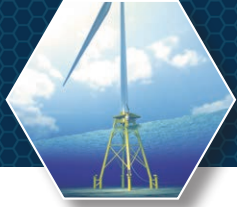


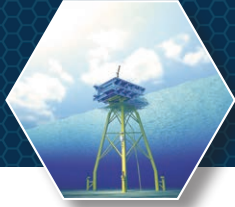


STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

# HYDRA-LOK™ Connections



OFFSHORE  
WIND PLATFORMS



SUBSTATIONS



TEMPLATES



JACKET STRUCTURES  
... and more



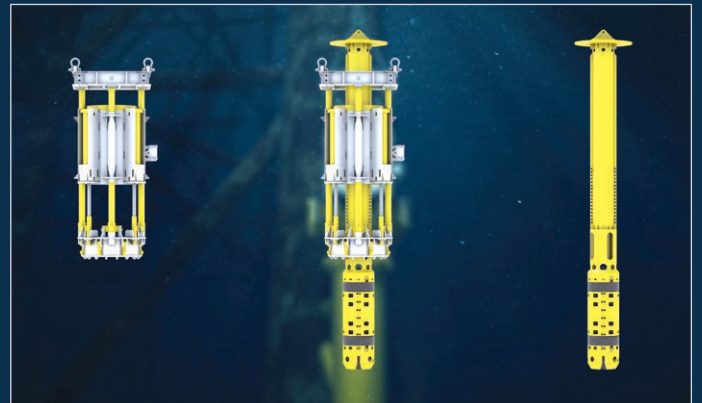
## PROVIDING RELIABLE STRUCTURAL SUPPORT SINCE 1980

Trusted for more than 40 years, Oil States Industries' patented HYDRA-LOK™ swaging system creates pile connections on offshore structures and repairs to platform seawater/firewater caissons, conductors and casing.

The system has been used on hundreds of structures, from subsea drilling templates to large deepwater jackets. HYDRA-LOK technology has also been adapted to perform localised pressure tests on casing joints, pipeline flanged/welded joints and emergency shutdown valves.

For smaller subsea protection structures where lower connection load capacities are needed, HYDRA-LOK LITE™ offers an optimal solution. HYDRA-LOK LITE provides a connection that is pressure-tight and as structurally strong as the parent casing for casing applications.

◀ Single operation structural levelling and pile connection using 54" HYDRA-LOK™ and Latch-Lok Jacking Tool





STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

# HYDRA-LOK™ Connections

## HYDRA-LOK at a Glance

### Single deployment • Rapid connection

- Immediate full-strength capacity
- Real-time verification

- Meets ISO 9001: 2015, ISO 14001: 2015 and OHSAS 18001:2007
- Forms connections on standard pile sizes ranging from 24 to 72-inch diameters and up to 84-inch for levelling, with a 20:1 to 40:1 diameter-to-wall thickness ratio (d/t)
- Holds Lloyds Register's 'Type Approval' and DNV's 'Approval in Principal'
- Bureau Veritas, the American Bureau of Shipping (ABS) have certified structures using HYDRA-LOK's swaged pile connections
- Built-in inspection system allows connections to be formed and examined in just two hours
- Reduces securing a four-pile structure with equipment handling to eight to 10 hours
- All swage tools and auxiliary equipment are tested to meet project operating pressures before offshore mobilisation
- Swage tools easily integrate with the Latch-Lok jacking system, allowing structures to be levelled and secured in a single-tool deployment operation.

### Minimal spread • Minimal team

- Environmentally safe

## HYDRA-LOK Connections

### Expandable Tubular System for Casing Connections

- Pressure testing
- Internal casing patch
- External tie-back connection
- Zonal isolation barrier
- Expandable liner hanger

HYDRA-LOK sealing/tubular expansion technology has a proven track record covering pile swaging, localised pressure testing and caisson repair operations. While most of these activities involve working pressures below 10,000 psi (690 bar), the basic HYDRA-LOK sealing arrangement can operate at pressures more than three times higher. This makes HYDRA-LOK ideal for casing and pipeline repair applications.

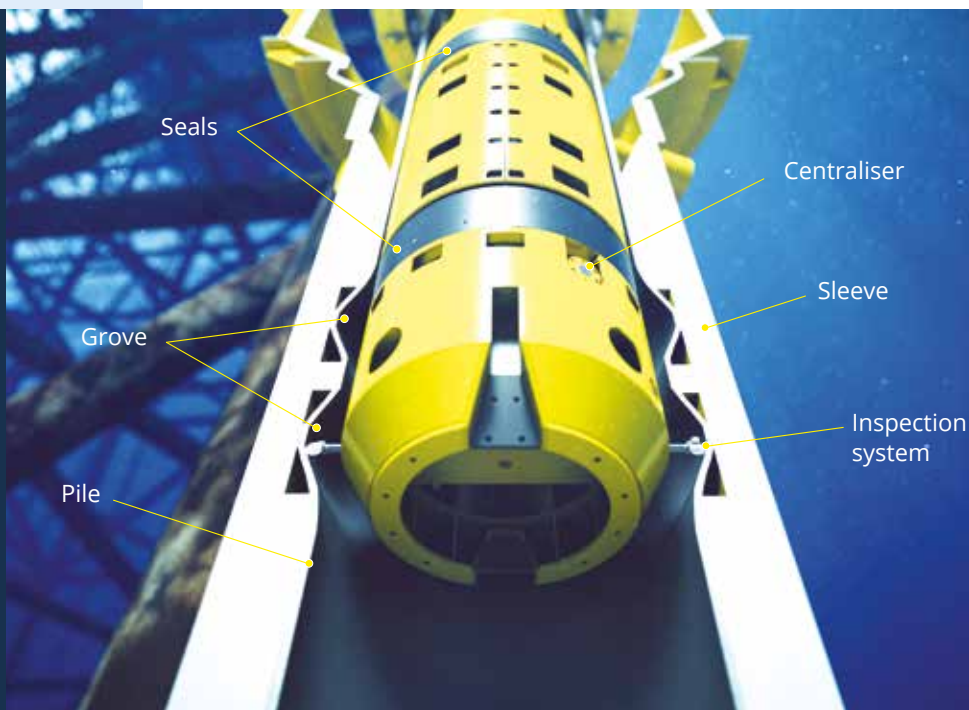
The casing connection system utilises the higher working pressure capability to "cold forge" pressure-tight, metal-to-metal connections (such as casing "cross-over" joints) or localised pressure testing.

The system was initially developed for a casing patch application, aiming to use a HYDRA-LOK tool to expand the top end of a slumped casing into a multi-groove, overshot sleeve fitted to the foot of a new casing string. A key advantage of the system is the tool's ability to be re-positioned to span the joint interface after forming the connection and then used to internally pressure test the connection to its full test pressure without repositioning.

The system is verified on 5" O.D. L80 and P110 casings and 9 5/8" O.D. P110 and XT155 casings. This sleeve geometry is optimised to allow a HYDRA-LOK tool to make a 9 5/8" casing connection in approximately 35 minutes that can operate at pressures up to 35,000 psi (2,414 bar). A final P110 test connection pressurised to an internal pressure of 11,000 psi (759 bar) was successfully loaded to 620Te.

54" jacket swage pile connection ►

The pipe is fully expanded over the distance between the swage tool seals to take up the annular clearance between the two tubulars and make full contact with the sleeve bore





## HYDRA-LOK Pile Connection Technique

### Overview

The HYDRA-LOK swage pile connection system is simple. Two tubulars - the pile and a sleeve fabricated to the structure - are connected through the hydraulic expansion of the pile into the sleeve. Depending on pile size, it typically takes one to two hours to form the swaged connection, which has immediate full-strength capacity for the pile expansion into the sleeve and hydraulic pressure release.

The pressure/volume (P/V) plot shows the stages of the expansion process:

1. The initial elastic expansion of the pile
2. Its yield and plastic expansion contact the internal diameter of the sleeve

The expansion increases with rising pressure, as the pile is forged into the bottom of the groove and against the sleeve bore up to the elastic limit of the sleeve material.

The connection forms when the calculated final pressure is reached, completing the process. Upon releasing the pressure, the sleeve contracts elastically onto the pile, creating an interference fit. Axial loads and bending moments are transferred from the structure into the pile through loading across the groove corners and the frictional forces generated between the two tubulars on release of the hydraulic swage pressure.

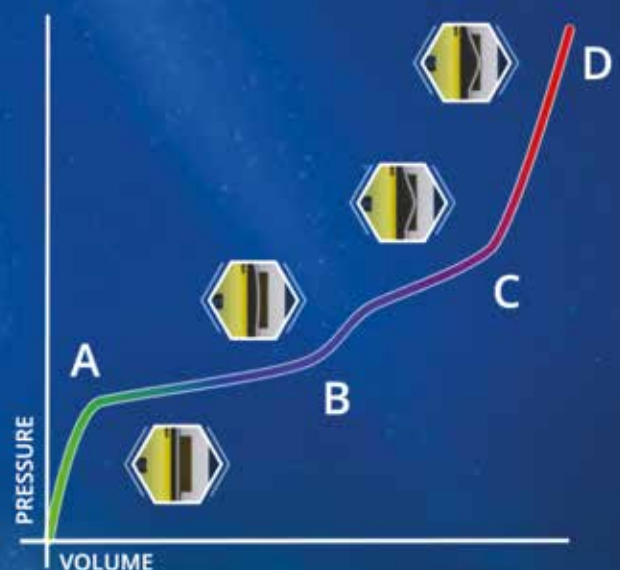
The technology can be used to secure any type of offshore structure with piled foundations. Pile-size connection diameters (in inches) range from:

- 24 to 36 for subsea protection structures, pre-drilling templates and small manifolds
- 36 to 60 for shallow water jackets and large subsea templates
- 60 to 72 for ice-resistant platforms, deepwater jackets and wind turbine generators



▲ Cut-out section through a two-groove HYDRA-LOK™ connection

### Immediate full strength connection on reaching calculated pressure



Expansion Pressure/Volume (P/V) plot ▲



STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

# HYDRA-LOK™ Connections

## Operational Sequence

The operational sequence to install an offshore structure using the HYDRA-LOK system is straightforward:

1. Set the structure on the seabed
2. Drive the piles
3. Deploy the HYDRA-LOK swage tool subsea to form the connections

Once subsea, the swage tool is stabbed into the pile and positioned within the sleeve relative to the pile-top elevation.

The swage tool is then centralised and isolation seals are inflated, trapping an annulus of water between the tool and pile, which is subsequently pressurised to expand the pile into the sleeve grooves.

Once the connection formation is complete, the swage tool inspection system is activated to confirm the correct connection geometry as the tool is lifted from the pile. The HYDRA-LOK tool is then transferred to additional piles and the process is repeated until all connections have been formed.



▲ ICE resistant platform installation - 72" pile connection

## Operational Control

The swaging operation is an accurately controlled and continuous process. Onshore engineering completed before mobilisation calculates the final swage pressure and volume required to form the connection. The swaging process is accurately and simply monitored by measurement of the pressure and volume of water pumped into the annulus between the pile and tool seals. A P/V plot allows the operator to visualise the process in real time and control the operation.

## Operational Advantages

- Real-time verification of connection formation
- Rapid, full-strength connection
- Fast, reliable operations reduce marine spread time
- Environmentally friendly and pollution-free
- Diverless in any current at any depth
- Short connection length lowers pile weight and cost
- Reduced equipment spread and labor cost

## HYDRA-LOK Connection Capacities

A firm and fixed connection between pile and structure is essential for platform stability and necessary to receive approval from certifying authorities. HYDRA-LOK has Lloyds Register of Shipping 'Type Approval' and DNV's 'Acceptance in Principle,' establishing basic compression, tension and bending strengths. Bureau Veritas, the American Bureau of Shipping (ABS) have approved HYDRA-LOK's use, and Joint Industry Study testing verifies HYDRA-LOK's fatigue performance. Metallurgy testing on the parent and weld metal as well as the corrosion behaviour of the completed connection has also been confirmed.

HYDRA-LOK connection sleeves are fabricated from standard offshore structural steels (EN10225 S355 G8+N, Z35), with the number of sleeve grooves required dependent upon the connection's required axial capacity.

Approved sleeve manufacturing methods include:

- **Type 1**  
**Machined from rolled and welded plate**  
The sleeve is rolled and fabricated from the plate with sufficient wall thickness to achieve a machined bore to the specified dimensions and tolerances while maintaining the required minimum wall thickness
- **Type 2**  
**Two thicknesses of plate rolled and welded into rings**  
The rings are welded together to produce the required sleeve geometry without machining, and project drawings indicate the plate thicknesses needed for producing the internal profile.

### Certifying Authority approved axial load capacities for 1, 2, 3 and 4 grooved connections at various pile sizes:

Pile Size (inches)	Wall Thickness (inches)	Connection Axial Load Capacity (Tons)			
		1 Groove	2 Groove	3 Groove	4 Groove
24	0.625 to 1.0	232 to 379	330 to 538	465 to 578	697 to 1137
30	0.75 to 1.5	292 to 570	415 to 810	585 to 1139	877 to 1709
36	1.0 to 1.5	466 to 799	663 to 1135	933 to 1597	1399 to 2396
42	1.0 to 2.0	546 to 1066	776 to 1515	1093 to 2132	1639 to 3198
48	1.25 to 2.25	779 to 1226	1107 to 1742	1557 to 2452	2336 to 3678
54	1.35 to 2.5	947 to 1716	1346 to 2438	1894 to 3431	2841 to 5147
60	1.5 to 3.0	1169 to 2279	1662 to 3238	2339 to 4557	3508 to 6836
72	2.0 to 3.5	1638 to 3195	2328 to 4540	3276 to 6390	4915 to 9584



54" swage HYDRA-LOK™ tooling ▲



7,000 ton Jacket Template, levelled and swaged in Caspian Sea ▲



STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

# HYDRA-LOK™ Connections

## HYDRA-LOK LITE for Subsea Structures

The HYDRA-LOK LITE “swaged” connection is a simple interference-fit sleeved joint between two plain steel tubulars. This solution is an alternative to the HYDRA-LOK structural pile connection with a heavy wall “grooved” sleeve arrangement that’s typically used on small subsea structures where the pile connection axial load requirement is low – 100 Tonne or less – and connection deflections are not critical. The connection is formed by locally expanding the inner tubular (pile) to contact the surrounding outer tubular (sleeve). The expansion process induces a small plastic deformation or “bulge” in the outer sleeve that’s 1 to 2% of the diameter.

With the release of hydraulic pressure used to form the swaged connection, the sleeve elastically contracts onto the pile to generate an interference fit connection between the two tubulars. The resulting connection capacity can be varied significantly by using dissimilar strength steels for the pile and sleeve.

A single HYDRA-LOK LITE connection takes approximately 30 minutes, and a single four-pile structure can normally be swaged within a total deck-to-deck time of eight hours.

## Offshore Operation

After positioning the HYDRA-LOK LITE swage tool within the pile/sleeve, the main seals are inflated by pumping water from the surface power pack via a service umbilical. The seals expand to contact the inside of the pile, trapping an annular volume of water around the tool centre body. This “annulus” and the seals are then pressurised together to expand the pile and the surrounding sleeve.

During the pressurisation process, a pressure and volume (P/V) plot is produced, providing real-time monitoring and verification of the swaging process. On completion of the swage, the hydraulic pressure is released at the tool to allow the seals to retract before the tool is withdrawn from the pile.



Cut-out section through a two-groove ▲  
HYDRA-LOK™ connection



▲ 36" Levelling & swaging tool single deployment in the Dutch Sector North Sea



## CASE STUDIES

### Agip

#### Cross-over Connection Installation

The operator required the casing configuration for two onshore wells to be changed approximately 200 metres below ground level. The plan was to carry out an explosive backoff at the required elevation on an existing 9 7/8" T95 casing joint, recover the upper casing, run in with a new 10 3/4" casing string and make up to the 9 7/8" T95 casing using a standard cross-over sub. As a contingency, the 9 7/8" casing could be cut and then swaged into a new 10 3/4" casing string using the HYDRA-LOK multi-groove overshot sleeve as the cross-over joint.

The existing 9 5/8" swage tool was modified for drill string deployment and remote operations, and a full 9 7/8" T95 test connection was made prior to mobilisation to the site. The operator successfully tested the connection to 300 Te axial load with simultaneous 3,000 psi internal pressure.

#### Highlights:

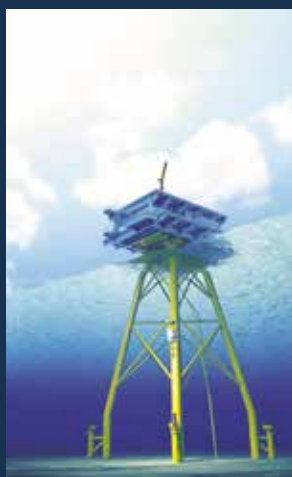
- New casing run with overshot HYDRA-LOK sleeve
- Existing steel casing swaged into overshot sleeve
- HYDRA-LOK tool run on drill pipe
- Connection made and tested in a single deployment
- Connected casing material up to 155 ksi yield
- Metal-to-metal seal
- No reduction in I.D.

### TOTAL

#### Pressure Testing

An operator wanted to pressure test some suspect 10 3/4" casing joints in five offshore high temperature/high pressure wells. In each well, the operator deployed the HYDRA-LOK tool on the drill string to a depth of approximately 300 metres and positioned it to span across the suspect casing joint. With the seals inflated and tool pressurised, necessary localised pressure integrity tests were conducted. Each joint was subjected to a hydrostatic pressure test at 11,000 psi, followed by a gas pressure test at 5,000 psi – without the need for tool recovery.

The tool for this project was purpose-built using the existing main sealing systems from the 9 5/8" swage tool. As part of the factory acceptance trials before mobilisation, the tool was pressure tested to 15,000 psi using water and 6,500 psi using nitrogen.





Oil States Industries sales, engineering & manufacturing facility | Heartlands, UK ▲

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