New Innovative Anchor Solution for Deepwater Mooring – Gravity Installed Anchors Reduce Time and Costs of Marine Operations

Jon Tore Lieng – CTO
Deep Sea Anchors

- Technology developer and provider of innovative anchor solutions for floating structures
- Expertise in marine soil mechanics
- Located in Trondheim, Norway
Available Anchor Types
Anchor Types
drag embedment - VLA

DENNLA – Bruce Anchors

STEVMANTA – Vryhof
Anchor Types cont.

- Suction anchor
- SEPLA
  - Suction Embedded Plate Anchor

- Pump skid

- Soft sediments

- Dimensions:
  - $D = 5\text{–}6.5m$
  - $L = 20\text{–}30m$
  - $W_{dry} = 120\text{–}250\text{tons}$

- Depth: $20\text{–}30m$
Seabed Installation of Suction Anchors

- Positioning
- Monitoring of
  - verticality
  - heading
  - clearance

Evacuation of entrapped water

Monitoring of
- verticality
- diff. pressure
- penetration

Recovery of pump skid lifting wire

Total time at seabed: 3–9 hours depending on anchor dimensions and sediments.
Hydraulic Pile hammer

D = 2-3m
L = 40-60m
W_{dry} = 100-200tons

Long Piles

Soft sediments
Criteria for Needed Deep Water Anchor

as defined by Deep-water Technology program – Norwegian Research Council 1995

- Anchor installation must be simple and cost effective
- The anchor must not be complicated or too expensive to fabricate
- Allow for taut leg mooring
Deep Penetrating Anchor – DPA™

Theoretical design
Deep Penetrating Anchor – DPA™

Typical inclined capacities: 650 to 1450 tons

Dry weight: 60 – 150 tons

Theoretical design
A Real Torpedo
Principles of Anchor Concept:

- **Optimum fluid dynamic design**
  to achieve high velocity and deep penetration.

- **Huge kinetic energy**
  derived through free-fall - no external energy source required.

- **Soil remolding during penetration**
  large friction resistance after consolidation.
Installation
may be installed with one vessel
• Deep Penetrating Anchors for floating structures:
  – FPSOs/FPSs
  – SPARs
  – Riser Buoys
  – MODUs
  – Offshore Energy Power Units

• Geographical areas of use:
  – All areas where soft sea bed conditions are found
  – No depth limitations
Keynote paper OTC (2004):

"Torpedo/DPA anchors appear to be the most promising option for improvement in cost reduction and simplifying installation."

Technology Assessment of Deepwater Anchors
Clarence J. Ehlers, et al.
Sr. Facilities Engineer ChevronTexaco/Exploration & Production Technology Co.
DPS/Floating Systems Unit/Anchors, Moorings & Risers Team
Suitable Geographical Areas
Technological Development

- Extensive theoretical research – CFD & geotechnical
- Economical evaluation – cost comparison with other solutions
- Small (1:25) lab and large (1:3) scale testing - Troll Field
- Full-scale pilot at the Gjøa Field leading to a qualified anchor in Q4 2009
Anchor velocity vs travel distance

Anchor Velocity vs Drop Height - 75ton DPA

- Terminal velocity: 37 m/sec
- Assumed velocity 25 m/sec at seabed (70% of terminal velocity)
- Drop height: minimum 50 m
Hydrodynamic Stability - monitored test

Final tilt ~ 1 dgr.
Installation of two 80t DPA™s at the Gjøa Field in the North Sea
Fabrication
Fabrication - Nose
DPA™s Ready for Transport to the North Sea
80t DPA™ as installed at the Gjøa Field

Characteristic capacity
~ 800t

Massive tip

Flukes 4m x 6m steel plates

1.2m diam. shank
Typical Mooring Scheme
DPA Locations at Gjøa

DPAs 1.5kM apart

Template BCD

DPA 1

Template E

DPA 2

DPAs to be used for both Template sites

Stiffer soil

Softer soil
Loading Direction

Limited loading direction

Omni-directional loading

Limited loading direction ±5°
Installation Vessel – Island Vanguard
Two DPA™s on Deck
DPAs on Deck of Island Vanguard
Container for instrumentation
Markings on Chain and Retrieval Wire for Instrumentation
Anchor Drop Configuration

- Drop height: 50-75m
- Release point
- Trailing chain length
- Instrumentation
- Permanent mooring line
- To stern roller
- Loop height
- Installed anchor
As Installed DPAs at Gjøa

DPA 1 (North)
Stiffer soil

DPA 2 (South)
Softer soil

Accuracy in horizontal plane: ± 1.5m
Qualified Technology within Statoil

APPROVAL IN PRINCIPLE
(Independent Review Certificate)

OBJECT : Deep Penetrating Anchor
MANUFACTURER : NLJ Products as Bælde
OWNER : Deep Sea Anchors AS Piriserter, Hamnegata 9, 7010 Trondheim
DNV PROJECT NO. : DNV Hovik Pr. No.71910113

This is to certify that the design methodology for:

Deep Penetrating Anchor

has been reviewed and found to meet the requirements according to the following rules, standards and recommendations (with comments):
Available AHTS for Efficient Installation

Deep Sea Anchors
www.deepseaanchors.com
Deep Sea Anchors

Why DPA?

- Installation time and costs
- Standard Anchor Handling Vessel (AHTS)
- No external energy source required
- Precise horizontal positioning
Why DPA? Cont.

- Independent of water depth
- No proof loading required
- High utilization of deck storage area
- More cost effective