite, coral and limestone, an anchor will not penetrate very deeply. Consequently the load applied to the anchor has to be held by the fluke tips of the anchor and a small portion of the fluke. This means that extremely high loads will be applied to the fluke tips, compared to normal soil conditions such as sand and clay.

For use in very hard soil conditions, Vryhof has designed the Stevshark anchor, a modified version of the Stevpris anchor. To create the Stevshark, the Stevpris anchor has been strengthened, consequently a Stevshark anchor having the same outside dimensions and holding capacity as a Stevpris anchor will be heavier.

Strength calculations of the Stevshark design have been made to guarantee sufficient strength in the fluke points. The Stevshark anchor is designed to withstand the application of the main part of the load on just its fluke tips.

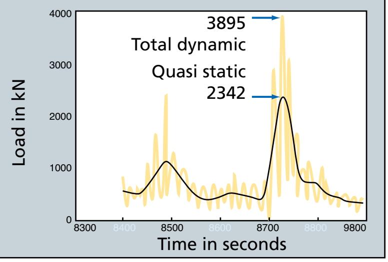
To promote penetration, the Stevshark anchor has a serrated shank and can be provided with cutter points on the fluke tips. Ballast weight can also be added inside the hollow flukes of the anchor, up to 35% of the anchor weight. This is important when working in very hard soil, where the anchor weight pressing on the fluke tips promotes penetration, i.e. increased bearing pressure.

Anchor loads and safety factors

The loads in a mooring system are caused by the wind, waves and current acting on the floater. Depending on the location of the floater in the world, different metocean conditions will prevail. In tables below, some extreme metocean conditions are presented for different areas.

The loads induced in the mooring system can be divided into quasi-static loads and total dynamic loads. The quasi-static loads are the loads resulting from statically offsetting the vessel position by wave induced motions, but does take into account dynamic forces. For quasi-static loads, the systems tend to move at a low frequency, generally with a period of 140 to 200 seconds.

On top of this quasi-static load there are the forces caused by dynamic effects such as momentum, inertia and fluid effects. High frequency motion can cause dynamic shock loads with a period of 10 to 14 seconds due to the rolling of the vessel and the movements of the anchor lines through the water. The quasi-static load plus the individual dynamic forces is called the total dynamic load. Generally the quasi-static loads will be equal to 50% to 90% of the total dynamic load. See fig. 2-15 for an example of the difference between the quasi-static load and the total dynamic load.



T-15

Location	Waveheight m	Wave period s	Windspeed m/s	Current m/s
Campos Basin	8 - 10	12 - 15	25	1
Gulf of Mexico	11	14	44 - 48	1
Northern North Sea	15 - 16	15 - 17	38 - 39	0.9- 1.2
Porcupine Basin	16 - 18	16 - 20	39 - 41	1.0 - 1.5
Vorine Basin	14 - 15	16 - 17	37 - 39	1.0 - 1.5
West of Africa	4 - 6	10 - 16	20	0.3 - 0.6
West of Shetlands	15 - 17	16 - 19	39 - 41	1.0 - 3.0

table G

Anchor loads and safety factors

The quasi-static and total dynamic loads are generally calculated for the intact and damaged load condition. The intact load condition is the condition in which all the mooring lines are intact. The damaged load condition is the condition in which one of the mooring lines has broken.

From the quasi-static load and the total dynamic load, the required holding capacity of the anchor can be calculated. This is called the ultimate holding capacity (UHC) for drag embedment anchors and the ultimate pull-out capacity (UPC) for VLAs. The required holding capacity is calculated by applying the factors of safety specified by the classification societies.

In the tables G and H, the factors of safety are presented for the different load conditions for drag embedment anchors (for instance the Stevpris Mk5 anchor), according to API RP 2SK. The factors of safety used by the major classification societies are generally similar to those given in API RP 2SK (2005).

For VLAs, the recently used factors of safety suggested by ABS, are presented in table I.

The factors of safety for VLAs are higher than the factors of safety required for drag embedment anchors, due to the difference in failure mechanisms. When a drag embedment anchor reaches its ultimate holding capacity, it will continuously drag through the soil without generating additional holding capacity, i.e. the load will stay equal to the UHC. When a VLA exceeds its ultimate pullout capacity, it will slowly be pulled out of the soil.

In table K the safety factors according to API RP 2SK for the mooring line are presented for comparison purposes.

Permanent mooring	Quasi-static load	Total dynamic load
Intact load condition	1.8	1.5
Damaged condition	1.2	1.0

table H

Temporary mooring	Quasi-static load	Total dynamic load
Intact load condition	1.0	0.8
Damaged condition	Not required	Not required

table I

VLA	Total dynamic load
Intact load condition	2.0
Damaged condition	1.5

table J

Mooring line safety factors	Quasi-static load	Dynamic load
Intact load condition	2.00	1.67
Damaged load condition	1.43	1.25
Transient load condition	1.18	1.05

table K

Drag embedment anchors

Drag embedment anchors are generally installed by applying a load equal to the maximum intact load. For permanent mooring systems the installation load should be held for the period specified by the classification societies (see table K). The anchor will then have penetrated to a certain depth, but will still be capable of further penetration because the ultimate holding capacity has not been reached. The anchor will also have travelled a certain horizontal distance, called the drag length. After installation the anchor is capable of resisting loads equal to the installation load without further penetration and drag. When the installation load is exceeded, the anchor will continue to penetrate and drag until the soil is capable of providing sufficient resistance or the ultimate holding capacity has been reached. However, there are certain effects which allow the anchor to withstand forces larger than the installation load without further penetration and drag. These are:

The set-up and consolidation effect

Set-up and consolidation mainly occur in clayey soils. The penetrating anchor disturbs the soil and the soil temporarily loses strength. With time, the disturbed clay reconsolidates to its initial shear strength, this takes from a few hours up to 1 month, depending on the soil type. Because not all the soil around the anchor is disturbed, the set-up effect factor is less than the sensitivity index indicates. The disturbance mainly reduces the soil resistance parallel to the fluke. On reloading, the parallel soil resistance gains strength, it takes a larger load to move the anchor again. Equilibrium dictates that also the normal load, i.e. the bearing soil resistance to the fluke, increases; consequently the load at the shackle increases also with the set-up factor. Observations on anchors for drilling rigs and theoretical considerations for a 3 to 4 week consolidation time demonstrate a typical set-up effect factor =1.5.

Classification society	Required duration of maintaining tension
Lloyd's Register of Shipping	20 minutes
American Bureau of Shipping	30 minutes
Det Norske Veritas (NMD)	15 minutes

table L

Anchor behaviour in the soil

The rate effect

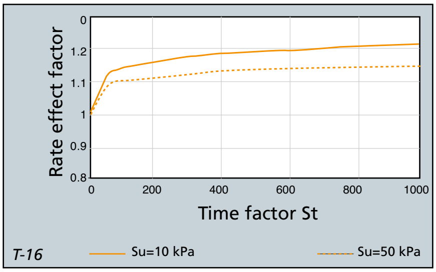
An increased rate of loading increases the soil resistance, consequently the anchor holding capacity increases. This must be taken into account with respect to total dynamic loads. For anchor behaviour the rate effect factor indicates how much higher the dynamic high frequency load may be without causing extra movement of the anchor once installed at the installation load. The rate of loading influences pore pressure variations, viscous inter-granular forces and inertia forces. Typical rate effect factors are 1.1 to 1.3 for total dynamic loads, see fig. T-16 where the rate effect is presented for two different soil conditions (Su = 10 kPa and Su = 50 kPa).

Using the rate effect and set-up factors, the behaviour of the anchor after installation can be predicted more accurately.

Vertical Load Anchors (VLA)

For a drag embedment VLA, installation is just like any conventional drag embedment anchor. During installation (pull-in mode) the load arrives at an angle of approximately 45 to 60° to the fluke. After triggering the anchor to the normal load position, the load always arrives perpendicular to the fluke. This change in load direction generates 2.5 to 3 times more holding capacity in relation to the installation load. This means that once the required UPC of the VLA is known, the required installation load for the VLA is also known, being 33% to 40% of the required UPC.

As a VLA is deeply embedded and always loaded in a direction normal to the fluke, the load can be applied in any direction. Consequently the anchor is ideal for taut-leg mooring systems, where generally the angle between mooring line and seabed varies from 25 to 45°.



T-16

Proof loads for high holding power anchors

Proof loading typically takes place at two moments in an anchors life time: post-manufacturing or after installation offshore.

Post manufacturing, the proof load according to Classification Societies' rules (table M) is applied at 1/3rd of the fluke length from the fluke tip and is carried out immediately upon completion of manufacturing of the anchor. It is obtained by placing the anchor in a test yoke in which a hydraulic cylinder applies the test loads, controlled by a calibrated system (fig. T-17).

Post-installation, the proof load is applied to the anchor in the soil (fig. T-18) for a given period of time that may vary slightly per Society (table N).

The Vryhof anchor types have been approved by the following Classification Societies:

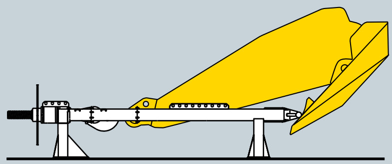
- The American Bureau of Shipping
- Bureau Veritas
- Det Norske Veritas - GL
- Lloyd's Register of Shipping
- Registro Italiano Navale
- USSR Register of Shipping
- Nippon Kaiji Kyokai
- Norwegian Maritime Directorate
- Biro Klasifikasi Indonesia

In the early days there were no specific regulations regarding the holding power and strength of mooring anchors. The rules which did exist were often followed regardless of the type of vessel.

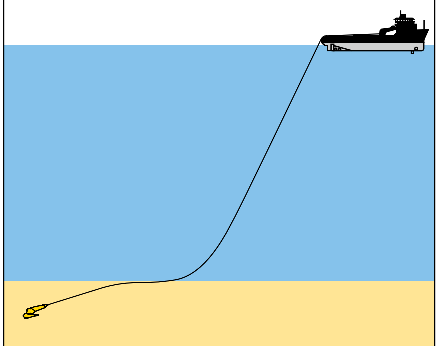
Some anchors were approved as 'high holding power' anchors. This so-called HHP approval was obtained after carrying out field tests in various types of soil in which it had to be shown that an anchor provided a holding power of at least twice that of a standard stockless anchor. If an HHP anchor was requested by the owner, the anchor has proof tested in strict accordance with the rules, nothing more. See table K for some examples of HHP anchor proof loads. A more detailed overview of HHP anchor proof loads is given in the product data section.

Anchor weight	Proof Load	factor
1 t	26 t	26 x
5 t	79 t	15 x
7 t	99 t	14 x
10 t	119 t	12 x
15 t	155 t	10 x
20 t	187 t	9 x

table M



T-17



T-18

Classification society	Required duration of maintaining tension
Lloyd's Register of Shipping	20 minutes
American Bureau of Shipping	30 minutes
Det Norske Veritas (NMD)	15 minutes

table N

Proof loads for high holding power anchors

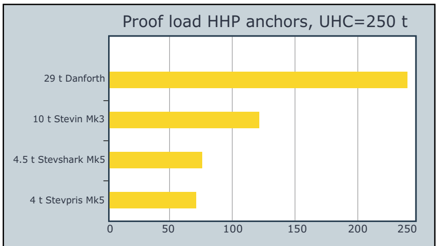
The use of the specified proof loads for HHP anchors can lead to situations where different types of anchors with the same holding capacity are proof loaded at different loads, see fig. T-19. From this figure it can be concluded that the proof load of the anchors should preferably be related to the break-load of the mooring line on the vessel.

Nowadays the rules and regulations are far more rigid, and the requirements have been substantially increased. There are now special rules for 'mobile offshore units' and 'permanently moored structures'.

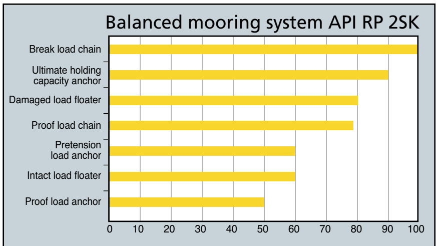
If anchors need mobile offshore units certification, the following properties may be required:

- Proof load of the anchors at 50% of the breaking load of the chain.
- Submission of a strength calculation of the anchor to the classification society prior to commencing anchor production: this includes determining the mechanical strength of the anchor as well as proving that the applied material can withstand the proof load.
- A statement of documented holding power from the anchor supplier.
- Submittal of a data book

In fig. T-20 a mooring system is shown in which all of the components are balanced. The strength of the mooring line, holding capacity of the anchor and strength of the anchor are all in the correct proportion and comply with the rules.



T-19



T-20

Certification

Requirements for offshore moorings

Offshore mooring anchors and anchoring equipment such as connectors have to be designed and fabricated in accordance with the requirements laid down by the Classification Authorities, such as ABS, DNV-GL, LR, BV etc. (table O). These requirements apply to the design, materials, manufacture and testing of the products.

The Classification Authorities follow procedures in order to establish compliance with the requirements and consequently approval and certification of the approval. The approvals can be issued for a 'Type design' or any 'individual design' and furthermore for 'materials approval' and 'production approval'.

Classification type approval / design approval

In order to obtain a Design approval the Class will review the full set of drawings, calculations and documentation upon which it will decide on conformity to the rules before issuing approval. For a type approval, special conditions will apply such as for the maximum capacity the approval is certified. After this approval, Class will issue a Type Approval or Design Approval and Certification for the anchors or connectors.

In general the main, hi-end design anchors and components for offshore mooring systems will have a Class Type Approval, whether for mobile or permanent application. This applies to a lesser extent for the large variety of general use connectors available in the market.

For permanent systems , such as the mooring of floating production units, a specific Project Design Approval will be issued, which for example includes a 25-year design life condition.

CLASSIFICATION RULES FOR ANCHORS - MOBILE MOORING / LONG TERM MOORING

1. Design Approval - Type Approval
- Anchor Drawings
- Structural Strength Calculations
- Fatigue Calculations

2. Material Approval
- Plate material and round bar
- Shackles

The Materials shall be manufactured and tested according to Class Rules at works which have been approved by Class according to EN-10204-3.2

3. Fabrication Approval

Fabrication of anchors shall be in accordance with Classification Rules for Production
- Approved Welding Procedure Qualifications and Welders Qualifications
- Approved Non-Destructive Testing Procedures

4. Requirements for Testing Anchors and Shackles

According Classification Rules for Testing Anchors and Shackles for Mobile Mooring and Long Term Mooring. Testing of anchors and shackles have to be witnessed by Classification Authorities

5. The Marking of Anchors

According Classification Rules for Identification and Marking of Anchors. Anchors have to be hard stamped by Classification Authority Stamp. Also the certificate numbers have to be hard stamped in the anchors

6. Anchor certificate

Anchor certificate has to be made by Classification Authority for each anchor

table O

Certification

Certification of materials and manufacturing

The materials, manufacturing process and testing or proof load will have to be approved by Class wich will issue material certificates for all materials or components used. The material requirements will then be mentioned in the Class Type or Design Approval of the relevant product. For the manufacturing an approval is required on the welding procedures and specifications, on welder qualifications, NDE inspection on all products and proof-load test (FAT) when applicable.

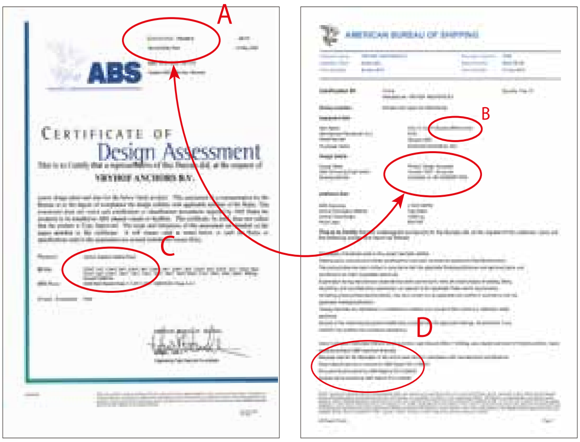
Generally inspection is based on review of the documentation and where deemed required by incidental audits or inspections of the materials or product. During the manufacturing surveys may apply. Proof loading or testing will at all times be witnessed by a representative of the Class.
After approval of the anchors and other components, the Classification Authority will issue a Class certificate with all details mentioned.

How to read the Certificate

A. Assure that the numbers correspond between the certificate and the inspection documents.
B. Product names Stevpris, Stevshark, Stevin, Stevmanta can only be carried on certificates made out to Vryhof.
C. Type Approval Specifies the anchor range covered by the Certificate.
D. Specs of certified materials for plate, pins and shackle.

TYPE APPROVAL CERTIFICATE

INSPECTION CERTIFICATE



Quality assurance

The application of more advanced and complex technology in anchor construction has brought about requirements for a systematic approach to quality. Vryhof Anchors is fully aware of the vital importance of managerial aspects and their influence on the total product quality.

Vryhof's quality management system according to ISO 9001 was certified by DNV already in 1992 for 'Design, Manufacture of anchors, and Sales of anchors and mooring components'. Continual improvement, evaluation and maintenance of the quality management system is essential for reliable and timely delivery of products.

Quality Control

Design and fabrication of anchors for mobile and permanent moorings are performed in accordance with applicable class rules. Fabrication and workmans hip must guarantee the best performance and quality and give full confidence to all clients and users. Quality control and inspections on all components in every stage of the production process ensure compliance with the high quality standards expected in the offshore industry.

Tests and inspections are witnessed by Class surveyors and documentation of every single item is reviewed and stamped. A compilation of certificates is presented to a client upon delivery. All production data is stored and saved digitally. Even after many years all information of every component must be traceable and retrievable.

HSE

With more than 40 years of anchor production and over 10,000 units sold, Vryhof is aware of its responsibility not only to deliver products of good quality and in time, but also produced safely with care for health of its employees and protection of the environment. This is also expected from all sub-contractors and suppliers, that are monitored and audited on a regular basis to ensure compliance to these standards.

An integrated HSE system provides all means for safe and responsible execution of the work and prevention of personal harm, material damage and environmental damage. Involvement of all employees, but also of the management is indispensable.

Anchor tests

Introduction

In addition to practical experience of users and associates, anchor tests are one of the most reliable means of forecasting anchor performance and thus making a proper choice of anchor type and size.

Examining anchor tests that have been carried out in the past, certain conclusions can be made:

- Many tests were undertaken in which the results were recorded accurately.
- Detailed reports, however, have not been very common.
- Anchor tests of the past are not always easy to interpret or compare because of different soil and anchor types.
- Test results have not always been interpreted independently.
- The more tests results are strictly compared to practical results, the better one can forecast the holding power and general behaviour in practice.

Vryhof is in the perfect situation of having detailed test data available together with extensive practical data obtained during installation and use of anchors on projects on site.

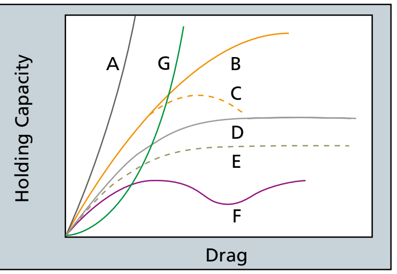
Research into anchor behaviour and the ultimate holding capacity of anchors is often carried out by testing a model anchor, preferably followed by a full-scale test in the field. The optimal anchor test consists of model tests with 10 kg anchors, followed by full-scale tests with 1 t and 10 t anchors. The anchors should be pulled until the ultimate holding capacity is reached.

It is obvious that full-scale testing of anchors can be expensive. Large AHVs, strong winches and strong mooring lines are required, which are not always available. For example, a 5 t Stevpris Mk5 anchor, deployed in sand, is capable of stopping a modern AHV at its full bollard pull. Testing a 10 t Stevpris Mk5 anchor to its ultimate holding capacity in sand would require a horizontal pulling capacity of approximately 600 t.

Anchor tests

If anchor tests are to be comparable, the testing program should preferably meet, as a minimum, the following criteria:

- An accurate and sophisticated measuring system should be used.
- The anchors should be tested up to their ultimate holding capacity.
- Drag and penetration of the anchor should be recorded during testing.
- The anchor should be held under tension with a blocked winch for 15 minutes, to investigate any drop in holding capacity.



T-21

Reading test curves

The behaviour of an anchor during tensioning can be accurately interpreted from the holding capacity versus drag curve. Sample test curves are presented in fig. T-21. Properly interpreted performance curves can explain a lot about anchor behaviour.

- Curve A is very steep and represents a streamlined anchor in very stiff soil.
- Curve B is a normal curve for anchors in sand and medium clay.
- Curve C is a curve of an unstable anchor. This can be caused by a wrong fluke/shank angle setting, a short stabiliser or a fluke that is too long.
- Curve D is a normal curve for an anchor in very soft clay.
- Curve E is an anchor with a 32° fluke/shank angle in very soft clay.
- Curve F represents an anchor that is turning continuously. This can be caused by the absence of stabilisers, a too large fluke/shank angle or a low efficiency anchor at continuous drag.
- Curve G represents an anchor penetrating in a layer of stiff clay overlain by very soft clay.

Anchor tests

Curves A, B, D, E and G show a very stable rising line, which indicates that the anchor builds up its holding capacity constantly until the ultimate holding capacity has been reached, after which the anchor shows continuous drag. The other curves are largely self-explanatory.

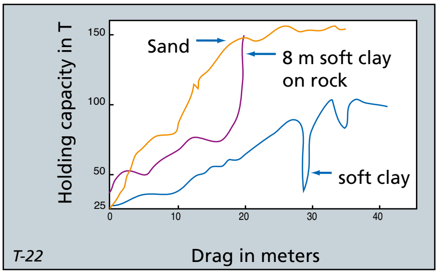
Test results

Vryhof's extensive database of test results with different anchor types, sizes and soil conditions, has been frequently used in anchor design. Data has been obtained from practice, scale models and from third parties. The data has been interpreted and afterwards incorporated in the ultimate holding capacity, drag and penetration graphs of the Stevin Mk3 and Stevpris Mk5 anchor as well as in the ultimate pull-out capacity graph of the Stevmanta VLA.

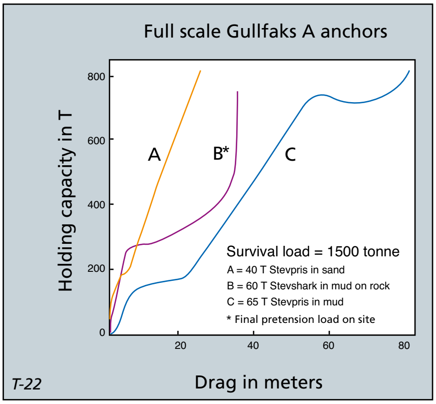
Norwegian Contractors (1984)

In 1984 Norwegian Contractors carried out tests at Digernessundet, Stord, Norway. The purpose of these tests was to determine the correct anchor type and size for the mooring system of the Gullfaks A platform during the construction of the platform at Digernessundet. Although the construction would take place at one location, it was known that three different types of soil conditions would be encountered: sand, soft mud and an 8 m mud layer on rock. After the initial trials the Stevpris anchor was selected for further testing.

The 3 T Stevpris anchor that was used for the tests at a 3.3° pulling angle, produced a maximum holding capacity of 150 T in the sand, 102 t in the very soft clay and 150 T in the layer of mud on rock. As the mooring system required a survival load of 1500 t, a 65 T Stevpris (mud location), 40 T Stevpris (sand location) and 60 T Stevshark (mud on rock location) were selected for the final mooring. Fig. 2-22 shows the test results of the 3 T Stevpris anchor, while fig. 2-23 shows the result of the tensioning of the final anchors with a load of 820 t.



T-22



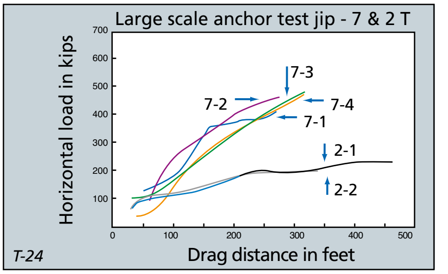
T-22

Anchor tests

Large scale anchor tests in the Gulf of Mexico

In 1990, tests were performed with 2 t and 7 T Stevpris Mk5 anchors, as part of an anchor test Joint Industry Project (JIP). The anchors were tested using a wire rope forerunner.

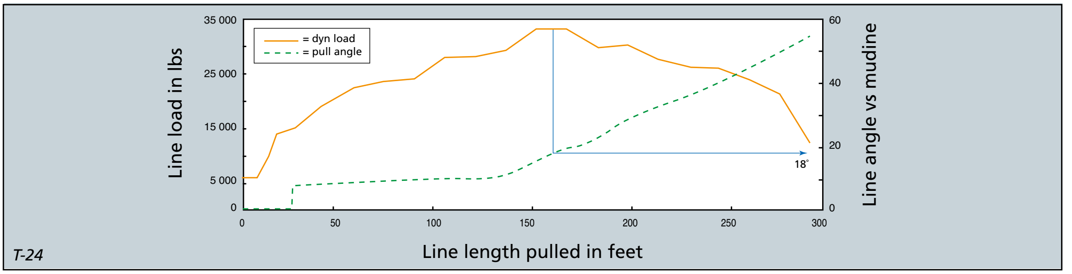
The 2 T Stevpris anchor was tested up to its ultimate holding capacity of 107 T (235 kips). Due to insufficient pulling capacity, the 7 T Stevpris anchor could not be pulled up to its ultimate holding capacity. Based on the results of tests, the ultimate holding capacity of the 7 T Stevpris anchor was calculated to be larger than 338 T (745 kips) (fig. 2-24).



T-24

Uplift

Stevpris anchors are well capable of resisting uplift loads when they are deeply embedded. Anchors in sand and firm to hard clays do not penetrate very deeply and only take small uplift loads. Stevpris anchors installed in very soft clay and mud penetrate deeply, a typical penetration for a 15 T anchor is 15 to 25 meters. Due to the inverse catenary in the soil, the anchor line arrives at the anchor shackle at an angle of 20° to 30° with the mud line. Once the anchor is installed, a load making an angle up to 20° with the horizontal at mud line will not change the loading direction at the anchor! A Stevpris anchor has been tested in the Gulf of Mexico with gradually increasing pull angle (fig. 2-25). The maximum resistance was obtained for 18° uplift at mud line.



T-24

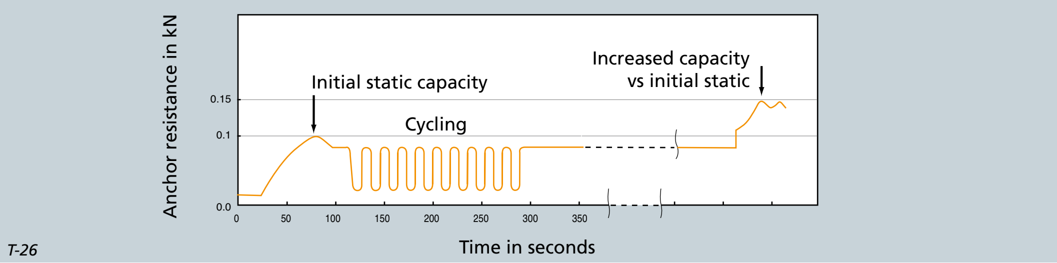
Anchor tests

Cyclic effect factor

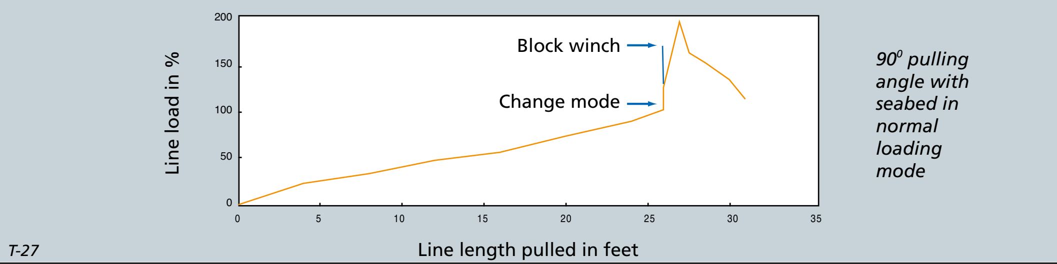
The loading at the anchor is cyclic. Exxon performed cyclic tests on anchors reported by Dunnavent and Kwan, 1993. Although the maximum cyclic load was less than the initial installation load, the static load applied after the cycling phase revealed 25 to 50% larger anchor resistance than the initial installation load (fig. 2-25). This effect is explained by further penetration of the anchor. Applying this knowledge to the anchors, the static anchor resistance after some storm loading improves by the cyclic effect factor of 1.25 to 1.5.

Tests with Stevmanta anchors

Tests have been performed in the Gulf of Mexico and offshore Brazil. The Stevmanta anchor being pulled in with a load equal to F, accepted a vertical load to the anchor of up to 2 times F! Amongst the many tests the anchor relaxation was measured. The anchor with a fluke area of 0.13 m^2 was pulled in at 0^o pull angle (fig. T-26), then loaded vertically to a load equal to 1.6 times the maximum installation load. At this load the winch was blocked.



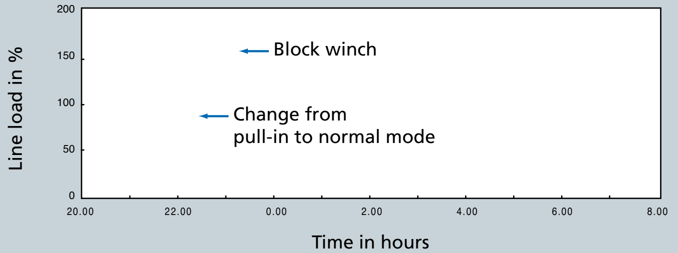
T-26



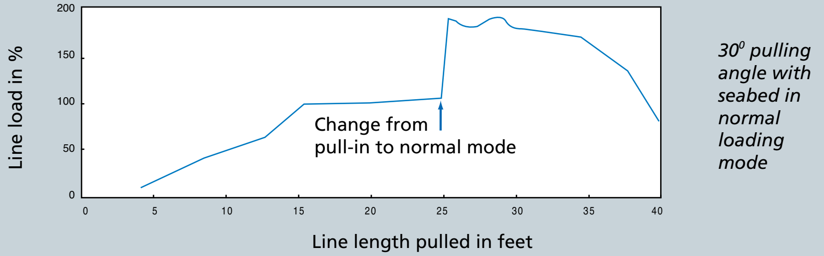
T-27

This permitted the monitoring of the anchor load over time (fig. T-27) as what would be expected in real circumstances with a constant loaded anchor line. The results show that the holding capacity of the anchor does not change significantly during continuous loading, as the observed decrease in tension was due to movement of the winch. The subsequent pulling at 7:00 AM showed that for only a small movement, the full plate capacity (2 x installation load) could be reached. Continuous pulling caused the anchor to loose resistance and break out.

To demonstrate that the feature of these anchors is not that of only a vertical resistance, the anchor was installed with a horizontal pull, the mode changed to the normal (vertical) mode and the anchor subsequently pulled with an uplift angle of 30o (fig. T-28). The behaviour is similar to the earlier vertical pull test. However, for the 30o pull angle the anchor did not break out but moved slowly through the soil in the direction of the pulling force. The graphs clearly show this effect and that the anchor can be used for substantial horizontal loads.



T-28



T-29

Soil table

Increasing grain size of particulate deposits →

Increasing lithification ↓

Cementation of soil	Approx. Rock strength	0.002 mm	0.063 mm	2 mm	60 mm	Total carbonate content %
Very weak to firmly cemented soil	Very weak	Carbonate clay	Carbonate silt	Carbonate sand	Carbonate gravel	90
			Siliceous carbonate silt	Siliceous carbonate sand	Mixed carbonate and non-carbonate gravel	50
		Calcareous clay	Calcareous silica silt	Calcareous silica sand		10
		Clay	Silica silt	Silica sand	Silica gravel	
Well cemented soil	Weak to moderately weak	Calcilutite (carb. Calystone)	Calcisiltite (carb. Siltstone)	Calcarenite (carb. Sandstone)	Calcirudite (carb. Conglom. Or Breccia	90
		Clayey calcilutute	Siliceous calcisiltite	Siliceous calcarenite	Conglomeratic calcirudite	50
		Calcareaous claystone	Calcareous siltstone	Calcareous sandstone	conglomerate Calcareous	10
		Claystone	Siltstone	Sandstone	Conglomerate or breccia	
(well cemented) rock	Moderately strong to strong	Fine-grained limestone		Detrital limestone	Conglomerat limestone	90
		Fine-grained agrillaceous limestone	Fine-grained siliceous limestone	Siliceous detrital limestone	Conglomerate limestone	50
		Calcareous claystone	Calcareous siltstone	Calcareous sandstone	Calcareous conglomerate	10
		Claystone	Siltstone	Sandstone	Conglomerate of Breccia	
	Strong to extremely strong	Crystalline limestone or marble				50
		Conventional metamorphic nomenclature applies in this section				

3

Practice

3. Practice

Although theoretical knowledge of anchors is essential for good anchor design and selection, the practical issues are just as important. The handling of an anchor and the selection and use of appropriate support equipment is of equal importance.

Anchor handling is a critically important and often complicated process. It is influenced by such factors as the weight and shape of the anchor, the nature of the soil, the depth of the water, the weather conditions, the available handling equipment and the type and weight of mooring line. It is for these reasons that anchor handling is a subject which requires careful consideration. Without proper anchor handling, optimal performance of an anchor is not possible.

In the process of handling anchors, various types of support equipment are necessary or beneficial. An anchor manual would be incomplete without consideration of these auxiliary items, the reasons for their use, their operation and the advantages and drawbacks involved.

This chapter gives an overview of the recommended procedures that should be followed for anchor handling and the types and use of the support equipment during the handling operations.

The following handling procedures are by no means complete, but they do give some suggestions which can be applied to each anchor handling procedure and adapted for specific circumstances and locations.

Some of the topics covered in this chapter are:
- Requirements for a soil survey
- Connection of the anchor to the mooring line
- Chasers
- Handling the Stevpris and Stevmanta anchors
- Handling the Stevtensioner
- Anchor handling/supply vessels.

Soil survey

For the dimensioning of drag embedment anchors, the availability of site-specific soil data is importa nt. For advice on specifying drag embedment anchor type/size and calculating expected behaviour, the site-specific soil data should be compared with soil data of previous drag embedment anchor (test) sites.

The soil survey requirement for the design of drag embedment anchors usually consists of only shallow boreholes, while in anchor pile design deep boreholes are required. For suction anchor design a more extensive soil investigation is generally required when compared to drag embedment anchors. When choosing between anchor pile, suction anchor and drag embedment anchor the financial implications of the soil survey should be taken into account.

A typical soil survey for drag embedment anchor design requires a survey depth of twice the length of the fluke in sand and 8 times the fluke length in very soft clay. In most cases a depth of 8 to 10 meters is sufficient, although in very soft clay a survey depth of 20 to 30 meters should be considered. For optimal drag embedment anchor dimensioning, each anchor location should ideally be surveyed. The soil investigation can consist of boreholes, vibrocores, cone penetration tests or a combination of these. Cone penetration tests including sleeve friction are preferred, but they should be accompanied by at least one vibrocore or sample borehole per site to obtain a description of the soil. Depending upon the type of survey performed and the soil conditions encountered, the survey report should present the test results obtained on site and in the laboratory including the points as shown in table Q.

It is possible to dimension the drag embedment anchors based on limited soil information (for instance fewer boreholes). The 'lack' of soil data can be compensated by choosing a conservative (larger) anchor size.

Typical contents survey report
• Cone penetration resistance. • Sleeve friction. • Pore pressure. • SPT values. • Granulometry and percentage fines. • Wet and dry densities. • Water content. • Drained and undrained triaxal tests. • Undrained shear strength, also remoulded. • Unconfined compression tests. • Plasticity limits. • Specific gravity. • $CaCO_3$ content. • Shell grading. • Angularity and porosity. • Compressibility. • Cementation. • Normalised rock hardness test (point load test). • RQD index, rock quality designation.

table P

Pile or anchor

The choice between piles and anchors is only possible for permanent systems. Piles are not a good investment when an anchored entity must be moved. But the choice is often made for piles subjectively; a pile does not drag! However, anchors that are properly pre-tensioned on site will also not drag.

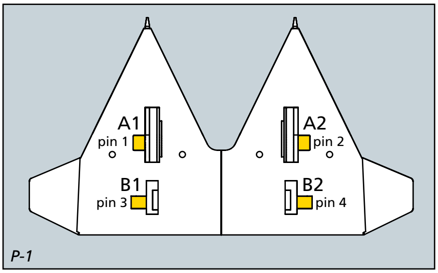
Experience has shown that a reliable choice between anchor and pile is merely a matter of economics. The required pile weight for a system is equal to the required weight of a Stevpris anchor. Piles cost about 40% of equivalent capability anchors. However, the installation costs for piles are much higher. Piles require a follower and a pile hammer. The installation spread for piles is much more significant; a crane barge with support spread versus the two anchor handling vessels. The weather downtime for a spread involving a crane vessel is much longer than when AHVs are used. To allow drag of the anchors during pretensioning, extra chain length is required. Sometimes the pretension load for piles is much less than for anchors. The survey work for anchors is generally much simpler than for piles. When abandoning a field, anchor removal is much cheaper than removal of installed piles. The choice between piles and anchors strongly depends upon the circumstances. The table N can help in estimating the costs for the two alternatives.

Suction piles are an alternative for drag embedment anchors and piles, also for MODU applications. The advantage is the accurate positioning of the suction piles. The disadvantage is the cost of the pile itself and the cost of the installation.

Description	Pile	Suction pile	Anchor
Soil survey	-	-	+
Procurement	+	-	-
Installation spread	-	-	+
Installation time	-	-	+
Pile hammer	-	+	+
Follower	-	+	+
Pump unit	+	-	+
Pretensioning	+	-	-
Extra chain	+	+	-
Rest value pile/anchor	-	+	+
Removal of anchor point	-	+	+
ROV	+	-	+

\+ less expensive - more expensive

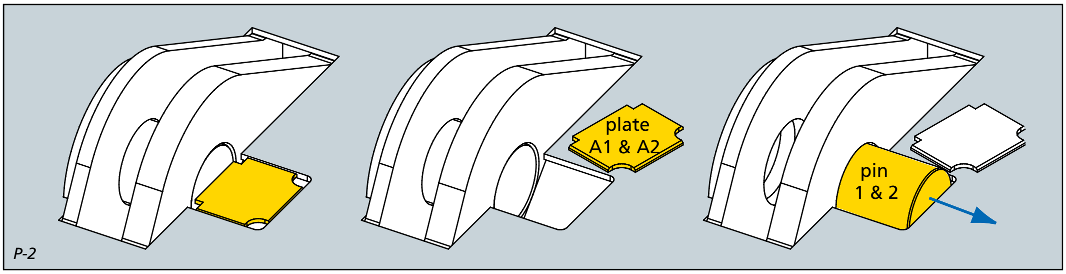
table Q



P-1

Forward fluke-shank connection

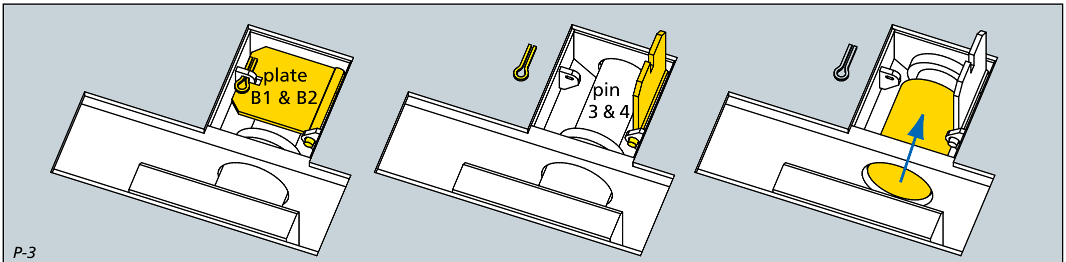
Remove the locking plates A1 and A2 which are tack-welded to the fluke. Move pins 1 and 2 to the outer side.



P-2

Aft fluke-shank connection

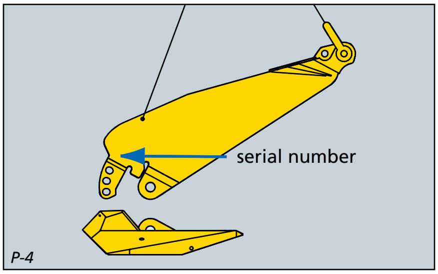
Remove the split-pins and open the locking plates B1 and B2. Move pins 3 and 4 to the outside (please assure to fully weld the locking plates back into position).



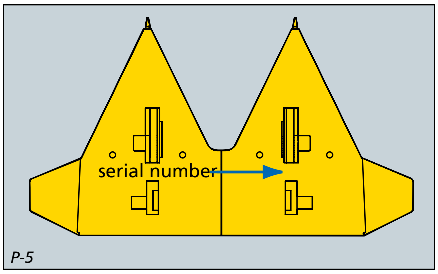
P-3

Attention

Make sure the serial number of the shank corresponds with the serial number of the fluke for reason of identification and certification.



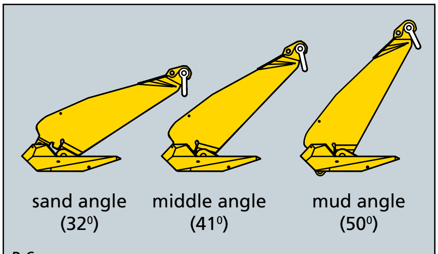
P-4



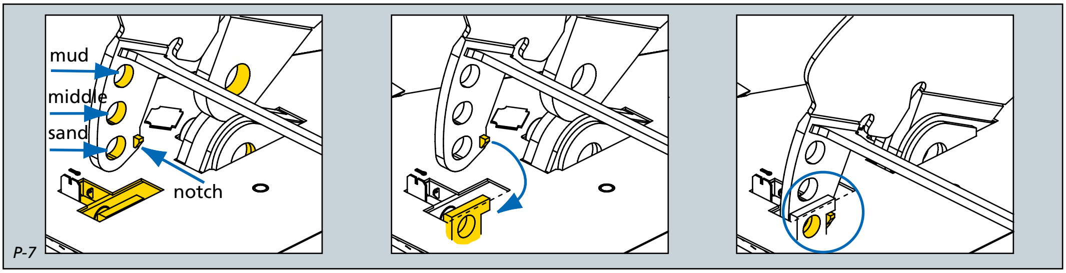
P-5

Fit the rear shank lugs into the fluke by means of a crane. Manoeuvre the rear shank lugs with the notch into the gap in the flukes, as indicated in the figures. When in position, rotate the shank forward to align the front pins with the shank.

Align pins 1 and 2 with the forward shank eyes. Move pins 1 and 2 back into position. Place the shank in the sand, middle or mud position. Align pins 3 and 4 with the rear shank lugs. Move pins 3 and 4 back into position. Fit and weld the locking plates A1 and A2 on the fluke. See welding detail below. Close the locking plates B1 and B2 and secure with split-pins.



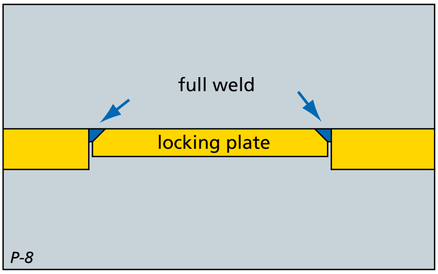
P-6



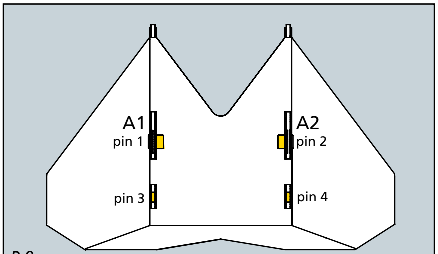
P-7

Vryhof recommended welding procedure for locking plates A1 and A2

Fillet weld with electrode	acc. AWS.E7018
Welding process	SMAW electrode
Welding position	2F
Material	S355J2G3 (St52-2N)
Preheat material	50° C
Interpass temp	max 250° C



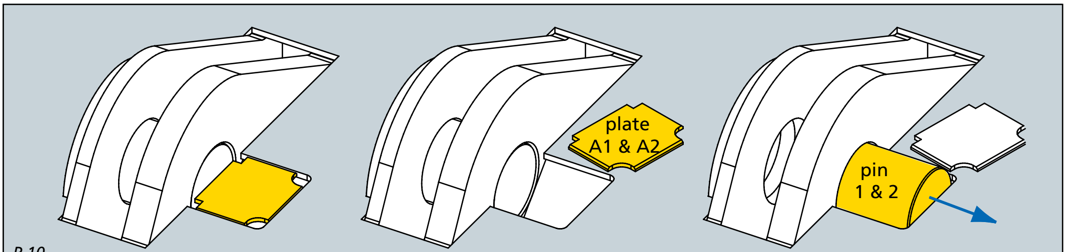
P-8



P-9

Forward fluke-shank connection

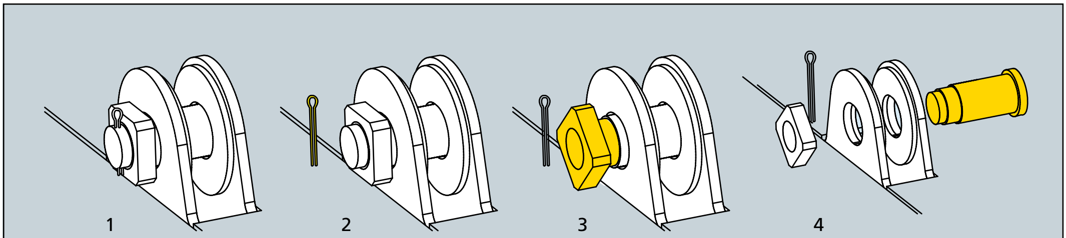
Remove the locking plates A1 and A2 which are tack-welded to the fluke. Move pins 1 and 2 to the inner side.



P-10

Aft fluke-shank connection

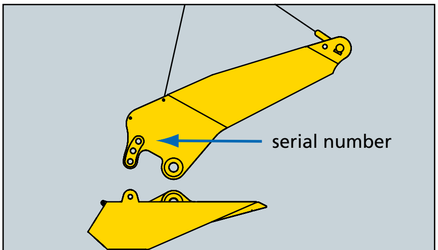
Remove the split-pins and nuts from pins 3 and 4 and move pins 3 and 4 to the outside (please assure to fully weld the locking plates back into position).



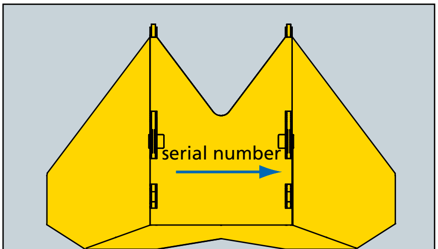
P-11

Attention

Make sure the serial number of the shank corresponds with the serial number of the fluke for reason of identification and certification.



P-12



P-13

Fit the rear shank lugs into the fluke by means of a crane. Manoeuvre the rear shank lugs into the gap in the flukes, as indicated in the figures. When in position, rotate the shank forward to align the front pins with the shank.

Align pins 1 and 2 with the forward shank eyes. Move pins 1 and 2 back into position. Place the shank in the sand, middle or mud position. Align pins 3 and 4 with the rear shank lugs and insert them in the lugs. Tighten the bolts and insert split pins 3 and 4. Fit and weld the locking plates A1 and A2 on the fluke. See welding detail below.

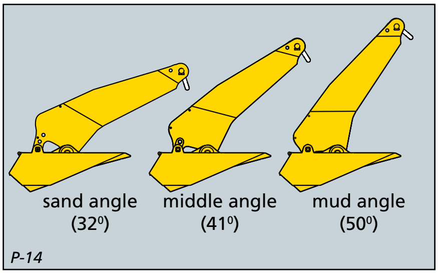
Locking strip

Before deploying the anchor, the anchor shackle pin needs to be secured by welding the locking strip parallel (5mm max. alowance) to a flat edge of the anchor shackle pin nut (fig. P-17).

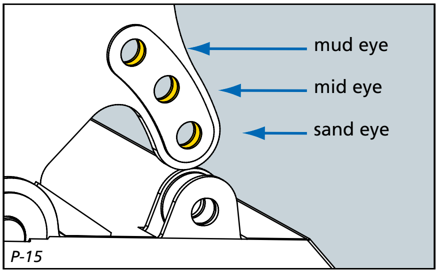
Vryhof recommended welding procedure for locking plates A1 and A2, and the locking strip

Fillet weld with electrode acc. AWS.E7018

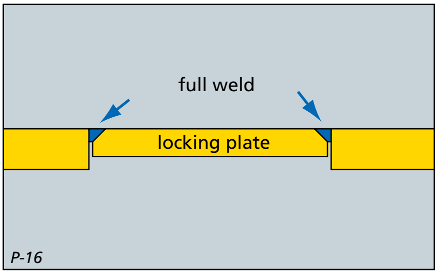
Welding process	SMAW electrode
Welding position	2F
Material	S355J2G3 (St52-2N)
Preheat material	50° C
Interpass temp	max 250 C



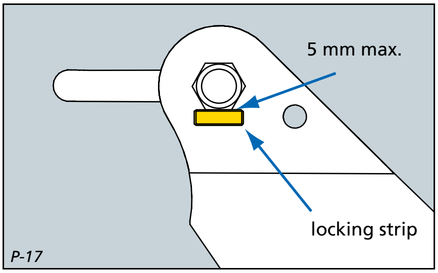
P-14



P-15



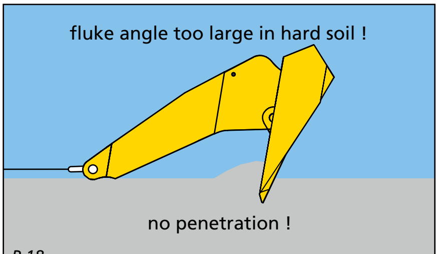
P-16



P-17

Setting the fluke/shank angle

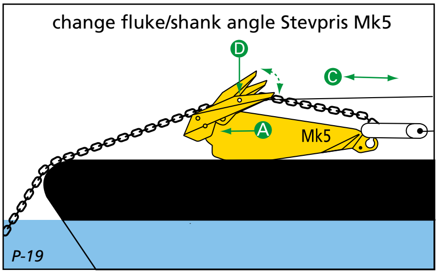
In soil such as sand and medium to hard clay, an anchor with a fluke/shank angle of 32° will give the highest holding power. An anchor with a 50° fluke/shank angle in this soil will not penetrate but will drag along the seabed. If used in mud a 50° fluke/shank angle is appropriate. An anchor with a 32° fluke/shank angle will penetrate less and generate lower holding capacity in mud (fig. P-18).



P-18

Changing the fluke/shank angle on the Stevpris Mk5

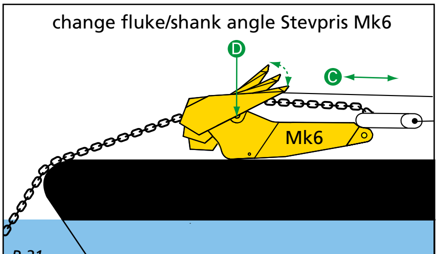
This can be carried out within half an hour with the Stevpris anchor upside down on deck.
Secure the anchor on deck. Connect a tugger wire (C) to the holes (D) on the bottom side of the fluke. Change from mud to sand angle by removing the locking plates (A) and move outwards the two rear pins in (B), decrease the fluke/shank angle by hauling the cable (C). Slide the pins in and fully weld the locking plates (A). Do not weld the locking plates to the pins (fig. P-19).



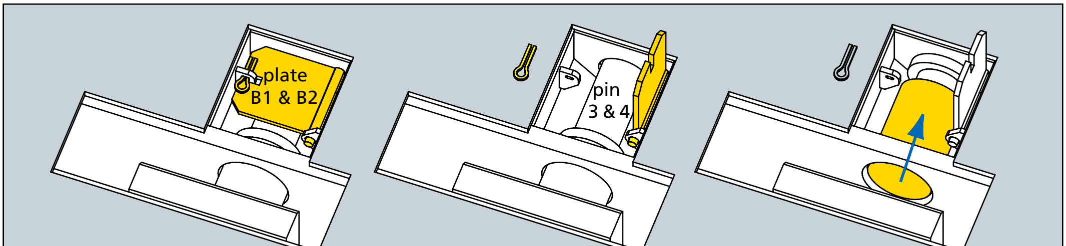
P-19

Changing the fluke/shank angle on the Stevpris Mk6

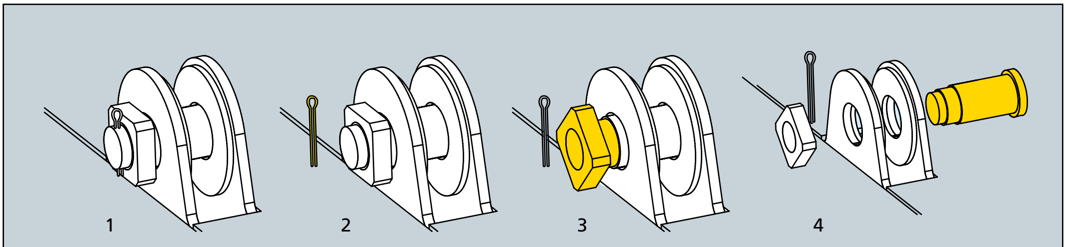
Changing the fluke/shank angle on the Stevpris Mk6 is similar to that of the Stevpris Mk5 (fig. P-21) the pin however remains in (A) and the locking plates are secured with cotter pins as illustrated in fig. P-22.



P-21



P-20



P-22

Rigging for assembly Stevpris Mk6

Rigging set for anchors

A special set of rigging components will help to safely and efficiently assemble the Stevpris anchor. The same set can be utilized for the bridle installation method.

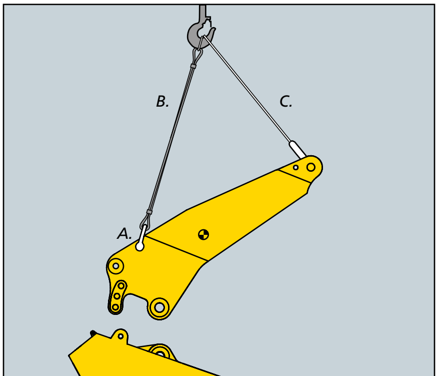
The example concerns a 15mT Mk6 anchor, but is in principle the same for every anchor weight. The set consists of:

A. Lifting shackles (17 mT WLL Bow shackle)
B. Sling, 26 mT, 2-leg, 4.75m long with ferrule secured soft eyes and master link at top. Proof load 39 mT.
C. Grommet, 6 mT, 6m EWL.

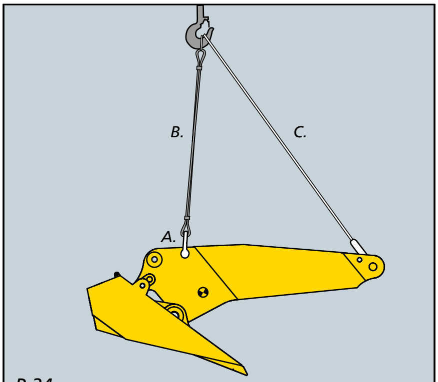
The set shown in the example is for an anchor to be set at sand angle, but will serve all 3 fluke angles as well as for assembly.
The sling is applied at full length, while the grommet is applied at half length (fig. P-23), choked for sand and basketed for mud angle and anchor assembly. Once the set has been rigged, the anchor can be lifted and held in position as to safely allow the mounting of the angle setting pins (see previous page).
To prepare the anchor for lifting, the lifting set is applied. Carefully start lifting to allow the anchor to adjust to the centre of gravity (see fig. P-24).

The lifting sling (B), also serves the deployment of the anchor by means of the bridle installation method. In this case the sling is mounted by means of the shackle to the reinforced eye in the fluke to ensure capacity to lift the anchor including fore runner and tail piece (fig. P-25).

For mobile or rig applied anchors a special set is required to withstand extra chain weight and wear.



P-23



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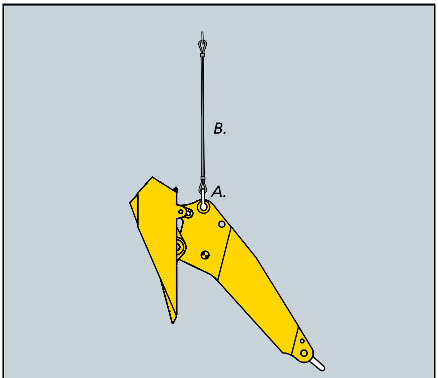


P-25

Connecting a swivel to the Stevpris anchor

To connect a swivel to the Stevpris anchor, several different configurations are possible. These are:

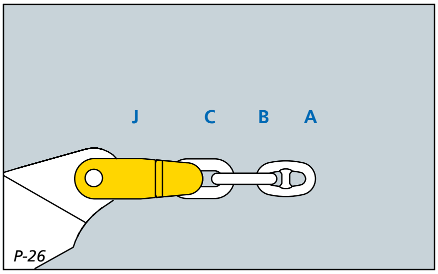
Type I - Is some industries the swivel is connected directly to the anchor head, thus omitting the anchor shackle (fig. P-26). *J swivel shackle, C end link, B enlarged link, A common link*

Type II - In the offshore industry the swivel is not connected directly to the anchor head, but to the anchor shackle (fig. P-27). *J swivel shackle, C end link, B enlarged link, A common link*

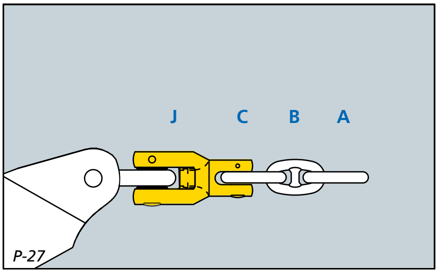
Type III - The swivel is connected to the anchor shackle via a special design end link (fig. P-28). *K special end link, J swivel, C end link, B enlarged link, A common link*

Type IV - The swivel is part of a forerunner connected to the anchor shackle, for instance the forerunners VA02, VA04 and VA06 described in the product data section (fig. P-29. *PL pear link, A common link, E kenter shackle, H anchor swivel, E kenter shackle, A common link*

Type V - The most commonly used composition of the forerunner fully in accordance with the regulations is to connect the swivel to a 5-link adaptor (in some cases 3 link adaptor). (fig. P-30). *C end link, B enlarged link, 3x A common link, E Kenter shackle, I Anchor swivel, E Kenter shackle, A Common link (ground chain).*



P-26



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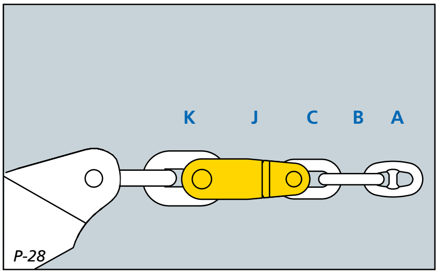

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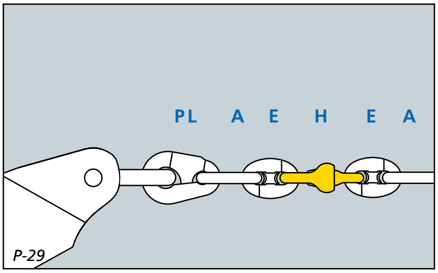

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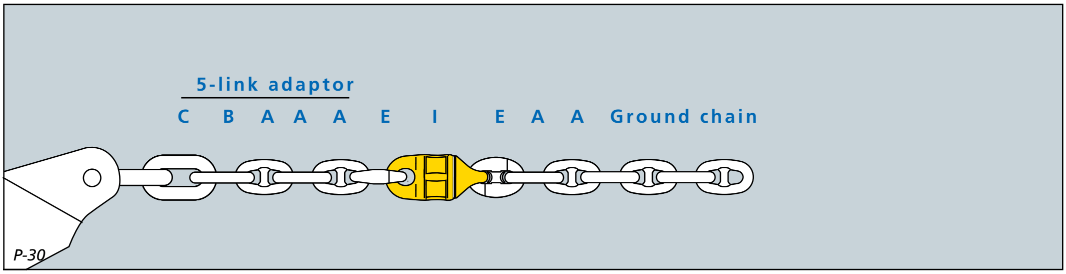


P-30

Always consult Vryhof for alternative methods or specific applications.

Connecting a swivel to the Stevpris anchor

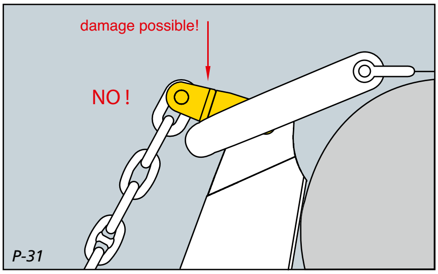
When a chaser is used in combination with the Stevpris and swivel, some of the configurations mentioned above are more suitable than others. In general, swivels are only designed to withstand longitudinal forces, and are usually not designed for use in combination with chasers. The design of the chaser tends to stop it at the swivel. Consequently, there will be high bending forces on the swivel, which can result in damage or even breakage.

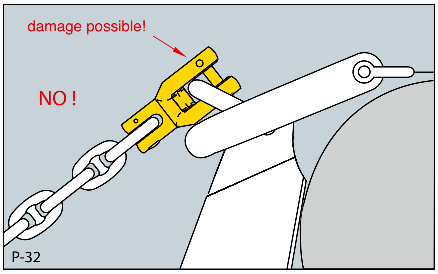
Generally, it is best when the swivel is fitted some distance from the anchor when a chaser is used. The chaser can then pass the swivel and stop on the anchor shank. When a load is applied to the chaser, the swivel is only loaded longitudinally. This means that in combination with the use of a chaser, the configuration type III and type IV are preferred.

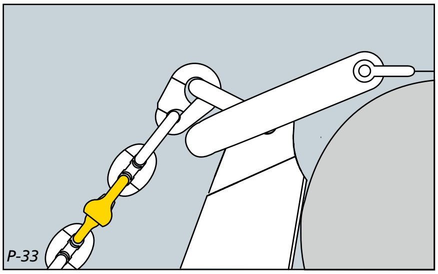
When the swivel (or swivel forerunner) is connected to the anchor shackle by means of an end shackle and a chaser is used, the end shackle and the anchor shackle should be connected bow through bow instead of pin through bow as is normal practice. This minimises the chance of damage to the shackles.

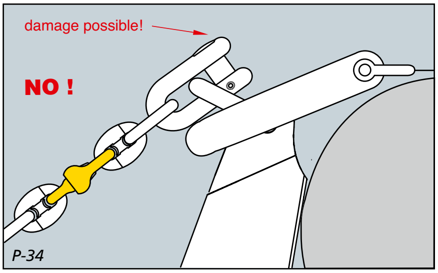
The illustrations fig. P-31 through fig. P-35 show how and how not to connect the swivel to the Stevpris anchor when using a chaser.

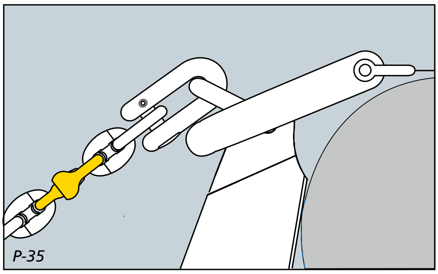
The best method for chasing with a swivel in the system is to maintain the tension of the anchor line as much as possible during chasing. This will make the chaser pass more easily over the swivel











Always consult Vryhof for alternative methods or specific applications.

Chasers and their application

To facilitate handling, pendant wires may be applied to retrieve the anchor. These wires are connected to a pendant eye situated on the anchor and equipped with a buoy for picking up. In deeper water higher anchor break-out forces are encountered, resulting in the need for longer, heavier pendant wires and consequently larger buoys. Due to wear caused by the continuous movement of the buoy by the waves, these pendants may break close to the buoy. The buoys would then float free and the anchors would be much more difficult to recover.

To overcome this, chasers were introduced. These are rings 'chased' along the cable towards the anchor and back again to a rig or handling vessel. Their function is to ensure both installation and break-out of the anchor without having to use a pendant line/buoy. The chaser system thus totally eliminates buoys, partly eliminates cables and reduces wear on the system. The cost of a chaser is small when compared to the cost of a mooring line. It is therefore extremely important from an operator's viewpoint that chasers do not inflict damage to the mooring lines.

Towing a chaser along mooring lines with, at times, high interface pressures, will result in wear. It is thus essential that such wear is taken by the chaser and not by the mooring line. The chasers Vryhof recommends are manufactured in a material that is softer than the steel used for the mooring line. Chaser wear is induced by the application of high interface pressure between the mooring line and the chaser. High interface pressure can arise from:

- Pulling the chaser along a slack mooring line.
- Maintaining high tension in the chaser work wire when chasing a tensioned mooring line.

Chasing operations are best carried out on mooring lines which are fully tensioned. There is little need for the application of high interface pressure while chasing, the permanent chaser is captive on the mooring line and, unlike the J-chaser, will not become disengaged due to a slack work wire. For optimum chasing operations, the length of the chaser pendant line should be at least 1.5 times the water depth.

Chaser types

There are many different types of chaser available on the market today. A selection of the different chaser types is described in more detail on this and the following pages. For the main dimensions of these chasers reference is made to the table on page 140.

The J-chaser

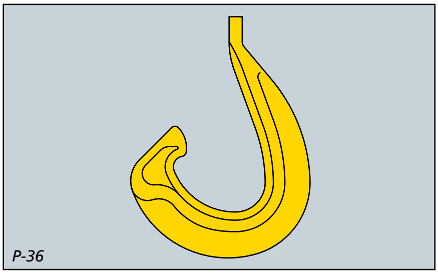
The J-chaser (fig. P-36) is used on mooring lines where the anchor has to be recovered and no permanent chaser has been installed, or the normal recovery mechanism has failed. In other cases the J-chaser is used simply to keep a chain free from a pipeline during deployment of the anchors. The chaser is deployed over the stern roller of an AHV at approximately $^1/_3$ of the water depth. The chaser is towed across the mooring catenary until it catches the chain. It is then towed into contact with the anchor shank/fluke for anchor break-out and retrieval.

The permanent chain chaser

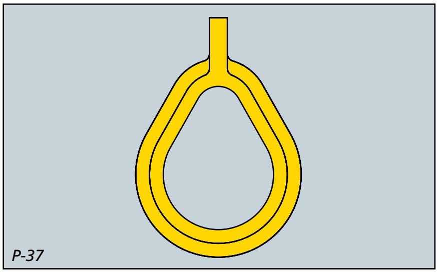
As a practical alternative to the buoy and pendant, the permanent chain chaser (fig. P-37) was introduced. Originally, simple shackles were used; these were followed by special cast oval rings which were attached to a pendant by a 'bight' of chain and shackle. Very soon afterwards the pear-shaped chaser with shackle eye was introduced. The design of these chasers offers superior sliding and penetration properties.

The detachable chain chaser

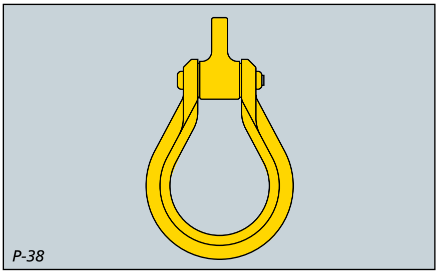
For rigs in service it is sometimes preferred to equip the mooring with a chaser which does not require the anchor chain to be broken and re-made. Detachable chain chasers (fig. P-38) were introduced to satisfy this need. The withdrawal and replacement of the single bolt permits easy assembly of the chaser on the mooring cable.



P-36



P-37

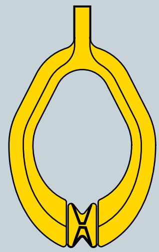


P-38

Chaser types

The permanent wire chaser

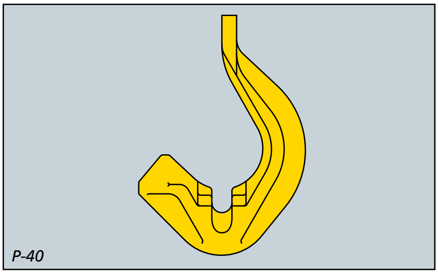
The permanent wire chaser (fig. P-39) was introduced when rigs moved to deeper waters, and composite wire/chain mooring systems became necessary. The chaser incorporates a 'rocker' which is centrally mounted on a hinge bolt. The rocker has two opposing grooves, and when the chaser is engaged with the mooring line, the wire slides through one of these grooves irrespective of the angle which the chaser makes with the mooring. The large radius at the base of the groove assists in reducing wear of the rocker and avoids severe 'opening' of the lay of the wire if a loop of wire is pulled during the handling process. The material of the rocker is not as hard as the material of the wire. This means that wear is taken by the rocker without damage to the wire and, because the rocker is easily removable, replacement is relatively inexpensive. The permanent wire chaser is easily detachable by removal and re-assembly of the hinge bolt and rocker.


P-39

Some designs of wire chaser incorporate fully rotating rollers over which the mooring wire passes. To be effective such rollers need to be of a large diameter and require to be supported by bearings. They are consequently larger, heavier and much more costly than the permanent wire chasers discussed above, and because of their size, they require more power at the AHV to penetrate the seabed and reach the anchor.

Chaser types

The J-lock chaser



P-40

The J-lock chaser (fig. P-40) has been designed so that it can slide along the chain in one direction and when the pulling direction is reversed, the chaser locks on the chain and does not slide any further. This means that the tension in the mooring line can be wholly transferred from the rig to the chaser. The J-shape permits catching the anchor chain after the anchor has been installed. This means that this chaser can be used to assist in unforeseen circumstances. The well-balanced and 'guiding' design of the chaser enables catching the chain when the chaser approaches a mooring at a point where the catenary angle is as high as 450.

When a normal permanent chaser is used under unforeseen conditions, there is the chance that the AHV cannot break out the anchor by means of the chaser. The J-lock chaser can help in such an instance. It is released from a second AHV and slides along the chain towards the anchor. The design prevents the J-lock chaser from sliding back. The J-lock chaser is stopped at the permanent chaser. If the winch pull of both tugs is now increased, the J-lock chaser prevents the permanent chaser from sliding away from the anchor. Consequently, the forces required do not increase, and the anchor can easily be broken out. After this operation, the J-lock chaser can be released again.

This chaser can also be used when a very heavy chain has to be installed. It assists during installation by lifting the chain.

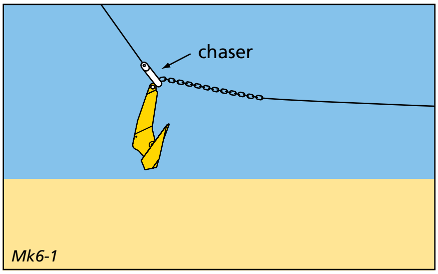
4

Installation

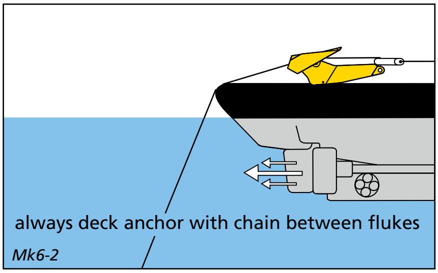
Introduction

Typical methods for deployment and retrieval of Stevpris anchors with an anchor handling vessel (AHV) are described below, focusing on the use of chasers for handling the anchor (fig. Mk6-1). This is the most common practice on mobile drilling rigs (MODUs). Handling using permanent pendant lines is similar.

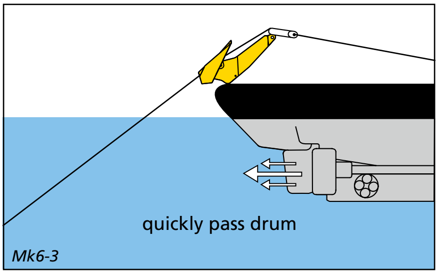
Deployment procedures for the Stevpris anchor will also be given for permanent moorings where chasers are normally not used.



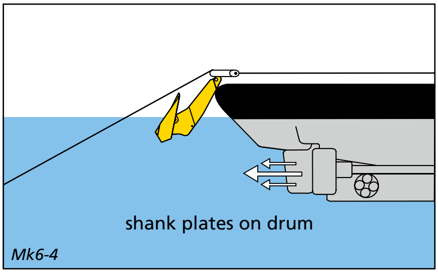
Mk6-1



Mk6-2



Mk6-3



Mk6-4

Stevpris deployment for MODUs

Laying anchors

The following method focuses on the use of chasers for handling the anchor.

It is preferred and by some operators required, to deck the anchor before run out to check the jewelry. Run the anchor line out the full distance with anchor on deck or on roller, with the chain between the flukes (fig. Mk6-2).

Boat increases power until anchor line tension rises on rig winch tension meter. When rig gives order to lower the anchor, veer pendant till anchor arrives at roller. Allow the anchor some speed to negotiate the bump at the change-over from the deck on to the roller (fig. Mk6-3).

If the anchor is kept on roller, keep triangular plates below the main shackle on the drum for stability of the anchor. Alternatively the chaser can be kept on deck/ roller. In this situation the propeller thrust passes underneath the anchor and does not influence the fluke (fig. Mk6-4). This also gives stability to the anchor when the AHV strips the chaser back or buoys off the pendant. Now the AHV can retrieve the chaser and return to the rig. If circumstances allow, the rig can tension up to the full pretension load directly.

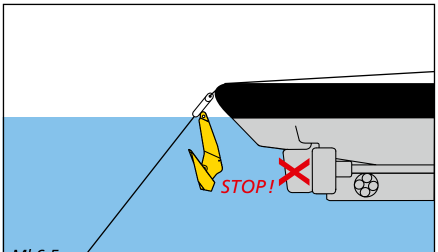
Reduce propulsion momentarily when anchor passes the propeller thrust, keep chaser on anchor head for control of anchor orientation and lower anchor (fig. Mk6-5).

Once below the propeller wash zone, reactivate and maintain propeller thrust to well above 30 tonnes. Keep constant tension in order to ensure anchor does not fall through chaser, i.e. anchor remains in the chaser and orientation of the anchor is correct (fig. Mk6-6).

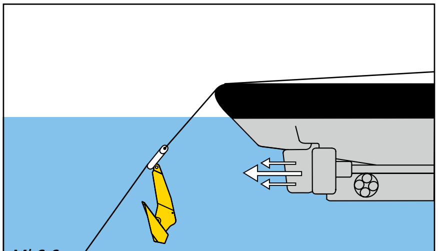
Note: In some circumstances AHVs prefer to run the anchor hanging from the pendant line below the propeller wash approximately 60 to 80 meter above the seabed. This method requires less power on the winch during the actual laying of the anchor. If this method is employed, make sure that at all times the anchor is correctly oriented in the chaser. Keep constant tension in the pendant line to prevent the anchor from falling through the chaser and possibly turning.

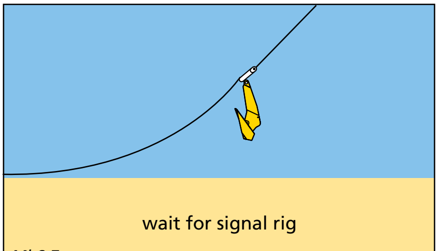
Stop lowering when anchor hangs 10 to 15 meter above the bottom and advise rig. Rig now instructs AHV to pay out until pendant line is 1.4 to 1.5 times the water depth in shallow water (100m) and 1.3 to 1.4 times in deeper water. AHV increases power till tension is again seen to rise at the rig, i.e. the load in the line is larger than the chain-soil friction (fig. Mk6-7).

Rig commences to pull in slowly. AHV further increases power until tension rises further at rig winch. At this moment rig orders AHV to lay the anchor. AHV immediately stops the propulsion and is consequently pulled backwards. AHV pays out pendant and maintains paying out pendant after anchor has landed on the bottom till a wire length of 1.5 to 2 times the water depth is out. Enough slack wire must be paid out not to disturb the anchor during buoying off or waiting. Stay above or behind the anchor.



Mk6-5


Mk6-6



Mk6-7

Stevpris installation

Rig continues heaving the cable to a sufficient load, equal to the total chain/soil friction plus 50 T to embed the anchor fully and create confidence in good setting. This also gives stability to the anchor when the AHV strips the chaser back or buoys off the pendant. Now the AHV can retrieve the chaser and return to the rig. If circumstances allow, the rig can tension up to the full pretension load directly (fig. Mk6-8).

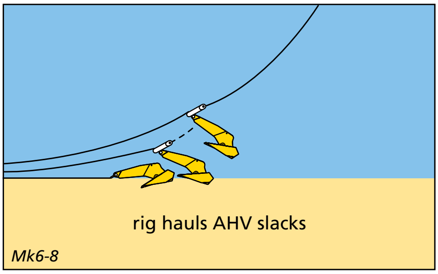
No extra pull after landing!

It is customary with older anchors such as Danforth, Moorfast, etc. to give another pull once the anchor is on bottom. Do not do this with Stevpris anchors.
Once the anchor hits the bottom, the AHV should not pull again. The pendant line must remain slack, otherwise anchor could land upside down! (fig. Mk6-9).
Suggestion: pre-load the anchors to the maximum required pretension load as soon as the chaser is 100 meter or more ahead of the anchor, i.e. do not wait. If anchor has not been laid correctly, a rerun can be made immediately.

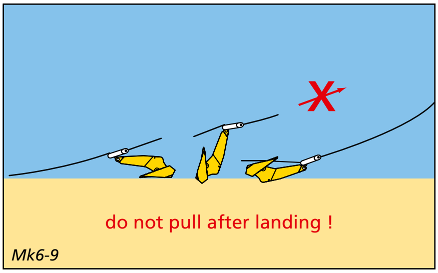
Retrieving anchors

The chaser should be brought to the anchor with a pendant of at least the length of 1.5 to 2 times the water depth, measured from the stern roller. The chaser should hang freely down from the anchor line till the bottom is reached, i.e. slack in the pendant line. A too short pendant and/or too little tension in the cable results in a situation as sketched (fig. Mk6-10).

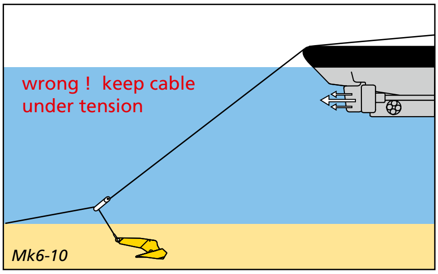
While chasing, the rig should maintain a tension of 60 to 70% of the pre-load tension. No tension should be in the pendant line to ensure its smooth passing over the chain. When the chaser is pulled into contact with the anchor shank, increase the AHV thrust and keep thrust while heaving, especially in rough water (fig. Mk6-11).



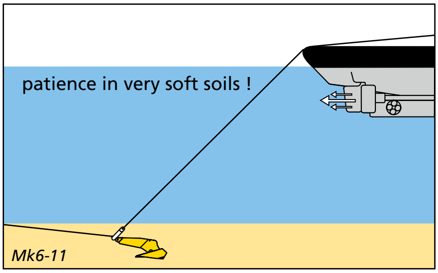
Mk6-8



Mk6-9



Mk6-10



Mk6-11

Stevpris installation

The motion of the vessel itself now helps to gradually break the anchor loose. Sequentially with the vessel's motion the pendant is shortened gradually. Anchors in very soft clay can be buried very deep. Have patience, take your time and be gentle with the equipment; the anchor will come. The rig can help and speed-up the operation by hauling the anchor line at the same time! Once the anchor is off the bottom, keep the chaser in contact with the bow shackle by maintaining sufficient vessel thrust (fig. Mk6-12).

Anchor orientation

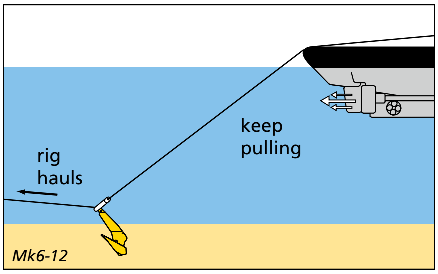
The anchor flukes are always oriented towards the rig, on deck the anchor lays on its back with the shackle towards AHVs bow and the cable between the upwards directed fluke points. Check jewellery (fig. Mk6-13).

It is important to control the anchor orientation at all times for easy racking, laying and decking of the anchor, i.e. keep the pendant line under tension while working with the anchor. If the anchor slides through the chaser, the anchor has to be pulled back to the stern roller and orientation checked (fig. Mk6-14).

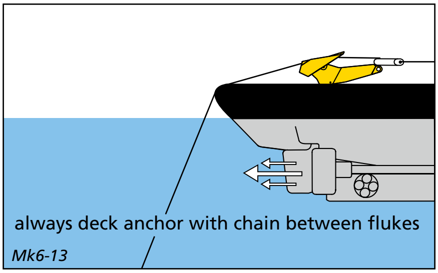
Decking the Stevpris anchor

If anchor is not correctly oriented, reduce propulsion and let anchor slide down through the chaser. Rotation is easier while near the rig where all loads are lower (fig. Mk6-15).

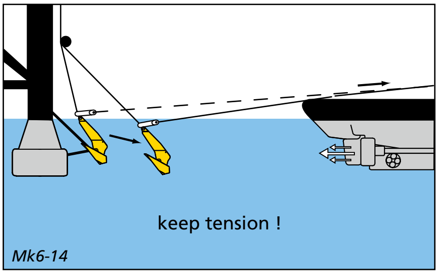
To aid visual inspection of the anchor's orientation, the shank heads of the Stevpris anchors are colored red and green, where starboard is green when the anchor rests on its back on deck.



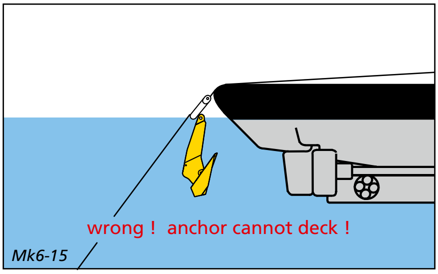
Mk6-12



Mk6-13



Mk6-14



Mk6-15

Always consult Vryhof for alternative methods or specific applications.

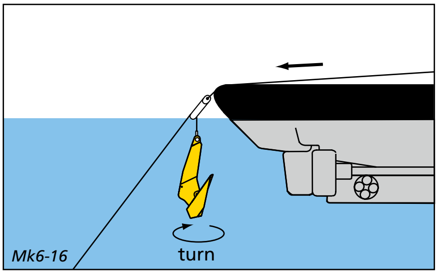
Turn the anchor with a shot of propeller wash. Then pay out the pendant, make sure the anchor is below the propeller wash away from the propeller influence zone (fig. Mk6-16).

Increase propulsion moving the AHV forward pulling chaser in contact with the anchor. Make sure the stern roller is perpendicular to the chain, the chain directing between the fluke points (fig. Mk6-17).

With sufficient bollard pull haul the pendant, stop / reduce thrust for only a few seconds when anchor passes the propeller wash onto the stern roller. Pull anchor on the stern roller, allow the anchor to turn with its back on the roller, fluke points up. Then pull further onto the deck (fig. Mk6-18).

With a little tension in the line, the chain hangs steep against the fluke points and anchor the cannot rotate easily (A). Before rotating the anchor, pull on the cable, the anchor will be free to turn (B) and (C) (fig. Mk6-19).

With the anchor on the stern roller reactivate propulsion. For inspection the anchor can be pulled on deck. If required, change the fluke angle to 32 degrees for hard soil or to 50 degrees for very soft soil. Note that every anchor type will be unstable and drag in hard soil, stiff clay or sand with a fluke angle set for mud! (fig. Mk6-20).



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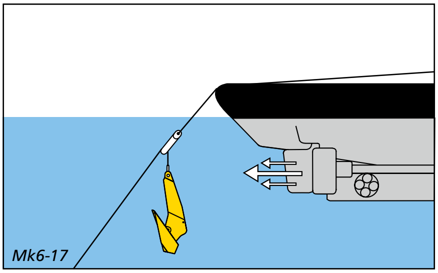
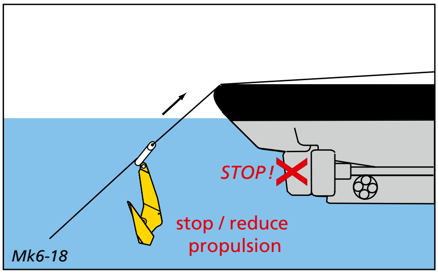
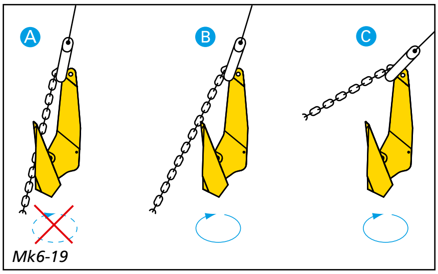
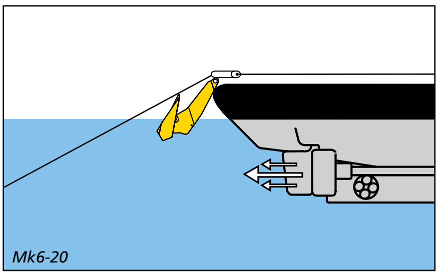

Mk6-17



Mk6-18



Mk6-19


Mk6-20

What not to do!

When the anchor is approaching the drum, if the AHV maintains thrust, the water flow will push the fluke (fig. Mk6-21).

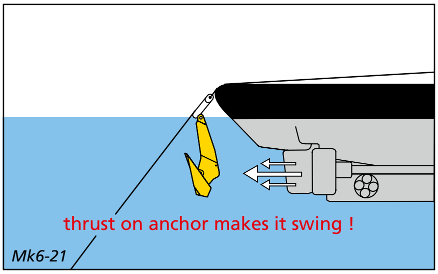
If the propeller is not stopped, the thrust risks turning the anchor around the cable which acts as a shaft (fig. Mk6-22).

The relative weight of the anchor increased by the thrust force on the fluke may cause the anchor and the cable to slide down through the chaser and control of anchor orientation is lost (fig. Mk6-23).

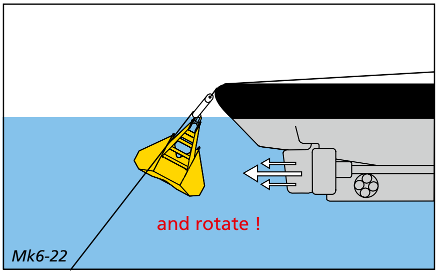
When the thrust is maintained while hauling in the chaser, the cable prevents the anchor to turn on its back at the stern roller. Boarding will be difficult now. The anchor could pass the stern roller on its side and get damaged!

So stop/reduce the thrust just before the anchor passes the propeller wash (fig. Mk6-24).

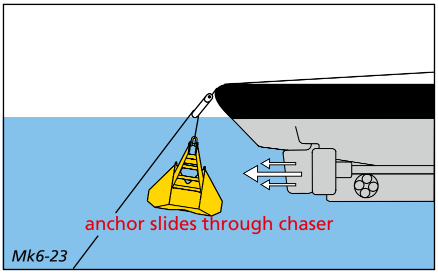
To aid visual inspection of the anchor's orientation, the shank heads of the Stevpris anchors are colored red and green, where starboard is green when the anchor rests on its back on deck.



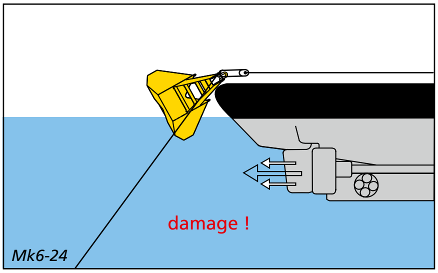
Mk6-21



Mk6-22



Mk6-23



Mk6-24

Always consult Vryhof for alternative methods or specific applications.

Racking the Stevpris

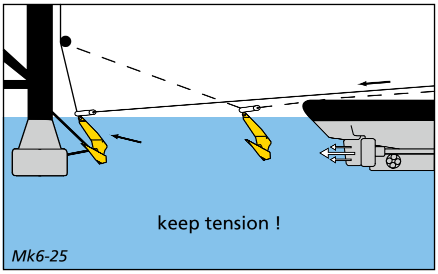
The rig heaves in anchor line, pulling the AHV towards it. AHV keeps sufficient tension in the pendant, the chaser remains in tight contact with anchor, anchor remains correctly oriented (fig. Mk6-25).

At some distance from the rig, AHV pays out winch wire while maintaining sufficient bollard pull (at least 1.5 times anchor weight) to keep the chaser on the anchor head. Anchor flukes point towards the rig. The rig hauls, the AHV veers while keeping some tension in the pendant line transferring the anchor to the bolster. The direction of the anchor cable must now be perpendicular to the rack (fig. Mk6-26).

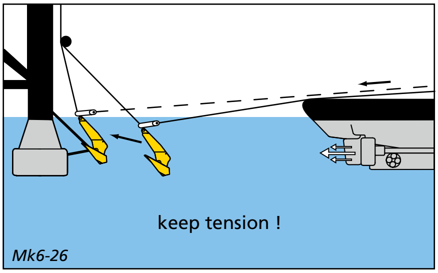
When the anchor arrives at the bolster, reduce tension to 15 tonnes. As soon as anchor is resting on the bolsters, slack the pendant wire completely. If the tension is not sufficient, anchor will fall out of the chaser and may rotate the anchor and make racking difficult. If this occurs, bring the anchor to the stern of the AHV, rotate the anchor with fluke points directing outwards and keep the chaser tight on the anchor (fig. Mk6-27).

Deploying Stevpris from the anchor rack

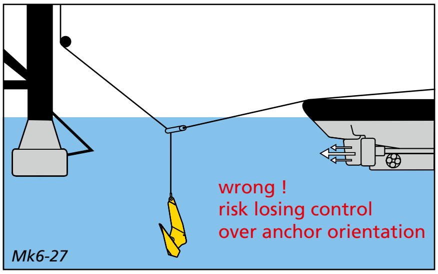
The AHV receives pendant from the rig and connects to the AHV winch wire. The AHV moves to a position to a good distance (but less than the water depth, for instance 50 meter dependent on weather) from the rig. Stop the winch and keep sufficient tension, 20 to 30 tonnes or more as required to maintain the chaser on the head of the anchor. The rig pays out the cable while the AHV hauls in on the winch. The AHV maintains sufficient tension while pulling the anchor to the stern roller. Reduce the power of the propeller as the anchor passes the wash zone and bring the anchor onto the roller for inspection and reactivate thrust (fig. Mk6-28).



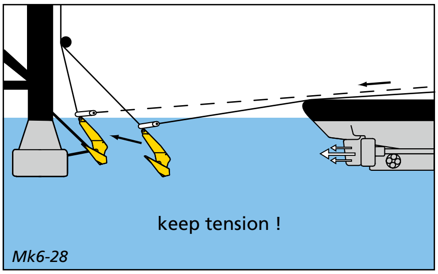
Mk6-25



Mk6-26



Mk6-27



Mk6-28

Boarding the anchor in deep water

In deep water the weight of the anchor line becomes of predominant importance. For line loads larger than 8 times the anchor weight the anchor could be pulled against the chaser as illustrated, it could even position itself upside down! In such cases boarding the anchor is difficult and damage might occur (fig. Mk6-29).

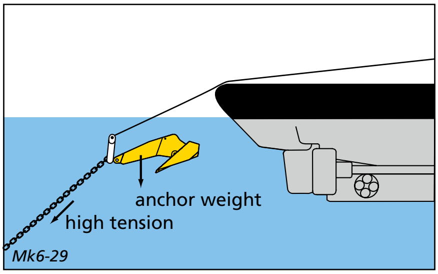
The best and preferred solution is to pull the anchor from the bottom and have the rig haul the anchor line, allowing the boarding of the anchor near the rig where loads are smaller.

If this is not possible or allowed for some reason, another solution is to reduce the weight that is hanging from the anchor. This can be done by lifting the anchor line using a lock chaser or grapnel handled by a second vessel (fig. Mk6-30).

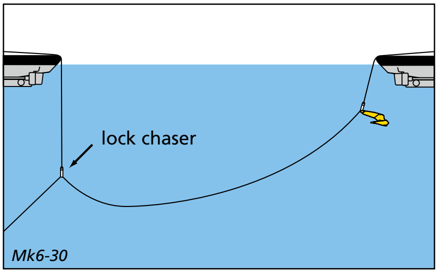
It is recommended to board the anchor with the chain between the fluke tips. The anchor fluke is generally designed to withstand loads up to 8 times the anchor weight (fig. Mk6-31).

If the anchor were to be to be accidentally pulled over the roller on to its side, due to the large forces damage might occur to the shank and fluke when the chain is hanging over the anchor (fig. Mk6-32).

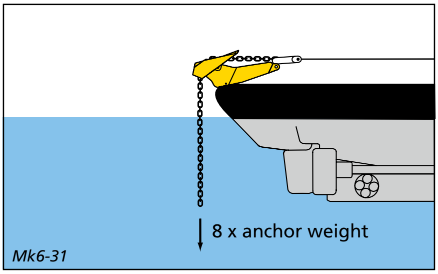
To aid visual inspection of the anchor's orientation, the shank heads of the Stevpris anchors are colored red and green, where starboard is green when the anchor rests on its back on deck.



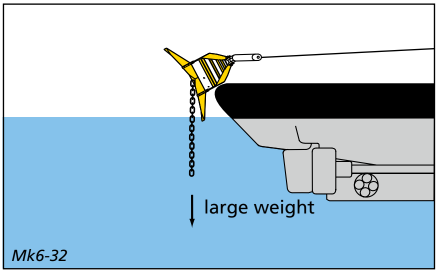
Mk6-29



Mk6-30



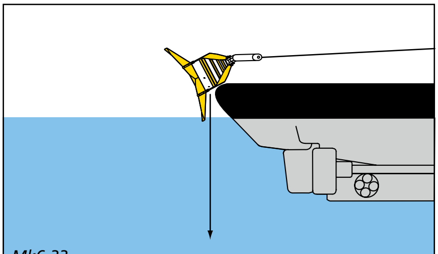
Mk6-31



Mk6-32

Always consult Vryhof for alternative methods or specific applications.

If boarding the anchor on its side is inevitable, make sure that before boarding, the vessel is turned to free the anchor line from the anchor and haul gently. The chain will pass the stern roller next to the anchor. However, this situation should be avoided as damage may occur (fig. Mk6-33).

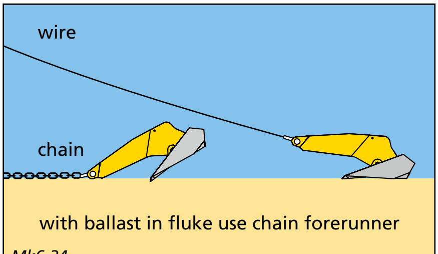


Mk6-33

Ballast in fluke

Using a wire rope forerunner and ballast material placed inside the hollow fluke, the anchor may not topple over with the fluke points directed downwards. A wire anchor line might be too light to position the anchor correctly and the anchor may not topple over, the anchor could skid over the seabed and prevent penetration.

Even if the fluke is ballasted, the weight of a chain forerunner will cause the shackle to topple and bring the fluke in penetration position (fig. Mk6-34).



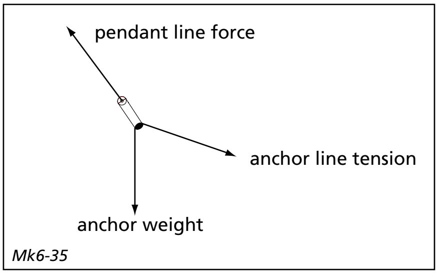
Mk6-34

Chaser equilibrium

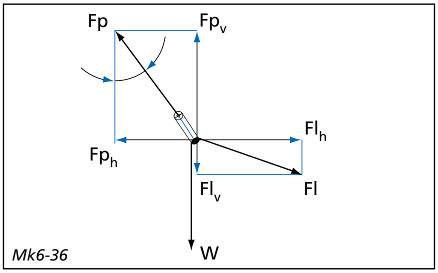
To control the anchor, the chaser collar must always be on the anchor head. The tension in the anchor cable must be equal or larger than 1.5 times the weight of the anchor. If not, the anchor slides through the chaser and the orientation is not controlled (fig. Mk6-35).

Equilibrium forces determine if chaser is in contact with the anchor. Near bottom, the vertical load at the chaser from the anchor line Flv is small. The chaser remains only in contact with the anchor if the bollard pull Fph is larger than the horizontal line load Flh which in turn must be larger than the anchor weight W (if not the anchor will slide down). The angle of the pendant line must be larger than 45° (fig. Mk6-36).

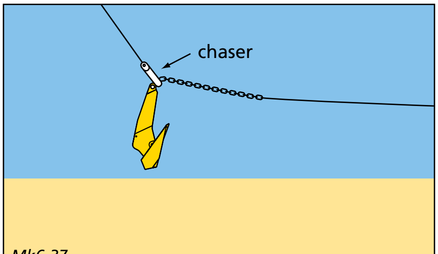
Recommendation: Bollard pull must always be equal or larger than the line tension, i.e. use a minimum bollard pull of 20 to 30 tonnes for a 12 to 15 tonne anchor. Use a minimum pendant line length of 1.4 to 1.5 times the water depth in shallow water (100m) and 1.3 to 1.4 times the depth in deeper water (fig. Mk6-37).



Mk6-35



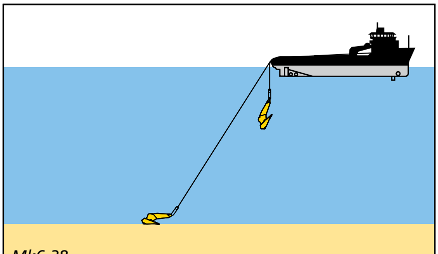
Mk6-36



Mk6-37

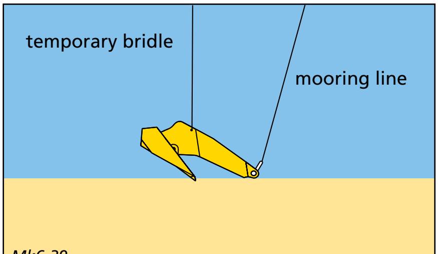
Deployment for permanent moorings

The simplest deployment procedure for the Stevpris anchor is to lower the anchor to the seabed using the mooring line. When the anchor is nearly on the seabed, the AHV should start moving slowly forward to ensure that the anchor lands correctly on the seabed (fig. Mk6-38).



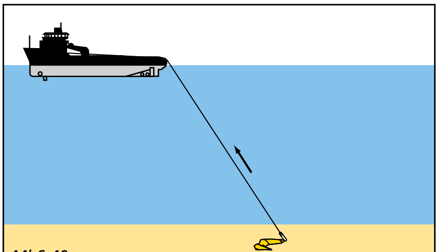
Mk6-38

Another option for the deployment of the Stevpris anchor is to connect a temporary installation bridle (wire rope) to the rear of the anchor. The bridle is connected to the padeyes situated at the back of the shank of the anchor. The AHV then lowers the anchor overboard while paying out the mooring line and the bridle simultaneously (fig. Mk6-39).



Mk6-39

To recover a Stevpris anchor after it has been installed, the AHV should take the mooring line and pull it in the opposite direction that the anchor was installed in, generally away from the centre of the mooring. The AHV should recover the mooring line till a length of approximately 1.5 times the water depth is still overboard.



Mk6-40

When only 1.5 times the water depth of mooring line is left overboard, the AHV should block the winch and keep a constant tension on the mooring line equal to the pre-load tension. Once the anchor starts to move in the soil, a lower tension in the mooring line can be used (fig. Mk6-40).

Piggy-backing

Introduction

Piggy-back is the practice of using two or more anchors in order to obtain holding power greater than can be achieved with one only. Piggy-backing is used when:

- Insufficient hold capacity is achievable by a single anchor.
- Anchor size or weight is limited by available installation equipment.
- As remedial action if an anchor has been improperly designed or sized for a particular environment.
- Soil conditions permit a limited burial depth permitting only smaller than required anchors.

Considerations to remember on piggy-backing:

- Installing a piggy-back system is more costly than the installation of a single anchor.
- If the mooring line of the second anchor is connected to the rear of the first anchor, the stability, penetration and holding capacity of the first anchor may be less than is the case for a single anchor. The force from the second anchor may tend to pull the fluke of the first anchor closed (hinging type anchors).
- If the piggy-back anchor is connected to the first anchor by means of a chaser, the chaser may obstruct penetration of the first anchor.
- Both anchors must be exactly in line with the mooring line load. The lead anchor may become unstable if a lateral load is applied.
- Two hinging anchors in piggy-back do not provide 2 times but only 1 to 1.6 times the individual holding capacity of the two anchors, for reasons described in second point above.
- If the first anchor is not influenced by the pull from the second anchor, and the second anchor (fixed fluke/shank type anchors) is connected at 3 to 4 shank lengths distance from the first anchor, the holding capacity of the 2 anchors may be up to 2.5 times the holding capacity of the individual anchors, due to the extra penetration of the second anchor.

Piggy-back methods

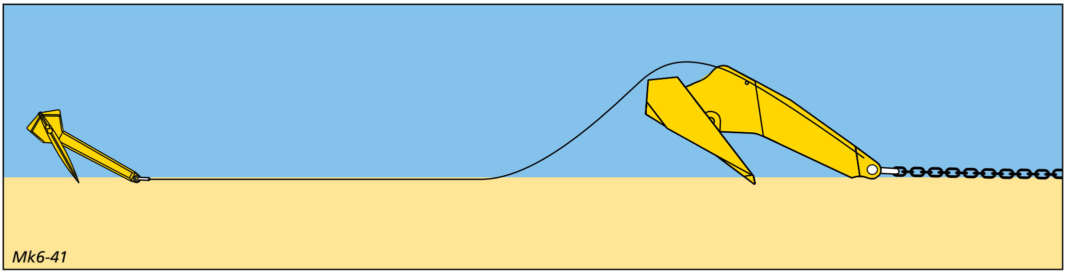
Piggy-backing involving hinging anchors

Since there is little difference between handling one hinging anchor or two, the first method is described with a Stevin anchor (hinging) in combination with a Stevpris anchor (non-hinging).
Here, the Stevpris is the main anchor and the Stevin is the back-up. This is the best solution when using a fixed shank anchor as the fluke of the Stevpris anchor can not be pulled closed. The pendant line is connected to the padeye near the anchor shackle so performance is not reduced.

Note: if the piggy-back anchor can not be laid in line with the mooring load, the piggy-back anchor makes the main anchor unstable. In such a case the Stevpris can better be placed as the second anchor.

For optimal performance of the combination, the pendant line between the two anchors should be wire rope, to promote penetration and obtain better holding capacity (fig. Mk6-41).

The installation procedure is described as follows:
- Pay out the main anchor as usual.
- Tension the mooring line until the anchor slips.
- Connect the second anchor to the pendant line.
- Bring the anchor to its location.
- Lower the piggy-back anchor and tension the mooring line again.
- Provide the pendant of the second anchor with a buoy for easy retrieval.



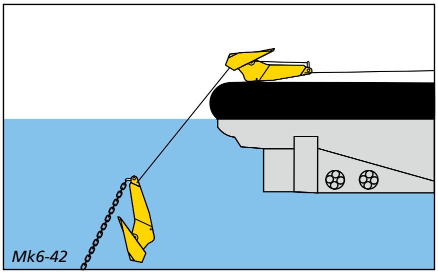
Mk6-41

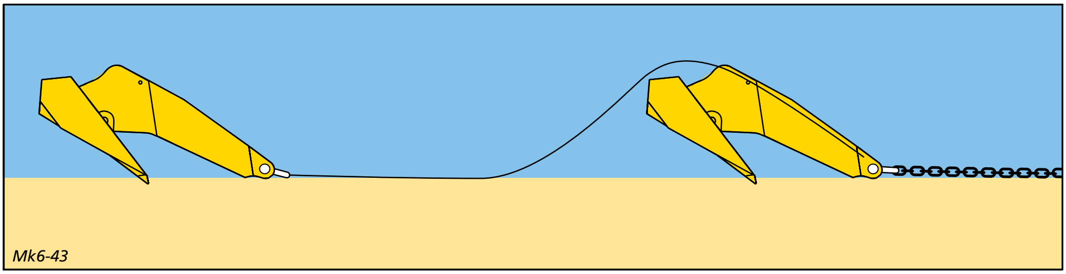
Piggy-back methods

Piggy-backing with two Stevpris anchors

When two Stevpris anchors are used in piggy-back, the holding capacity of the combination may be equal or higher than the sum of the individual holding capacities of the anchors. The installation procedure of two Stevpris anchors in piggy-back is as follows:

- Pay out the main Stevpris anchor with the mooring line connected to the anchor shackle and the pendant line (wire rope for optimal performance and approximately three times the shank length of the first Stevpris anchor) connected to the padeye behind the anchor shackle.
- Connect the other end of the pendant line to the anchor shackle of the second Stevpris anchor (fig. Mk6-43).
- To lower the second Stevpris anchor to the seabed, a second pendant line is connected to the padeye behind the anchor shackle.
- Using the second pendant line, the Stevpris anchors are lowered to the seabed and positioned and buoyed off.
- The Stevpris anchors are then tensioned by pulling on the mooring line (fig. Mk6-42).


Mk6-42

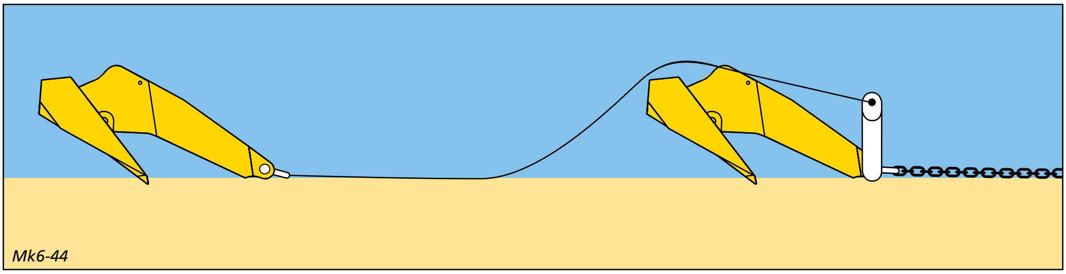

Mk6-43

Piggy-backing by using a chaser

Sometimes chasers are used to connect the piggy-back anchor to the first anchor (fig. Mk6-44), although a pendant line connected directly to the padeye behind the main anchor shackle of the first anchor is preferred.

The installation procedure described for two Stevpris anchors is also applicable when a chaser is used for the connection.

During the deployment of the piggy-back combination, care must be taken that anchors are installed in line with the load.

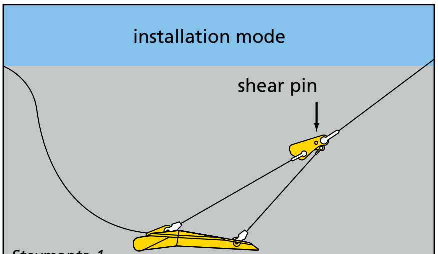


Mk6-44

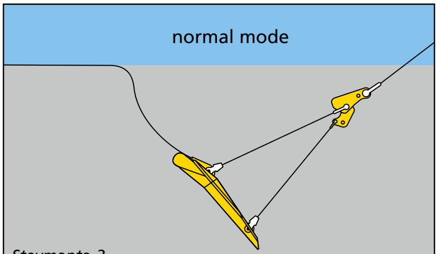
Stevmanta VLA installation

Introduction

The Stevmanta VLA consists of an anchor fluke which is connected with wires to the angle adjuster. The angle adjuster is responsible for changing the anchor from the installation mode to the vertical (or normal) loading mode.



Stevmanta-1



Stevmanta-2

There are many options to install VLA anchors. The most efficient methods are based on two different principles:
- Double line installation method using the fixed angle adjuster.
- Single line installation method using the shear pin angle adjuster.

The double line installation method is typically used when it is preferable to install the anchor with a steel wire rope installation line instead of using the actual mooring line (for example polyester).

The following three typical methods for installing the Stevmanta VLA are discussed:
- Single line installation method.
- Double line installation method.
- Double line installation method using the Stevtensioner.

It is also possible to use the Stevtensioner with the single line installation method, however because this is very similar to the double line installation method with Stevtensioner, it is not presented here.

Single line installation procedure

This procedure requires only one AHV for installation of the Stevmanta. The Stevmanta is deployed with the shearpin angle adjuster. The mode of the anchor changes when the shearpin breaks at a load equal to the required installation load. When the shear pin breaks, the Stevmanta changes from the installation mode to the normal (vertical) loading mode (fig. Stevmanta-1 and fig. Stevmanta-2).

Stevmanta VLA installation

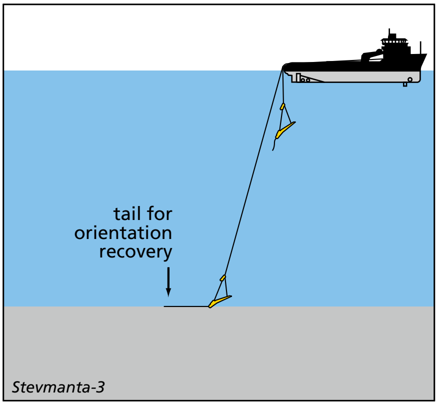
Installation procedure

In the installation procedure an optional tail has been included on the Stevmanta. The tail assists in orientation of the Stevmanta on the seabed.

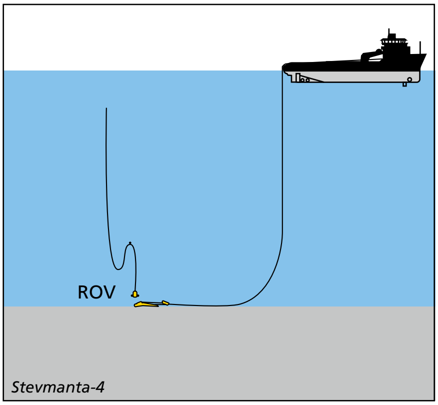
Connect the installation/mooring line to the angle adjuster on the Stevmanta on the AHV. Lower the Stevmanta overboard. The Stevmanta will descend tail first, i.e. the tail will be the first part to reach the seabed (fig. Stevmanta-3).

When the Stevmanta is on the seabed, an ROV can optionally inspect the anchor (position and orientation). The AHV starts paying out the installation/ mooring line while slowly sailing away from the Stevmanta (fig. Stevmanta-4).

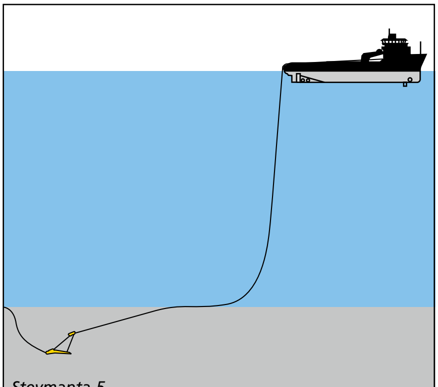
When enough of the installation/mooring line has been paid out, the AHV starts increasing the tension in the installation line. The Stevmanta will start to embed into the seabed (fig. Stevmanta-5).



Stevmanta-3



Stevmanta-4


Stevmanta-5

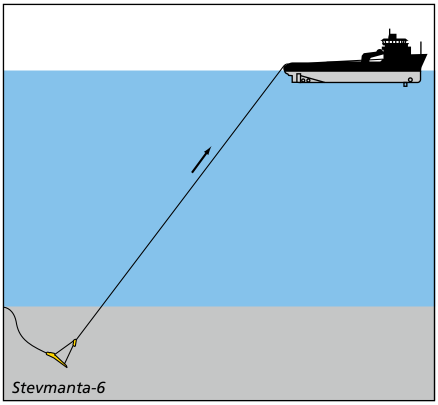
Stevmanta VLA installation

When the predetermined installation load has been reached with the AHVs bollard pull, the shearpin in the angle adjuster parts, triggering the Stevmanta into the normal (vertical) loading mode. This can be clearly noticed on board the AHV, as the AHV will stop moving forward due to the sudden increase in holding capacity. Now that the Stevmanta is in the normal (vertical) loading mode, the AHV can continue to increase the tension in the (taut-leg) installation/mooring line up to the required proof tension load (fig. Stevmanta-6).

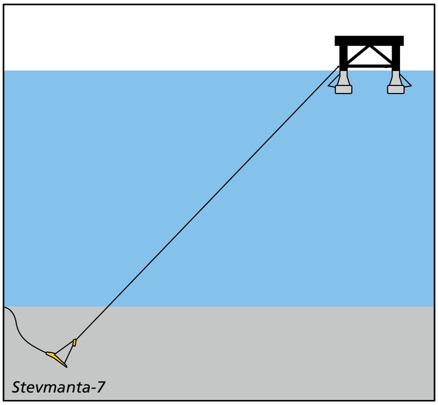
After the Stevmanta has been proof tensioned to the required load, the installation/mooring line can be attached to the floater. In case of a pre-laid mooring, the mooring line can be buoyed off, for easy connection later (fig. Stevmanta-7).

Stevmanta retrieval

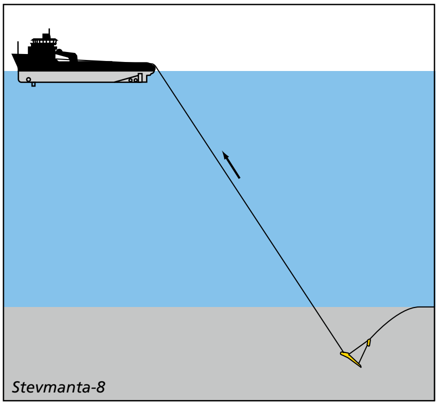
The Stevmanta is easily retrieved by pulling on the 'tail'. Connection to the tail can be achieved either with a grapnel or by using an ROV (fig. Stevmanta-8).



Stevmanta-6



Stevmanta-7



Stevmanta-8

Double line installation procedure

This procedure requires two AHVs. The Stevmanta is deployed with the fixed angle adjuster. The mode of the anchor (installation mode or normal (vertical) loading mode) is chosen by pulling on either the installation line or the mooring line.

The Stevmanta is in the installation mode when the installation line is tensioned, i.e. the line on the front of the angle adjuster (fig. Stevmanta-9).

The Stevmanta is in the normal (vertical) loading mode when the mooring line is tensioned, i.e. the line on the rear of the angle adjuster (fig. Stevmanta-10).

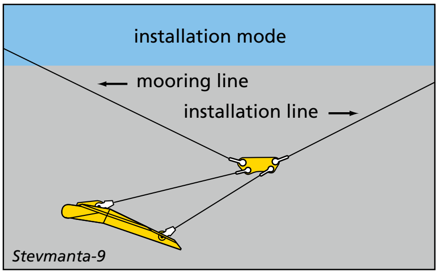
During the installation AHV1 handles the steel installation line and AHV2 handles the mooring line, for instance polyester (fig. Stevmanta-11).

In the installation procedure an optional subsea recovery buoy can be included in the installation line. The recovery buoy is connected to the installation line via a delta plate at approximately 90m from the Stevmanta (fig. Stevmanta-12).

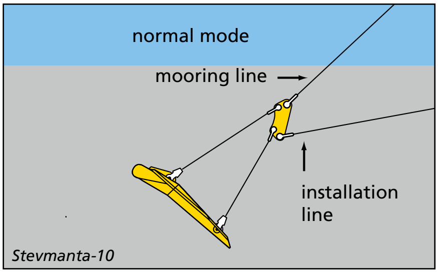
In the double line installation the Stevmanta is installed by connecting the installation line to the angle adjuster on the Stevmanta on board AHV1. Passing the mooring line from AHV2 to AHV1 and connecting it to the angle adjuster.

Lowering the Stevmanta VLA overboard by keeping tension on both the installation line (AHV1) and the mooring line (AHV2).

When the Stevmanta is on the seabed, an ROV can inspect the anchor's position and orientation. AHV2 slackens the tension in the mooring line and AHV1 starts paying out the installation line while slowly sailing away from the Stevmanta (fig. Stevmanta-13).



Stevmanta-9



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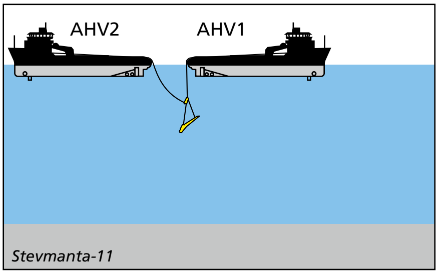

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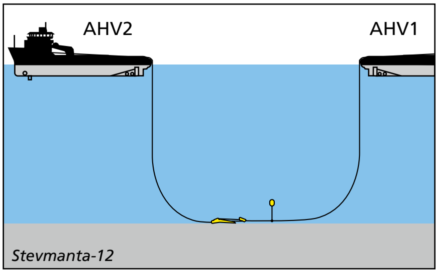

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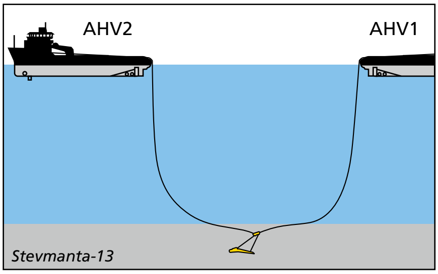


Stevmanta-13

Stevmanta VLA installation

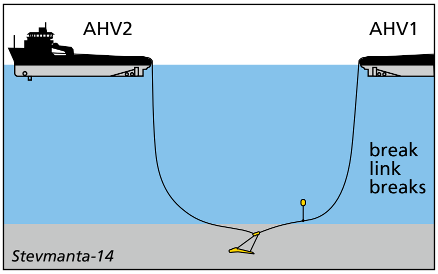
When enough of the installation line has been paid out, AHV1 starts increasing the tension. The Stevmanta will start to embed into the seabed. AHV2 keeps the mooring line slack by keeping the same distance from AHV1. If more bollard pull is required than one AHV can deliver, AHV2 can buoy off the mooring line and pull with AHV1 in tandem.

When the predetermined installation load has been reached, the breaking device in the installation line parts (break shackle connecting the installation line to the delta plate), freeing the installation line from the Stevmanta (fig. Stevmanta-14).

If the optional recovery buoy is used, the breaking device is placed on the delta plate connecting it to the installation line and AHV1. AHV1 is now no longer connected to the Stevmanta and the installation line can be recovered on deck (fig. Stevmanta-15).

AHV2 can now start increasing the tension in the mooring line. If AHV2 can not generate enough bollard pull to reach the required proof tension load, AHV1 can be connected in tandem to AHV2 to generate additional bollard pull.

After the Stevmanta has been proof tensioned to the required load, the mooring line can be attached to the floater. In case of a pre-laid mooring, the mooring line can be buoyed off, for easy connection later on (fig. Stevmanta-16).



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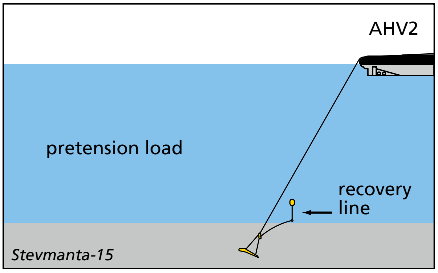

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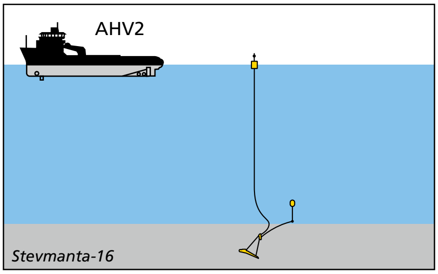
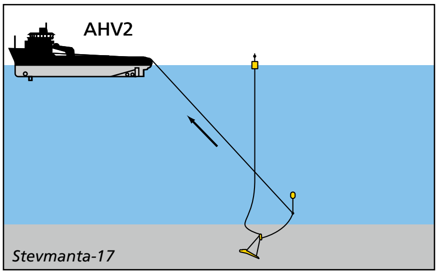


Stevmanta-16



Stevmanta-17

Stevmanta retrieval

The Stevmanta is recovered from the seabed by returning to 'installation mode' instead of the normal (vertical) loading mode. The AHV picks up the recovery buoy from the seabed and by pulling on the installation load at an angle of approximately 450 with the seabed, the anchor is easily retrieved (fig. Stevmanta-17).

Always consult Vryhof for alternative methods or specific applications.

Single line installation with Stevtensioner

The Stevmanta VLA is deployed with the shear pin angle adjuster. The mode of the anchor changes when the shear pin breaks at a load equal to the required installation load. When the shear pin breaks, the Stevmanta VLA changes from installation mode to the normal (vertical) loading mode.

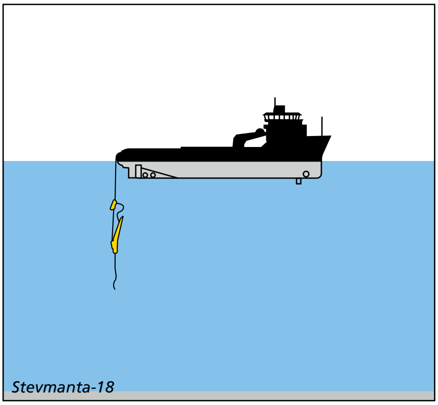
In the installation procedure a tail (approximately 30m length, consisting of a length of wire with approximately 5m of chain on the end) has been included on the Stevmanta VLA. The tail assures correct orientation of the Stevmanta VLA on the seabed.
Connect the tail to the rear of the fluke of the Stevmanta VLA #1. Connect the forerunner to the angle adjuster of the Stevmanta VLA on the AHV.

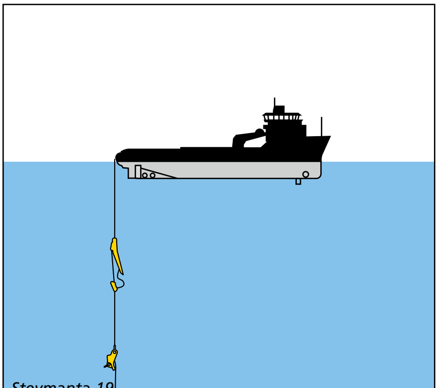
Lower Stevmanta VLA #1 overboard (fig. Stevmanta-18). The Stevmanta VLA will be going downwards tail first, i.e. the tail will be the first part that reaches the seabed.

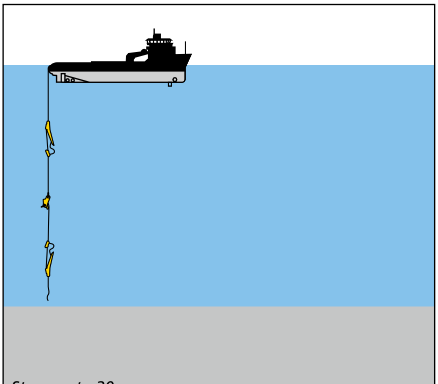
Connect the tensioning chain to the forerunner on Stevmanta VLA #1 using the subsea connector and pass the other end through the Stevtensioner. This end of the chain is terminated with a male part of the subsea connector.

Connect the forerunner of Stevmanta VLA #2 to the passive side of the Stevtensioner. As part of the forerunner a tri-plate is included with the male part of the subsea connector between the Stevtensioner and the tri-plate. The male part of a subsea connector is connected to the third hole of the tri-plate. Connect the AHV work wire to the tail of Stevmanta VLA #2 using a subsea connector.

Deploy the Stevtensioner and Stevmanta VLA #2 overboard by slacking the AHV work wire (fig. Stevmanta-19 and fig. Stevmanta-20).


Stevmanta-18


Stevmanta-19


Stevmanta-20

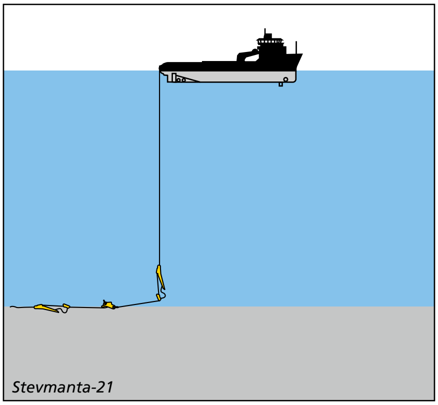
Stevmanta VLA installation

When the tail of Stevmanta VLA #1 touches the seabed, the resistance of the tail will orient the Stevmanta in the heading of the AHV which is moving forward slowly. The AHV places the Stevmanta on the seabed and continues with the deployment of the rest of the system (Stevtensioner and Stevmanta VLA #2) (fig. Stevmanta-21).

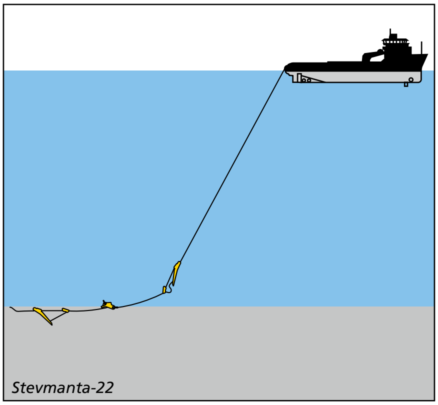
When Stevmanta VLA #2 is near the seabed, the AHV stops the winch and increases the tension in the mooring system (fig. Stevmanta-22). This will start to embed Stevmanta VLA #1. When a tension of approximately 1000 kN has been reached, the AHV can lay down Stevmanta VLA #2 on the seabed. The purpose of the applied tension is to ensure that Stevmanta VLA #1 is embedding properly and to take the slack out of the system.

When Stevmanta VLA #2 has been placed on the seabed, the AHV continues to deploy the work wire until the tail and the subsea connector are on the seabed. When this has been accomplished, the AHV stops paying out the work wire and the ROV is sent down to disconnect the subsea connector from the tail on Stevmanta VLA #2. The female part of the subsea connector (connected to the work wire) is then moved to the male part of the subsea connector connected to the tensioning chain above the Stevtensioner (fig. Stevmanta-23).

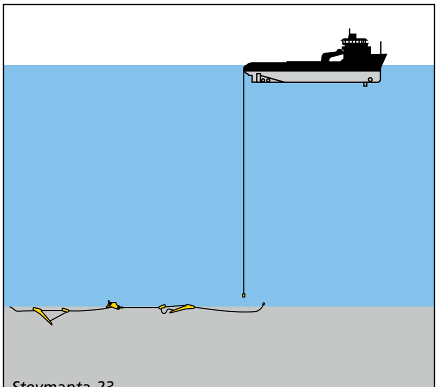
Always consult Vryhof for alternative methods or specific applications.



Stevmanta-21



Stevmanta-22



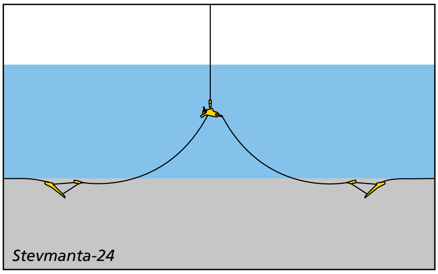
Stevmanta-23

Stevmanta VLA installation

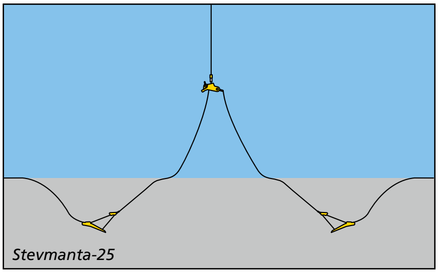
With the work wire now connected to the tensioning chain, the AHV can start the tensioning operation. This will generally consist of 4 to 7 yo-yo procedures to reach the required tension at the anchors. (fig. Stevmanta-24 and fig. Stevmanta-25).

When the tension in the system reaches the break load of the shear pins in the angle adjuster of the Stevmanta VLAs, these will break and trigger the Stevmanta VLAs to their normal loading mode (fig. Stevmanta-26). When the AHV continues to increase the tension in the system, the anchors will be proof loaded in their normal loading mode. After the proof loading of the anchors the tensioning of the anchors is now complete.

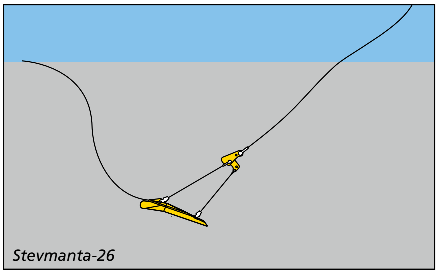
With the tensioning of the anchors completed, the ROV disconnects the subsea connector between Stevmanta VLA #1 and the Stevtensioner (fig. Stevmanta-27), as well as that between the Stevtensioner and VLA #2. The anchor forerunners are now no longer connected to the Stevtensioner. The AHV can start recovering the Stevtensioner with the tensioning chain by winching in the work wire (fig. Stevmanta-28). The ROV can be used to connect the mooring lines (with separate female connectors) to the male connectors on the anchor forerunners.



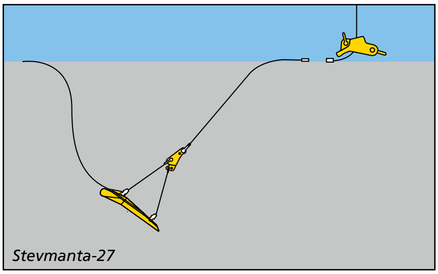
Stevmanta-24



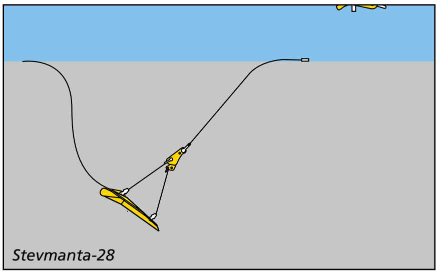
Stevmanta-25



Stevmanta-26



Stevmanta-27

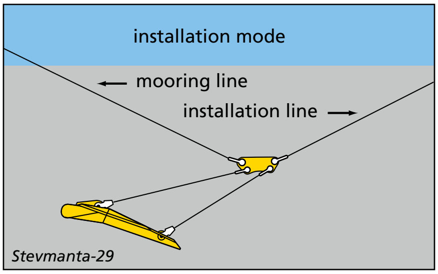


Stevmanta-28

Stevmanta VLA installation

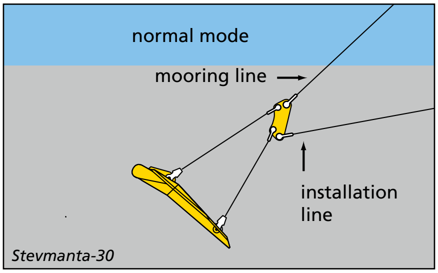
Double line installation with Stevtensioner

The Stevmanta is deployed with the fixed angle adjuster. The mode of the anchor (installation mode or normal (vertical) loading mode) is chosen by pulling on either the installation line or the mooring line. The Stevmanta is in the installation mode when the installation line is tensioned, i.e. the line on the front of the angle adjuster (fig. Stevmanta-29).



Stevmanta-29

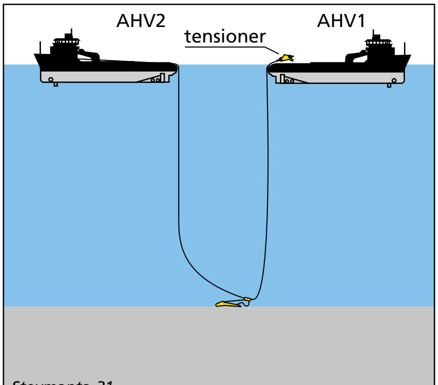
The Stevmanta is in the normal (vertical) loading mode when the mooring line is tensioned, i.e. the line at the rear of the angle adjuster. During the installation AHV1 handles the installation line (preferably chain and steel wire) and AHV2 handles the mooring line, for instance polyester (fig. Stevmanta-30).



Stevmanta-30

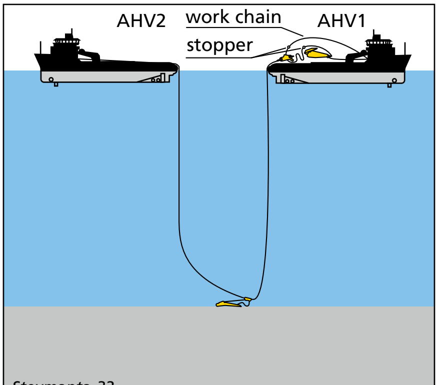
The installation procedure with the Stevtensioner requires a reaction anchor (the typical use of the Stevtensioner is presented in the next chapter). In this case the reaction anchor can be either a Stevpris or Stevmanta. For now a Stevpris is shown as reaction anchor and is to be on the active side of the Stevtensioner.

Connect the installation line to the angle adjuster on the Stevmanta on AHV1. Pass the mooring line from AHV2 to AHV1 and connect it to the angle adjuster.
Lower the Stevmanta to the seabed by keeping tension on both the installation line and mooring line.
Connect the installation line to the passive side of the Stevtensioner. A breaklink can be installed between the Stevtensioner and the installation line on the passive side (fig. Stevmanta-31).



Stevmanta-31

Connect the installation line to the reaction anchor. Pass the installation line through the Stevtensioner (fig. Stevmanta-32).



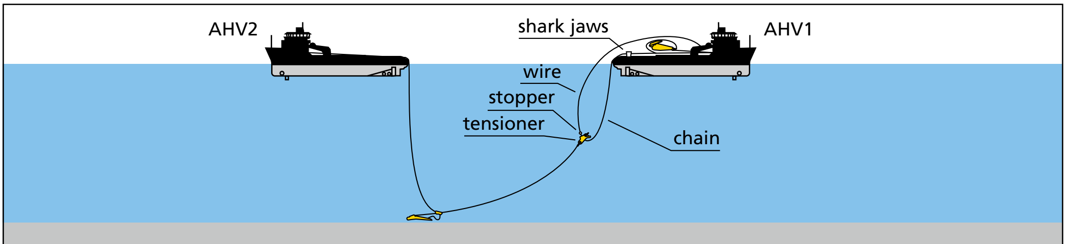
Stevmanta-32

Stevmanta VLA installation

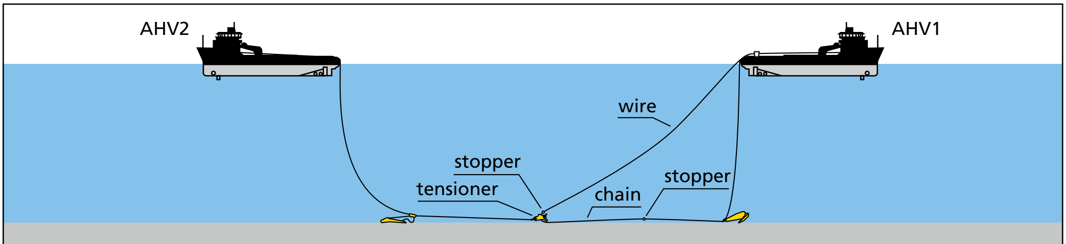
Sail to set-down position of the reaction anchor (AHV1 only). AHV2 stays above the Stevmanta. During the movement of AHV1, the installation line of the Stevmanta has to be paid out (fig. Stevmanta-33).

Lower the Stevtensioner and reaction anchor to the seabed (fig. Stevmanta-34).

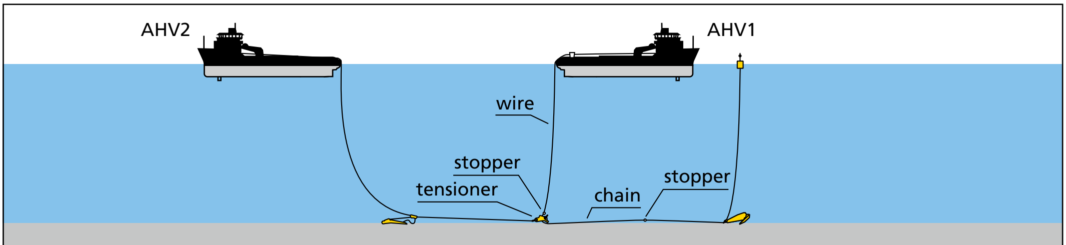
Buoy off the retrieval line (or mooring line) of the reaction anchor. AHV1 sails to tensioning point and starts taking in the slack of the tensioning line (fig. Stevmanta-35).



Stevmanta-33



Stevmanta-34



Stevmanta-35

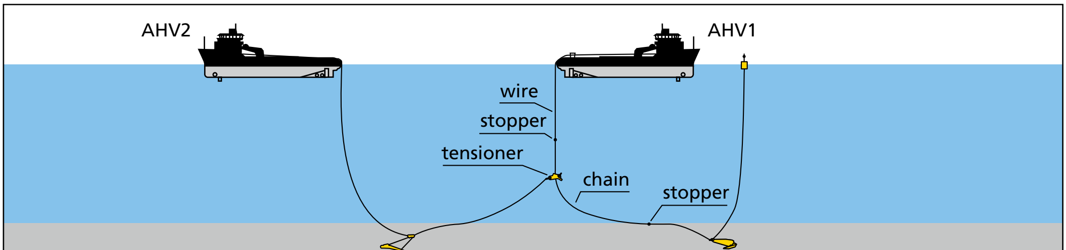
Stevmanta VLA installation

Start the tensioning procedure (yo-yoing) (fig. Stevmanta-36).

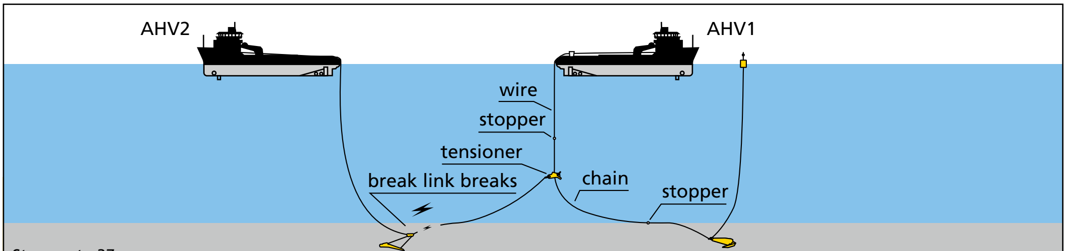
The breaklink will break on the Stevmanta when the required installation load has been reached (fig. Stevmanta-37).

Recover the Stevtensioner, the installation line and the reaction anchor to AHV1.

Always consult Vryhof for alternative methods or specific applications.



Stevmanta-36

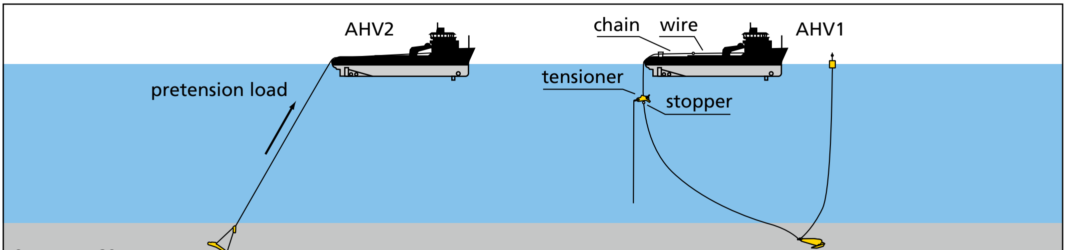


Stevmanta-37

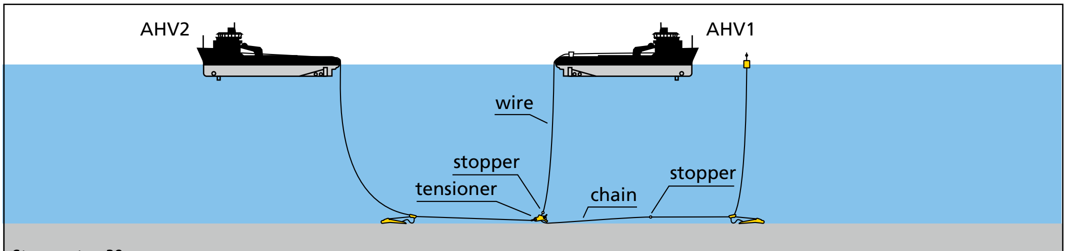
Stevmanta VLA installation

AHV2 can now proof tension the Stevmanta and then buoy off the mooring line. Installation of the Stevmanta is now complete (fig. Stevmanta-38).

Instead of using a reaction anchor, two Stevmantas can also be installed at the same time. After completion of the tensioning (yo-yoing), AHV2 proof tensions one Stevmanta while AHV1 recovers the Stevtensioner and disconnects it from the installation line of the other Stevmanta. This Stevmanta can then also be proof tensioned (fig.Stevmanta-39).



Stevmanta-38



Stevmanta - 39

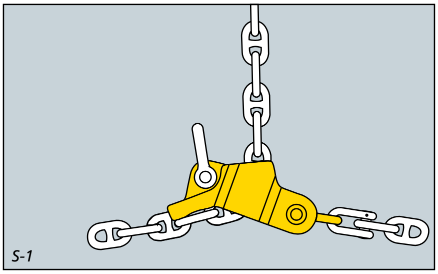
Introduction

The Stevtensioner is used for cross tensioning of diametrically opposed anchor legs. The Stevtensioner is generally used for the installation of (semi) permanent floating structures such as the SPM buoy, STL, TLP, FPS, FPSO, etc. After the tensioning operations the Stevtensioner is demobilised and ready for the next project. The Stevtensioner can however also be used for permanent tensioning purposes, becoming a part of the mooring system.

The Stevtensioner can be deployed from a crane barge, AHV or any vessel having enough crane/winch capacity to pull the required vertical force. Models VA220 and VA500 were designed for handling a single size of chain. The Stevtensioner models VA600, VA1000 and VA1250 can handle chain diameter ranging from 76 mm up to 152 mm. Because of this variety in chain sizes additional work chain may not be required (fig. S-1).

The working principle of the tensioner

The Stevtensioner is based on the principle that a vertical load to a horizontal string causes high horizontal loads. Typically to achieve the required horizontal pretension load at the anchor points, the vertical pulling force only needs to be 40% of this pretension. The anchor line tension is measured by a measuring pin located inside the Stevtensioner and as such well protected against damage caused by handling and lifting operations (fig. S-2).

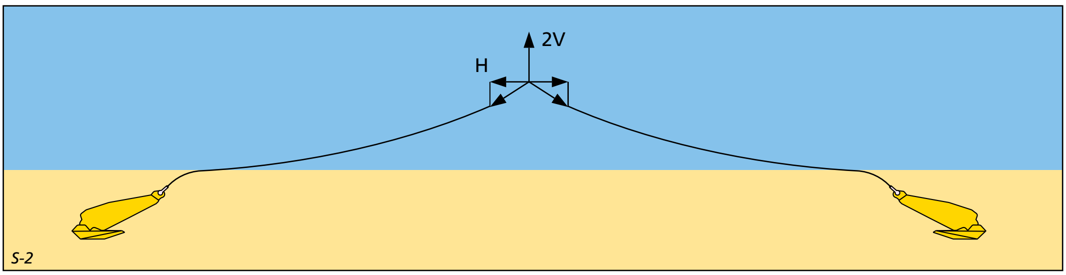


S-1

The new Stevtensioner models offer the following features:

- Smaller dimensions, reduced weight and improved handling, but heavy enough to easilty slide down the mooring line.
- Designed to smoothly guide at least 5 links and therefore prevent chain getting stuck inside.
- Due to economical volume/weight ratio, the new Stevtensioner models allow for containerised freight by either sea or, for rush deliveries, by air.
- The integrated shape allows for smooth passage over stern roller.
- Load measuring pin is equipped with two independent sets of strain gauges. The umbilical cable connections are protected against handling and lifting operations. These connections may be used for acoustic transfer of the signals.

table S

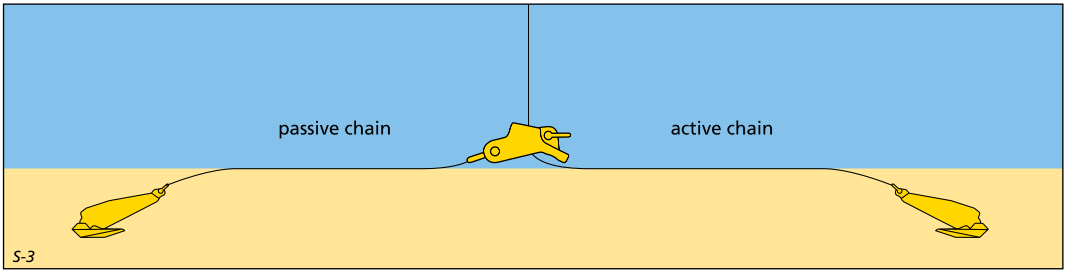


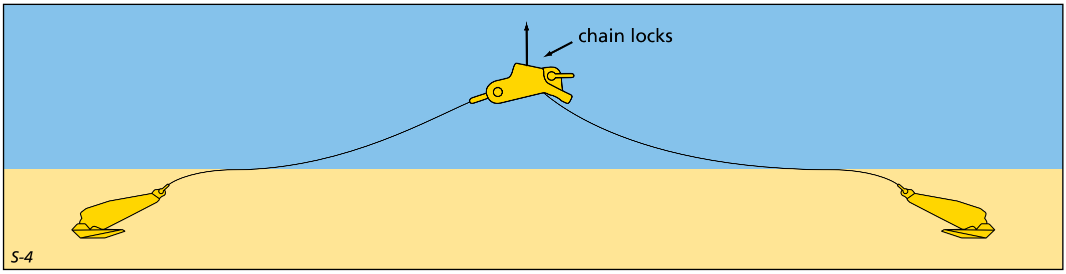
S-2

The Stevtensioner

One anchor line (passive line) is attached to the tension measuring pin at the Stevtensioner and remains a fixed length during operations. The opposite anchor line (active line) passes through the Stevtensioner and varies in length during the operations.. Tensioning starts by applying the yo-yo movement to the active line (fig. S-3).

When the Stevtensioner is lifted by the active chain, a chain link becomes locked within the Stevtensioner. When the Stevtensioner is lifted from the seabed, the passive and active mooring lines are also lifted. Consequently the anchors or piles are loaded and cause an inverse catenary of the mooring line in the soil, as well as causing a drag anchor to drag and embed. In other words: chain length is gained. Lowering the Stevtensioner slackens the anchor lines and allows it to slide down over the active chain. By repeating this several times (called the yo-yo movement), the horizontal load on the anchor points increases. Generally the required horizontal load is achieved after 5 to 7 steps. Once tensioning is completed, the Stevtensioner can be recovered by hauling in the lifting/pennant wire causing the Stevtensioner to slide up along the active chain to the surface (fig. S-4).





Measurement of the tensions applied

Fig. S-5 shows the curve recorded during tensioning of chains connected to piles for the Coveñas Pipeline Project in Colombia. The graph shows a total of 5 heaves (yo-yo's), each resulting in a higher tension.

Different methods can be applied to verify the tension in the chain. These are discussed below.

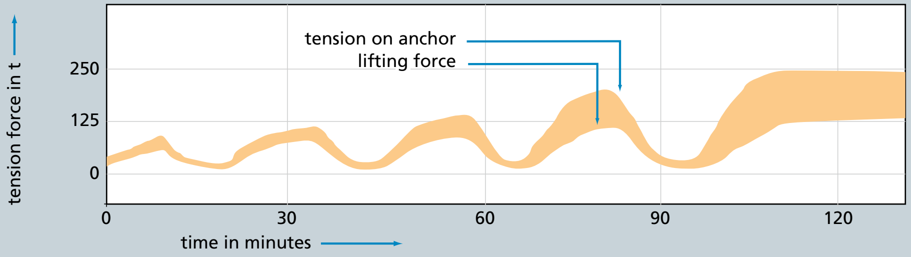
Computer calculations

Prior to the tensioning operations analysis is undertaken of the known parameters of submerged chain weight, length and composition of the mooring lines and the required installation or proof-load tension. This gives a target passive side chain tension at a predicted vertical heave height of the Stevtensioner (from the seabed). The passive side chain tension at the point the chain connects to the Stevtensioner can be monitored and recorded and this combined with the target tension greatly simplifies the tensioning operations.

However, if needed, the tension in both the passive and active chain can be calculated post operations by means of catenary calculations. Besides the known parameters, other parameters measured during tensioning need to be incorporated in the calculation, such as:

- Height of the Stevtensioner above the seabed.
- Vertical pulling load.
- Mooring anchoring point separation.

By using this method the tension in the chain can be calculated at any height of the Stevtensioner above seabed. This method is independent of the water depth.



S-5

Umbilical cable and measuring pin

The standard and preferred method to measure the chain tension at the Stevtensioner is by use of a measuring pin. The pin is an integral part of the Stevtensioner housing and is equipped with strain gauges. All tension level data can be recorded and presented on deck during tensioning on a readout unit or retrieved at a later time. Several means of recording or transferring the data from the Stevtensioner to the deck of the installation vessel are available.

- **Umbilical Cable**

The use of an umbilical cable is an effective method in water-depths down to approximately 300m using an electrical powered winch and down to approximately 150m using a hand winch. Each has slip rings which allows the umbilical cable to be hauled on board without disconnecting the umbilical. The umbilical cable is usually connected at deck level prior to deployment, but can be connected by ROV if available. The measurement is insensitive to cable length and waterdepth.

- **ROV Connection**

If a work-class ROV is available then the umbilical cable can be connected once the Stevtensioner has been deployed and lowered to an appropriate depth for the ROV to operate. An ROV stab is used to make the connection at the Stevtensioner, the umbilical cable being disconnected after the operations have been completed and the Stevtensioner is ready to be retrieved to deck level.

- **Acoustic Data Transmission**

For depths greater than approximately 100m, acoustic transmission of tension data to the installation vessel becomes viable. An acoustic modem can be mounted upon the Stevtensioner with the acoustic signal being received by either an on board system (such as HiPAP) which is preferable or by installed microphone pickups.

- **Local Storage and Data Display.**

This equipment is a local archiving system which is mounted onto the Stevtensioner and records the load cell reading and surrounding water pressure. A visible readout displays the load and pressure enabling it to be monitored by ROV. The data is recovered (downloaded) from the unit when it is back on deck.

Duration of pretensioning anchors and piles

Once the required tension has been achieved, the tension has to be maintained for a certain duration. This period is described in the table below for various Certification Authorities.

Certification Authority	Required duration of maintaining tension
Lloyds Register of Shipping	20 minutes
American Bureau of Shipping	30 minutes
Det Norske Veritas (NMD)	15 minutes

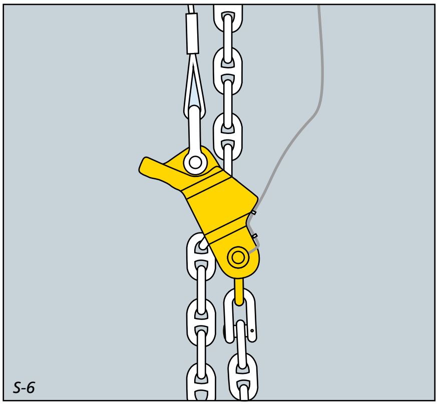
In the case of a drag anchor this duration must be continuous, but in the case of piles, it may be acceptable to accumulate the duration.

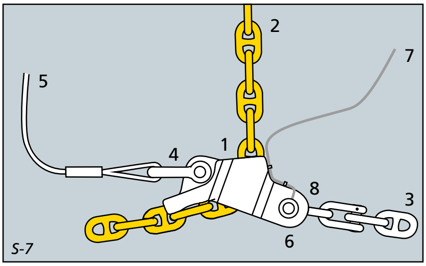
Handling the Stevtensioner

Handling operations can generally be described as follows:

- Positioning the anchors and paying out the chain
- Connecting all necessary hardware for tensioning operations on deck of barge or AHV
- Deploying Stevtensioner to the seabed and positioning of the installation vessel
- First lift (yo-yo)
- Series of yo-yo's
- Maintain required tension for a specified period of time
- Retrieve the Stevtensioner and disconnect
- Prepare for next tensioning

A Stevtensioner can be deployed from a crane barge, Anchor Handling Vessel or any vessel having enough crane/winch capacity to lift the required vertical force.


S-6



S-7

General handling procedure

General handling procedure using a crane barge or AHV for Stevtensioner models VA600, VA1000 and VA1250 is presented in fig. S-6 and S-7.

Connection

Pass the active chain (2) through the tensioner (1) on deck. Connect passive chain (3) to measuring pin shackle (8). Connect dislock wire (5) to shackle (4). Connect umbilical cable (7) to read-out system on deck and to the measuring pin (6).

Lowering

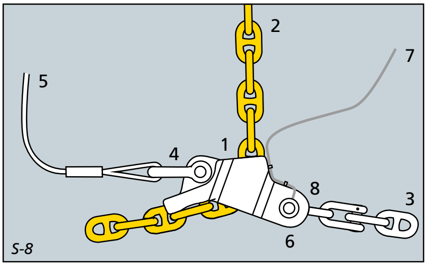
Fix active chain (2) to winch or crane hook. Slack dislock wire (5) and lower Stevtensioner to seabed. Stevtensioner will pass over active chain (2).

The Stevtensioner

Tensioning mode

When Stevtensioner is on seabed, slack dislock wire (5) before the first yo-yo, and keep slack during all yo-yos!

Tensioning is achieved by pulling on active chain (2). The mooring lines will be lifted from the seabed causing the anchors or piles to be loaded. After each yo-yo active chain is gained. The active chain can only pass through the Stevtensioner in one direction. Approximately 4 to 7 yo-yos are required to obtain the required pretension load (fig. S-8).



S-8

Retrieving

When tensioning is completed be sure to lower the Stevtensioner to seabed and slack off active chain (2) before retrieving Stevtensioner with dislock wire (5). Pull on dislock wire (5). Stevtensioner will pass over chain (2). Disconnect Stevtensioner on deck of the barge or AHV.

Stevtensioner Product Range

The following Stevtensioners are available from Vryhof Anchors.

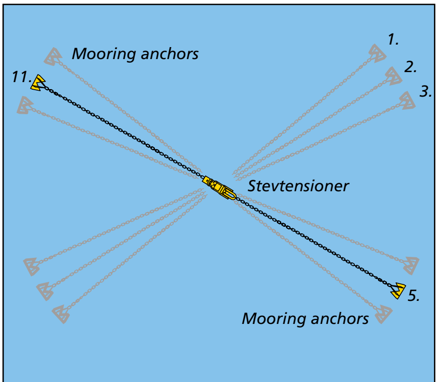
Stevtensioner model	Maximum horizontal load [t]	Suitable* for chain size with Kenter shackle [mm]	Suitable* for chain size without Kenter shackle [mm]	Size Stevtensioner lxhxw [m]	Weight Stevtensioner [t]
VA 600	600	76 - 84	76 - 87	2.2 x 0.9 x 0.6	3.8
VA1000	1000	102 - 117	102 - 135	3.1 x 1.2 x 0.8	7
VA1250	1250	114 - 132	114 - 152	5.3 x 1.8 x 1.0	17

* The suitability only refers to the section of chain passing through the Stevtensioner. Chain or wire not passing through the Stevtensioner may have any dimension.

table T

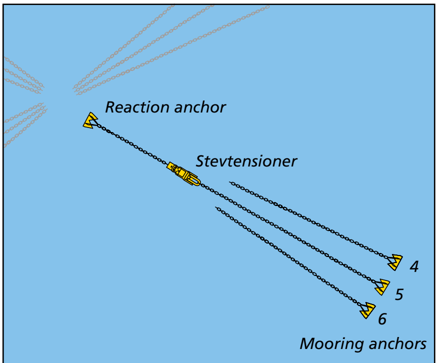
Stevtensioning modes
Essentially, there are three modes of conducting Stevtensioning operations:

Cross-tensioning opposing anchoring points
This applies the tensioning load simultaneously to two opposing anchors in the mooring spread. With this process both anchoring points are subjected to the tension load at the same time, hence two anchors may be installed in one operation or the inverse catenary of two anchor piles can be developed in one operation (fig. S-9).



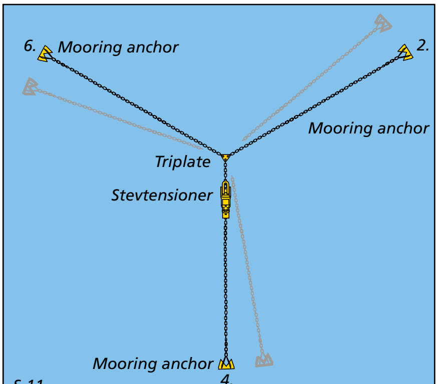
S-9

Tensioning against a reaction anchor
In appearance this is the same as cross-tensioning, but a temporary reaction anchor is used rather than an opposite mooring system anchoring point. The reaction anchor is laid on the azimuth of the system anchoring point (or on the central azimuth of an anchor cluster) and is recovered after the operations are complete. The reaction anchor must be of an appropriate size for the imposed loads and soil type (fig. S-10).



S-10

Simultaneous tensioning of 3 anchor points (3-way tensioning)
If the mooring system is symmetric in layout, mooring line length and composition and required installation load, then the Stevtensioner may be used to impose tension simultaneously to 3 equally spaced mooring lines (fig. S-11).



S-11

Required Installation Vessel
As the Stevtensioner converts a small vertical load to a much higher horizontal load, much smaller capacity and less costly vessels can be used for the operations and a fairly modest AHV or crane barge can be used for the work. It is recommended that a capacity of at least 120% of the required vertical load at the waterline is available.

Within shallow waters it may be necessary for the Stevtensioner to be lifted above the water-line. In such circumstances an AH cannot be used and a crane barge would be needed.

Supply vessels/anchor handling vessels

Drilling rigs are generally moored with 8 to 12 anchors. These are laid in a mooring pattern. Originally normal tugs were used for these operations, but very soon, there was a call for specialised vessels.

For anchor handling vessels, it is very important to be able to work quickly and effectively. Much depends on the expertise of the captain and crew. The equipment and its design are also extremely important. Engine power has to be sufficient to handle chain and/or wire and anchors at the water depth concerned. The newest generation of AHVs has bollard pulls far in excess of 380 T.

Care should be given to the rated maximum bollard pull which in reality might be less, depending on the simultaneous use of other power consuming equipment such as bow (and sometimes) stern thrusters, winches, etc.

The quoted winch capacity often causes confusion. An AHV owner demonstrates maximum pulling capacity at the bare drum during the maiden trip, but a contractor requires high winch output when the drum is 70 to 100% wound with wire under working conditions. It is also possible that an owner limits the pressure of the hydraulic system below factory limits, to reduce winch wear and repair costs.

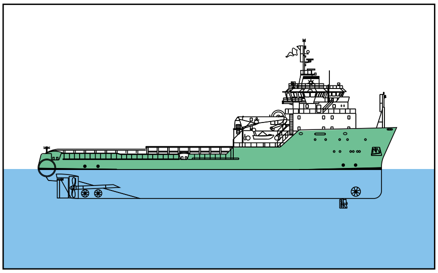
The dynamic capacity of the winch brake is particularly important when a long heavy chain must be deployed. Hydraulically and electrically braked drums are more efficient than band brakes.

For handling chain, many supply vessels have chain lockers below decks and a wildcat above the chain locker to handle the chain.

To ensure easy handling of chain and wire, simple, well-constructed tools are necessary. An experienced crew will also make the handling easier.

These specialised anchor handling vessels (AHVs) now have:

- A large deck space.
- Powerful winches, with auxiliary winches to reel extra wires.
- Large chain lockers, for storage of the chain.
- Large wire storage capacity.
- An adapted seaworthy design and very manoeuvrable with bow and stern thrusters. Some even with a dynamic positioning system.
- Space for drilling mud and fuel tanks for supply to drilling rigs.
- Small auxiliary cranes.
- One or two sets of towing pins and shark jaws.
- A stern roller that sometimes consists of two individually rotating drums.



Pre-installation of a mooring system

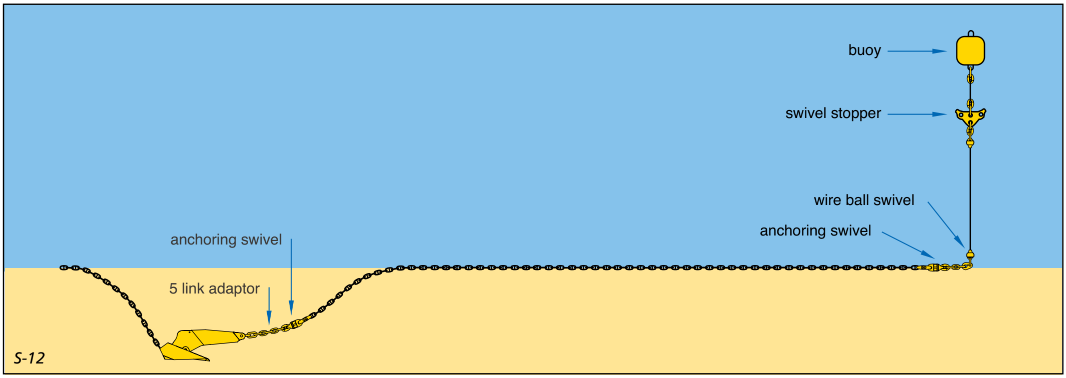
There are several reasons for an operator to choose for pre-installation of a mooring system. In case of a permanent system this choice seems obvious, for mobile units however the objectives may vary from case to case.

Generally it is believed that installation of the mooring system in advance of arrival of the MODU reduces the time required for the rig move and reduces downtime. Although this is a significant saving, the objective of avoiding weather window limitations and operational delays, such as relocation or re-setting of the anchors, is an even more considered objective.

The preparations for the pre-installation of a mooring system, such as mooring design do not differ from the conventional system, except for operations in areas where special certification is required, the responsibility for which is normally delegated to the installation contractor by the operator.

Installation of the system itself, also referred to as 'pre-laid', does not differ from any other installation and can generally be performed by a single AHV. Planned timing of the operation may experience more equipment availability and when tensioning operations are included the planning may further reduce the capacity and costs of the AHV required.

The pre-installed mooring lines are generally buoyed off to keep them free from the seabed to facilitate easy pick-up at the time the MODU arrives to be hooked-up to the mooring system (fig. S-12).



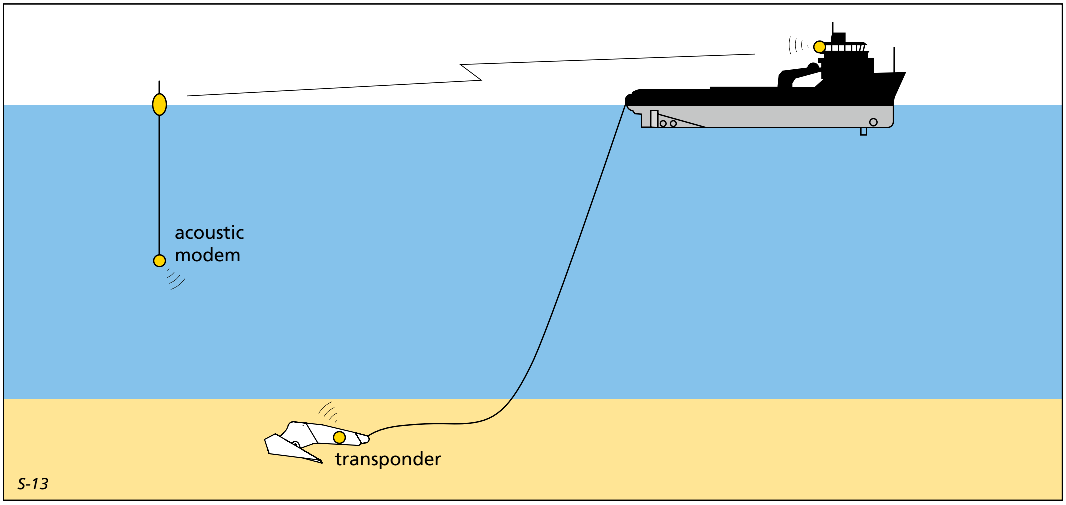
S-12

Stevtrack installation monitoring system

For decades a calculation method served to determine a drag anchor's final position in the seabed. As the need for factual, measurable data an electronic data acquisition system became evident, and was developed by Vryhof.

This system, called Stevtrack, consists of a transponder on each of the anchors, a set of signal transmission equipment, a deep water transducer if required and a surface read-out computer that translates the received data into graphic images and data read outs (fig. S-13).
When the anchor touches the seabed, its transponder transmits to the read-out unit on deck its orientation: pitch and roll. After it has confirmed the correct position on the seabed and during pull in, it accurately reports the load on the anchor and its depth and drag length until final penetration.

The pull-in force measured this way is far more accurate than that read on the anchor handler's winch. One of the aims in the further development of the system is to have the system approved to replace the loading otherwise required by the Qualification Authorities.
The system also allows monitoring post-installation behaviour of the mooring system, measured at intervals depending on battery capacities. It stores all data in a file, allowing to retrieve historical data for a certain location of specific soil type.



S-13

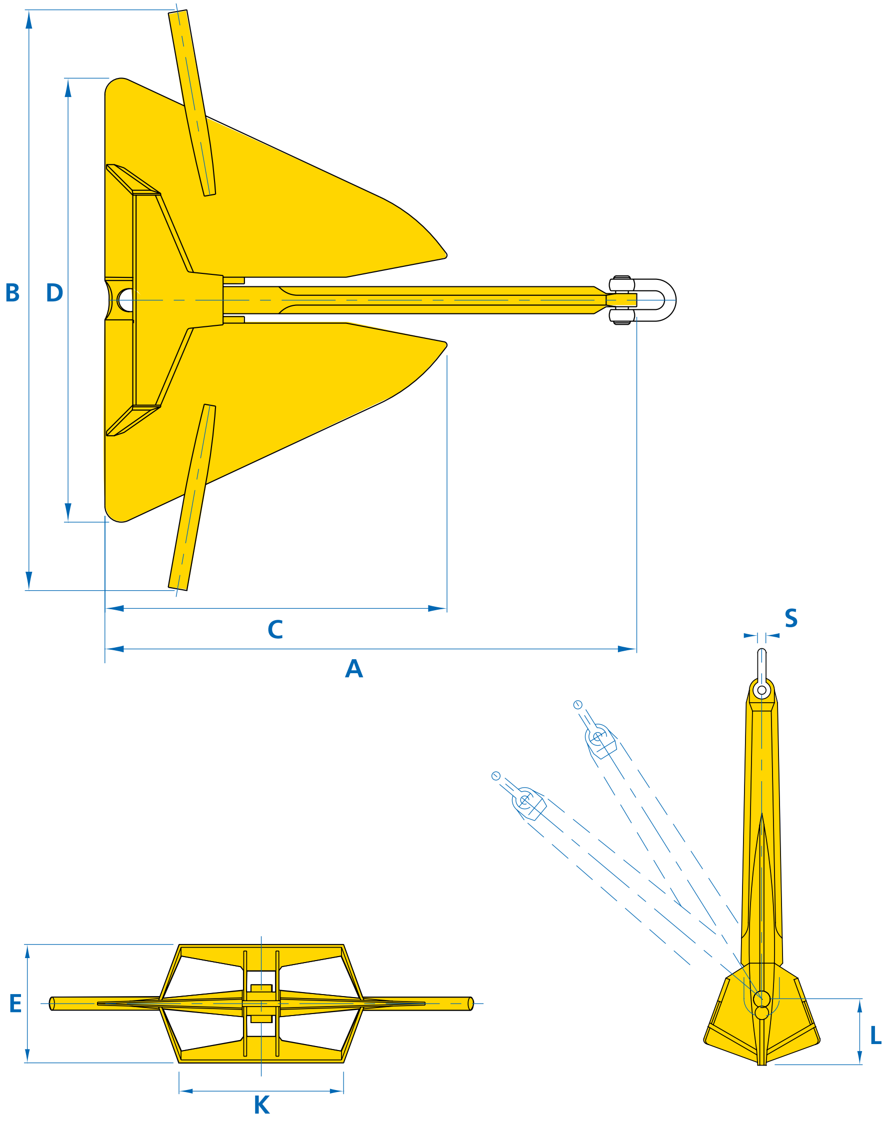
5

Product Data

In this edition of the Vryhof anchor manual, we have given the reader as much information as we imagined would normally be needed. Undoubtedly some is missing. This can be Vryhof-specific or general information. Vryhof-specific information can be related to brochures, detailed handling recommendations and product data. Most data you will find available on the Vryhof website www.vryhof.com. Otherwise more specific data or information can be optained on request.

To make the next edition of the anchor manual suit the requirements of the reader even better, your suggestions or comments, including the feed-back from your operations, are most welcome.

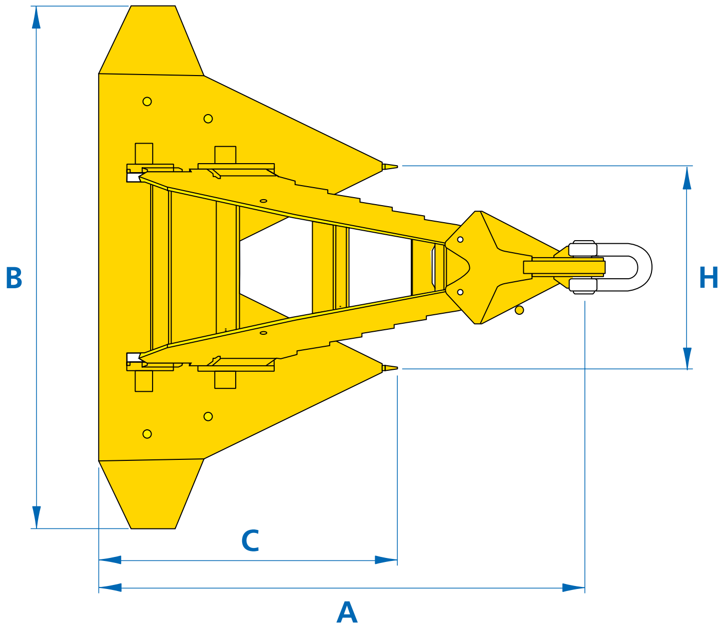
Dimensions of the Vryhof Stevin® Mk3 anchor

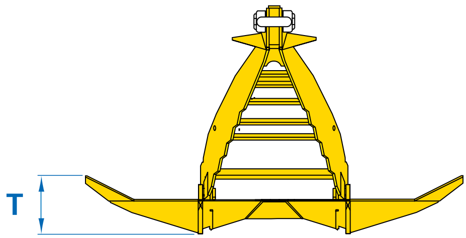


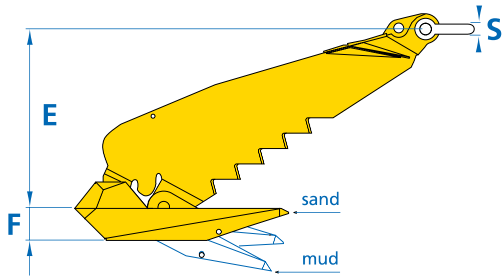
Note: The dimensions of the Stevin Mk3 anchor may be changed for specific applications

Main dimensions Stevin Mk3 dimensions in mm anchor weight in kg										
weight	1000	1500	3000	5000	7000	9000	12000	15000	20000	30000
A	2429	2774	3493	4120	4602	5012	5516	5942	6372	7289
B	2654	3038	3828	4538	5077	5521	6076	6545	6986	7997
C	1559	1785	2249	2667	2983	3244	3570	3846	4100	4694
D	2023	2316	2918	3460	3871	4209	4632	4990	5324	6094
E	737	843	1063	1260	1409	1533	1687	1817	2048	2345
K	1010	1156	1456	1727	1932	2100	2312	2490	2674	3061
L	412	471	594	704	788	857	943	1016	1083	1240
S	60	65	80	80	90	100	110	120	160	180

Dimensions of the Vryhof Stevshark® Mk5 anchor



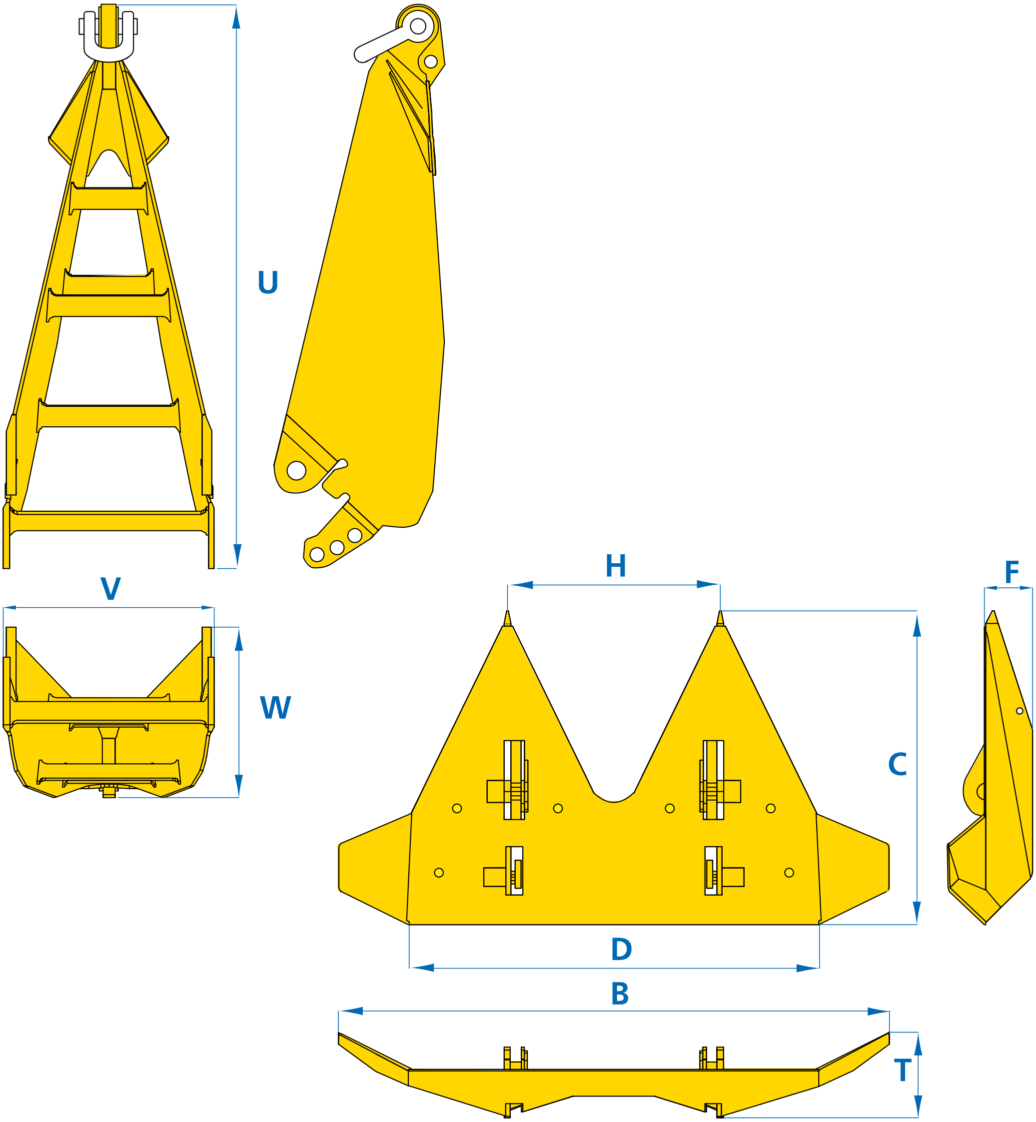




Note: The dimensions of the Stevshark Mk5 anchor may be changed for specific applications

Main dimensions Stevshark Mk5 dimensions in mm anchor weight in kg													
weight	1500	3000	5000	8000	10000	12000	15000	18000	20000	22000	25000	30000	65000
A	2862	3605	4275	4999	5385	5723	6165	6551	6785	7004	7309	7767	10051
B	3085	3886	4608	5389	5805	6169	6645	7062	7314	7550	7879	8373	10834
C	1755	2212	2622	3067	3304	3511	3782	4019	4163	4297	4484	4765	6166
E	1458	1837	2178	2547	2743	2915	3140	3337	3457	3568	3723	3957	5120
F	263	332	393	460	495	526	567	602	624	644	672	714	924
H	1192	1502	1780	2082	2243	2383	2567	2728	2826	2917	3044	3235	4186
S	80	90	110	130	140	150	160	170	180	190	200	210	300

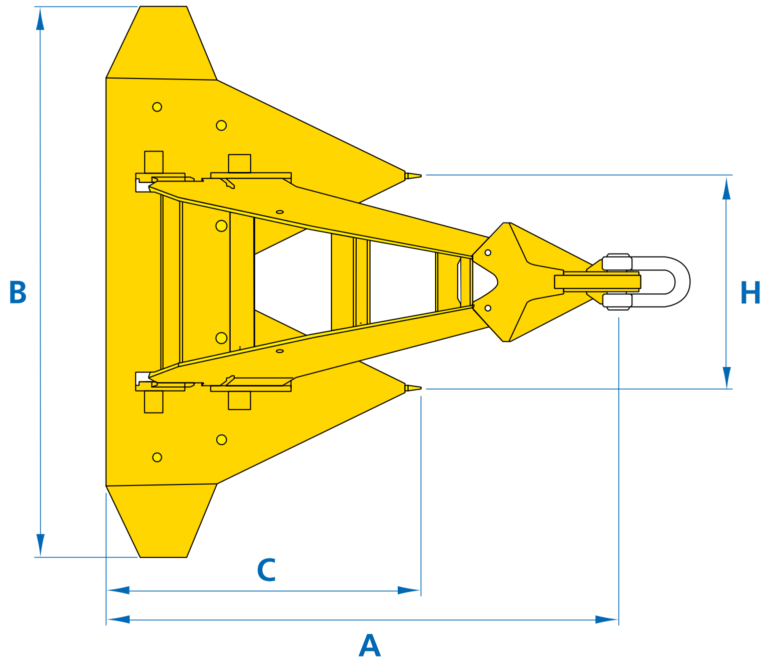
Dimensions of the Vryhof Stevpris® Mk5 anchor

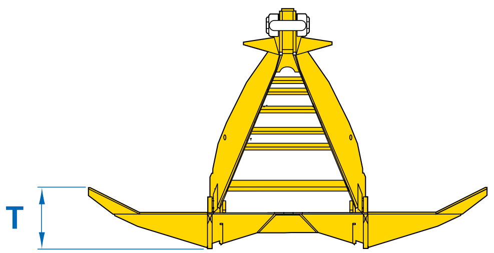


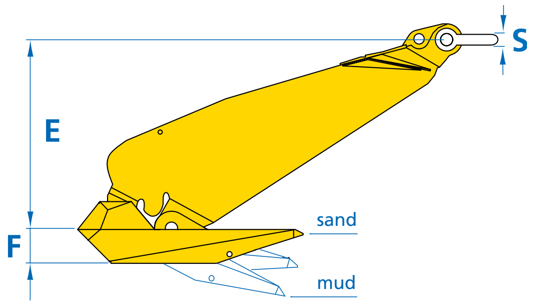
Note: The dimensions of the Stevpris Mk5 anchor may be changed for specific applications

Transport dimensions Stevpris Mk5 dimensions in mm anchor weight in kg													
weight													
anchor	1500	3000	5000	8000	10000	12000	15000	18000	20000	22000	25000	30000	65000
fluke	600	1300	2100	3400	4300	5200	6400	7700	8600	9400	10700	12900	27900
shank	900	1700	2900	4600	5700	6800	8600	10300	11400	12600	14300	17100	37100
B	3184	3999	4750	5550	5980	6348	6848	7278	7547	7799	8123	8650	11193
C	1812	2283	2707	3166	3411	3625	3904	4149	4297	4436	4629	4919	6365
D	2367	2969	3529	4122	4442	4714	5087	5407	5609	5799	6035	6431	8322
H	1232	1538	1831	2140	2301	2443	2642	2808	2920	3016	3135	3345	4328
T	494	623	739	864	930	989	1065	1132	1172	1210	1263	1342	1737
U	3294	4141	4913	5747	6190	6578	7090	7533	7806	8060	8406	8936	11563
V	1221	1526	1817	2120	2285	2422	2618	2783	2891	2994	3108	3321	4297
W	984	1240	1470	1719	1852	1968	2120	2253	2334	2409	2514	2671	3456

Dimensions of the Vryhof Stevpris® Mk5 anchor





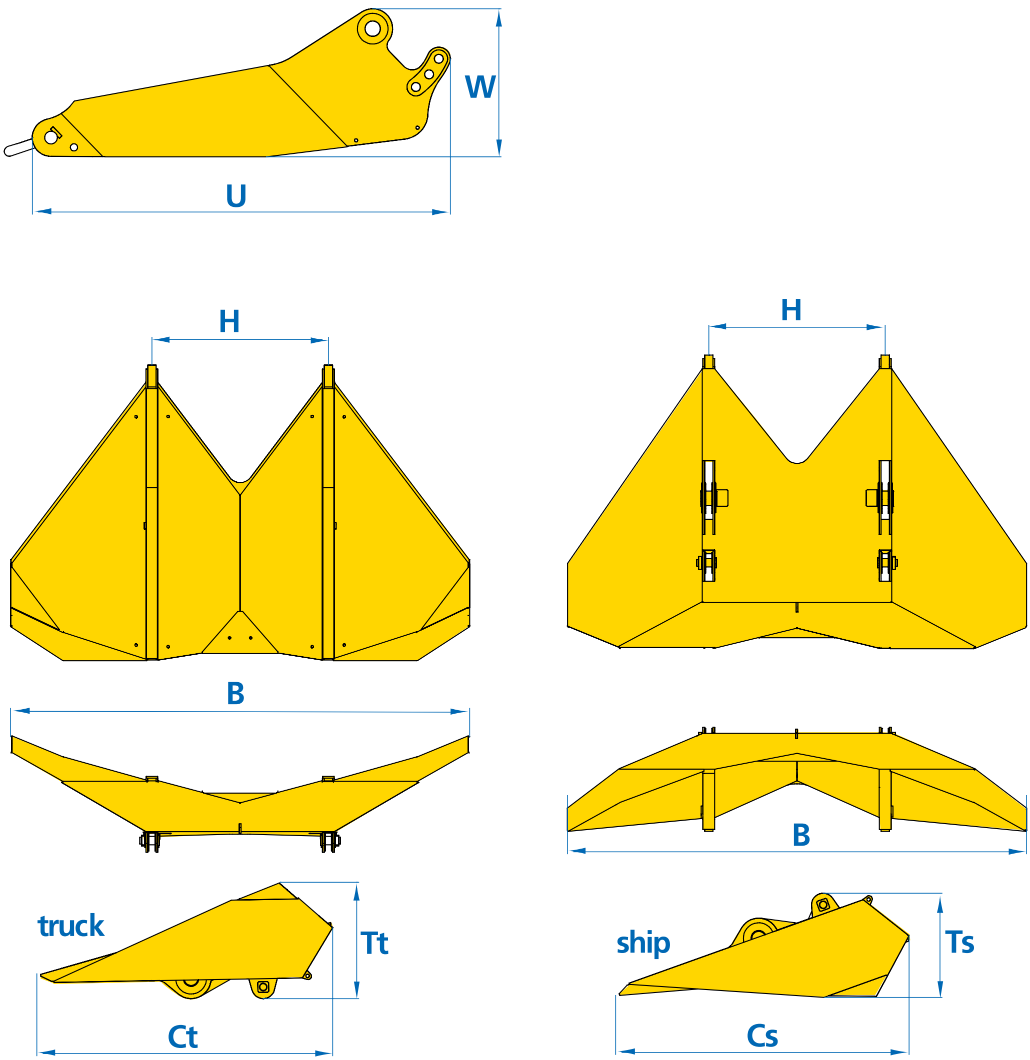


Note: The dimensions of the Stevpris Mk5 anchor may be changed for specific applications

Main dimensions Stevpris Mk5 dimensions in mm anchor weight in kg

weight	1500	3000	5000	8000	10000	12000	15000	18000	20000	22000	25000	30000	65000
A	2954	3721	4412	5161	5559	5908	6364	6763	7004	7230	7545	8018	10375
B	3184	4011	4756	5563	5992	6368	6860	7290	7550	7794	8133	8643	11184
C	1812	2283	2707	3166	3410	3624	3904	4149	4297	4436	4629	4919	6365
E	1505	1896	2248	2629	2832	3010	3242	3446	3569	3684	3844	4085	5286
F	271	342	406	474	511	543	585	622	644	665	694	737	954
H	1230	1550	1837	2149	2315	2460	2650	2816	2917	3011	3142	3339	4321
T	493	622	738	862	929	988	1064	1131	1171	1209	1262	1341	1736
S	80	90	110	130	140	150	170	180	190	200	200	220	300

Dimensions of the Vryhof Stevpris® Mk6 anchor

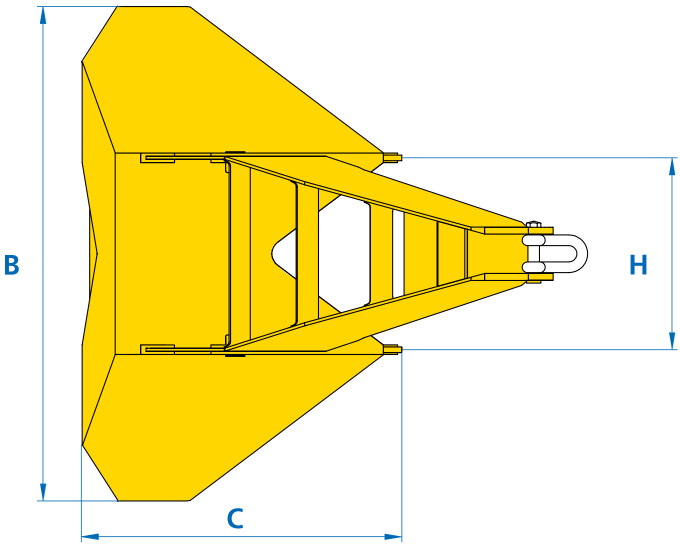


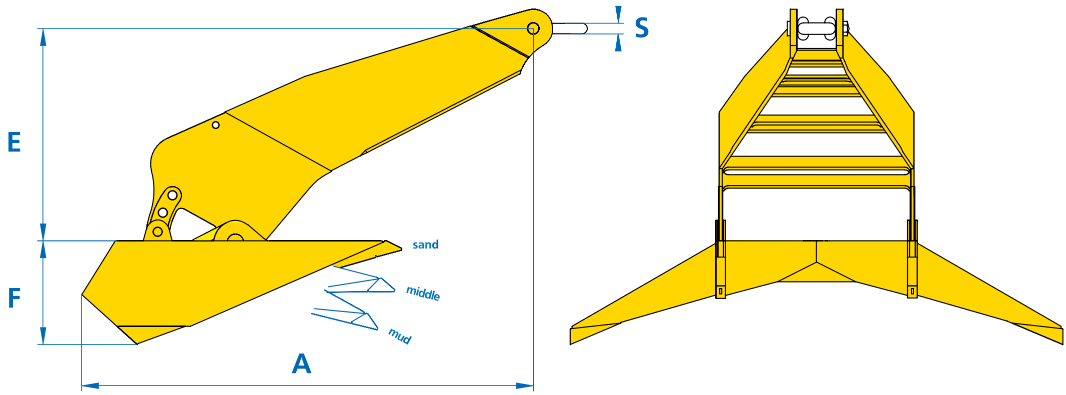
Note: The dimensions of the Stevpris Mk6 anchor may be changed for specific applications

Transport dimensions Stevpris Mk6 dimensions in mm anchor weight in kg

weight	1500	3000	5000	8000	10000	12000	15000	18000	20000	22000	25000	30000
B	3060	3870	4600	5390	5810	6170	6680	7100	7370	7630	7960	8450
Ct	1980	2490	2950	3450	3720	3950	4260	4520	4690	4840	5050	5360
Cs	1960	2470	2930	3430	3690	3920	4230	4490	4650	4800	5010	5320
H	1170	1490	1780	2090	2250	2390	2610	2780	2890	3000	3140	3320
Tt	780	980	1160	1360	1460	1550	1680	1780	1840	1900	1990	2110
Ts	700	880	1040	1220	1310	1390	1500	1590	1650	1700	1780	1890
U	2790	3520	4170	4880	5260	5590	6020	6400	6620	6840	7140	7580
V	1210	1540	1830	2150	2320	2460	2690	2860	2970	3090	3230	3420
W	990	1250	1480	1730	1860	1980	2130	2270	2350	2420	2530	2690

Dimensions of the Vryhof Stevpris® Mk6 anchor



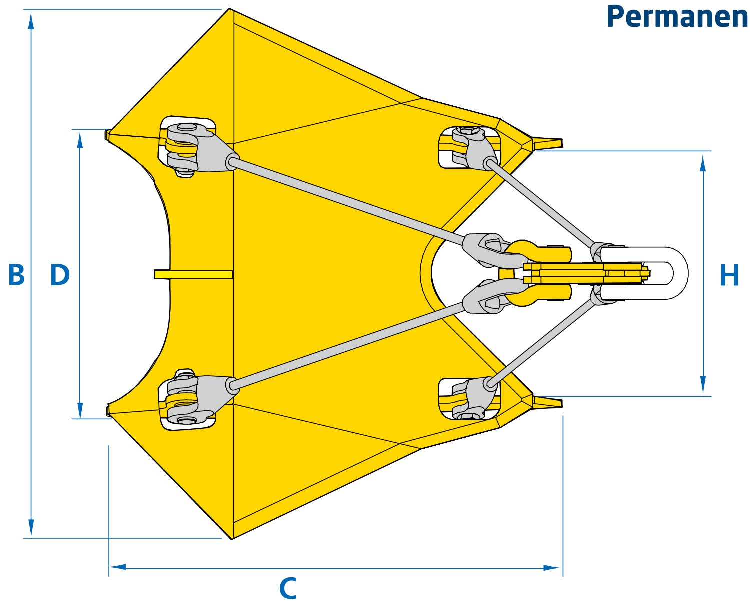


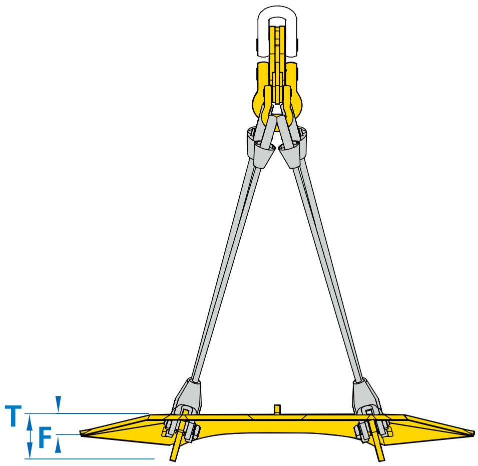
Note: The dimensions of the Stevspris Mk6 anchor may be changed for specific applications

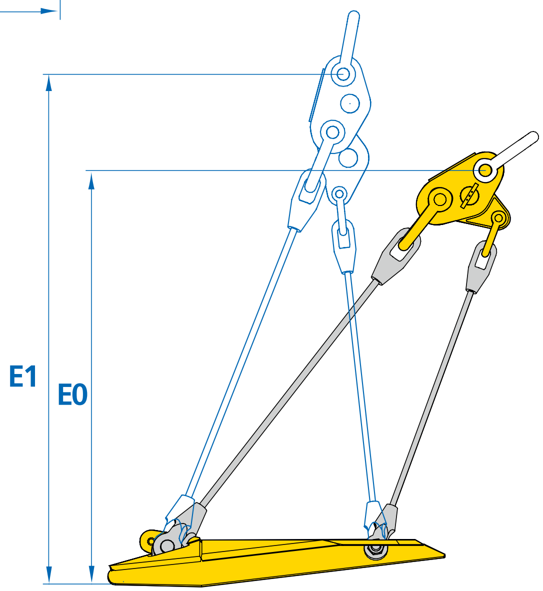
Main dimensions Stevpris Mk6 dimensions in mm anchor weight in kg												
weight	1500	3000	5000	8000	10000	12000	15000	18000	20000	22000	25000	30000
A	2797	3523	4178	4886	5263	5593	6025	6402	6631	6845	7143	7591
B	3059	3870	4602	5390	5807	6171	6679	7101	7368	7625	7962	8451
C	1981	2495	2958	3460	3728	3961	4267	4534	4696	4848	5059	5376
E	1321	1664	1973	2308	2486	2642	2846	3024	3132	3234	3374	3586
F	641	808	958	1120	1206	1282	1381	1468	1520	1569	1637	1740
H	1170	1490	1781	2090	2253	2394	2610	2777	2890	3002	3138	3324
S	65	80	100	120	130	140	160	170	180	190	200	210

Dimensions of the Vryhof Stevmanta® VLA anchor

Permanent applications





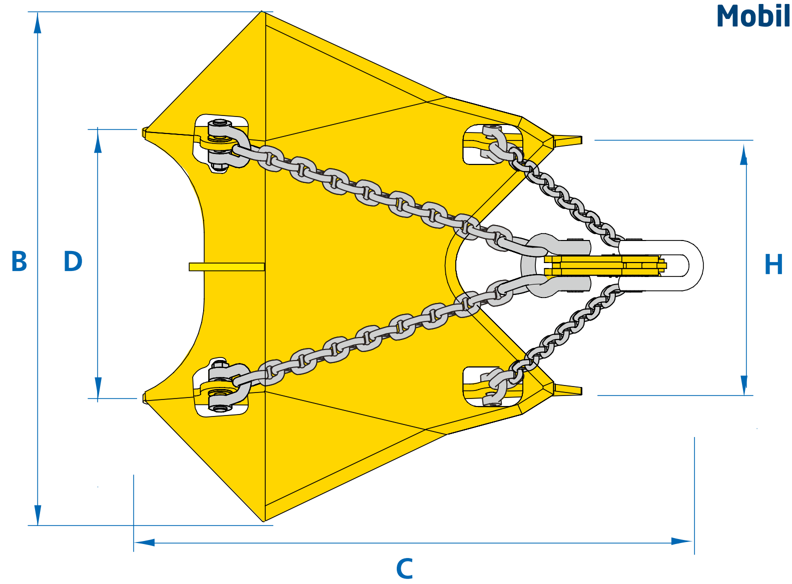


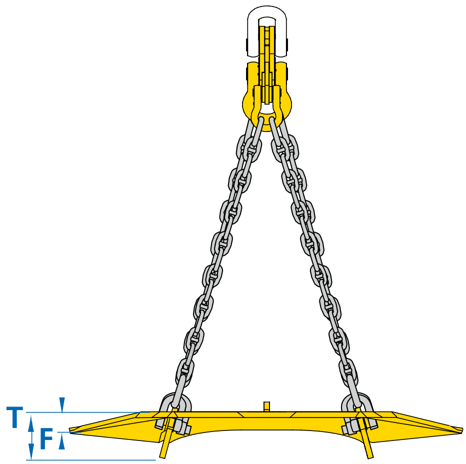
Note: The dimensions of the Stevmanta VLA anchor may be changed for specific applications

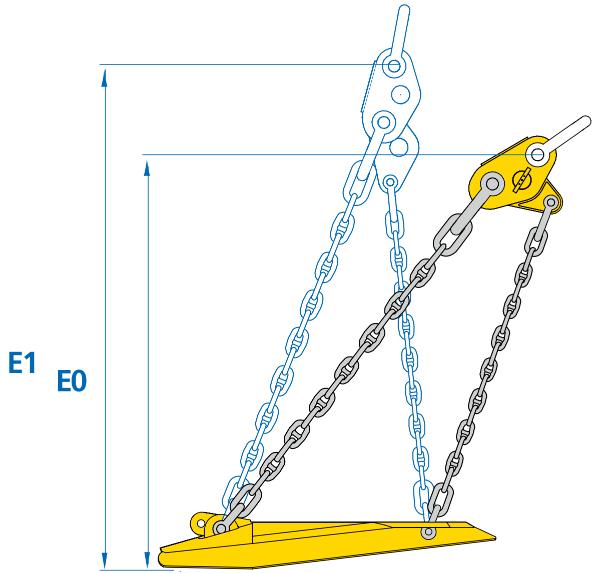
Main dimensions Stevmanta VLA dimensions in mm area in m²							
area	5	8	10	12	15	17	20
B	3143	3975	4445	4869	5443	5795	6286
C	2976	3765	4209	4611	5155	5488	5953
D	1945	2460	2750	3013	3368	3586	3890
E0	3075	3890	4349	4764	5326	5670	6150
E1	3371	4264	4767	5222	5839	6216	6742
F	172	217	243	266	298	317	344
H	1459	1845	2063	2260	2527	2690	2918
T	639	809	904	991	1107	1179	1279

Dimensions of the Vryhof Stevmanta® VLA anchor

Mobile applications





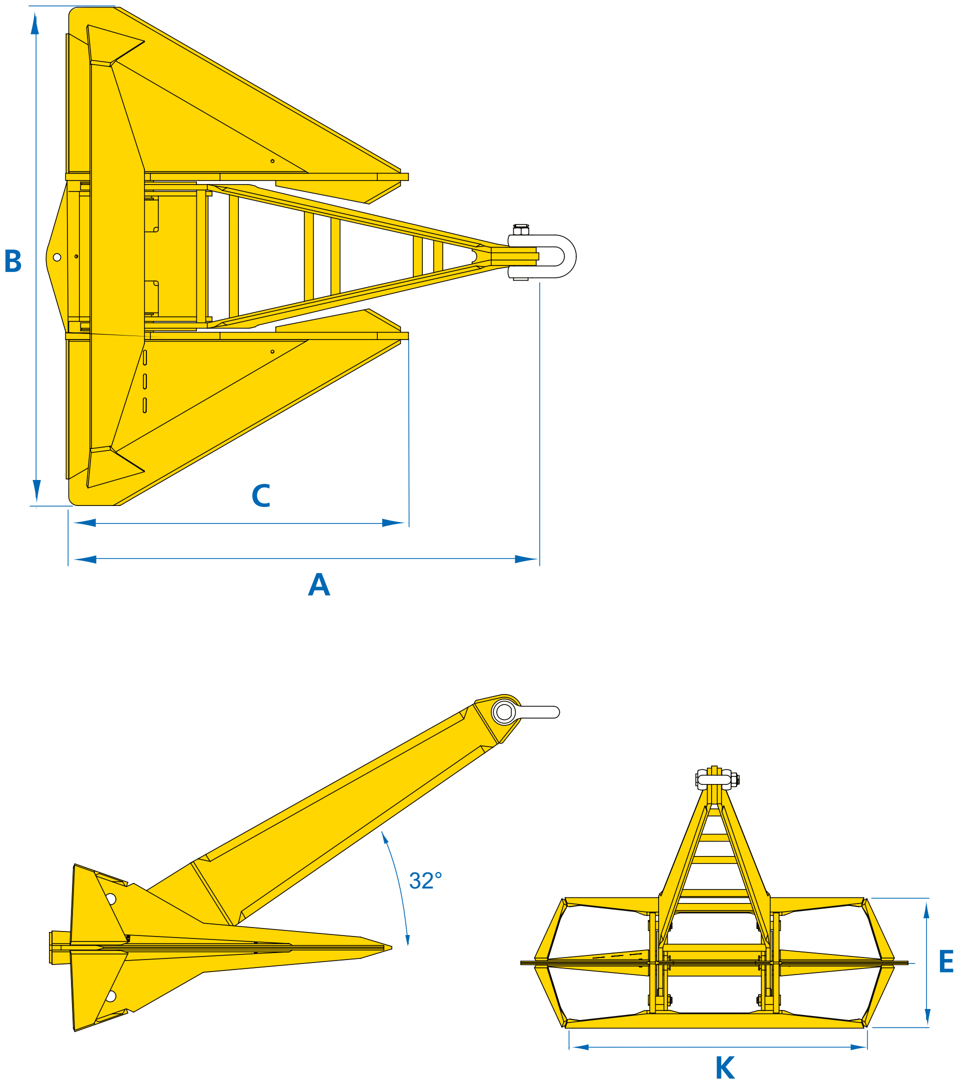


Note: The dimensions of the Stevmanta VLA anchor may be changed for specific applications

Main dimensions Stevmanta VLA dimensions in mm area in m²							
area	5	8	10	12	15	17	20
B	3143	3975	4445	4869	5443	5795	6286
C	2976	3765	4209	4611	5155	5488	5953
D	1945	2460	2750	3013	3368	3586	3890
E0	3075	3890	4349	4764	5326	5670	6150
E1	3371	4264	4767	5222	5839	6216	6742
F	172	217	243	266	298	317	344
H	1459	1845	2063	2260	2527	2690	2918
T	639	809	904	991	1107	1179	1279

Dimensions of the Vryhof Stevin® Mk6 anchor

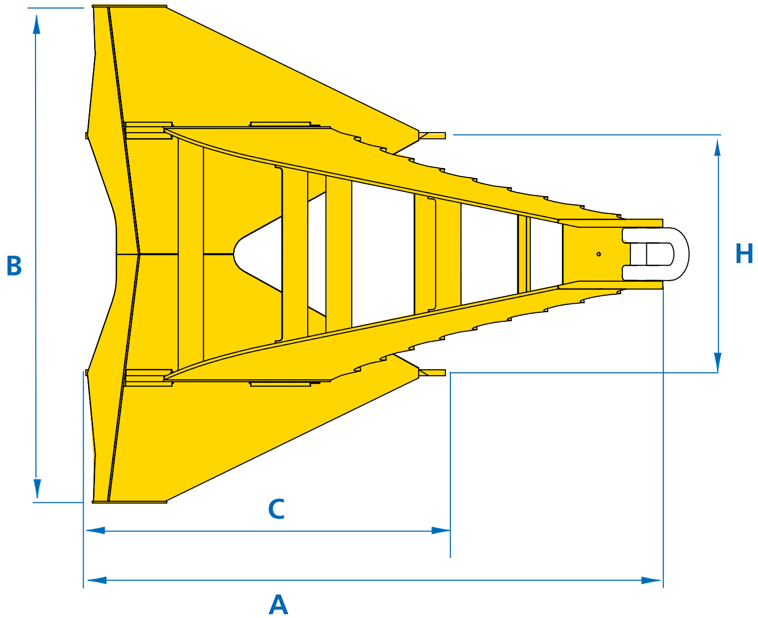
Preliminary

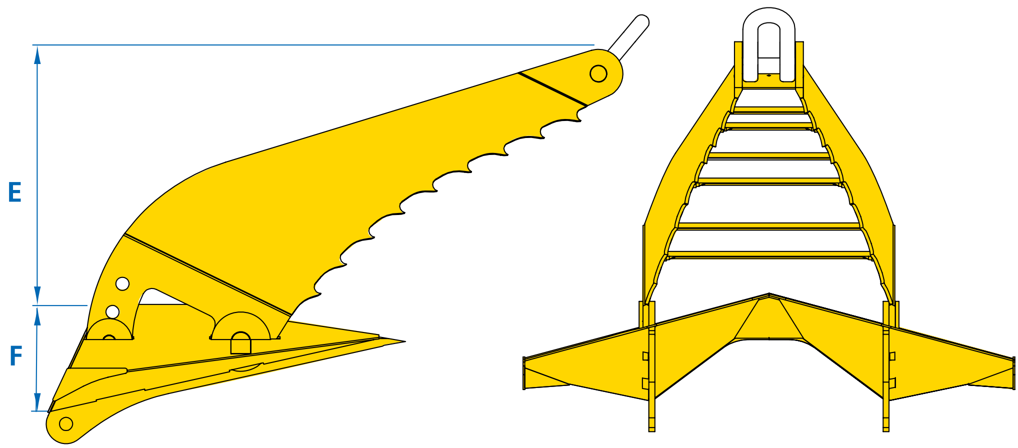


Dimensions available on request

Dimensions of the Vryhof Stevshark® Mk6 anchor

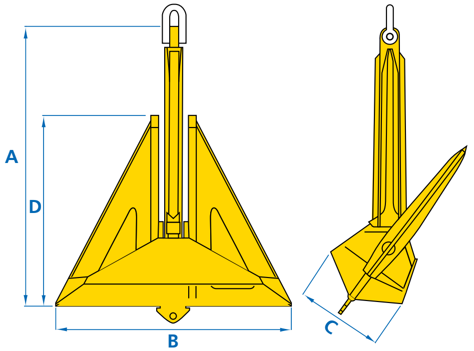
Preliminary

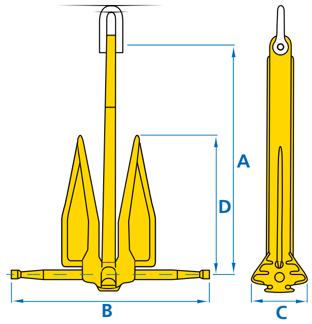




Dimensions available on request

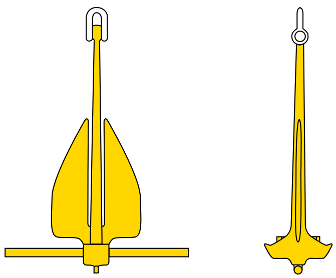
Dimensions of other anchor types

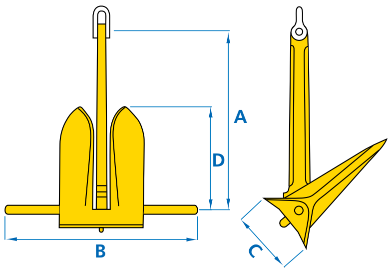




Flipper Delta					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
2205	1000	2605	1960	740	1560
5512	2500	3150	2660	1005	2130
11023	5000	3945	3300	1260	2660
16535	7500	4565	3850	1435	3080
22046	10000	5040	4270	1600	3400
26455	12000	5335	4530	1705	3600
33069	15000	5735	4845	1830	3875
44092	20000	6405	5410	2010	4320
71650	32500	7320	6200	2310	4930
88185	40000	7850	6650	2480	5290

Danforth					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
1000	454	1830	1580	410	1100
2500	1134	2260	2140	560	1350
5000	2268	2780	2700	710	1650
10000	4536	3510	3330	890	2100
12000	5443	3730	3540	945	2240
14000	6350	3920	3720	995	2360
16000	7257	4100	4000	1040	2470
20000	9072	4370	4150	1110	2620
25000	11340	4710	4470	1195	2820
30000	13608	5000	4750	1270	3000

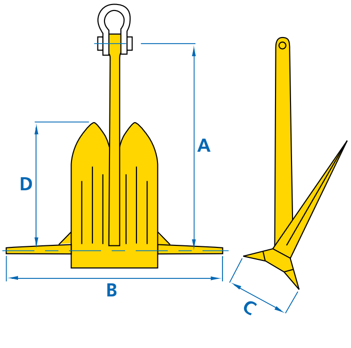


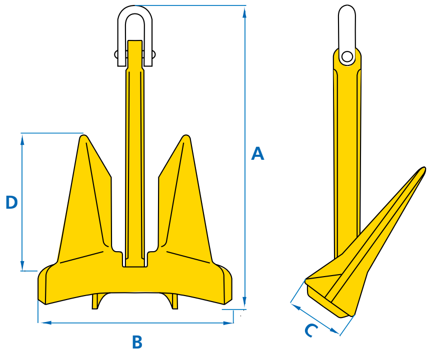


LWT					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
1000	454	1905	1803	622	1168
5000	2268	2997	2845	984	1829
10000	4536	3658	3480	1245	2235
15000	6804	3988	3791	1362	2438
20000	9072	4394	4166	1499	2692
25000	11340	4851	4521	1708	2946
30000	13608	5029	4801	1715	3073
35000	15876	5283	5055	1803	3226
40000	18144	5537	6096	1905	3327
60000	27216	6350	7061	2184	3810

Moorfast					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
1000	454	1549	1905	483	940
6000	2722	2565	3632	787	1549
10000	4536	3327	3988	1041	2032
12000	5443	3531	4242	1092	2159
16000	7257	3886	4750	1219	2388
20000	9072	4166	4978	1295	2591
30000	13608	4801	5512	1499	2997
40000	18144	5436	6299	1600	3226
50000	22680	5639	6528	1676	3353
60000	27216	5893	6883	1778	3556

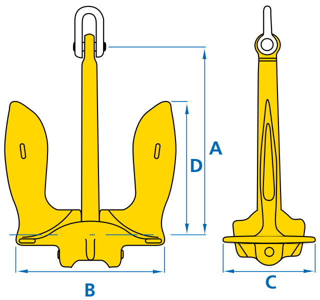
Dimensions of other anchor types





Stato					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
3000	1361	3277	2769	860	1829
6000	2722	3658	3632	960	2337
9000	4082	4064	4318	1090	2540
15000	6804	5182	5690	1370	3200
20000	9072	5334	5842	1420	3277
25000	11340	5740	6248	1540	3480
30000	13608	5969	6528	1570	3683
35000	15876	6299	6883	1670	3886
40000	18144	6553	7188	1750	4064
60000	27216	7540	8120	2000	4570

AC14					
weight		A	B	C	D
lb.	kg.	mm	mm	mm	mm
2844	1290	2025	1568	470	1067
4630	2100	2382	1844	553	1255
6746	3060	2700	2091	627	1423
12368	5610	3305	2559	768	1741
18298	8300	3793	2916	875	1984
23149	10500	4073	3154	946	2146
29762	13500	4429	3249	1029	2333
41447	18800	4946	3829	1149	2606
44092	20000	5049	3909	1173	2660
50706	23000	5290	4095	1229	2787



US Navy Stockless					
weight		A	B	C	D
lb.	kg	mm	mm	mm	mm
1000	454	1072	841	521	772
5000	2268	1854	1437	889	1319
10000	4536	2337	1810	1121	1661
15000	6804	2680	2089	1295	1861
20000	9072	2946	2280	1413	2094
25000	11340	3175	2456	1522	2256
30000	13608	3372	2608	1616	2394
35000	15876	3550	2743	1703	2523
40000	18144	3708	2872	1778	2619
60000	27216	4775	3194	2218	3375

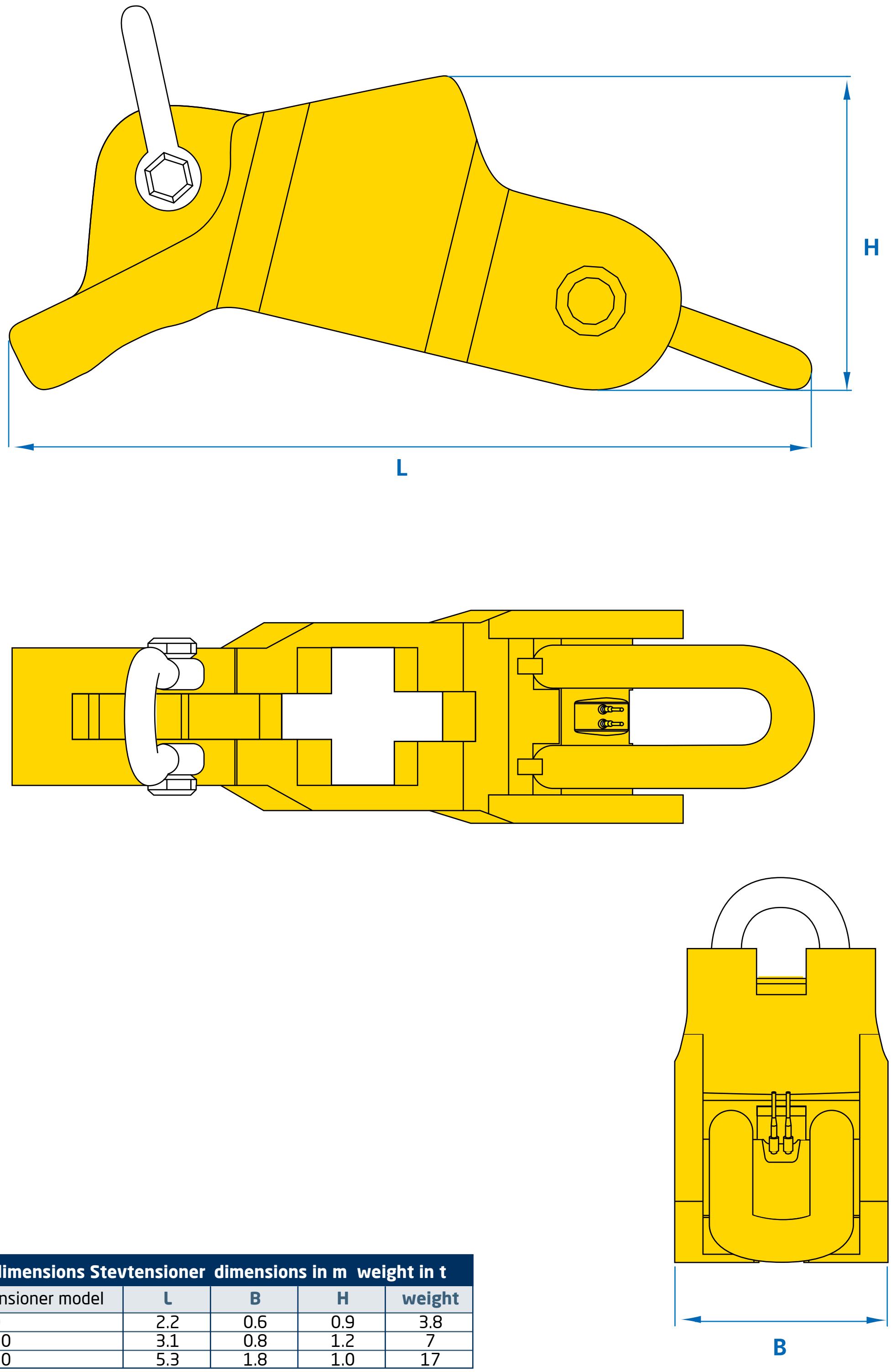
Proof load test for HHP anchors (US units)

anchor weight lbs	proof load kips	anchor weight lbs	proof load kips	anchor weight lbs	proof load kips
100	6.2	4100	92.5	10000	165.8
125	7.3	4200	94.2	11000	174.5
150	8.2	4300	95.9	12000	184.8
175	9.1	4400	97.5	13000	194.7
200	9.9	4500	99.1	14000	205.2
250	11.5	4600	100.7	15000	214.3
300	12.9	4700	102.3	16000	222.9
350	14.2	4800	103.9	17000	230.9
400	15.5	4900	105.5	18000	239
450	16.7	5000	107	19000	245
500	18.1	5100	108.5	20000	250.4
550	19.2	5200	110	21000	256.7
600	20.5	5300	111.4	22000	263.5
650	21.7	5400	112.9	23000	270.9
700	23	5500	114.4	24000	277.2
750	24.3	5600	115.9	25000	282.8
800	25.5	5700	117.4	26000	289.2
850	26.6	5800	118.7	27000	296.7
900	27.8	5900	120	28000	304.9
950	28.9	6000	121.4	29000	312.3
1000	29.8	6100	122.7	30000	318.9
1100	32.1	6200	124.1	31000	326.9
1200	34.5	6300	125.4	32000	333.7
1300	36.8	6400	126.8	33000	341.2
1400	39.1	6500	128.2	34000	348
1500	41.3	6600	129.5	35000	354.8
1600	43.5	6700	130.8	36000	361.6
1700	45.8	6800	132	37000	368.4
1800	48.2	6900	133.2	38000	375.2
1900	50.3	7000	134.4	39000	382
2000	52.3	7100	135.7	40000	388.8
2100	54.5	7200	136.9	42000	400.6
2200	56.6	7300	138.1	44000	411.5
2300	58.6	7400	139.3	46000	425.1
2400	60.8	7500	140.6	48000	437
2500	62.8	7600	141.6	50000	449.1
2600	64.8	7700	142.7	52000	460.4
2700	66.8	7800	143.7	54000	472
2800	68.8	7900	144.7	56000	484.3
2900	70.7	8000	145.7	58000	496.5
3000	72.6	8100	146.8	60000	508.4
3100	74.5	8200	147.9	62000	519.3
3200	76.4	8300	149	64000	530.2
3300	78.3	8400	150	66000	541
3400	80.1	8500	151.1	68000	551.9
3500	81.9	8600	152.2	70000	562.8
3600	83.7	8700	153.2	75000	590
3700	85.5	8800	154.3	80000	617
3800	87.2	8900	155.2	82500	630
3900	89	9000	156.2		
4000	90.7	9500	161.1		

Proof load test for HHP anchors (SI units)

anchor weight kg	proof load kN	anchor weight kg	proof load kN	anchor weight kg	proof load kN
50	29.7	2000	434.3	7000	970.3
55	31.7	2100	450	7200	987
60	34	2200	466	7400	1002
65	35.3	2300	480.7	7600	1018
70	37	2400	495	7800	1034
75	39	2500	509.7	8000	1050
80	40.7	2600	524.3	8200	1066
90	44	2700	537	8400	1078
100	47.3	2800	550.3	8600	1088.7
120	53	2900	563.7	8800	1099.3
140	58.3	3000	577	9000	1110
160	63.7	3100	589	9200	1120.7
180	68.4	3200	601	9400	1132
200	73.3	3300	613	9600	1148
225	80	3400	625	9800	1162.7
250	85.7	3500	635.7	10000	1173.3
275	91.7	3600	645	10500	1210
300	98	3700	655.7	11000	1240
325	104.3	3800	666.3	11500	1266.7
350	110.3	3900	677	12000	1300
375	116	4000	687	12500	1340
400	122	4100	696.3	13000	1380
425	127.3	4200	706	13500	1410
450	132	4300	715.7	14000	1450
475	137.3	4400	725.7	14500	1483.3
500	143	4500	735	15000	1520
550	155	4600	742.3	15500	1553.3
600	166	4700	751.7	16000	1586.7
650	177.3	4800	760	16500	1620
700	188	4900	769	17000	1653.3
750	199	5000	777	17500	1686.7
800	210.7	5100	786	18000	1720
850	221.3	5200	797.3	18500	1753.3
900	231	5300	808.7	19000	1780
950	241.7	5400	818	19500	1800
1000	252.3	5500	827.3	20000	1833.3
1050	262	5600	836.3	21000	1900
1100	272.7	5700	845	22000	1956.7
1150	282.7	5800	855.7	23000	2016.7
1200	292	5900	866.3	24000	2070
1250	302	6000	877	25000	2130
1300	311.7	6100	887	26000	2190
1350	321	6200	897.3	27000	2250
1400	330.3	6300	908	28000	2303.3
1450	339.7	6400	917.3	29000	2356.7
1500	349	6500	926.7	30000	2410
1600	366.7	6600	936	31000	2463.3
1700	384	6700	944.7	32000	2516.7
1800	401	6800	953	34000	2623.3
1900	418.3	6900	961	36000	2730

Dimensions of Vryhof tensioners



Main dimensions Stevtensioner dimensions in m weight in t				
Stevtensioner model	L	B	H	weight
VA600	2.2	0.6	0.9	3.8
VA1000	3.1	0.8	1.2	7
VA1250	5.3	1.8	1.0	17

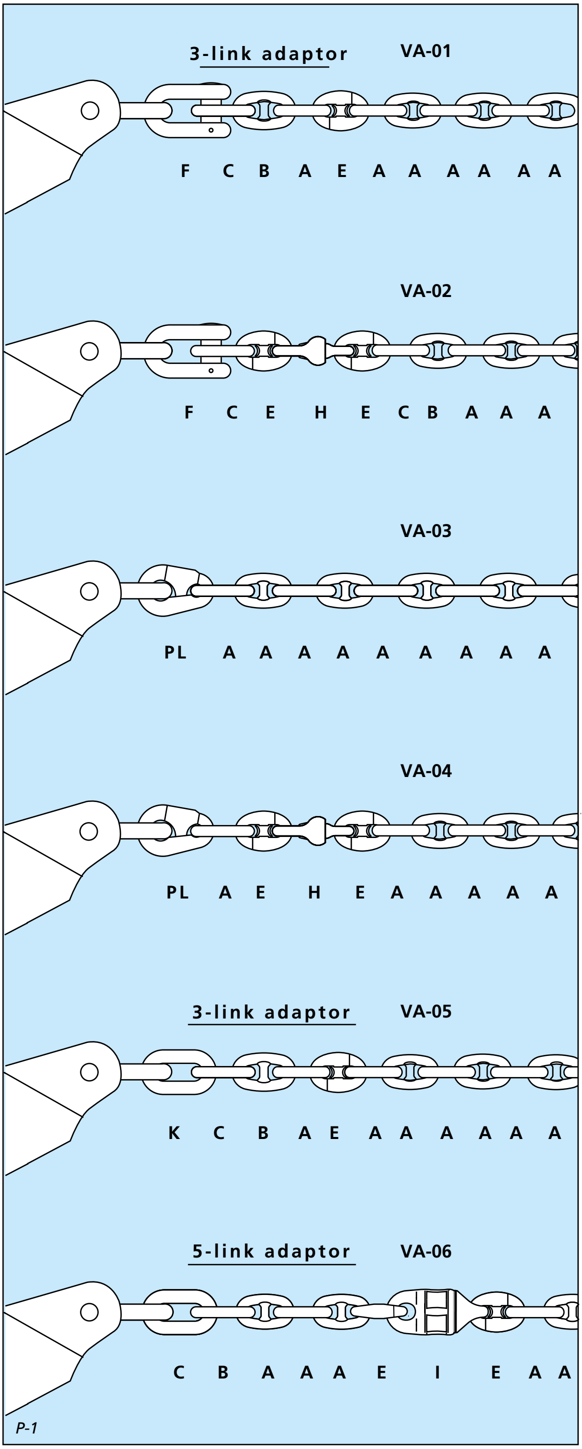
Proof load/break load of chains (in US units)

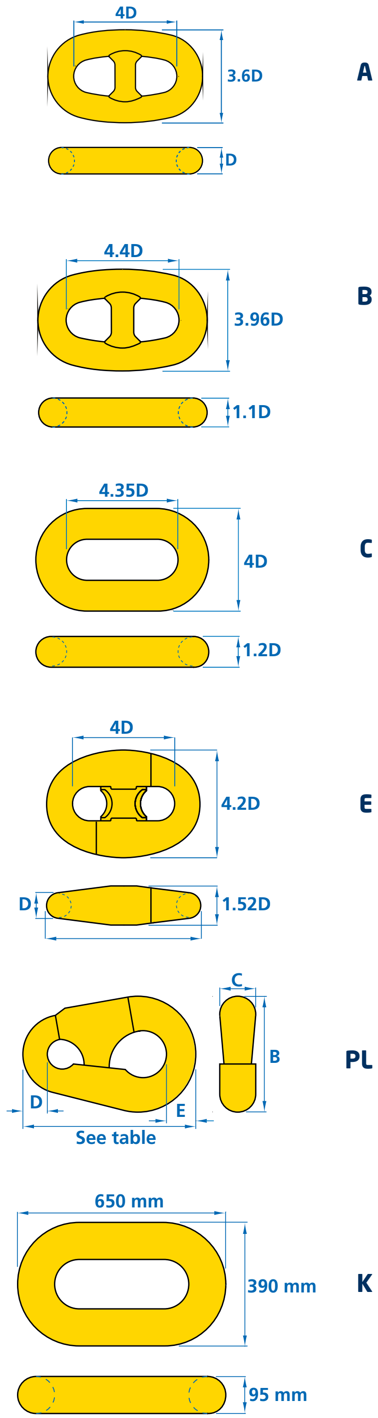
diameter	Proof load								Break load					Weight	
	R4-RQ4		R3S		R3	RQ3-API	R5		R4-RQ4	R3S	R3	RQ3-API	R5		
	stud	studless	stud	studless studless	stud studless	stud	stud	studless	stud and studlless					stud	studless
inches	kips	kips	kips	kips	kips	kips	kips	kips	kips	kips	kips	kips	kips	lbs/ft	lbs/ft
3/4	75	66	62	60	54	49	87	77	95	86	77	73	111	5	5
13/16	88	77	73	71	63	57	102	90	111	101	90	86	130	6	6
1	131	116	110	106	95	85	153	136	167	152	136	128	195	10	9
1 1/8	165	146	138	133	119	107	335	298	210	191	171	162	428	12	11
1 1/4	203	179	169	163	147	132	236	210	257	234	210	198	301	15	14
1 3/8	244	216	203	197	176	158	284	252	310	281	252	238	362	18	16
1 1/2	289	255	241	233	208	187	335	298	366	333	298	282	428	21	20
1 5/8	337	298	281	271	243	218	391	348	427	388	348	329	499	25	23
1 3/4	388	343	323	313	280	252	451	401	492	447	401	379	575	29	27
1 7/8	443	391	369	357	320	287	514	457	562	510	457	432	656	33	31
2	500	443	417	403	361	324	582	517	635	577	517	489	741	38	35
2 1/16	531	469	442	427	383	344	616	548	673	612	548	518	786	40	37
2 1/8	561	496	468	452	405	364	652	580	712	647	580	548	832	43	39
2 3/16	593	524	494	478	428	384	689	612	752	684	612	579	878	45	42
2 1/4	625	553	521	504	452	405	727	646	793	721	646	611	926	48	44
2 5/16	658	582	549	530	476	427	765	680	835	759	680	643	975	51	46
2 3/8	692	612	577	558	500	449	804	715	878	798	715	676	1026	54	49
2 1/2	762	674	635	614	550	494	886	787	967	878	787	744	1129	59	54
2 5/8	835	738	696	672	603	541	970	862	1059	962	862	815	1237	65	60
2 11/16	872	771	727	702	630	565	1013	900	1106	1005	900	852	1292	69	63
2 3/4	910	805	758	733	657	590	1058	940	1154	1049	940	889	1348	72	66
2 7/8	988	874	823	796	714	640	1148	1020	1253	1139	1020	965	1464	79	72
3	1069	945	891	861	772	693	1242	1103	1356	1232	1103	1044	1583	86	78
3 1/16	1110	982	925	894	802	719	1290	1146	1408	1280	1146	1084	1644	89	81
3 1/8	1152	1019	960	928	832	747	1339	1189	1461	1328	1189	1125	1706	93	85
3 3/16	1194	1056	995	962	863	774	1388	1233	1515	1377	1233	1167	1769	97	88
3 1/4	1237	1094	1031	997	894	802	1438	1278	1570	1427	1278	1209	1833	100	92
3 5/16	1281	1133	1068	1032	925	830	1489	1323	1625	1477	1323	1251	1898	104	95
3 3/8	1325	1172	1105	1068	957	859	1540	1368	1681	1528	1368	1295	1964	108	99
3 1/2	1416	1252	1180	1140	1022	918	1645	1462	1796	1632	1462	1383	2097	116	106
3 9/16	1462	1292	1218	1177	1056	947	1698	1509	1854	1685	1509	1428	2165	121	110
3 5/8	1508	1334	1257	1215	1089	977	1752	1557	1913	1739	1557	1473	2234	125	114
3 3/4	1603	1417	1336	1291	1158	1039	1862	1655	2033	1848	1655	1566	2374	134	122
3 13/16	1651	1460	1376	1330	1192	1070	1918	1704	2094	1903	1704	1613	2446	138	126
3 7/8	1699	1503	1416	1369	1227	1101	1975	1754	2156	1959	1754	1660	2518	143	130
3 15/16	1749	1546	1457	1409	1263	1133	2032	1805	2218	2016	1805	1708	2590	147	135
4	1798	1590	1498	1448	1299	1165	2089	1856	2281	2073	1856	1756	2664	152	139
4 1/8	1899	1679	1582	1529	1371	1231	2206	1960	2409	2189	1960	1855	2813	162	148
4 1/4	2001	1770	1668	1612	1445	1297	2325	2066	2538	2307	2066	1955	2965	172	157
4 3/8	2105	1862	1754	1696	1521	1365	2446	2174	2671	2427	2174	2057	3119	182	166
4 1/2	2211	1955	1843	1781	1597	1433	2570	2283	2805	2549	2283	2160	3276	192	176
4 5/8	2319	2050	1932	1868	1675	1503	2695	2394	2941	2673	2394	2265	3435	203	186
4 3/4	2428	2147	2023	1956	1753	1574	2821	2507	3080	2799	2507	2372	3597	214	196
4 7/8	2538	2245	2115	2045	1833	1645	2950	2621	3220	2926	2621	2480	3761	226	206
5	2650	2344	2209	2135	1914	1718	3080	2736	3362	3055	2736	2589	3926	238	217
5 1/8	2764	2444	2303	2226	1996	1791	3211	2853	3506	3186	2853	2700	4094	250	228
5 1/4	2878	2545	2398	2319	2079	1865	3345	2971	3651	3318	2971	2812	4264	262	239
5 3/8	2994	2647	2495	2412	2162	1940	3479	3091	3798	3451	3091	2925	4435	274	251
5 1/2	3111	2751	2592	2506	2247	2016	3615	3211	3946	3586	3211	3039	4608	287	262
5 5/8	3228	2855	2690	2601	2332	2093	3752	3333	4095	3722	3333	3154	4783	301	275
5 3/4	3347	2960	2789	2696	2417	2170	3890	3456	4246	3859	3456	3270	4959	314	287
5 7/8	3467	3066	2889	2793	2504	2247	4029	3579	4398	3997	3579	3387	5136	328	299
6	3587	3172	2989	2890	2591	2325	4169	3704	4551	4135	3704	3504	5315	342	312
6 1/8	3709	3279	3090	2987	2678	2404	4309	3829	4704	4275	3829	3623	5494	356	325
6 1/4	3830	3387	3192	3086	2766	2483	4451	3954	4859	4416	3954	3742	5675	371	339
6 3/8	3953	3495	3294	3184	2855	2562	4593	4081	5014	4557	4081	3861	5856	386	353
6 1/2	4076	3604	3396	3283	2944	2642	4736	4208	5170	4698	4208	3981	6038	401	367
6 5/8	4199	3713	3499	3383	3033	2722	4879	4335	5327	4841	4335	4102	6221	417	381
6 3/4	4323	3822	3602	3482	3122	2802	5023	4463	5483	4983	4463	4223	6404	433	395
6 7/8	4447	3932	3706	3582	3211	2882	5167	4591	5641	5126	4591	4344	6588	449	410
7	4571	4042	3809	3682	3301	2963	5311	4719	5798	5269	4719	4465	6772	466	425
7 1/8	4695	4152	3913	3782	3391	3043	5456	4847	5956	5412	4847	4586	6956	482	440
7 1/4	4820	4262	4016	3882	3481	3124	5600	4976	6114	5556	4976	4708	7140	500	456

Proof load/break load of chains (in SI units)

diameter	Proof load								Break load					Weight	
	R4-RQ4		R3S		R3	RQ3-API	R5		R4-RQ4	R3S	R3	RQ3-API	R5		
	stud	studless	stud	studless studless	stud studless	stud	stud	studless	stud and studlless					stud	studless
mm	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kN	kg/m	kg/m
19	331	293	276	267	239	215	385	424	420	382	342	324	491	8	7
20.5	385	340	320	310	278	249	447	397	488	443	397	376	570	9	8
22	442	390	368	356	319	286	513	456	560	509	456	431	654	11	10
24	524	463	436	422	378	339	608	541	664	604	541	511	776	13	12
26	612	541	510	493	442	397	711	632	776	706	632	598	907	15	14
28	707	625	589	570	511	458	822	730	897	815	730	691	1048	17	16
30	809	715	674	651	584	524	940	835	1026	932	835	790	1198	20	18
32	917	811	764	738	662	594	1065	946	1163	1057	946	895	1358	22	20
34	1031	911	859	830	744	668	1198	1064	1308	1188	1064	1007	1527	25	23
36	1151	1018	959	927	831	746	1338	1188	1460	1327	1188	1124	1705	28	26
38	1278	1130	1065	1029	923	828	1485	1319	1621	1473	1319	1248	1893	32	29
40	1410	1247	1175	1136	1018	914	1639	1456	1789	1625	1456	1377	2089	35	32
42	1548	1369	1290	1247	1118	1004	1799	1599	1964	1785	1599	1513	2294	39	35
44	1693	1497	1411	1364	1223	1097	1967	1748	2147	1951	1748	1654	2508	42	39
46	1843	1630	1536	1485	1331	1194	2141	1903	2338	2124	1903	1800	2730	46	42
48	1999	1767	1666	1610	1443	1295	2322	2063	2535	2304	2063	1952	2961	50	46
50	2160	1910	1800	1740	1560	1400	2510	2230	2740	2490	2230	2110	3200	55	50
52	2327	2058	1939	1874	1681	1508	2704	2402	2952	2682	2402	2273	3447	59	54
54	2499	2210	2083	2013	1805	1620	2904	2580	3170	2881	2580	2441	3703	64	58
56	2677	2367	2231	2156	1933	1735	3111	2764	3396	3086	2764	2615	3966	69	63
58	2860	2529	2383	2304	2066	1854	3323	2953	3628	3297	2953	2794	4237	74	67
60	3048	2695	2540	2455	2201	1976	3542	3147	3867	3514	3147	2978	4516	79	72
62	3242	2866	2701	2611	2341	2101	3767	3347	4112	3737	3347	3166	4802	84	77
64	3440	3042	2867	2771	2484	2230	3997	3551	4364	3965	3551	3360	5096	90	82
66	3643	3221	3036	2935	2631	2361	4233	3761	4621	4200	3761	3559	5397	95	87
68	3851	3406	3209	3102	2782	2496	4475	3976	4885	4440	3976	3762	5706	101	92
70	4064	3594	3387	3274	2935	2634	4723	4196	5156	4685	4196	3970	6021	107	98
73	4392	3884	3660	3538	3172	2847	5104	4535	5572	5064	4535	4291	6507	117	107
76	4731	4183	3942	3811	3417	3066	5498	4884	6001	5454	4884	4621	7009	126	116
78	4962	4388	4135	3997	3584	3216	5766	5123	6295	5720	5123	4847	7351	133	122
81	5317	4702	4431	4283	3840	3446	6179	5490	6745	6130	5490	5194	7877	144	131
84	5682	5024	4735	4577	4104	3683	6602	5866	7208	6550	5866	5550	8418	155	141
87	6056	5355	5046	4878	4374	3925	7037	6252	7682	6981	6252	5916	8971	166	151
90	6439	5693	5365	5187	4650	4173	7482	6647	8167	7422	6647	6289	9539	177	162
92	6699	5923	5582	5396	4838	4342	7784	6916	8497	7722	6916	6544	9924	185	169
95	7096	6275	5913	5716	5125	4599	8246	7326	9001	8180	7326	6932	10512	198	181
97	7365	6513	6138	5933	5319	4774	8559	7604	9343	8490	7604	7195	10911	206	188
100	7776	6876	6480	6264	5616	5040	9036	8028	9864	8964	8028	7596	11520	219	200
102	8054	7122	6712	6488	5817	5220	9359	8315	10217	9285	8315	7868	11932	228	208
105	8478	7497	7065	6829	6123	5495	9851	8753	10754	9773	8753	8282	12560	241	221
107	8764	7750	7304	7060	6330	5681	10184	9048	11118	10103	9048	8561	12984	251	229
111	9347	8265	7789	7529	6750	6058	10861	9650	11856	10775	9650	9130	13847	270	246
114	9791	8658	8159	7887	7071	6346	11378	10109	12420	11287	10109	9565	14506	285	260
117	10242	9057	8535	8251	7397	6639	11902	10574	12993	11807	10574	10005	15174	300	274
120	10700	9461	8916	8619	7728	6935	12434	11047	13573	12334	11047	10452	15852	315	288
122	11008	9734	9173	8868	7950	7135	12792	11365	13964	12690	11365	10753	16308	326	298
124	11319	10009	9432	9118	8175	7336	13153	11686	14358	13048	11686	11057	16768	337	308
127	11789	10425	9824	9497	8515	7641	13700	12171	14955	13591	12171	11516	17466	353	323
130	12265	10846	10221	9880	8858	7950	14253	12633	15559	14139	12663	11981	18171	370	338
132	12585	11129	10488	10138	9089	8157	12972	11525	15965	14508	12993	12294	16538	382	348
137	13395	11844	11162	10790	9674	8682	15565	13829	16992	15441	13829	13085	19844	411	375
142	14216	12571	11847	11452	10267	9214	16520	14677	18033	16388	14677	13887	21061	442	403
147	15048	13306	12540	12122	10868	9753	17487	15536	19089	17347	15536	14700	22294	473	432
152	15890	14051	13241	12800	11476	10299	18464	16405	20156	18317	16405	15522	23540	506	462
157	16739	14802	13949	13484	12089	10850	19452	17282	21234	19297	17282	16352	24799	540	493
162	17596	15559	14663	14174	12708	11405	20447	18166	22320	20284	18166	17188	26068	575	525
165	18112	16016	15094	14590	13081	11739	21047	18699	22976	20879	18699	17693	26833	596	545
168	18631	16474	15525	15008	13455	12075	21649	19234	23633	21477	19234	18199	27601	618	564
171	19150	16934	15959	15427	13831	12412	22253	19771	24292	22076	19771	18707	28371	640	585
175	19845	17548	16538	15986	14333	12863	23061	20488	25174	22877	20488	19386	29400	671	613
178	20367	18010	16972	16407	14709	13201	23667	21027	25836	23479	21027	19896	30173	694	634
180	20715	18318	17263	16687	14961	13427	24072	21387	26278	23880	21387	20236	30689	710	648
185	21586	19088	17989	17389	15590	13991	25084	22286	27383	24884	22286	21087	31980	750	685

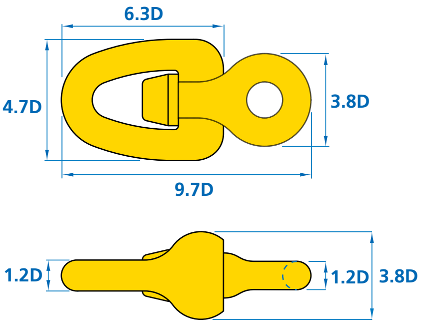
Chain components and forerunners



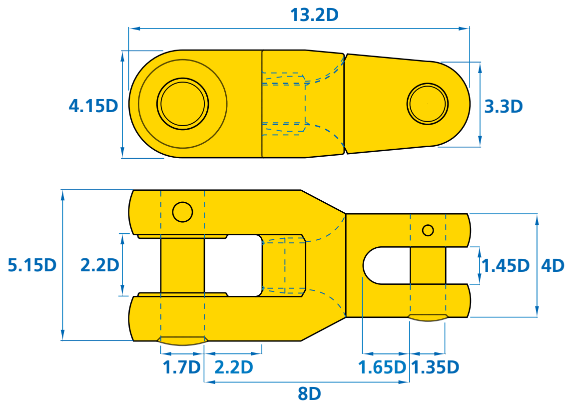


Note: the D in the dimensions shown refers to the chain dimension tables on the previous pages.

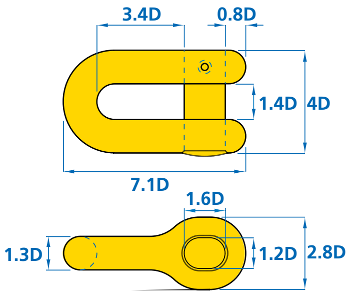
Chain components and forerunners



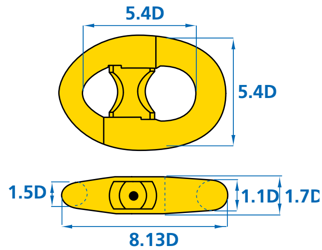
H



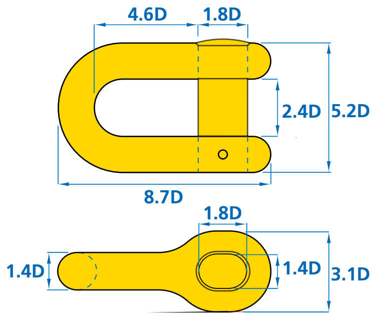
J



G



T



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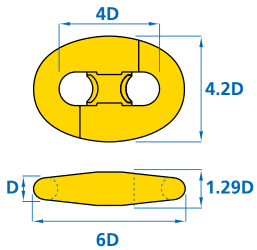
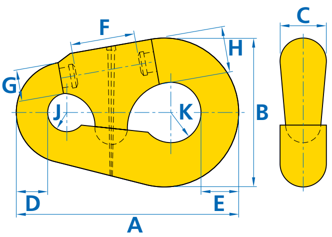


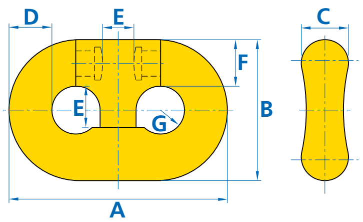
D

- **A** = common link
- **B** = enlarged link
- **C** = end link
- **D** = slim kenter shackle
- **E** = joining kenter shackle
- **F** = large D-type shackle
- **G** = joining shackle D type
- **H** = anchor swivel
- **J** = anchor swivel
- **K** = special end link
- **T** = trident shackle
- **PL** = pear link

Connecting links

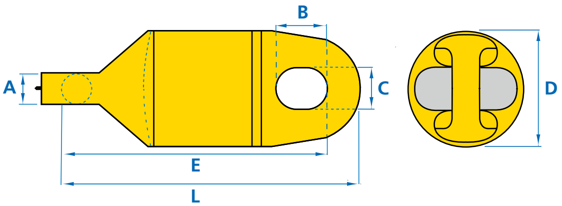


Pear shaped anchor connecting link (pearlink) dimensions in mm												
NO	chain size	A	B	C	D	E	F	G	H	J	K	kg
4	32 - 40	298	206	59	40	48	83	44 x 44	56	26	43	13
5	42 - 51	378	260	76	51	64	100	51 x 60	74	32	52	27
6	52 - 60	454	313	92	60	76	121	62 x 73	88	37	64	49
7	62 - 79	562	376	117	79	95	149	85 x 79	111	48	76	94
8	81 - 92	654	419	133	92	124	149	111 x 102	130x133	54	79	149
9	94 - 95	692	435	146	98	130	159	124 x 137	141	57	83	236
10	97 - 102	889	571	190	121	165	190	130	181	73	108	386
11	103 - 108	940	610	203	127	175	203	156	200	76	111	418

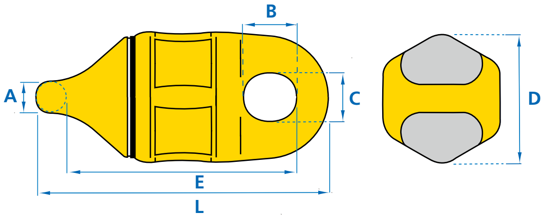


Detachable chain connecting link (C-connector) dimensions in mm								
chain size	A	B	C	D	E	F	G	weight kg
62 - 64	381	246	79	64	73	78	42	32.0
66 - 67	400	246	83	67	78	79	44	37.0
68 - 70	419	275	92	73	83	90	46	45.5
71 - 73	438	283	94	73	85	93	48	48.5
74 - 76	457	295	95	76	90	94	50	54.5
78 - 79	476	308	102	79	92	96	52	62.5
81 - 83	495	320	103	83	92	103	55	73.0
84 - 86	514	332	107	86	100	107	57	80.5
87 - 89	537	350	116	92	105	114	59	93.5
90 - 92	552	356	119	92	106	116	61	97.5
94 - 95	571	368	122	95	114	119	62	116.0
97 - 98	590	381	127	98	117	121	67	123.0
100 - 102	607	394	132	102	119	122	68	130.0

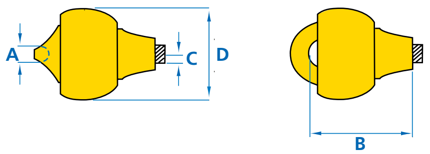
Swivels



Mooring swivel dimensions in mm			
Type	177 M5	231 M5	193 M5
A	84	92	98
B	148	149	148
C	233	234	233
D	340	340	358
E	636	660	715
L	820	860	919
MBL (kN)	7210	8420	9540

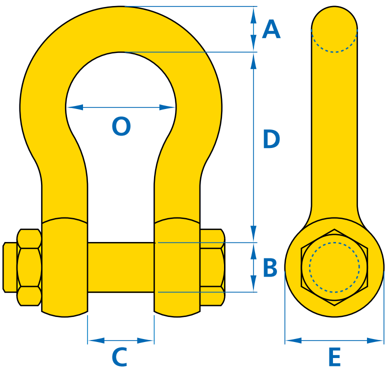


Anchoring handling swivel dimensions in mm			
Type	**209**	**210**	**223**
A	91x98	76	58
B	142	128	100
C	134	121	88
D	380	342	260
E	655	559	425
L	850	715	541
MBL (kN)	7210	5100	2698

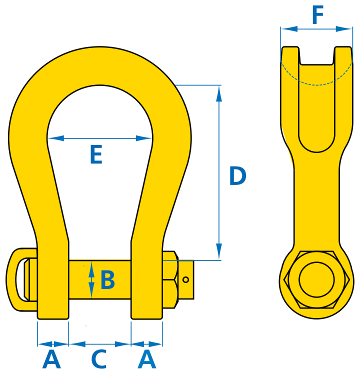


Anchoring Ball swivel dimensions in mm							
Type	**323**	**334**	**356**	**376**	**389**	**300**	**308**
A	76	90	88	90	83	94	76
B	462	481	508	501	474	711	470
C	83	89	95	89	83	95	83
D	427	559	559	457	427	559	427
MBL (kN)	5160	6450	7210	6450	6085	7950	5160

Shackles



Anchor bow shackle



Sling shackle

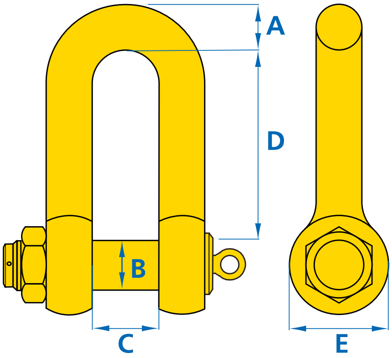
Anchor Bow shackle
According to U.S. federal specification (RR-C-271) dimensions in mm

SWL t	A	B	C	D chain shackle	D anchor shackle	E	O anchor shackle	Weight Chain shackle KG	Weight anchor shackle KG
35	50	57	83	171	197	114	138	18.16	20.65
42.5	57	65	95	190	222	130	160	27.8	29.3
55	65	70	105	203	254	140	180	35.1	41
85	75	80	127	230	330	160	190	60	62.3
120	89	95	146	267	381	190	238	93	109.5
150	102	108	165	400	400	216	275	145	160
200	120	130	175	500	500	260	290	180	235
250	125	140	200	540	540	280	305	225	285
300	135	150	200	600	600	300	305	305	340
400	165	175	225	650	650	350	325	540	570
500	175	185	250	700	700	370	350	580	685
600	195	205	275	700	700	410	375	850	880
700	205	215	300	730	730	430	400	920	980
800	210	220	300	730	730	440	400	990	1110
900	220	230	320	750	750	460	420	1165	1295
1000	230	240	340	750	750	480	420	1315	1475
1200	250	280	400	840	840	560	500	1700	1900
1500	260	325	460	840	870	650	600	2500	2800

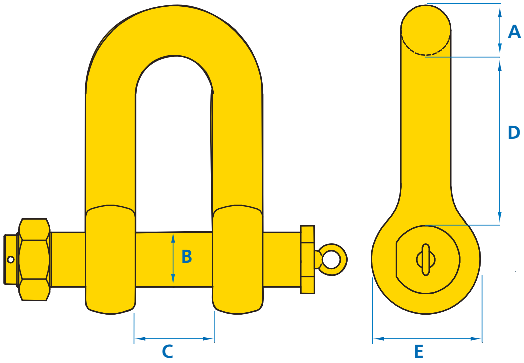
Sling shackle dimensions in mm

SWL t	A	B	C	D	E	F	weight kg
75	70	70	105	290	186	120	67
125	85	80	130	365	220	150	110
150	89	95	140	390	250	170	160
200	100	105	150	480	276	205	220
250	110	120	170	540	300	240	320
300	122	134	185	600	350	265	350
400	145	160	220	575	370	320	635
500	160	180	250	630	450	340	803
600	170	200	275	700	490	370	980
700	190	215	300	735	540	400	1260
800	200	230	325	750	554	420	1430
900	220	255	350	755	584	440	1650
1000	240	270	380	760	614	460	2120
1250	260	300	430	930	644	530	2400
1500	280	320	460	950	680	560	2980

Shackles



Stevpris Mk5 anchor shackle



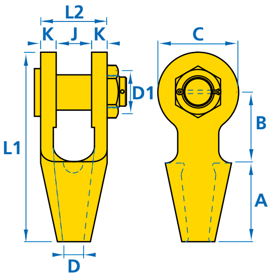
Stevpris Mk6 anchor shackle

Stevpris Mk5 and Mk6 anchor shackle dimensions in mm

Bow				pin	length		weight
dia A	inside width C	inside lenght D	E	dia B	Mk5	Mk6	kgs
60	90	211	136	68			30
65	100	221	144	72			37
75	110	246	160	80			52
80	125	275	180	90			79
90	135	310	190	95	410	570	89
100	155	360	220	110	455	620	129
110	170	390	240	120	485	690	168
120	185	420	260	130	520	740	214
130	200	455	280	140	545	800	271
140	210	490	300	150	585	840	335
150	225	520	320	160	620	900	403
160	240	550	340	170	655	940	491
170	255	585	360	180	690	980	606
180	270	615	380	190	730		713
190	290	665	410	205			867
200	305	700	430	215			1000
210	320	730	450	225			1154
220	335	765	470	235			1395
230	340	780	490	245			1483

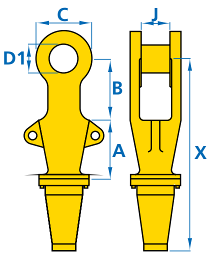
Open fields reflect sizes that may vary. Please consult Vryhof for detailed specification.

Wire rope sockets



NO	MBL	Rope diameter		A	B	C	D	D1	J	K	Weight
	tons	mm	inch								kg
128	280	49 - 54	2-2 1/8	216	228	216	57	95	101	46	60.5
130	360	55 - 60	2 1/4-2 3/8	228	250	236	63	108	113	53	90
132	450	61 - 68	2 1/2-2 5/8	248	273	264	73	121	127	60	122
135	480	69 - 75	2 3/4-2 7/8	279	279	276	79	127	133	73	157
138	520	76 - 80	3-3 1/8	305	286	284	86	133	146	76	195
140	600	81 - 86	3 1/4-3 3/8	330	298	296	92	140	159	79	221
142	700	87 - 93	3 1/2-3 5/8	356	318	340	99	152	171	83	281
144	875	94 - 102	3 3/4-4	381	343	362	108	178	191	89	397
146	1100	108 - 115	4 1/2	460	480	440	125	190	208	101	570
150	1250	122 - 130	5	500	500	560	138	250	210	120	980
160	1400	140 - 155	5 1/2-6	580	500	600	160	275	230	140	-
170	1600	158 - 167	6 1/2	675	600	650	175	290	230	175	-

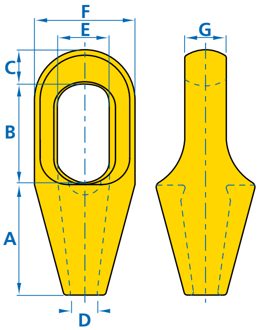
Table: Open spelter socket dimensions in mm



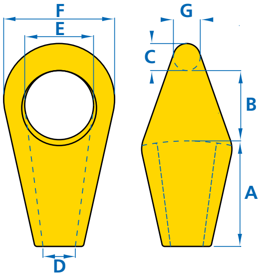
Open spelter socket dimensions in mm

NO	MBL t	for wire dia. mm	A	B	C	D1	J	X
338	650	75 - 84	375	298	296	140	159	1050
340	820	85 - 94	410	320	340	152	171	1170
344	1000	95 - 104	425	343	362	178	191	1300
346	1200	105 - 114	500	500	440	200	200	1570
350	1500	115 - 130	580	580	580	250	220	1800
370	1700	131 - 144	625	625	625	280	230	1940
380	1900	145 - 160	700	700	680	300	250	2150

Wire rope sockets



Closed spelter socket dimensions in mm												
NO	MBL	Rope diameter		A	B	C	D	E	F	G	Weight
	tons	mm	inch								kg
222	280	49 - 51	$2-2\frac{1}{8}$	216	224	62	57	96	193	82	36.5
224	360	55 - 60	$2\frac{1}{4}-2\frac{3}{8}$	228	247	73	63	108	216	92	50
226	450	61 - 68	$2\frac{1}{2}-2\frac{5}{8}$	248	270	79	73	140	241	102	65
227	480	69 - 75	$2\frac{3}{4}-2\frac{7}{8}$	279	286	79	79	159	273	124	93
228	520	76 - 80	$3-3\frac{1}{8}$	305	298	83	86	171	292	133	110
229	600	81 - 86	$3\frac{1}{4}-3\frac{3}{8}$	330	311	102	92	184	311	146	142
230	700	87 - 93	$3\frac{1}{2}-3\frac{5}{8}$	356	330	102	99	197	330	159	170
231	875	94 - 102	$3\frac{3}{4}-4$	381	356	108	108	216	362	178	225
233	1100	108 - 115	$4\frac{1}{2}$	450	425	120	125	235	405	190	340
240	1250	122 - 130	5	500	475	120	138	260	515	210	-
250	1400	140 - 155	$5\frac{1}{2}-6$	580	550	150	160	300	510	250	-
260	1600	158 - 167	$6\frac{1}{2}$	675	600	175	175	325	600	300	-

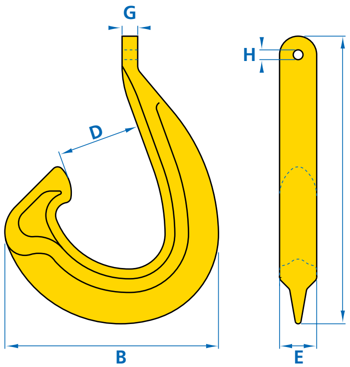


Advantages of the CR socket

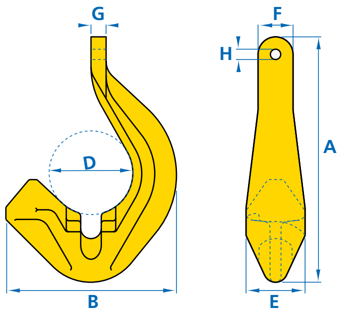
- Guaranteed high breaking load.
- Integrated non rotating stopper system which prevents the tamp from turning or slipping out of the cone.
- An open-window side for easy rope handling.
- A high performance connection for the right combination with a detachable link.
- No rings in the cone to a give a maximum rope /socket connection.
- Impact value of min. 27 Joule at -40˚C.

CR-socket dimensions in mm									
NO	MBL t	rope dia mm	A	B	C	D	E	F	weight kg
522	250	49 - 54	215	125	55	57	115	200	30
524	300	55 - 60	230	145	65	63	135	230	46
526	400	61 - 68	250	160	75	73	150	270	62
527	500	69 - 75	280	175	80	79	165	300	87
528	600	76 - 80	310	190	85	86	175	325	110
529	700	81 - 86	340	205	100	92	200	350	135
530	800	87 - 93	360	220	105	99	205	360	160
531	900	94 - 102	380	240	110	108	225	380	208
533	1000	108 - 115	450	260	125	120	240	420	270

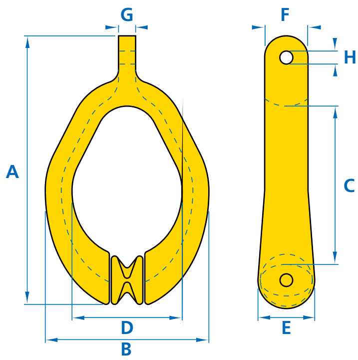
Main dimensions chasers



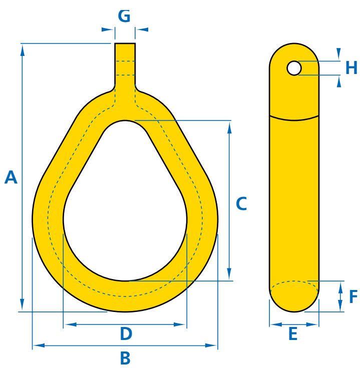
J-Chaser
VA 101



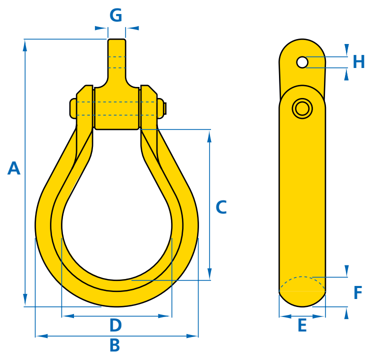
J-Lock Chaser
VA 115



Permanent Wire Chaser
VA 210-213-214-215-4214



Permanent Chain Chaser
VA 102-106-110-112-4110



Detachable Chain Chaser
VA 107-108-111

Main dimensions chasers dimensions in mm

Type	A	B	C	D	E	F	G	H	proofload t	weight kg
VA 101	2483	1829	-	699	305	-	124	86	250	1882
VA 102	1657	1143	991	762	305	191	124	86	250	1088
VA 106	1702	1168	991	762	381	203	130	99	250	1451
VA 107	1886	1143	1080	762	305	191	124	86	250	1238
VA 108	1931	1168	1067	762	381	203	130	99	250	1656
VA 110	1867	1245	1130	838	330	203	130	99	250	1433
VA 111	1994	1245	1130	838	330	203	130	99	250	1742
VA 112	2210	1384	1397	953	356	260	130	99	250	2064
VA 115	2083	1486	-	711	533	305	124	86	250	1778
VA 210	2073	1245	1203	838	432	330	130	99	250	1959
VA 213	1962	1099	1086	692	445	330	130	99	250	1846
VA 214	2318	1308	1397	902	508	330	130	99	250	2530
VA 215	2051	1168	1060	711	445	356	178	127	400	2495
VA 4214	2546	1422	1397	903	610	394	394	144	400	4070
VA 4110	2040	1361	1130	838	406	280	191	144	400	2390

Main dimensions chasers

Note: the VA115 is available in two versions: the VA 115/35 for $2^1/_2$" to $3^1/_2$" chain and the VA115/45 for $3^3/_4$" to $4^1/_2$" chain.

Restoration of worn chaser profiles

Worn profiles may be restored by application of a weld deposit. Care must be taken to ensure a satisfactory bond between parent material and the weld deposit and to avoid the generation of a brittle structure in the area of repair.

The following procedure is recommended:

- The area to be welded must be cleaned to a bright metal finish.
- Prior to the commencement of welding, the parent material should be pre-heated to 180-200 °C and the pre-heat temperature is to be maintained during welding.
- The initial layer of weld deposit should be effected by a high nickel electrode such as: Metrode C.I. softlow nickel – N.I.O. 8C.2FE A.W.S. No.A5.15.ENI-CL.
- Subsequent layers of welding may be laid using a less noble electrode such as: Metrode CI special cast Ni Fe – FE.55.NI-1.3.C A.W.S. No. A5.15.ENI.FE.CI.
- Each successive layer of weld must be cleaned and hammered.
- On completion of welding, the built-up zone and surrounding area should be insulation wrapped to permit slow cooling.

In order to prevent damage to chaser or anchor head please consult Vryhof for the appropriate anchor/chaser combination.

Mooring line catenary

When the mooring line of a floater is deployed, part of the mooring line will lay on the seabed and part of the mooring line will be suspended in the water. The part of the mooring line that is suspended in the water will take on a catenary shape. Depending on the waterdepth, the weight of the mooring line and the force applied to the mooring line at the fairlead, the length of the suspended mooring line (S in [m]) can be calculated with:

$$S = \sqrt{d \times \left\{ \frac{2 \times F}{W} - d \right\}}$$

with d : the waterdepth plus the distance between sealevel and the fairlead in [m]

F : the force applied to the mooring line at the fairlead in [t]

and w : the unit weight of the mooring line in water in [t/m]

The horizontal distance (X in [m]) between the fairlead and the touchdown point of the mooring line on the seabed can be calculated with:

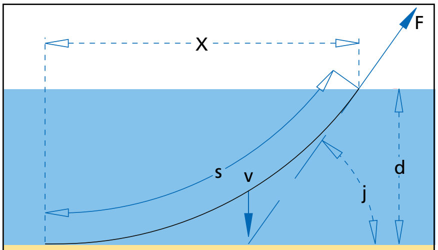
$$X = \left\{ \frac{F}{w} - d \right\} x\, {}^{e}\log \left\{ \frac{S + \frac{F}{w}}{\frac{F}{w} - d} \right\}$$

The weight of the suspended chain (V in [t]) is given by:
V = w x S

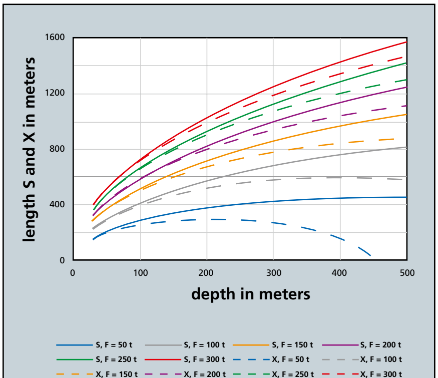
See fig. C-1 for a clarification of the symbols used. The angle is the angle between the mooring line at the fairlead and the horizontal.

Example

In fig. C-2, the suspended length S and the horizontal distance X are plotted for a 76 mm chain for different loads F (ranging from 50 t to 300 t). The suspended weight of the mooring line is plotted in fig. C-3. The submerged unit weight of the 76 mm chain is 0.110 t/m.
The mooring line tension at the fairlead can be calculated with $f = \frac{d.w}{1-\cos(j)}$.



C-1



C-2

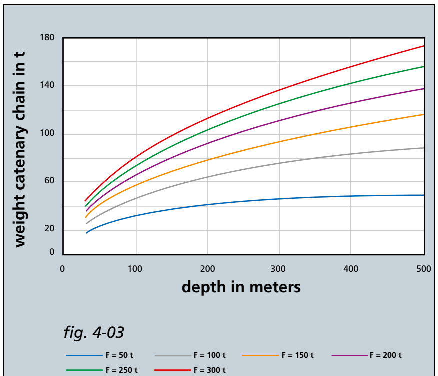


fig. 4-03

C-3

Mooring line holding capacity

Mooring line holding capacity on the seabed

The holding capacity (P) in [t] of the part of the mooring line that is laying on the seabed, can be estimated with the following equation:

P = f x l x w

with

f	:	friction coefficient between the mooring line and the seabed
l	:	the length of the mooring line laying on the seabed in [m]
w	:	the unit weight of the mooring line in water in [t/m]

If no detailed information on the friction coefficient is available, the following values can be used:

mooring line type	friction coefficient starting	sliding
chain	1.0	0.7
wire rope	0.6	0.25

The values for the friction coefficient given under starting can be used to calculate the holding capacity of the mooring line, while the values given under sliding can be used to calculate the forces during deployment of the mooring line.

Wire rope

Depending on the required service life of the mooring system, the following types of wire rope are recommended:

Design life	**recommended product type**
Up to 6 years	Six strand
Up to 8 years	Six strand c/w zinc anodes
Up to 10 years	Six strand c/w 'A' galvanised outer wires & zinc anodes
10 years plus	Spiral strand
15 years plus	Spiral strand c/w Galfan coated outer wires
20 years plus	Spiral strand c/w HDPE sheathing

The two rope constructions have differing properties. The advantages of each of the rope types are presented in the following table:

Spiral strand	**six strand**
Higher strength/weight ratio	Higher elasticity
Higher strength/diameter ratio	Greater flexibility
Torsionally balanced	Lower axial stiffness
Higher corrosion resistance	
Higher fatigue resistance	

Properties of spiral stand wire rope

Nominal Diameter mm (inch)	MBL kN	Axial Stiffness MN	Nominal Weight in kg/m		Submerged nominal weight kg/m	Nominal Steel Area mm²	Sheathing Thickness mm
			Unsheathed	Sheathed			
76 (3)	5647	557	28.4	30.4	23.8	3377	8
82 (3.25)	6550	627	33.0	35.1	27.5	3917	8
90 (3.5)	7938	760	39.9	42.9	33.4	4747	10
95.5 (3.75)	8930	855	44.9	48.1	37.5	5341	10
102 (4)	10266	982	51.6	55.3	43.1	6139	11
108 (4.25)	11427	1093	57.5	61.3	48.0	6834	11
114 (4.5)	12775	1222	64.2	68.3	53.6	7640	11
121.5 (4.75)	14362	1353	72.2	76.5	59.7	8589	11
127 (5)	15722	1481	79.1	83.6	66.0	9403	11
133 (5.25)	17171	1599	86.8	91.5	72.4	10314	11
141 (5.5)	19180	1799	97.5	102.4	81.5	11609	11
146.5 (5.75)	20469	1940	105.1	110.2	87.7	12515	11
153 (6)	22070	2110	114.5	119.7	95.5	13616	11

Properties of six strand wire rope						
Diameter mm	(inch)	MBL kN	Axial Stiffness MN	Rope weight kg/m	Submerged rope weight kg/m	Torque Factor Nm/kN
64	2.5	3360	189.4	17.3	15.3	4.7
71	2.75	3990	233.0	20.8	18.3	5.2
77	3	4767	278.8	25.7	22.7	5.8
83	3.25	5399	319.7	29.5	26.0	6.3
89	3.50	6414	415.2	35.0	30.9	6.9
96	3.75	6965	483.8	40.5	35.7	7.5
102	4	7799	573.5	44.5	39.3	8.1
108	4.25	8240	642.1	49.8	43.9	8.6
114	4.50	9172	707.0	55.3	48.8	9.1
121	4.75	10055	775.7	60.6	53.5	9.7
127	5	11134	866.6	67.7	59.8	10.2
133	5.25	11728	912.9	73.8	65.5	10.6
140	5.50	12925	1006.1	80.9	71.7	11.2

Note: MBL based on 10 years design life.
Torque factor presented in the last column is an approximate value at 20% applied load.

Installation of sheathed spiral strand

The limiting factors for the installation of a sheathed spiral strand are defined by the properties of the sheathing. The maximum bearing pressure (σ_b) on the sheath is limited to 21 N/mm² to avoid permanent deformation.

The minimum bending diameter permitted can be calculated using the following formula:

$$D = (4 \times W) / (\pi \times \sigma_b \times \{d \times 0.15 \times t\}^{0.5})$$

Where :

D = sheave diameter mm
W = line load N
d = sheathed cable diameter mm
t = sheathing radial thickness mm
σ_b = maximum bearing pressure N/mm²

The above formula ensures no damage to the sheathing through bending. In addition to prevent damage to the cable within the sheathing, the minimum bending diameter is 24 times the unsheathed cable diameter., i.e. D > 24 x (d - 2 x t).

Synthetic ropes

Rope properties		
	Polyester	Dyneema
Material	Polyester	**H**igh **M**odulus **P**oly**E**thylene
Construction	Parallel strand construction	Parallel strand construction
Protective cover	Polyester	Composite yarn
Color of rope	White with marker yarns	White
Specific gravity	1.38 - sinks	0.975 - floating
Melting point	251° C	145° C
Abrasion resistance	Excellent	Excellent
UV resistance	Excellent	Good
Temperature resistance	Workable at sub-zero temperatures	Medium
Chemical resistance	Good	Excellent
Water absorption/fibers	< 0.5%	< 0.05%
Water uptake	+ / - 30%	n.a
Dry & weight conditions	Wet strength equals to dry strength	Wet strength equals to dry strength

Polyester mooring line: strength table

Diameter mm	MBL k/N	Total weight kg/m		Submerged weight kg/m		Stiffness kN		
		@2% MBL	@20% MBL	@2% MBL	@20% MBL	EA[1]	EA[2]	EA[3]
113	3723	8.8	8.2	2.1	1.9	7.19e+04	8.43e+04	1.10e+04
137	5754	12.9	12.0	3.1	2.9	1.18e+05	1.38e+05	1.80e+05
154	7446	16.2	15.1	3.9	3.6	1.57e+05	1.84e+05	2.40e+05
169	9138	19.5	18.2	4.7	4.4	1.96e+05	2.30e+05	2.99e+05
183	10830	22.8	21.2	5.5	5.1	2.35e+05	2.76e+05	3.59e+05
195	12522	26.0	24.2	6.2	5.8	2.74e+05	2.22e+05	4.19e+05
207	14215	29.2	27.2	7.0	6.5	3.14e+05	3.68e+05	4.79e+05
227	17261	35.0	32.6	8.4	7.8	3.53e+05	4.14e+05	5.39e+05
245	20307	40.7	37.9	9.7	9.1	3.27e+05	3.83e+05	4.99e+05

Note : Minimum Breaking Load (MBL) in spliced condition.
Weights are presented for a rope loaded to 2% and 20% of MBL
[1] cycling between 10 - 30 % MBL
[2] cycling between 20 - 30 % MBL
[3] cycling between 40 - 50 % MBL

Production and construction in accordance with recognized standards. The properties of various rope sizes are presented in the following tables.

Dyneema

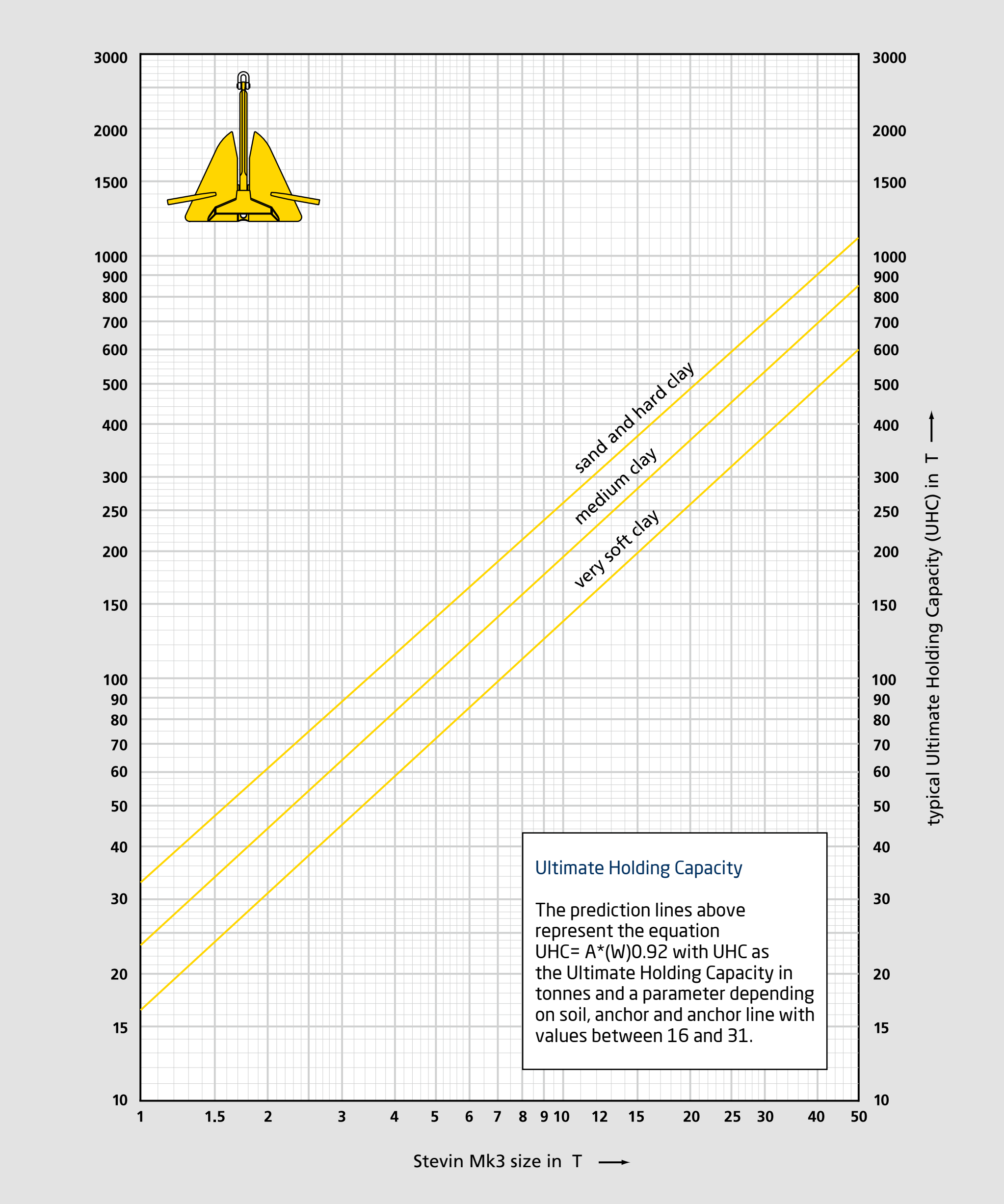
Diameter mm	MBL k/N	Weight kg/m	stiffness EA k/N
81	3649	3.30	2.03e+05
87	4397	3.83	2.43E+5
93	5108	4.34	2.84e+05
98	5838	4.85	3.24e+05
103	6568	5.35	4.05e+05
108	7298	5.85	4.05e+05
113	8027	6.34	4.46e+05
117	8757	6.83	4.87e+05
121	9487	7.32	5.27E+05
129	10946	8.28	6.08e+05
133	11676	8.76	6.49E+05
137	12406	9.24	6.89e+05
140	13136	9.72	7.30E+05
144	13865	10.2	7.70E+05
147	14595	10.7	8.11e+05
150	15325	11.1	8.51E+05
154	16055	11.6	8.92e+05
157	16784	12.1	9.32+E+05
160	17541	12.5	9.73E+05
163	18244	13.0	1.01e+06
166	18974	13.5	1.01E+06
169	19703	13.9	1.09e+06
171	20433	14.4	1.14E+06
174	21163	14.9	1.18E+06
177	21893	15.3	1.22e+06
180	22622	15.8	1.26E+06
182	23352	16.3	1.30e+06
185	24082	16.7	1.34E+06
187	24812	17.2	1.38e+06

Note : MBL in spliced condition.

Recommended practise for handling fibre rope mooring lines before and during installation

- Ropes should not be permanently installed around bollards or fairleads.
- A minimum bending radius should be observed. The minimum bend radius (D/d) with very low line tensions should be larger than 6.
- When unreeling the rope, maximum line tension should be observed, to avoid pulling the rope into the underlying layer.
- Torque or twist in the rope should be avoided.
- Fibre ropes should not be run over surfaces which have sharp edges, grooves, nicks or other abrasive features.
- Care should be taken when applying shearing forces to the rope.
- There should be no “hot work” such as welding in the vicinity of the rope.
- Frictional heat from excessive slippage of the fibre rope over a capstan, drum, etc. must be avoided.
- Care should be taken that ropes do not get knotted or tangled.
- Rope contact with sharp gritty materials should be avoided.
- Abrasion or fouling of the mooring line with other anchoring equipment such as anchor, steel wire rope, chain and connectors must be avoided.
- Chasers should not be used on fibre ropes.
- Shark jaw stoppers designed for use with steel wire rope or chain should not be used for handling fibre ropes.
- It should be avoided that the ropes undergo more than 1000 loadcycles with a line tension smaller than 5% of the MBL.
- Pre-deployed lines should not be left buoyed at the surface waiting connection to the platform, unless a minimum line tension of 5% (for polyester) of the MBL is maintained.
- If the fibre rope is laid on the seabed, it must be protected against external abrasion and ingress of abrasive particles.

The Stevin® Mk3 anchor UHC chart

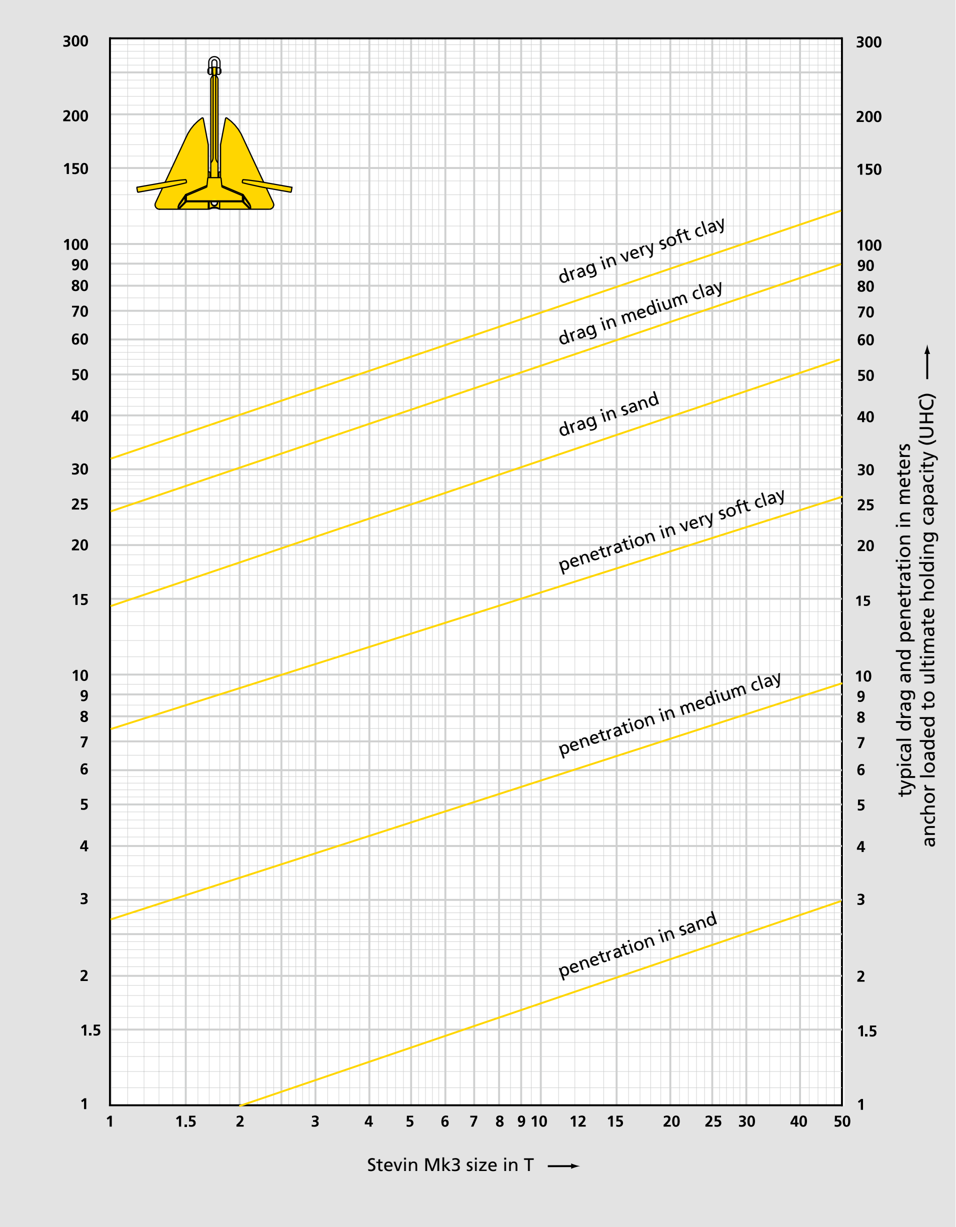


The Stevin Mk3 design line very soft clay represents soils such as very soft clays (mud), and loose and weak silts.
The line is applicable in soil that can be described by an undrained shear strength of 4 kPa at the surface increasing by 1.5 kPa per meter depth or in the equation Su = 4+1.5*z. with Su in kPa and z being the depth in meters below seabed. In very soft soils the optimum fluke/shank angle is typically 50 deg.

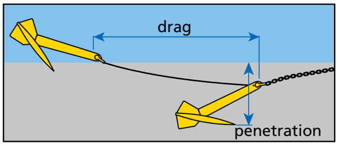
The design line sand represents competent soils, such as medium dense sands and stiff to hard clays and is based on a silica sand of medium density. In sand and hard clay the optimal fluke/shank angle is 32°.

The medium clay design line represents soils such as silt and firm to stiff clays. The fluke/shank angle should be set at 32° for optimal performance.

The Stevin® Mk3 anchor drag and penetration chart

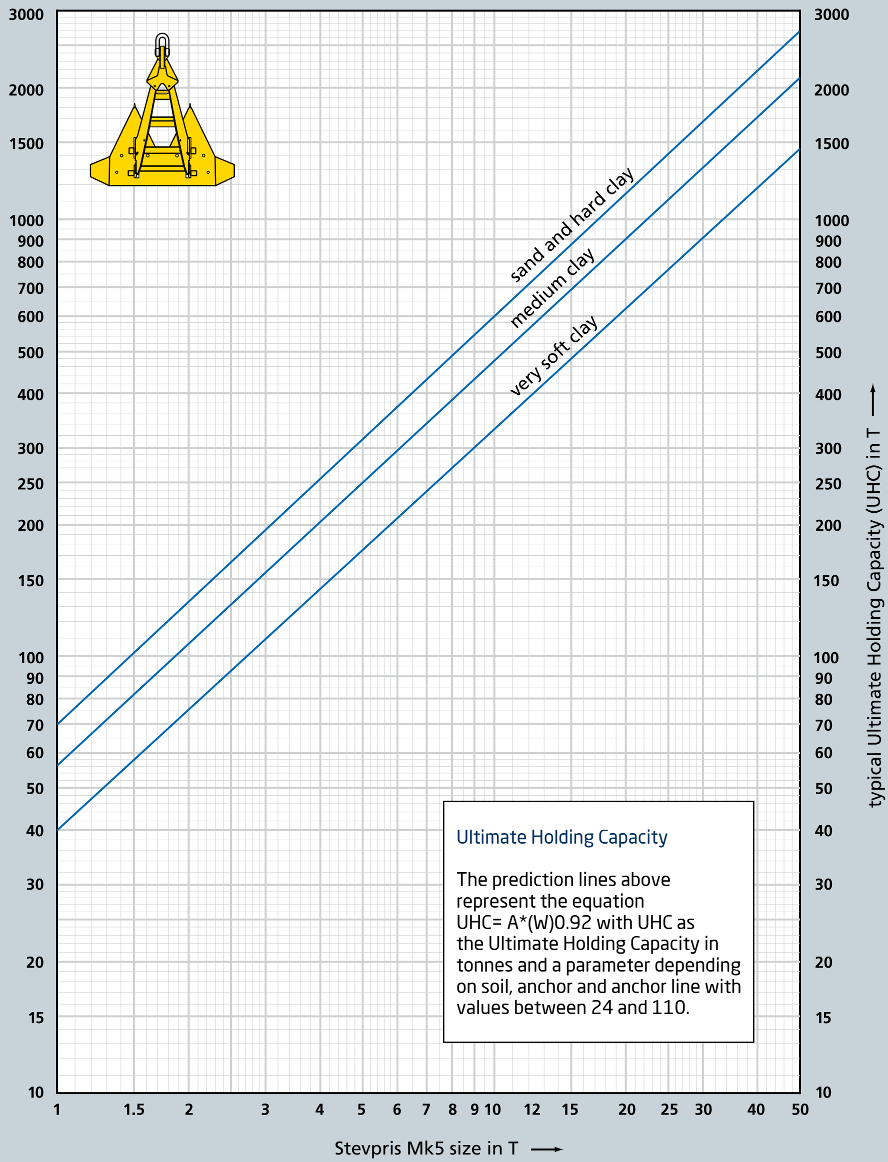


anchor load as % of UHC	drag % max drag	penetration as % max penetration
70	48	80
60	37	68
50	27	55
40	18	42
30	9	23



Example: loading 70% of ultimate holding capacity corresponds with 48% of maximum drag and 80% of maximum penetration at ultimate holding capacity.

The Stevpris® Mk5 anchor UHC chart



Ultimate Holding Capacity

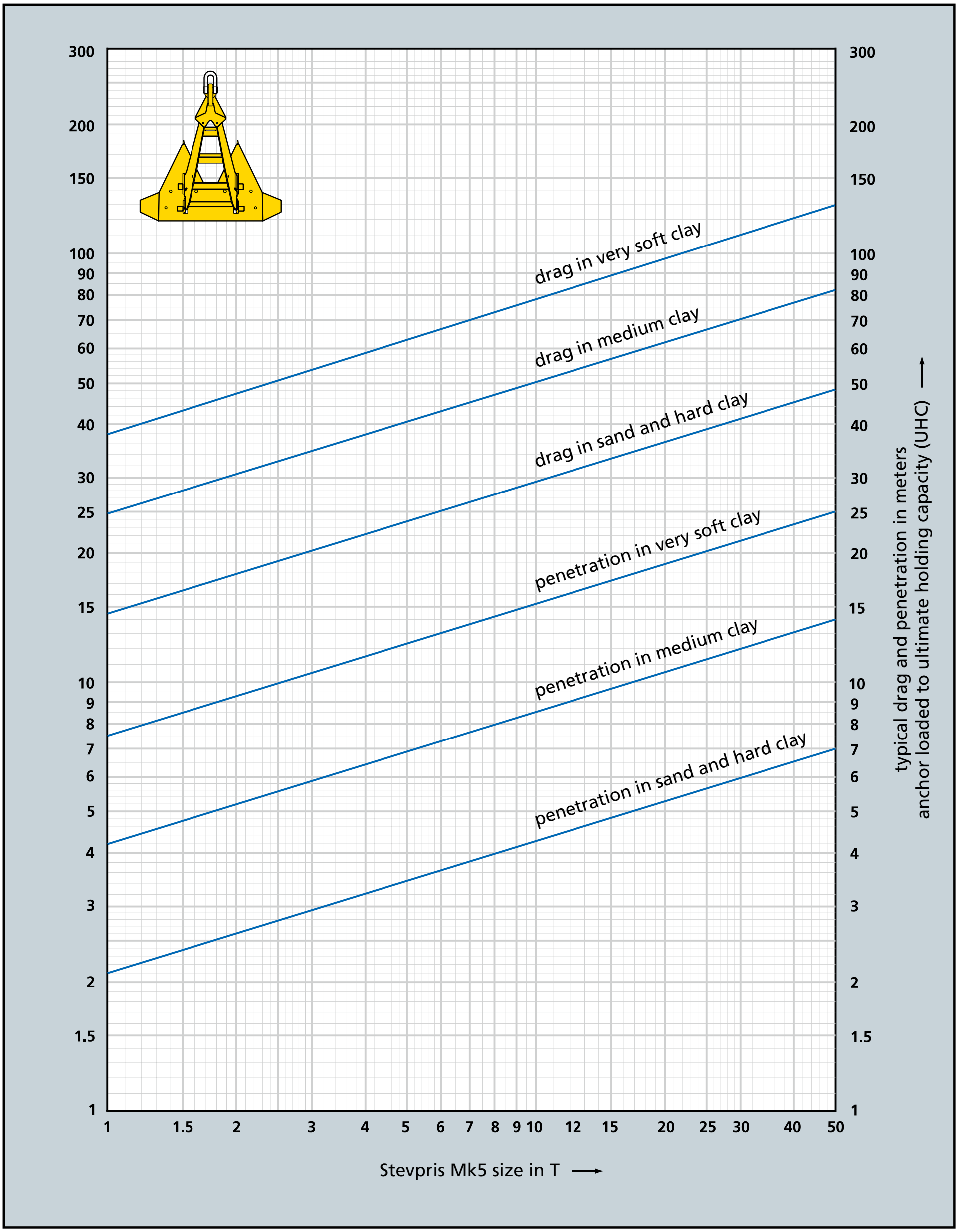
The prediction lines above represent the equation UHC= A*(W)0.92 with UHC as the Ultimate Holding Capacity in tonnes and a parameter depending on soil, anchor and anchor line with values between 24 and 110.

The Stevpris Mk5 design line very soft clay represents soils such as very soft clays (mud), and loose and weak silts.
The line is applicable in soil that can be described by an undrained shear strength of 4 kPa at the surface increasing by 1.5 kPa per meter depth or in the equation Su = 4+1.5*z. with Su in kPa and z being the depth in meters below seabed. In very soft soils the optimum fluke/shank angle is typically 50 deg.

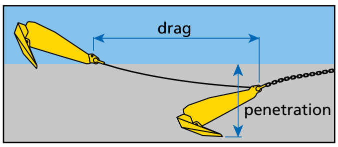
The design line sand represents competent soils, such as medium dense sands and stiff to hard clays and is based on a silica sand of medium density. In sand and hard clay the optimal fluke/shank angle is 32°.

The medium clay design line represents soils such as silt and firm to stiff clays. The fluke/shank angle should be set at 32° for optimal performance.

The Stevpris® Mk5 anchor drag and penetration chart

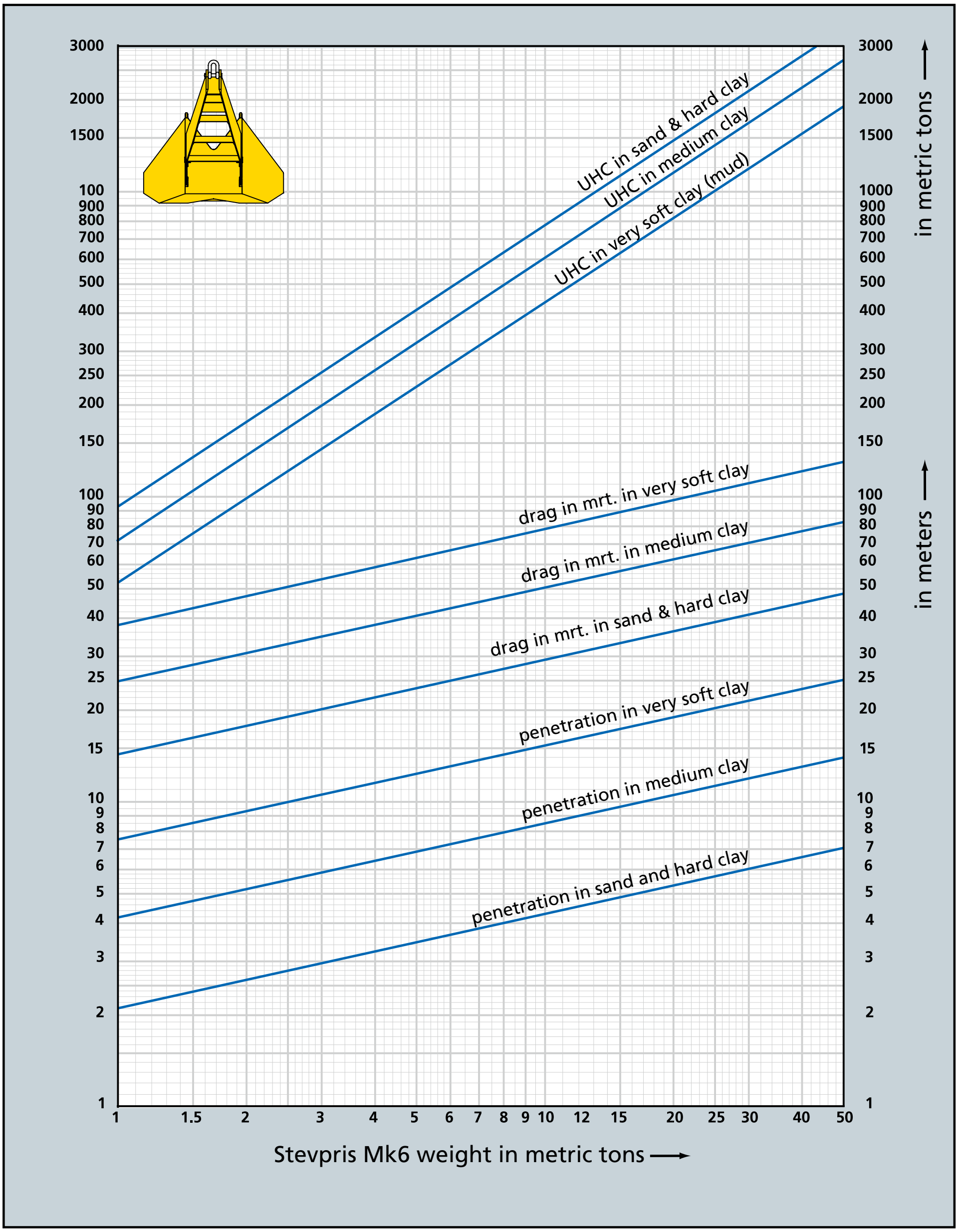


anchor load as % of UHC	drag % max drag	penetration as % max penetration
70	48	80
60	37	68
50	27	55
40	18	42
30	9	23

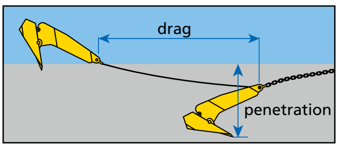


Example: loading 70% of ultimate holding capacity corresponds with 48% of maximum drag and 80% of maximum penetration at ultimate holding capacity.

The Stevpris® Mk6 anchor UHC, drag and penetration chart

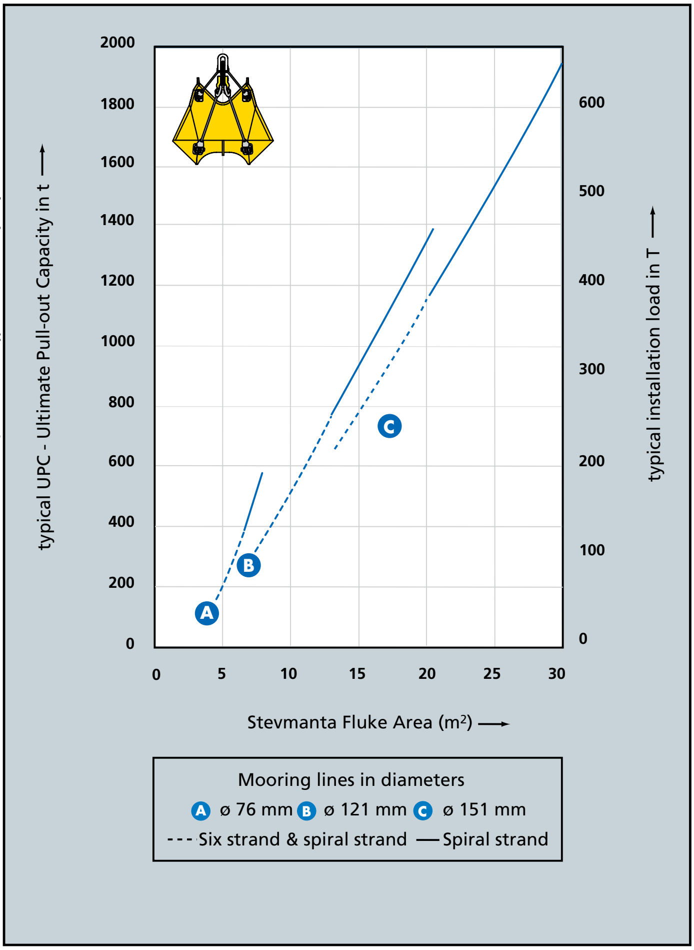


anchor load as % of UHC	drag % max drag	penetration as % max penetration
70	48	80
60	37	68
50	27	55
40	18	42
30	9	23



Example: loading 70% of ultimate holding capacity corresponds with 48% of maximum drag and 80% of maximum penetration at ultimate holding capacity.

The Stevmanta® anchor VLA UPC chart



Typical Ultimate Pull-out Capacity (UPC)

The prediction lines on the "UPC chart" can be expressed in the equations as stated below:

$$D = 1.5 * k^{0.6} * d^{-0.7} * A^{0.3} * \tan^{1.7}(\alpha)$$

where,

D = Stevmanta penetration depth [m]

k = quotient Undrained Shear Strength clay [kPA] and depth [m]

d = mooring line or installation line diameter [m]

A = Stevmanta fluke area [m²]

α = Stevmanta fluke / shank angle [deg]

$$UPC = N_c * S_u * A$$

where,

UPC = Ultimate Pull-out Capacity [kN]

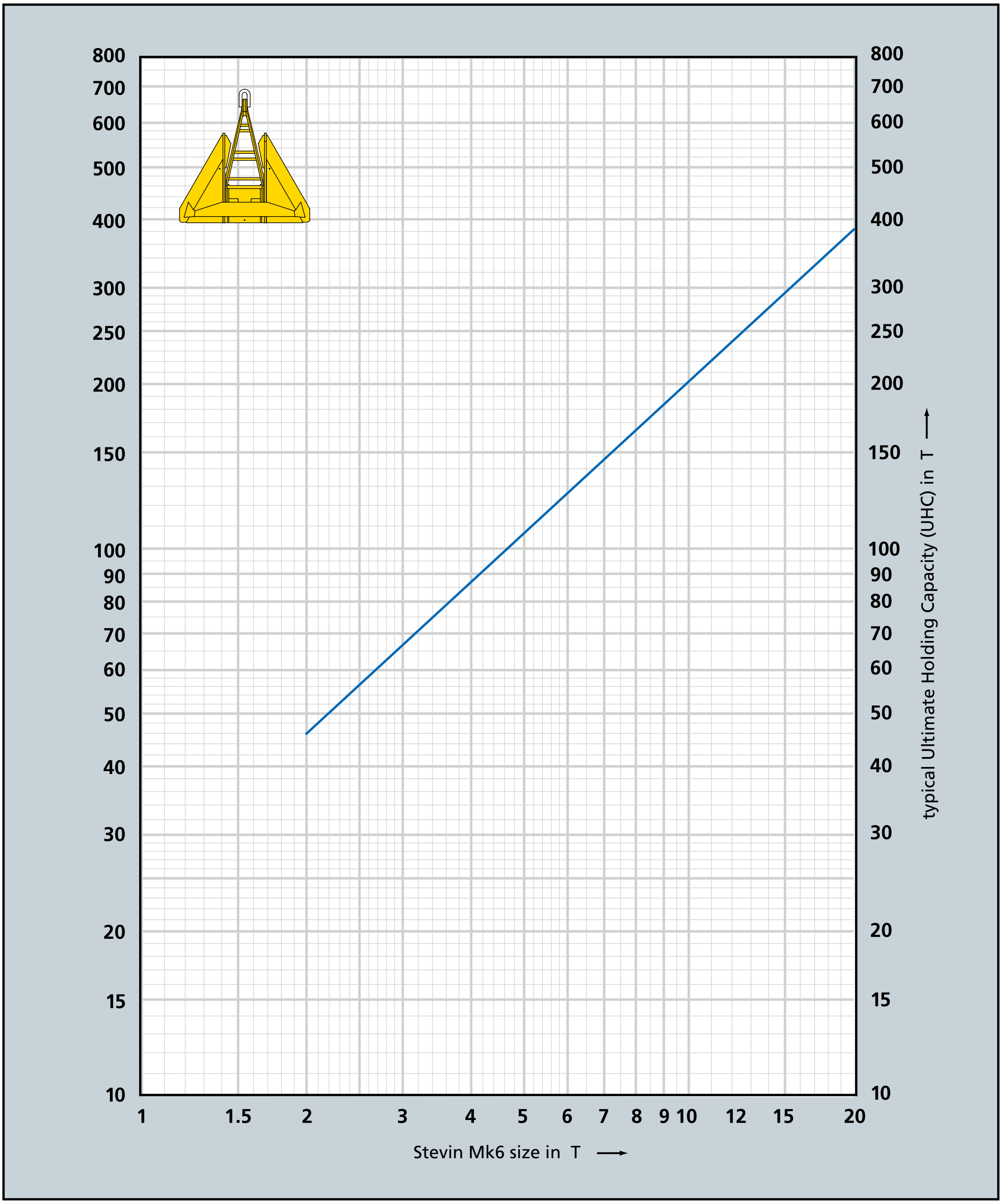
Nc = Bearing Capacity Factor

Su = (k *D), Undrained Shear Strength clay [kPa]

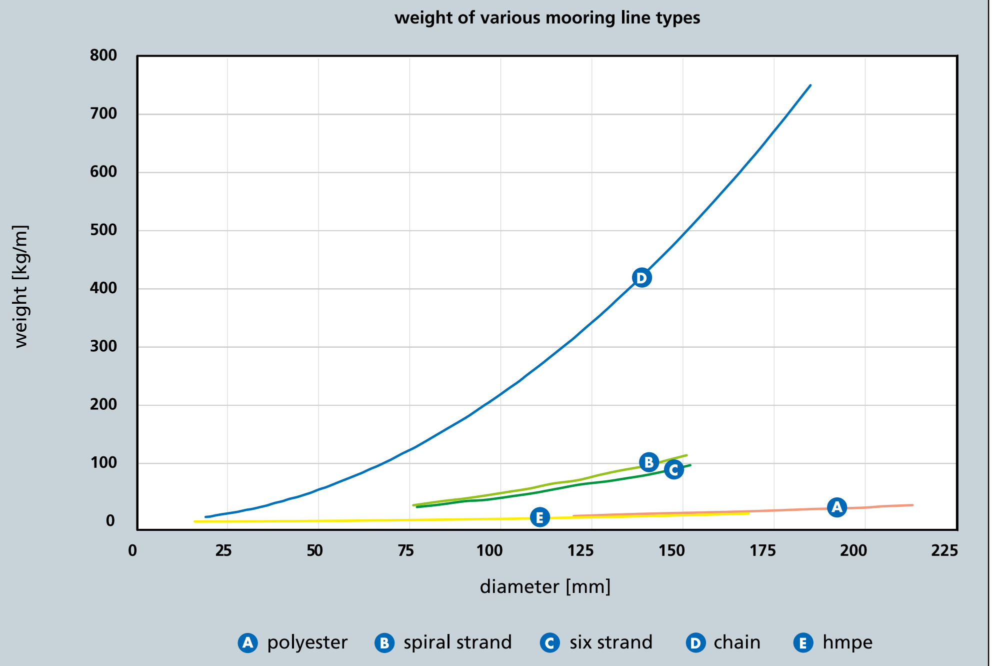
A = Stevmanta fluke area [m²]

The UPC graph incorporates a N_c- value of 10, α-value of 50 degrees and k-value of 2. The graph clearly illustrates the influence of the diameter of the mooring line or installation line, and whether six strand or spiral strand is used. The typical installation load to obtain a specified UPC is presented on the right vertical axis of the graph.

Preliminary holding power data Stevin® Mk6 anchor



Comparison various mooring line types



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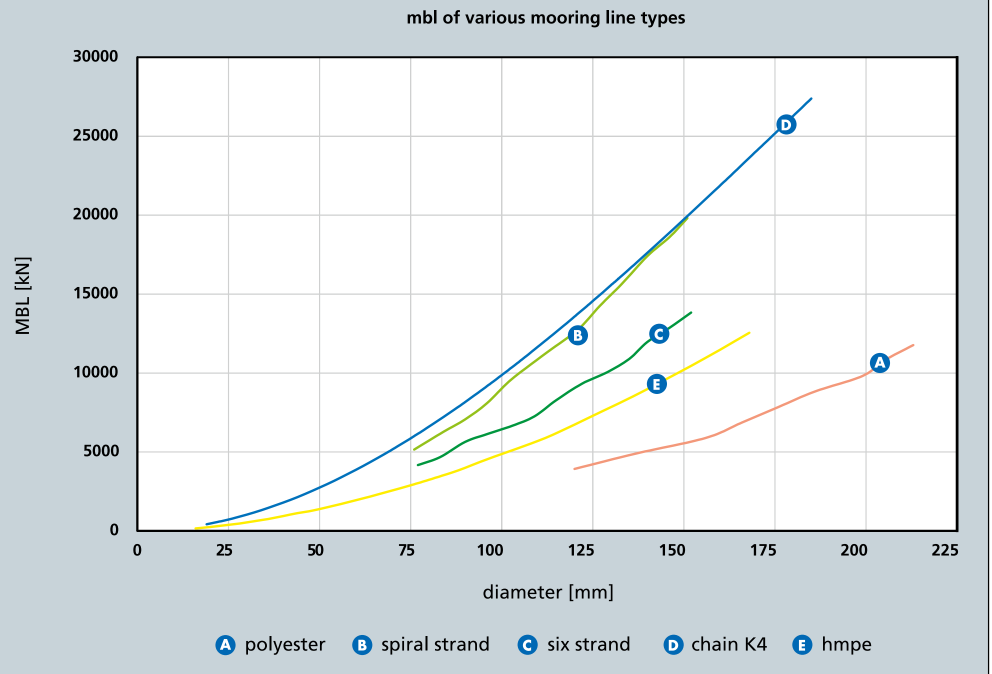

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Conversion table

	to convert from		multiply by	to obtain	
length	millimetres	mm	0.03937	inches	in
	metres	m	3.28084	feet	ft
	kilometres	km	0.62137	miles	mi
	kilometres	km	0.53996	nautical miles	nmile
	inches	in	25.4	millimetres	mm
	feet	ft	0.30480	metres	m
	miles	mi	1.60934	kilometres	km
	nautical miles	nmile	1.852	kilometres	km
area	square millimetres	mm2	0.00155	square inches	in2
	square metres	m^2	10.76391	square feet	ft^2
	square kilometres	km2	0.38610	square miles	mi2
	square inches	in^2	645.16	square millimetres	mm^2
	square feet	ft2	0.09290	square metres	m2
	square miles	mi^2	2.58999	square kilometres	km^2
volume	millilitres	ml	0.06102	cubic inches	in3
	litres	l	0.26417	gallons (US)	gal
	cubic metres	m3	35.31467	cubic feet	ft3
	cubic inches	in^3	16.38706	millilitres	ml
	gallons (US)	gal	3.78541	litres	l
	cubic feet	ft^3	0.02832	cubic metres	m^3
mass	kilograms	kg	2.20462	pounds	lb
	metric tons	t	1.10231	short tons	US ton
	pounds	lb	0.45359	kilograms	kg
	short tons	US ton	0.90718	metric tons	t
density	kilograms per cubic metre	kg/m3	0.06243	pounds per cubic foot	lb/ft3
	pounds per cubic foot	lb/ft^3	16.01846	kilograms per cubic metre	kg/m^3
force or weight	kilonewtons	kN	0.22481	kips	kip
	kilonewtons	kN	0.10197	metric tons	t
	metric tons	t	2.20462	kips	kip
	kips	kip	4.44822	kilonewtons	kN
	metric tons	t	9.80665	kilonewtons	kN
	kips	kip	0.45359	metric tons	t
pressure or stress	kilopascals	kPa	20.88555	pounds per square foot	psf
	megapascals	MPa	0.14504	kips per square inch	ksi
	pounds per square foot	psf	0.04788	kilopascals	kPa
	kips per square inch	ksi	6.89472	megapascals	MPa
velocity	metres per second	m/s	1.94384	knots	kn
	metres per second	m/s	2.23694	miles per hour	mph
	knots	kn	0.51444	metres per second	m/s
	miles per hour	mph	0.44704	metres per second	m/s
temperature	degrees celsius	˚C	multiply by 1.8 then add 32	degrees fahrenheit	˚F
	degrees fahrenheit	˚F	subtract 32 then multiply by 0.555	degrees celsius	˚C

Terminology

A

Abrasion
The wear of wire or fiber rope caused by sliding friction over fixed surfaces.

AHV
Anchor handling vessel.

Anchor Plan
A preparatory plan to moor a vessel, taking into account all obstacles in the vicinity and indicating the direction and length of the mooring lines as well as the position of the anchor points.

Astern
The movement of the ship's engines in reverse, to cause the stern first movement of the vessel.

B

Beam
The extreme width of a vessel, broadside.

Bird caging
The flaring out of wires in wire rope around the full diameter of a rope, with resulting kinks in the wire.

BOEM
The Bureau of Ocean Energy Management, Regulation and Enforcement (USA).

Bollard
Single posts secured to a tugs deck, a pier.

Bollard Pull
An expression which is used to grade the capacity of a tug or anchor handling vessel and its efficiency. It is generally expressed in tonnes.

Bow chain stopper
A mechanical device for securing chafe chains onboard a tanker.

Braided rope
Rope constructed by braiding or interweaving strands together.

Breaking length
The length of rope, whose mass will equal that of its breaking strength.

Breaking strength
The load require to pull a wire, strand or rope to destruction.

Bridle
A two-legged rigging arrangement, either to tow or lift, usually forming an equilateral triangle.

Bridle plate
A triangular steel plate to which chain bridle legs are connected.

Buoyancy
The ability of an object to float partly submerged due to watertight compartments.

C

CALM
Catenary Anchor Leg Mooring system.

Capstan
A vertically mounted warping drum with its motor secured below decks. The sides of the drum are fitted with 'whelps' to provide improved holding for mooring rope turns.

Catenary
Deflections of a mooring line suspended or attached at two points caused by the weight of the mooring line.
CBS
Calculated breaking strength.
Chafe chain
A length of stud-link chain at the end of an SPM mooring hawser which passes through a ship's fairlead and is used to connect the SPM mooring hawser to the bow chain stopper of a tanker.
Chain
A connected, flexible series of links, used for binding, connecting or other purposes.
Chain Locker
A compartment below the vessel's deck in which mooring chain can be stored.
Chain stopper
A device used to secure chain, thereby relieving the strain on the windlass; also used for securing the anchor in the housed position in the hawser pipe.
Chase Wire
Length of wire rope used as the primary component when chasing to anchors to unseat or when running out anchors to deploy.
Chaser
A ring-like component secured around the mooring wire/chain used during installation and retrieval of anchors.
Classification society
Member of the International Association of Classification Societies (IACS). They provide a framework for maritime safety and regulation by way of compliance verification. Some are specialist in the marine and or offshore industry.
Configuration
A listing of mooring components in a specific mooring system, including anchor, wire, chain, connecting links, etc.
Core (wire rope)
The axial member of a wire rope about which the strands are laid.

D

Displacement
The mass of water in tonnes displaced by a vessel at a given draft.
Drag
An effect which opposes the ship's forward motion and can be caused by shell/hull friction, rudder action or appendages extending from the hull, effectively reducing the ship's speed. The term is also used to describe a ship dragging its anchor.
Drag Embedment Anchor
An anchor type that is pulled into the seabed in order to provide the required holding power.
DWT
Deadweight tonnage of a vessel at the maximum summer draft, expressed in tonnes.

F

Fairlead

Metal fittings which lead lines in the direction desired Fake. To lay out a line in long, flat bights.

Fender

A purpose-built addition to the ship's hull to prevent damage when mooring alongside a jetty or other hard surface.

FPSO

Floating Production, Storage and Offloading unit.

FSO

Floating Storage and Offloading unit.

G

Ganger Length

A short length of anchor cable set between the anchor crown 'D' shackle and the first joining shackle of the cable. The length may consist of just a few links which may or may not contain a swivel fitting.

Grapnel

The grapnel is merely a shank with four or more tines. It has a benefit in that, no matter how it reaches the bottom, one or more tines will be aimed to set.

Grommet

An assembly of rope spliced into an endless loop then two legs seized together to form a single length.

H

Hawser

A term which refers to a mooring line, commonly a large diameter fibre rope or wire rope.

Heading

That direction in which the ship is pointed. It is usually compass referenced.

Heel

That angular measure that a vessel will be inclined by an external force, e.g. wind or waves. The condition can also occur during a turning manoeuvre.

Holding Power

An expression used to describe the holding power of an anchor, measured by its efficiency (holding power=weight*efficiency). Class A anchors have an efficiency of 33 to 55. Class B anchors 7 to 25 and Class C anchor 14 to 26.

J

Jewelry

Various components used to connect mooring chain, wire, and anchors

Joining Shackle

A single specialized shackle that joins two shackle lengths of cable. The most common joining shackle employed is the 'kenter shackle' but 'D' lugged joining shackles are also employed for the same purpose.

L

Laid rope

Rope constructed by laying and twisting several strands together. The direction of the twist is opposite that of the strand twist. Common forms are three, four and six strand (with core).

Lee
That side of the ship that lies away from the wind. Opposite to the weather.
Linear density
The weight per unit length of the rope.

M
MBL
Minimum breaking load of a new mooring line or chain, as declared by the manufacturer. It does not include allowance for splicing (mooring line) or for wear and tear.
Messenger
A light line used for hauling over a heavier rope or hawser Monkey Fist.
Weighted knot in the end of a heaving line.
Messenger Line
A light line employed as an easy to handle length, used to pass a heavy mooring hawser, as with a ‘slip wire’.
Minimum yield load
The mooring load applied to a mooring fitting (eg. Bow fairlead, bow chain stopper) that, if exceeded, would cause permanent (plastic) deformation of the fitting, its components or foundations and, therefore, impair or otherwise compromise its continued safe use.
MODU
Mobile Offshore Drilling Unit. A generic term for several classes of self-contained floatable or floating drilling machines such as jack-ups, semisubmersibles, and submersibles.
Mooring
The term used to describe a vessel secured to the seabed with anchors.
Mooring Anchor
A heavy anchor employed as a permanent mooring for buoys or floating offshore installations (Rigs, production vessels).
Mooring Buoy
A large buoy to which ships can moor using mooring lines or by means of the anchor cable.
Mooring hawser
An assembly of rope and fittings, terminations, flotation aids and anti-chafe protection.
Mooring Line
A steel wire rope, a natural fibre or manmade fibre rope used to tie up and secure the vessel to the seabed. A generic term which can also include mooring wires.
Mooring Shackle
A heavy duty bow shackle, listed under the anchors and cables components. It is used when the vessel needs to moor up to buoys.
Mooring Swivel
An additional fitting placed into the mooring line. The swivel ensures that components in the mooring line can rotate without building torque.

O
OCIMF
Oil Companies International Marine Forum, a London based organisation of marine representatives from SPM terminal operators, primarily oil companies.

OIM
Offshore Installation Manager.
Onshore
That direction towards the coastline from seaward (opposite is offshore).

P
Pad eye (horizontal, vertical)
A metal structure with a hole for a shackle or pin (on a vertical pad eye, the axis of the hole is parallel to the deck. On a horizontal pad eye, the axis is perpendicular to the deck. Vertical pad eyes are often referred to as free-standing pad eyes).
Pay out
To slack off on a line.
PCC
Permanent chain chaser.
Pendant
A single wire or chain that leads from the apex of a towing bridle to the tow line.
Pitch
The vertical rise or angle to horizontal of an object.
Pop-Up Pins
Pins located near the stern roller of an anchor handling vessel used primarily to secure mooring chain, wire, and other components during mooring operations.
Port side
A reference to the left side of the vessel when looking forward.
PTC
Polyester tubular cloth.
PU
Polyurethane elastomer.

R
Reference load
A nominal pre-tension load, approximately 1% of the breaking load, which is applied to the rope to remove slack when taking certain measurements.
Roll
The horizontal beam movement of a ship or object.
Rope
A group of strands of fibers or wires, twisted or braided together, to form a single pliable member .

S
SWL
Safe working load. A load less than the yield or breaking load by a safety factor defined by a code, standard or good engineering practice.
Shackle (anchor, chain)
U-shape metal fittings, closed at the open end with a pin; used to connect wire and chain to pad eyes, etc.

Shark Jaw
A device located near the stern roller of an anchor handling vessel used primarily to secure mooring chain, wire, and other components during mooring operations.
Shuttle tanker
An oil tanker specially designed or adapted for loading at offshore terminals requiring specialised mooring or bow loading equipment.
SPM - Single Point Mooring
An integrated mooring arrangement for bow mooring a tanker or floating production system.
SALM
Single Anchor Leg Mooring system.
Single rope assembly
An assembly of a single rope with terminations at each end. Ancillary equipment fitted as requested.
Splice
End connection of a rope by means of a splicing the end into the rope.
Spliced eye
A loop formed at the end of a rope and secured by interweaving the strands or braids.
Spring line
A mooring or docking line leading at an angle less than 45 degrees with the fore and aft lines of the ship; used to turn a ship or prevent it from moving ahead or astern.
Starboard
Defined by the right of the ship when facing forward. Starboard is indicated by a green light or painted surface.
Stopper
A length of rope or chain employed to temporarily take the weight of a rope or wire, while it is transferred from a winch to secure cleats or bollards.
Stopper
A short length of rope secured at one end and used to stop it from running.
Swivel
An anchor chain component fitted to turn freely and reduce twisting and kinking of the anchor chain.
SWL
Safe working load. The load that a rope or working gear may carry economically and safely.

T

Tandem mooring
A hawser-mooring arrangement between two vessels, either bow-to-bow or bow-to-stern. It is normally taken to mean a mooring arrangement between the bow of a conventional tanker and the stern of bow of an FPSO or FSO.
Thimble
A grooved metal component fitted snugly into an eye splice.
Tugger
Small winches typically located forward of the back deck on the port and starboard sides and used to assist in handling smaller loads.

Turret
A vertical column around which a vessel – mostly an FPSO - can weathervane (sometimes 360 degrees) while the anchor lines attached to its bottom hold it in place. Through an ingenious system fluids can be transferred between the ship and the turret.

Type Approval
An abstract endorsement by the classification society of the anchor's design, or "type", which is in turn classified according to its category of performance.

V

Veer
To pay out chain or line

W

Wave Height
That vertical distance between the crest of a wave and the lower part of the trough.

Wave Length
Is defined by the distance between two adjacent crests of waves.

Wet breaking strength
The average breaking strength of prototype ropes that have been soaked in water and conditioned by 10 load cycles.

Windlass
The name given to a heavy duty mooring winch in the fore part of the vessel engaged as an anchor cable lifter. They are generally multi-purpose, providing warping barrels for mooring rope use.

Wire rope
Rope made of wire strands twisted together, as distinguished from the more common and weaker fiber rope.

Wire rope pendant
A long wire strap.

Work Wire
Shorter length of wire rope, usually attached directly to the winch drum.

Keyword register

Keyword register

Keyword register

Keyword register

Keyword register

Vryhof is a trusted partner to many of the offshore industry's leading companies, delivering innovative and customer-focused anchoring and mooring solutions. We are committed to the highest standards of safety and integrity and are proud of our legacy and impeccable track record, delivering value in everything we do. Our 50-year history of setting standards and leading the way in the offshore sector makes us unique in terms of our expertise and breadth of services.

In recent years, Vryhof and its installation partners have taken full scope permanent mooring projects for offshore oil & gas and renewables applications by offering innovative and cost effective solutions including design, procurement, installation, life extension and decommissioning.

Vryhof consists of: Deep Sea Mooring, MoorLink and Vryhof Anchors.

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