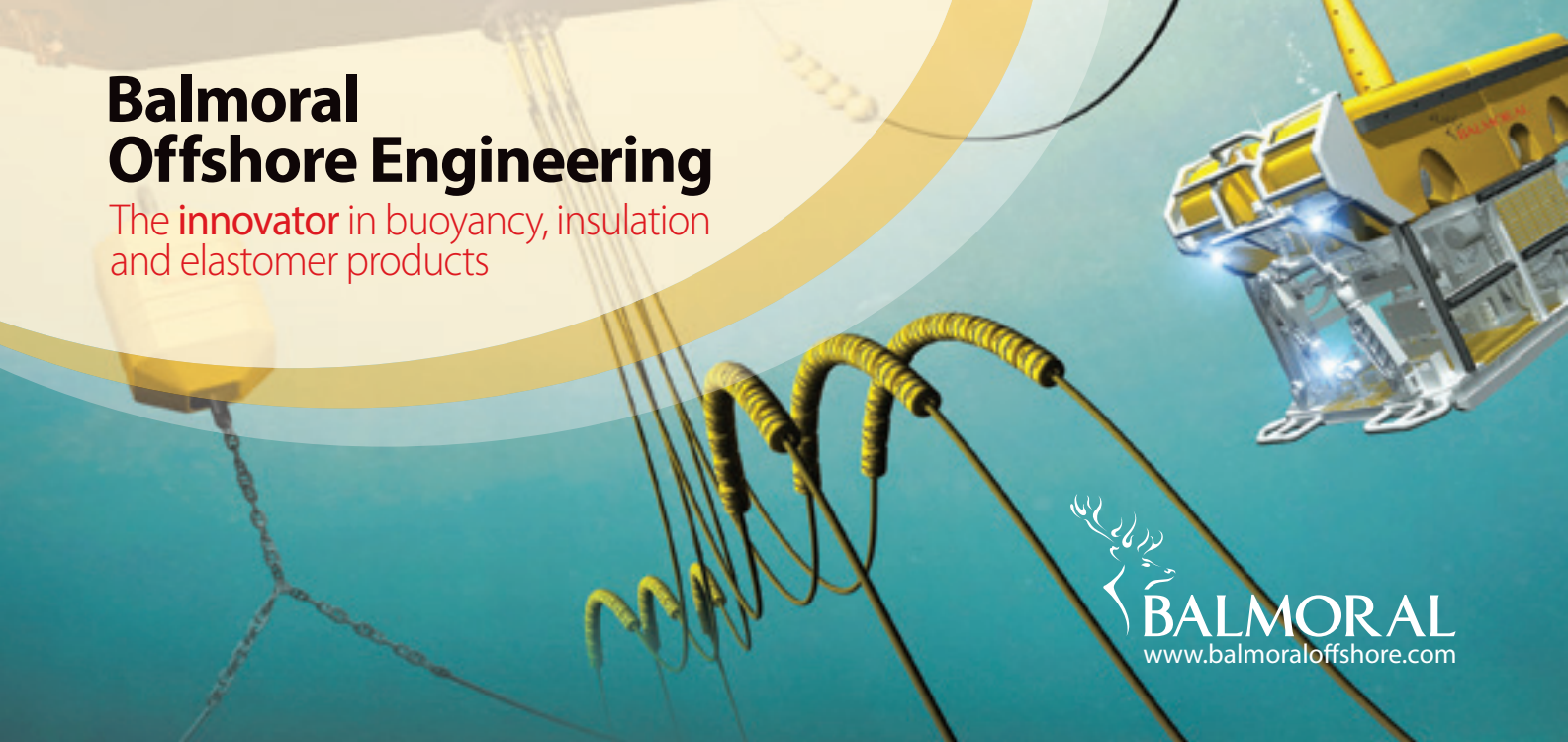
Balmoral
Offshore Engineering
The innovator in buoyancy, insulation
and elastomer products
BALMORAL
www.balmoraloffshore.com

James S Milne

James S Milne CBE DL Hon DBA DHC
Chairman and Managing Director,
Balmoral Group

Chairman's message

While this great industry of ours has seen major changes in the past few years we have continued with our strategy of investment in Balmoral Offshore Engineering.

People, plant and processes have all received major investment in terms of training, new facilities and improved manufacturing procedures respectively.

Our key differentiators are that of continuous investment in R&D and innovation; as a privately owned company we return a significant amount of our profits directly back into the organisation. Technical expertise – our people are the industry's most experienced within their specialised areas of operation: Manufacturing efficiency – our 'operational excellence group' is tasked with optimising all processes and resources to add value for our customers.

The industry's most comprehensive, accessible and commercially available hyperbaric facility opened its doors in early 2018 when the new Balmoral Subsea Test Centre was launched. With more than £20m being spent on the centre we are proud to offer a wide range of test facilities to third parties spanning the subsea, renewables, defence and oceanographic sectors.

With a number of new and exciting products in the market, and with more to follow, I hope you continue to use Balmoral as your supplier of choice. Remember, wherever you are in the world, we are never further than a 'phone call away.

Balmoral Group

Established in 1980 Balmoral Group Holdings Ltd is a privately owned company comprising several operating divisions.

Balmoral Offshore Engineering specialises in subsea buoyancy, flotation, insulation, elastomer and renewable energy products while Balmoral Tanks provides water and wastewater solutions to the anaerobic digestion, civil and environmental engineering sectors. Balmoral Park is the Group's property development and management arm.

At Group HQ in Aberdeen the company has invested in a pioneering subsea product design and manufacturing facility that includes laboratory, design engineering, production, project management and testing facilities that are unrivalled in the industry.

Balmoral Tanks designs and produces efusion® and digestore® epoxy coated and concrete tanks respectively for the water, wastewater and anaerobic digestion markets. A new factory in South Yorkshire, representing a £10m+ investment, was commissioned in 2018. The company also operates a highly specialised design and manufacturing business in South Wales that provides hot press GRP and steel sectional tanks as well as cylindrical steel tanks for the global water storage and fire-fighting sectors.

Balmoral Park Ltd is the company's property development division. Covering some 18 acres Balmoral Business Park in Aberdeen is home to three auto dealerships; Audi, Mini and Nissan, and features a 40,500sqft high-specification office pavilion.

These businesses are run by defined management and operations teams that are wholly responsible for their unit's profit and loss activity. All are dedicated to the company's philosophy of innovation and continuous improvement.


Group HQ, Aberdeen, Scotland

Balmoral Offshore Engineering

Balmoral Offshore Engineering is focused on technologically-driven composite and polymer solutions for today's demanding subsea and deepwater oil and gas industry.

Proprietary laboratory, hydrostatic and mechanical testing facilities enable Balmoral to research, identify and develop cost effective materials across a spectrum of applications. The company continues to make significant investments in the most comprehensive syntactic, composite and polymer processing facilities the sector has ever seen and its offshore products are used in the deepest and most hostile waters of the world.

Providing services from concept development through detailed design, toolmaking, manufacturing and testing Balmoral Offshore Engineering's products are aligned to specific segments of the offshore oil and gas industry, namely, exploration, marine/installation and production.

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2015

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2012

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2010

HSEQ

Balmoral acknowledges the importance of health and safety and is committed to providing a safe and healthy working environment for its employees, subcontractors and visitors, on or off-site.

The company is a member of the British Safety Council, holding 4-star certification, and operates a management system that is certified to BS OHSAS 18001.

Environmental impact

Protecting the environment from the impact of its activities is central to all Balmoral operations. This includes a commitment to continual improvement in operational performance ensuring minimal environmental impact. The company operates a management system to the requirements of EN ISO 14001.

Quality assurance

Balmoral's stated aim is to become the first choice supplier in its sector and the company is committed to providing products and services that exceed customer expectations.

A key objective is the implementation and continuous improvement of a Quality Management System that is certified to BS EN ISO 9001 and in adherence to the American Petroleum Institute's specification for marine drilling riser equipment: API 16F.

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FPAL empowered by Achilles

Member BRITISH SAFETY COUNCIL

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Engineering design, research and development

A significant differentiator at Balmoral, as a privately owned company, is the ability to invest in continuous research and development programmes.

Taking a proactive response to the ever-changing environment of industry and manufacturing, Balmoral has identified the advantages to be achieved by instigating an innovation development capability that expands the focus beyond the immediate expectations of customers and their current requirements.

Balmoral is renowned for its pioneering spirit and by introducing a dedicated resource, known internally as the 'Balmoral R&D Team', the company will broaden its horizons with a focus on supported markets, product solutions, and routes-to-market.

The development projects are managed using the recognised industry methodology for project management; API RP 17Q, controlling and steering progression of activities through Technology Readiness Levels.

Augmented by contemporary 3D modelling, finite element analysis, CFD, lab and testing facilities, the engineering design department is wholly committed to a policy of continuous innovation and improvement.

The team is encouraged to develop professional relationships with customers to help it deliver a personalised service at all levels and at all times.

Development and test laboratories

Due to the complexities of bespoke project testing, stringent customer specifications and compliance to global industry standards, Balmoral continually invests in state-of-the-art laboratory test equipment to ensure these requirements are satisfied. This programme of investment ensures the company retains total control over time schedules, test conditions and methodologies used to fulfil customer requirements.

Balmoral's technical team has taken occupation of the company's new custom designed and purpose built laboratories at company HQ in Aberdeen. The new facility houses a state-of-the-art temperature and humidity controlled laboratory that is fully furnished with a wealth of chemical, thermal, hydrostatic and mechanical test equipment.

- A range of universal testing machines (10 tonnes maximum load) capable of performing fatigue, tensile, compression, flexure and hydrostatic pressure testing using a complementary pressure vessel at temperatures of -70ºC-+350ºC
- Dynamic fatigue test equipment for testing polyurethane materials fully submerged at elevated temperature
- Differential scanning calorimeters for determining specific heat capacity, glass transition temperatures and oxidation induction time of polymer products
- Lasercomp Fox 50 thermal analyser for the determination of thermal conductivity
- Gas pyknometers for determining the true density of materials such as powders and gels
- Temperature controlled water ageing baths
- Hydrothermal ageing cells for long term analysis of materials up to 260ºC
- Laboratory scale pressure vessels capable of operating at sub-ambient temperature to 200ºC and up to 10,150psi, 700bar
- Temperature and humidity environmental cabinets
- UV weathering cabinet
- Karl Fischer titrator for determination of water content
- Automated titrators for quantitative analysis
- Lab scale CNC machine for test piece preparation

As well as providing professional in-house services, the development laboratory is available for third party development and testing programmes.

Project management

With extensive experience of managing the design, manufacture and despatch of subsea buoyancy, insulation and elastomer products, Balmoral Offshore Engineering's project management team works closely with clients to ensure projects are delivered on time and on budget.

As members of the Association of Project Management, Balmoral Offshore Engineering's PM team operates to recognised global competency standards from order placement through to delivery and installation where contracted.

apm CORPORATE AFFILIATE

Manufacturing

Balmoral's policy of continuous improvement means that the company is constantly developing its manufacturing operations to retain its place at the forefront of buoyancy, insulation and elastomer production technology.

Now offering even more efficiency and automation the facility has been re-designed and laid out to provide consistently high quality fit-for-purpose products on a continuous basis.

Comprising a range of syntactic, hot and cold cure processing capabilities and what is believed to be the industry's only dedicated marine anti-fouling coating line, as well as an advanced polyurethane elastomer processing facility – supported by macrosphere tumblers, shakers, vacuum chambers and curing ovens – the facility represents a huge step forward in the way buoyancy and elastomer products are manufactured.

Toolmaking, steel fabrication and machining

Falling within the company's philosophy of maintaining control of all operations as far as possible, Newcastle-based rotational mould making business Kirkdale 2000 Ltd was acquired by Balmoral in 2014.

Now known as Balmoral Newcastle, Kirkdale was recognised within the rotomoulding industry as a byword for uncompromising quality and it is Balmoral's aim to develop and grow this part of the business.

Complementing the existing fabrication facility, Balmoral Newcastle supports the company's growing demand for high quality rotational moulding tools, steel fabrication and machining requirements. The service means that the company is in total control of these time-critical processes and doesn't have to rely on external suppliers or out-sourcing.

Not only does this ensure delivery schedules are met it also means that costs are kept under very strict control; time and cost savings that ultimately benefit customers.

Rotational moulding

Balmoral operates a highly developed in-house rotational moulding facility at Group HQ in Aberdeen.

This facility produces the shells for many of Balmoral Offshore Engineering's products including distributed buoyancy modules and modular buoyancy elements.

These shells are roto-moulded in medium density polyethylene providing a one piece, seamless product with no structural welds or inherent stresses. The manufacturing process is automated providing a high quality and consistent product.

This in-house capability affords the company total control over material selection, dimensional tolerances and, ultimately, project scheduling.

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 operates a fully automated system that provides syntactic material of a consistent quality which is critical to the manufacture of 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.

This investment in production technology ensures top quality products that are exceptionally suited to the hostile deepwater environments commonly experienced by the industry today.

Manufacturing Engineering Group (MEG)

The Manufacturing Engineering Group implements lean manufacturing methodologies and continuous improvement practices to drive operational excellence. This helps to understand value streams and how, by improving these, it can improve the company's service to the customer.

The MEG takes a systematic approach to all processes in achieving world class performance by efficiently using tools and equipment, optimising resources and the elimination of process waste and inefficiencies.

Accredited, cost effective, safe solutions

Balmoral boasts an extensive track record in some of the most onerous operating conditions in the world. As the industry continues its journey into deeper waters the company differentiates itself by providing fully accredited, safe and highly cost effective design and manufacturing solutions.

In March 2013 the American Petroleum Institute (API) released specifications 17L1 for flexible pipe ancillary equipment and 17L2 recommended practice for flexible pipe ancillary equipment.

The API 17L specification stipulates the minimum requirements for the design, material selection, manufacture, documentation, testing, marking and packaging of flexible pipe ancillary equipment including buoyancy modules, clamping systems, bend stiffeners and restrictors.

The API standard covers all materials, design, testing and manufacturing methodologies used in the system to provide uplift of up to 4.65Te at water depths to 10,000ft.

To achieve Bureau Veritas approval in line with API 17L standards Balmoral successfully completed an 11 month development programme that consisted of four phases: quality audit; design review; material qualification; inspection and testing.

Clients should enquire whether or not their supplier is accredited in line with API standards to ensure the optimum products and services for their project are provided.

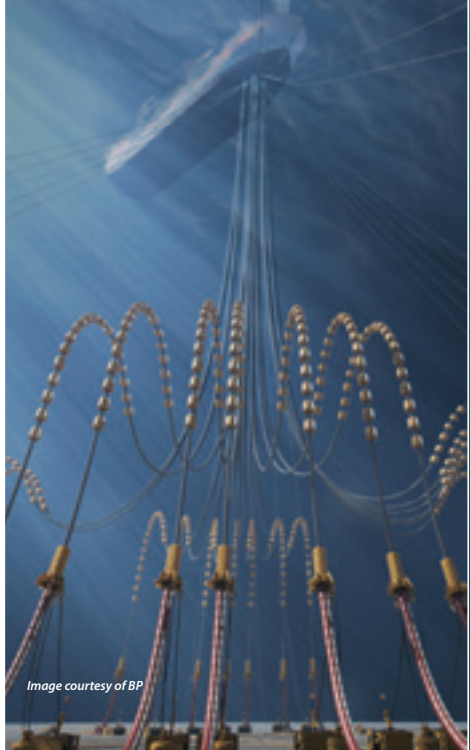


Image courtesy of BP

Operational sectors

SURF

- Distributed riser buoyancy
- Buckle mitigation buoyancy
- Bend stiffeners
- Bend restrictors
- J-tube seals
- Cable and flowline protection
- VIV strakes
- Marine antifouling systems
- Riser tower buoyancy
- Auxiliary products

Distributed riser buoyancy

Operating what is probably the most advanced buoyancy manufacturing plant in the industry, Balmoral provides high quality, consistent modules which result in low water absorption and compression throughout their service life. Balmoral distributed buoyancy modules are fully accredited by Bureau Veritas to API 17L standards.

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 and assist in achieving particular configurations which include steep, lazy, W-wave and pliant.

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 at the forefront of significant R&D efforts to meet this challenge and has developed a number of solutions for deep and ultra-deepwater environments.

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.

In higher temperature applications the buoyancy modules can incorporate convection channels.

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.

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-visibility pigmentation
- Customised graphics option

Installation times
Balmoral provides installation tools with its distributed buoyancy modules which dramatically reduce installation times. When properly deployed a pair of Balmoral DBMs can be fully installed in under six minutes.

Typical example of a three-piece clamp

Clamping options

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

High performance clamp

This one-piece product is designed for high clamping load situations to resist the axial movement of large buoyancy and ballast loadings. The high performance 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 the flowline using a specialised tool allowing accurate 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 one-piece 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 torqueing 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

This three-piece device is 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 integrally clamped module removes the need for a separate clamping system by attaching directly onto flexible flowlines, rigid pipelines, umbilicals 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

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 so that expansion, or buckle, is allowed to take place in a safe and 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.

Bend stiffeners

Balmoral bend stiffeners are fully accredited by Bureau Veritas to API 17L standards using specifically formulated polyurethane materials and are engineered to suit project operational parameters.

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.

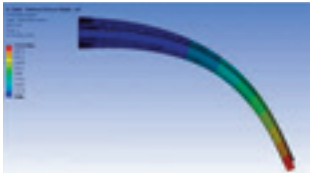
Stiffeners are typically conically shaped polyurethane mouldings with a cylindrical bore that slips over the pipe, umbilical or cable.

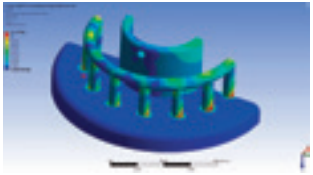
Manufacturing and materials

BOE has invested heavily in the technology and infrastructure to produce what are thought to be the largest bend stiffeners in the world. The upgraded capability allows the company to produce stiffeners in excess of 15m long.

A key aspect of the BOE bend stiffener/restrictor development program has been to negate the significant health and safety issues associated in traditional elastomer stiffener supply. The material systems used in BOE products meet the increasing demand for minimum hazard at all stages of manufacture and use.

BOE does not use carcinogenic aromatic amine cross-linkers and uses only 'stripped' prepolymers, ie, materials that are essentially free of volatile and toxic TDI. Additionally, BOE bend stiffeners comply with Norwegian Product Regulation 2.3 which bans the use of toxic mercury catalysts.





Bend stiffener design analysis

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

Information that is critical to bend 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.

Balmoral bend stiffeners are comprehensively flex-fatigue tested and Lloyds approved.

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.

Balmoral SolGuard®
UV protection coating

The vast majority of offshore elastomer products are used subsea where UV degradation is not an issue.

However, a limited number of moulded products are deployed above the surface and by far the most critical in terms of performance and consequences of failure are bend stiffeners.

To overcome this issue, Balmoral developed its unique SolGuard UV protection system which effectively creates an overcoat layer preventing UV penetration through to the underlying bend stiffener.

Dynamic bend stiffeners

Dynamic bend stiffeners provide localised stiffening for umbilicals and flowlines in demanding applications. They are designed to protect the minimum bend radius (MBR) inflicted by flexing while under axial loads and also to prevent fatigue failure.

The end steelwork on dynamic stiffeners is custom-designed and fully encapsulated to connect with the matching project hardware.

Balmoral's proprietary manufacturing capability means that stiffeners of virtually any size can be produced.

Static bend stiffeners

Balmoral static stiffeners provide overbend protection during installation and overboarding procedures. They support and control the minimum bend radius on flexible pipe and cable at the end fitting and mid-line joints.

The standardised Orcabend design and modular tooling means that static stiffeners can be offered on a very quick turnaround.

Split bend stiffeners

These Orcabend-designed products are generally produced for retrofitting on to umbilicals, cables and flowlines already in service.

Split stiffeners can be used on a number of end fittings and are usually strapped or bolted in place.

Bend restrictors

Bend restrictors prevent over-bending at the interface between flexible flowlines/umbilicals/cables and rigid structures 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 between the flexible line and rigid structures such as wellhead connections, J-tube exits, rigid pipe crossovers and PLET connections.

Accredited by Bureau Veritas to API 17L standards, BOE standard bend restrictors are manufactured in rigid structural polyurethane two piece units that are bolted together around the pipe.

Boltless bend restrictor

Balmoral has extended its bend restrictor range to include a genuinely boltless restrictor (patent pending) – the first on the market. This boltless solution means that installation times can be slashed offering huge savings in offshore installation costs.

Although there are products on the market that claim to be boltless, none of them actually are. In the case of Balmoral's boltless restrictor, industry leading performance is retained while offering significantly reduced installation time and costs.

Ensuring the new restrictor's suitability for global deployment, design methodologies and material selection are fully compliant to API 17L 1&2 standards.

Bend restrictor design analysis

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

- Flexible pipe OD
- 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

Bend restrictor end fittings

Balmoral offers a variety of options for bend restrictor end fittings (reaction collars) where a robust design is required to provide the smooth transfer of load from the project interface to the end of the restrictor string ensuring protection is maintained at all times.

Forged reaction flange

Using this method, Balmoral bend restrictors couple to the structure by means of a flanged (male) end fitting. Forged reaction flanges are manufactured using compliant material as a single body which is machine finished and requires no welding. They are supplied as split units and bolted together using B7M bolts.

Forged reaction flanges are coated with a standard marine grade paint system (NORSOK System 7B) and couple with the client's end fitting. Balmoral does not supply the bolts to connect the reaction flange to the end fitting but this can be arranged if required.

PU reaction flange

PU reaction flanges are the connecting point between PU bend restrictors and the subsea termination interface; these are designed to match clients' end fittings. The PU reaction flange design is based on the bend restrictor as both components share the neck and pin geometric sections and utilise the same material.

PU reaction collar

Using this method, bend restrictors couple to the structure by means of a PU fitting connected to a steel flange located within the groove of the end fitting. Steel flanges are supplied in two halves with a pitch circle diameter (PCD) to match the PU end fitting.

All the options above can be supplied in Balmoral's standard welded assembly format.

Image courtesy of BP

J-tube seals

J-tube seals are used to provide sealing and corrosion protection between flexible risers and the so called J- or I-tubes found on offshore installations.

Balmoral Offshore Engineering provides diverless and diver-installed seals that are available in a range of sizes for pre- or retrofitting; all manufactured to API 17L standards.

Additionally, centralisers can be specified to maintain the cable position within a J-tube while bend restrictors or stiffeners can assist with positioning and stability.

Cable and flowline protection

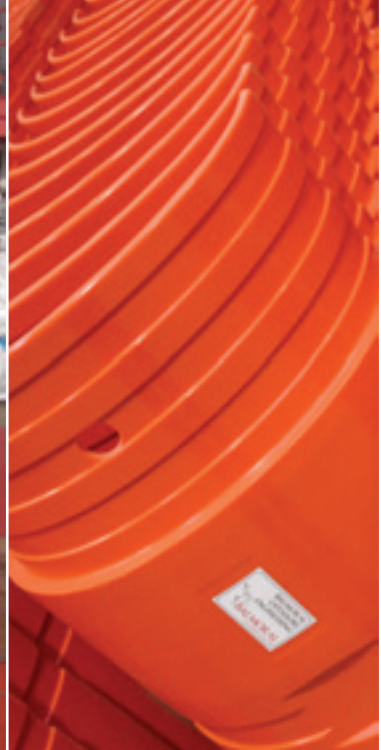
Balmoral Duraguard™ was developed for the protection of subsea cables, flexible jumpers, flexible flowlines and riser touchdown zones although many other applications have been identified.

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, thicknesses and lengths. Typical lengths are determined by the individual half shell weight and can vary from 500-2000mm in length.

Balmoral provides four differing systems:

- Duraguard Standard
- DuraguardPlus™ – As Duraguard standard but supplied as one-piece hinged modules with integrated banding system
- Duraguard HD™ ballast system
- Duramat™



Duraguard HD ballast system
For projects which demand cable protection with added ballast, Duraguard HD (High Density) ballast system 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 2300-8000kg/m^3 can be achieved with the Duraguard HD ballast system.

Buoyancy
Standard PU is practically 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.

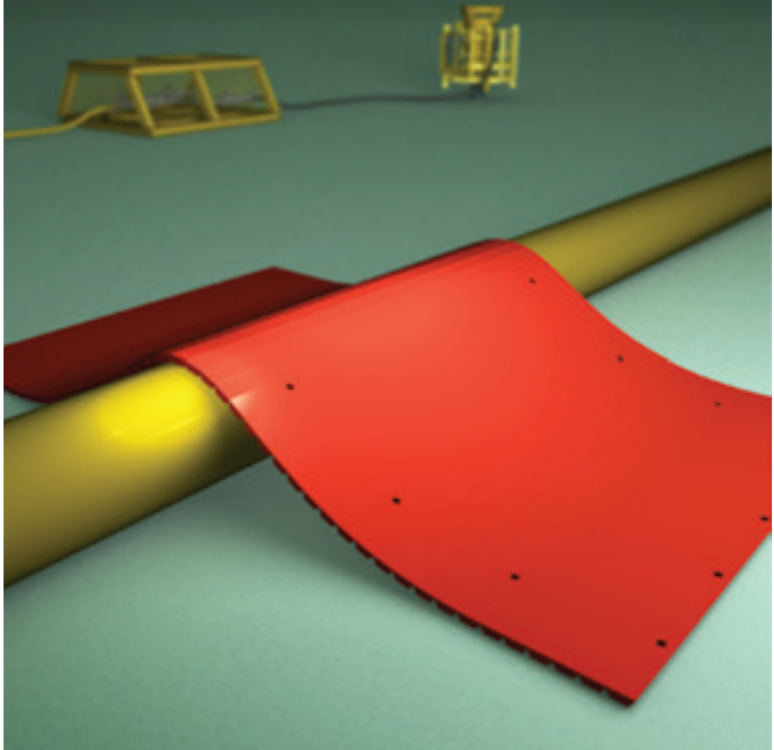
Incanell or titanium bands are normally set 300mm apart. Adjacent segments with overlapping ends are added to provide a continuous protected length.

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.



VIV strakes

Vortex induced vibrations (VIV) can be detrimental to slender tubular elements, such as risers.

This is 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 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.

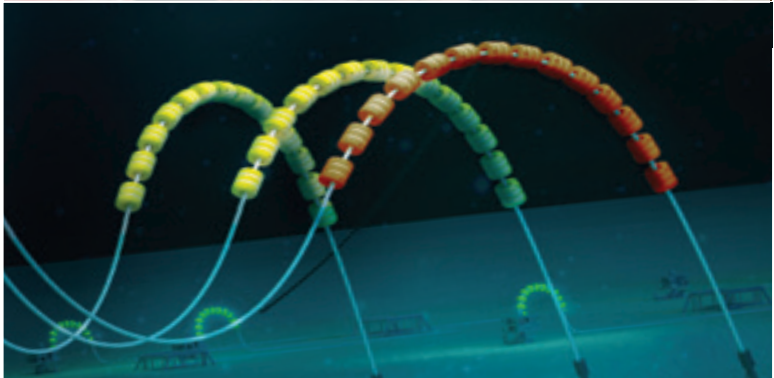
The most widely used technique to reduce VIV on cylindrical structure is a helical strake system. BOE strakes are available in marine grade abrasion resistant polyurethane elastomer or a marine grade composite material and can be supplied to accommodate various installation methods including onshore, shipboard, stinger or diver/ROV retro fitting.

Marine antifouling systems

Marine biofouling is an issue which must be seriously considered when installing any structure or launching any vehicle into an aquatic environment. Accumulation of fouling organisms leads to increases in submerged weight but, far more importantly, such fouling significantly affects the hydrodynamic performance of subsea structures and equipment.

At Group HQ in Aberdeen, Balmoral operates what is believed to be the industry's only purpose built marine antifouling coating line. The semi-automated facility enables the company to apply a range of coatings to its surface and subsurface products.

Recovered distributed buoyancy module fouled with Lophelia pertusa



Uncoated panels with extensive marine growth

Balmoral CuNiClad coated panels

Balmoral CuNiClad®

The entire product surface is coated with discrete CuNi granules so that there are no gaps in the protection onto which fouling can accumulate. As each granule is supported on, and in, a polyurethane matrix, despite the nobility of copper metal there is no possibility of galvanic corrosion of underlying steelwork and, additionally, no electrical continuity across the coated surface which, if applied to a CP-protected substrate, could otherwise interfere with the anti-fouling properties of the copper alloy.

Balmoral CopperClad™

Balmoral Offshore Engineering worked with a market-leading marine antifouling paint supplier to develop Balmoral CopperClad™ which is a complete coating and application system designed to achieve outstanding bonding performance between polyethylene or polyurethane substrates and a slow biocide release antifouling coating system.

Balmoral CopperClad is based upon a silyl-acrylate binder that exhibits continuous slow solution and hydrolysis in seawater. This gradually releases biocide components into the surface/water interface to ensure continuous protection of the coated structure.

Full technical details of these systems can be obtained by contacting Balmoral Offshore Engineering.

Riser tower buoyancy

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

Ultra-deepwater fields have attracted much attention in recent years and have generated a range of riser solutions to transport the produced hydrocarbon fluids to the surface processing facility. In some cases these solutions reflect the particular expertise of the main contractor while project-specific requirements dominate in other scenarios.

Established solutions include steel catenary risers, flexible flowlines in wave or MWA configuration, single leg top-tension risers and hybrid riser towers. The last-named refers to multiple risers grouped around a single core pipe where the entire assembly is supported in vertical orientation by a massive buoyancy assembly. Due to operational depths going to some 2000msw the majority of solutions require buoyancy to provide hydrodynamic stability and/or riser tension reduction.

© Subsea 7

With the particular field configurations, depths of reservoirs and relatively benign sea states found offshore West Africa, the hybrid riser tower (HRT) has assumed a dominant position. With the proven success of HRTs in four major West African projects to date the same solution offers significant potential for other deepwater projects both there and elsewhere in the world.

The hybrid riser tower typically comprises 4-12 individual risers grouped around a central core pipe anchored to the seabed and supported by a massive air can at the top. Further to this tower-top air can, buoyancy is routinely provided along the length of the bundle and on occasion at the upper and lower riser tower assemblies – URTA and LRTA respectively.

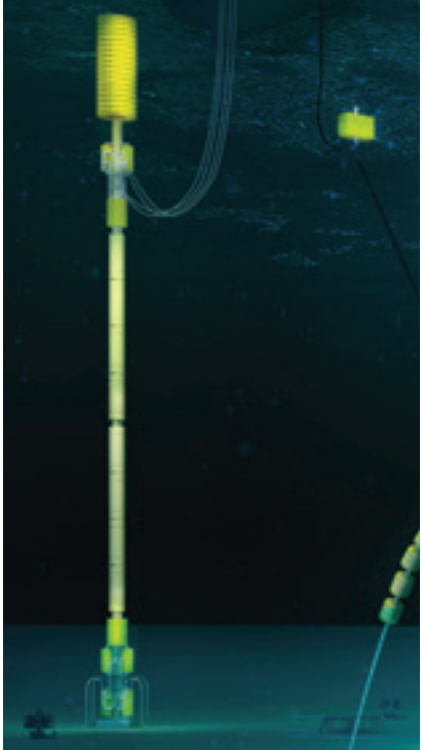
The primary purpose of the bundle, URTA and LRTA buoyancy systems is to facilitate surface tow-out of the bundle, however the same buoyancy also contributes to the stability of the vertical HRT when in service.

Durafloat HT™ high temperature buoyancy
In project situations involving low wax-content oil or high wellhead temperatures, ie, where the insulation requirement for process fluids is relatively modest, it is usually most cost-effective to provide the insulation requirement for production and gas lift risers within a hybrid riser tower by means of external 'wet' insulation coatings on the individual risers.

In this situation, the HRT syntactic foam is provided for buoyancy purposes only. The primary buoyancy requirement here is to facilitate surface tow-out of the assembled HRT, however the HRT syntactic buoyancy modules also augment the tower top steel buoyancy can in providing long-term stability of the vertical HRT after installation and may also serve to reduce tensile loadings within the central tendon pipe.

Here, and in direct contrast to the situation where the syntactic foam is intentionally providing thermal insulation, the module and riser systems are specifically designed to minimise exposure of the syntactic foam to elevated temperatures as a result of proximity to hot risers. This is because syntactic foam, as a polymer material, loses mechanical properties when the temperature rises. As a consequence, denser, stronger and therefore more expensive foam is required for elevated temperature than would be for service at deep ocean temperature.

Due to the modest thermal efficiency of most deepwater wet insulation materials, and despite design efforts in mitigation, there is often a degree of local water heating surrounding insulated lines which, in turn, results in local heating of adjacent syntactic foam modules.



Through extensive development, qualification work and actual HRT project experience, Balmoral has unrivalled knowledge of the syntactic foam design requirements for the entire spectrum of service depths to 3000msw and foam exposure temperatures to 55°C. The loss of mechanical performance associated with increased temperature is inversely related to the difference between the glass transition temperature (Tg) of the epoxy systems in the syntactic foam and the foam exposure temperature.

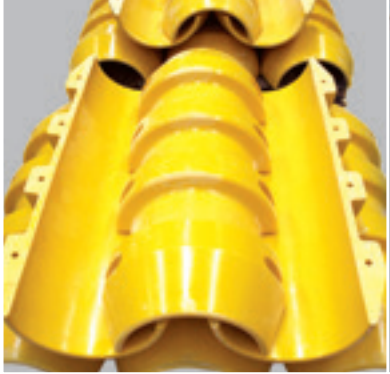
For foam exposure temperatures up to absolute maximum 30°C, increased density ratings of the standard syntactic foam components used in drilling riser buoyancy foam may be employed. However, for critical service at temperatures from 30-55°C, Balmoral developed a syntactic foam system containing special high-Tg epoxy syntactic and composite macrospheres which delivers both superior mechanical properties at all temperatures of interest and also shows reduced loss of mechanical performance with increased temperature. This generic foam system, called Durafloat HT, was supplied for use on the hybrid riser tower modules and associated buoyancy for the CLOV project in Block 17, offshore Angola.

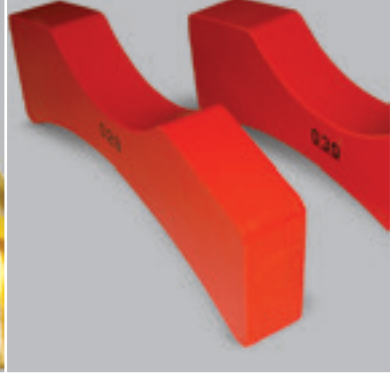
Auxiliary products

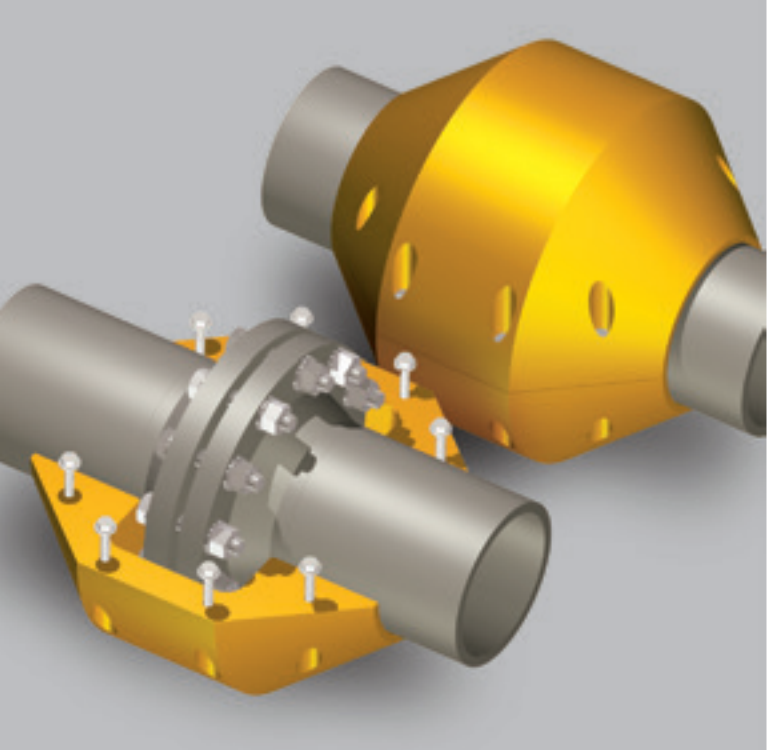
Clamps, saddles, centralisers and spacers
To help with varying offshore operations, including pipeline installation and cable laying, BOE introduced a range of auxiliary products such as clamps, riser clamps, centralisers and spacers.

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

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 3000msw 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.

Marine

- Surface/subsurface buoyancy
- ROV / AUV buoyancy
- Flexlink umbilical 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 installation project.

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

Modular buoyancy

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

Offering 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 0-3000msw.

These modules incorporate 'flats' which provide easier handling and deck storage whilst simultaneously improving robustness.

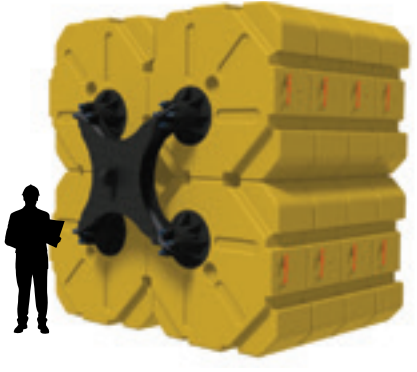
These are believed to be the most user-friendly subsurface buoys on the market.

Modular buoyancy range
Designed for use from 0-3000msw 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.

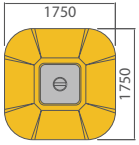
BOE's modular buoyancy utilises a range of tough, abrasion resistant core materials contained within a rotational moulded polyethylene shell. Other external finishes are available on request.

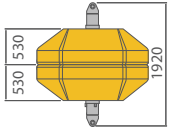
MB60 modular buoys
Used predominantly as support buoys and in suspended mooring systems BOE MB60 modular buoys are available in sizes ranging from 100-300 tonnes.

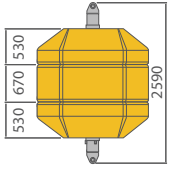
The rotationally moulded shells are filled with a resilient core material to provide long lasting practically maintenance free performance.

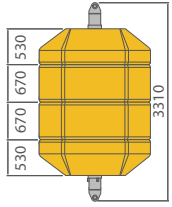


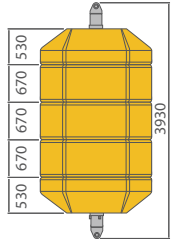
MB17 Modular buoyancy general arrangements









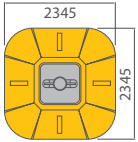


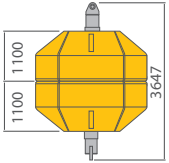
Weight in air (kg)
Nominal buoyancy (kg)

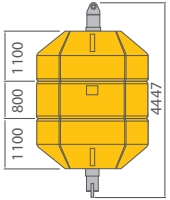
Surface	708	**1695**	975	**3279**	1241	**4863**	1507	**6447**
300msw	1333	**1070**	2104	**2149**	2875	**3229**	3646	**4308**
500msw	1405	**999**	2233	**2021**	3061	**3042**	3890	**4064**
1000msw	1422	**912**	2270	**1880**	3118	**2848**	3966	**3815**
1500msw	1520	**815**	2447	**1703**	3374	**2592**	4301	**3481**
2000msw	1634	**701**	2653	**1497**	3672	**2294**	4691	**3091**

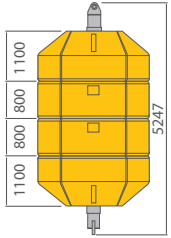
Note: All weight in air and buoyancy values are nominal and subject to specific configuration.
Buoyancy values can be increased by approximately 0.4 - 0.75 tonnes per configuration with the addition of a thin mid module.

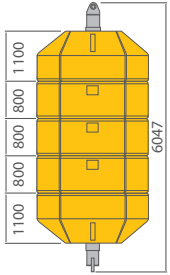
MB23 Modular buoyancy general arrangements









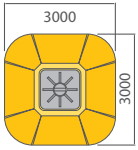


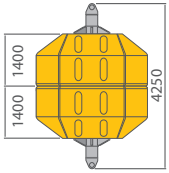
Weight in air (kg)
Nominal buoyancy (kg)

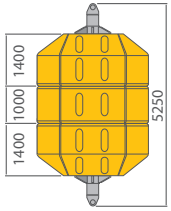
Surface	1645	**7061**	2179	**10597**	2714	**14134**	3249	**17670**
300msw	4033	**4673**	5693	**7083**	7354	**9494**	9014	**11905**
500msw	4305	**4401**	6094	**6683**	7883	**8965**	9672	**11247**
1000msw	4394	**4165**	6227	**6392**	8060	**8559**	9893	**10756**
1500msw	4767	**3792**	6776	**5813**	8785	**7834**	10794	**9855**
2000msw	5203	**3356**	7417	**5172**	9632	**6987**	11846	**8803**

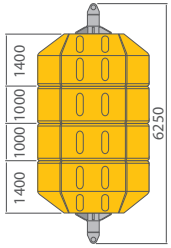
Note: All weight in air and buoyancy values are nominal and subject to specific configuration.
Buoyancy values can be increased by approximately 0.75 - 1.5 tonnes per configuration with the addition of a thin mid module.

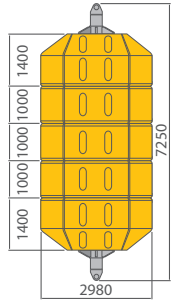
MB30 Modular buoyancy general arrangements









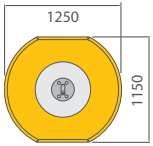


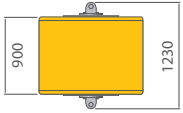
Weight in air (kg)
Nominal buoyancy (kg)

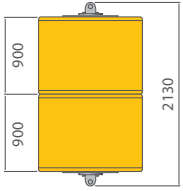
Surface	3457	**16254**	4518	**23763**	5579	**31274**	6640	**38784**
300msw	8915	**10796**	12348	**15907**	15836	**21017**	19296	**26128**
500msw	9537	**10174**	13271	**15011**	17005	**19847**	20739	**24684**
1000msw	9729	**9529**	13557	**14160**	17385	**18791**	21213	**23421**
1500msw	10582	**8676**	14785	**12932**	18988	**17186**	23192	**21442**
2000msw	11578	**7680**	16218	**11499**	20860	**15316**	25500	**19134**

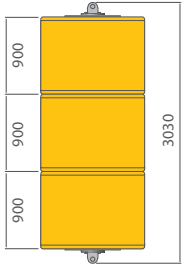
Note: All weight in air and buoyancy values are nominal and subject to specific configuration.
Buoyancy values can be increased by approximately 1.75 - 3.5 tonnes per configuration with the addition of a thin mid module.

CMB Cylindrical modular buoyancy general arrangements







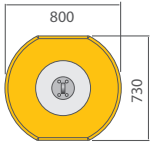


Weight in air (kg)
Nominal buoyancy (kg)

Surface	289	**890**	376	**1819**	463	**2749**
300msw	587	**592**	972	**1223**	1357	**1855**
500msw	621	**558**	1040	**1156**	1458	**1753**
1000msw	632	**527**	1063	**1094**	1493	**1660**
1500msw	679	**480**	1156	**1000**	1633	**1521**
2000msw	733	**426**	1265	**896**	1796	**1358**

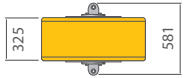
Note: All weight in air and buoyancy values are nominal and subject to specific configuration.

MCMB Mini cylindrical modular buoyancy general arrangements

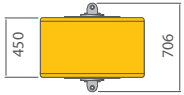


MCMB1

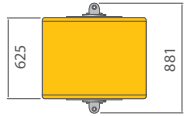
MCMB2



MCMB3



MCMB4



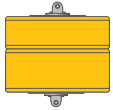
Weight in air (kg)
Nominal buoyancy (kg)

Surface	99	**77**	103	**108**	109	**158**	118	**229**
300msw	130	**46**	144	**67**	167	**101**	199	**149**
500msw	133	**43**	148	**62**	173	**95**	208	**140**
1000msw	135	**38**	150	**56**	175	**87**	211	**129**
1500msw	139	**34**	156	**50**	184	**78**	224	**116**
2000msw	145	**28**	164	**43**	195	**67**	238	**102**

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

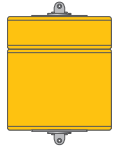
MCMB Mini cylindrical modular buoyancy general arrangements continued

MCMB 5
MCMB 1 + MCMB 2

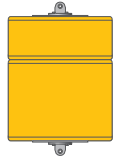


MCMB 6
MCMB 2 + MCMB 3

MCMB 7
MCMB 1 + MCMB 4



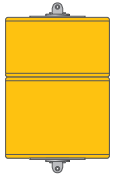
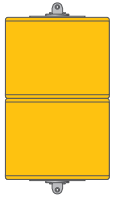
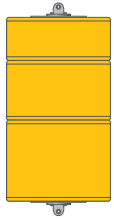
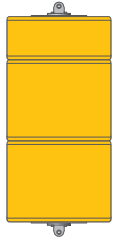
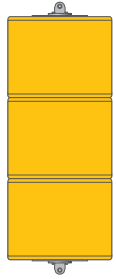
MCMB 8
MCMB 2 + MCMB 4



Weight in air (kg) **Nominal buoyancy (kg)**								
Surface	115	**202**	126	**283**	131	**324**	135	**354**
300msw	187	**130**	224	**185**	242	**212**	256	**233**
500msw	195	**122**	235	**174**	255	**200**	270	**219**
1000msw	198	**112**	239	**160**	259	**184**	274	**202**
1500msw	209	**101**	254	**145**	276	**167**	293	**184**
2000msw	222	**88**	272	**127**	297	**147**	315	**161**

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

MCMB Mini cylindrical modular buoyancy general arrangements continued

MCMB 9 MCMB 3 + MCMB 4	MCMB 10 MCMB 4 + MCMB 4	MCMB 11 MCMB 2 + MCMB 3 + MCMB 4	MCMB 12 MCMB 2 + MCMB 4 + MCMB 4	MCMB 13 MCMB 4 + MCMB 4 + MCMB 4
				
Weight in air (kg) **Nominal buoyancy (kg)**				
141 **405**	150 **476**	157 **530**	166 **601**	182 **723**
279 **267**	311 **315**	336 **351**	368 **399**	423 **481**
294 **252**	329 **297**	356 **331**	391 **376**	451 **454**
300 **233**	336 **275**	363 **306**	399 **348**	460 **421**
321 **211**	361 **250**	391 **278**	430 **317**	498 **383**
347 **186**	390 **220**	424 **246**	467 **280**	542 **339**

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

Anchor pendant buoys (APB)

Balmoral Offshore Engineering offers a range of surface buoyancy that 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.

Mooring buoys

The Balmoral mooring buoy range is unique and was designed and developed 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.

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

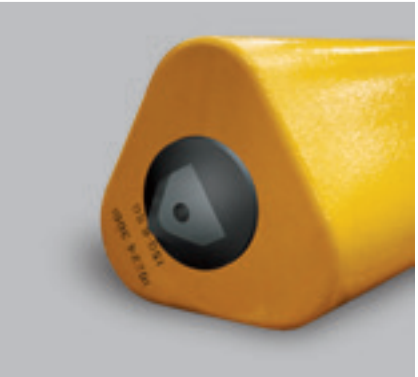
Operating depth (msw)	Weight in air kg / Nominal buoyancy kg			
	OF1	OF2	OF3	OF4
1000	7.9 / 7.7	11.9 / 12.2	21.2 / 23.2	43.8 / 50.4
1500	8.1 / 7.5	12.3 / 11.8	22 / 22.4	45.6 / 48.6
2000	8.9 / 6.7	13.4 / 10.6	24.2 / 20.2	50.4 / 43.8
2500	9.2 / 6.4	14 / 10	25.4 / 19	53.1 / 41.1
3000	9.8 / 5.8	14.9 / 9.2	27 / 17.4	56.6 / 37.6
6000	10.6 / 5	16.2 / 7.9	29.6 / 14.8	62.3 / 31.9
Bore ØID mm	19.05	38.1	38.1	38.1

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.



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 125-175kg with depth rating capabilities of 610-3050msw.

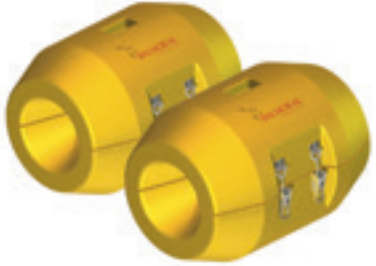
Umbilical floats

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

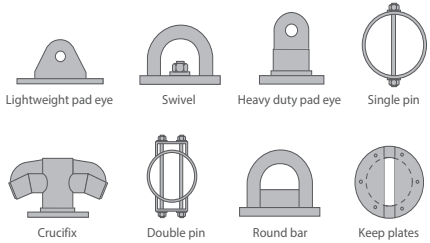


Umbilical float values		
Operating depth (msw)	**Weight in air (kg)**	**Nominal buoyancy**
1000	14.7	15.2
1500	15.9	14
2000	17.3	12.6
2500	18.1	11.8
3000	19.1	10.8

Fittings

A wide range of steelwork is available to complement Balmoral Offshore Engineering's surface and subsurface products.

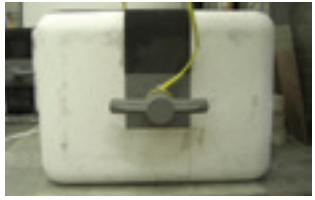
This includes crucifix, pad eye, round bar, swivel, double and single pin, keep plates and through-hawse end fittings.



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 repair personnel travelling the world on a regular basis.



ROV/AUV buoyancy

With advances in deepwater technology the need for remote intervention as part of 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 for operating at depths to 7000msw.

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

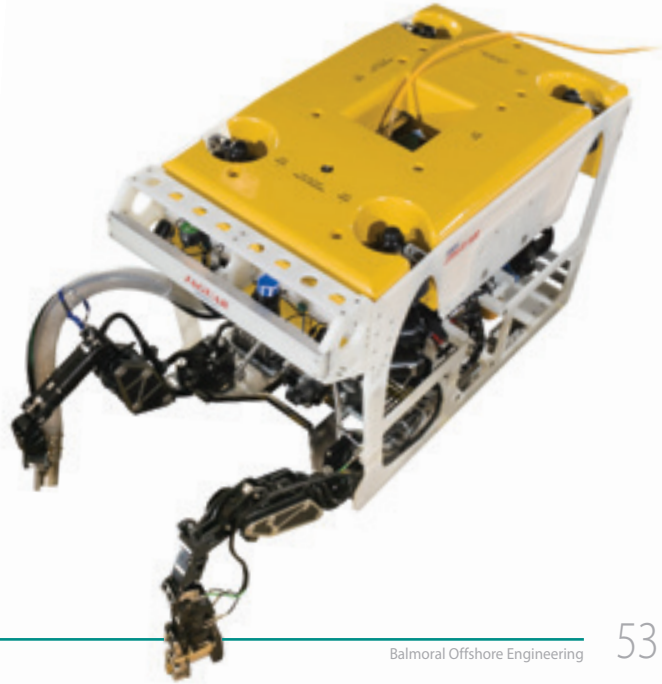
Composite foam systems
A "composite" buoyancy system refers to a syntactic foam comprising glass microspheres and macrospheres held together within an epoxy resin system to create a homogenous matrix.

Composite buoyancy systems are cast using dedicated mould tooling providing repeatable consistent production and are therefore ideally suited in applications such as work class ROVs – 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.



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 this is a premium product and is therefore typically selected for more demanding service conditions such as extreme operating depths and/or service criticality such as manned service.

The ultra-low density range of pure syntactic foam is 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 Balmoral's 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 moves 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 ultra-low density range (LDF)	
Operating depth (ft/msw)	**Typical core density kg/m³**
3250 / 1000	395
6500 / 2000	435
9850 / 3000	450
13100 / 4000	470
16500 / 5000	490
23000 / 7000	565

ROV/AUV external finishing
Selecting a coating for buoyancy modules of any type is a critical issue. These coatings provide impact and abrasion resistance while offering a high visibility smooth gloss finish.

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

Standard finishes are provided in high gloss yellow, orange, red or white. Other colours are available to suit project parameters. An extremely high quality smooth finish is available for specialised applications.

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 buoyancy machining and milling
Balmoral Offshore Engineering operates an in-house ROV buoyancy block milling capability.

Taking internal control of this process allows Balmoral to create intricate ROV PFS and LDF buoyancy profiles with virtually no size limitations using its 5-axis CAD/CAM-controlled milling facilities.

Drilling

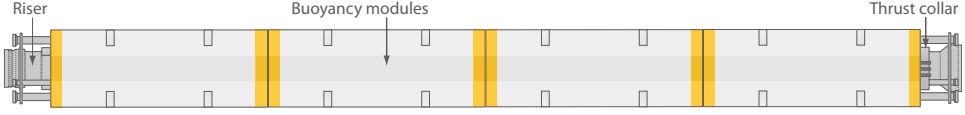
- Drilling riser buoyancy
- Riser impact protection
- Riser stacking shims
- Pin and box end protection
- Riser clamps
- Balmoral Casing Guard

Drilling riser buoyancy

Drilling riser buoyancy provides uplift while reducing the submerged weight of the riser joints. This helps to minimise top tension and prevent stress in the riser as well as reducing loadings during deployment and 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 vessel while supporting choke, kill and auxiliary lines. Balmoral Offshore Engineering consistently manufactures high quality modules while its in-house hyperbaric test centre offers test facilities to 7000msw equivalent.

The riser is also used to guide tools into the well and serves as a running/retrieving string for the BOP.



Dressed marine 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.

Durafloat™ and 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.

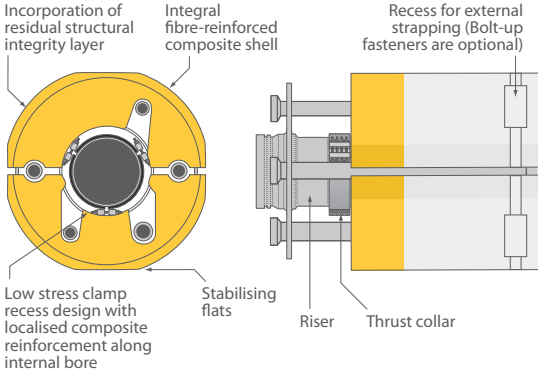
Similarly, the requirement for ultra-safe modules has grown in response to the extreme conditions which are now commonplace in today's operating environments.

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.

Durafloat RIS safety design features



External finishing
Drilling riser buoyancy operates in extreme conditions and must withstand harsh and constant handling. Durafloat modules benefit from an integral composite epoxy skin that delivers a robust impact resistant performance.

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

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 operations environment.

A fully comprehensive handling and stacking manual is available from the company on request.

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.

Durafloat Superlite™ and Superlite-X™

Drill riser buoyancy to 15000ft

Having successfully developed its Durafloat drill riser buoyancy to working depths of 12000ft, Balmoral recognised that further performance improvements were required.

Basing their work on the original Durafloat system, Balmoral's technical and engineering teams developed a lighter syntactic material for use at operational extremes to 15000ft.

However, the essential increase in mechanical performance required to operate at these depths cannot be accompanied by a reduction in available buoyancy, and so foam density reduction was targeted alongside mechanical performance improvement.

The result of the R&D programme is Durafloat Superlite and Durafloat Superlite-X. With these latest additions, Balmoral Offshore Engineering now offers market-leading densities and performance levels across the entire spectrum of drilling operations.

All Balmoral Durafloat and Durafloat Superlite modules feature a number of advanced performance-related benefits including:

- Extreme impact resistant shell
- Anti-fracture reinforcement
- Enhanced flexure resistance
- Improved stacking and storage capability
- Localised recess reinforcement

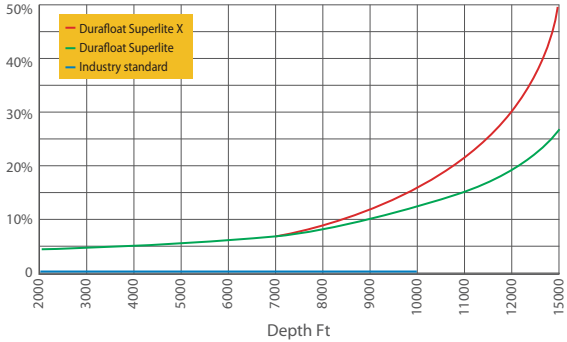
In simple terms, more uplift is provided for the cost when specifying Durafloat Superlite and Durafloat Superlite-X.

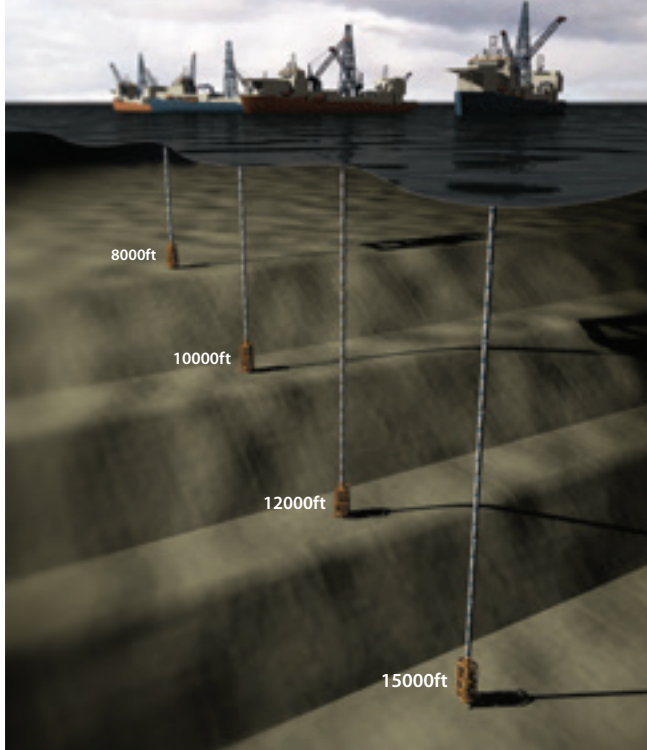
More uplift for your money

This chart shows how much more uplift is provided by Durafloat Superlite and Superlite-X systems in comparison to industry standard systems.

Even at 7000ft there is approximately 10% improved uplift performance. When depths of 12000-15000ft are reached this increases by an outstanding 30-50% respectively.

Uplift improvements over standard drill riser buoyancy systems





Riser impact protection

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

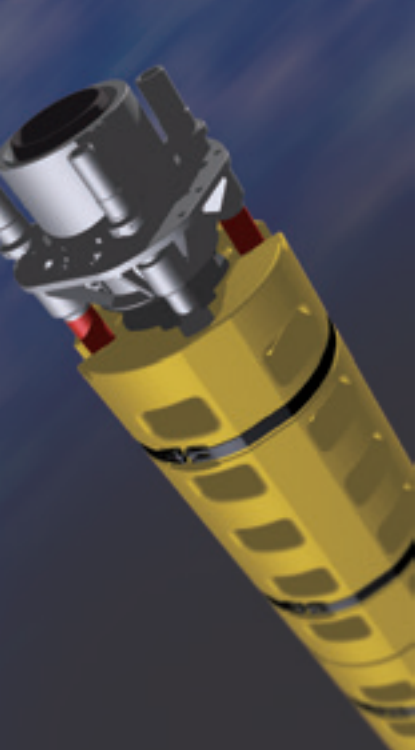
When running a bare riser string, ie, without buoyancy modules, several problems can be encountered on the drill platform including:

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

To minimise damage during operations Balmoral Offshore Engineering provides a selection of riser impact protection systems:

- Rotationally moulded polyethylene modules for standard protection
- A combination of polyethylene and polyurethane elastomer modules for heavy duty protection and maximum stacking

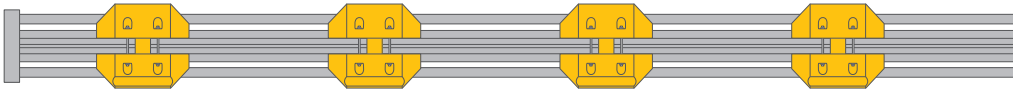
These products are engineered to provide maximum impact and abrasion protection whilst at the same time being lightweight and easy to handle.



Riser stacking shims

In addition to riser impact protection modules BOE manufactures polyurethane elastomer stacking shims which provide intermediate protection along the riser length and are suitable for protecting standard slick joints, pup and telescopic joints.

Dressed drilling riser section with shims



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.

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

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

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

Riser clamps

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

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 – quite often "burn outs" from thick steel sheet – which are 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 specific riser requirements

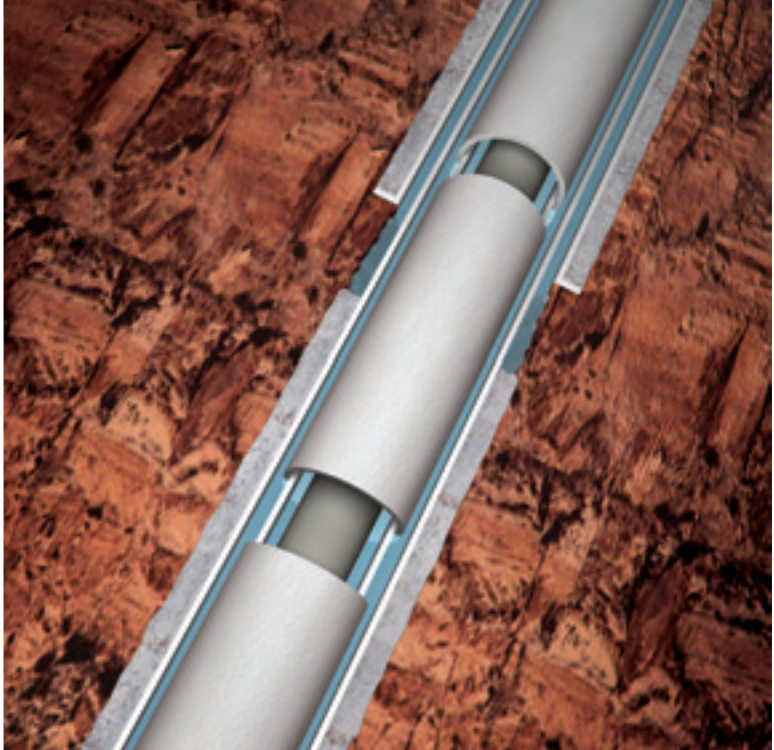
Balmoral Casing Guard

Annular pressure build-up (APB) mitigation
As a subsea well is drilled, successively smaller casings are introduced creating a number of fluid-filled annular spaces. Only the inner-most annulus can bleed off through the subsea tree.

The outer annuli may be open to fluid movement through open shoes but, in practice, these annuli frequently get plugged off during cementing by formation collapse or solids settlement.

Due to the combination of extreme water depths and hole depth in many offshore wells, HP/HT reservoir fluids can reach temperatures as high as 350ºF while flowing. When a well is brought on line these hot fluids rise up the casing string, elevating the temperature of the casings and annular fluids during flow.

If thermal expansion of the annular fluids is restricted by plugging, a major pressure increase, known as annular pressure build-up (APB), occurs. Pressure increases of 80-150psi are typical, meaning that even a relatively modest temperature increase of 100ºF can result in pressures approaching 15,000psi.



It is not generally cost effective and, in many cases, practical to design the casing string to tolerate the potentially massive APB's in modern wells. Engineered APB mitigation systems are therefore required to accommodate such expansion.

APB is known to have caused the rupture of intermediate and production casings on several wells over the last 10 years or more. The financial impact and recovery implications of such failures are enormous.

Application and operation of Balmoral Casing Guard
Balmoral Casing Guard is supplied as an easy-to-install kit for site application. It is routinely supplied as foam quadrants, typically 0.5-1.5m in length.

These quarter cylinders are bonded to the outside diameter to create a continuous cylindrical section or, where a complete cylinder could later result in restricted fluid flow, in two or three sections around the casing outside diameter. The effective outside diameter of the installed BCG quadrants is restricted to minimise damage to the foam during casing deployment.

Once installed and the coated casing run, BCG has no detectable effect upon normal well operations and remains passive. When the design collapse conditions are reached, BCG responds immediately to provide the degree of APB mitigation specified by the project engineering design team.

Balmoral Subsea Insulation

Balmoral Subsea Insulation was launched in 2017 to complement the company's existing shroud and doghouse insulation product lines. Significant investment was made in new facilities to build on the experience gained through the company's previous insulation and pipe coating business, Balmoral Webco, which was operational 1990-1997.

Field or factory application

Balmoral designed and created specialised field application units (FAU) that are effectively containerised 'factory in a box' solutions designed for global deployment. The FAU's are fully autonomous with minimal reliance on yard support for onshore, site-based coatings. They are equipped to apply Balmoral Elastotherm systems to meet and exceed client insulation and flow assurance requirements.

Underpinned by the company's industry-leading reputation for customer focus and project governance, Balmoral's highly skilled and experienced supervisory and application teams are trained to ensure a consistently high level of customer service is delivered. This ensures professional, controlled and on-time completion of insulation activities at client locations around the world.

Design and testing

Balmoral Subsea Insulation draws on the company's extensive engineering experience and comprehensive R&D programme to offer FEA or CFD analysis of project design parameters to ultimately provide the most cost effective coating solutions. Early dialogue with clients means that optimum fit for purpose, through life solutions can be identified and implemented.

New, state of the art, technical and subsea test centre facilities offer extensive laboratory and test capabilities to ensure all materials meet stringent industry requirements, including ISO 12736.

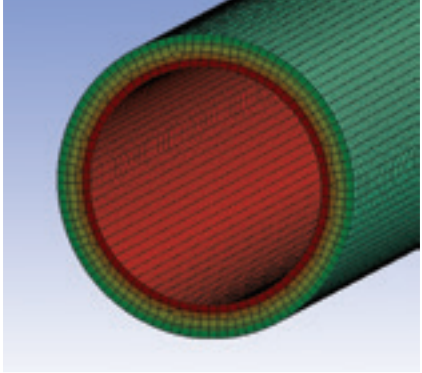
Applications and advantages

Balmoral Elastotherm insulation systems are suitable for use both as cast-in place 'wet' insulation on 'Christmas trees', manifolds, jumpers and spool pieces, and also in modular systems such as connectors and flange covers. The company offers subsea insulation systems suitable for a wide range of applications, including:

- Excessive depth/hydrostatic pressure, eg;
  up to 3000 msw for Elastotherm™ S1 & S2
  up to 7000 msw for Elastotherm™ T & HT
- High hot/dry service temperature, eg;
  up to 150°C for Elastotherm™ S1 & S2
  up to 125°C for Elastotherm™ T
  up to 135°C for Elastotherm™ HT
- Hot/wet conditions, eg;
  up to 135ºC for Elastotherm™ S1 & S2
  up to 90°C for Elastotherm™ T
  up to 120°C for Elastotherm™ HT
- Where constant insulation properties are required through service life
- Where in-service fatigue or high coating strains during installation are anticipated

Specific advantages of Elastotherm solid systems include:

- Immunity to hydrostatic compression due to the absence of hollow glass or polymer microspheres
- Combined insulation and anticorrosion performance
- Outstanding tensile and impact performance



Materials

Balmoral's proprietary elastomer-based product range comprises both unfilled silicone and elastomer systems. These are designed to offer fit for purpose, cost effective, through life solutions as described below:




Typical properties:	Elastotherm™ T	Elastotherm™ HT	Elastotherm™ S1	Elastotherm™ S2
Maximum operating temperature Hot/Wet (°C)	90	120	135	135
Maximum operating temperature Hot/Dry (°C)	125	135	150	150
Maximum service depth (msw)	7000	7000	3000	3000
Density (kg/m^3)	1159	1142	1078	1075
Hardness	93° Shore A	74° Shore D	43° Shore A	42° Shore A
Thermal conductivity (W/mk)				
At ambient temperature	0.185	0.189	0.181	0.177
Maximum temperature[1]	0.186	0.201	0.173	0.170
Specific heat (J/kg.K)				
At ambient temperature	1705	1379	1631	1548
Maximum temperature[2]	2329	1844	1831	1788
Tensile stress at break (MPa)				
At ambient temperature	15.2	32.7	7.0	4.3
Tensile elongation at break (%)				
At ambient temperature	168	15.9	270	238

1 *Maximum temperature of test equipment, 100°C* 2 *Maximum test temperature of 145°C for all materials*

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 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. Balmoral's 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

Balmoral Subsea Test Centre

The industry's most comprehensive, accessible and commercially available hyperbaric facility opened its doors in 2018 when the new Balmoral Subsea Test Centre was launched. With more than £20m being spent on the centre a wide range of test facilities is available to third parties spanning the subsea, renewables, defence and oceanographic sectors.

Hydrostatic testing

Substantial investment has been made in improving and expanding the Balmoral Subsea Test Centre which is now the most comprehensive commercially available hydrostatic test facility in Europe.

Upgraded vessels, 40 tonne lifting crane, remote monitoring software and procedures are in place offering independent testing for all types of subsea equipment to 7000msw equivalent.

Standard tests include:

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

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 that provide highly detailed results for analysis, while a computer controlled hydrostatic test system that automatically performs customisable tests using high capacity intensifier pumps via touch screen is available on vessels TC1, 2 and 3. This allows pressure and temperature data to be fed back to a networked server providing remote real-time test monitoring.

A pan and tilt subsea camera can be placed in the vessels to visually monitor tests when required.

Vessel specifications

Vessel	Orientation	Internal length		Internal dia		Safe working pressure		Fresh water temp	Penetrator quanitity	Penetrator ID	Crane capability
		mm	ft/in	mm	ft/in	psi	bar	ºC		mm	Tonnes
TC 1	Vertical	8,970	29' 5"	2,500	8' 2"	6,880	475	Ambient	8	100	40
TC 2	Vertical	7,010	23'	1,800	5' 10"	6,880	475	Ambient to 50	2	100	40
TC 3	Vertical	7,200	23' 7"	1,830	6'	5,940	410	Ambient	2	80	40
TC 4	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 5	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 6	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 7	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 8	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 9	Vertical	2,500	8' 2"	500	1' 7"	7,680	530	Ambient	2	60	40
TC 10	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient	2	60	40
TC 11	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient	2	60	40
TC 12	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient	2	60	40
TC 13	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient	2	60	40
TC 14	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient to 50	2	60	40
TC 15	Vertical	2,500	8' 2"	500	1' 7"	10,150	700	Ambient to 50	2	60	40
TC 16	Horizontal	10,400	34' 1"	1,320	4' 3"	5,190	358	Ambient	2	70	12
TC 17	Vertical	5,000	16' 5"	1,520	4' 11"	1,390	96	Ambient	2	60	12
TC 18	Vertical	6,000	19' 8"	1,570	5' 1"	2,240	155	Ambient	2	60	12
TC 19	Vertical	7,000	22' 11"	1,570	5' 1"	6,380	440	Ambient	2	60	12
TC 20	Vertical	2,380	7' 9"	482	1' 7"	10,150	700	Ambient	3	25	12
TC 21	Vertical	2,380	7' 9"	482	1' 7"	10,150	700	Ambient	3	25	12
TC 22	Vertical	2,380	7' 9"	482	1' 7"	10,150	700	Ambient to 50	3	25	12
TC 23	Vertical	1,010	3' 3"	360	1' 2"	5,940	410	Ambient	1	50	12

Mechanical testing

Balmoral's multi-purpose load rig performs the following test-types and is available for third party use:

- Axial and lateral slip loads to 60t
- Static loading and 3-point bend to 100t
- Bend restrictor/stiffener load to 10t
- Bend restrictor locking radius measurement under load
- Compression and shear testing on companion cylinders to 200t and tensile testing to 150t
- Dropped weight and swing arm impact testing
- Lifting point/insert load testing

Submersion test tanks

Test tanks are available for the following procedures:

- Product weight in water and air
- ROV submersion and functionality
- Submersion and gas leakage
- Underwater NDT inspection
- Flotation
- Riser testing
- Abandonment and cutting tool trials
- Stack up trials

Submersion test tank specifications

Tank	Length		Width		Depth		Fresh water temp	Crane capability
	mm	ft/in	mm	ft/in	mm	ft/in	ºC	Tonnes
Test tank 1	6,500	21' 3"	3,500	11' 5"	4,000	13'	Ambient	40
Test tank 2	6,600	21' 6"	2,300	7' 5"	2,200	7' 2"	Ambient	12
Test tank 3	Ø9,000	29' 6"	Ø9,000	29' 6"	4,500	14' 9"	Ambient	-

For full product details, white papers, case studies and company updates visit www.balmoraloffshore.com

Balmoral Offshore Engineering, Aberdeen
Balmoral Park, Loirston, Aberdeen AB12 3GY
+44 (0)1224 859000 | offshore-sales@balmoral.co.uk

Balmoral Offshore Engineering, Newcastle
+44 (0)191 338 5513 | offshore-sales@balmoral.co.uk

Balmoral Offshore Engineering, Houston
+1 8324 313224 | usa@balmoral.co.uk

Balmoral Offshore Engineering, Brazil
+55 21 2533 3435 | brazil@balmoral.co.uk

Asia Pacific
asiapacific@balmoral.co.uk

India
india@balmoral.co.uk

Canada
canada@balmoral.co.uk

South Korea
southkorea@balmoral.co.uk

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Balmoral core values

The values described below apply to employee relationships with all customers – whether that is within Balmoral Offshore Engineering or with the company's highly valued client base.

Customer focus	Leading and working together as a team to deliver high quality products on time at the best possible price with no surprises
Respect	Treating clients and colleagues as we wish to be treated ourselves, with respect and decency
Integrity	Reliability, flexibility, honesty, openness and fairness. Supporting clients and colleagues at all times with a focus on the common end goal
Accountability	Being proactive in setting and achieving objectives. Taking responsibility in one's role and enhancing the company reputation at all times
Innovation	A commitment to the company's philosophy of innovation, continuous improvement and clear communication, internally and externally
Motivation	Maintaining a focus on aligning efforts and energy to achieve common goals, ie, successful projects. Constantly seeking to add value

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