[0022] In accordance with the certain illustrated embodiments of the present invention, the aforesaid load bearing surfaces of the closure plug and the open end channel of the heat exchanger tube preferably include a first set of hubs provided (e.g., machined) on the closure plug and a second complimentary set of hubs provided (e.g., machined) on the open end channel portion of the heat exchanger tube such that when the closure plug is rotated, the first set of hubs engage (interdigigate) with the second set of hubs. It is to be appreciated that one or more sets of hub sections may be provied on the closure plug and/or open end channel of the heat exchanger so as incorporate a raised section (e.g., a rail) configured to (i) prevent over rotation, (ii) provide a bearing surface for insertion of the closure plug, while (iii) preventing damage to load bearing surfaces of both the closure plug and the open end channel of the heat exchanger tube.

[0023] In yet another aspect, provided is a heat exchanger assembly including an elongated tubular heat exchanger enclosure defining an interior chamber. A tube sheet is positioned within the interior chamber of the heat exchanger enclosure separating the interior chamber into a shell side and a channel side. The interior ~~portion~~ chamber is configured to removably receive a tube bundle positioned within the shell side of the interior chamber. An annular sleeve member is positioned within the channel side of the interior chamber of the heat exchanger enclosure. An annular elastic torsion member is positioned within the channel side of the interior chamber of the heat exchanger enclosure such that the sleeve member is positioned between the tube sheet and the elastic torsion member. The elastic torsion member has an inner circumference deflectable relative to its outer circumference for torsioning the elastic torsion member. Additionally, the heat exchanger may further one or more of the following: i) a partition assembly wherein the sleeve member is positioned within the channel side of the interior chamber of the heat exchanger enclosure to direct fluid from a port extending through

exchanger enclosure reduce load on the elastic torsion member by deforming the closure assembly distal from the tube sheet, and the elastic torsion member is configured to deflect elastically up to an elastic deflection limit and deflect plastically above the elastic deflection limit such that the elastic torsion member accommodates differential thermal expansion to avoid damage to components of the heat exchanger when the heat exchanger is under preload and expected pressure and thermal loads.

[0024] ~~In yet another aspect,~~ There is provided ~~is~~ a process for assembling a tube heat exchanger assembly including providing an elongated heat exchanger enclosure having an interior chamber and defining a longitudinal axis and having an open cylindrical channel end. A closure assembly is provided having a locking assembly configured to secure to the open cylindrical channel end of the elongated heat exchanger enclosure. The locking assembly of the closure assembly is inserted into the open cylindrical channel end axially along the longitudinal axis of the interior chamber of the heat exchanger such that load bearing surfaces of each of the closure assembly and an interior wall of the elongated heat exchanger enclosure do not contact one another. The closure assembly is turned about the longitudinal axis of the elongated heat exchanger enclosure to cause the locking assembly to removably secure to a cooperating locking assembly provided on the interior wall of the elongated heat exchanger enclosure to cause the load bearing surfaces to contact one another such that a load is transferred between the closure assembly and the elongated heat exchanger. Additionally, the process for assembling the tube heat exchanger may further one or more of the following: i) the closure assembly is turned less than 360 degrees to cause the locking assembly of the closure assembly to removably secure to the cooperating locking assembly provided on the interior wall of the elongated heat exchanger enclosure; ii) the locking assembly of the closure assembly and the locking assembly provided on the interior wall of the elongated heat

[0025] ~~In still another aspect,~~ There is also provided ~~is~~ a closure assembly configured to removably secure to an open channel end of an interior chamber of a heat exchanger assembly including a cylindrical shaped lock ring member defining a cylindrical outer surface portion and a cylindrical shaped interior portion. The outer surface portion is provided with a plurality of spaced-apart lock ring hub sections configured to interdigitate with corresponding channel hub sections formed on a cylindrical inner surface portion of the heat exchanger assembly. A cylindrical shaped cover member secured is concentric with the interior portion of the lock ring member. Additionally, the closure assembly may further one or more of the following: i) wherein the cover member is removably secured to the lock ring member with the lock ring member having an inner diameter surface with a shoulder configuration configured receive a cooperating shoulder configuration provided on an outer diameter surface of the cover member; ii) each lock ring hub section extends at prescribed angle extending from the outer surface portion of the lock ring member configured to interdigitate with corresponding angled hub sections provided in each channel hub section formed on the cylindrical inner surface portion of the heat exchanger assembly; iii) an upwardly extending flange member provided on the lock ring member configured to stop rotation of the closure assembly into the interior chamber of the heat exchanger assembly; iv) a diaphragm configured to be positioned adjacent to the lock ring and cover members; v) a plurality of adjustable outer elongate lock ring compression members removably securable in the lock ring member, each outer elongate lock ring compression member passing through a respective hole coaxially formed with a longitudinal axis in the lock ring member so as to transmit a force to a first compression ring, which transmits a force to a rim portion of the diaphragm, and a diaphragm gasket compressed against the diaphragm such that the diaphragm is positioned intermediate the diaphragm gasket and the first compression ring member through adjustment of the outer

What is claimed is:

1. A heat exchanger assembly comprising:

an elongated tubular heat exchanger enclosure defining an interior chamber;

a tube sheet positioned within the interior chamber of the heat exchanger enclosure and separating the interior chamber into a shell side and a channel side wherein the interior ~~portion~~ chamber is configured to removably receive a tube bundle positioned within the shell side of the interior chamber;

an annular sleeve member positioned within the channel side of the interior chamber of the heat exchanger enclosure; and

an annular elastic torsion member positioned within the channel side of the interior chamber of the heat exchanger enclosure with the sleeve member positioned between the tube sheet and the elastic torsion member, the elastic torsion member having an inner circumference deflectable relative to its outer circumference for torsioning the elastic torsion member.

2. The heat exchanger assembly as recited in claim 1, further including:

a partition assembly comprising the sleeve member positioned within the channel side of the interior chamber of the heat exchanger enclosure to direct fluid from a port extending through the heat exchanger enclosure to at least two or more tubes in a tube bundle;

a tube sheet gasket positioned between the tube sheet and a shoulder formed within the interior chamber of the heat exchanger enclosure; and

a bearing ring positioned within the interior chamber of the heat exchanger enclosure with the the elastic torsion member positioned between the sleeve member and the bearing ring.

3. The heat exchanger assembly as recited in claim 1, further including at least two ports extending through the heat exchanger enclosure for allowing fluid to enter and exit the channel side of the interior chamber of the heat exchanger enclosure.

4. The heat exchanger assembly as recited in claim 3, wherein the elastic torsion member is configured to deflect elastically up to an elastic deflection limit and deflect plastically above the elastic deflection limit such that the elastic torsion member deflects elastically to accommodate differential thermal expansion and avoid damage to components of the heat exchanger enclosure when the heat exchanger enclosure is under preload and expected pressure and thermal loads.

5. The heat exchanger assembly as recited in claim 4, wherein the elastic torsion member is configured to pivot at a first contact area where the elastic torsion member contacts the sleeve member and at a second contact area where the elastic torsion member contacts the bearing ring.

6. The heat exchanger assembly as recited in claim 1, wherein the elastic torsion member has a quadrilateral cross-section having rounded corners.

7. The heat exchanger assembly as recited in claim 1, further including a plurality of elastic torsion members stacked in series relative to one another.

8. The heat exchanger assembly as recited in claim 6, wherein the elastic torsion member is configured to have an outer radius “A” and an inner radius “B”, wherein the outer radius is less than an inner radius of a channel of the interior chamber configured to receive a tube bundle, wherein the ratio of “A” to “B” is less than 3.

9. The heat exchanger assembly as recited in claim 8, wherein the elastic torsion member is configured to have a height "H" that is approximately 50% of its elastic deflection limit, and has a thickness "T" such that the elastic torsion member deforms plastically above its elastic deflection limit.

10. The heat exchanger assembly as recited in claim 6, further including a closure assembly for sealing the channel side of the interior chamber of the heat exchanger enclosure, wherein the closure assembly includes a lock ring member and a cover member which are removably secured to the heat exchanger enclosure with a locking assembly.

11. The heat exchanger assembly as recited in claim 10, wherein the locking assembly includes a plurality of spaced-apart lock ring hub sections configured to interdigitate with corresponding channel hub sections formed on a cylindrical inner surface portion of the heat exchanger enclosure.

12. The heat exchanger assembly as recited in claim 10, further including:

a diaphragm positioned with the channel side of the interior chamber adjacent to the lock ring and cover members; and

a diaphragm gasket compressed against the diaphragm when the lock ring member is removably secured to the heat exchanger enclosure.

13. The heat exchanger assembly as recited in claim 12, the closure assembly further including:

a plurality of first elongate compression members provided along an outer radius portion of the closure assembly so as to transmit a force to a first compression ring, which transmits a force to a rim portion of the diaphragm and the diaphragm gasket; and

a plurality of second elongate compression members provided along an inner radius portion of the closure assembly so as to transmit a force to a second compression ring, which transmits a force against a portion of the diaphragm causing a portion of the diaphragm to deflect distal from the cover member and towards the elastic torsion member when the closure assembly is removably secured to the heat exchanger enclosure.

14. The heat exchanger assembly as recited in claim 13, wherein the tube sheet, sleeve member, bearing ring, first and second compression rings, lock ring, and first and second compression members are configured to remain elastic up to or above a total axial load from preload, thermal and pressure loads when the closure assembly is secured to the heat exchanger enclosure.

15. The heat exchanger assembly as recited in claim 14, wherein when the elongate compression members are preloaded, the compression members impart the preload through a first axial load path to a first contact area of the elastic torsion member, which transmits the preload through a torsional load path through the elastic torsion member to a second contact area of the elastic torsion member, which transmits the preload through a second axial load path to a tube sheet gasket.

16. The heat exchanger assembly as recited in claim 15, wherein:

pressure loads from process fluids in the heat exchanger enclosure are within a normal prescribed threshold range, the elastic torsion member is configured to deform elastically enabling its outer circumference to axially move towards the closure assembly;

pressure loads from process fluids in the heat exchanger enclosure reduce load on the elastic torsion member by deforming the closure assembly distal from the tube sheet; and

the elastic torsion member is configured to deflect elastically up to an elastic deflection limit and deflect plastically above the elastic deflection limit such that the elastic torsion member accommodates differential thermal expansion to avoid damage to components of the heat exchanger enclosure when the heat exchanger enclosure is under preload and expected pressure and thermal loads.

~~17. A process for assembling a tube heat exchanger assembly comprising:~~

~~providing an elongated heat exchanger enclosure having an interior chamber and defining a longitudinal axis and having an open cylindrical channel end;~~

~~providing a closure assembly having a locking assembly configured to secure to the open cylindrical channel end of the elongated heat exchanger enclosure;~~

~~inserting the locking assembly of the closure assembly into the open cylindrical channel end axially along the longitudinal axis of the interior chamber of the heat exchanger such that load bearing surfaces of each of the closure assembly and an interior wall of the elongated heat exchanger enclosure do not contact one another; and~~

~~turning the closure assembly about the longitudinal axis of the elongated heat~~

~~exchanger enclosure to cause the locking assembly to removably secure to a cooperating locking assembly provided on the interior wall of the elongated heat exchanger enclosure to cause the load bearing surfaces to contact one another such that a load is transferred between the closure assembly and the elongated heat exchanger.~~

~~18. The process for assembling a tube heat exchanger as recited in claim 17, wherein the closure assembly is turned less than 360 degrees to cause the locking assembly of the closure assembly to removably secure to the cooperating locking assembly provided on the interior wall of the elongated heat exchanger enclosure.~~

~~19. The process for assembling a tube heat exchanger as recited in claim 18, wherein the locking assembly of the closure assembly and the locking assembly provided on the interior wall of the elongated heat exchanger enclosurecooperatively form a bayonet locking assembly.~~

~~20. The process for assembling a tube heat exchanger as recited in claim 19, wherein the bayonet locking assembly includes:~~

~~a plurality of spaced-apart lock ring hub sections provided on an outer surface portion of the closure assembly; and~~

~~a plurality of spaced-apart lock ring hub sections provided on the interior wall of the elongated heat exchanger enclosure configured to interdigitate with corresponding channel hub sections formed on the closure assembly.~~

~~21. The process for assembling a tube heat exchanger as recited in claim 19, further including, and prior to inserting the locking assembly:~~

~~inserting a tube sheet gasket into the open cylindrical channel end axially along the longitudinal axis of the elongated heat exchanger enclosure to be positioned adjacent a channel shoulder configuration formed in the elongated heat exchanger enclosure;~~

~~inserting a tube sheet into the open cylindrical channel end axially along the longitudinal axis of the elongated heat exchanger enclosure to be positioned adjacent the tube sheet gasket so as to define a shell side and a channel side within the interior chamber of the elongated heat exchanger enclosure, wherein the interior chamber is configured to removably receive a tube bundle positioned within the shell side of the interior chamber;~~

~~inserting an annular sleeve member into the open cylindrical channel end axially along the longitudinal axis of elongated heat exchanger enclosure to be positioned adjacent the tube sheet;~~

~~inserting an elastic torsion member into the open cylindrical channel end along the longitudinal axis of the elongated heat exchanger enclosure so as to be positioned adjacent the sleeve member;~~

~~inserting a bearing ring into the open end of the cylindrical channel along the longitudinal axis of the elongated heat exchanger enclosure so as to be positioned adjacent the elastic torsion member; and~~

~~inserting a diaphragm into the open end of the cylindrical channel along the longitudinal axis of the elongated heat exchanger enclosure so as to be positioned adjacent the bearing ring.~~

~~22. The process for assembling a tube heat exchanger as recited in claim 21, further including:~~

~~adjusting a plurality of first outer elongate compression members provided along an outer radius portion of the closure assembly which extend in the closure assembly coaxially along longitudinal axis of the closure assembly so as to transmit a force to a first compression ring, which transmits a force to a rim portion of the diaphragm and the diaphragm gasket so as to compress the diaphragm gasket against the diaphragm; and~~

~~adjusting a plurality of second inner elongate compression members provided along an inner radius portion of the closure assembly which extend in the closure assembly coaxially along longitudinal axis of the closure assembly so as to transmit a force to a second compression ring, which transmits a force against a portion of the diaphragm causing a portion of the diaphragm to deflect distal from the closure assembly and towards the elastic torsion member of heat exchanger assembly when the closure assembly is secured to the heat exchanger enclosure.~~

~~23. The process for assembling a tube heat exchanger as recited in claim 22, wherein the tube sheet, sleeve member, first and second compression rings, closure assembly, and each of the first and second elongate compression members are configured to remain elastic up to or above a total axial load from preload, thermal and pressure loads when the closure assembly is secured to the heat exchanger enclosure.~~

~~24. The process for assembling a tube heat exchanger as recited in claim 23, wherein when the elongate compression members are preloaded, the compression members impart the preload through a first axial load path to a first contact area of the elastic torsion member, which~~

~~transmits the preload through a torsional load path through the elastic torsion member to a second contact area of the elastic torsion member, which transmits the preload through a second axial load path to a tube sheet gasket.~~

~~25. The process for assembling a tube heat exchanger as recited in claim 24, wherein the torsional load is resisted by an increase in stress and a torsional rotation enabling the first contact area of the elastic torsion member to move towards the tube sheet.~~

~~26. The process for assembling a tube heat exchanger as recited in claim 25, wherein the closure assembly includes positioning a cylindrical shaped cover member having an outer diameter to be secured concentric with an interior portion of a cylindrical shaped lock ring member defining a cylindrical outer surface portion and a cylindrical shaped interior portion wherein the outer surface portion is provided with the locking assembly of the closure assembly.~~

~~27. A closure assembly configured to removably secure to an open channel end of an interior chamber of a heat exchanger assembly, comprising:~~

~~a cylindrical shaped lock ring member defining a cylindrical outer surface portion and a cylindrical shaped interior portion wherein the outer surface portion is provided with a plurality of spaced-apart lock ring hub sections configured to interdigitate with corresponding channel hub sections formed on a cylindrical inner surface portion of the heat exchanger assembly; and~~

~~a cylindrical shaped cover member secured concentric with the interior portion of the lock ring member.~~

28. The closure assembly as recited in claim 27, wherein the cover member is removably secured to the lock ring member whereby the lock ring member has an inner diameter surface with a shoulder configuration configured receive a cooperating shoulder configuration provided on an outer diameter surface of the cover member.

29. The closure assembly as recited in claim 27, wherein each lock ring hub section extends at prescribed angle extending from the outer surface portion of the lock ring member configured to interdigitate with corresponding angled hub sections provided in each channel hub section formed on the cylindrical inner surface portion of the heat exchanger assembly.

30. The closure assembly as recited in claim 27, further including an upwardly extending flange member provided on the lock ring member configured to stop rotation of the closure assembly into the interior chamber of the heat exchanger assembly.

31. The closure assembly as recited in claim 27, further including a diaphragm configured to be positioned adjacent to the lock ring and cover members.

32. The closure assembly as recited in claim 31, further including:

a plurality of adjustable outer elongate lock ring compression members removably securable in the lock ring member, each outer elongate lock ring compression member passing through a respective hole coaxially formed with a longitudinal axis in the lock ring member so as to transmit a force to a first compression ring, which transmits a force to a rim portion of the diaphragm; and

a diaphragm gasket compressed against the diaphragm such that the diaphragm is positioned intermediate the diaphragm gasket and the first compression ring member through adjustment of the outer elongate lock ring compression members when the lock ring member is removably secured to the interior chamber of the tubular heat exchanger assembly.

33. The closure assembly as recited in claim 32, further including a plurality of inner adjustable elongate cover compression members removably securable in the cover member, each inner elongate cover compression member passing through a respective hole coaxially formed with a longitudinal axis in the cover member so as to transmit a force to a second compression ring, which transmits a force against a portion of the diaphragm causing a portion of the diaphragm to deflect distal from the cover member and towards the interior chamber of heat exchanger assembly when the closure assembly is removably secured to the open end of the interior chamber of the heat exchanger assembly.

34. The closure assembly as recited in claim 33, wherein the first and second compression rings, compression rods and compression bolts are configured to remain elastic up to or above a total axial load from preload, thermal and pressure loads when the closure assembly is removably secured to the open end of the interior chamber of the heat exchanger assembly.

35. The closure assembly as recited in claim 27, wherein the outer surface portion of the lock member is provided with an upstanding grove formed substantially perpendicular to the longitudinal axis of the lock ring member configured to slidably receive in a corresponding notch formed in the inner surface portion of the heat exchanger assembly perpendicular to the longitudinal axis of the

~~heat exchanger axis for facilitating insertion of the lock ring member in the inner surface portion of the heat exchanger assembly.~~

~~36~~17. An operation method for a heat exchanger assembly comprising a tubular heat exchanger enclosure configured for accomodating differential thermal expansion of internal components in an interior chamber of the heat exchanger enclosure during heating and cooling sequences, the method comprising:

receiving a preload with an elastic torsion member within the interior chamber of the heat exchanger enclosure such that the elastic torsion member receives a torsional load and elastically deflects to accommodate the preload; and

receiving a thermal load with the heat exchanger assembly to differentially thermally expand the internal components in the interior chamber of the heat exchanger enclosure such that the torsional load received by the elastic torsion member increases and further elastically deflects to accommodate the thermal load.

~~37~~18. The operation method of claim ~~36~~17, further comprising:

receiving a pressure load within the interior chamber of the heat exchanger enclosure that reduces the torsional load received by the elastic torsion member by elastically deflecting a closure assembly removably attached to the heat exchanger enclosure and relaxing the elastic torsion member to accommodate the pressure load.

~~38~~19. The operation method of claim ~~36~~17, wherein the differentially thermally expanding the internal components comprises accommodating differential thermal expansion of at least the

bearing ring, elastic torsion member, sleeve member and tube sheet without causing plastic deformation of at least the bearing ring, elastic torsion member and sleeve member.

~~39~~20. The operation method of claim ~~36~~17, wherein elongate compression members are used to preload the elastic torsion member such that the compression members impart the preload through a first axial load path to a first contact area of the elastic torsion member, which transmits the preload through a torsional load path through the elastic torsion member to a second contact area of the elastic torsion member, which transmits the preload through a second axial load path to a tube sheet gasket.

~~40~~21. The operation method of claim ~~39~~20, wherein the elastic torsion member is configured to pivot at the first contact area where the elastic torsion member contacts a sleeve member and at the second contact area where the elastic torsion member contacts a bearing ring.

~~41~~22. The operation method of claim ~~36~~17, further comprising:

inserting a tube sheet gasket into an open cylindrical channel end axially along the longitudinal axis of the ~~elongated~~ heat exchanger enclosure to be positioned adjacent a channel shoulder configuration formed in the ~~elongated~~ heat exchanger enclosure;

inserting a tube sheet into the open cylindrical channel end axially along the longitudinal axis of the ~~elongated~~ heat exchanger enclosure to be positioned adjacent the tube sheet gasket so as to define a shell side and a channel side within the interior chamber of the ~~elongated~~ heat exchanger enclosure, wherein the interior chamber is configured to removably receive a tube bundle positioned within the shell side of the interior chamber;

inserting an annular sleeve member into the open cylindrical channel end axially along the longitudinal axis of ~~elongated~~ heat exchanger enclosure to be positioned adjacent the tube sheet;

inserting ~~an~~ the elastic torsion member into the open cylindrical channel end along the longitudinal axis of the ~~elongated~~ heat exchanger enclosure so as to be positioned adjacent the sleeve member;

inserting a bearing ring into the open end of the cylindrical channel along the longitudinal axis of the ~~elongated~~ heat exchanger enclosure so as to be positioned adjacent the elastic torsion member; and

inserting a diaphragm into the open end of the cylindrical channel along the longitudinal axis of the ~~elongated~~ heat exchanger enclosure so as to be positioned adjacent the bearing ring.

~~42~~23. The operation method for a tubular heat exchanger enclosure as recited in claim ~~36~~17, further including affixing a closure assembly to an open end portion of the interior chamber, the closure assembly including a deflectable diaphragm and bearing ring and further including a mechanism for imparting the preload to the elastic torsion member.