Balmoral Offshore Engineering

Buoyancy, insulation and elastomer products




THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2010

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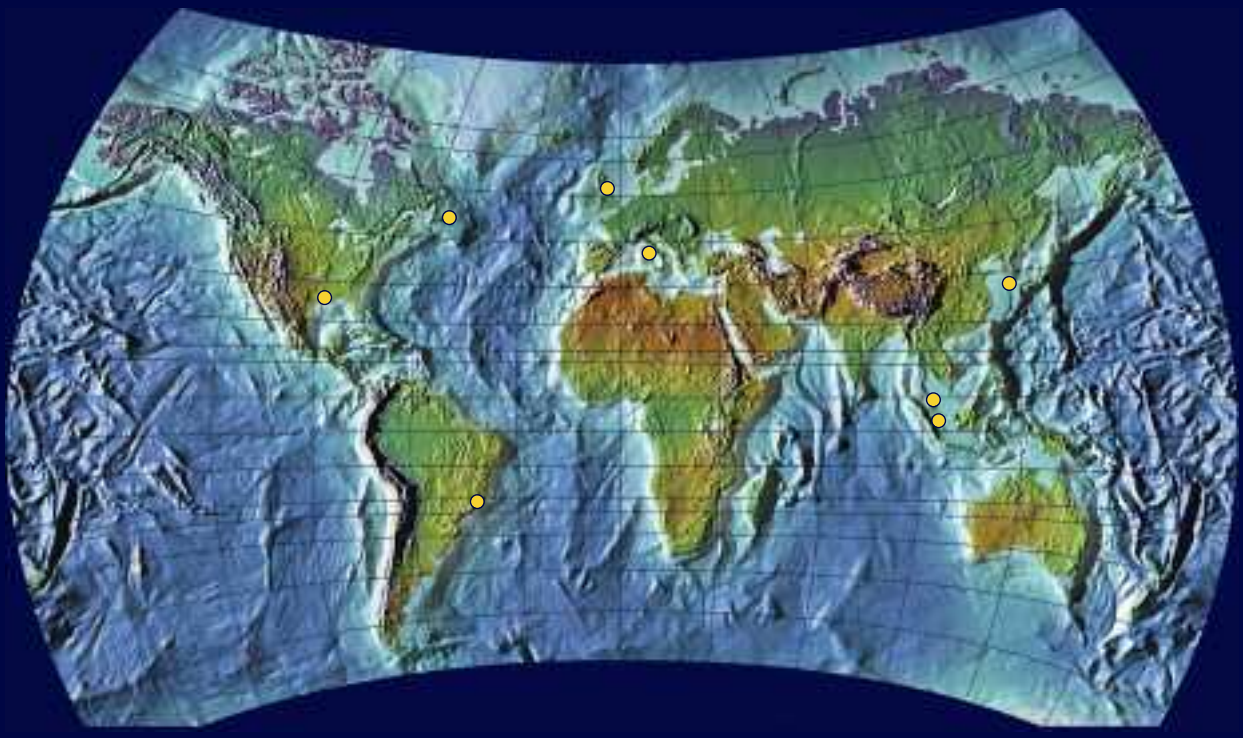
Balmoral Offshore Engineering: Developing global relationships



Project portfolio

Alba
Agbami
AKPO
ASAP
Åsgard
Azurite
BC10
Block 31
Brent
Britannia
Canapu
Dalia
Djambala
Dunbar
Ekofisk
Elgin/Franklin
Foinaven
Galapagos
Gimboa
Galahad
Girassol
Green Canyon
Heidrun
Ivanhoe/Rob Roy
Janice
Jubilee
Kizomba
Kristin
Liuhua
Livorno
MA:D6
Miller
Olowi
OYO
Pazflor
Pluto
Poinsettia
Pompano
Pyrenees
Ruby
Scarv
Schiehallion
Snorre
Thunder horse
Troll
Typhoon
Tyrihans
Visund
Wandoo
Xijang/Wenchang

Representation

Brazil
Canada
Italy
Korea
Malaysia
Singapore
United Kingdom (HQ)
USA

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Balmoral Offshore Engineering

Buoyancy, insulation and elastomer products

Balmoral
Offshore Engineering: Core values

Balmoral
Offshore Engineering

Client focus

A client focused company, Balmoral Offshore Engineering is dedicated to cost effective technology-led composite and polymer solutions for the subsea and deepwater oil and gas sector. It benefits from the industry's most comprehensive range of syntactic/composite/polymer processing facilities designed exclusively to produce high performance products for long term projects.

Balmoral's team of specialist engineers has provided subsea products to the international market since 1980. In-house laboratory, hydrostatic and mechanical testing facilities enable the company to research and identify cost effective materials across a spectrum of applications.

From surface navigation buoyancy to full ocean depth, Balmoral products, including thermal insulation, rigid and distributed riser, ROV/AUV and subsurface buoyancy through to elastomer cable protectors, bend restrictors, stiffeners, clamps and riser protection guards, are in use around the world.

Providing a service from concept development through detailed design, manufacturing and testing, Balmoral Offshore Engineering will help you realise your project's potential.

Balmoral Group

Balmoral Offshore Engineering is a division of Balmoral Comtec Ltd which is wholly owned by Balmoral Group Holdings Ltd, a privately owned company headquartered in Aberdeen, UK. The company has been providing solutions to the offshore oil and gas, seismic, renewable energy and marine industries since 1980.

The Group comprises a number of distinct business units and divisions including Balmoral Offshore Engineering, Balmoral Advanced Composites, Balmoral Park and Balmoral Tanks.

The enterprise is built upon research, development and technical innovation. It is this commitment to progress that has helped the Group achieve its status as a market leader in its chosen sectors.

The strategy is well recognised by Balmoral's client base. Independent surveys link attributes such as innovation, technology, engineering proficiency and proactiveness with Balmoral.

The Balmoral name has become a brand in its own right, synonymous with product development, technical excellence and manufacturing efficiency.

Balmoral Park, 45 acre Aberdeen HQ

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Health and Safety

Balmoral recognises the importance of Health and Safety and is committed to providing a safe and healthy working environment for its employees, subcontractors and visitors, whether on or off site.

The company is a member of the British Safety Council, holds 4-star certification from that organisation, and operates a management system that is designed to comply with the requirements of BS OHSAS 18001:2007.

Environmental impact

Balmoral is dedicated to protecting the environment from the impact of its activities. This includes a commitment to the continual improvement in operational performance ensuring minimal environmental impact.

The company operates a management system in response to the requirements of EN ISO 14001:2004.

Quality Assurance

Balmoral's goal is to become the first choice, best in class supplier in its sector and is committed to supplying products and services that exceed the needs and expectations of its customers.

A major element of this objective is the implementation and continuous improvement of a Quality Management System that conforms to the requirements of BS EN ISO 9001:2008 and adherence to the American Petroleum Institute's specification for marine drilling riser equipment (API 16F:2004).

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Design engineering, manufacturing, project management and testing

Design engineering, manufacturing, project management and testing

Design engineering

Balmoral's design team has a wealth of engineering design expertise at its fingertips. Augmented by state-of-the-art 3D modelling, finite element analysis, CFD, lab and testing facilities, the company is totally committed to the highest standards of performance.

A core function of the Balmoral team is to develop close working relationships with clients allowing them to develop a comprehensive understanding of key requirements and ultimately deliver a personalised service at all levels.

Manufacturing

Balmoral Offshore Engineering has taken advantage of recent developments in materials, plant and processing techniques to install highly efficient, automated buoyancy manufacturing facilities.

Comprising thermoplastic syntactic, aliphatic amine cold cure and anhydride hot cure manufacturing capabilities, supported by highly engineered macrosphere production tumblers, shakers, vacuum chambers and curing ovens, this facility represents a step change in the way buoyancy products are manufactured.

The company has also created a state-of-the-art polyurethane elastomer processing facility that benefits from in-house design, engineering and testing support.

Most commonly used as a moulding material for riser, cable, flowline and product protection applications, PU elastomer is a tough, fatigue resistant substance which is ideally suited to impact and abrasion resistant products.

Syntactic production and curing

The combination of hollow glass microspheres and a resin matrix, known as syntactic foam, is central to any buoyancy manufacturing operation. Balmoral has introduced, for the first time, an automated system which provides consistent quality syntactic material, critical to achieving high performance buoyancy and insulation products.

By implementing hot and cold cure processing, supported by refined hardware to provide control over temperature, duration and cool-down times, Balmoral Offshore Engineering has overcome product failure issues such as stress, material instability and brittleness that are experienced by traditional manufacturing operations.

Ultimately, BOE products are capable of performing in hostile deepwater environments commonly experienced in the industry today.

Deepwater focus

Continually investing in materials innovation, Balmoral Offshore Engineering is highly focused on the developing deep and ultra-deepwater markets.

The company is committed to a continuous programme of research and development to provide cost effective, fit for purpose products based on its intimate knowledge of composite and polymer materials.

Being the first company to develop and test 7000m syntactic drill riser buoyancy and ROV materials Balmoral has further invested in creating the industry's most comprehensive deepwater buoyancy manufacturing and testing facilities.

Project management

With more than 25 years' experience in managing the design, manufacture and delivery of subsea buoyancy and elastomer equipment - using the latest management tools and standards - Balmoral Offshore Engineering's project management team works closely with clients to deliver projects on time and on budget.

As members of the Association of Project Management, Balmoral Offshore Engineering trains its project team to recognised global competency standards. This addresses the growing project management requirements of clients from order placement through to delivery and installation where appropriate.

association for project management
apm Corporate Member

> As members of the Association of Project Management, Balmoral Offshore Engineering trains its project team to recognised global competency standards.

Testing

Balmoral Subsea Test Centre

The Balmoral Subsea Test Centre offers a comprehensive range of test procedures including hydrostatic, mechanical and laboratory testing. Although predominantly used for in-house testing and development work these facilities and services are offered for use to external customers.

Hydrostatic testing

Balmoral Offshore Engineering's Subsea Test Centre operates a comprehensive suite of hydrostatic pressure vessels to meet in-house development and production testing demands.

These test facilities are also available to provide a hydrostatic pressure testing service for external clients. Testing can be performed at pressures up to and including 7000msw equivalent.

Mechanical testing

Large scale load testing equipment is available to perform a diverse range of tests including slip testing of clamping systems, flexure testing of buoyancy modules and load testing of bend limitation devices such as restrictors and stiffeners.

Development laboratory

Balmoral Offshore Engineering's development laboratory is equipped with all necessary testing equipment required to ensure the highest standards of quality and performance are achieved by BOE products.

Drilling

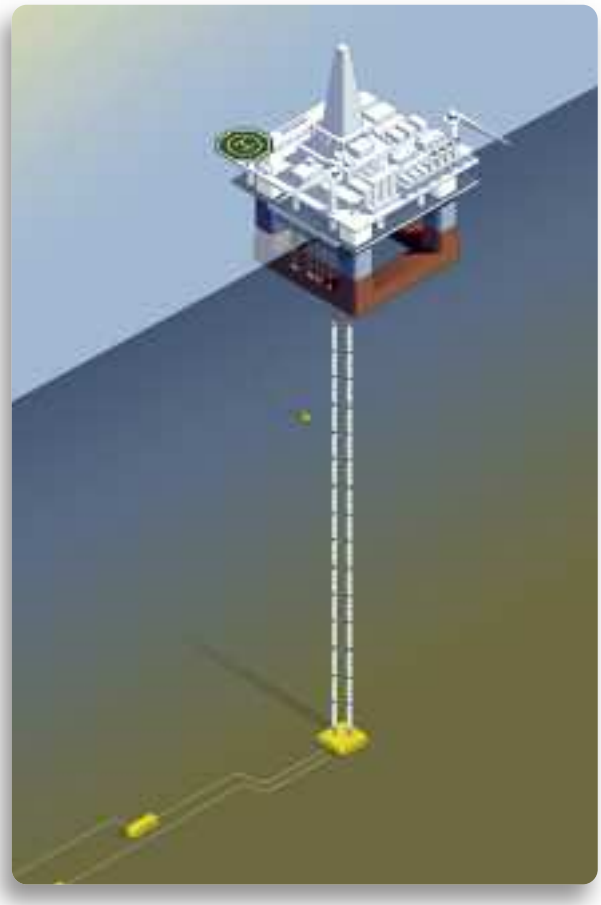
Drilling riser buoyancy
Riser protection
Pin and box end protection
Riser clamps
Strakes and fairings

Drilling riser buoyancy

Balmoral Offshore Engineering has invested heavily in its manufacturing facility in Aberdeen. The plant manufactures very high quality, consistent modules while the in-house hydrostatic test centre offers test capabilities to 7000msw equivalent.

Drilling riser buoyancy provides lift while reducing the submerged weight of the riser joints. This helps to minimise top tension and prevent stress in the riser while reducing loadings during deployment/retrieval of the blow-out preventer (BOP) stack.

Drilling risers extend from the BOP to the drilling vessel with their primary function being the provision of fluid communications between the well and the drilling vessel while supporting the choke, kill and auxiliary lines. The riser is also used to guide tools into the well and serves as a running/retrieving string for the BOP.



Dressed drilling riser joint

Balmoral drilling riser buoyancy modules are fitted around the riser with moulded apertures accommodating auxiliary lines and riser clamps.

The vertical lift of the syntactic modules is transferred to the riser by a thrust collar fitted to the riser pipe below the upper coupling. A matching collar is normally installed at the lower end of the assembly to facilitate the transfer of the module weight during handling.

Drilling riser buoyancy

Durafloat™ RIS (Residual Integrity System)

The demands placed on drilling riser buoyancy have increased dramatically as the industry continues its exploration and development of ever deeper waters. Similarly, the requirement for ultra-safe modules has grown in response to the extreme conditions which are now commonplace in today's operating environments.

Balmoral Offshore Engineering's design team was tasked with the development of a high performance ultra-safe riser buoyancy system to accommodate and perform in the most arduous of conditions. The team created a specialised riser buoyancy series, Durafloat RIS, comprising a high impact protective skin and residual integrity system. Significantly, Durafloat RIS is designed to minimise the risk of cracking and fracture while delivering safe high performance uplift.

Buoyancy plays a critical role in the dynamic performance of the riser string and Durafloat RIS is an important step forward for the industry. Its contribution to safety and performance should not be underestimated.

External finishing

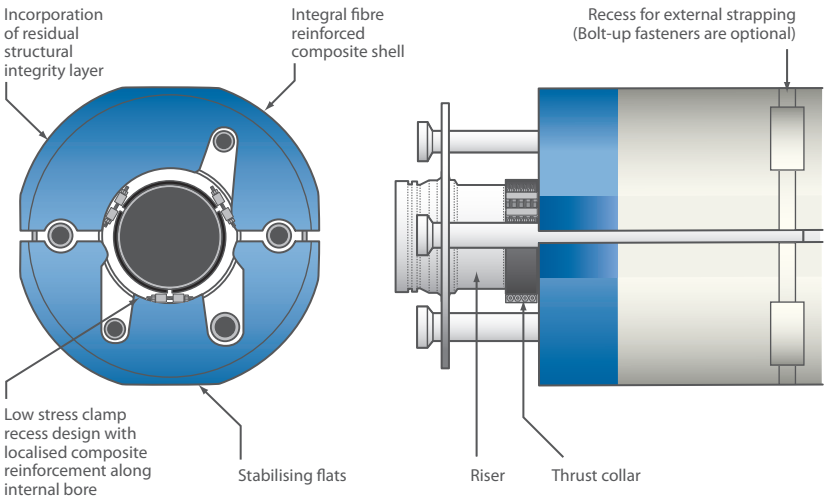
Drilling riser buoyancy operates in extreme conditions and must withstand harsh and constant handling. Durafloat modules incorporate an integral composite epoxy skin to deliver a robust impact resistant performance.

API 16F

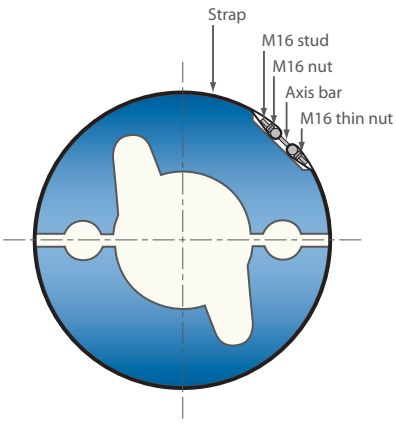
Balmoral Durafloat RIS modules are designed, manufactured and type tested in full accordance with API 16F.

Durafloat RIS structural integrity feature minimises module break-up in the event of fracture

Durafloat RIS safety design features



Strapping detail



Drilling riser buoyancy

Attachment methods

Balmoral Offshore Engineering offers strapping with stainless steel axis bars and stud bolts as standard attachments between module and riser.

Further options are available including through bolts located in reinforced pockets or stainless steel U-bolts with enclosed Kevlar strapping.

Dependent on riser geometry these options can be located within the pitch circle diameter (PCD) of the auxiliary lines thus reducing the transverse bending moment on the buoyancy module.

Module stability

300mm flats are standard across the Durafloat range. This allows effective stacking in the yard and in the offshore environment.

Flexural pads

Flexural pads are built into BOE buoyancy modules at strategic locations to ensure that excessive bending loads are not transferred from the riser to the module when lifted in the horizontal plane.

Module repair service

BOE offers a comprehensive global repair service for damaged buoyancy modules that includes repair of full breaks and rebuilding of missing sections. The company's skilled buoyancy refurbishment technicians are available for field work at most locations worldwide.

Colour coding

A colour system exists for quick identification of differing depth rated modules. A typical example of this is shown below:

Typical colour coding standards

Identification colour	Depth rating	
	Feet	Metres
Green	0-2000	0-610
Blue	2001-3000	611-914
Yellow	3001-4000	915-1219
Orange	4001-5000	1220-1524
Black	5001-6000	1525-1829
Red	6001-7000	1830-2134
Purple	7001-8000	2135-2438
Brown	8001-9000	2439-2743
Grey	9001-10000	2744-3048
Light blue	10001-11000	3049-3353
Tan	11001-12000	3354-3658

Other materials are available for ultra-deepwater applications to depths of 7000m

Client's drilling riser buoyancy modules before repair

Client's drilling riser buoyancy modules after repair

Riser protection

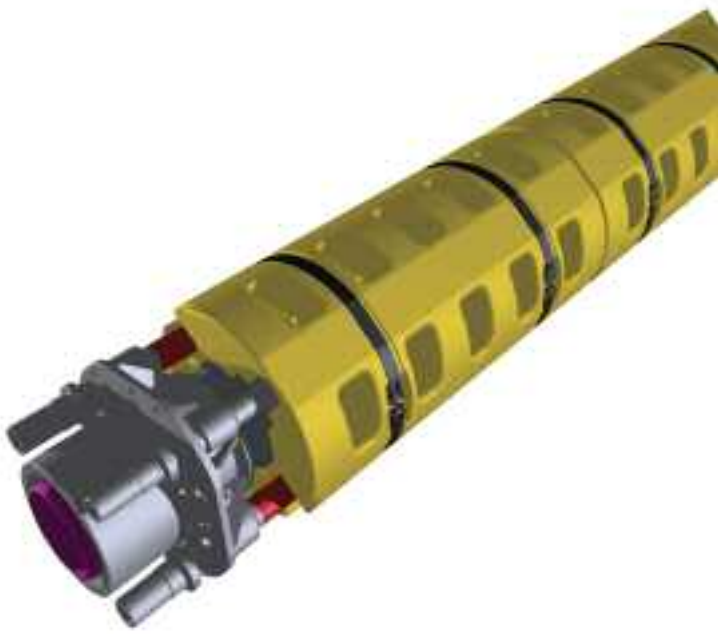
When running a bare riser string, ie, without buoyancy modules, several problems can be encountered on the drill platform including:

- Storage difficulties because of the differences and irregularities in profile
- Impact damage while being passed through the rotary table

To minimise any risk of damage during operations Balmoral Offshore Engineering provides a range of riser impact protection systems.

Moulded in tough, abrasion resistant, polyurethane elastomer to the same geometry as drill riser buoyancy modules, and incorporating an integrated fastening system, this product is engineered to provide maximum impact and abrasion protection whilst at the same time being light and simple to handle.

The Balmoral riser impact protection system allows the bare joint to be stored in the same stack as buoyant riser joints while minimising the chance of operational damage during deployment and recovery.



> Engineered to provide maximum impact and abrasion protection

Pin and box end protection

When transporting and storing drill riser joints, pin and box end connectors are always subject to potential damage. To prevent unnecessary and expensive repair work to these critical areas, Balmoral Offshore Engineering provides a range of lightweight, high impact and abrasion resistant elastomer protectors.

Solution

With growing numbers of drilling contractors recognising the latest in high performing PU pin and box end protection, Balmoral Offshore Engineering can help you achieve easier handling, fitting, transportation and storage by specifying these highly cost-effective products.

Traditional steel protectors

Very heavy, 50kg+ each
Low abrasion resistance
Prone to corrosion
Heavy two-man handling
Unwieldy installation
Generally one-off use due to irreparable damage
Difficult to identify

Balmoral elastomer protectors

Typically 25kg or less per unit
Exceptional abrasion resistance
Non-corrosive PU-based materials
Meets H&S criteria for single-man lift
Quick and simple installation, no tools required
Can be re-used over many projects
Corporate graphics can be moulded into the product

Riser clamps

A conventional drill riser comprises of a 21" diameter main line with choke, kill, booster and hydraulic lines surrounding it. These service lines require to be connected to the main body by means of clamps to prevent buckling when the riser is operational.

Historically, steel clamps have been used - frequently "burn outs" from thick steel sheet - which were heavy and cumbersome when attaching to the riser. However, as drilling depths become greater the requirement for weight saving on riser strings has increased.

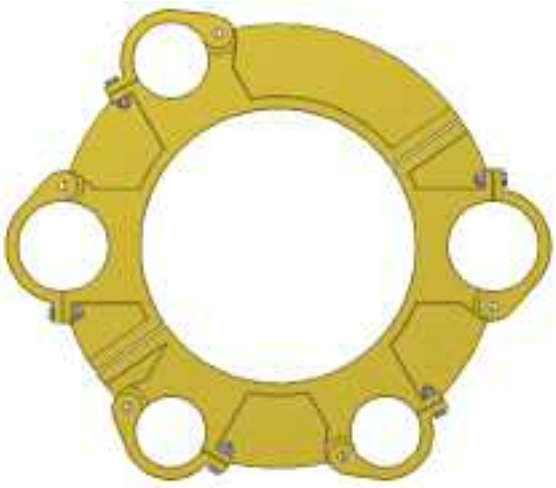
One area where this has been possible is through the evolution of polymer riser clamps. Initially the steel clamp evolved to a combination of a steel strap with polymer elements and thereafter to a full polymer product.

Maintaining its policy of product innovation and continuous improvement, Balmoral Offshore Engineering optimised its riser clamp design in terms of functionality, handling and ease of attachment to the riser string.

The design optimisation process resulted in a clamp that is:

- Extremely robust
- Highly impact resistant
- Offers a significant weight saving when compared to steel
- Vastly reduced assembly time
- Custom designed to suit riser requirement

Polymer riser clamps are now recognised as an industry standard high performance solution whilst offering significant riser string weight reduction in deep and ultra-deepwater environments.



Strakes and fairings

The offshore industry is currently embarking upon new and challenging deepwater projects involving floating production systems using a range of steel riser configurations in vertically tensioned free-standing or catenary configurations. In service, these risers are subjected to a number of actions including dynamic wave and vortex induced loads.

For risers installed in deepwater and facing adverse environmental conditions these loads may lead to a critical situation for the structure due to over stressing, buckling, brittle fracture or fatigue.

In particular vortex induced vibrations (VIV) can be detrimental to slender tubular elements such as risers, due to the severe fatigue impact associated with the varying stresses resulting from large amplitude vibrations. To counteract such fatigue impact, VIV needs to be suppressed.

The most widely used technique to reduce VIV on cylindrical structure is a helical strake system.

BOE strakes are available in marine grade abrasion resistant polyurethane elastomer or a marine grade composite material and can be supplied to accommodate various installation methods including onshore, shipboard, stinger or diver/ROV retro fitting. They are supplied as interlocking circular half shells which are secured by a metallic strapping system.

Subsea, umbilicals, risers and flowlines (SURF)

Distributed buoyancy
Buckle mitigation buoyancy
Piggyback clamps
Saddles
Centralisers
Spacers
Flange protectors
Bend stiffeners
Bend restrictors
Cable and flowline protection

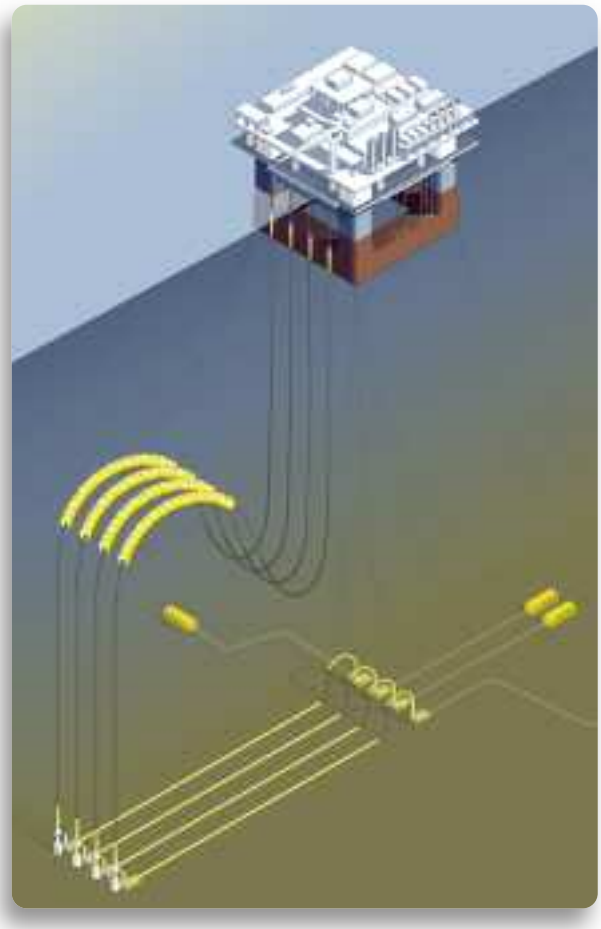
Distributed buoyancy

The use of flexible pipe in offshore oil and gas production is usually grouped into two categories; static and dynamic. Dynamic applications normally involve an offshore floating production facility or terminal connected to another floating facility or fixed structure.

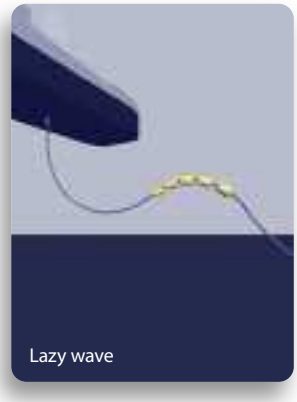
Flexible pipe and umbilicals require the use of buoyancy modules to reduce topside or tension loads to achieve particular configurations which include lazy, steep, pliant and W-wave.

BOE distributed buoyancy modules generally consist of an internal clamping system and syntactic foam buoyancy elements. The buoyancy elements are supplied in two halves incorporating a moulded internal recess that is configured to transfer the forces from the buoyancy to the clamp and subsequently the riser. This recess also accommodates bending of the riser during service. The internal clamping system is fixed to the pipe and the two half modules are fastened around the clamp.

Deepwater projects require modules and clamps to be designed for operating depths in excess of 3000msw where substantially larger modules and extreme clamping loads are demanded. BOE has been driving a significant R&D programme to meet this challenge and has developed a number of solutions for deep and ultra-deepwater environments.



Typical distributed buoyancy configurations



Distributed buoyancy

Product design, engineering and materials

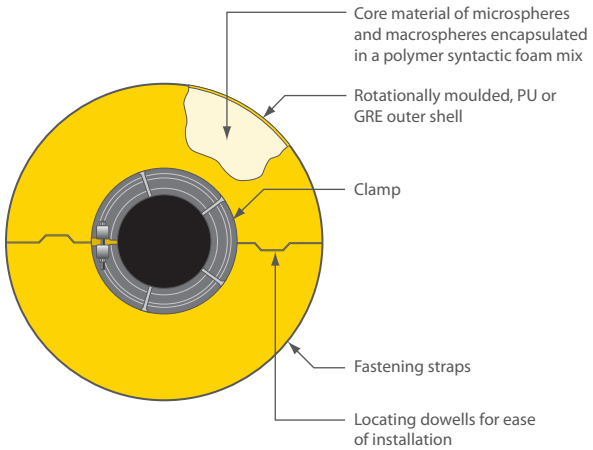
The densities and composition of the modules are based on operational requirements such as hydrostatic pressure, uplift, water ingress, riser diameter, length, etc.

However, the main elements of the modules comprise microspheres and macrospheres encapsulated in a polymer syntactic foam matrix.

Operating what is probably the most advanced buoyancy manufacturing plant in the industry, Balmoral provides very high quality, consistent modules which result in low water absorption and compression throughout their service life.

In higher temperature applications the buoyancy modules incorporate convection channels.

Distributed buoyancy design features



Fastening systems

The buoyancy elements are fastened around the clamp and riser using two sets of securing straps, usually made from Kevlar. The straps are tensioned using cross bar and screw mechanisms and fitted into moulded-in recesses on the body of the buoyancy element.

Balmoral also offers a bolted fastening system.

External finishing

BOE provides finishing options of rotationally moulded polyethylene, polyurethane elastomer or GRE external skins which offer the following benefits:

- Abrasion and impact resistance
- Enhanced water ingress performance
- Marine growth resistance
- High-vis pigmentation
- Customised graphics option

Distributed buoyancy

Distributed buoyancy clamping options

As the requirement for flexible risers and umbilicals progresses into ever deeper water, the performance of the clamping systems required to maintain the buoyancy, ballast or tethers in position has changed significantly. On occasion, risers also have an insulating layer which in many cases will be subject to creep over the service life of the riser.

The range of variables encountered through the design life of the clamp includes variation in diameter due to changes in internal pressure, flexing of the riser/umbilical as well as temperature and tension fluctuation.

Whilst the clamps are fitted directly onto the outer layers of the riser/umbilical, they are normally required to transfer the clamping load through the outer layers to the internal armour layers. This load transfer is designed to prevent slippage between the layers - caused by in-service and deployment loads - with an acceptable safety factor.

Balmoral Offshore Engineering has designed a new generation of clamps to ensure optimum performance for specific operating conditions.

High performance clamp

This product is designed for high clamping load situations to resist the axial movement of large buoyancy and ballast loadings. The clamp is designed to control the contact pressure onto the flowline allowing the accommodation of large diameter expansion/contraction due to its low stiffness and excellent spring properties. The clamp is installed directly onto a flowline using an installation tool allowing accurate clamping loads to be generated while minimising installer fatigue.

The High Performance clamp in summary:

- Suited for high loading/large buoyancy applications
- Riser outer diameter tolerance accommodated by hinge feature
- Riser diameter variations during operation accommodated by excellent spring properties of clamp assembly

Intermediate clamp

Designed for intermediate load situations this clamp resists the axial movement of moderately large buoyancy and ballast loadings.

The Intermediate clamp is engineered to control the contact pressure onto the flowline allowing it to accommodate large diameter contractions due to the low stiffness and excellent spring properties of the material.

The clamp can be installed directly onto a flowline with torquing bolts or through the use of an installation tool to induce a load into the clamping strap.

The Intermediate clamp in summary:

- Best suited for intermediate loading applications where low clamping pressures are essential
- Riser diameter variations are readily accommodated due to the excellent spring stiffness of the clamp assembly

Standard clamp

Designed to clamp directly onto flexible flowlines, risers and umbilicals to prevent a module assembly from sliding along the length of the flowline whilst allowing the module to rotate freely.

This clamp is best suited for umbilical or small diameter risers where low clamping pressures are required.

The Standard clamp in summary:

- Best suited for low clamping pressure applications
- Riser outer diameter tolerance readily accommodated while retaining consistent clamping load to resist slippage

Integral clamp

The Integral clamp module removes the need for a separate clamp by clamping directly onto flexible flowlines and risers. Custom designed pads placed within the recess of the module accommodate riser diameter expansion and contraction while generating consistent clamping loads to resist slippage.

These pads also allow the module to accommodate upper and lower deviations of the nominal outer diameter of the flowline. The module can be installed using hydraulic cylinders, removing the need for bolting modules together and minimising installer fatigue.

The Integral clamp in summary:

- Variation in riser outer diameter is readily accommodated while generating consistent clamping loads to resist slippage
- The clamping load can be generated by hydraulic tool, minimising installer fatigue

Buckle mitigation buoyancy

A further form of distributed buoyancy is used for buckle mitigation purposes. On lengthy subsea flowlines, for example, it is necessary for pipeline engineers to consider the issue of upheaval buckling.

If a pipeline is carrying high temperature product it is inevitable that expansion will occur along the steel pipe. Although the pipe may expand in diameter, most occasions see the pipe increase significantly in length. If both ends of the pipe are fixed this longitudinal expansion can potentially transform into a buckle situation with catastrophic results.

To mitigate this phenomenon designers incorporate pre-determined buoyant zones along the pipeline such that expansion, or buckle, will take place in a safe controlled way. These buoyancy modules must maintain their integrity as the pipeline "bends" during installation and operation.

Balmoral distributed buoyancy modules are based on high performance syntactic foams which are designed to meet exacting performance, strength, and installation project requirements through life of field and in water depths of 100-4000msw.

In a typical 25 year design life, buckle mitigation modules may travel over 15km of sea bed as the pipe oscillates through expansion and contraction. For this reason the external shell must be highly abrasion resistant and materials such as polyethylene, elastomer or GRE are ideally suited to this purpose.

Balmoral's unique range of clamping systems is used in conjunction with its distributed buoyancy products ranging from integral clamps, particularly suited to steel pipelines and umbilicals, to a patented composite clamp design for flexible flowlines as well as steel and composite stop collars.

Piggyback clamps, saddles, centralisers, spacers and flange protectors

To help with numerous offshore operations, including pipeline installation and laying, BOE developed a range of auxiliary products such as piggyback clamps, riser clamps, centralisers and spacers.

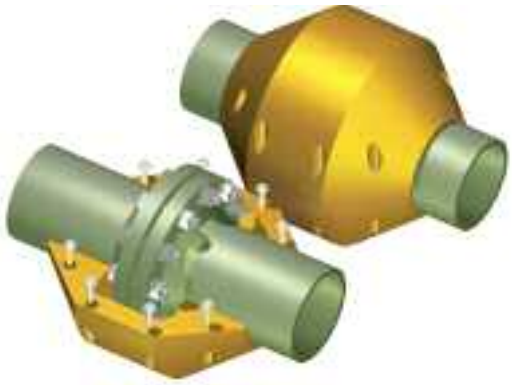
Available in a range of elastomeric materials from flexible to rigid, these mouldings can be supplied in a variety of colours to aid identification during installation.

Depending on the application and service life, the clamps may be secured by means of strapped or bolted attachment.

Flange protectors

Designed to protect and insulate subsea pipeline and floating hose flange connections, BOE flange protectors operate in depths exceeding 3000m and are formed using two half-shells.

Lightweight and ROV friendly, these products benefit from longitudinal and radial seals which restrict seawater ingress between the covers and are designed for lifetime of field use.



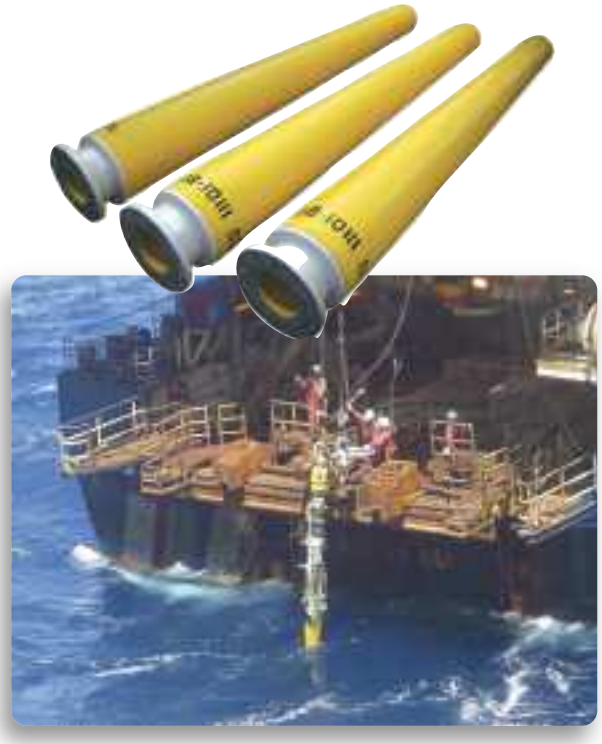
Bend stiffeners

Bend stiffeners are used to support flexible pipe, umbilicals and cables when connected to rigid structures or a floating production system where there is a requirement to control the minimum bend radius of the pipe. They are usually attached at either the topside or seabed connection.

In dynamic applications bend stiffeners require to have sufficient fatigue resistance to control the in-service bend radii and sustain the cyclic loads to the end of the specified life whereas in static applications they protect against gross over-bending.

Stiffeners are typically conically shaped polyurethane mouldings with a cylindrical bore that slips over the pipe, umbilical or cable.

Balmoral bend stiffeners are designed in accordance with API 17J Appendix B using specifically formulated polyurethane materials and are engineered to suit specific operational parameters.



Design analysis

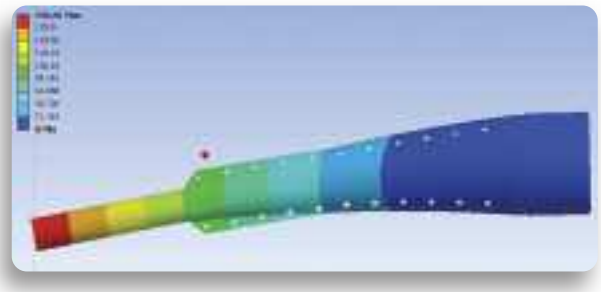
Balmoral uses the proprietary package 'Orcabend', an industry standard for many years, to generate the profile for the active conical section of the stiffener.

Information that is critical to the stiffener design includes:

- Tension and angle data from the riser analysis
- Temperature
- Interface detail
- Riser end-fitting profile
- Diameter and stiffness
- Minimum bend radius
- Riser analysis fatigue data

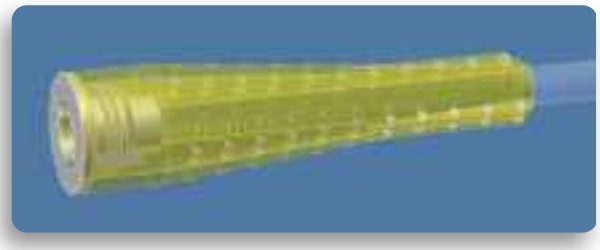
Balmoral's FEA package is used to verify the Orcabend design and analyse the end-fitting structure. This process can also provide thermal analysis if required.

A combination of Orcabend and FEA technologies allows split stiffeners to be designed for retro fitting.



Stiffener interface structure

A smooth transition is required between the rigid flange and the flexible cone of the stiffener. BOE's design achieves this by creating both rigidly bonded and un-bonded areas that provide deflection and minimum stress in these localised areas.



Bend restrictors

Designed as interlocking elements, bend restrictors prevent over-bending at the interface between flexible flowlines, umbilicals and cables and rigid structures such as wellhead connections, J-tube exits, rigid pipe crossovers and PLET connections by mechanically locking up.

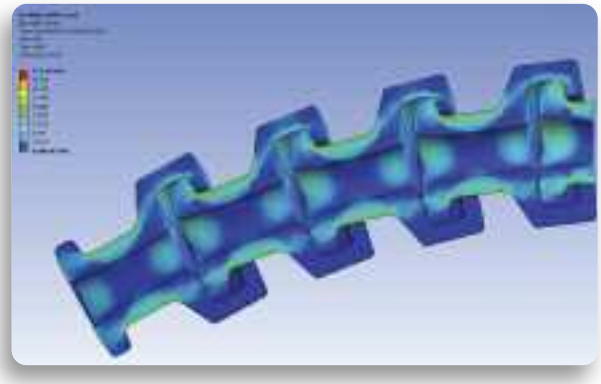
They are normally used in static applications but, unlike bend stiffeners, only provide protection once the pipe has achieved the desired bend radius.

Designed in accordance with API 17J Appendix B, BOE bend restrictors are manufactured in rigid structural polyurethane two piece units that are bolted together around the pipe.

Design analysis

BOE restrictors are designed using 'Orcabend', the recognised industry standard, using the following information:

- Flexible pipe OD
- Flexible pipe if heated
- Minimum bend radius
- Service life
- Length of coverage by angle or length
- Support structure details
- Flexible pipe min and max internal temperatures; operation and installation
- Flexible pipe min and max thermal conductivity value if pipe is heated
- Min and max installation air temperature
- Min and max seawater operation temperature
- Installation and operation shear force
- Installation and operation bending moment
- Flexible pipe stiffness if not taken into consideration in the bending moment and shear force loads



Cable and flowline protection

Duraguard™

Duraguard was developed for the protection of subsea cables, flexible jumpers, flexible flowlines and riser touchdown zones although many other applications have been identified.

Balmoral Duraguard provides a cost effective localised impact and abrasion protection system and is supplied as pairs of interlocking half shells secured around the core product using circumferential straps.

It is manufactured in a range of polyurethane elastomer grades, depending on the specific operational conditions, and can be supplied in a wide range of diameters, wall thickness and lengths. Typical lengths are determined by the individual half shell weight and can vary from 500-2000mm.

In addition to providing mechanical protection, Duraguard HD can be supplied in a highly ballasted form to enable its use as ballast or stabilising systems.

Duraguard HD™

For projects which demand cable protection with added ballast, Duraguard HD (High Density) provides much more than straightforward abrasion and impact resistance.

Heavy filler materials are added to the Duraguard mix to increase density and overall weight. The ballast provided gives extra on-bottom stability while the added mass improves dynamic response thus reducing the risk of clashing.

Densities ranging from 2300-11,000kg/m^3 can be achieved with Duraguard HD.

Duraguard applications

Ballast
Filler materials can be added to increase density and provide extra stability.

Buoyancy
Standard PU is more or less neutrally buoyant in seawater. However, hollow microspheres can be added to reduce density and provide uplift ranging typically from 650-800kg/m^3.

Impact absorption
PU is a relatively resilient material which can absorb moderately heavy impact. Reinforced options are available for extreme environments.

Protection
Protects risers from abrasion/gouging at touchdown points, over rough seabeds, coral or rock.

Stiffening
Duraguard provides added stiffness to support cable over the seabed and/or assist in laying operations.

Thermal insulation
Lab tests have shown a significant increase in thermal insulation performance when Duraguard is fitted.

Duraguard installation

Duraguard can be fitted during unreeling/laying or prior to reeling and is installed by placing the two modules around the flowline and banding them into place. Bands are normally set 300mm apart. Adjacent segments with overlapping ends are added to provide a continuous protected length.

Duramat™

Moulded in marine grade polyurethane elastomer, Duramat provides dropped object impact and abrasion protection to seabed umbilicals, flowlines and pipelines.

During manufacture, the PU is filled with barites that provide ballast and prevent tidal movement while the grooved element design allows flexing and separation of the protected lines.

Duramat is ROV and diver installable and is generally supplied with through holes for rope handling. Typically provided in 3000x3000x40mm sections, the mats can be custom sized to meet project specifications.

> Duramat provides dropped object impact and abrasion protection to seabed umbilicals, flowlines and pipelines

Thermal insulation

Balmoral Supatherm™
Balmoral SupathermPlus™
Balmoral Elastotherm™
Insulation covers
Doghouses
Wellhead insulation
Diving bell insulation

Thermal insulation

Balmoral Supatherm and Balmoral SupathermPlus

Balmoral Supatherm and Balmoral SupathermPlus are epoxy resin syntactic foam insulation systems developed for the simultaneous provision of buoyancy and/or thermal insulation in hot/wet conditions at temperatures in the range of 90-110ºC respectively.

Balmoral SupathermPlus utilises the same hydrolysis-resistance resin system as Balmoral Supatherm but simply omits the hollow glass microspheres. As well as being immune to hydrostatic compression, this non-cellular system exhibits extremely low water ingress rates and saturation values.

The Balmoral Supatherm range is typically used in flooded, modular insulation systems on manifolds, 'Christmas trees', hybrid riser towers and flooded sealine bundles.

Balmoral Elastotherm

Balmoral Elastotherm is Balmoral's range of PU-based insulation which comprises both syntactic foam and solid elastomer systems. PU syntactic foam systems are based on the use of pre-formed hollow microspheres suspended in a thermoset PU elastomer matrix.

Applications of PU insulation are typically cast-in-place 'wet' insulation on 'Christmas trees', manifolds, jumpers, spool pieces and in modular systems on connectors and flange covers.

Thermal insulation

Balmoral Supatherm

The Balmoral Supatherm insulation system is based on a thermoset epoxy resin syntactic foam, originally developed for the simultaneous provision of buoyancy and/or thermal insulation on flooded sealine bundles and hybrid riser towers where lifetime tolerance to hot/wet conditions at temperatures exceeding 90°C in depths to 3000msw.

This exceptional performance characteristic also makes Balmoral Supatherm ideal for other high temperature 'flooded shell' insulation systems.

The material has an extremely high glass transition point (Tg), so that full mechanical support for the hollow glass microspheres is maintained to well beyond all anticipated service conditions. This outstanding mechanical support allows the use of much lower density glass microspheres than is feasible with any other insulation system. This, in turn, results in the achievement of outstandingly low k-values; far below those of any competing insulation system.

The ultimate performance limit for all glass syntactic foams operating in hot/wet conditions is not related to the matrix resin system but rather to the dissolution of the hollow glass microspheres at temperatures beyond 90-95°C. With glass dissolution, the thickness of the microsphere walls progressively decreases, eventually leading to microsphere collapse. What is left behind is a 'relic structure' of water-impregnated resin matrix. Associated with this water penetration is a massive increase in k-value, with a fully-saturated syntactic epoxy having a k-value of up to 0.4 W/m.k; a 300+% increase.

Typical Balmoral Supatherm 1500 mechanical and thermal properties; nominally 1400msw, 90°C rated

Property	Value
Density @ 20°C	580kg/m³
Tensile strength @ 20°C	20MPa
Tensile modulus @ 20°C	1700MPa
Elongation at break @ 20°C	3%

Uniaxial compressive strength MPa

4°C	20°C	40°C	70°C	90°C
40	40	37	35	29

Uniaxial compressive modulus MPa

4°C	90°C
1550	1350

Compressive strain at break	5%
Poissons ratio @ 20°C	0.33
Shear strength @ 20°C	17MPa
Flexural strength @ 20°C	25MPa
Bulk modulus @ 20°C	1530MPa

Hydrostatic collapse pressure Bar g

4°C	20°C	40°C	70°C	90°C
>460	>420	>415	>395	>370

Elastic compression @ 135bar 55°C % bv	<1.0
Est average EOL water ingress 150mm thick section 4-70°C gradient % bw	<2.0
Est EOL increase in k-value ex compression & water ingress @ 1500msw, 100mm section 4-70°C gradient %	<10.0
Creep @ 135bar 55°C % bv (design for 0.5%)	None detected

Coefficient of thermal expansion mm/mm°K

4-70°C	4-90°C
$39x10^{-6}$	$41x10^{-6}$

Thermal conductivity W/mK

4°C	20°C	40°C	70°C	90°C
0.094	0.097	0.100	0.105	0.110

Glass transition temperature°C	≥ 160
Specific heat capacity 4-90°C J/kgK	≥ 1600

Water diffusion coefficient mm²/s

20°C	40°C	70°C	90°C
0.094	0.097	0.100	0.105

Water saturation value % bw

20°C	40°C	70°C	90°C
4.12	4.25	4.30	4.37

Proposed dimensional tolerances mm

Length	St'ness V&H	Warping	Critical areas
+/—6	+/—5	+/—2	+/—2

Thermal insulation

Balmoral SupathermPlus

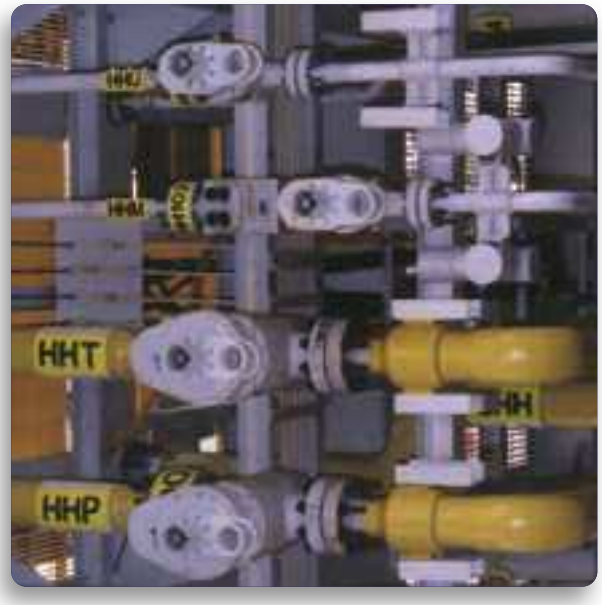
To eliminate problems associated with glass microsphere dissolution, Balmoral SupathermPlus utilises the same hydrolysis-resistant resin system as Balmoral Supatherm syntactic foam but simply omits the hollow glass microspheres. As well as being essentially immune to hydrostatic compression, this non-cellular resin system exhibits extremely low water ingress rates and saturation values.

As a result, whilst the start-of-life k-value of SupathermPlus is higher than that of a syntactic foam system, it suffers negligible deterioration at depth over its service life.

The particular advantage of the microsphere-free Balmoral SupathermPlus system is that its ultra-stable k-value is achieved and maintained at temperatures up to and beyond 110°C, temperatures at which all microsphere-containing systems – and the majority of pure polymer systems such as polyurethane and commodity epoxies – would have suffered massive water ingress, degradation and k-value increase.

Applications

The Balmoral Supatherm insulation systems are most commonly used in flooded, modular insulation systems for manifolds, 'Christmas trees', hybrid riser towers, flooded sealine bundles and connectors and flanges in insulated flowlines.



Balmoral SupathermPlus mechanical and thermal properties
Unlimited depth rating

Property	Value
Density @ 20°C	1150kg/m³

Tensile strength MPa

20°C	40°C	70°C	90°C	110°C
64	60	51	45	35

Tensile (Young's) modulus MPa

20°C	40°C	70°C	90°C	110°C
2595	2520	2460	2410	2720

Tensile strain at break %

20°C	40°C	70°C	90°C	110°C
4.6	5.2	5.4	4.7	3.2

Uniaxial compressive strength MPa

4°C	20°C	40°C	70°C	90°C	110°C
106	83	73	67	63	49

Uniaxial compressive modulus MPa

4°C	20°C	40°C	70°C	90°C	110°C
2150	1940	1980	1935	1815	1835

Compressive strain at break @20°C	6.4%
Shear strength @ 20°C	48.00MPa
Flexural strength @ 25°C	99.62MPa
Flexural modulus @ 20°C	2420MPa
Hydrostatic collapse pressure @ 90°C	Not measurable
Est elastic compression @ 135bar 55°C % bv	<0.5
Est EOL water ingress 150mm thick section 4-70°C gradient % bw	<<1.0
Est EOL increase in k-value ex compression & water ingress @ 1500msw, 100mm section 4-90°C gradient %	<2.0
Hydrostatic creep @ 135bar 55°C % bv	0
Coefficient of thermal expansion mm/mm°K @ 4-70°C	57 x $10^{-6}k^{-1}$

Thermal conductivity W/mK

4°C	40°C	90°C
0.21	0.22	0.24

Glass transition temperature°C	≥ 160
Specific heat capacity 4-90°C J/kgK	≥ 1600

Proposed dimensional tolerances mm

Length	St'ness V&H	Warping	Critical areas
+/—6	+/—5	+/—2	+/—2

Thermal insulation

Balmoral Elastotherm

The Balmoral range of PU-based insulation comprises both syntactic foam and solid elastomer systems.

PU syntactic foam systems are based on the use of pre-formed hollow microspheres suspended in a thermoset PU elastomer matrix.

The hollow microsphere material may be either thermoplastic polymer or glass. Polymer microspheres are extremely thin wall, so offer significantly better insulation properties than glass microsphere-based systems, however, with their thin wall and modest polymer mechanical properties, they are unable to make a significant contribution to the compression resistance of the foam. Polymer sphere syntactic polyurethane foam (SPU) is therefore restricted to service in relatively shallow water (0-350msw).

Glass microspheres are extremely creep resistant and demonstrate high hydrostatic collapse values. Glass syntactic polyurethane foam (GSPU) is suitable for service at water depths to 3000msw. Balmoral provides both polymer sphere (SPU) and glass microsphere (GSPU) versions of syntactic polyurethane.

The temperature resistance of PU syntactic foams varies according to the nature of the hollow microspheres and also upon whether water is present at the hot interface.

The polymer microspheres are chemically inert and so the temperature resistance of SPU mirrors that of the PU elastomer matrix - typically 110ºC hot/dry and 90ºC hot/wet.

Glass microspheres have an alkaline surface which can accelerate thermal and hydrolytic degradation. GSPU is therefore typically limited to 100ºC hot/dry & 70ºC hot/wet.

Solid PU insulation

Solid elastomer systems are used in situations where service conditions preclude the use of Elastotherm syntactic systems, for example:

- Excessive depth/hydrostatic pressure
  eg >350msw for Elastotherm SPU and
  >3000msw for Elastotherm GSPU
- High service temperature
  eg >110ºC for SPU and
  >100ºC for GSPU
- Hot/wet conditions
  eg >90ºC for SPU and
  >70ºC for GSPU
- Field application, including girth weld coating, in adverse environmental conditions
- Where constant insulation properties are required through service life
- Where in-service fatigue or high coating strains during installation are anticipated

Particular advantages of Elastotherm solid elastomer systems include:

- Immunity to hydrostatic compression
- Combined insulation and anticorrosion performance
- Outstanding flexural, tensile and impact performance

Applications

Balmoral Elastotherm PU insulation systems are suitable for use both as cast-in-place 'wet' insulation on 'Christmas trees', manifolds, jumpers, spool pieces and in modular systems on connectors and flange covers.

Balmoral Elastotherm syntactic polyurethane service values

	Balmoral Elastotherm SPU		Balmoral Elastotherm GSPU		Balmoral Elastotherm S		Balmoral Elastotherm HT	
	Hot/Dry	**Hot/Wet**	**Hot/Dry**	**Hot/Wet**	**Hot/Dry**	**Hot/Wet**	**Hot/Dry**	**Hot/Wet**
Max depth ft/msw	1155/350	1155/350	9900/3000	9900/3000	Unlimited	Unlimited	Unlimited	Unlimited
Max temperature ºC	110	90	100	70	115	70	130	90

Note: The depth and temperature values for SPU are quoted in isolation: compressive creep may set lower limit values in combination.

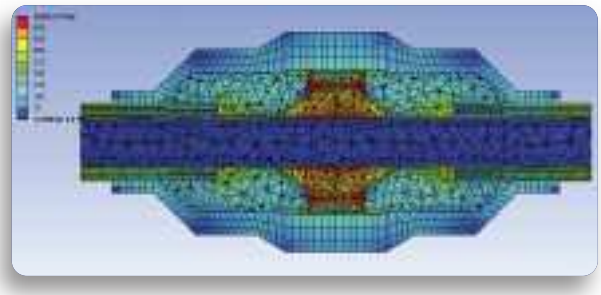
Insulation products

Insulation covers/Doghouses

Subsea pipelines, flowlines, risers and associated equipment carrying high temperature hydrocarbons must be insulated to prevent cooling and solidifying during the flow process. However the connections between the lines and subsea equipment can form cold regions unless properly protected. Balmoral Offshore Engineering has developed a range of insulation products to help maintain the overall flow assurance.

Using static or transient finite element analysis, Balmoral designs insulation covers tailored to match either a project's required overall heat transfer coefficient or design 'cool down' time and incorporate radial and longitudinal seals to ensure thermal integrity. The BOE field-proven sealant system helps prevent excessive water movement either from within the insulation covers or into the assembly.

The covers can be designed to be mounted onboard the offshore construction vessel or installed subsea by either a diver or remotely operated vehicle. The cover mounting procedure and closure system must be safe, fast and easy, requiring the minimum number of standard tools.



Wellhead insulation

Balmoral Supatherm wellhead insulation is installed as half-shell systems and suitable for factory and field installation while Balmoral Elastotherm is used as cast-in-place 'wet' insulation and can also be applied as a modular system.

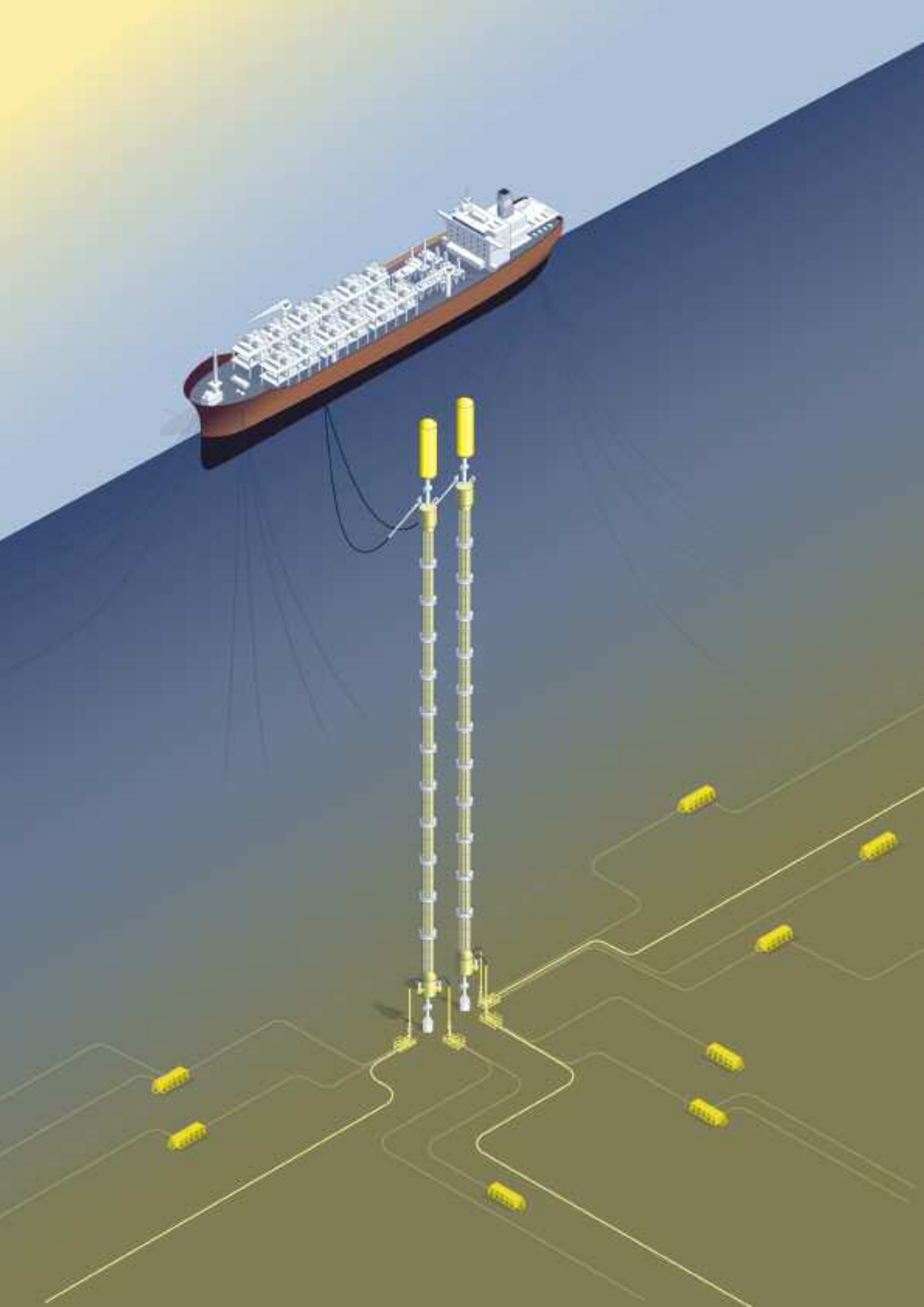
Both options are widely used on 'Christmas trees', manifolds, jumpers, spool pieces and connectors.

Diving bell insulation

One of the more versatile materials for providing both insulation and buoyancy on diving bells is copolymer PVC foam.

This material can be thermoformed to match the contours of cylinders and spheres without the requirement for expensive moulds. Layers are built up to provide the required insulation and/or buoyancy values and an external coating can be applied to provide a tough impact and abrasion resistant finish.

Copolymer PVC foam systems are used to depths of 600-700msw while alternative materials are available for operation beyond these depths.



Hybrid riser tower buoyancy

Balmoral Flowtherm™

Balmoral FlowthermPlus™

Hybrid riser tower buoyancy

Water depths, seabed conditions, high pressures and high temperatures are all factors that are considered when designing systems for the extraction of hydrocarbons in deep and ultra-deepwater fields.

Production elements including risers, flowlines and pipelines are particularly prone to temperature reduction, creating the potential for wax and hydrate formation.

Hydrocarbons can reach the wellhead at temperatures of 50-90ºC and typically comprise of a mix of gases, paraffinic material, waxes and, frequently, water.

As the hydrocarbons travel through the system it is inevitable that temperatures will fall, potentially causing wax and gas hydrates to precipitate and become deposited on the flowline walls. This, of course, will lead to flow rate depletion and, ultimately, choking.

To counter these challenges, Balmoral Offshore Engineering has developed Balmoral Flowtherm and Balmoral FlowthermPlus.

Balmoral Flowtherm and Balmoral FlowthermPlus

Balmoral Flowtherm and Balmoral FlowthermPlus represent two grades of pumpable liquid that demonstrate insulation properties typically found in rigid solid polymer and syntactic systems.

They are gel-based thixotropic materials used to provide insulation and buoyancy in a variety of subsea applications including uplift and insulation in riser towers and can assist with tow-out and installation procedures.

Hybrid riser tower buoyancy

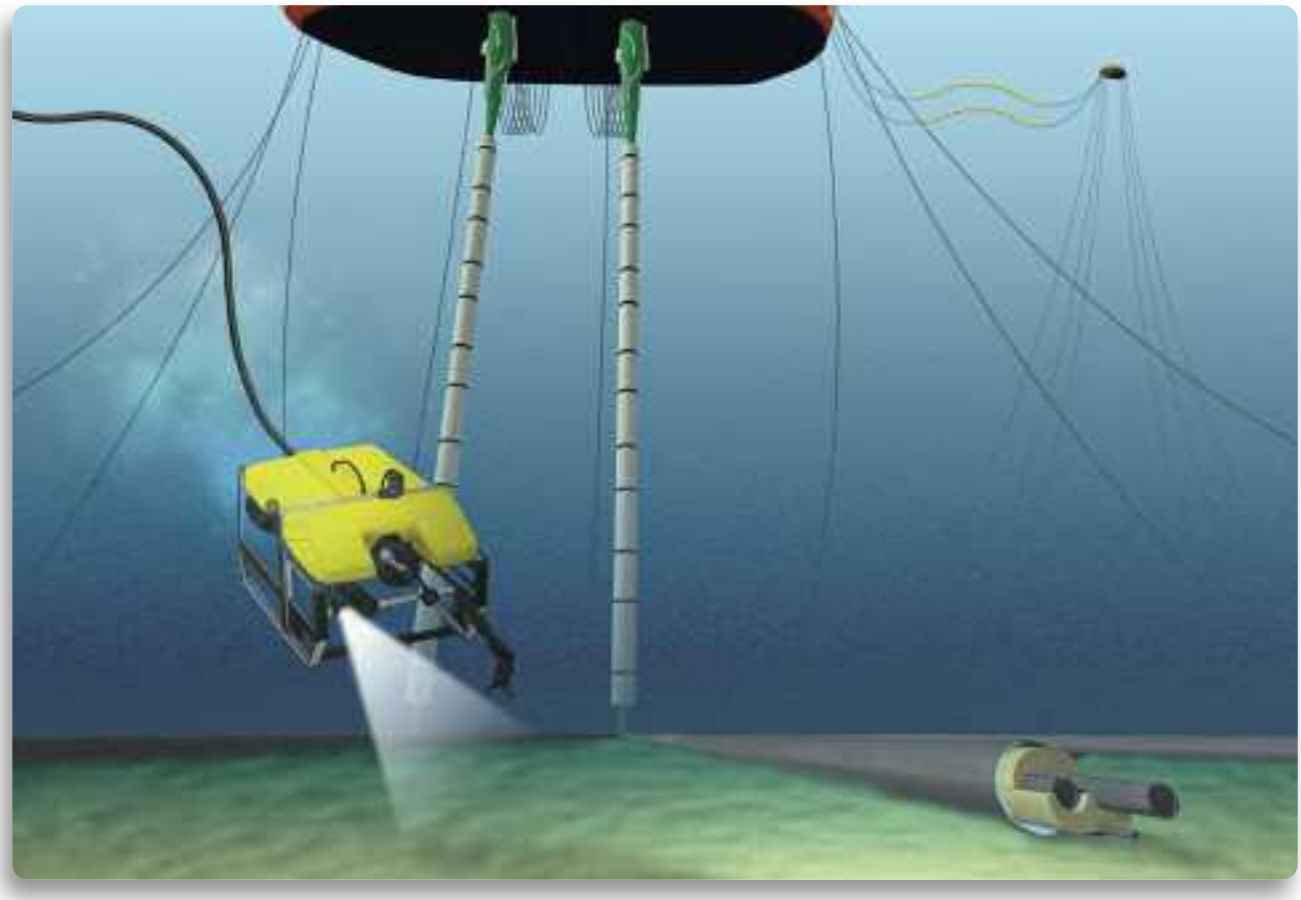
Engineering design and materials development

Balmoral's technical team has earned a reputation for delivering the right solution to the right place at the right time.

For more than 20 years the company's experienced scientists and technologists have provided combinations of insulation and buoyancy to assist in the exploration and exploitation of ever deeper waters and ever harsher environments.

The company's R&D programme has evolved to include material innovation and, in conjunction with process engineers and technicians, the optimisation of production processes and control techniques designed to improve safety, quality and productivity.

The technical team is available to discuss your project requirements at any time.



Hybrid riser tower buoyancy

Balmoral Flowtherm and Balmoral FlowthermPlus

Balmoral Flowtherm and Balmoral FlowthermPlus are gel-based thixotropic systems that provide insulation and buoyancy in a variety of subsea applications.

Balmoral Offshore Engineering has developed two grades of Flowtherm that combine the advantages of a pumpable liquid with the insulation properties typically found in rigid solid polymer and syntactic systems.

Balmoral Flowtherm and Balmoral FlowthermPlus are thermally and rheologically stable systems. Being non-volatile, they will not evaporate or dry out under normal operating conditions and, due to their thixotropy characteristics, will not float or wash away should the outer container become damaged.

Balmoral Flowtherm and Balmoral FlowthermPlus systems will not pour or flow under their own weight, making it impossible for damaging convection currents to arise within the insulation. Flowtherm exhibits major shear thinning, which allows ready pumping; immediately after pumping shear ceases, the thixotropy is re-established.

Balmoral Flowtherm is a glass microsphere-filled system, designed for operating temperatures to 90ºC with wet exposure, and water depths to 3000msw. Independent testing has demonstrated that Balmoral Flowtherm will suffer minimal hydrostatic compression during a typical 20 year service life.

Balmoral FlowthermPlus is an unfilled system, designed for operating temperatures in excess of 120ºC, and service depths to 7000msw.

Balmoral Flowtherm systems can be installed using a variety of positive displacement pumps and are supplied in 205 litre drums or 1000 litre totes.

Applications

Riser towers, tow-out installation procedures, pipe in pipe, doghouses, retrofit buoyancy installation and many others.

Balmoral Flowtherm typical service values

Parameter	Typical values	
	Balmoral Flowtherm	Balmoral FlowthermPlus
Depth Capability ft/msw	10000/3000	23100/7000
Density kg/m^3	616	850
Viscosity, Pa.s @ 25ºC (shear rate)	20 (200sec^{-1})	10 (50sec^{-1})
Thermal Conductivity @ 20ºC Wm-1K-1	0.1203	0.16
Thermal Conductivity @ 40ºC Wm-1K-1	0.1231	0.162
Thermal Conductivity @ 70ºC Wm-1K-1	0.1268	0.165
Thermal Conductivity @ 90ºC Wm-1K-1	0.1294	0.169
Thermal Stability ºC Dry/Wet	90/150	150/150
Bulk Modulus MPa	1650	1515

Marine

Surface/subsurface buoyancy

- Oceanus™ floats
- Tri-buoys
- Umbilical floats
- One-piece subsurface buoyancy
- Mini cylindrical modular buoyancy (MCMB)
- Cylindrical modular buoyancy (CMB)
- Modular buoyancy
- Anchor pendant buoys (APB)
- Navigation aids
- Fenders
- Mooring buoys
- Fittings

Buoyancy repairs

ROV/AUV buoyancy

Surface/subsurface buoyancy

Providing a range of surface/subsurface products including one-piece, modular, 'off-the-shelf' and ROV/AUV buoyancy, with a wide variety of fittings and accessories, Balmoral Offshore Engineering offers a comprehensive range of solutions for your subsea project.

- Oceanus floats
- Tri-buoys
- Umbilical floats
- One-piece subsurface buoyancy
- Mini cylindrical modular buoyancy (MCMB)
- Cylindrical modular buoyancy (CMB)
- Modular buoyancy
- Anchor pendant buoys (APB)
- Navigation aids
- Fenders
- Mooring buoys
- Fittings
- Buoyancy repairs

Surface/subsurface buoyancy

Oceanus floats

Balmoral Offshore Engineering's design team created the Oceanus float to provide a range of standard, readily available, buoyancy units suitable for all ocean depths.

Oceanus floats comprise a high performance low density composite foam buoyancy core, encapsulated within a tough impact and abrasion resistant polyethylene shell and are supplied in a variety of colours with moulded-in client graphics where required.

To simplify the handling of Oceanus floats during deployment and recovery, each Oceanus features a pair of recessed lifting holes sized to accommodate 'gloved hands'. The floats also incorporate a series of flat surfaces to assist on-board stability and facilitate close grouping as part of operation or storage.

The standard range of Oceanus floats covers four uplift capacities and six standard operating depths.

Oceanus float values

Operating depth msw	Weight in air kg / Nominal buoyancy kg			
	OF1	OF2	OF3	OF4
1000	8.1 / 7.5	12 / 11.5	21 / 20.8	45.8 / 47.9
1500	8.8 / 6.9	13 / 10.5	22.9 / 19	50 / 43.6
2000	8.5 / 7.1	12.7 / 10.9	22.1 / 19.7	48.4 / 45.3
2500	9.2 / 6.4	13.7 / 9.8	24 / 17.8	52.8 / 40.9
3000	9.8 / 5.9	14.5 / 9	25.5 / 16.3	56.3 / 37.4
6000	11.4 / 4.3	17 / 6.5	30 / 11.8	66.5 / 27.2
Bore ØID mm	19.05	38.1	38.1	38.1

Tri-buoys

Tri-buoys offer a simple cost effective solution where additional buoyancy may be required as part of an installation operation or small permanent mooring.

The tri-buoys are finished either in GRP or elastomer and are supplied with central steelwork bearing a pad eye and swivel at either end. If required a smooth central bore can be created to enable the use of a mooring rope.

Balmoral tri-buoys provide a buoyancy uplift of between 125-175kg with depth rating capabilities of 610-3050msw.

Surface/subsurface buoyancy

Umbilical floats

BOE provides a range of floats to suit most control umbilicals. These floats comprise a pair of symmetrical half shells which are profiled to permit the line to flex within its specified bend radius.

Each float is manufactured using a low density composite foam core covered in a high performance impact and abrasion resistant polyethylene shell.

BOE's umbilical floats are hinged using two stainless steel latches. The floats are designed to grip the umbilical by means of a natural rubber internal grommet.

Balmoral umbilical floats are designed to suit umbilical diameters ranging from 25mm-50mm OD. Umbilical floats can be supplied to suit larger diameter umbilicals if required.

Umbilical float values

Operating depth msw	Weight in air kg	Nominal buoyancy kg
1000	14.7	15.2
1500	15.9	14.0
2000	17.3	12.6
2500	18.1	11.8
3000	19.1	10.8

One-piece subsurface buoyancy

Balmoral provides a range of one-piece subsurface buoys, suitable for service to 3000msw, which have a proven track record on subsea projects undertaken by marine installation contractors.

These products are manufactured using a central tension member encapsulated within a syntactic foam core of varying densities to suit the required depth rating.

External finishes include rotationally moulded polyethylene, polyurethane elastomer and glass reinforced vinyl-ester, giving a durable, abrasion resistant surface finish. The external surface is pigmented with a high visibility colour – typically yellow, white or orange – to assist with deployment and retrieval although other colours are available on request.

One-piece subsurface buoyancy

Buoy type	Depth rating/nominal buoyancy				Dimensions mm		Over flats
	2200m	1500m	1000m	500m	Length	Dia	
OPB A	2560	2920	3150	3325	2600	1810	1650
OPB B	2060	2348	2538	2678	2200	1810	1650
OPB C	1539	1760	1905	2012	2350	1450	1320
OPB D	1056	1211	1312	1388	1750	1450	1320
OPB E	778	896	974	1032	1600	1310	1100
OPB F	539	625	681	722	1400	1310	1100
OPB G	272	320	352	375	1125	1060	910

These buoys are available for service to 3000m.
Please contact BOE for further information.

Surface/subsurface buoyancy

Modular buoyancy

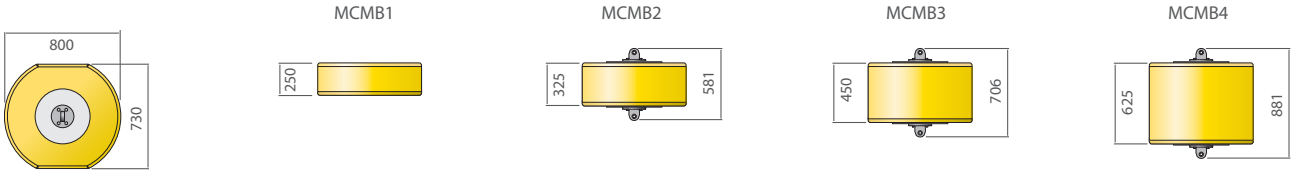
Balmoral has developed its range of modular subsurface buoyancy products to include standardised "off-the-shelf" solutions.

Designed to offer a cost effective and rapid response to immediate buoyancy requirements, the new buoys complement the company's existing range of products suitable for use from 0-2000msw.

These modules incorporate 'flats' which provide easier handling and deck storage whilst simultaneously improving robustness. We believe these are the most user-friendly subsurface buoys on the market.

Mini cylindrical modular buoys (MCMB)

MCMB Buoyancy modules



Weight in air (kg)
Nominal buoyancy (kg)

Surface	59	**99**	71	**148**	86	**210**
250msw	90	**68**	115	**105**	147	**149**
500msw	100	**58**	129	**90**	167	**129**
1000msw	109	**45**	141	**72**	184	**111**
1500msw	116	**38**	151	**63**	198	**98**
2000msw	113	**41**	147	**67**	192	**104**

MCMB Typical configurations

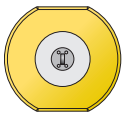
Weight in air (kg)
Nominal buoyancy (kg)

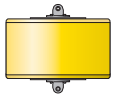
Surface	87	**191**	113	**284**	139	**377**
250msw	141	**137**	190	**207**	240	**276**
500msw	159	**119**	216	**181**	273	**243**
1000msw	174	**96**	238	**149**	302	**201**
1500msw	186	**85**	255	**132**	324	**179**
2000msw	181	**89**	248	**139**	315	**188**

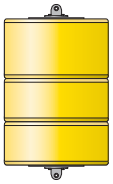
Note: All buoyancy and weight in air values are nominal and subject to specific configuration.

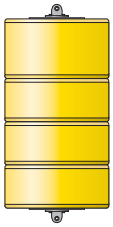
Surface/subsurface buoyancy

MCMB Typical configurations continued

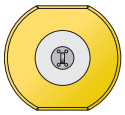


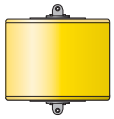






Weight in air (kg) **Nominal buoyancy (kg)**	1xMCMB3		1xMCMB3 + 1xMCMB2		1xMCMB3 + 2xMCMB2		1xMCMB3 + 3xMCMB2	
Surface	71	**148**	101	**273**	135	**394**	168	**519**
250msw	115	**105**	175	**199**	241	**288**	304	**383**
500msw	129	**90**	200	**175**	275	**254**	349	**338**
1000msw	141	**72**	221	**143**	306	**210**	388	**279**
1500msw	151	**63**	237	**127**	328	**187**	417	**250**
2000msw	147	**67**	230	**134**	319	**196**	405	**261**

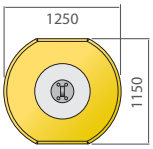


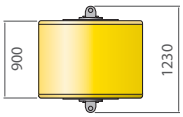


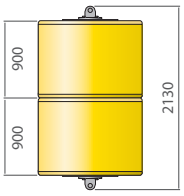
Weight in air (kg) **Nominal buoyancy (kg)**	1xMCMB4		2xMCMB4		3xMCMB4	
Surface	86	**210**	143	**460**	201	**703**
250msw	147	**149**	265	**338**	384	**520**
500msw	167	**129**	305	**298**	444	**459**
1000msw	184	**111**	341	**247**	497	**383**
1500msw	198	**98**	367	**221**	536	**344**
2000msw	192	**104**	356	**232**	520	**360**

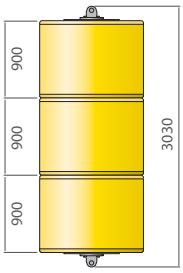
Cylindrical modular buoys (CMB)

CMB1 general arrangements









Weight in air (kg) **Nominal buoyancy (kg)**						
Surface	746	**1674**	1051	**3226**	1356	**4779**
250msw	1205	**1215**	1881	**2396**	2558	**3577**
500msw	1356	**1064**	2154	**2123**	2953	**3182**
1000msw	1501	**919**	2416	**1861**	3332	**2802**
1500msw	1490	**848**	2398	**1763**	3306	**2679**
2000msw	1539	**799**	2487	**1675**	3434	**2550**

Note: All buoyancy and weight in air values are nominal and subject to specific configuration.

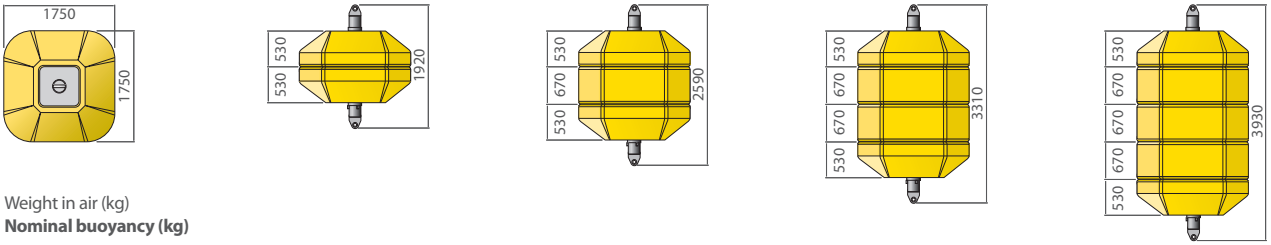
Surface/subsurface buoyancy

Modular buoyancy

Designed for use from 0-2000msw these buoys are used predominantly as suspended moorings or subsea markers. Balmoral modular buoyancy is highly adaptable and can be fitted with a comprehensive range of end fittings.

BOE's modular buoyancy utilises a range of tough, abrasion resistant core materials contained within a rotational moulded polyethylene shell. Other external finishes are available on request.

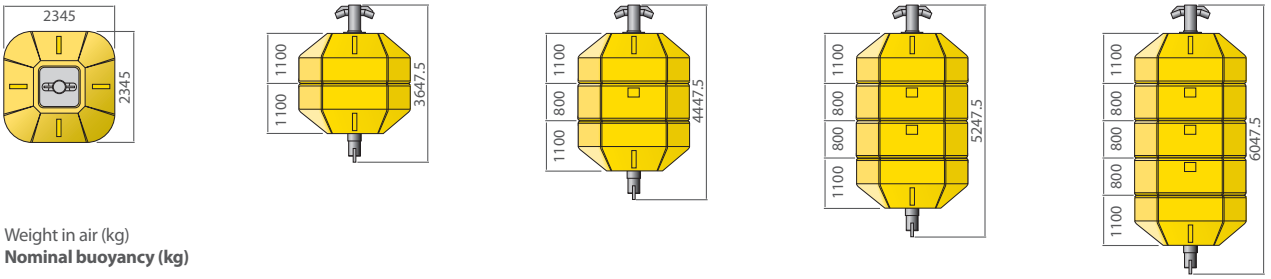
MB17 General arrangements



Weight in air (kg)
Nominal buoyancy (kg)

Surface	746	**1674**	1051	**3226**	1356	**4779**	1661	**6331**
250msw	1205	**1215**	1881	**2396**	2558	**3577**	3234	**4758**
500msw	1356	**1064**	2154	**2123**	2953	**3182**	3752	**4241**
1000msw	1501	**919**	2416	**1861**	3332	**2802**	4248	**3744**
1500msw	1490	**848**	2398	**1763**	3306	**2679**	4213	**3594**
2000msw	1539	**799**	2487	**1675**	3434	**2550**	4381	**3426**

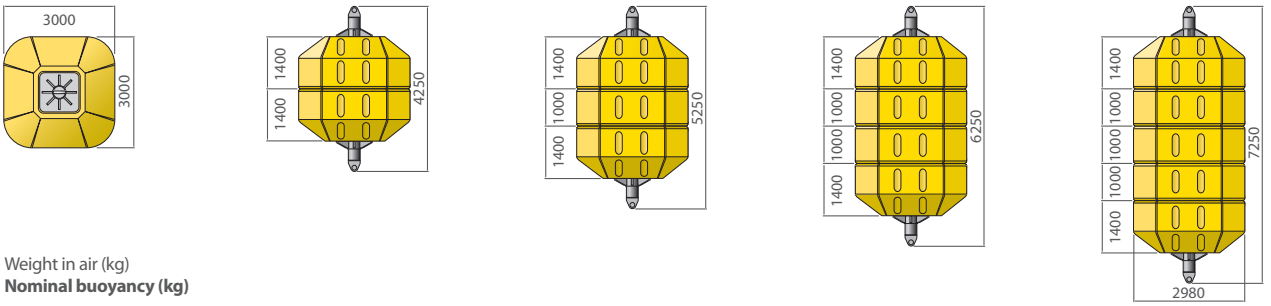
MB23 General arrangements



Weight in air (kg)
Nominal buoyancy (kg)

Surface	1773	**6968**	2396	**10421**	3020	**13874**	3644	**17326**
250msw	3526	**5215**	4977	**7841**	6427	**10467**	7877	**13093**
500msw	4103	**4638**	5825	**6992**	7547	**9347**	9270	**11701**
1000msw	4656	**4084**	6639	**6178**	8622	**8272**	10605	**10365**
1500msw	4617	**3949**	6582	**6020**	8547	**8091**	10511	**10162**
2000msw	4804	**3762**	6857	**5745**	8910	**7728**	10963	**9710**

MB30 General arrangements



Weight in air (kg)
Nominal buoyancy (kg)

Surface	3688	**15458**	4902	**22553**	5839	**29239**	7191	**36098**
250msw	7575	**11571**	10489	**16966**	13126	**21951**	16179	**27110**
500msw	8854	**10293**	12327	**15128**	15523	**19554**	19134	**24154**
1000msw	10080	**9066**	14090	**13365**	17823	**17255**	21971	**21318**
1500msw	9994	**8733**	13966	**12955**	17937	**17176**	21909	**21398**
2000msw	10409	**8319**	14562	**12359**	18715	**16399**	22868	**20439**

Note: Thin-mid modules are available for these ranges to provide a broad range of configuration and operating parameters. Please contact BOE for further details.
All buoyancy and weight in air values are nominal and subject to specific configuration.

Surface/subsurface buoyancy

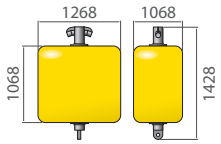
Anchor pendant buoys (APB)

Balmoral Offshore Engineering offers a range of surface buoyancy which includes mooring buoys, anchor pendant buoys, support buoys, chain-through buoys and pick-up buoys which are extremely robust and suitable for the most severe environments.

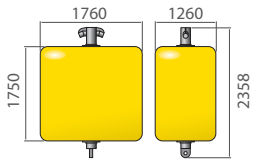
These buoys are typically constructed from a rigid polyurethane foam core, cast around a central steel tension member that is reinforced with a glass reinforced polyester skin. The buoys are clad in a resilient polyethylene layer which is externally coated with a tough abrasion resistant polyurethane elastomer skin.

These units are suitable for deployment over the stern roller of anchor handling vessels on the market.

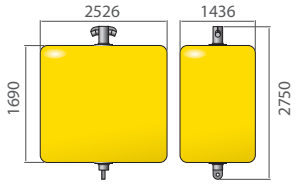
APB1 | Weight 310kg | **Nom buoyancy 1000kg**



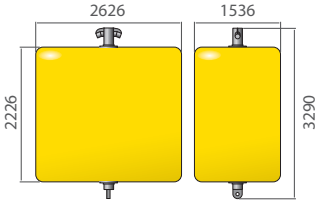
APB2 | Weight 560kg | **Nom buoyancy 2000kg**



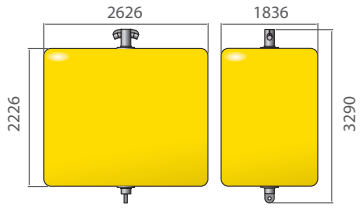
APB4 | Weight 1160kg | **Nom buoyancy 4000kg**



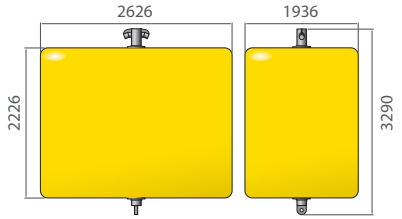
APB6 | Weight 1330kg | **Nom buoyancy 6000kg**



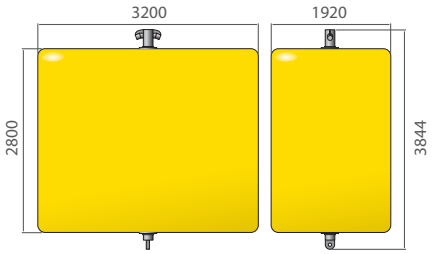
APB8 | Weight 1580kg | **Nom buoyancy 8000kg**



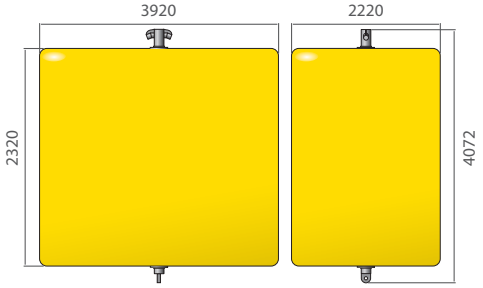
APB10 | Weight 1770kg | **Nom buoyancy 10000kg**



APB15 | Weight 2360kg | **Nom buoyancy 15000kg**



APB20 | Weight 2860kg | **Nom buoyancy 20000kg**



Note: All buoyancy and weight in air values are nominal and subject to specific configuration.

Surface/subsurface buoyancy

Navigation aids and marker buoys

Balmoral Offshore Engineering designs and manufactures a range of GRP, rotationally moulded and elastomer navigation, marker and data collection buoys.

These products can be fully fitted to your requirements or can be provided as a basic structure allowing you to customise to specification.

Fenders

Highly stress absorbent with low reaction forces, and catering for ship dead-weights ranging from 150-350,000 tonnes, Balmoral's elastomer foam fenders are constructed using a central tension member surrounded by a polyethylene foam core.

The tear resistant skin is formed using high tensile fibre reinforced polyurethane elastomer resulting in a rugged, virtually unsinkable, product.

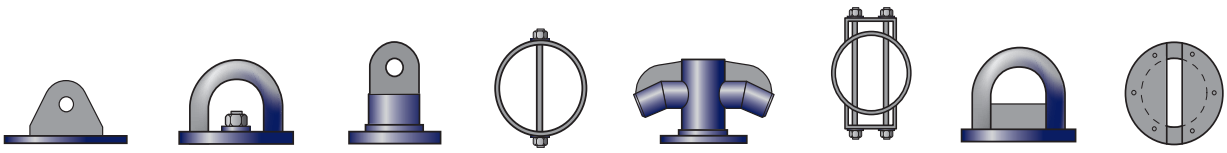
Mooring buoys

The BOE range is unique and was developed and designed in-house. Two forms of standard mooring buoys are available, ie, cylindrical and rectangular in section.

Specials are available and are usually based on a standard modular construction incorporating platforms, ladders, solar panels, electronic monitoring and lighting equipment.

Fittings

A wide range of steelwork is available to complement Balmoral Offshore Engineering's surface and subsurface products. This includes crucifix, pad eye, round bar, swivel, double and single pin, keep plates and through-hawse end fittings.



Lightweight pad eye | Swivel | Heavy duty pad eye | Single pin | Crucifix | Double pin | Round bar | Keep plates

Buoyancy repairs

It is vital that repair and refurbishment is carried out by fully qualified teams that understand the materials, procedures and environments to which marine buoyancy is exposed.

Balmoral benefits from many years' design, manufacture and materials experience and has dedicated teams of experienced repair personnel travelling the world on a regular basis.

Drilling riser buoyancy modules before and after repair

ROV/AUV buoyancy

With advances in deepwater technology the need for remote intervention as part of the field installation has seen major increases in the number of deepwater remotely operated and autonomous underwater vehicles. As the complexity of these vehicles evolves the demand for lower density, high performance composites buoyancy systems has increased.

This is an area where Balmoral has made significant technological advances. The use of conventional cast composite buoyancy packs still has many commercial benefits for large vehicles used for trenching of pipelines or submarine cables. However, for deep dive work class ROVs, operating beyond 2000msw, the performance benefits of Balmoral's LDF series becomes significant.

This low density, pure foam composite provides the operator an opportunity to increase the uplift (buoyancy) of the vehicle thereby resulting in increased payload capacity. It also provides an opportunity to reduce the size of the buoyancy modules thereby reducing the overall weight and dimensions of the vehicle.

Balmoral LDF buoyancy is available from stock and available for operating to depths of 7000msw.

Balmoral also supplies ROV support equipment for use on the umbilical systems including floats and FlexLink, a buoyant umbilical bend control system.

The 3000msw-rated Fugro FCV3000 ROV at launch offshore Brazil.
Image reproduced with the kind permission of Fugro

ROV/AUV buoyancy

Composite foam systems

A "composite" buoyancy system refers to a syntactic foam comprising glass microspheres and macrospheres held together within an epoxy resin system to create a homogenous matrix.

Composite buoyancy systems are cast using dedicated mould tooling providing repeatable consistent production and are therefore ideally suited in applications such as work class ROV's, particularly on a multi-build requirement.

Each component within any given Balmoral syntactic foam is individually rated for specific operating depths resulting in a strong, lightweight composite formulation.

There is an overlap in the operating depth ranges which is caused by macro efficiency changes in design operating depths. This means that more efficient, lower density, composites may generate improved uplift for a given volume as the operating depth increases.

Composite buoyancy systems comprise an integrated shell to ensure maximum protection of the core material in the event of accidental impact.

Composite foam material values

Typical operating depth ft/msw	Typical core density kg/m³	
	GRE	Carbon
1500/457	346	-
2000/610	358	-
3000/915	385	-
4000/1220	417	403
5000/1524	455	432
6000/1829	479	450
7000/2134	514	476
8000/2439	535	491
9000/2744	565	515
10000/3049	586	530

Pure foam systems

Pure foams offer many advantages over macrosphere composite foam systems including robustness, ease of repair and modification in the event of damage or design changes, and extremely low water ingress rates. It should be noted, however, that these are 'premium products' and are therefore typically selected for more demanding service conditions such as extreme operating depths and/or service criticality such as manned service.

Two ranges of pure syntactic foam are available, differing primarily in core density. Both the "Standard Range" and the "Ultra-Low Density Range" are normally produced in pre-cast blocks. These blocks may be supplied for client assembly or can be factory assembled into finished buoyancy modules.

The buoyancy performance of the ultra-low density material is understood to be unique amongst ROV buoyancy foams in that the buoyancy does not progressively reduce due to hydrostatic compression as the ROV flies into deeper water. This is because the bulk modulus - ie, the compressibility under hydrostatic pressure - of the foams is marginally less than sea water.

Pure foam standard range (PFS)

Typical operating depth ft/msw	Typical core density kg/m³
5750/1750	560
8200/2500	585
10000/3000	610
15000/4500	635
20000/6000	660
23000/7000	710

Pure foam ultra-low density range (LDF)

Typical operating depth ft/msw	Typical core density kg/m³
5000/1500	400
6500/2000	430
10000/3000	450
16500/5000	510
23000/7000	550

ROV/AUV buoyancy

ROV/AUV external finishing

The selection of a barrier coating on buoyancy modules of any type is a critical issue. These coatings provide impact and abrasion resistance while offering high visibility smooth gloss finishes.

The most frequently supplied ROV/AUV coating is a 3-5mm spray applied elastomer. This is applied to all upper and external surfaces to give a very effective coating for work class ROVs.

Standard finishes are provided in smooth high gloss yellow, orange, red or white. Other colours are available to suit project parameters.

Where a quantity of modules of the same generic shape is required, in applications such as skid module blocks or trim modules for example, Balmoral provides an alternative to PU or GRP skins by utilising rotationally moulded polyethylene shells.

Polyethylene is a material used extensively in the offshore industry and these shells can be manufactured for heavy duty applications with thicknesses ranging from 6-14mm.

Provision should be made within the design to accommodate the tolerances applicable to rotationally moulded products.

ROV/AUV buoyancy

FlexLink™ umbilical buoyancy

Flexlink was developed to meet the needs of large, tracked, trenching vehicles that operate on the sea bed.

To prevent these vehicles damaging their control lines, FlexLink is installed at the tether point to provide a continuous, articulate buoyant section above the vehicle, thereby ensuring the umbilical remains out of the vehicle work zone at all times.

FlexLink is used as a permanent installation which is designed to pass through the sheave wheels of launch and recovery systems (LARS).

FlexLink is supplied for installation onto umbilicals ranging in size 25-75mm OD while the buoyancy can be specified to suit project requirements. Typical uplift ranges from 6-12kg/m in design operating depths of 0-6000msw.

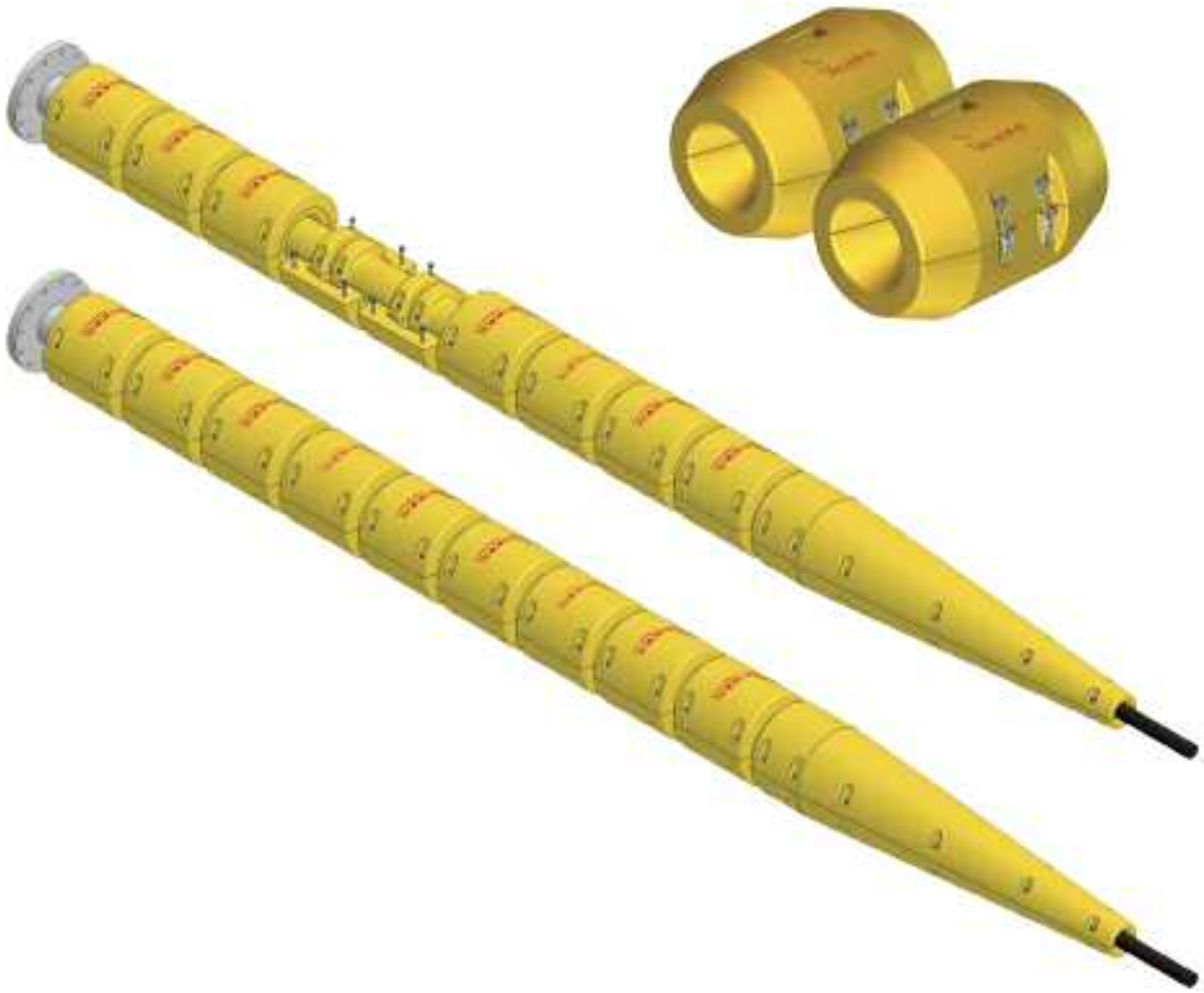
Umbilical floats

BOE provides a range of floats to suit most control umbilicals. These floats comprise a pair of symmetrical half shells which are profiled to permit the line to flex within its specified bend radius.

Each float is manufactured using a low density composite foam core covered in a high performance impact and abrasion resistant polyethylene shell.

BOE's umbilical floats are hinged using two stainless steel latches. The floats are designed to grip the umbilical by means of a natural rubber internal grommet.

Balmoral umbilical floats are designed to suit umbilical diameters ranging from 25mm-50mm OD. Umbilical floats can be supplied to suit larger diameter umbilicals if required.

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Balmoral Subsea Test Centre

Hydrostatic testing
Mechanical testing
Development laboratory

Balmoral Subsea Test Centre

The Balmoral Subsea Test Centre offers a comprehensive range of test procedures including hydrostatic, mechanical and laboratory testing. Although predominantly used for in-house testing and development work these facilities and services are available to external customers.

Hydrostatic testing

Substantial investment has been made in improving and expanding the Balmoral Subsea Test Centre which now offers the largest commercially available hydrostatic vessel in Europe. Upgraded vessels, software and procedures are in place offering independent testing for all types of subsea equipment to 7000msw equivalent.

Standard tests available include:

- Uplift determination
- Water ingress
- Instrumented buoyancy loss
- Hydrostatic compression and creep
- Hydrostatic collapse
- Bulk modulus
- Buckle arrestment performance

The hydrostatic vessels use air driven liquid pumps and can accommodate electric, hydraulic and instrumentation connections. Each vessel can be fitted with chart recorders, pressure and temperature data loggers providing highly detailed results for analysis.

Development laboratory

The laboratory at Balmoral Offshore Engineering is equipped with the very latest in development, testing analysis and inspection equipment. Run by a highly experienced and dedicated technical team the lab is at the centre of the company's R&D programme.

As well as providing a professional in-house service, Balmoral's lab is available for external development and testing programmes.

Balmoral hydrostatic testing facilities

Vessel	Safe working pressure		Internal length		Internal dia		Orient-ation
	psi	bar	ft/in	mm	in	mm	
PV1	5200	358	35′6″	10825	52″	1320	Hor
PV2	10000	700	7′9″	2380	19″	485	Vert
PV3	10000	700	7′9″	2380	19″	485	Vert
PV4	10000	700	7′9″	2380	19″	485	Hor
PV5	10000	700	1′	300	5.5″	140	Vert
PV6	6000	410	29′6″	9000	72″	1830	Hor

Displacement tanks are available for large scale uplift testing. Internal dimensions of the two tanks are:

- 6250x2250x1300mm deep
- 9800x2500x2750mm deep (unfilled weight 16 tonne)

Mechanical testing

A multi-purpose load rig, capable of performing axial slip loads, lateral and static loading, three-point bending and clamp overload tests has also been installed.

The test centre provides the industry with a fully comprehensive single source for buoyancy and PU product requirements from concept to testing.

Common oilfield terminology

A

Abandon To permanently plug a well, usually with cement plugs, and recover all possible downhole equipment. A well is abandoned if it is dry or has ceased to produce.

Abnormal pressure Well pore pressure that is either higher or lower than normal formation pressure.

Acidize Acid is pumped into the producing zone to increase the flow of oil or gas. The acid dissolves formation limestone improving the flow into the well.

Air drilling Compressed air is used in place of drilling fluids to carry cuttings from the drill bit to the surface.

Annular velocity The velocity or speed of a fluid, normally drilling fluid or cement, circulating in the annulus.

Annulus The space between either the drill string and well bore/casing or between the production tubing and casing.

Anticline A geological structure in which the strata are curved or domes.

API gravity An American Petroleum Institute (API) standard measurement of the density of liquid hydrocarbons. The lighter the oil, the higher the API gravity.

Appraisal well A well drilled to determine the size, reserves and possible production rates of a newly discovered field.

Aquifer The production of groundwater from a formation below the water table.

Associated gas Natural gas found with oil, either in the dissolved form or as a cap of free gas above the oil.

B

Barite Barium sulphate, a mined mineral used to increase the density of drilling fluids.

Barrel of oil One barrel is equal to 42 US gallons, approx 159 litres or 35 imperial gallons.

bbl One barrel of oil.

bcf Billion cubic feet. A unit often used to measure the size of a gas field.

bcm Billion cubic metres.

Bend restrictors Usually fitted around a flowline in static load applications to prevent damage where excessive bending may occur.

Bend stiffeners Designed to provide support for cables or flowlines as they emerge from permanent structures.

Bentonite Colloidal clay consisting predominantly of sodium montmorillonite. It is used as a viscosifier and fluid loss reducer in drilling fluids.

Bit Cutting tool fixed to the bottom of the drill string.

Blooie line Flowline used when drilling with air or gas.

Blowout Uncontrolled escape of drilling fluid, gas, oil or water from the well when formation pressure is greater than the hydrostatic pressure of the fluid in the well.

Blowout preventers (BOP) Stack of high pressure valves at the top of the casing to control or shut off the flow of gas or fluids to the surface.

bopd Barrels of oil per day.

Bottom-hole pressure (BHP) Pressure of the formation or reservoir at the bottom of the well.

Bottom-hole assembly (BHA) Lower section of the drill string typically consisting of bit, bit sub, stabilisers and drill collars.

Bottoms-up Stage at which drilling fluid and cuttings arrive at the surface having been circulated up from the bottom of the well.

bpd Barrels of oil per day.

Bridging agent Materials added to drilling fluid to control or prevent loss of fluid into the formation.

Bromide brine Sodium, calcium or zinc bromide added to water to increase its density. The brines are used in well work-overs and completions.

BTU British Thermal Unit, measurement of heat needed to raise the temperature of one pound of water by 1° Fahrenheit.

Buckle mitigation buoyancy Mitigates the effects of longitudinal buckling along a steel pipeline.

Buoyancy The buoyancy (upward) force on an object is equal to the weight of fluid that it displaces. This applies to the atmosphere as well as the hydrosphere and works for airships, balloons, submarines, boats and buoys.

C

Calliper log Tool that measures the diameter of a well over its depth.

Cap rock Rock with very low permeability that forms an effective cap or seal above a reservoir. Shales, salts and anhydrite are typical types of cap rock.

Casing Steel pipe that is used to line and protect the well after it's been drilled. The casing string is formed from sections of pipe screwed together.

Casing point Depth at which the drilling of a particular section of hole is stopped and casing is run.

Cementing Procedure where cement is used to fill the space between casing and well bore. The cement holds the casing in place and isolates one section of the well from another.

Centrifuge Device designed to mechanically separate high specific gravity solids from a drilling fluid.

Choke Valve-like device used to control flow when testing a well.

Choke line Pipe that runs from the blowout preventer (BOP) to the choke manifold. The choke line and manifold are used during well control procedures.

Christmas tree Series of valves mounted on top of a well to control production.

Circulation Movement of drilling fluid from the mud pits, through the pump, drill pipe, bit and annulus before returning to the mud pits.

Coiled tubing Continuous length of pipe used in place of drill pipe.

Completion Range of steps taken to bring a well into production.

Completion fluid Non-damaging, low solids fluid designed to complete a well. The fluid is pumped into the hole before production operations start.

Concession Specific area over which a company has a licence to carry out exploration and development activities.

Condensate Hydrocarbons which are gaseous under reservoir conditions but liquid when pressures and temperatures are reduced.

Conductor pipe First string of casing used on a well to isolate the shallow unconsolidated formations.

Connate water Water that was trapped containing sedimentary deposits during rock formation.

Coring Sampling of an in-situ column of rock using a core barrel.

Crown Series of pulleys at the top of a derrick.

Cuttings Particles of rock cut by the drill bit and circulated to the surface by the drilling fluid (mud).

D

Darcy Unit of permeability. A porous medium has a permeability of 1 Darcy when a pressure of 1atm on a sample 1cm long and 1sq cm in section will force a liquid of 1cp viscosity through the sample at the rate of 1cc per sec.

Day rate Cost of renting a drilling rig for a day.

Depletion Reduction in hydrocarbons following production.

Density The density of an object is a measure of the mass per unit volume = M/V

Derrick Tapered towered mast used in a crane-like function to support the drill string.

Derrickman Member of the crew that works in the derrick, racking and unracking drill pipe when manoeuvring it into and out of the hole.

Desander Cyclone type device used to separate solid particles, typically sand, from a drilling fluid.

Development well Well drilled into a proven hydrocarbon reservoir before going into full production.

Deviated well Non-vertical well.

Differential pressure sticking This occurs when part of the drill string, normally the collars, sticks to the wall cake resulting in the non-uniform distribution of pressure around the drill string.

Directional drilling Controlled drilling of a well in a pre-determined direction or path.

Distributed buoyancy System used to provide flexible pipe and subsea umbilicals

Dogleg Bend or elbow caused by a change of direction in the well.

Doghouse Drilling crew office and coffee room on the rig floor.

Drill collar Thick walled section of the drill string fitted between the drill bit and the drill pipe providing the necessary weight on the bit for efficient drilling.

Drill stem test Test to determine whether oil and/or gas have been found in commercial quantities.

Drill-in fluid Low solids, non-damaging fluid formulated specifically for drilling through reservoirs.

Drilling fluid Viscous water or oil-based fluid circulated down through the drill pipe and up the annulus to carry the cuttings to the surface while maintaining good hole conditions.

Drilling fluid engineer Person responsible for the formulation, testing and treatment of a drilling fluid.

Dry gas Natural gas of methane and limited amounts of ethane, propane and butane.

Dry hole Well that has failed to find oil or gas in commercial quantities.

DST Drill stem test.

Dual completion Completion of a well with two producing reservoirs

Durafloat™ RIS Marine drilling riser buoyancy featuring residual integrity system

Duraguard™ Cable protection system used on flowlines, umbilicals, hoses and cables.

Duster Dry hole

Dynamic positioning Method used to maintain a semi-submersible or drillship on its exact location. Thrusters are used to counter adverse weather and sea conditions.

E

Electric log Electrical survey of an uncased well to obtain information concerning the porosity, permeability and fluid content of the formations drilled.

Elevators Hinged clamp-like device which closes around the top of the drill string to pull it out of or lower it into the hole.

Enhanced oil recovery (EOR) Number of processes used to produce oil from a reservoir that has lost its natural pressure.

Evaporite Sedimentary rock formed by evaporation. Limestone, gypsum and anhydrite are examples.

Exploration well Well drilled to find new deposits of hydrocarbons.

F

Farm in/Farm out Agreement between oil companies where the owner of a block assigns an interest in the block to another willing to fund part or all of the exploration costs.

Fault Geological term denoting a break in the formation, upward or downward, in the subsurface strata.

Field Geographical area covering an oil or gas reservoir.

Filter cake Suspended solids from drilling fluid that are deposited on a porous medium (the formation), normally under pressure. The filter or wall cake formed on the sides of the hole should be tough, thin and slick with low permeability.

Fish Name applied to any equipment or tooling left in the well. It could be hand tools, frill pipe or other specialist equipment.

Fishing Variety of procedures used to retrieve tools, pipe or other objects lost in the well.

Flaring Burning of unwanted produced gas.

FlexLink™ Umbilical buoyancy used to prevent ROV/AUV vehicles from damaging their control lines.

Flowline Large diameter pipe carrying the circulating drilling fluid from the top of the bell nipple to the shale shakers.

Fluid loss Measurement of the relative amount of fluid lost from the drilling fluid to a permeable formation when under pressure.

Formation Group of rocks of the same age.

Formation damage Damage done to the productivity of a well as a result of invasion into the formation by drilling fluid solids or filtrate.

Formation pressure Bottom hole pressure of a well when it is shut in.

Formation water Salty water underlying oil or gas in a formation.

FPSO Floating Production Storage and Offloading facility.

Fracture Crack within a rock.

Fracture gradient Pressure needed to create fractures in a formation at a specific depth.

Fracturing Applying hydraulic pressure to a reservoir to create or enlarge fractures through which hydrocarbons can be produced.

Common oilfield terminology

G

Galena Lead sulphide (Pbs) with a specific gravity of approximately 7.0 is used to formulate very high density drilling fluids, normally for well control purposes.

Gas cut Oil or drilling fluid, which has been invaded by gas.

Gas hydrate Result of natural gas molecules being trapped in molecules of ice and formed in conditions of extreme cold.

Gas injection Re-injection of gas into a well either for the maintenance of reservoir pressure or for conservation purposes.

Gas/oil ratio Volume of gas produced per barrel of oil.

Geopressure Pressure within a formation.

Geothermal gradient Measurement of the increase in temperature with increases in depth. Average geothermal gradients range from 25-30ºC per kilometre.

Geronimo line Steel cable running from the derrick to the ground at a safe distance from the rig floor. The cable is used by the derrickman to slide down as a quick route of escape should there be a requirement to descend rapidly.

Gauge hole Drilled hole that is close to the same diameter as the drill bit.

Gumbo Hydrophilic formation (shale) that swells and becomes soft and sticky when wet, often plugging the annulus, flowline and shaker screens.

Gunk plug Slurry in crude or diesel oil, normally containing bentonite, cement or guar gum used to control losses of drilling fluid into a formation.

H

Hook Piece of equipment attached to the bottom of the travelling block from which the swivel, kelly and drill string are hung.

Horizontal well Section of a well drilled at more than 80º from vertical. Horizontal well sections are normally drilled through a reservoir to maximise production.

HTHP High temperature, high pressure. An HTHP well is one where both pressure and temperature are higher than average. Generally this means a bottomhole temperature in excess of 149ºC and a pressure gradient greater than 0.8psi/ft.

Hydrocarbon Compounds of hydrogen and carbon, which may exist as a solid, gas or liquid and generally used to describe oil, gas or condensate.

Hydrocyclone Range of devices to reduce the solids content of drilling fluids. The hydrocyclones with larger cones are used as desanders while those with smaller cones are used as desilters.

Hydrogen sulphide (H2S) Poisonous gas which is lethal even at low concentrations. The gas smells like rotten eggs at low concentrations but is odourless at high concentrations. It is also highly corrosive.

Hydrostatic head Pressure exerted by a column of fluid usually expressed in pounds per square inch.

I

Inhibitive mud Drilling fluid that has been formulated to minimise the hydration and swelling of clays and shales.

Injection well Well used for the pressured injection of water or gas into a reservoir.

Intermediate casing String or strings of casing run into the hole to isolate the hole sections below the surface casing but above the production string.

Invert emulsion-drilling fluid Water in oil emulsion drilling fluid where fresh or salt water is the dispersed or internal phase and oil is the external phase.

J

Jacket Lower section of an offshore platform.

Jackup rig Offshore rig with support legs that are lowered onto the seafloor to raise the actual rig above the water and out of the way of any wave action.

K

Kelly Hexagonal shaped section of pipe mounted above the drill pipe to transfer rotary drive from the rotary table to the drill pipe and the bit. The Kelly has a hole through its centre through which the drilling fluid is pumped down the drill string to the bit.

Keyseat Groove worn into the side of a well that has a smaller diameter than the hole. The groove is normally similar in diameter to the drill pipe meaning the larger sections of tooling, such as the bit, are unable to go through the grove and become stuck.

Kick Influx of oil, water or gas while drilling. This occurs because the hydrostatic head of the drilling fluid in the well is less than the pressure in the formation.

Kill Procedures used to stop a well from flowing out of control. Higher density drilling fluids are used to increase the hydrostatic head.

Kill line Pipe connected to the annulus below the blowout preventers allowing drilling fluids to be pumped directly into the annulus when the blowout preventers are closed.

L

Lag time Time taken for cuttings to be carried from the bit to the surface.

Leakoff test Test carried out to find the pressure required to break down a formation allowing fluid to leak off into it. The test is generally carried out on the formation immediately below the casing shoe to establish what the maximum drilling fluid weight can be in the particular hole section.

Limestone Sedimentary rock predominantly of calcium carbonate.

Liner Section of pipe set through the reservoir that does not go to the top of the well but is suspended from the bottom of the previous casing string.

Lipophilic Affinity for oil.

Liquefied natural gas (LNG) Naturally occurring gas, predominantly methane, that has been liquefied for transportation purposes.

Liquefied petroleum gas (LPG) Hydrocarbon that is gaseous at atmospheric pressure and temperature but is kept in the liquid state by pressure to allow for effective storage and transportation.

Logging while drilling (LWD) Evaluation of formations as they are being drilled. The measuring tools are fitted into the bottomhole assembly.

Lost circulation Loss of drilling fluid into the formation creating partial or total failure to return to the surface.

M

Making a connection Approx 9m length of drill pipe connected to the drill string to increase its length as the depth of the well grows.

Marine drilling riser buoyancy (MDRB) Serves many functions including the reduction of the submerged riser weight and the provision of 'lift'.

Mass The mass of an object is a measure of the amount of matter that it contains.

mboe Million of barrels of oil.

Millidarcy 1/1000 darcy, a measurement of the permeability of rocks. Please refer to "Darcy".

mcfd Millions of cubic feet per day. Gas measurement.

Modular buoyancy Used predominantly as suspended moorings or subsea markers.

Moonpool Large opening located in the centre of a drillship through which the drilling process is carried out.

Mousehole Hole in the rig floor used to hold a length of drillpipe before adding it to the drill string when making a connection.

mtoe Millions of tons of oil equivalent.

Mud Generic term for water or oil based drilling fluids.

Mud logging Continuous analysis of the cuttings and drilling mud circulating from the bottom of a well.

Multilateral Central wellbore from which a number of wells branch out in different directions.

N

Natural gas Naturally occurring mixture of hydrocarbons with methane as the predominant part.

Net pay Part of a formation that has oil and/or gas in commercial quantities.

O

Offset well Well that is close to an existing well from which data is taken to assist in the planning of the new well.

Oceanus™ floats A range of standard buoyancy units suitable for all ocean depths

Oceanus Oceanus was a waterway which the Greeks and Romans believed to be an enormous river encircling the world. In Greek mythology, this world-ocean was personified as a Titan, a son of Uranus and Gaia.

In Hellenistic and Roman mosaics, this Titan was often depicted as having the upper body of a muscular man with a long beard and horns and the lower torso of a serpent.

Oil base mud Drilling fluid in which oil is the continuous or external phase.

Oil show Small amount of oil found in the well or in a sample of rock.

OPEC Organisation of Petroleum Exporting Countries.

Open hole Section of the well bore that has not been cased.

Operator Company that holds the rights to drill wells and produce hydrocarbons from a specific block or field. The operating company may be a member of a consortium that acts on its behalf.

P

Packer Piece of equipment used to pack off or seal the wellbore. The device is run into the hole to the depth required and then expanded using a variety of mechanisms.

Pay zone Section of rock from which oil and/or gas is produced.

PDC bit Type of drill bit which uses polycrystalline diamond compact cutters to cut the rock formations.

Penetration rate Measurement of the number of feet or metres drilled per hour.

Perforations Holes made in the casing, cement and formation to allow formation fluids to enter the well bore.

Permeability Measurement of a rock's capacity in relation to the movement of fluids through its pores.

Pipe rams Valve-like part of the blowout preventer comprising semi circular holes that, when closed, form a seal around the drill pipe.

Platform Fixed offshore structure attached to the seabed.

Plug and abandon Permanently close a well down either because it has ceased being productive or because it has failed to find commercial quantities of hydrocarbons.

Pore pressure The pressure of fluids in a reservoir.

Porosity Measurement of pore space as a percentage of total rock mass.

Probable reserves Reserves of oil or gas which have yet to be proven but which are thought to have a reasonable chance of being produced.

Proven reserves Reserves of oil or gas which are near certain to be recoverable under current operating and commercial conditions.

PSA Production sharing agreement.

R

Rathole Hole in the rig floor in which the kelly is stored when not in use.

Reaming Technique used to return an under gauge hole to its correct gauge size.

Recoverable reserves Amount of oil and/or gas that is expected to be produced from a well.

Reservoir rock Permeable and porous rock (limestone, sandstone, dolomite) containing commercial quantities of petroleum.

Reverse circulation Circulation of drilling fluid down through the annulus and back up through the drill pipe. This is the opposite of that normally used.

Riser Large diameter pipe connecting a rig to the subsea blowout preventer and the hole itself.

Rotary table Circular section of the drill floor that is rotated clockwise transmitting its power through the Kelly to the drill string.

Roughneck Member of the drilling crew working on the rig floor.

Round trip Removal of the drill pipe and bottom hole assembly from the well, typically to change the bit, before running the complete drill string back into the hole.

Roustabout General rig worker.

S

Salt-water flow Uncontrolled invasion of salty water into the wellbore.

Secondary recovery Recovery of petroleum by injecting gas or water into a reservoir to increase reservoir pressure.

Sedimentary rock Rocks formed by the laying down of matter in the sea, river or lake. Limestone, sandstone and shale are sedimentary rocks.

Seismic survey Seismographic investigation of subsurface rock formations using low frequency soundwaves, recording and analysis.

Shale Sedimentary rock consisting of clay and sand.

Shale shaker Series of vibrating sieves over which the drilling fluid is passed to screen out the drilled cuttings carried up from the bottom of the well by the fluid.

Shut in pressure Pressure of a well after it has been shut in for a defined period.

Sidetrack Well that kicks off from the original well normally to bypass a section of the original hole because it has collapsed or contains junk.

Common oilfield terminology

S *continued...*

Sour gas Gas which contains acid such as hydrogen sulphide and carbon dioxide.

Source rock Sedimentary rock capable of producing hydrocarbons.

Specific gravity Weight of a specific volume of a material compared to the weight of an equal volume of water.

Spud First stage of the actual drilling of a well.

Step-out well Well drilled to find the outer limits of a field.

Stimulation Variety of processes used to increase the productivity of a well, normally acidising or fracturing.

Supatherm Bundle hybrid offset riser buoyancy system

Suspended well Well that has been temporarily capped.

Swab Wireline technique using special tooling designed to initiate production from a well.

Sweet crude Oil with very low sulphur and hydrogen sulphide content.

Syntactic foam A composite material consisting of manufactured hollow spheres embedded in a resin matrix.

Synthetic drilling field Invert emulsion drilling fluid that uses a synthetic fluid as the external continuous phase in place of oil.

T

tcf Trillion cubic feet.

Tight hole A well drilled under strict terms of secrecy.

Tongs Large wrenches used to tighten joints on the drill string.

Tool joint Box and thread at the end of drillpipe sections used to join individual sections together.

Toolpusher Drilling contractor's rig supervisor.

tpes Total primary energy supply.

Topdrive Piece of equipment used to rotate the drill string. Mounted below the hook, the topdrive can be used in place of a rotary table and kelly.

Tubing Small diameter length of pipe run inside the casing through which oil or gas are produced.

Turnkey contract Contract in which one of the parties agrees to drill a well to a certain depth or stage for an agreed specific sum.

tvd True vertical depth, ie, the vertical distance from the bottom of the well to the rig.

U

Underbalance When the formation pressure is greater than the hydrostatic pressure.

Underground blowout Unrestricted influx of fluid from one formation to another.

Underream Enlarging a well's diameter from its original drilled size.

V

Viscosity Internal resistance of a fluid to flow.

Volume The volume of an object is a measure of the space that it occupies.

W

Water flooding Secondary recovery method of increasing production of oil by injecting water into a reservoir.

Well control Variety of techniques used to control the flow of formation fluids into the wellbore.

Whipstock Device used to deflect or change the direction of a well.

Wildcat well Well drilled in an unproven area.

Wiper trip Withdrawal of the drill string to clean up problematic sections of open hole.

Workover Remedial work carried out on an existing well to increase production.

Product index A-Z

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