The largest anchors ever!

In January 2007 Vryhof loaded out 8 huge 75 ton Stevshark anchors from the manufacturing plant in Rotterdam, readying them for a very, very long haul through the Panama Canal to their final destination in Alaska. Eh ... Alaska? Are offshore developments speeding up such that they need anchors? No, not to worry you are not missing a boat; this simply concerns a secret mission.

The 75 tons anchors are the biggest in Vryhof's history and believed the biggest in the offshore industry. Vryhof did produce a 65 ton Stevpris Mk3 in the 1980s and later even a 60 ton Stevshark was built, however the current ones include 15 tons of ballast and are thus actually 75 tons.

With records like this, normally one uses superlatives, compare it to the size or weight of the Eiffel Tower. Stuff like that. Well, to speak in aviator terms, the anchors wing span is 12 meters (that's one heck of a stretched limo) or their weight equals 35 American cars.

Vryhof Anchors long standing client Rasmussen Equipment Co, located in Seattle Washington (USA), was to deliver the anchors to Manson Construction Company Inc. a US-based international contractor active in offshore, dredging, bridge building etc. Manson's client was the Boeing Company of America, which needs no introduction, whose client was MDA to moor their new SBX.

Transport of the anchors was to go via the Panama Canal, then right up to Seattle not exactly your average offshore destination. From there they were to load out for the second leg of their travels to Alaska.

Continued on next page
MAD, SBX, VA STK 75 T. This starts to sound like a James Bond Movie. Well, partly that fits. The anchors are to become part of the International Missile Defense Systems, or more precise to moor a Sea-Based X-band Radar.

It does make an interesting combination, where the most hyper-tech industry chooses the most traditional high-tech way of mooring system around. Anchors.

**Transporting SBX anchors**

“If you have transported anchors as often as we have, you might call it a routine operation.” says BGT Transport Director Hans Verrijp when he critically follows the load out of the SBX anchors in Rotterdam. Vryhof and BGT Transport go back a long way and have transported anchors over road, rail, through mountains passes (more than just once!) by airplane, helicopter and yes also over water. Some anchors are more difficult than others. But not so much because of extreme dimensions. Let’s not forget that transportation efficiency is nowadays one of the design criteria.

“We learned of the record size anchors last October and were given a time window of early 2007 delivery”, says Hans “and we can normally live with a time window like that. Generally we start setting off the possible way of transport against the cost, a rather important driver. In this case the dimensions more than the weight were criteria that limit the choices, so that we could not transport over road and then the destination, Seattle, doesn’t leave very many variations either. It’s one straight line to Panama, followed by a straight line up North. I mean, no real use into looking at crossing Canada is there?”

As it turned out there was only one liner available for that route so we did secure a quote in time to assure the client we would get his anchors to Seattle. When we later specified the loads; 8 flukes of 40,8 tons and 8 shanks of 34.2 tons and they looked at the dimensions, sure enough they suddenly discovered they could not take it on the ship they had offered. “Capacity problems do not leave much space for negotiating ...” grins Hans “so that we had to be creative and after a while settled for two different calls of the vessel to Vlissingen (Flushing) harbour in the South West of Holland.

On January 15, just before the load out was to commence, two anchors were assembled on the quay side for the shooting of some commemorative photos with the client reps present and the fabrication plant staff on the photo too! The second load left 29th of January and all were transferred to the ocean liner on February 7 with ETA in Seattle on March 15.
Photo: Anchor manufacturing plant crew, Vryhof staff and client representatives at a short commemorative photo shoot.
Subsea Tensioning for Cost-Effective Installation

The proof testing of installed anchor points for permanently moored facilities such as CALM buoys and FPSOs is a critical aspect of the overall certification and approval process for these systems. For drag embedment anchor solutions, the proof test includes setting the anchors into the seabed and ensuring they do not drag beyond allowable limits. Where vertically installed anchor points are involved, such as driven piles or suction anchors, the proof test performs the dual role of not only verifying the anchor point capability but of also embedding the mooring line at the pile into the seabed in a characteristic inverse catenary curve. The loads required are often high, typically being 80% of the maximum intact design load, and the hold period for the proof test is dictated by class society rules, ranging from 15-30 minutes.

The Stevtensioner
Applying these (substantially horizontal) proof loads in the field requires high bollard pull vessels, or by means of cross-tensioning on deck using a crane, fixed winch or chain jack system. However, subsea tensioning can offer significant time and cost benefits and reduced risk over other conventional mooring system proof testing methods, using a device like the Vryhof Stevtensioner. This is basically a chain shortening clutch, which passes chain through it in the slack condition but locks onto the chain under load. An anchor line is attached to one side of the Stevtensioner, an opposed anchor line is passed through it and up to the surface. A vertical pull on this riser induces more than double that pull in the horizontal legs, just like a bowstring.

The Benefits
The potential benefits of subsea tensioning are numerous, particularly saving time and money during installation. It can be applied to all types of mooring systems and anchor provided a working chain section is included, in shallow or deep waters. In symmetrical systems anchors can be cross-tensioned as opposed pairs, halving the number of tensioning operations required, or individual anchors can be tensioned using a temporary reaction anchor. The loads seen at the installation vessel are reduced, reducing the size of equipment required and more importantly lowering risk to equipment and personnel. The reduced required vertical pull enables a wider range of vessels to be considered for tensioning operations, and obviates the need for bollard pull or crane capacity in excess of required installation load. Subsea tensioning can be performed from anchor handling vessels or modest crane barges, helping to...
reduce overall installation cost. The load in the horizontal anchor leg can be measured at the Stevtensioner by means of an integral load cell and the data recorded in real time on deck via an umbilical cable or acoustic modem in deeper water depths. Subsea tensioning equipment is relatively compact in size so can be sent by air freight to reduce mobilisation time.

The Tensioning Process
Once the anchors have been laid on the seabed, or piles installed and the mooring lines laid, the Stevtensioner is connected and deployed to the seabed. The tensioning process involves repeatedly heaving up and slacking back the Stevtensioner in a yo-yo action to remove slack from the system and progressively build up the load in the horizontal legs until the required tension is achieved. Typically 4-6 yo-yo cycles are needed and cross-tensioning a pair of anchors takes around 6 hours from connecting the Stevtensioner to de-rigging it (depending on system parameters).

Example CALM buoy installation
The installation of a CALM buoy typifies the benefits of subsea tensioning, where a six-leg symmetrical spread mooring requires only three tensioning operations to proof test the system. In March 2006 the Vryhof Stevtensioner was used on such a project offshore Libya, where a complete CALM buoy mooring was installed, proof tested and hooked up in only 16 days, including 2 days transit time from the mobilisation port of Malta, and 2 days of weather downtime. Six 1.5m diameter piles were driven 15m into the seabed, six 300m long 92mm diameter studless anchor chains laid, cross-tensioned with the Stevtensioner to 200 tonnes, and the buoy connected, all in only 12 operating days on site. This was completed by the Saipem 3000 crane vessel for ENI Oil.

The Complete Service
Vryhof Anchors provide comprehensive subsea tensioning services for the installation of all offshore mooring systems, including feasibility study, equipment hire, and provision of supervisory personnel offshore. A range of Stevtensioners are held in stock to cover chain sizes up to 135mm and loads up to 1000 tonnes can be handled.
Drag Embedded Plate Anchors

Ratio between installation load and Ultimate Pull-out Capacity (UPC)

Introduction.
When using drag embedded plate anchors (for example the Stevmanta VLA), a key parameter is the relationship between the generated ultimate pull-out capacity (UPC) and the applied installation load at the anchor shackle ($F_{\text{inst}}$). In common design practice for these anchors, the ratio $\text{UPC} / F_{\text{inst}}$ ranges between 2 and 3.5 depending on anchor resistance and soil properties. This article examines the influence of various anchor geometry and soil parameters on this ratio.

UPC and installation load.
The UPC of a plate anchor is defined as:

$$\text{UPC} = N_c \times s_u \times A \quad \text{(1)}$$

where

- $N_c$ = bearing capacity factor
- $s_u$ = undrained shear strength at penetration depth
- $A$ = plate area

The load at the anchor shackle ($F_{\text{inst}}$) required to penetrate the drag embedded plate anchor to penetration depth can be evaluated with the following relationship:

$$F_{\text{inst}} = \frac{\sum N_c \times s_u \times A \times \cos \alpha}{\sum \mu_{\text{bearing}} \times \mu_{\text{shearing}} \times \mu_{\text{fluke}}}$$ \quad \text{(2)}

where

- $\mu_{\text{shearing}}$ = the area of shearing surface $i$ relative to the fluke area ($A$)
- $\mu_{\text{bearing}}$ = of bearing surface $j$ relative to the fluke area ($A$)
- $s_u$ = the sensitivity of the soil
- $\alpha$ = the angle between the fluke surface and the applied mooring line force

By combining equations (1) and (2), the following relationship is found between the UPC and $F_{\text{inst}}$:

$$\text{UPC} = \frac{\sum N_c \times s_u \times A \times \cos \alpha}{\sum \mu_{\text{shearing}} \times \mu_{\text{bearing}} \times \mu_{\text{fluke}}}$$ \quad \text{(3)}

Evaluation of the ratio $\text{UPC} / F_{\text{inst}}$.
The ratio of $\text{UPC} / F_{\text{inst}}$ will be evaluated for a number of different values of $s_u$ and mooring line angles varying from 0 to 90 degrees. Table 1 presents the results for mooring line angles varying between 40 and 65 degrees which is the normally used range for plate anchors in clay.

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Thin plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>$s_u = 1$</td>
</tr>
<tr>
<td>40°</td>
<td>4.6</td>
</tr>
<tr>
<td>45°</td>
<td>4.2</td>
</tr>
<tr>
<td>50°</td>
<td>3.9</td>
</tr>
<tr>
<td>55°</td>
<td>3.4</td>
</tr>
<tr>
<td>60°</td>
<td>3.0</td>
</tr>
<tr>
<td>65°</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Evaluation of the ratio $\text{UPC} / F_{\text{inst}}$.
The ratio of $\text{UPC} / F_{\text{inst}}$ will be evaluated for a number of different values of $s_u$ and mooring line angles varying from 0 to 90 degrees. Figure 2 shows the results of the analysis. In table 2 the results are presented for mooring line angles varying between 40 degrees to 65 degrees which is the normally used range for plate anchors in clay.

<table>
<thead>
<tr>
<th>Case 2</th>
<th>Typical anchor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>$s_u = 1$</td>
</tr>
<tr>
<td>40°</td>
<td>2.1</td>
</tr>
<tr>
<td>45°</td>
<td>2.0</td>
</tr>
<tr>
<td>50°</td>
<td>1.8</td>
</tr>
<tr>
<td>55°</td>
<td>1.6</td>
</tr>
<tr>
<td>60°</td>
<td>1.4</td>
</tr>
<tr>
<td>65°</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Evaluation of the ratio $\text{UPC} / F_{\text{inst}}$.
The ratio of $\text{UPC} / F_{\text{inst}}$ has been evaluated for a number of different values of $s_u$ and mooring line angles varying from 0 to 90 degrees. Figure 1 shows the results of the analysis. In table 1 the results are presented for mooring line angles varying between 40 degrees to 65 degrees which is the normally used range for plate anchors in clay.

<table>
<thead>
<tr>
<th>Case 3</th>
<th>Typical anchor</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>$s_u = 1$</td>
</tr>
<tr>
<td>40°</td>
<td>2.1</td>
</tr>
<tr>
<td>45°</td>
<td>2.0</td>
</tr>
<tr>
<td>50°</td>
<td>1.8</td>
</tr>
<tr>
<td>55°</td>
<td>1.6</td>
</tr>
<tr>
<td>60°</td>
<td>1.4</td>
</tr>
<tr>
<td>65°</td>
<td>1.2</td>
</tr>
</tbody>
</table>

The bearing capacity factor ($N_c$) has been taken equal to 12, a conservative assumption based on recent research.
Table 3 - UPC / \( F_{\text{inst}} \) for varying
\( \alpha \) and bearing area

<table>
<thead>
<tr>
<th>( \alpha )</th>
<th>( \sum I_{\text{bearing}} )</th>
<th>0.1</th>
<th>0.15</th>
<th>0.2</th>
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</thead>
<tbody>
<tr>
<td>40°</td>
<td>4.4</td>
<td>3.4</td>
<td>2.8</td>
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<tr>
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<tr>
<td>50°</td>
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<td>2.9</td>
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<td>3.3</td>
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<td>2.2</td>
<td>1.8</td>
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</tr>
<tr>
<td>65°</td>
<td>2.4</td>
<td>1.9</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 4 - UPC / \( F_{\text{inst}} \) for varying
\( \alpha \) and shearing area

<table>
<thead>
<tr>
<th>( \alpha )</th>
<th>( \sum I_{\text{bearing}} )</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>40°</td>
<td>3.7</td>
<td>3.5</td>
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<tr>
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<td>55°</td>
<td>2.8</td>
<td>2.6</td>
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<td>60°</td>
<td>2.4</td>
<td>2.3</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>65°</td>
<td>2.1</td>
<td>1.9</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>

Case 4. The anchor from case 2 is evaluated in a soil with a sensitivity of 3 while the shearing area is varied. The bearing area is constant (0.15 times \( A \)). In table 4 the results are presented for mooring line angles varying between 40 degrees to 65 degrees.

Conclusions:
From the analysis, the following can be concluded.
• For drag embedded plate anchors the ratio between the ultimate pull-out capacity (UPC / \( F_{\text{inst}} \)) is dependant on anchor geometry and soil properties.
• The ratio UPC / \( F_{\text{inst}} \) increases with increasing soil sensitivity.
• The ratio UPC / \( F_{\text{inst}} \) increases with decreasing mooring line angle (\( \alpha \)), i.e. with smaller fluke/shank angle.
• The ratio UPC / \( F_{\text{inst}} \) increases with decreasing bearing area.
• The ratio UPC / \( F_{\text{inst}} \) increases with decreasing shearing area.
• A ratio UPC / \( F_{\text{inst}} \) of 2 to 3.5 is a typical value for deep water applications, i.e. soil with high sensitivity.

References:

Figure 1 – infinitely thin plate without shank
Figure 2 – typical drag embedded plate anchor
We are pleased to announce that Kevin Firth has joined the Vryhof team to further strengthen the commercial and business development functions. Kevin will work on all Vryhof products and services but his primary focus will be the expanded development of the DeepRope polyester mooring line offering in the widest sense.

Many Vryhof clients will doubtless remember Kevin from his former lives at Bridon and Marlow Ropes where he was involved in too many deepwater mooring projects to remember over a 20 year period.

Kevin has returned from a four year sabbatical in subsea production systems and now claims a Christmas Tree isn’t always green with brightly coloured lights and baubles! Already the expanded team is working well with the winning of the contract for the FPSO Gimboa moorings ropes from Saipem. Kevin looks forward to re-forging old acquaintances at OTC and beyond.

Kevin knows the ropes and will provide an important addition to the Bexco/Vryhof relationship.
The World according to...
Numbers and little facts.

The price of oil is fluctuating, changing almost every day. Why? There is no direct reason for that. One day there are reports that the consumption is declining. The next day it is being reported that demand will exceed production. One incident results in a higher price almost overnight.

At the time of writing this article the price is again well above $60.- per barrel, after hitting the $50.- not too long ago. Basics for energy demand are still very much related to demand by nations like India and China. Those economies are still growing at a very fast pace and there are no signs this will change in the foreseeable future.

It is expected that the Indian economy will surpass the economy of the U.S. by 2050. The Chinese will achieve that by 2035.

The Indians will use 3 times more crude oil by 2020 than they do now. With 70% of its oil imported, this will put pressure on the supply of Middle Eastern oil, possibly resulting in a race for supply from those sources.

It was reported that China holds in excess of 1000 billion US dollars and this will not stop.

ONE THOUSAND BILLION, how many zero’s is that?

For resources, China is focussing on Africa, where they buy raw materials, while investing a lot of money in several African countries, building roads etc. This indicates that their economy will grow at the fast pace we have used to. Another item of concern is how this growth will influence the environment. There are concerns that the impact will be enormous.

Ethanol fuel?
Corn growers especially in the U.S. benefit from giant increases in the price. As a result, the corn as basis of foods becomes more costly. For instance the price of tortilla’s in Mexico, food for the poor, has risen dramatically. Corn prices have soared 119 % since late 2005. This while the tortilla accounts for half of the calories the average Mexican consumes every day. The rise in corn prices is also believed to influence the Peso, which has fallen against the US dollar as one of the few currencies. This is serious business for the second biggest economy in South America.

Bio-fuel, using waste instead of corn, is heavily subsidized. The cost price however is much higher than that of corn based production. Still, Ethanol accounts only for a fraction of the energy demand.

Thailand plans to allow import of palm oil. This because they most likely can not produce enough palm oil themselves for their biodiesel manufacture. This in spite of the fact that importing the oil will be at substantial higher prices than if manufactured locally. In addition a shortage of palm oil for cooking purposes is expected.

In Brazil ethanol is made from sugar cane, which is cheaper than US corn ethanol and has hardly any effect on food commodity prices.

Last little fact.
The European Union have passed a bill to reduce the annual CO2 emission by 20%. This will most likely mean that they want to reduce cars running on diesel (rather common in Europe), whereas they have promoted the use of diesel run cars in the seventies.

In conclusion, for now I will continue driving my car, which runs on regular, although unleaded, gasoline at a modest speed of 90 - 100 kilometers / hour, on a sunny day, without any head wind and no traffic to speak of, averaging 6 kilometers to the liter.

Just like I guess most of you will do.

Jan Mouthaan
InterMoor was founded in 2004 when Acteon purchased the assets of Technip Offshore Moorings. Since then, InterMoor has tripled its business due to the market conditions and being made an independent company. This expansion is a combination of organic growth, investment in mooring hardware and infrastructure, and Acteon’s acquisitions of various companies.

Due to the strong market demands in the Gulf of Mexico after the disastrous hurricane season in 2005, InterMoor is in the process of acquiring an additional $20 million in mooring hardware. The hurricanes have changed mooring practices in the Gulf of Mexico such that many of the rigs have upgraded from eight point mooring systems to twelve point mooring systems. This, along with the continuing increase of subsea infrastructure, has created a strong demand for preset mooring systems, which is a large part of InterMoor’s business. Parts of this hardware are a purchase of 32 anchors from Vryhof. The anchors being purchased are Stevpris NG and Stevmanta anchors.

InterMoor is constructing a new 960,000 square feet (89,197 square meter) facility in Fourchon, more than 2.5 times the size of the current facility. The new facility will allow to better serve the Gulf of Mexico clients for load out and storage facilities. A heavy lift crane will be added.

Outside of the U.S. market, InterMoor do Brasil was formed in September 2006. From Rio de Janeiro full service mooring capabilities will be offered. Some of these services through Fluke Engenharia, who is a licensed Vryhof fabricator.

InterMoor is also actively working with two other Acteon companies to provide unique solutions for the offshore oil and gas industry. With Menck, the supplier of deepwater underwater pile driving hammers, they develop operational procedures and technology for the installation of driven piles and conductors from lower cost alternative vessels. 2H Offshore, the deepwater riser specialist company, and InterMoor collaborate in various issues that relate to both mooring and risers, including mooring integrity management.

All of this expansion makes InterMoor better suited to provide the industry with more cost efficient solutions.
API recommendation
Hurricane Moorings - Interim Guidance Revisited

The 1st MODU recommended practice, released in 1987 by API, specified a design environment lower than the five to ten year return period in the present version of the API RP 2SK, principally driven by the MODU mooring capabilities available at that time. The latest version of the recommended practice "Design and Analysis of Stationkeeping Systems for floating Structures", API RP 2SK, dated October 2005 incorporates already more severe metocean design data.

The mooring failures occurring during the Hurricanes of 2004 and 2005 suggested that the design recommendations were not sufficiently effective. The Offshore Operators Committee launched a Joint Industry Project entitled "US Gulf of Mexico (GOM) Mooring Strength Reliability" (MODU JIP) that started in September/October 2005 with the task to improve the design recommendations for the 2006 hurricane season. This all happened in close cooperation with API who would publish the new recommendations. Studies were initiated. Mooring failures were analysed using measured data obtained from the hurricanes, common practices on mooring inspection were evaluated, historical and recent weather data were analysed again and combined in a new database, methods of mooring design were critically looked at, more focus was given to the risk a mooring can impose on its surrounding.

All these studies will bring us also a big step forward in the design methodology of moorings, but a thorough study takes time, more time even if the problems are complex and if there are many participants and interested parties. The workgroup that compiled the latest edition of API RP 2SK was asked to continue their work and propose recommendations for the 2006 hurricane season. Initially the proposed recommendations were to be part of a commentary to the existing RP 2SK, but time was insufficient and the recommendations were published in May 2006 as a separate document supplementing the latest edition of RP 25K; "Interim Guidance for Gulf of Mexico MODU Mooring Practice - 2006 Hurricane season" API RP 95F, first edition.

The workgroup RP 25K continued their task preparing the complete document as a commentary to the RP 25K. Agreement was reached on increased metocean design data, on calculation methods and mooring analysis, on risk assessment, on mooring system improvement, on mooring installation and inspection, on anchor system considerations and even on most of the wording of the recommendations.

Although progress of the workgroup was good, one essential issue was pushed forward but still remained to be decided on: the design return period. Some parties are of the opinion that the present return period of 5- to 10-year should be increased to 50- or 100-year or even more; other parties believe that the increased metocean design data and increased factors of safety already result in a sufficient increase of mooring strength with respect to the present RP 25K and that a return period between 5 and 50 would be preferred.

It has been decided not to wait for the results of the discussion on return periods and for now go forward on the same basis as proposed in the Interim Guidance 2006. It seems as if the RP 25K workgroup document will be published as a 2nd edition of the "Interim Guidance for Gulf of Mexico MODU Mooring Practice – 2007 Hurricane Season" showing a required return period larger or equal to 10.

The result of the mentioned design return period discussion may be published in the "Interim Guidance 2008", but hopefully much earlier in a final document of "Commentary" added to API RP 25K.

By Gijs Degenkamp
Vicinay-Cadenas S.A., the Spanish manufacturer and supplier of mooring chain, represented by Vryhof Anchors in the Netherlands, has opened an ultramodern Forging Plant close to the town of Galdames, some 30 kilometers from Bilbao, Vicinay’s home town. The plant was developed as to be able to cope with an increasing order portfolio from the offshore industry that apart from chain also includes forged mooring components.

The production floor layout of the new plant was primarily driven by Vicinay’s management plan - based on OHSAS 18001:99 - that not only includes the obvious larger production capacity won through higher efficiency, but balances these parameters with matters such as health & safety, environmental considerations such as the use of eco-friendly fuels.

The new plant is designed to an annual output of 800 tonnes of items between 40 and 2.500 kilograms.