

## Anchoring Solutions for Offshore Renewable Systems

by  
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Vryhof Anchors BV – Netherlands

Seminar : Energy Decision, with focus on Renewables and Offshore Wind,  
30 October 2014, Tokyo – Japan

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### Company milestones

- Founded in 1972
- Stevin®, Stevpris®, Stevshark®, Stevmanta®, Stevtensioner®, Stevtrack® Vryhof trade marks and patented products
- HQ and R&D centre near Rotterdam
- Fabrication at Rotterdam harbour
- Offices worldwide: Vryhof Americas (Houston), Vryhof Singapore, Vryhof France (Paris), Vryhof do Brazil (Rio de Janeiro), Vryhof Russia (Moscow)
- ISO 9001:2008 Certified
- Type Approvals from ABS, DNV, BV, and the design approvals and good working experience by all Classification Societies (Certifying Authorities); LRS, ClassNK, Rina, RMRS, CCS, etc.

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### Contents

- Introduction
- Mooring systems
- Offshore foundations: Anchors
- Fluke anchors (Stevpris, Stevshark) and Plate anchors (Stevmanta VLA)
  - Design
  - Installation
- Real time tracking of anchor parameters (Stevtrack)
- Selected project examples and reliability levels
- Conclusions

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### Many offshore units around the world are floating structures and are moored

#### OIL & GAS

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### The Vryhof scope

- Design, manufacturing and supply of High Holding Power (HHP) anchors, suction piles, dynamically embedded anchors, gravity anchors, and tensioning equipment
- Selection and supply of fit-to-purpose mooring line components and connectors on behalf of clients
- Operating an alliance of leading manufacturers of mooring line components
- Offshore Installation assistance
- FEED studies and other Engineering services

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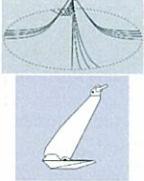
### Renewable Energy, Offshore and Civil Constructions

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### Mooring systems in general

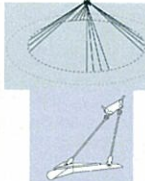
**Catenary Mooring**

- chain
- wire rope
- drag embedment anchor



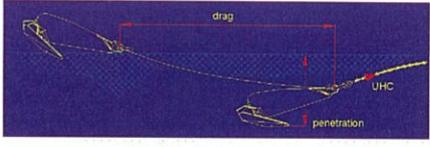
**Taut and Semi-taut Mooring**

- synthetic rope
- wire rope
- vertical loaded anchor (VLA)



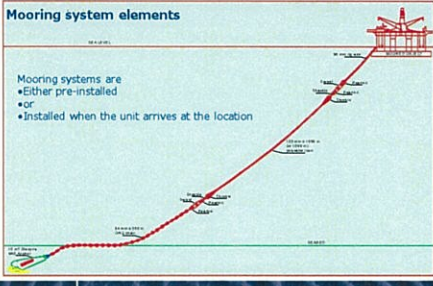
**vryhof anchors** | Anchoring Solutions For Offshore Renewable Systems by Sverre Arntsen, Sverre Arntsen Energy Division. Much focus on renewables and offshore wind.

A drag embedment anchor is pulled in (dragged in) to the seabed. The capacity and performance is a function of anchor type/size and the in-situ geotechnical conditions.



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### Mooring system elements




Mooring systems are

- Either pre-installed
- or
- Installed when the unit arrives at the location

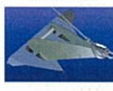
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Majority of the moored structures around the world uses drag anchors; Vryhof only over 10.000 anchors - about 1.800 anchors on permanent systems


Stevin




Stevpris Mk5



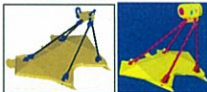
Stevshark Mk5



Stevpris Mk6




Stevmanta VLA




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### Anchoring options




gravity anchor




pile



suction pile



Gravity installed: DPA, torpedo, etc



drag embedment anchor

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### Installation records: project distribution world-wide



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Only a special category of drag embedment anchors is suitable for offshore use

A Class anchors

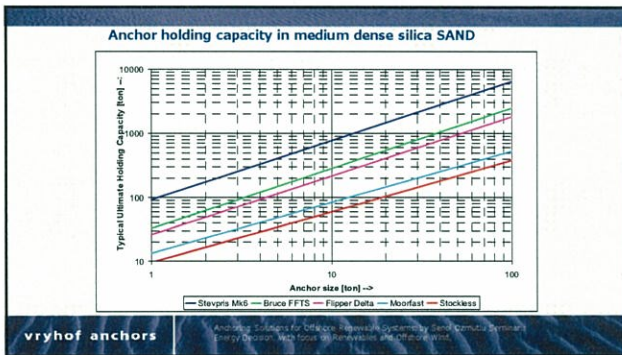
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Anchor Solutions for Offshore Renewable Systems by Sord, Ozturk, Semren Energy Division. Much focus on Renewables and Offshore Wind.

Mounting and changing fluke-shank angle is simple and quick 25 - 40 min

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Anchor Solutions for Offshore Renewable Systems by Sord, Ozturk, Semren Energy Division. Much focus on Renewables and Offshore Wind.



Numerous Installation means and methods are applicable

See our anchor manual or visit [www.vryhof.com](http://www.vryhof.com)

Stevpris® /Stevshark® handling/deployment with chaser

always deck anchor with chain between flukes

rig hauls ANV stacks

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Anchor Solutions for Offshore Renewable Systems by Sord, Ozturk, Semren Energy Division. Much focus on Renewables and Offshore Wind.

DESIGN PROCESS : requirements / specs

Client specifies

- Mooring / metocean conditions
- Type of mooring system
  - Spread or single point
  - Catenary or taut or semi-taut
- Type of moored object
  - Permanent (FPSO, FSO, FPI)
  - Temporary (MODU, barge, etc)
- Mooring line characteristics
- Anchor loads (quasi-static / dynamic)
  - intact
  - damaged
  - transient
- Specifications and applicable codes

Client may provide

- Site conditions
  - Location (maps)
  - Bathymetry
  - Geophysical data
  - Geohazards
  - Geological data
  - Geotechnical data

Suitable anchor

- type & size
- fluke/shank angle setting
- Drag + Penetration
- Inverse catenary of fore-runner
- Installation requirements
- Installation performance
- Long term performance

Client

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Other installation options for drag embedment anchors are to use surface or subsea tensioning methods: REDUCING OFFSHORE INSTALLATION COSTS!!

- High horizontal loads with vertical pull in the order of 40% to 50% of the required tension
- Use of small installation vessels
- Real-time measurement and record of tension data
- Less sensitive to sea state

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**Chain Adjuster and Inline pre-tensioner tool**  
 Reducing offshore installation and platform/floater costs!!

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 Energy Division, with focus on Renewables and Offshore Wind

**Stevmanta VLA is suitable for**  
 high mooring loads with 0 to 90 uplift angle at the mudline AND  
 loading directions with 360 degrees freedom (weathervaning systems)

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**Stevpris® /Stevshark® can be retrieved**  
 by

- using mooring line itself
- PCP
- Recovery pennant
- Recovery bridle

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**Stevmanta VLA Single line installation**

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**STEV MANTA VLA: anchor of choice for semi-taut and taut leg moorings with very high vertical and horizontal loads**

**Permanent moorings**

**Temporary moorings, MODUs**

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**Stevmanta VLA recovery**

1) With tail

2) With special sockets

3) pull-back the installation line: double line and fixed angle adjuster option

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**As well as using advanced tools like Stevtrack**  
**with the real time measurement of load at the anchor and anchor positions/orientations**

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**WindFloat – Principal Power - Portugal**

- WD: 45 m
- Soil:
  - Limited soil data
  - Combination of sand, gravel, clay
  - layered soils
- Catenary chain + wire mooring
- 4 x 9,5+3.5 mT Vryhof Stevshark Mk5
- Installation: Bourbon
  - AHV + Stevensioner

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**Vryhof is heavily involved in Marine Renewable Energy Systems**

We have supplied to the following projects in the world

- Hywind – Statoil – Norway
- Windfloat – Principal Power – Portugal
- University of Maine – VoltumUS – USA
- Fukushima Kizuna – IHI/JMU – Japan
- Fukushima Mirai – Mitsui – Japan
- Fukushima – Mitsubishi – Japan
- SKWID – Modec – Japan

We support developers, engineers and others doing research on Floating renewables

- Principle Power – EDP-R – Repsol
- Iberdrola
- Mainstream Renewables
- Acciona
- Technip
- DCNS
- EDF-EN
- Clear Path Energy
- Tech LLC .....

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**University of Maine – VoltumUS 1:8 - USA**

- WD: 60 m
- Soil:
  - Sandy, shells, bedrock
- Catenary chain
- 3 x 0.2 mT Vryhof Stevshark Mk5®
- Installation: Maine Maritime Academy
  - Tugboat and construction Barge

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**Hywind - Norway**

- WD: 186-204 m
- Soil: soft clay – side loads
- Catenary chain + wire mooring
- 3 x 16 mT Vryhof Stevshark Mk5®
  - Catenary = vertical movement of the floater
  - Stiffness = clump weight mounted on the line
- Installation: Viking Moorings / Technip
  - AHV

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**Fukushima Forward - Japan**

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**Fukushima Forward - Japan**



<p><b>IMAC (former IHI)</b> Fukushima Kizuna Water depth = 120 m Anchors: 4 x 22.5m<sup>2</sup> Vryhof Stevshark Mk5® with 8.8 mT ballast with special cutter points Installed in: July 2013</p>	<p><b>MITSUI</b> Fukushima Mirai Water depth = 122-123 m Anchors: 6 x 25m<sup>2</sup> Vryhof Stevshark Mk5® with 9.8 mT ballast with special cutter points Installed in: November 2013</p>	<p><b>MITSUBISHI</b> Fukushima - Water depth = 125 m Anchors: 8 x 25.5 m<sup>2</sup> Vryhof Stevshark Mk5® with 11.5 mT ballast with special cutter points Anchors installed in: July 2014</p>
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**vryhof anchors** | Anchoring Solutions for Offshore Renewable Systems by Sverre Omholt Sembrun Energy Division. High focus on Renewables and Offshore Wind.


**WindFloat Atlantic**



Water depth = 100 m  
3 floating wind turbines  
Anchors (provisional) : Vryhof Stevshark Mk5®  
Installation Planned : 2017

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**MODEC – SKWID – Saga Prefecture - Japan**



Water depth = 53 m  
Anchors: 4 x 25 m<sup>2</sup> Vryhof Stevshark Mk5® with 9.8 mT ballast with special cutter points  
Anchors installed in: September 2013  
Unit to be hooked-up in 2014 - 2015

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**WindFloat Pacific**



Water depth = 350 m  
5 floating wind turbines  
Installation Planned : 2017

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**INFLOW – Fos Sur Mer - France**



Water depth = 55-65 m  
Anchors (provisional) : Vryhof Stevpris Mk6®  
Installation Planned : 2016

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**Provence Grand Large - France**




Water depth = ~100 -120 m  
Anchors (provisional) : Vryhof Stevpris Mk6®  
Installation Planned : 2017-2018


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**Other renewable energy projects**

DCNS Winflo



IDEOL Floatgen



.... And further Wave, Tidal, Current, and Thermal devices

**vryhof anchors** | Anchoring Solutions for Offshore Renewable Systems by Semaconnect, Germany  
Energy Division, West focus on Renewables and Offshore Wind

**CONCLUSIONS**

- Drag Embedment Anchors (DEA) are simple but robust offshore foundations
- Design is based on soil mechanics principles
- Requires less soil data (i.e. huge cost savings in site investigation campaigns)
- Well tested and proven technology
- Large track record worldwide; Vryhof only over 10000 anchors
- Anchor capacity, penetration, drag, and long term behavior are well predicted
- DEAs are field load tested; reliability level is verified before put in service
- Simple installation methods: the installation does not require special vessels
- DEAs are recoverable and re-usable
- DEAs are cheaper than other offshore foundations; less offshore installation budget

**vryhof anchors** | Anchoring Solutions for Offshore Renewable Systems by Semaconnect, Germany  
Energy Division, West focus on Renewables and Offshore Wind