Metal-to-Metal Casing and Liner Solutions
Gas-tight technology for the life of the well
Metalmorphology
Metal-to-metal sealing and anchoring technology

Metalmorphology® metal-to-metal sealing and anchoring technology uses direct hydraulic pressure to shape metal downhole, enabling metal-to-metal connections that provide high axial load and pressure containment.

- Typically a casing joint or stinger is morphed into a grooved receptacle to engage and seal, forming a permanent connection.
- The two tubular components are connected using pressure delivered via a setting tool operating at high pressure at the connection interface.
- A low pressure is applied at surface, and downhole intensifiers increase the pressure to the level required at the tool.

Advantages of using Metalmorphology technology
- Contains no moving parts
- Conforms to the tubular ID, capable of performing within API, tolerance, and ovality
- Does not use cone expansion techniques and is not limited to single weight range increments
- Maintains material properties after morphing
- Creates a high-axial-load metal-to-metal, gas-tight connection between two casing strings

Cutaway of a casing joint morphed into a receptacle. Compression blocks are seen in the crushed state because of the morphing of the tubular into the receptacle.

Downhole mechanics
- Landing edges of the casing stub and the receptacle have high residual contact pressure profile, ensuring a metal-to-metal seal.
- Plastic strains in outer and inner tubular remain within specified material properties.
- Burst, collapse, and bidirectional load capabilities can be predicted by using finite element analysis (FEA) and are verified with qualification testing.

A typical morph pressure curve shows the material plastic expansion and final morph pressure.

FEA study shows stresses of casing tubular morphed into receptacle.
Metal-to-metal, gas-tight solutions
Casing and liner systems based on Metalmorphology technology

Casing Reconnect
The Casing Reconnect® metal-to-metal, gas-tight casing repair system provides an in situ means of restoring a downhole casing connection.

Liner Tieback
The metal-to-metal, gas-tight liner tieback systems tie a liner system to surface with a full metal-to-metal connection created downhole. The latest offering provides ream-down capabilities and therefore the benefit of having a full casing string to surface.

Load Anchor
The load anchor system provides full metal-to-metal anchoring of downhole equipment. It is an effective anchor for high-axial-load applications where sealing is not required.
Casing Reconnect

Metal-to-metal, gas-tight casing repair system

Restore casing integrity with expansion technology

The Casing Reconnect metal-to-metal, gas-tight casing repair system creates a gas-tight metal-to-metal seal connection downhole by using the patented morphing technology to morph the existing customer casing into a receptacle. The pressures required to achieve morphing depend on the specific casing in the well and the desired test pressures. On surface, the pressure required is typical to standard operations, and these are multiplied downhole by an intensifier. All of the pressure is contained within the setting tool and the area of the casing being morphed.

The end result is a fullbore, high-tensile-strength, gas-tight, V0-rated connection. No elastomers are required for the connection.

Available sizes

<table>
<thead>
<tr>
<th>Size</th>
<th>in</th>
<th>mm</th>
<th>ID</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 in</td>
<td>8.535</td>
<td>216.8</td>
<td>12.347</td>
<td>314.1</td>
</tr>
<tr>
<td>95/8 in</td>
<td>9.190</td>
<td>233.4</td>
<td>12.191</td>
<td>309.7</td>
</tr>
<tr>
<td>93/8 in</td>
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<td>233.4</td>
<td>12.191</td>
<td>309.7</td>
</tr>
<tr>
<td>133/8 in</td>
<td>13.333</td>
<td>338.9</td>
<td>12.347</td>
<td>313.6</td>
</tr>
<tr>
<td>135/8 in</td>
<td>13.333</td>
<td>338.9</td>
<td>12.347</td>
<td>313.6</td>
</tr>
<tr>
<td>14 in</td>
<td>13.333</td>
<td>338.9</td>
<td>14.000</td>
<td>355.6</td>
</tr>
</tbody>
</table>

Sample Casing Reconnect System Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>9%/in</th>
<th>9%/in</th>
<th>13%/in</th>
<th>13%/in</th>
<th>14 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal casing size, in</td>
<td>9%/in</td>
<td>9%/in</td>
<td>13%/in</td>
<td>13%/in</td>
<td>14 in</td>
</tr>
<tr>
<td>Nominal ID, in/mm</td>
<td>8.535</td>
<td>8.535</td>
<td>12.191</td>
<td>12.347</td>
<td>14</td>
</tr>
<tr>
<td>Casing drift, in/mm</td>
<td>8.535</td>
<td>8.535</td>
<td>12.191</td>
<td>12.347</td>
<td>14</td>
</tr>
<tr>
<td>Casing weight, lbm/ft [kg/m]</td>
<td>53.5</td>
<td>53.5</td>
<td>72</td>
<td>72</td>
<td>92</td>
</tr>
<tr>
<td>Casing grade</td>
<td>C110</td>
<td>P110</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal pressure, psi [MPa]</td>
<td>2.865</td>
<td>2.865</td>
<td>5.000</td>
<td>5.000</td>
<td>7.35</td>
</tr>
<tr>
<td>External pressure, psi [MPa]</td>
<td>2.865</td>
<td>2.865</td>
<td>6.860</td>
<td>6.860</td>
<td>10.0</td>
</tr>
<tr>
<td>Axial compression, lbf [daN]</td>
<td>69,000</td>
<td>69,000</td>
<td>1,465,000</td>
<td>1,465,000</td>
<td>1,465,000</td>
</tr>
<tr>
<td>Axial tension, lbf [daN]</td>
<td>1,147,000</td>
<td>1,147,000</td>
<td>1,465,000</td>
<td>1,465,000</td>
<td>1,465,000</td>
</tr>
</tbody>
</table>

Ratings represent qualification achieved based on specific requirements and do not represent maximum achievable rating on the connection. Additional qualification testing can be conducted in casing in which higher ratings are required.

Basic operational sequence

1. Casing cut and dressed. Casing Reconnect system spaced out with new casing, which is set in a surface hanger.
2. Setting tool positioned on depth using the integrated latch mechanism.
3. Hydraulic pressure applied, monitored, and controlled from surface.
4. Setting tool recovered to surface, leaving a morphed metal-to-metal, gas-tight connection.

Casing Reconnect System Saves Customer USD 3 Million

Case Study

Challenge

While running the 13¾-in Q125 casing section in a new-drill water injector, a customer was unable to land and set in the hanger, so the casing was cemented high. The customer then needed to reconnect the casing to the subsea wellhead with a tight gas seal to avoid a time-consuming sidetrack and an estimated cost of USD 3 million.

Solution

Using the Casing Reconnect system, the operator reinstated the 13¾-in Q125 casing with full integrity and no reduction in ID, avoiding running a whipstock and sidetrack.

Results

Within 2 days, the Casing Reconnect system achieved a permanent metal-to-metal, gas-tight, axial-load-bearing connection with full integrity and ID, enabling drilling to continue as planned.
Liner Tieback System Saves Time and Cost in High-Risk Wells

**Case Study**

**Challenge**
An operator in the North Sea wanted to install a 9½-in liner and tieback system designed for the life of the well. The tieback system was to be cemented. Although engineers were aware of the challenges of running the liner string to TD because of the reservoir characteristics and well trajectory, the customer wanted to gain the benefits of having a continuous casing string from TD to surface.

**Solution**
The liner tieback system with ream-down option was used successfully. The liner was run to TD with the robust setting adapter enabling ream-down running with high torque, high tensile strength, and high pumpthrough capacity. The liner hanger was landed and cemented in place. The tieback string was then deployed and morphed at the receptacle into the existing liner string.

**Results**
The liner tieback system was successfully used to create a continuous, full metal-to-metal production string from TD to surface. The solution enabled ream-down running for the liner system and maintained the integrity of a full casing string. This eliminated the challenge of running the entire production string in a single run.

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**Liner Tieback**

**Metal-to-metal, gas-tight liner tieback system**

- **Rated up to 2,500,000 lbf [1,122,000 daN]**
- **Rated up to 8,000 psi [55 MPa]**
- **Rated up to 160 degC [320 degF]**

**APPLICATIONS**
- Extended-reach drilling
- Deviated wells
- Deepwater wells with heavy production strings
- Wells with architecture or conditions that make it challenging to run long casing strings

**FEATURES**
- ISO 14310 V0 rating
- Installation depth not limited by liner space-out
- Eliminates need for polished bore receptacle (PBR) elastomeric sealing
- Enables planning for well integrity over the field’s lifetime
- Has the capabilities of a ream-down liner system with the integrity of a full casing string

**Available sizes**

<table>
<thead>
<tr>
<th>Diameter</th>
<th>ID in</th>
<th>OD in</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 in</td>
<td>7</td>
<td>71/2</td>
</tr>
<tr>
<td>9½ in</td>
<td>9½</td>
<td>10</td>
</tr>
<tr>
<td>14 in</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

**Basic operational sequence**
1. Liner tieback system is positioned below or above the liner hanger.
2. Tieback casing is run into the liner tieback system.
3. Setting tool is positioned.
4. Hydraulic pressure is applied, monitored, and controlled from surface.
5. Setting tool is recovered, leaving a morphed, metal-to-metal, gas-tight connection.

**Ream-down liner tieback system**
The ream-down liner tieback system integrates the conventional liner tieback system with the setting adapter from the field-proven COLOSSUS® liner hanger systems. This optional combination enables reliable high-torque deployment for liners in challenging environments. The system can be used with or without packers and hangers, depending on the application.

**Ream-down system features**
- Liner can be cemented or uncemented.
- In the hangerless ream-down option, the liner assembly has a stick OD with no moving parts, slips, gauge rings, or elements.
- The assembly diameter is maintained at connection OD to prevent increases in equivalent circulating density (ECD).
- Liner hanger is optional and can be used when the liner casing must be in tension.
- High torque—up to 60,000 ft.lbf is available while reaming down at the interface between the running tool and the setting adapter.
- After morphing, a full-ID, metal-to-metal, gas-tight connection exists from TD to the wellhead.
- A full system recovery option is available for this method.

**Liner Tieback System Technical Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range (psi)</th>
<th>Range (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal pressure</td>
<td>5,000-24,500</td>
<td>35-171</td>
</tr>
<tr>
<td>External pressure</td>
<td>4,200-29,300</td>
<td>29-200</td>
</tr>
<tr>
<td>Axial compression</td>
<td>350-3,000</td>
<td>24-200</td>
</tr>
<tr>
<td>Axial tension</td>
<td>300-3,000</td>
<td>21-200</td>
</tr>
<tr>
<td>Torque deployment</td>
<td>300-3,000</td>
<td>21-200</td>
</tr>
</tbody>
</table>

**Challenges**

- Run into the well with expandable stinger and space out correctly for casing hanger.
- When casing hanger is landed, run into the well with morphing tool, position in stinger, and complete morph operation.
- Pull out of the well.
- A full recovery option is also available.

*The liner tieback system can be run with the Schlumberger integrated liner hanger running tool to form a ream-down system. It is also compatible with other vendors’ liner hanger and packer equipment.*

*Control to be positioned below the liner top to fail safe.
Load Anchor
Metal-to-metal anchor for tieback casing

Well integrity assurance
The load anchor is set against the outer casing above the hanger to remove excessive compression loading from the hanger and tieback seal. The load anchor can also be used to prevent movement of the tieback casing to help maintain the integrity of traditional seal stacks and PBR systems.

APPLICATIONS
- Anchor casing, tieback, and hanger to enable higher load capacity
- Lock uncemented tieback strings in place without space-out issues

BENEFITS
- Reduces the effect of thermal expansion while anchoring extended-reach drilling completion strings
- Enables use of conventional liner hanger equipment that would otherwise be unable to support heavy axial loads

FEATURES
- Cost-effective, nonsealing, robust metal-to-metal load anchor system
- Bidirectional high axial-load-bearing capability
- Effectiveness for the life of the well
- Applicability for fully anchored uncemented tieback
- Compatibility with NACE MR0175 standard for sour service

Available sizes

<table>
<thead>
<tr>
<th>Size</th>
<th>OD (in)</th>
<th>Nominal ID (in)</th>
<th>Internal pressure (psi)</th>
<th>External pressure (psi)</th>
<th>Axial compression (lbf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 3/8 in</td>
<td>5.750</td>
<td>6.375</td>
<td>11,000</td>
<td>13,400</td>
<td>1,300,000</td>
</tr>
<tr>
<td>10 3/8 in</td>
<td>12.125</td>
<td>12.125</td>
<td>9,760</td>
<td>5,880</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

Sample Load Anchor Technical Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>7 3/8 in</th>
<th>10 3/8 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>OD (in)</td>
<td>5.750</td>
<td>12.125</td>
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<tr>
<td>Internal pressure (psi)</td>
<td>11,000</td>
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<tr>
<td>External pressure (psi)</td>
<td>13,400</td>
<td>5,880</td>
</tr>
<tr>
<td>Axial compression (lbf)</td>
<td>1,300,000</td>
<td>1,000,000</td>
</tr>
</tbody>
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Typical applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assisting Line Hanger</td>
<td>Conventional liner system</td>
</tr>
<tr>
<td>Supporting Tieback Load</td>
<td>Load anchor supports tieback load</td>
</tr>
<tr>
<td>Assisting Supplemental Hanger System</td>
<td>Conventional hanger system</td>
</tr>
<tr>
<td>Load anchor supports supplemental load</td>
<td></td>
</tr>
</tbody>
</table>

Load Anchor Proves Viable to Ensure Life-of-Well Connection

Challenge
An operator in the Gulf of Mexico wanted to install a 7 3/8-in liner and tieback system designed for the life of the well. A Schlumberger liner tieback system was to be installed and left uncemented below the conventional hanger system, eliminating conventional liner tieback seals. However, because the uncemented 7 3/8-in tieback string’s worst-case discharge (WCD) loads were well beyond the conventional hanger slip load design, it was necessary to develop a bidirectional casing load anchor that could engage the host casing string without pipe movement and keep the liner in place without transmitting the loads to the liner hanger.

Solution
The load anchor needed high bidirectional load-bearing capability so that the drilling and completion operations could proceed as planned. Using Metalmorphology technology, Schlumberger created a bidirectional casing load anchor without conventional slips or hydraulic cylinders and which would not require pipe movement to engage the host casing. The capability was successfully demonstrated and qualified in a test well.

Results
The test demonstrated the technology’s extremely high bidirectional load-bearing capability; metal-to-metal contact with no moving parts, setting cylinder, or seals; full internal pressure integrity; no internal restrictions; life of well connector; and functionality without cementing.