**MAROKO Coupling Test Results**

**Overview**

The MAROKO connector is a patented weldless mechanical coupling that has been designed to connect steel pipes without the need to weld.

This document provides an overview of the tests undertaken to date in order to verify the products performance under combinations of internal pressure and external load. The tests, along with a solid design basis and manufacturing QA will qualify the product for Lloyds TYPE approval in the size range 1” n.b to 16” n.b. and with design pressures up to 10,000 psi (ANSI 2500lb equivalent).

The approval will qualify the connector as a permanent connection system for all piping classes including Hydrocarbon.

The connectors design complies with the requirements of the ASME B31 piping codes, ASME Div VIII and the IACS P2 specification. API compliance is not currently possible due to the removal of the API 6H specification which covered mechanical connectors.

**Product Overview**

The connector comprises 3 key elements

* A centre sleeve that spans the pipes being connected.
* 2 half shell clamps that lock the connector to the pipes and the centre sleeve.
* A unique and patented ‘Radial Wedge Seal’ that provides a metal seal between the pipe and the centre sleeve.

The half clamps grip the connecting pipes by means of grooves machined into the pipes periphery.

The clamps are closed by tensioning through bolts.

The seals are energised by cap head bolts.

The connector can be classified as a ‘groove type connector’ that is considered to be a permeant connection method for metallic piping systems. It is possible to remove and reuse the connector.

**Test Couplings**

The following coupling sizes were used for the main test programme.

2” to suit Schedule 40 pipe (Grade B). The design pressure for this coupling is equal to the maximum allowable design pressure for the specified pipe, (2377 psi) in accordance with ASME B31.3 (based upon minimum wall thicknesses). (The design pressure for an ANSI B16.5 900 LB rated weld neck flange is 2220 psi).

4” to suit Schedule 120 pipe (Grade B). The design pressure for this coupling is equal to the maximum allowable design pressure for the specified pipe (3655 psi) in accordance with ASME B31.3 (based upon minimum wall thicknesses). (The design pressure for an ANSI B16.5 1500 LB weld neck flange is 3705 psi).

8” to suit Schedule 80 pipe (Grade B). The design pressure for this coupling is equal to the maximum allowable design pressure for the specified pipe (2114 psi) in accordance with ASME B31.3 (based upon minimum wall thicknesses). (The design pressure for an ANSI B16.5 900 LB weld neck flange is 2220 psi).

The test programme was designed to test the connectors on the pipe they would normally connect in an operational scenario, with the exception of the bust testing where the objective is to ensure the couplings strength far exceeds that of the pipe, so heavy wall pipe was used.

**Tests**

The following tests were successfully completed with no signs of pressure loss, structural failure or connector movement.

* Tightness Test – Assembly and pressure test to 1.5 times design pressure.
* Pull Out Test – Internal pressure (design) and tensile pull
* Burst Pressure Test – Internal pressure to a minimum of 4 times the design pressure.
* Vibration (Fatigue) – varying amplitudes and frequencies
* Fire Test – In accordance with API 6FB
* Gas Test – internal pressure (bubble test)
* 4-point bend with internal pressure both low pressure and high bend and high pressure and low bend tests were undertaken.
* Ultimate pull out – to failure.

All tests were either undertaken at UKAS accredited test facility and / or Lloyds witnessed.

**Pipes and Test Pressures**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Coupling Nominal Bore | Pipe Schedule | Nominal Wall Thickness (in) | Design Pressure (psi) | Equivalent ANSI Rating | Hydrotest pressure (psi) |
| 2" | 40 | 0.154 | 2377 | 900 LB | 3566 |
| 4" | 120 | 0.438 | 3655 | 1500 LB | 5483 |
| 8" | 80 | 0.5 | 2114 | 900 LB | 3171 |
|  |  |  |  |  |  |
| **Coupling Proof (Burst) Test** | |  |  |  |  |
| Coupling Nominal Bore | Pipe Schedule | Nominal Wall Thickness (in) | Design Pressure (psi) | Target Pressure  (psi) | Achieved Pressure  (psi) |
| 2" | 40 | 0.154 | 2377 | 9508 | 10745 |
| 4" | 120 | 0.438 | 3655 | 14620 | 18101 |
| 8" | 80 | 0.5 | 2114 | 8456 | 12913 |
|  |  |  |  |  |  |

Note: Tests stopped due to pipe yielding / safety

In addition, a 4” 420 bar (design pressure) coupling was internally tested by BHR Group to 1600bar, at this pressure the pipe failed catastrophically.

**Vibration**

Tests performed in accordance with IACS P2

All tests were performed at 15-35 Deg C with hydraulic oil as the test medium and with an internal pressure equal to the couplings design pressure.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coupling Dia | Design Pressure | No of Cycles | Amplitude (mm) | Frequency (hz) |
| 2” | 2377 psi | 3,000,000 | +/- 0.06 | 100 |
|  |  | 3,000,000 | +/- 0.50 | 45 |
|  |  | 3,000,000 | +/- 1.5 | 10 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coupling Dia | Design Pressure | No of Cycles | Amplitude (mm) | Frequency (hz) |
| 4” | 3655 psi | 3,000,000 | +/- 0.06 | 100 |
|  |  | 3,000,000 | +/- 0.50 | 45 |
|  |  | 3,000,000 | +/- 1.5 | 10 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coupling Dia | Design Pressure | No of Cycles | Amplitude (mm) | Frequency (hz) |
| 8” | 2144 | 3,000,000 | +/- 0.06 | 100 |
|  |  | 3,000,000 | +/- 0.50 | 45 |
|  |  | 3,000,000 | +/- 1.5 | 10 |

**Pull Out Test**

The tests were undertaken in accordance with IACS PC specification and with internal pressure equal to the couplings design pressure.

|  |  |  |
| --- | --- | --- |
| Coupling Size | Design Pressure | Applied Tensile Load |
| 2” | 2377 psi | 46.9 Kn |
| 4” | 3655 psi | 258.7 Kn |
| 6” | 2144 psi | 5497 Kn |

**Ultimate Pull Out Test**

A 4” coupling (with internal pressure equal to its design pressure (3655) psi) was subjected to a tensile pull until either pressure loss or mechanical failure occurred.

The applied tensile load equalled 1356 Kn – pipe failure / pull out.

**Bend and Pressure**

4-point bend test with internal pressure.

2 sets of tests undertaken on each of the 2”, 4” and 8” couplings.

Low pressure (500psi) / high bend

High pressure (design pressure) / low bend

The applied bending moment, in both scenarios was sufficient to generate a minimum combined pipe wall stress of 80% smys.

**Fire Test**

4” and 8” couplings have successfully passed the API 6FB Pt 1 fire test.

**Gas Bubble**

4” 3655 psi coupling successfully passed a gas bubble test.