



DRILLING & PRODUCTION SYSTEMS

FlexJoint™ Technology





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The Breakthrough that Changed an Industry

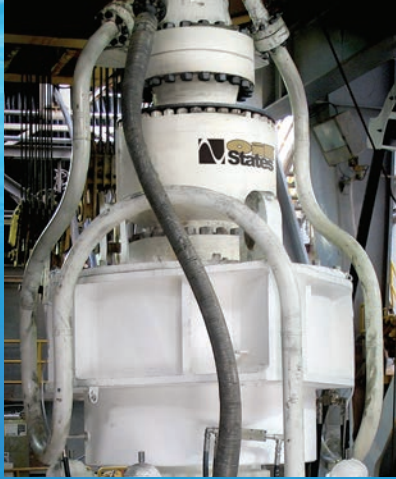
Oil States Industries' FlexJoint® technology was introduced to the offshore petroleum industry in 1976 as a frictionless, maintenance-free alternative to the ball joint. Since then, it has become the industry standard for a wide range of offshore applications where robust, flexible and durable connections are required between surface and seabed.

Developed originally to connect risers and seabed-mounted drilling equipment, the breakthrough flexible joint design features a spherical elastomeric flex element capable of withstanding high axial load with pressure while allowing optimal flexibility.

Today, its value extends across a variety of applications, from SCRs to moorings – with new deepwater advances on the horizon.

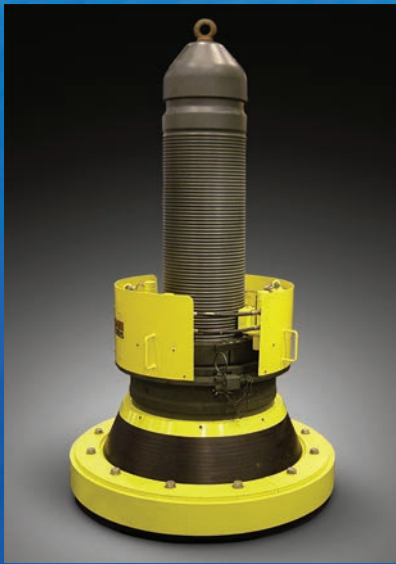
FlexJoint™ Assembly Pressure Containment Applications	FlexJoint™ Assembly Non-Pressure Containment Applications
Subsea Drilling Riser	Tendon Bearing
Intermediate Drilling Riser	Turret Bearing
Diverter Drilling Riser	Gimbal Bearing
Steel Catenary Riser (SCR)	Riser Tower Mooring
Water Uptake Riser	
Lockseal*	

*Military Applications. Due to the sensitive nature of these products information is not provided.



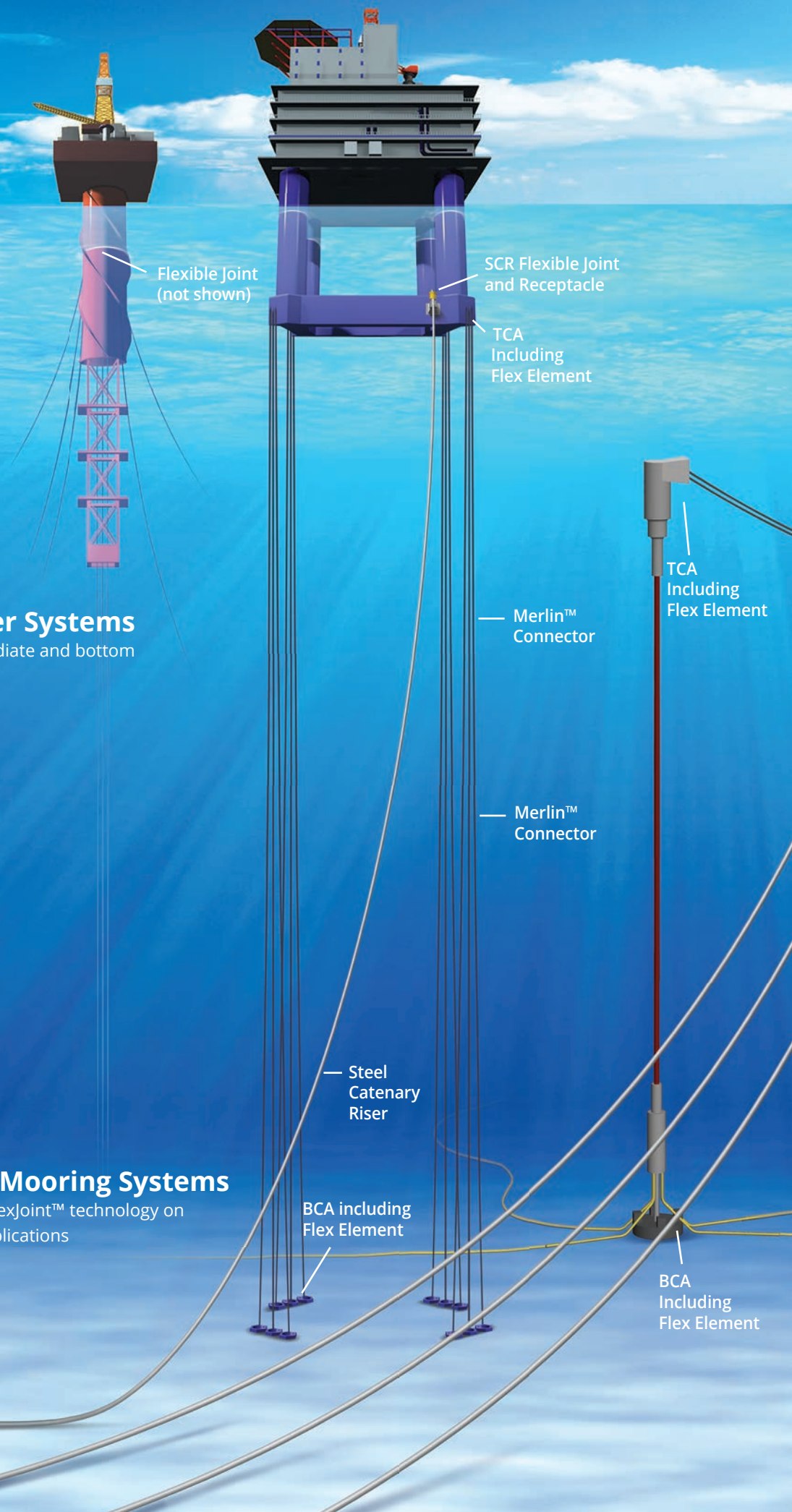
FlexJoint™ Drilling Riser Systems

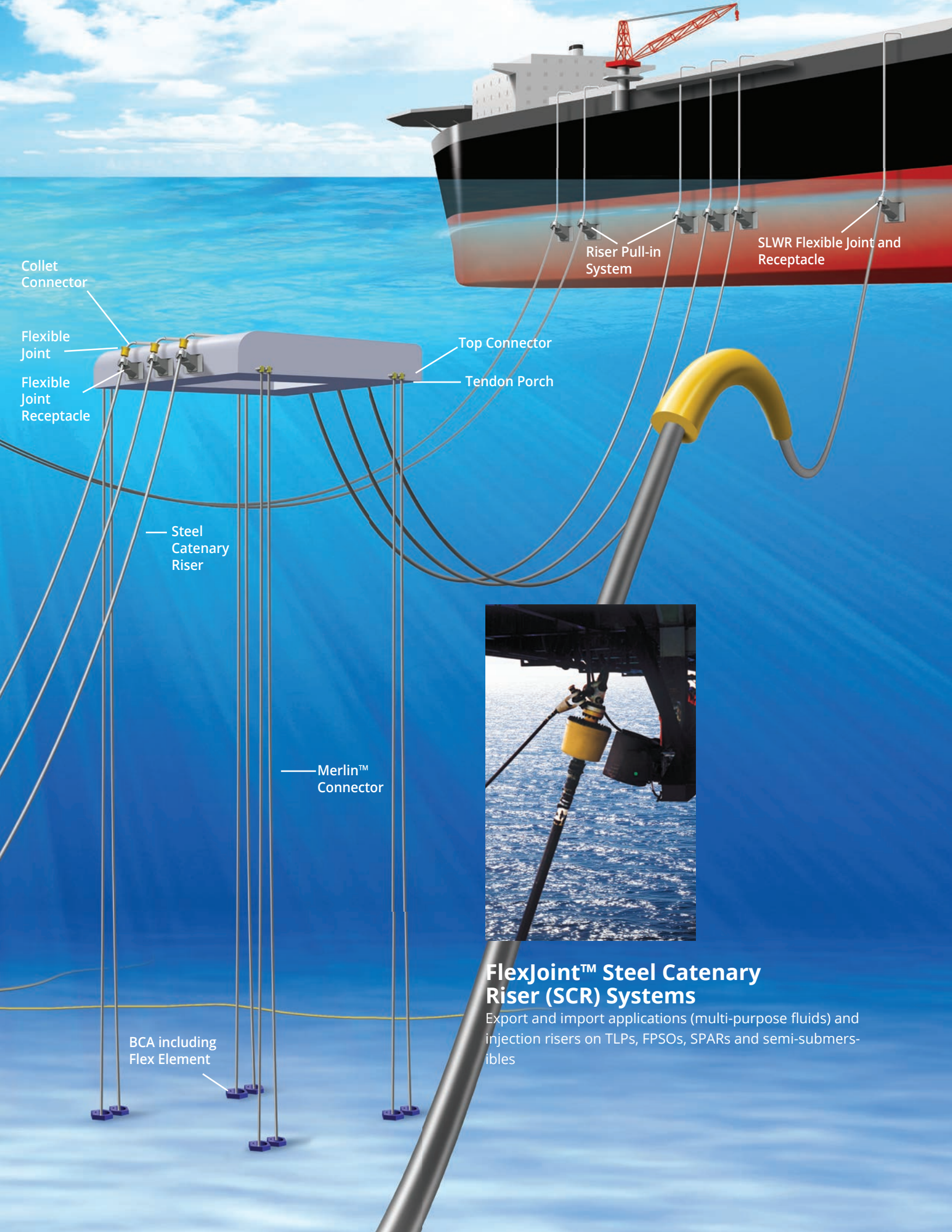
Reliable flexibility at the top, intermediate and bottom levels of a drilling riser



FlexJoint™ Deepwater Mooring Systems

Deepwater mooring systems using FlexJoint™ technology on TLPs, riser towers and alternative applications





Collet Connector

Flexible Joint

Flexible Joint Receptacle

Steel Catenary Riser

Merlin™ Connector

BCA including Flex Element

Riser Pull-in System

SLWR Flexible Joint and Receptacle

Top Connector

Tendon Porch



FlexJoint™ Steel Catenary Riser (SCR) Systems

Export and import applications (multi-purpose fluids) and injection risers on TLPs, FPSOs, SPARs and semi-submersibles

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The benefits of FlexJoint™ Technology

Oil States FlexJoint technology is trusted industry-wide for providing reliable, flexible and versatile connections for a growing range of applications, including drilling and production risers, TLPs, SCRs and deepwater moorings.

- Highly reliable: flexible, frictionless pressure-tight joints accommodate extremes of load and motion
- Cost-effective: precision manufactured, tested and inspected in our quality-controlled facilities, FlexJoint technology provides long service life and reliable operation
- Proven: at depths of 12,000 feet, internal pressures up to 12,000 psi, axial loads of 11 million lbs. and rotation angles of $\pm 30^\circ$
- Adaptable: accommodates axial loads, rotation requirements, fatigue condition and temperature variations of today's most challenging offshore environments – and tomorrow's

Legendary reliability with FlexJoint technology is a product of Oil States' rigorous quality control measures, third-party testing protocols, and analysis of customer specifications.

Our highly controlled manufacturing processes and computerized molding ensure precise tolerances for each elastomeric bearing.

Deepwater Mooring Systems

Oil States is a leading designer, manufacturer, and installer of engineered components for deepwater mooring systems using FlexJoint technology.

Highly reliable and proven, Oil States' tendon connection systems comprise the following:

- Top Connector Assembly (uses FlexJoint Technology for the tendon bearing)
- Bottom Connector Assembly (uses FlexJoint Technology for the tendon bearing)
- Merlin™ TLE Couplings
- Optional Tendon Tension Monitoring System (TTMS) for TLP installations

Top Connector Assembly (TCA)

The TCA is a unique connector design that secures the tendon to the hull while providing adjustment for proper tendon loading.

The TCA consists of the following major sub-assemblies:

- A bowl and slips-style locking mechanism that incorporates a tendon bearing. This assembly mounts on the TLP hull porch.
- The Length Adjustment Joint (LAJ), which comprises the top joint of the tendon and is grooved over a length of approximately 1.5 to 3 meters.

The TCA is engaged using a remote operated Slip Adjustment Tool that is removed after tendon lock-off.

Bottom Connector Assembly (BCA)

Bottom Connector Assemblies are used to connect the bottom of each tendon to the seabed. The interaction of internal and external lugs mate the RotoLatch™ to the receptacle as it is lowered into place. Disconnection can be achieved by indexing the lugs and pulling the RotoLatch vertically out of the Receptacle. The RotoLok™ Bottom Connector system retains the functional and structural features of the RotoLatch System, but includes a mechanism to provide absolute unlatching control.

Alternative Applications

The versatility of Oil States' FlexJoint products offers engineers and designers great latitude in the application of new technology while conforming to environmental and regional parameters. Flexible joints can be used at the top and bottom of flexible jumpers, while the RotoLatch can be used as an end connection for buoyancy tank and bottom connections.



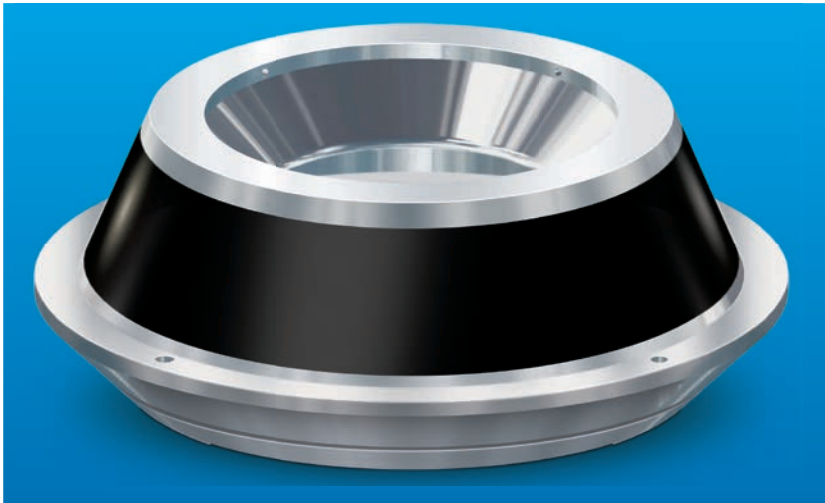
Mooring Connection Systems Related Equipment

Merlin™ Tendon Couplings

Merlin TLE Couplings consist of male and female connectors welded at either end of the tendon pipe. These unique couplings permit pre-welded tendon pipe segments 30 to 90 meters long to be safely assembled offshore without welding. Merlin TLE Couplings include a preload against operating tension, thereby minimizing stress concentrations to extend the service life. The connector's unique grooved thread profile provides clear evidence of proper mating and prevents connector back-off under fatigue loadings.

Tendon Tension Monitoring Systems (TTMS)

The TTMS uses patented Variable Reluctance Measurement Technology (VRMT) to precisely measure and monitor tendon tension on TLP installations. The reliability and long-term stability of this technology has been proven on diverse in-line TLP tendon applications in the Gulf of Mexico. These installations use a Load Measurement Unit (LMU) near the top of the tendon to house the sensors and transmitter data used to calculate load, direction and bending moment information to a central computer monitoring station.



FlexJoint™ Tendon Bearing

Oil States' tendon bearings are used in both TCA and BCA assemblies. The tendon bearings minimize the bending moment at the top and bottom of each tendon, significantly reducing fatigue damage despite the high tension and nearly constant motion of the moored structure.



Merlin Connection Make Up



Load Measurement Unit (LMU)

Alternative Applications

The versatility of Oil States' FlexJoint products offers engineers and designers great latitude in the application of new technology while conforming to environmental and regional parameters. Flexible joints can be used at the top and bottom of flexible jumpers, while the RotoLatch can be used as an end connection for buoyancy tank and bottom connections.



Drilling Riser Systems

Oil States is the leading provider of flexible joints for critical connections at the top, intermediate, and bottom levels of a drilling riser.

Drilling Riser Systems provide:

- A reliable and cost effective leak-proof connection
- A low angular stiffness under high axial tensions and extreme internal pressures
- A means of reducing the bending stresses in the riser and the reaction forces to the subsea stack
- Provides omnidirectional angular flexing capability
- Dampens vibrations and accommodates shock loadings
- Operates reliably in an H2S environment

Diverter Flexible Joint

The Diverter Flexible Joint is installed at the top of the riser below the diverter housing where it will encounter significant compression. It is capable of free angular rotation of $\pm 15^\circ$, up to 4,000 kips tension and 500 psi maximum pressure. The Diverter Flexible Joint is available in different configurations based on the maximum working tension requirements. The Diverter II Flexible Joint contains two flex elements (double-ended) for applications requiring rotation at both ends. Each flex element comprises a primary and secondary flex element. The Diverter III Flexible Joint utilizes one flex element for situations with one fixed end and the other subject to rotation.

Diverter II	-1	-2	-3	-5	-8
Max. Working Tension (kips)	500	1,000	2,000	2,500	4,000
Max. Operating Pressure (psi)	500	500	500	500	500

Diverter III	
Max. Working Tension (kips)	2,000
Max. Operating Pressure (psi)	500



Intermediate Flexible Joint

The Intermediate Flexible Joint is a double-ended version of the Subsea Flexible Joint designed for installation below the telescopic joint. It has the capacity to handle rotation angles up to $\pm 20^\circ$, axial tension up to 4,000 kips and pressure up to 3,000 psi. When necessary, it can also withstand extreme compression loading with limited rotation through metal-to-metal contact of its internal elements.

Intermediate	-1	-2	-3	-4
Max. Working Tension (kips)	2,000	2,600	2,000	4,000
Max. Operating Pressure (psi)	2,000	2,500	3,000	3,000

Field-proven at Macondo

Oil States Flexible Joint technology provided the critical seal in capping the Macondo well in 2010. It withstood over-rotation and extreme well bore temperatures and pressures for an extended duration. This sealing technology is only available with the Oil States FlexJoint Assembly.



BOP Stack with Subsea Flexible Joint



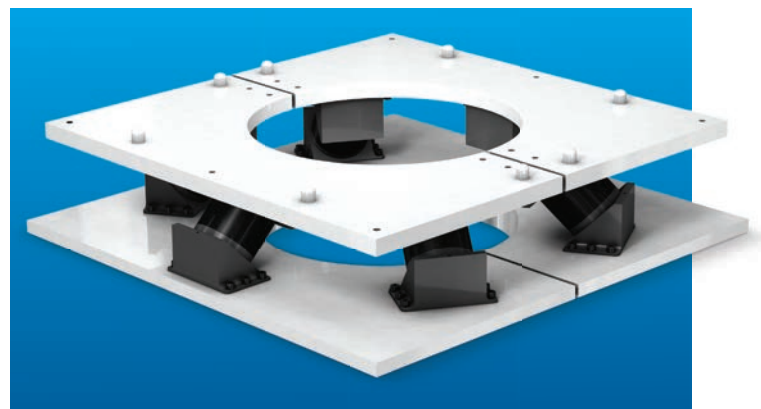
Subsea Flexible Joint

The Subsea Flexible Joint is used to couple the riser to the subsea stack. It is designed to operate in water depths up to 12,000 feet and is capable of angular deflection of $\pm 10^\circ$ and maximum axial tension up to 3,500 kips. This flexible joint is also designed to withstand extreme internal pressures, tensions and rotations. Working pressure ranges from 600 to 6,000 psi.

Subsea								
Nominal Rating (ksi)	LP	2.0K	2.5K	3.0K	3.5K	4.0K	5.0K	6.0K
Max. Tension (kips)	1,000	2,000	2,000	2,000	2,500	2,500	2,500	3,500
Max. Operating Pressure (psi)	600	2,000	2,500	3,000	3,500	4,000	5,000	6,000

Gimbal Bearing

Proven through more than 25 years of offshore application, the Oil States gimbal bearing is designed to absorb loads imposed on the spider/riser due to vessel motion. It is installed directly between the spider and the rotary table and is composed of two halves, each housing three or four flex elements depending on the gimbal bearing diameter size. These gimbal bearings are available in 49.5", 60", and 75" I.D. sizes. The flexible bearings are made of high-grade steel and nitrile elastomer for durability and long service life under harsh conditions.





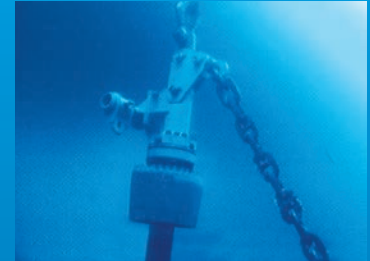
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Steel Catenary Riser Systems

A major coup for the advancement of FlexJoint connection technology came with the introduction of the Steel Catenary Riser (SCR) Flexible Joint on the Shell Auger Tension Leg



Platform (TLP) in the early 1990s. The SCR Flexible Joint became key to deepwater development because of the ability to adapt its design to accommodate the demanding axial loads, rotation requirements, fatigue conditions, pressure and temperature variations present in the Gulf of Mexico and other field developments. The importance of the SCR Flexible Joint to future deepwater development has prompted Oil States to embark on the development of a Second-Generation SCR Flexible Joint with greater load, rotation, pressure, and temperature capability.

Oil States' SCR FlexJoint Technology is reliable and trusted by the offshore industry for use in export and import applications (multi-phase fluids) on offshore structures such as TLPs, FPSOs, SPARs and semi-submersibles.

SCR FlexJoint Size (nominal riser O.D. inch)	Operating Pressure (psi)	Angular Cocking (±deg)	Axial Tension (kips)
4.5	4,550	20	117
5.0	2,850-6,300	11-23	110-483
6.0	4,550-7,850	14-20	150-478
7.0	2,850-10,000	11-23	200-679
8.0 ⁽¹⁾	2,220-12,090	12-25	90-1,200
10.0 ^(1, 2)	2,000-9,800	14-25	150-2,977
12.0 ^(1, 2)	1,350-3,600	13-25	280-2,220
14.0	1,315-3,600	14-20	220-5,400
16.0	750-5,400	14-30	300-1,829
18.0	1,860-3,000	12-24	300-1,475
20.0	1,100-3,650	15-25	500-3,250
24.0	125-3,700	15-20	787-3,892

1. Also manufactured in Pipe-In-Pipe (PIP) configurations.
2. Also manufactured in High Pressure-High Temperature (HPHT) configurations.



Second-Generation Flexjoint Technology for New Offshore Demands

Deeper, harsher and more challenging than ever, the offshore environments in which our customers operate are changing. That's one reason Oil States is developing a new generation of SCR Flexjoint technology with even greater load, rotation and temperature capability. This new technology will provide a revolutionary design and simpler, more cost-effective configuration.

- Operating pressures in excess of 10,000 psi.
- A more efficient cooling mechanism to support higher fluid temperature SCR flexible joint designs
- Improved design capable of higher axial loads
- Equivalent or improved operating capabilities but with savings in lead-time and material cost

Ask your Oil States' representative for additional information.



Gen II Flexjoint Technology



Full-scale Prototype Test



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SCR Flexible Joint Accessories and Services



SCR Receptacle

One of the most common hang-off methods for an SCR flexible joint is a basket-style receptacle. Oil States can design and fabricate receptacles to mate with the platform interface and provide customer-specified hangoff installation and azimuth/heading for the basket. An SCR Receptacle typically consists of a cast steel basket housed in a steel plate structure with lifting eyes for handling. Optional custom features such as a guide cone, guide bars/plates can be added.

Oil States can design, fabricate and supply interface components to accommodate either receptacle or pull-in installation.

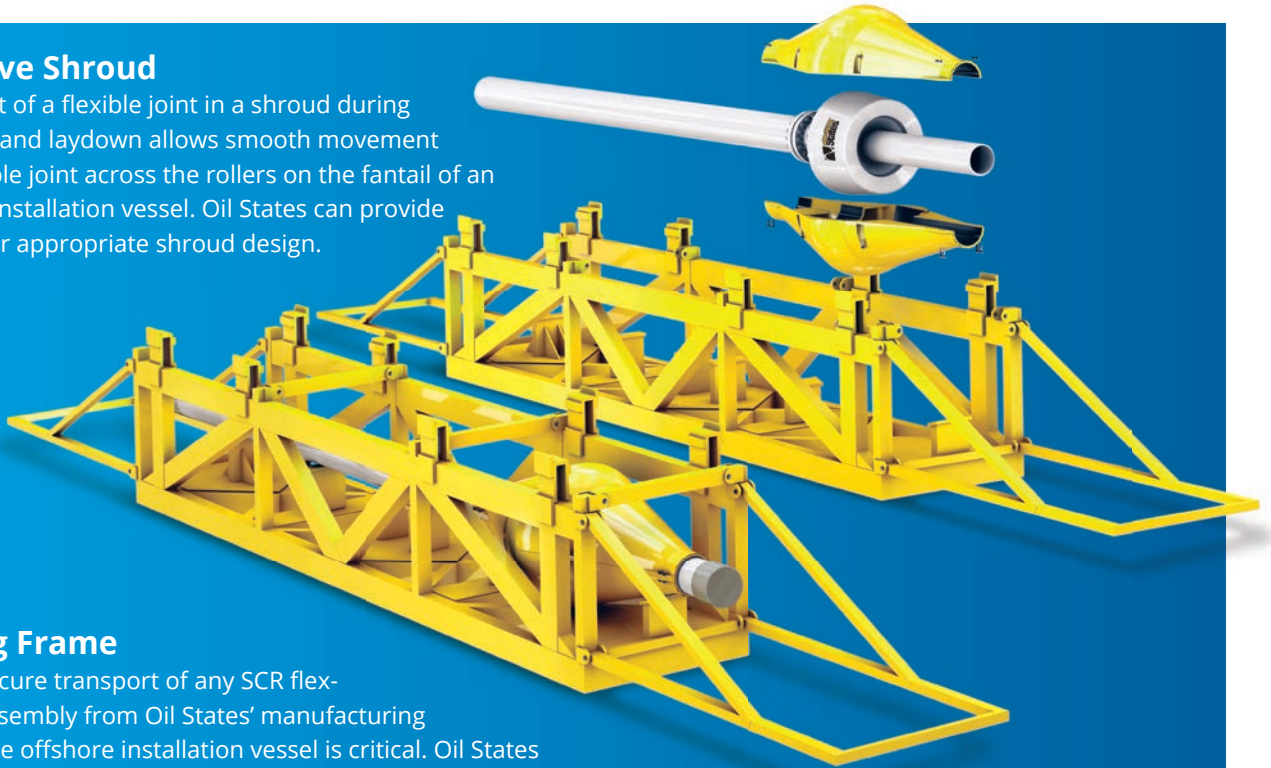
SCR FlexJoint Laydown Tool

To prevent over-rotation and assure proper compression of the flex element, Oil States can design for purchase or lease a factory-installed laydown tool that maintains a predetermined preload throughout the installation/laydown period. Upon recovery of the riser, the tool is removed to permit installation of the SCR flexible joint.



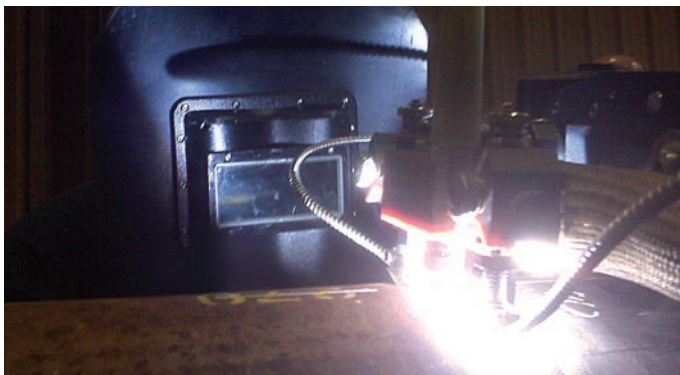
Protective Shroud

Encasement of a flexible joint in a shroud during installation and laydown allows smooth movement of the flexible joint across the rollers on the fantail of an S-Lay riser installation vessel. Oil States can provide guidance for appropriate shroud design.



Shipping Frame

Safe and secure transport of any SCR flexible joint assembly from Oil States' manufacturing facility to the offshore installation vessel is critical. Oil States offers purpose-built welded steel transport frames for purchase or lease to protect individual flexible joints and installed accessories during land and sea loading and transport activities. Upon request, two-high, stackable frames are available to reduce deck congestion.

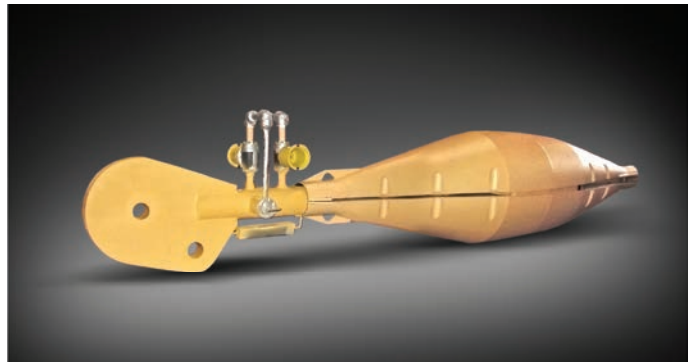


Welding for Critical Flowline Systems

Oil States accommodates customer schedules more efficiently by supplying welding work in combination with the SCR flexible joint. This service typically includes the development and qualification of a welding procedure which is subsequently used to attach a hold collar SCR riser pipe assembly to the end of the SCR flexible joint extension – all according to the most exacting quality standards.

Pull-in Head

Upon request, Oil States can design and fabricate pull-in heads to meet the specific needs of each project.





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