



STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

Hydra-Lok™ Caisson Repair





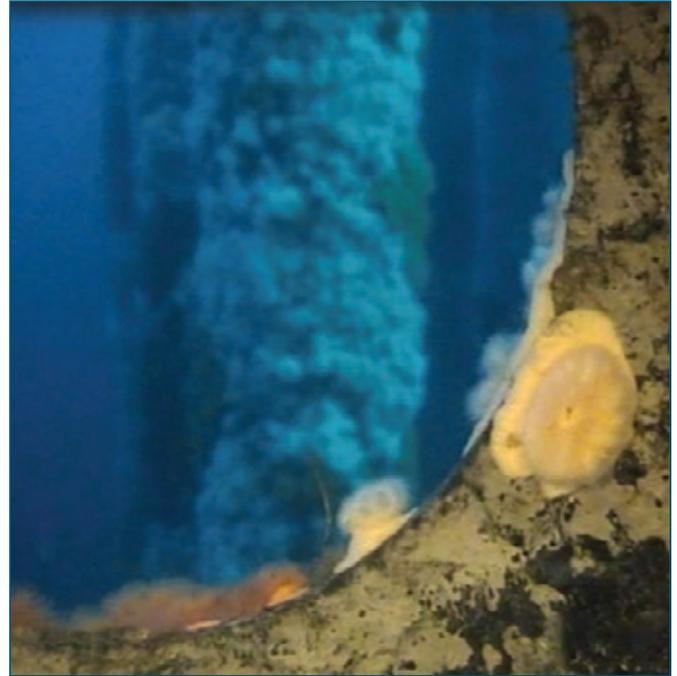
Caisson Integrity

Main Causes for Caisson Damage

- Depleted structural or pump anode defense
- Localized internal corrosion (wall thinning)
- Stress cracking (longitudinal or circumferential)
- General deterioration
- Through wall penetration

Typical Damage to Caissons

Caissons are part of an offshore platform structure and are often safety and or production critical in the extraction of seawater by means of submersible electric or diesel pumps within the caisson. The extracted seawater is then used on the platform for the cooling, production and fire services. Due to the in-service life extension of the platform, these caissons are notorious for suffering severe corrosion damage in the area around the pump caused by galvanic action between the pump and the caisson. Severe localized corrosion can cause through hole defects, leading to pump inefficiency and in certain instances can cause the caisson to fail and sever.

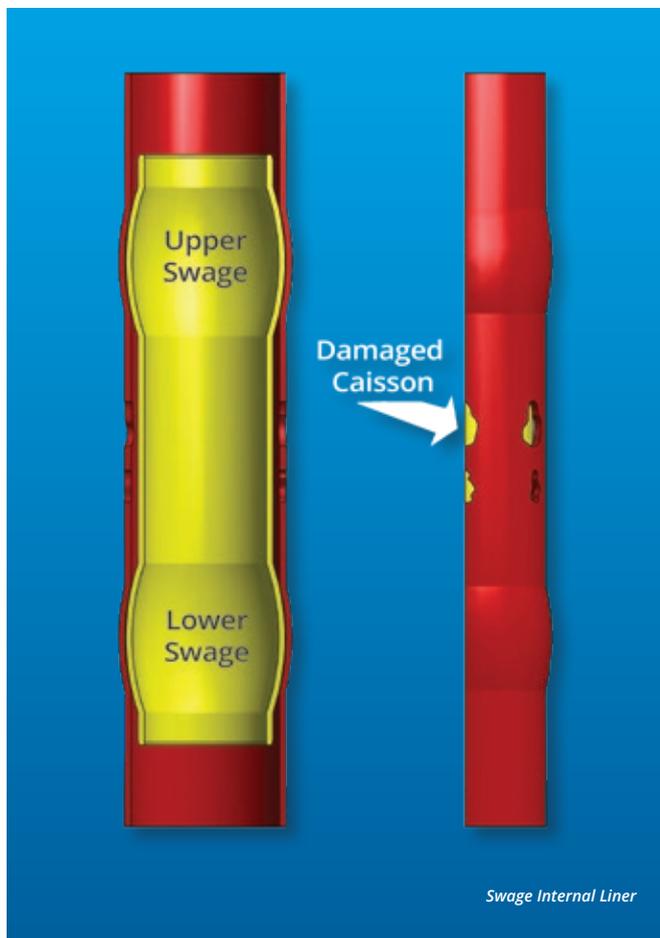


Corrosion through the side of a caisson

From initial platform commissioning, corrosion protection systems, such as anodes and or chemical dosing systems, are installed to prevent corrosion. However, when these defenses are depleted and/or not renewed, the corrosion that follows can be aggressive and rapid. Another example of localized damage due to the effects of waves & currents is stress or fatigue cracking (circumferential welds), where a caisson passes through a guide or the oscillation of the pump centralizes which again, can result in failure.

These cases, combined with general deterioration, when the caisson fails and breaks away, the pump is left exposed with operating inefficiency. Worst case scenario, the pump and pump string can sever and drop within the severed caisson section. Falling caisson can cause serious damage to jacket members, seabed equipment or expensive repairs to pipelines. Internal caisson degradation and pump string failure are becoming an increasing issue and can become a significant operational risk with the potential of causing a dropped object scenario.

Oil States Industries offer a permanent caisson repair integrity solution to primarily deploy within the existing caisson with a secondary cylindrical liner sleeve fabricated from material grade steel. This would then be positioned on both sides of the damaged areas and plastically expanded into the existing undamaged caisson parent material.



Swage Internal Liner

Caisson Inspection

- Visual inspection
- High pressure water jet cleaning
- Debris & object retrieval
- 3rd Party UT corrosion mapping inspection

Visual Inspection

An offshore caisson visual inspection is carried out before and after repair operations. Oil States Industries has a range of purpose built camera systems, which provide real-time footage, from the initial screening to close up identification as part of an on-site assessment.

Caisson Cleaning

In addition to the visual inspection, it is necessary to clean and then visually inspect the caisson. The cleaning operation is carried out using high pressure water jetting in conjunction with water flushing to wash out any debris. The post cleaning visual inspection ensures there are no obvious restrictions and identifies the area and extent of the internal damage of the caisson.

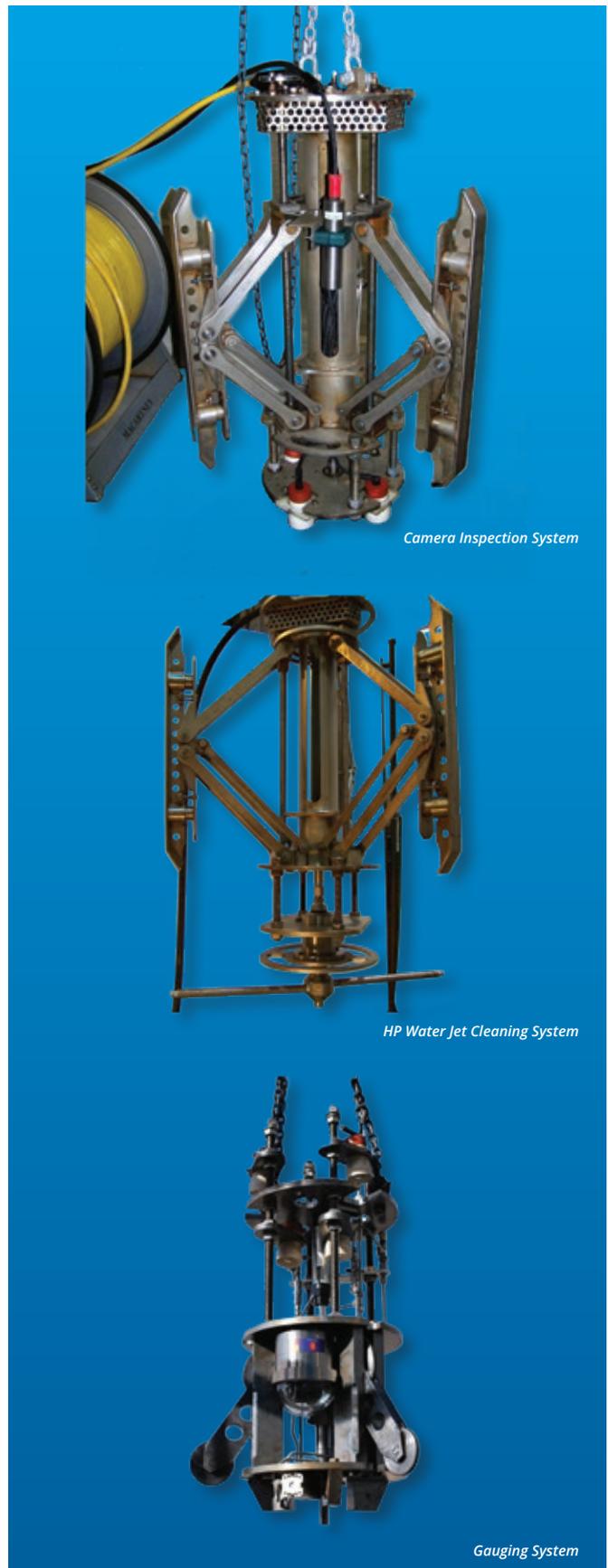
Inspection Options

Oil States specializes in fast turnaround bespoke solutions and offers in-house engineering from the initial design concept through to offshore implementation with minimal downtime. Our experience in the field of caisson inspection also includes retrieval of pump section (strings), pump baskets, anodes, ant, fouling units and other internal obstructions and debris items.

Oil States' gauging system can monitor and log any change to a section of caisson or any reduction in the bore by measurement of the inside diameter. The system can simultaneously carry out a video survey to assess caisson condition.

Capabilities include the initial camera survey, followed by a quick development retrieval system e.g. hydraulic grab with the option of a combined camera system to ensure any obstructions or debris are removed. Various gravity deployed systems, electrically or hydraulically operated from the platform, can be adapted for other similar retrieval applications.

Typical retrieval applications are: anodes, pump strings, detached pump baskets, internal coating detachment, foreign objects and general debris.



Camera Inspection System

HP Water Jet Cleaning System

Gauging System



Typical Caisson Repair Sequence

It is necessary to remove the pump and its riser sections from the caisson. It is common for the pump to be refurbished and anodes to be replaced at the same time a repair is carried out.

The caisson is given an initial camera visual inspection to assess its condition, the amount of marine growth and corrosion scale present. The internal bore of the caisson is then cleaned using high pressure water jetting. This removes any growth and thick scale to allow passage of the liner to the site of the damage. After cleaning, a further and more detailed camera visual inspection accurately fixes the position and extent of the damage and ascertains the condition of the rest of the caisson. The survey is then used to determine the position of the liner and tooling from the top of the caisson.

The liner is usually a plain tubular, ideally of a single length, which is lowered into the caisson and supported on the top. The Hydra-Lok™ swaging tool is then lowered inside and connected to it by hydraulically operated rods to hold it during the lowering operation. The support pads are removed from the liner and the combined tool and liner lowered as a single unit to the repair location.

Once in position the liner is expanded into two positions, above and below the damaged area. The process, which takes approx. 30 minutes, is controlled by the Pressure/Volume Plot as shown below.



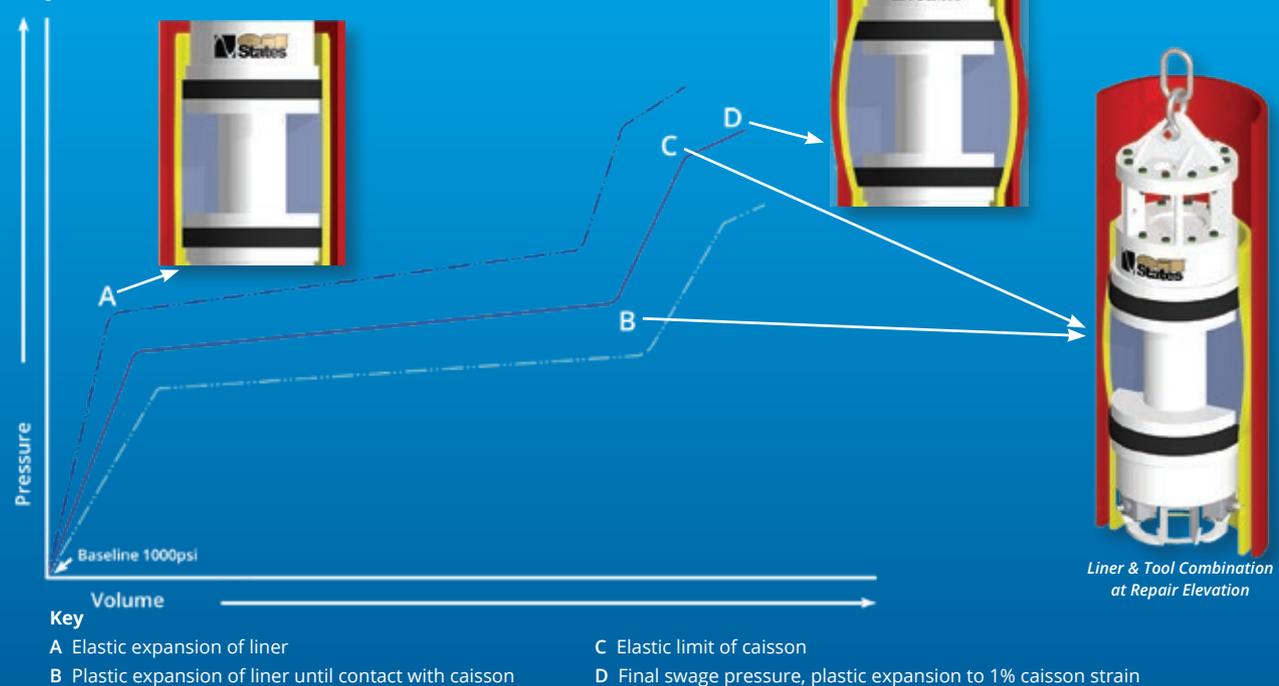
Top of Caisson Post Clean

The liner is now structurally connected to the caisson either side of the damage and capable of withstanding any environmental loading for which it was originally designed.

Expansion Pressure/Volume (P/V) Plot

The Pressure/Volume Plot is a clear, quantifiable 'picture' of the expansion of the liner and caisson and provides the operator with accurate, real-time management of the swaging operation.

Expansion Pressure/Volume (P/V) Plot



Hydra-Lok™

Oil States developed the Hydra-Lok™ tubular expansion technique in the 1980's and has used this system to repair damaged caissons by internally attaching a liner to bridge the damaged area.

The swaged repair is made from inside the caisson, which eliminates any external working including diving. In addition to being safer and lower in cost, the reinstatement can be carried out in all but the most severe weather conditions. For that reason repairs do not normally need to be scheduled during a platform shutdown.

Caisson Repair Features

- Expansion technique
- Diverless
- No halt in production
- Cost effective
- Non weather dependent

Caisson & Liner Details

Caissons with OD sizes from 323.9 mm diameter (12.75 inches) to 1100 mm diameter (43.3 inches) and with wall thickness ranging from 9.5mm (0.375 inches) to 28mm (1.1 inches) have been repaired. Many types of liner have been employed for special applications ranging in thickness from 7.5mm (0.3 inches) to 30mm (1.18 inches). Final liner lengths have varied from 3.75 meters to 46 meters. Most repairs are carried out from the pump room which does not have access to the platform crane. This limits liner lengths to the height of the compartment. Liners are therefore usually made up of approx. 3 meter lengths which are connected together over the caisson. They may be connected together by welding but, as 'hot working' is often undesirable, this is usually done by using proprietary connectors. When the final length is made up, the liner is 'drifted' through the caisson to the repair location to ensure there are no hang-up points before returning it to the top of the caisson for assembly to the tool. The tool liner combination is then lowered to the repair location to carry out the repair.

- Liner Parameters
- Caisson OD from 12.75" - 43"+
- Lengths from typically 3m up to 47m
- Connectors or welding solutions
- High expansion to pass internal restrictions
- Extend broken caissons
- Realign crooked caissons
- Bespoke solutions



Liner Connector Assembly



Liner Connector Make-up Trials



STRUCTURAL INTEGRITY & ABANDONMENT SERVICES

Hydra-Lok™ Caisson Repair

High Expansion Liners

In certain cases, caissons have for one reason or another, a restriction in the bore. This may be caused by a change in thickness, a splice inserted at the time of jacket installation or even an earlier swage repair carried out at an upper level.

These restrictions sometimes need to be passed to reach a new area of damage below.

Oil States Industries has developed a system, which uses high expansion liners which pass through the upper restriction and to then repair the lower damage.

Special Repairs

Caissons come in various diameters, wall thicknesses etc. and the damage they sustain, whether from corrosion or stress, can vary enormously. If the damage has reached an advanced stage, then the caisson may have actually parted.

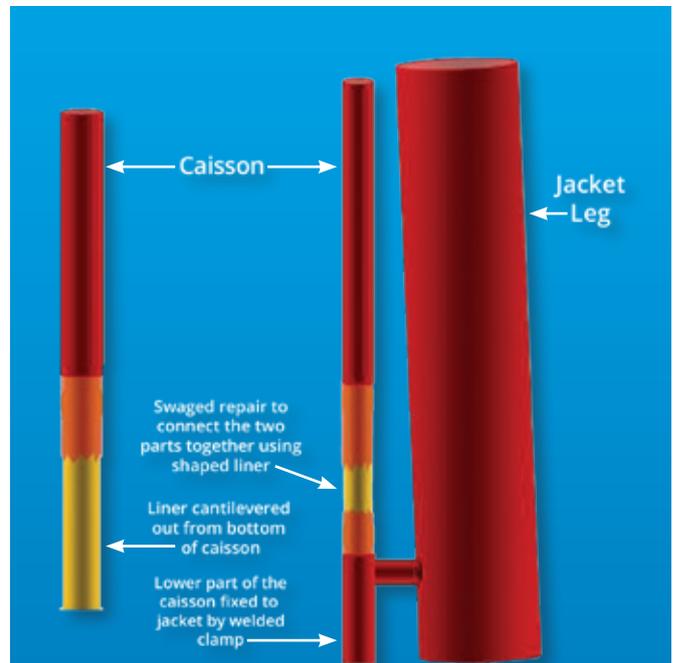
In the situation where the caisson hangs freely within guides from an upper dead-weight support, parting of the tubular results in the lower section of the caisson dropping to the seabed. A repair liner with its upper end swaged into the remaining caisson and its lower end cantilevered out, can be used to extend a severed caisson. A number of such caissons have been extended in this way, typically by 3 to 4 meters, and up to 12 meters.

When the caisson is clamped or supported at multiple elevations, parting of the tubular results in unexpected twisting of the caisson and clamps, which can lead to fatigue cracking in the jacket leg. To rectify this problem, a repair liner with a shaped 'nose' can be installed to realign and reconnect the two parts of the caisson back together.

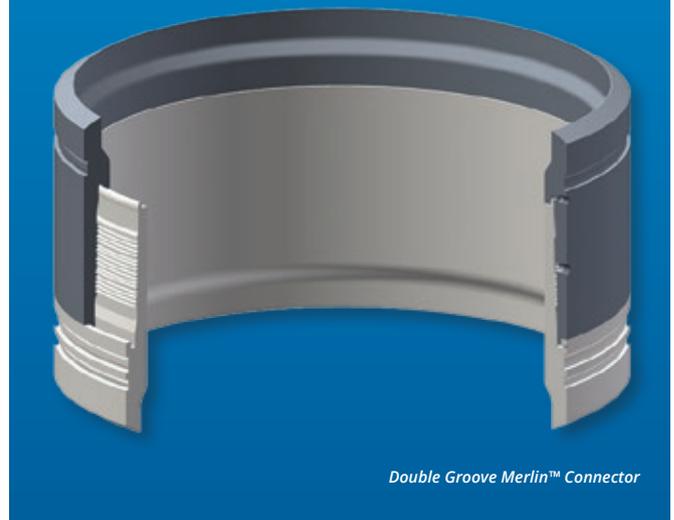
New Caisson

In instances where inspection has identified defects at multiple elevations that negate the use of internal swage liner repair, Oil States have a long history of providing a mechanically connected solution.

Our Merlin™ connector has been field proven in a variety of applications, from Caissons, Risers, Conductors, Casing and TLP tethers we have supplied over 450,000 of these connectors over our 30 year history. Specific advantages include non-rotational make-up using our own bespoke tooling, dual metal to metal sealing faces, onshore NDT of welds and the ability to tension test a made-up connection before running.



Support Caisson Repair



With the Merlin™ connection taking three minutes to make-up and verify and no requirement for hot work permits, it is ideally placed to offer a much more cost effective solution than welding.

Oil States have field proven sizes ranging from 6.625" to 72" including Merlin™ pipe in pipe solutions and, as we manufacture everything including rental tooling in-house, we have the experience to deliver your entire project on budget and on time.

The Hydra-Lok™ Track Record

Since 1996 Oil States Industries has been providing caisson internal swage liner repairs as part of the platform asset integrity management. To date, over 159 caissons have been repaired worldwide. Size of caissons range from 323.85mm (12.75") up to 1100mm (43") OD with liner lengths ranging from 2.35 meters up to 47 meters. The swaging operating equipment spread is compact and easily transportable; 3rd party jetting units can be locally sourced to avoid increased shipping costs.

Our track record is unique as we liaise directly with the asset holder/operators and have worked with clients such as:

- Shell UK
- BP UK
- BG Group
- Nexen
- Statoil
- Wintershall Norge
- Marathon
- Apache
- Maersk
- EnQuest
- TAQA
- Conoco Phillips
- Repsol Sinopec Resources
- Repsol Norge
- Centrica
- CNRI
- BP Norway
- ExxonMobil



Swage Tool Mobilization



Caisson Joint Section with Dead Weight Support



Intermediate Caisson Joint Section



Caisson Section
Transition Cone & Crash Barrier



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