TRELLEBORG

Subsea Buoyancy

Subsea Arch

The Arch Structure is a steel framework within which sits a composite or steel buoyancy element. An arch can be used as a method to manage riser configuration.

The Subsea Arch comprises of three main elements: Arch Structure, Mooring System and Seabed Anchor Base. The Arch Structure is a steel framework within which sits a composite or steel buoyancy element. Risers are laid over the Arch into gutters which prevent their MBR being violated, and are held in position in the gutter by a clamping system. The Mooring System tethers the buoyant Arch to the seabed and usually comprises lengths of chain, steel wire, man-made rope/fibres and various shackles, triplates etc. for connection at each end. The Seabed Anchor Base is a gravity base, suction assisted or piled structure used to hold the buoyant Arch in position on the seabed.

More specifically in Floating Production scenarios dynamic risers, cables and umbilicals often require to be held subsea in a geometric configuration known as a wave from vessel or platform to the riser base. For particular applications where some lateral restraint of risers is also required due to hydrodynamic conditions and seabed layout, a Subsea Arch System is required to provide buoyant upthrust to the risers.

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Component Description

Arch Structure

The purpose of the arch structure is to generate sufficient buoyancy to support a series of risers laid over it, whilst preventing the riser from overbending.

The Arch Structure consists of the following components:

- Buoyancy elements
- Steel frame
- Riser clamps

Buoyancy Element

The buoyancy elements are sized to provide sufficient buoyancy uplift to support the risers and frame. The buoyancy can be provided using pressurised steel tanks or by means of a foam core inside a tough abrasion resistant external skin. The foam system utilised is rated for continuous operation at the specified water depth for a design life of up to 30 years and may be either Co-polymer or Syntactic.

Depending on the overall buoyancy required from the Arch a number of discrete buoyancy elements may be built.

The finished buoyancy elements are assembled within the Arch structure steel frame, which provides a stable arch geometry and affords the elements impact and abrasion protection.

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Component Description

Steel Frame

The main Arch structure comprises a steel frame which performs the following functions:

- Houses the buoyancy elements
- Provides a structural connection with the mooring system
- Incorporates the gutters within which the risers sit when installed

To ensure that the steel frame has a low weight in water, it is usually fabricated using specially selected standard tubular mambers. The shape, size and length of the gutters are carefully designed to ensure that risers are prevented from overbending during all possible operating conditions and environmental loads. This requires close co-operation with both the riser manufacturer and designer of the system as a whole.

Once the steel frame has been designed, a final verification of its structural integrity is undertaken using 3D Finite Element Modelling, which is undertaken by our in-house design engineering team.

The steel frame is protected from corrosion by means of a suitable subsea paint system in combination with a Cathodic Protection system (designed to DNV/NORSOK codes)

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Component Description

Riser Clamps

The risers are held in position on the Arch using clamps. The clamps are generally a split steel fabrication designed to withstand the differential tensions which occur as the riser passes over the Arch.

We make use of out vast experience of designing clamps to ensure that the flexible pipes and umbilicals can be clamped without generating excess clamping pressures, whilst allowing for their diameter variations during service.

Clamps can be designed to allow for both diver intervention and diverless connection to the main Arch Structure.

Mooring Structure

The mooring structure usually consists of a series of tether lines terminating in shackles which connect the Arch to the Subsea Anchor.

The tether lines are rated in accordance with relevant DNV Safety Factors and can be made from either traditional chain or state-of-the-art man made fibres such as parallel fibre polyester or Kevlar ropes.

We are also able to design and manufacture all the ancillary items required such as Triplates, ROV friendly connection systems etc. All the components of this mooring system are fully load tested to ensure compliance with the relevant Codes, Standards and Specifications being used for a particular project.

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Design and Engineering

As with most of our engineered products, we provide a Design data sheet in order to understand the particular project requirements, these are available on request from our sales department.

From the information provided by the client, our deisgn team can calculate the required Arch System dimensions, load ratings and weights. From this information Project Engineers are then able to co-ordinate the complex logistics required to source and fabricate all the components of the system.

The buoyancy element will be sized to provide the required 'upthrust to the risers', accounting for the weight in water of the Arch structure, mooring system, marine growth and buoyancy loss over the design life.

The shape of the Arch structure, the rating of the mooring system and the configuration and weight of the Anchor base are calculated in conjunction with the riser system dynamic analysis and therefore require close co-ordination and co-operation with the riser system designer.

The complete Arch Structure can be built to suit a design life of up to 30 years using special subsea coating and cathodic protection systems.

All design and engineering work conducted by us is in accordance with the latest international codes and specifications (e.g. DNV, API, ISO etc.)

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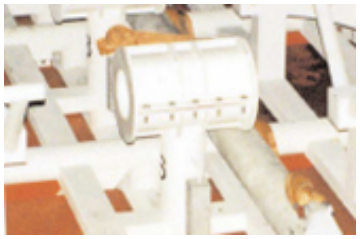

Mid Water Subsea Arch Clamp

Mid Water Subsea Arch Clamps hold risers laid in gutters in position within a subsea arch.

Mid Water Subsea Arch Clamps hold risers laid in gutters in position within a subsea arch. The clamps are generally a split steel fabrication designed to withstand the differential tensions occurring as the riser passes over the arch.

The mid water subsea arch clamps are an integral part of the subsea arch. We make use of our vast experience of designing clamps to ensure that the flexible pipes and umbilicals can be clamped without generating excessive clamping pressures, whilst allowing for their diameter variations during service.

Clamps can be designed to allow both diver interventtion and diverless connection to the main acrch structure.

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Seabed Anchor Base

The Anchor bases are usually designed around steel 'eggbox' fabrication, incorporating a skirt to penetrate the seabed soil.

We make use of applicable buoyancy loading and seabed geotechnical data to generate an anchor design, usually based on a simple gravity base concept.

Design requirements usually include both a detailed geotechnical and structural design report, both of which can be undertaken by our engineering personnel.

The Anchor bases are usually designed around steel 'eggbox' fabrication, incorporating a skirt to penetrate the seabed soil. The 'eggbox' is then filled with a suitable ballast material, such as high density concrete, iron ore or other suitable high density material.

The anchor base design also has to incorporate suitable lifting points as well as mooring system connecting points which may all require to be designed to allow connection and disconnection by ROV.

Often the anchors may comprise of multiple units which may each be easily lifted by the crane capacity available on offshore installation vessels. The multiple units are then designed to 'dock' together to provide a single structure with the required total weight in water.

As with the steel frame structure the Anchor Bases are protected from corrosion by painting and cathodic protection.

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Materials & Testing

Materials

The main materials of construction for various components of the Subsea Arch System are as follows:

Buoyancy Element
Pressurised Steel Tanks or Foam Core (Co-polymer or Syntactic)
Tough Polyurethane Elastomer Skin or High Density Polymer Shell

Arch Structure
High strength structural steel

Mooring System
Parallel Fibre Polyester or Kevlar in a tough, abrasion resistant sheath, chain or wire rope

Seabed Anchor
High strength structural steel frame
High density ballast system (e.g.lead, iron ore, concrete)

Corrosion Protection
Coating System to NORSOK M-CR-501
Specifications + Cathodic Protection using Zn-Al-In Anodes

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Materials & Testing

Testing

The testing conducted on the Subsea Arch can be split into two categories:

- Buoyancy & Weight control
- Functional testing

Buoyancy & Weight Control

In order to ensure that the Subsea Arch will generate the specified buoyancy all foam components are subject to a rigorous programme of qualifiaction and process control testing including the following:

- Density checks
- Hydrostatic crush pressure testing
- Water absorption testing
- Buoyancy loss checking

In addition to this, carefully controlled weight control procedures are followed during fabrication of the steel frame structure, clamps, mooring system and anchor base.

Functional Testing

Function Testing of the subsea arch systems includes the following:

- Weigh all components
- Fit-up and assembly of all components
  (including padeyes, shackles, clamps in arch, risers in clamp etc)
- Load testing of padeyes
- load testing of mooring system
- Axial load test of clamps

Transport & Logistics

As the arch structure and gravity bases may be large both dimensionally and in weight, delivery to the final destination may require special transport and logistical arrangements.
Our in-house shipping/export department are able to arrange quayside load outs, vessels and trans-shipments and final delivery together with all necessary Customs and Delivery paperwork formalities necessary to ensure this is a smooth operation.
This means clients can be assured that deliveries can be made even to the remotest parts of the world.

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