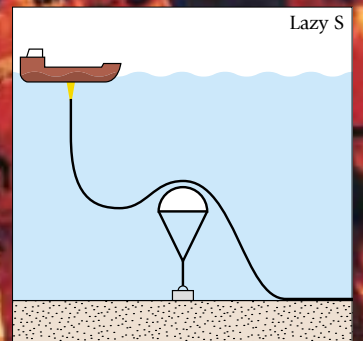
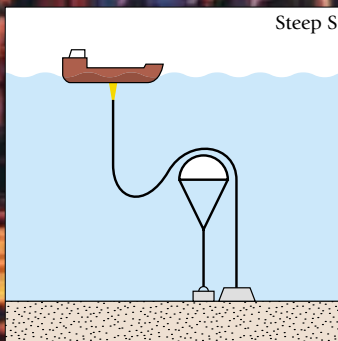


Engineering excellence
in a global market



Engineered products
Subsea Arch Systems



2 x 8,000kg CRP Syntactic Foam Buoyancy Elements supporting the steel frame/gutters



Subsea Arch Systems

APPLICATIONS

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.

CRP have now built up an impressive track record of designing and building Subsea Arches for customers and projects around the world.

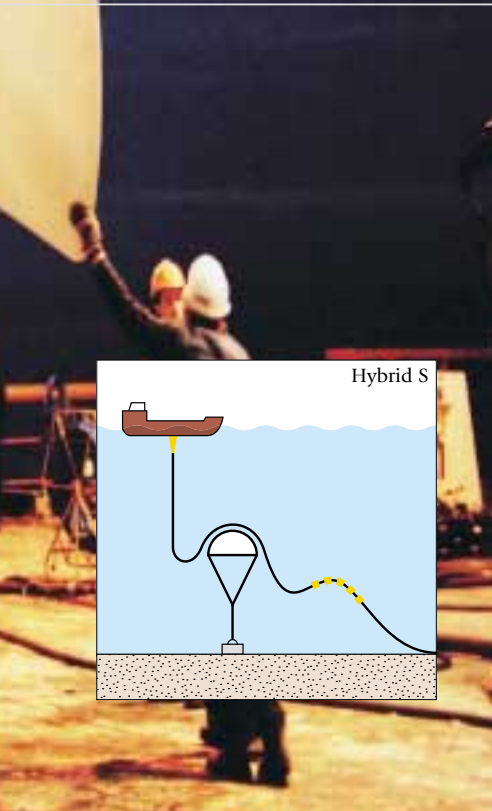
The Subsea Arch comprises three main elements - Arch Structure, Mooring System, Seabed Anchor Base.

The Arch Structure is usually fabricated from a steel framework, within which sits a buoyancy element, this can be composite or steel.

The 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 is used to tether the Buoyant Arch to the seabed - it usually comprises lengths of chain, steel wire, manmade ropes or fibres and various shackles, triplates etc. for connection at each end.

The Seabed Anchor Base is a structure used to hold the buoyant Arch in position on the seabed, and can be either a gravity base, suction assisted or piled structure.



DESIGN AND ENGINEERING

As with most CRP engineered products, CRP provide a Design Data Sheet (DDS) in order to understand the particular project requirements, these are available on request from the CRP Sales Department.

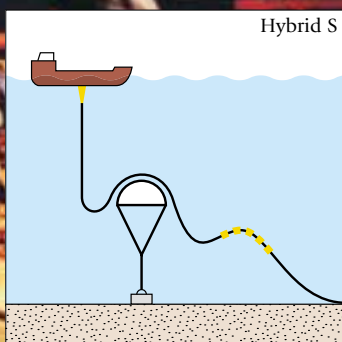
From the information provided by the client, CRP's experienced design engineering team can calculate the required Arch System dimensions, load ratings and weights. From this information Project Engineers are then able to co-ordinate the complex logistics required to source and fabricate all the components 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 up to 30 years using special subsea coating and cathodic protection systems.

All design and engineering work conducted by CRP is in accordance with the latest International Codes and Specifications (e.g. DNV, API, ISO etc).



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 upon 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.



Buoyancy Elements being loaded into steel frame.

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 members. 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 cooperation with both the riser manufacturer and designer of the riser 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 CRP's 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).

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.

CRP makes use of its 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 intervention and diverless connection to the main Arch Structure.



Riser Gutter fabrication.

Mooring System

The Mooring System 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' manmade fibres such as parallel fibre polyester or kevlar ropes.

CRP are also able to design and manufacture all the ancillary items required such as Tri-plates, 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.



Corrosion protection – subsea paint system and anodes.

Seabed Anchor Base

CRP make use of the 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 CRP design 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



Gravity base prior to filling with ballast.

Materials

The main materials of construction for the 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

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 qualification and process control testing including the following:-

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

In addition to this, very 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 clamp

Transport & Logistics

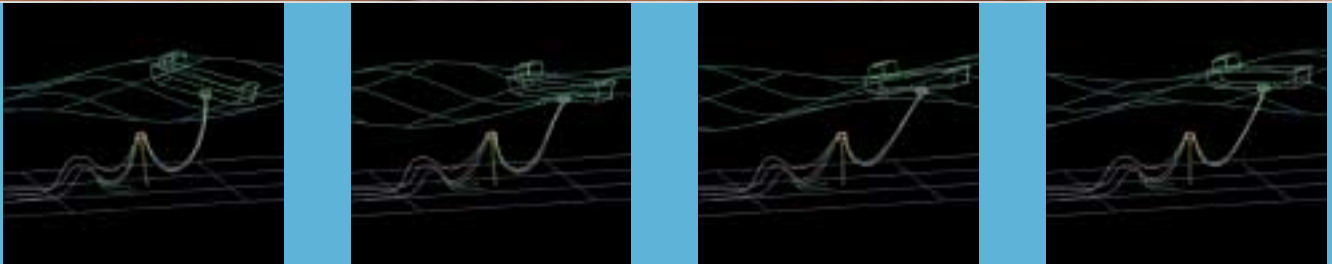
As the arch structure and Gravity Bases maybe large both dimensionally and in weight, delivery to the final destination may require special transport and logistical arrangements.

CRP's in-house Shipping/Export Department are able to arrange quayside load-outs, vessels, and trans-shipments and final delivery together with all the necessary Customs and Delivery paperwork formalities necessary to ensure this is a smooth operation.

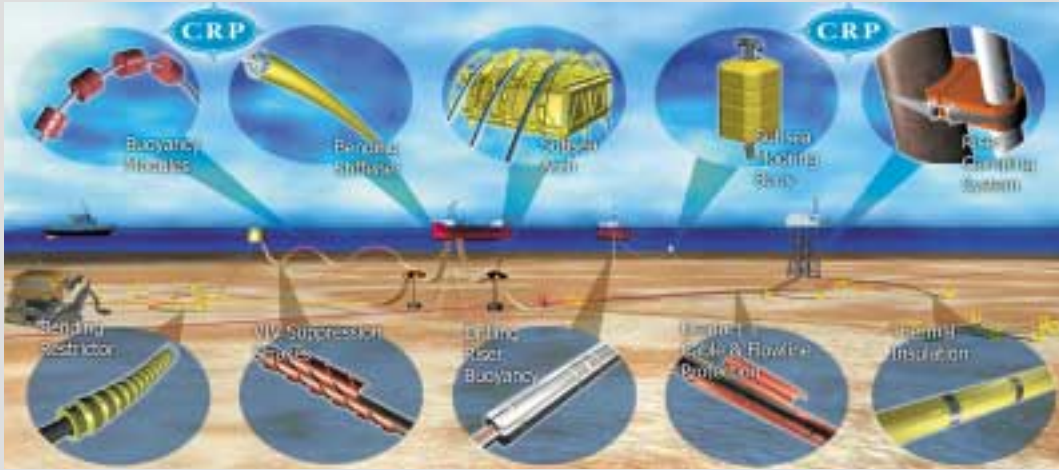
This means clients can be assured that deliveries can be made even to the remotest parts of the world.



Complete Arch 'skeleton' ready for first stage of the coating process



Dynamic modelling of Subsea Arch prior to manufacturing (images courtesy of MCS International).



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