Patent Description (with Claims)

Fibreglass-Reinforced Epoxy Liner System Assembly Design, with Insulating Liner having Similar Coefficient of Thermal Expansion as Carbon Steel

Background

[0001] In the oil and gas industry, a common issue faced by many oil and gas producers is the corrosive condition experienced in “sour service” wells which contains significant amounts of hydrogen sulphide, carbon dioxide, and other corrosive agents; sometimes seawater for offshore wells. This corrosive medium would result in corrosion pitting and stress cracking when in contact with unprotected carbon steel piping systems resulting in high costs of maintenance and replacement. Various methods have been developed to extend the service life of tubular piping systems in sour service oil and gas wells.

[0002] To reduce the effects of corrosion, one common method used in the industry is to clad or line the inner tubing diameter with a thin layer of corrosion-resistant and chemically inert material, e.g. fibreglass-reinforced epoxy. This liner is usually lined internally through the entire length, ending at the pin connector. The liner is then held in place at both pipe ends with an end cap, which ensures the fixed positioning of the liner relative to the pipe body. In a threaded and coupled connection, the pin connectors are threaded and made up with a box coupling, and and elastomeric seal ring is placed in the gap between the pin connectors, which is easily compressible to insulate this gap. Theoretically, this should help to reduce corrosion occurring at the pin and box connector interface.

[0003] One common issue faced using current designs is the displacement of the seal ring due to exposure to the rapid flow of production fluids. The seal ring could be dislodged due to a variety of reasons and common failure modes such as: (i) over-compression of the seal ring due to over-torque of the connection at high temperatures; (ii) under-compression of the seal ring due to under-torque of the connection which may cause the loose seal ring to be easily displaced; (iii) thermal expansion and protrusion of the seal ring due to elevated temperatures. When the seal ring is displaced, it may be sucked into the fluid flow and thus enabling the corrosion process to occur at the exposed carbon steel within the connection.

[0004] Fibreglass-reinforced epoxy is a common material used to line the inner diameter of carbon steel tubular piping systems due to its relatively inert chemical properties and fluid impermeability. The liner is then held in place at both pipe ends using an end cap. It has a comparatively better thermal compatibility with carbon steel compared to other thermoplastics because the average coefficient of thermal expansion of fibreglass-reinforced epoxy is similar to that of carbon steel (fibreglass-reinforced epoxy: 19×10^{-6} / °C; carbon steel: 12×10^{-6} / °C). At elevated temperatures

of up to 90°C in sour service wells, for an average pipe length of 9 metres, there is a very small expansion differential of around 4mm to 6mm between the inner fibreglass-reinforced epoxy liner and and the carbon steel tubing. Due to this small expansion differential, it is possible for the fibreglass-reinforced epoxy liner to be end-capped approximately level to the end facing of the carbon steel pipe, without any significant inward buckling of the inner fibreglass-reinforced epoxy liner due to thermal expansion.

[0005] As such, there is a need for a novel fibreglass-reinforced liner system design that addresses the above-mentioned common issue of seal ring dislodging due to over-compression due to (i) over-torque of the connection, or (ii) thermal expansion and protrusion of the seal ring.

Summary of the Disclosure

[0006] The disclosed inventive design comprises a fibreglass-reinforced epoxy inner pipe liner held in place at both ends of the pipe by end caps. It is housed within a specially designed threaded and coupled connection, which is suitable for use in tubular piping systems. The carbon steel box coupling of the connection would have a recessed groove in the middle of the coupling to house a compressible elastomeric seal ring. The carbon steel pin connector design would remain unchanged from the original, other than the addition of the internal liner material.

[0007] For the first aspect of the disclosed inventive design, this involves a precisely-designed external shoulder on the carbon steel pin connector which would snugly fit the edge of the box connector upon final make-up, acting as a precise torque stop. This torque stop would help to set a fixed degree of compression for the elastomeric seal ring during said make-up, preventing displacement of the seal ring due to over- or under-compression.

[0008] For the second aspect of the disclosed inventive design, there is a recessed groove in the middle of the carbon steel coupling. The groove is precisely designed to house and seat the T-shaped compressible elastomeric seal ring snugly in such a way to prevent displacement of the seal ring; even when the seal ring undergoes some thermal expansion in the elevated temperature conditions within the well, or when the seal ring is undergoing a fixed degree of compression upon final make-up of the carbon steel connection.

[0009] The third aspect of the disclosed inventive design is a gas-tight (metal-to-metal) seal profile interaction between the carbon steel pin connector and the box coupling, designed for tubular piping systems with high internal pressure. This metal-to-metal seal profile arises due to a seal interference between both the pin connector and the box coupling, achieving full seal interference upon final make-up. This is important to achieve overall gas-tightness for the connection and prevent any gas leak paths from occurring. For tubular piping systems with low pressure, this gas-tight metal-to-metal seal profile would be an optional feature.

[0010] The fourth aspect of the disclosed inventive design is a corrosive-resistant, chemically inert and impermeable layer of fibreglass-reinforced epoxy, able to withstand elevated temperatures within the tubular piping system, and with a relatively similar coefficient of thermal expansion as carbon steel. This layer acts as an inner liner to insulate the carbon steel pipe body against corrosive conditions. The method of installation of the fibreglass-reinforced epoxy layer can be one of the two described methods, either by (i) running a pre-rolled fibreglass-reinforced epoxy tube into the carbon steel pipe and sealing the annulus with a filler material, or (ii) via direct coating of the inner surface of the carbon steel pipe. The fibreglass-reinforced epoxy liner should be a thin layer, in order to maximize the running drift of the entire liner system and also to maximize the fluid flowrate.

[0011] The fifth aspect of the disclosed inventive design is a stiff elastomeric end cap, placed at both ends of the carbon steel pipe at the pin end. The shape of the cross-section profile of the end cap is in a F-shaped geometry, wherein the tails extend a short distance inwards along the longitudinal pipe axis, and would hold the above-mentioned fibreglass-reinforced epoxy layer in place relative to the pin connectors. The end caps are stiff enough to resist against the liner system collapsing inwards at the pin connectors. However, the end caps would not be fixed or attached to the carbon steel pin connector, in order to provide some free allowance for the fibreglass-reinforced epoxy liner to expand longitudinally along the pipe axis during elevated temperature conditions.

[0012] The sixth aspect of the disclosed inventive design is a precisely-designed compressible elastomeric seal ring which would be placed in the middle of both carbon steel pin connectors, and insulate the gap between both pin connectors. The elastomeric seal ring would also insulate the middle of the box coupling against exposure to the flow of production fluid. Its precise position is aided by the presence of the recessed groove in the middle of the carbon steel coupling. The precise position is important to ensure a fixed degree of compression of the seal ring upon final make-up of the connection. This is to prevent excessive compression and protrusion of the seal ring, exposing it to the large forces from the flow of production fluid. Such forces could displace the seal ring or remove it entirely from its intended position and purpose. The shape of the cross-section profile of the elastomeric seal ring is in a T-shaped geometry, which is designed to prevent the seal ring from inwards movement into the flow of production fluid. Upon final make-up, the carbon steel pin connectors would compress and hold the T-body of the seal ring in place; and the T-arms of the seal ring would be blocked by the pin connectors from any inwards radial movement into the centre of the tubular piping system.

[0013] The seventh aspect of the disclosed inventive design is a thin layer of non-structural filler material that would fill the annulus between the layer of fibreglass-reinforced epoxy liner and the carbon steel pipe body if the liner is installed via method (i) in paragraph **[0010]**. The filler material is meant to provide a backing for the thin layer of fibreglass-reinforced epoxy liner, allowing smooth transfer of the tubular piping system internal pressure forces from the fibreglass-reinforced epoxy liner, to the filler material, and finally to the carbon steel pipe body. A common filler material used in the

industry is cement mortar, but other filler materials like grout or polymers may be suitable if they are corrosion-resistant and able to withstand the corrosive conditions and high temperatures within the tubular piping system.

Brief Description of Drawings

[0014] Figure 1A shows a cross sectional view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly, inclusive of the relevant components of the present disclosure;

[0015] Figure 1B shows a plan view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly;

[0016] Figure 2A shows a perspective view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly;

[0017] Figure 2B shows a perspective and sectioned view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly, inclusive of the relevant components of the present disclosure;

[0018] Figure 3A shows a cross sectional view of an embodiment of the disclosed specially designed carbon steel pin connector, showing an external shoulder which would act as a torque stop during final make-up with the carbon steel coupling connector;

[0019] Figure 3B shows a plan view of an embodiment of the disclosed specially designed carbon steel pin connector;

[0020] Figure 4 shows a perspective view of an embodiment of the disclosed specially designed carbon steel pin connector;

[0021] Figure 5A shows a cross sectional view of an embodiment of the disclosed specially designed carbon steel coupling connector, showing a recessed groove at the centre of the coupling which would partially house the disclosed elastomeric seal ring;

[0022] Figure 5B shows a plan view of an embodiment of the disclosed specially designed carbon steel coupling connector;

[0023] Figure 6A shows a perspective and sectioned view of an embodiment of the disclosed specially designed carbon steel coupling connector, showing a recessed groove at the centre of the coupling which would partially house the disclosed elastomeric seal ring;

[0024] Figure 6B shows a perspective view of an embodiment of the disclosed specially designed carbon steel coupling connector;

[0025] Figure 7A shows a perspective view of the disclosed layer of fibreglass-reinforced epoxy liner, housed within a sectioned pin connector assembly;

[0026] Figure 7B shows a perspective view of the disclosed layer of fibreglass-reinforced epoxy liner, within the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly;

[0027] Figure 8A shows a cross sectional view of an embodiment of the disclosed stiff elastomeric end cap, illustrating the F-shaped geometry of the cross-section, and designed in a way so as to hold the fibreglass-reinforced epoxy liner in place at the carbon steel pin connector;

[0028] Figure 8B shows a plan view of an embodiment of the disclosed stiff elastomeric end cap;

[0029] Figure 8C shows a front view of an embodiment of the disclosed stiff elastomeric end cap;

[0030] Figure 8D shows a perspective view of an embodiment of the disclosed stiff elastomeric end cap;

[0031] Figure 9A shows a perspective view of an embodiment of the disclosed stiff elastomeric end cap, housed within a sectioned pin connector assembly;

[0032] Figure 9B shows a perspective view of an embodiment of the disclosed stiff elastomeric end cap, housed within a sectioned pin connector assembly relative to the disclosed layer of fibreglass-reinforced epoxy liner;

[0033] Figure 9C shows a perspective view of an embodiment of the disclosed stiff elastomeric end cap, housed within a pin connector assembly;

[0034] Figure 10A shows a cross sectional view of an embodiment of the disclosed compressible elastomeric seal ring, showing the T-shaped geometry of the cross section of the seal ring;

[0035] Figure 10B shows a plan view of an embodiment of the disclosed compressible elastomeric seal ring;

[0036] Figure 10C shows a front view of an embodiment of the disclosed compressible elastomeric seal ring;

[0037] Figure 10D shows a perspective view of an embodiment of the disclosed compressible elastomeric seal ring;

[0038] Figure 11 shows a perspective view of an embodiment of the disclosed compressible elastomeric seal ring, housed within a sectioned view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly.

Detailed Description

[0039] Figures 1A, 1B, 2A, and **2B** illustrate in various views the details of a typical prior art Fibreglass-Reinforced Epoxy Liner System Assembly design with its

associated and relevant components. **Figure 1A** shows a cross-sectional view of the overall disclosed inventive design, where the assembly is housed within a specially designed premium carbon steel threaded and coupled connection comprising two pin connectors **12**, and a box coupling **13**. The pin connectors **12** and the box coupling **13** achieve connection integrity upon final make-up using a compatible and specially designed thread profile **16**. This thread profile **16** has some degree of thread interference between the pin and coupling threads, where thread interference refers to a degree of tightness in the thread profile **16** requiring power-tightening upon final make-up.

[0040] Each pin connector **12** and box coupling **13** assembly has a metal-to-metal seal profile **14** which allows the connection assembly to achieve gas-tightness. This metal-to-metal seal profile **14** is achieved due to seal interference between both the pin connector **12** and box coupling **13**. Seal interference refers to a degree of tightness between both seal surfaces in the pin connectors **12** and the box coupling **13** requiring power-tightening upon final make-up to form a complete gas-tight seal. This gas-tight metal-to-metal seal is designed for tubular piping systems with high internal pressure and is optional for tubular piping systems with low internal pressure.

[0041] Each pin connector **12** has an external shoulder **15** which acts as a torque stop during final make-up, preventing the connection from being over-torqued or over-tightened. Under-torque or under-tightening can also be easily identified via a gap between the external shoulder **15** and the coupling end. This can be resolved easily by further tightening the connection until the gap is closed and the coupling end touches the external shoulder **15**. This torque stop function need not be limited to the external shoulder **15** design as shown in the typical prior art within **Figure 1A**; an intermediate shoulder design between the pin and coupling would serve the same torque stop function as well. This external and/or intermediate shoulder would provide a snug fit and stop limit once the maximum number of turns to make-up is achieved, which is vital to prevent over- or under-compression of the compressible elastomeric seal ring **20** for it to fulfil its intended insulation purpose.

[0042] At the middle of the box coupling **13**, there is a recessed groove **17** specially designed and machined to partially house the compressible elastomeric seal ring **20**. The recessed groove **17** would assist to hold the T-arms of the compressible elastomeric seal ring **20**, preventing the compressible elastomeric seal ring **20** from deviating from its intended location at the middle of the box coupling **13** even when the seal ring undergoes compression from each pin connector **12**, or during thermal expansion from the elevated temperature within the tubular piping system.

[0043] Figures 3A, 3B, and **4** illustrate in different views the cross-sectional and external details of the specially designed premium pin connector **12**. The features of the pin connector **12** include an external upset **23** with reference to the diameter of the pipe body **22**. This is to provide a thicker pipe cross-sectional area to cater for the machining of the external shoulder **15** area, allowing a firm and unyielding engagement between the coupling end and the external shoulder **15**. Situated near the external shoulder **15** is the metal-to-metal seal profile **14** which would interact with the seal

profile of the box coupling **13** to form a gas-tight seal and prevent gases escaping via the connection from within the tubular piping system. This arises due to a purposefully designed seal interference between the pin connector **12** and box coupling **13**, reaching full seal interference and preventing gas from escaping the connection upon final make-up. Another feature of the pin connector **12** is the specially designed premium thread profile **16** which would interlock with the thread profile of the box coupling **13** as well, achieving connection integrity via thread engagement and interference when the connection is screwed into position upon final make-up.

[0044] Figures 5A, 5B, 6A, and **6B** illustrate in different views the cross-sectional and external details of the specially designed premium box coupling **13**. The features of the box coupling **13** which are similar to the features of the pin connectors **12** include the specially designed premium thread profile **16** and the metal-to-metal seal profile **14**. One notable and unique feature of the box coupling **13** is the recessed groove **17** which is illustrated clearly in **Figures 5A** and **6A**, of which its functions have been outlined in paragraph **[0042]** above. The coupling ends **24** are designed to snugly fit into the external shoulder **15** of the pin connector **12** during final make-up; usually with some degree of inward taper to prevent the coupling end **24** from flaring outward upon reaching final make-up position.

[0045] Figure 7A illustrates a perspective view of the disclosed layer of fibreglass-reinforced epoxy liner **18**, relative to the cross-sectional view of the pin connector **12** assembly. In addition, the other components making up the pin connector **12** assembly are the stiff elastomeric end cap **19**, and filler material **21** that would fill the annulus between the fibreglass-reinforced epoxy liner **18** and the carbon steel pin connector **12**. **Figure 7B** illustrates another perspective view of the fibreglass-reinforced epoxy liner **18**, this time relative to the cross-sectional view of the overall disclosed inventive design of the Fibreglass-Reinforced Epoxy Liner System Assembly. The chemically inert fibreglass-reinforced epoxy liner **18** would serve to insulate the carbon steel tubular piping system internally from corrosive fluids, and the stiff elastomeric end caps **19** along with the compressible elastomeric seal ring **20** would insulate the interface between the carbon steel pin connectors **12** and the box coupling **13**.

[0046] Figures 8A, 8B, 8C, and **8D** illustrate in different views the cross-sectional and external details of a typical prior art of the specially designed stiff elastomeric end cap **19**. The cross-section of the end cap **19** is in a F-shaped geometry, and clearly illustrates two tails extending longitudinally inward along the pipe axis; the inner tail **25** being longer and the outer tail **26** being shorter (inner and outer being relative to the tubular piping system outer diameter). The inner tail **25** is meant to hold and cap the end of the fibreglass-reinforced epoxy liner **18**, being stiff enough to hold the end of the fibreglass-reinforced epoxy liner **18** without any inwards collapse even in elevated temperature conditions. The outer tail **26** is meant to provide filler room between the fibreglass-reinforced epoxy liner **18** and the carbon steel pin connector **12**, to allow room for the filler material **21** to fill the space. Between the inner tail **25** and outer tail **26** is a groove **27** that is designed to be of the same thickness as the layer of fibreglass-reinforced epoxy liner **18**, in which the end of the fibreglass-reinforced epoxy liner **18** would fit nicely into the groove **27**. The end flare **29** would extend radially outwards to

the same level as the outer diameter of the pin connector **12** end, which would fit nicely in the right-angle corner **28** of the end cap **19**. The end flare **29** is meant to insulate the pin connector **12** end from being exposed to the corrosive fluid within the tubular piping system.

[0047] Figure 9A illustrates a perspective view of the features of the stiff elastomeric end cap **19** relative to a cross-sectional view of the pin connector **12** assembly. Being stiff in nature, the inner tail **25** would hold the end of the fibreglass-reinforced epoxy liner **18** without any inwards collapse, pushing the fibreglass-reinforced epoxy liner **18** against the inner diameter of the pin connector **12**. The outer tail **26** is illustrated to provide filler room for the filler material **21** to fill the space between the layer of fibreglass-reinforced epoxy liner **18** and the pin connector **12**. **Figure 9B** illustrates the same perspective view of the stiff elastomeric end cap **19**, this time with the fibreglass-reinforced epoxy liner **18** in position. **Figure 9C** illustrates the end flare **29** which would surround the pin connector **12** end to insulate the carbon steel from corrosive fluid within the tubular piping system. The end flare **29** would also serve as the contact surface between the pin connector **12** assembly and the compressible elastomeric seal ring **20** in the final make-up position.

[0048] Figures 10A, 10B, 10C, and **10D** illustrate in different views the cross-sectional and external views of a typical prior art compressible elastomeric seal ring **20**. In **Figure 10A**, the main features of the compressible elastomeric seal ring **20** comprise of the two T-arms **30** and the T-body **31**. The two T-arms **30** serve the function of situating the compressible elastomeric seal ring **20** at the middle of the overall Fibreglass-Reinforced Epoxy Liner System Assembly, as they would be partially housed in the recessed groove **17** in the middle of the inner diameter of the box coupling **13**. The T-body **31** is designed to be narrower than the T-arms **30**, as the T-body **31** would undergo regular and constant compression forces acted upon it during final make-up by the pin connectors **12** via the end flare **29** contact surface. This narrower T-body **31** would also prevent the seal ring from dislocating from its intended position, as any movement of the T-arms **30** would be restricted by the pin connectors **12** and the recessed groove **17**. This effectively prevents the entire compressible elastomeric seal ring **20** from being dislodged or pulled into the fluid flow within the tubular piping system. **Figure 11** illustrates the position of the compressible elastomeric seal ring **20** relative to the cross-section of the overall Fibreglass-Reinforced Epoxy Liner System Assembly.

Claims

[0049] The features which are believed to be novel in the disclosed inventive design are set forth in the appended claims below. Any modifications, variations, or changes made to the embodiments described above would be apparent to those familiar with liner systems for tubular systems conveying corrosive oil and gas fluids under elevated temperature and pressure, and the Fibreglass-Reinforced Epoxy Liner System Design described herein thus encompasses such modifications, variations, or changes and are not limited to the specific embodiments described herein.

1. A carbon steel connection to house the Fibreglass-Reinforced Epoxy Liner System Assembly, comprising the following components:

    a. Two specially designed carbon steel pin connectors, one at the field end and one at the mill end, which are both configured to have compatible thread profiles with the carbon steel box coupling and able to be fully made up to make a solid integral carbon steel connection assembly.

    b. A specially designed carbon steel box coupling configured to have compatible thread profiles with the carbon steel pin connectors.

    c. In high internal pressure tubular piping systems, the pin connectors and box coupling would have some degree of thread interference to ensure appropriate connection tightness and integrity upon final make-up. This thread interference feature would be optional for tubular piping systems with low internal pressure.

2. The carbon steel pipe connection assembly of claim **1**, wherein a metal-to-metal seal profile interaction between the individual carbon steel pin connector and the carbon steel box coupling would achieve gas-tightness of the connection. This metal-to-metal seal profile arises due to seal interference between both the pin connector and the box coupling, achieving full seal interference upon final make-up. This gas-tight metal-to-metal seal would be designed for tubular piping systems with high internal pressure and would be an optional feature for tubular piping systems with low internal pressure.

3. The carbon steel pipe connection assembly of claim **1**, wherein both pin connectors respectively have an intermediate and/or external shoulder as a torque stop during final make-up. This intermediate and/or external shoulder would provide a snug fit and stop limit for the box coupling end once the maximum number of turns to make-up is achieved, to ensure precise make-up position and prevent over- or under-compression of the seal ring from occurring so that the seal ring can achieve its insulation purpose.

4. The carbon steel pipe connection assembly of claim **1**, wherein a recessed groove at the centre of the carbon steel box coupling can partially house a T-shaped compressible elastomeric seal ring.

5. A chemically inert and impermeable layer of fibreglass-reinforced epoxy, able to withstand elevated temperatures within the tubular piping system, and with a relatively similar coefficient of expansion as carbon steel; lined along the inner diameter of the carbon steel pipe using either one of the described methods below:

a. By running a pre-rolled fibreglass-reinforced epoxy tube into the carbon steel pipe and sealing the annulus between the fibreglass-reinforced epoxy tube and the carbon steel pipe with a filler material or;

b. By direct coating of the fibreglass-reinforced epoxy material onto the inner surface of the carbon steel pipe.

6. The fibreglass-reinforced epoxy liner layer of claim **5**, wherein the thickness of the layer should be thick enough to provide an impermeable insulation for the carbon steel pipe body against corrosive oil and gas fluids; while being thin enough to ensure the fluid flow rate is not significantly decreased by the reduced inner diameter due to the addition of the fibreglass-reinforced epoxy liner.

7. A stiff elastomeric end cap, placed at both ends of the fibreglass-reinforced epoxy liner at the end of the respective pin connectors.

8. The end cap of claim **7**, wherein the end cap extends a short distance inward along the longitudinal axis and would hold the above-mentioned fibreglass-reinforced epoxy layer in place relative to the inner diameter of the carbon steel pipe.

9. The end cap of claim **7**, wherein the end cap is made with an elastomeric material stiff enough to hold the fibreglass-reinforced epoxy liner and resist against the fibreglass-reinforced epoxy liner system collapsing radially inwards at the pin connectors.

10. The end cap of claim **7**, wherein the end cap would not be permanently affixed or attached to the carbon steel pin connectors to provide some free allowance for the fibreglass-reinforced epoxy liner to expand longitudinally along the pipe axis during elevated temperature conditions.

11. The end cap of claim **7**, wherein the end flare would insulate the carbon steel pin connector end from corrosive fluids within the tubular piping system. The end flare would also serve as the contact surface between the pin connector assembly and the compressible elastomeric seal ring in the final make-up position.

12. A compressible elastomeric seal ring placed between both carbon steel pin connectors, sealing the gap between both pin connectors, and insulating the centre of the carbon steel box coupling. The compressible elastomeric seal ring would prevent corrosive fluid contact with the box coupling and block the fluid from flowing into the carbon steel connection through the connection thread.

13. The compressible elastomeric seal ring of claim **12**, wherein the location of the seal ring between both carbon steel pin connectors is designed to a precise position in the middle of both pin connectors of claim **1(a)**; aided by the presence of the

recessed groove in the middle of the carbon steel box coupling which would house the seal ring.

14. The compressible elastomeric seal ring of claim **12**, wherein the shape of the cross-section profile of the seal ring is in a T-shaped geometry. The T-arms of the elastomeric seal ring fit snugly into the recessed groove at the centre of the carbon steel coupling and the T-body is held in place by both carbon steel pin connectors upon achieving final make-up position.

15. The compressible elastomeric seal ring of claim **12**, wherein the T-arms of the elastomeric seal ring are held in place by both carbon steel pin connectors, blocking the seal ring from ingress into the path of fluid flow within the tubular piping system.

16. The compressible elastomeric seal ring of claim **12**, wherein the elastic nature of the elastomeric seal ring material allows for compression of the T-body of the seal ring by both carbon steel pin connectors in the final make-up position. The compressed T-body of the seal ring would fill up all available gaps between both pin connectors, insulating the centre of the carbon steel box coupling and connection from corrosive fluids within the tubular piping system.