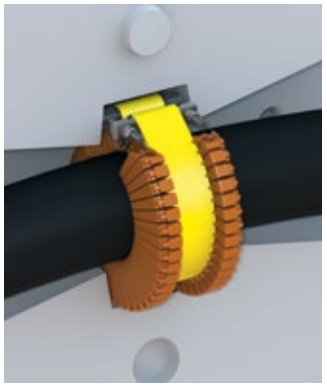
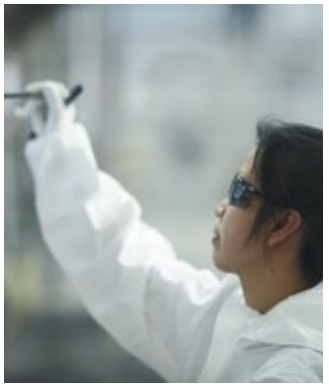






Permanent buoyancy systems

MATRIX COMPOSITES & ENGINEERING

Matrix
Composites & Engineering

Contents

Permanent buoyancy systems

Matrix manufactures a range of buoyancy solutions for long term (permanent) subsea applications. The buoyancy is qualified for life-of-field applications and includes:

- Distributed buoyancy clamping system
- Buoyancy building block system
- Steel catenary riser buoyancy
- Mid-water arch buoyancy
- Production riser buoyancy (including hybrid tower buoyancy)
- Turret buoyancy
- Permanent subsea mooring buoyancy
- Pipeline buckle mitigation buoyancy
- Customised applications requiring life-of-field buoyancy including cobra head/umbilical termination systems, PLET covers etc

Matrix also designs, manufactures and supplies customised buoyancy solutions designed to meet a client's specific requirements.

Permanent subsea mooring bouyancy

Mid-water arch bouyancy (Ichthys Project, Australia)

Distributed buoyancy modules (CLOV Project, West Africa)

Modular bouyancy module (Gorgon Project, Australia)

Materials qualification testing

To ensure the properties and performance of its subsea materials, Matrix undertakes vigorous testing and verification. This confirms that the proposed materials are fit for purpose and in line with the requirements of quality standards ISO-13628-16 and API 17L, and other specifications from clients and project developers.

Matrix has developed its own set of testing procedures to incorporate both industry and client driven standards. This allows for a consistent and comprehensive set of tests for its syntactic foams and thermoplastic material that will be used in a subsea environment for up to 40 years.

Material qualification tests

Throughout the manufacturing process, a regime of production verification tests can be applied including:

- Abrasion resistance
- Hardness
- Hydrostatic strength
- Entrapped air
- Bulk modulus and rate of buoyancy loss
- Shear strength, modulus, strain at break
- Tensile strength, modulus, strain at break
- Compressive strength, modulus, strain at break
- Density
- Water absorption
- Creep testing
- Ageing resistance testing (thermal degradation)
- Fatigue testing

The material qualification tests listed above are verified during the project and can be witnessed by clients and third party approval bodies if required.

Throughout the manufacturing process, a regime of verification tests and samples are collected to ensure the manufactured parts remain within agreed tolerances. Matrix has invested heavily in its testing capabilities to ensure the majority of tests can be performed on-site, thus eliminating potential bottlenecks in the process flow.

At the commencement of every SURF project, clients are invited to Matrix's production and quality meetings. During these meetings project specific measures and controls are agreed upon to ensure all concerns are dealt with in the process controls. A standard set of controls exists, although additional measures specific to a particular project can be incorporated.

Distributed buoyancy clamping system

Matrix has extensive expertise in the design and manufacture of distributed buoyancy clamping (DBC) systems that support flexible risers with diameters up to 600mm.

The DBC system is comprised of two half buoyancy modules manufactured from advanced composite materials and compliant with the applicable international standards. The system also consists of an internal modular flexible riser clamp that can be used across a range of riser diameters and product specifications, as well as a set of standard external module clamping straps.

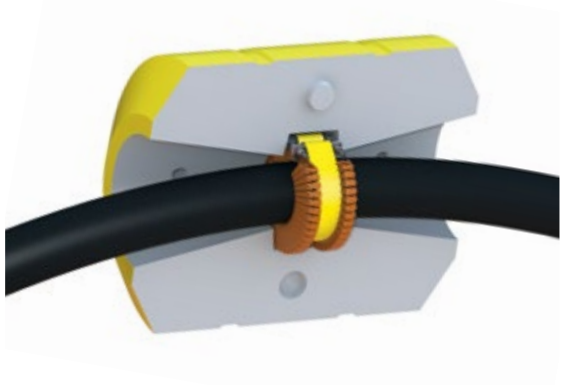
Designed for easy offshore installation, clients can make significant savings on offshore vessel time. The DBC system is delivered ready to install.

Clamp

- Takes approximately three minutes to install
- Reduced weight due to its advanced polymer design
- Cost effective modular design
- Simple installation tooling
- Short manufacturing lead time due to modular design
- Complies with ISO 9001 and ISO 13628-16, third party verified by Bureau Veritas

Buoyancy module

- Lightweight and robust
- Impact and abrasion resistant surface materials
- Range of long-life solutions for varying water depths
- Low density, ultralight buoyancy solutions
- High quality, low variation, large volume part manufacturing
- Rapid turnaround for modular projects
- High visibility marine grade paint finish



IsoBlox™ buoyancy building block system

Used for mooring and installation purposes, Matrix's IsoBlox™ buoyancy building block system is available in a modular or block design. The buoyancy is comprised of a closed cell syntactic foam system covered by tough integrated fibreglass and aramid skin.

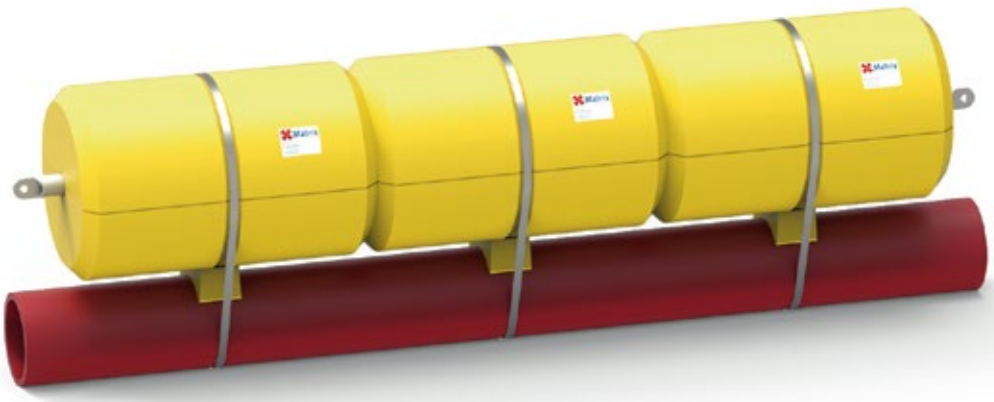
The blocks can be fastened together to produce any number of customised shapes, sizes and uplifts ranging from three tonnes to 150 tonnes or more.

Further options are available on request, including ultralight syntactic foam densities where greater uplift per module and a lower dry weight (mass) are required. With warehouses in the US and Australia, Matrix can stock and supply the IsoBlox™ buoyancy building block system as and when required.

Steel catenary riser buoyancy

A steel catenary riser (SCR) is a flexible steel pipe that conveys well fluids from the subsea wellhead to the floating production vessel. Matrix provides buoyancy for any SCR size and configuration.

- Large number of standard arrangements
- Easily customised to most uplift requirements
- Range of depth ratings from 500msw to 3,000msw
- Quick to install during the SCR lay operations
- Design life of up to 40 years



Mid-water arch buoyancy

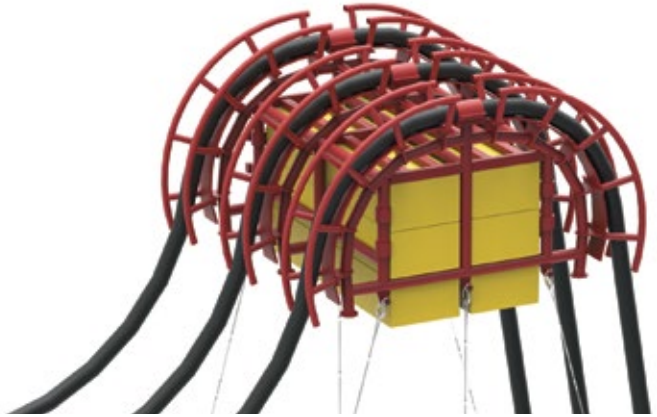
Mid-water arches (MWA) support the weight of pipelines and umbilicals as they rise from the seabed to the surface and provide a way of de-coupling the movement of the surface vessel from the subsea production system.

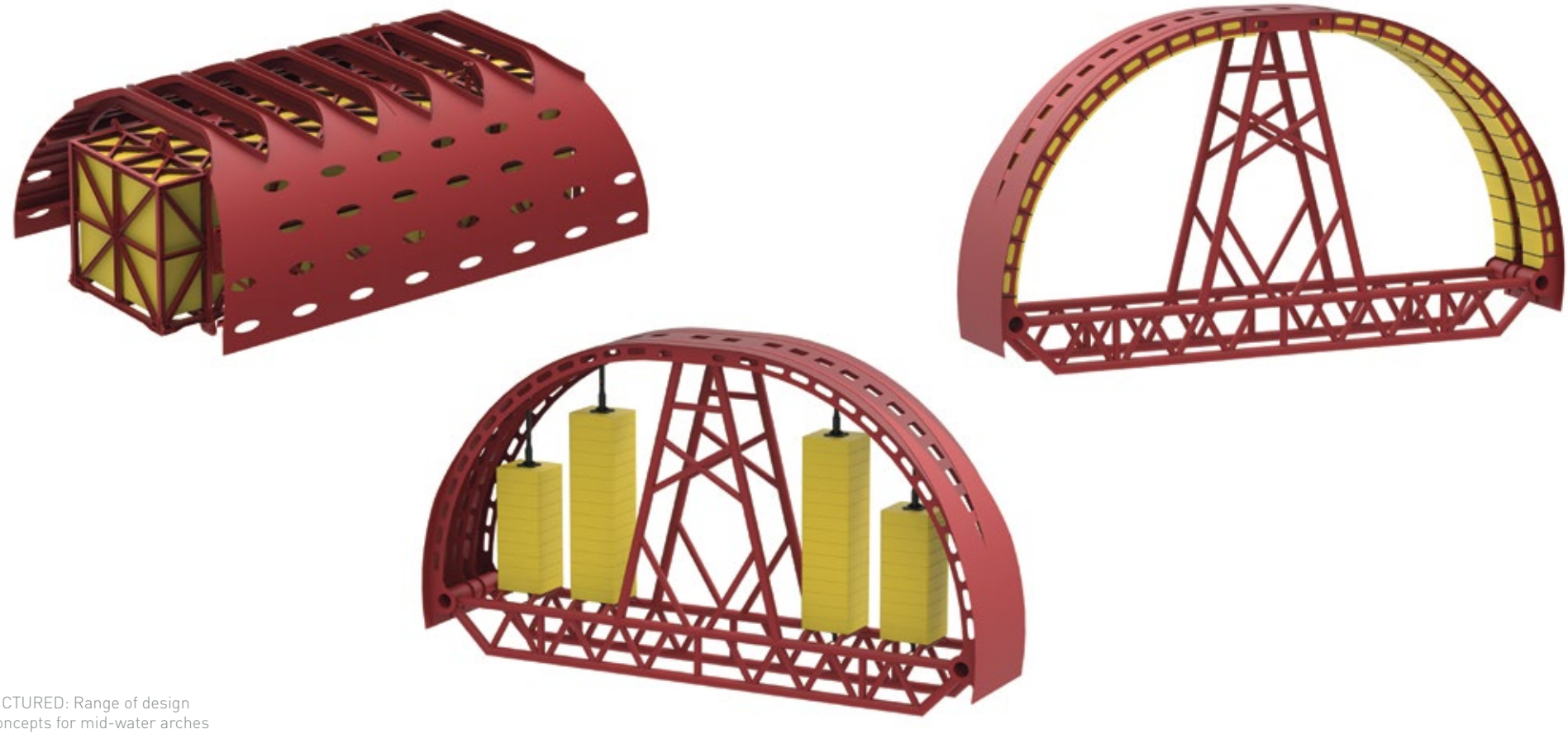
While steel pressure vessels have typically been used to provide MWA buoyancy, a range of problems exist when transitioning to deeper water.

To avoid these problems, Matrix manufactures composite syntactic foam buoyancy for MWA systems as an alternative to steel pressure vessels.

Matrix has developed a range of modular buoyancy designs which can be customised to suit the client's project design. Due to the company's large scale manufacturing and technology capabilities, Matrix produces high quality production buoyancy designed for long-term immersion. Matrix offers clients a complete MWA design service.

- Cost effective alternative to steel pressure vessel systems for MWA's systems. The cost effectiveness increases as the water depth and uplift increases
- Lower transportation and installation costs due to a lower dry weight than pressure vessels at deep water depths
- Longer design life with lower maintenance and inspection requirements than pressure vessel systems
- Steel pressure vessels often don't meet the design intent at the following water depths:
    - 500msw for MWA's with a net buoyancy requirement of > 100 tonnes
    - 400msw for MWA's with a net buoyancy requirement of > 200 tonnes



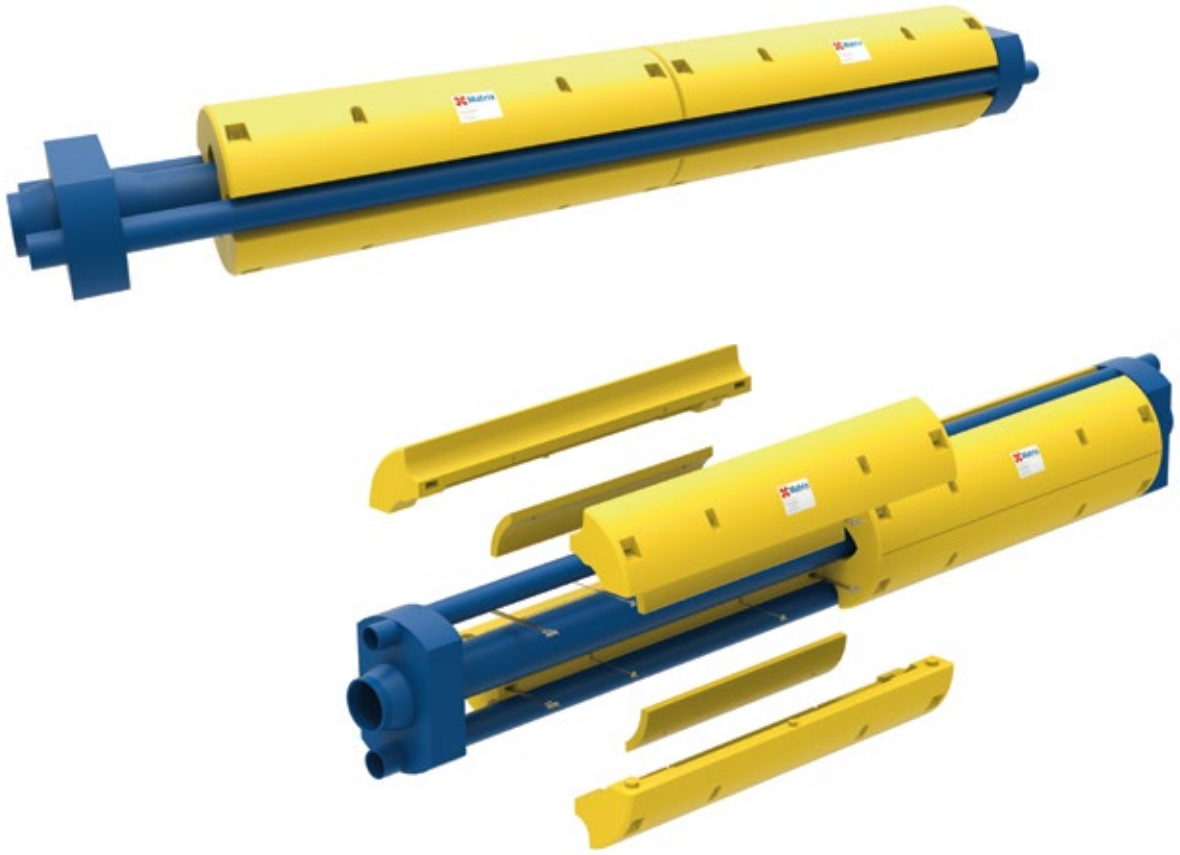


PICTURED: Range of design concepts for mid-water arches

Production riser buoyancy

Utilising the same composite syntactic foam and advanced composite laminate technologies as its market leading riser buoyancy systems, Matrix manufactures and supplies buoyancy modules required by HRTs to ensure riser tensioning is within limits.

- High part accuracy - guaranteed target buoyancy string tolerances of ± 2%
- Tailored for specific applications and available in a range of densities
- Easily assembled - ease of interface fit-up, with all module designs test fitted
- Fully interchangeable modules
- Superior performance in hot and humid conditions
- Lightweight, robust and damage tolerant
- Internal composite reenforcement improves the modules flexural strength



Turret buoyancy

FPSOs with a disconnectable turret or buoy system allow a vessel to weathervane according to prevailing environmental conditions. If conditions become dangerous, the ship can disconnect from the mooring system and safely sail away.

The mooring buoy is fixed to the seabed by catenary anchor legs. The buoy supports the crude oil and gas risers and is connected by a structural connector to the fixed turret. The fixed turret extends up through the tanker and is supported on a weathervaning bearing.

The turret contains the reconnection winch, flow lines, control manifolds and fluid swivels located above the main deck. The buoy provides support to the risers and mooring lines when disconnected.

There are two types of turret mooring systems including the buoy turret mooring (BTM) system and the riser turret mooring (RTM) system.

- No single point of failure can occur compared with standard pressure vessel design
- Easily customised to any uplift requirement using a standardised block system
- Range of depth ratings
- Life-of-field operation with minimal inspection or maintenance requirements

Permanent subsea mooring buoyancy

Mooring or large floating structures such as FPSOs, semi-submersible drilling rigs and tankers often require permanently secured subsea buoyancy modules.

Matrix's composite syntactic foam system can be used to manufacture buoys of all sizes for use in depths up to 3,000msw and providing lift capacity greater than 150 tonnes.

- Large number of standard arrangements
- Easily customised to most uplift requirements
- Range of depth ratings from 500msw to 3,000msw
- Lightweight, robust and damage tolerant
- Design life of up to 40 years

Pipeline buckle mitigation buoyancy

Subsea pipelines expand and contract and move across the seabed as the temperature changes which can lead to buckling.

Pipeline buckle mitigation buoyancy is used to avoid this by reducing the weight in water of the suspended pipeline system. Matrix has designed a closed cell syntactic foam system covered by an integrated fibreglass and aramid skin which protects the buoyancy against abrasion as the pipeline moves across the seabed.

- Customised to most pipeline diameters and uplift requirements
- Range of designs available
- Range of depth ratings from 500msw to 3,000msw
- Life-of-field application of up to 40 years

Customised permanent applications

VersaSlab is a standard range of composite syntactic sheets and foam blocks used to produce buoyancy devices for low volume, permanent subsea applications. This may include buoyancy for cobra head umbilical termination assemblies, or buoyancy to reduce the mass of a steel cover allowing for ROV operation. VersaSlab is available in a variety of standard sizes and grades and is ideal for ROV applications including ROV tooling skids and buoyancy packs.

VersaSlab can be designed, manufactured and delivered in a significantly shorter time frame and for a lower cost than customised buoyancy products. Design costs are kept to a minimum as the product can adapt to a variety of configurations and applications. Labour costs are also significantly lower as the availability of large sizes eliminates the need to bond multiple small blocks together which reduces assembly times. Stocked in Australia and the US, clients have rapid access to buoyancy as and when required.

VersaSlab is fully machineable and can be coated with a variety of surface treatments including fibreglass reinforced plastic (FRP), thermoplastic and polyurethane skin systems.

The approximate uplift in seawater for an engineered shape can be determined as follows:

$$\text{Uplift [kg]} = (1025\ [\text{kg/m}^3] - \rho\ [\text{kg/m}^3]) \times \text{Part Volume } [\text{m}^3]$$

Calculated uplift does not take into account the weight of the skin system.

Depth rating (msw)	Buoyancy type	Density (p) [kg/m³]	Depth rating [msw]	Buoyancy type	Density (p) [kg/m³]
300	Binary	327	1500	Hybrid	450
600	Standard	392	1500	Ultralight	426
600	Binary	368	2250	Standard	542
600	Ultralight	356	2250	Ultralight	477
1000	Standard	408	2250	Hybrid	505
1000	Ultralight	374	3000	Standard	614
1000	Hybrid	392	3000	Ultralight	526
1500	Standard	472	3000	Hybrid	558

Providing innovative solutions

Matrix is a leading developer of syntactic foam technology and has been providing the global oil and gas industry with innovative solutions for over 15 years. Its 20,000m^2 facility in Western Australia boasts some of the latest technologies producing durable products for use in subsea and other challenging environments.

Matrix has a global service and distribution network and can provide clients with local service and support.

ABOVE: Located in the Australian Marine Complex, the southern hemisphere's premier integrated marine industrial facility

RIGHT: One of Matrix's highly qualified material scientists

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