

ANTI-ROTATION DEVICE FOR HYDRAULIC CONNECTORS

RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application No. 61/895,245 filed October 24, 2013, the disclosure of which is hereby incorporated by
5 reference herein in its entirety.

FIELD OF THE DISCLOSURE

The disclosure is directed to the field of hydraulic connectors generally, and more specifically to locking devices for hydraulic connectors comprising a polymer or fluoropolymer material.

10 BACKGROUND OF THE DISCLOSURE

The use of hydraulic connectors fabricated from polymers or fluoropolymers have found favor in the handling of caustic fluids, such as found in the semiconductor and related industries. A characteristic of these connectors is that they tend to loosen after reaching elevated temperatures. For example, fluoropolymer hydraulic connectors have
15 been observed to loosen after just a single thermal cycle to approximately 200 °C (about 393 °F). Repeated thermal cycling can cause the connector to loosen further. Also, once loosened, vibration experienced by the hydraulic connector during operation can cause further loosening. Eventually, the loosening can cause the hydraulic connector to leak. Fittings can also loosen under vibration conditions such as when complete assemblies with
20 fittings are shipped from the assembly location to their final destination.

A system that prevents hydraulic connectors from loosening to the point of leaking would be welcomed.

SUMMARY OF THE DISCLOSURE

Various embodiments of the present disclosure provide a mechanism whereby
25 threadably engaged connectors, such as compression fittings, are permitted to rotate only a fraction of a turn after loosening. For many applications, the limited degree of loosening is sufficient to prevent the onset of leaking. Some embodiments can also be retrofitted to commonly used compression fittings, such as flare, insert, or insert style fittings, as well as the PRIMELOCK fittings manufactured by Entegris, Inc.

30 Structurally, various embodiments of the hydraulic connector assembly disclosed herein comprise a male body threadably engaged with a female nut, the male body

including a stop tab that extends radially outward therefrom, the female nut being concentric about a central axis and including a recess formed on an exterior surface thereof, the female nut including a proximal end that is distal to the stop tab. An anti-rotation band is engaged with and extends tangentially around the female nut to define a proximal edge of the anti-rotation band. The anti-rotation band includes a protrusion having a base portion and a projecting portion, the base portion extending radially inward from an interior surface of the anti-rotation band, the projecting portion of the protrusion extending beyond the proximal edge of the anti-rotation band in a direction parallel to the central axis. The base portion of the protrusion can be disposed within the recess of the female nut. In various embodiments, rotation of the female nut relative to the male body causes the anti-rotation band to rotate therewith and causes the projecting portion of the protrusion to engage with the stop tab of the male body, thereby preventing further rotation of the female nut.

In various embodiments, a hydraulic connector assembly is disclosed, comprising a male body threadably engaged with a female nut, the male body including a stop tab that extends radially outward therefrom, the female nut being concentric about a central axis and including a recess formed on an exterior surface thereof. An anti-rotation band is engaged with and extends tangentially around the female nut to define a proximal edge of the anti-rotation band. The anti-rotation band can include a protrusion having a base portion and a projecting portion. The base portion can extend radially inward from an interior surface of the anti-rotation band, the base portion being disposed within the recess of the female nut. In one embodiment, the projecting portion of the protrusion extends beyond the proximal edge of the anti-rotation band in a direction parallel to the central axis. Rotation of the female nut relative to the male body causes the anti-rotation band to rotate therewith and causes the projecting portion of the protrusion to engage with the stop tab of the male body, thereby preventing further rotation of the female nut. The stop tab can be arcuate. The recess can be substantially parallel to the central axis. In one embodiment, the recess is one of a plurality of recesses defined on the exterior surface and distributed about the central axis, each of the plurality of recesses being dimensioned to mate with the base portion of the protrusion. The recesses can be uniformly distributed about the central axis. In one embodiment, the anti-rotation band extends tangentially around the circumference of the exterior surface of the female nut. In one embodiment, anti-rotation band includes free ends and complementary clasp arrangements for

joining the free ends together. The hydraulic connector assembly can further comprise a retention ring coupled with the anti-rotation band, the retention ring maintaining the protrusion in an orientation for engagement with the stop tab. In one embodiment, the retention ring is a verification structure.

5 In various embodiments, a maximum degree of rotation of the female nut relative to the male body before the protrusion engages the stop tab is between 60° and 90° inclusive. For some of these embodiments, the maximum degree of rotation is not greater than 80°. In some embodiments, the maximum degree of rotation of the female nut relative to the male body before the protrusion engages the stop tab is between 65° and 75°
10 inclusive. In still other embodiments, a maximum degree of rotation of the female nut relative to the male body before the protrusion engages the stop tab is between 3° and 25° inclusive. In certain embodiments, the maximum degree of rotation of the female nut relative to the male body before the protrusion engages the stop tab is between 5° and 20° inclusive; for some of these embodiments, the maximum degree of rotation is not greater
15 than 15°; for others of these embodiments, the maximum degree of rotation is not greater than 10°.

 In various embodiments of the disclosure, an anti-rotation band for a hydraulic connector is disclosed, comprising a band portion including opposed free ends and defining a proximal edge, and a plurality of protrusions that extend from the band portion,
20 each of the plurality of protrusions extending proximal to the proximal edge. The band portion can define a surface extending from the proximal edge of the band portion, wherein each of the plurality of protrusions includes a base portion, each of the base portions extending from the surface of the band portion. In one embodiment, the band portion is a cable tie.

25 In one embodiment, the plurality of protrusions comprises three protrusions. A distance between a first of the three protrusions and a second of the three protrusions is equal to a distance between the second of the three protrusions and a third of the three protrusions. The band can be arcuate, with the surface being an interior surface. The anti-rotation band can further comprise a clasping arrangement for selectively joining the
30 opposed free ends of the band portion. In one embodiment, the anti-rotation band is substantially circular about a central axis when the opposed free ends are selectively joined with the clasping arrangement, such that a first of the three protrusions and a second of the three protrusions are centered about the central axis to define a first angle,

and the second of the three protrusions and a third of the three protrusions are centered about the central axis to define a second angle, the first angle being substantially equal to the second angle. In one embodiment, the first angle and the second angle are substantially 60°.

5 In various embodiments of the disclosure, a method for preventing a hydraulic connector assembly from leaking is disclosed, comprising:

- providing an anti-rotation band that includes a band portion and a protrusion that extends from the band portion, the protrusion including a base portion that extends laterally from the band portion and a projecting portion extending axially from the base portion; and
- 10 • providing a set of instructions on a tangible medium, the instructions including:
 - wrapping the anti-rotation band around a female nut of a hydraulic connector assembly; and
 - 15 ○ securing the anti-rotation band on the female nut so that the projecting portion of the protrusion extends tangentially adjacent to a stop tab located on a male body of the hydraulic connector assembly.

In some embodiments, the anti-rotation band provided in the step of providing an anti-rotation band includes clasp structures for securing the anti-rotation band to the female nut. In other embodiments, the method comprises providing a standard cable tie, wherein the standard cable tie is utilized in the step of securing the anti-rotation band on the female nut. In various embodiments, the set of instructions further comprises inserting the protrusion in a recess defined on an outer surface of the female nut, such that the projecting portion of the protrusion extends tangentially adjacent to a stop tab located on a male body of the hydraulic connector assembly. In one embodiment, the protrusion is integrally formed with the band portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a fully assembled hydraulic connector assembly in an embodiment of the disclosure;

FIG. 2 is a sectional view of the hydraulic connector assembly of FIG. 1;

FIG. 3 is an exploded view of the hydraulic connector assembly of FIG. 1, *sans* the connection verification structure;

FIG. 4 is a perspective view of the hydraulic connector assembly of FIG. 1, *sans* the connection verification structure;

FIG. 5 is a perspective view of an anti-rotation band in isolation in an embodiment of the disclosure;

FIGS. 6 through 8 are enlarged partial views of clasping arrangements for the anti-rotation bands in embodiments of the disclosure;

FIG. 9 is an enlarged, partial view of an open ended anti-rotation band in an
10 embodiment of the disclosure;

FIG. 10 is an anti-rotation band comprising a modified cable tie in an embodiment of the disclosure;

FIG. 11 is an enlarged, partial sectional view of a modified cable tie anti-rotation band in an embodiment of the disclosure;

15 FIG. 12 is a perspective view of an anti-rotation band in isolation that includes three protrusions and two locking apertures in an embodiment of the disclosure; and

FIGS. 13A through 13F are end views of the three-protrusion anti-rotation band of FIG. 12 in interaction with stop tabs of a male body of a connector at various angular orientations.

20 DETAILED DESCRIPTION OF THE FIGURES

Referring to FIGS. 1 through 5, a hydraulic connector assembly 30 is depicted in an embodiment of the disclosure. The hydraulic connector assembly 30 includes a male body 32, a female nut 34 and an anti-rotation band 36. Optionally, the hydraulic connector assembly 30 can also include a connection verification structure 38.

25 The male body 32 includes a tubular portion 42 and a threaded connector portion
44 concentric about a central axis 46. The threaded connector portion 44 can be
characterized as having a proximal end 48 and a distal end 52. An external thread 54 is
formed on an exterior surface 56 of the threaded connector portion 44. In one
embodiment, the tubular portion 42 and the threaded connector portion 44 are bridged by a
30 flange portion 58 at the proximal end 48 of the connector portion.

For purposes of this application, “proximal” refers to a direction along the central axis 46 that progresses from the female nut 34 through the male body 32, and “distal” refers to a direction along the central axis 46 that progresses from the male body 32 through the female nut 34. The proximal direction is represented by arrow 60 and the distal direction by arrow 61 in FIG. 2.

In one embodiment, the connector portion 44 includes at least one stop tab 62 that extends radially outward from the connector portion 44, the stop tab(s) 62 being proximal to the external thread 54 and distal to the flange portion 58. In the depicted embodiment, the stop tabs 62 are diametrically opposed to each other on the male body 32 (identified as 62a and 62b in FIG. 3), each extending tangentially to define an arcuate segment 64 about the central axis 46 having a tangential dimension. In one embodiment the tangential dimension is about 30°.

The female nut 34 can be characterized as having a proximal end 72 and a distal end 74, and includes an interior surface 76 having internal threads 78 formed thereon for threadable engagement with the external thread 54 of the male body 32. The female nut 34 includes an exterior surface 82 that includes structure defining a plurality of recesses 84. The recesses 84 can extend from the proximal end 72 to the distal end 74 to define axially-extending channels. In one embodiment, the exterior surface 82 includes a necked down portion 86 at the proximal end 72.

The anti-rotation band 36 includes a band portion 88 that can be an arcuate structure having an interior surface 92. The anti-rotation band 36 is arranged to wrap at least partially around the exterior surface 82 of the female nut 34, thereby defining a proximal edge 90 and a distal edge 96. In the depicted embodiment, the interior surface 92 conforms to the contour of the necked down portion 86 of the female nut 34.

In one embodiment, at least one protrusion 94 projects radially inward from the interior surface 92. The protrusion(s) 94 can be characterized as extending laterally from the band portion 88 and as having a distal or base portion 102 and a proximal or projecting portion 104. The base portion 102 projects radially inward from the interior surface 92 of the anti-rotation band 36, and is dimensioned to have a width 106 that provides a sliding fit within the recesses 84 of the female nut 34. For embodiments that include the necked down portion 86 of the female nut 34, the base portion 102 can be formed to have a profile 108 that complements the profile of the necked down portion 86. The projecting portion

104 of the protrusion(s) 94 extends beyond the proximal edge 90 of the anti-rotation band 36.

5 In some embodiments, the anti-rotation band 36 extends tangentially around the circumference of the exterior surface 82 of the female nut 34. In one embodiment, the anti-rotation band 36 includes free ends 112 and 114 that comprise claspings arrangements 116 with complementary claspings structures for selectively joining the free ends 112 and 114.

10 The connection verification structure 38, if utilized, includes an outer wall 122 from which an interior flange portion 124 extends radially inward and registers against the flange portion 58 of the male body 32. The function of the connection verification structure 38 is to provide visual and audible verification that the female nut 34 properly secured to the male body 32, as described, for example, in "PrimeLock® Minimum Tube Unions," P/N 01-1023457 (Rev. C 03/13), March 2013, available at <http://www.entegrisfluidhandling.com/Documents/3110-7235-0313.pdf>, last visited on 15 October 23, 2013, the disclosure of which is hereby incorporated by reference herein in its entirety except for express definitions contained therein.

20 In assembly, a hose (not depicted) is fed through the female nut 34 and slid over the tubular portion 42 of the male body 32. The female nut 34 is then threaded onto the connector portion 44 and tightened to a prescribed torque specification to affect a compression fit on the hose. The anti-rotation band 36 is then strapped onto the exterior surface 82 of the female nut 34 at the distal end 74 of the female nut 34 so that the base portion(s) 102 of the protrusion(s) 94 are disposed in a respective one of the plurality of recesses 84. (For embodiments incorporating the connection verification structure 38, the necked down portion 86 of the female nut 34 is surrounded by the outer wall 122 in the assembled configuration, as depicted in FIG. 2.) In this way, the anti-rotation band 36 is coupled to the female nut 34 so that the anti-rotation band 36 rotates with the female nut 34.

30 Also in this configuration, the projecting portion(s) 104 of the protrusion(s) 94 extend beyond the proximal end of the female nut 34, so that the projecting portion(s) 104 are tangentially adjacent the stop tab(s) 62. Herein, "tangentially adjacent" means to be adjacent in the θ direction of the right-cylindrical coordinate system of FIG. 3, such that rotation of the stop tab(s) about the central axis 46 would cause contact with the projecting

portion(s) 104. In one embodiment, the projecting portion(s) 104 of the protrusion(s) 94 extend past the stop tab(s) 62. That is, the proximal extremity of the projecting portion(s) 104 are proximal to the stop tab(s) 62.

5 In operation, when the female nut 34 is loosened and incidentally rotates about the central axis 46, the anti-rotation band 36 is carried therewith. In this way, anti-rotation band 36 and accompanying protrusion(s) 94 are also rotated until contact is made between the projecting portion 104 and the stop tab(s) 62. Once such contact is made, the anti-rotation band 36—and therefore the female nut 34—cannot rotate further.

10 The connection verification structure 38, or similar structure having the wall 122 and interior flange portion 124, can function as a retention ring that prevents the anti-rotation band 36 from sliding off the proximal end 72 of the female nut 34, and also can maintain the protrusion(s) 94 in an orientation for engagement with the stop tab 62.

In various embodiments, a pair of protrusions 94a and 94b are utilized, as depicted in the various embodiments and identified in FIG. 4. In one assembled configuration, the protrusions 94a and 94b straddle the stop tab 62. In other configurations (not depicted), the pair of protrusions 94a and 94b can be disposed between the pair of stop tabs 62a and 62b. The spacing between the protrusions 94a and 94b can be such that only a small angle of incidental rotation (e.g., on the order of $\theta = 5^\circ$) is permitted in one of the configurations, while a larger angle of incidental rotation (e.g., on the order of $20^\circ - 30^\circ$) is permitted before there is engagement between the one of the protrusions 94a or 94b and the stop tab 62.

25 In other configurations (not depicted), the pair of protrusions 94a and 94b can be disposed between the pair of stop tabs 62a and 62b (e.g., FIG. 3). In such a configuration, incidental rotation would occur until one of the protrusions 94a or 94b makes contact with one of the stop tabs 62a or 62b. Again, the magnitude of the angle of incidental rotation is a matter of the spacing of the protrusions 94a and 94b relative to the stop tabs 62a and 62b.

30 In one non-limiting example embodiment, the protrusions 94a and 94b are centered substantially 60° apart relative to the central axis 46, with tangential spacing between the protrusions 94a and 94b on the order of 58° to 54° , and the stop tabs 62a, 62b each occupying an angular dimension on the order of 40° to 50° inclusive. By this arrangement, for two stop tabs 62a and 62b, the maximum rotation of the female nut 34 before one of

the stop tabs 62a or 62b engages one of the protrusions 94a or 94b is on the order of 62° to 76° if the stop tabs 62a, 62b are both outside the interval between the protrusions 94a and 94b; the maximum rotation of the female nut 34 before one of the stop tabs 62a or 62b engages one of the protrusions 94a or 94b is on the order of 4° to 18° if one of the stop tabs
5 62a, 62b is within the interval between the protrusions 94a and 94b.

Again, the actual maximum degree of rotation before engagement between the protrusion 94 and the stop tab 62 depends on the specific dimensions and layout of the stop tab 62 and protrusions 94. In some embodiments, for configurations where the stop tabs 62a, 62b fall outside the interval between protrusions 94a and 94b, the maximum
10 rotation is in the range of 60° to 90° inclusive; in other embodiments, the maximum rotation is in the range of 60° to 80° inclusive; in still other embodiments, the maximum rotation is in the range of 65° to 75° inclusive. For configurations where the stop tabs 62a, 62b fall within the interval between protrusions 94a and 94b, the maximum rotation can be in the range of 3° to 25° inclusive for various embodiments; for some embodiments, the
15 maximum rotation can be in the range of 5° to 20° inclusive; for still other embodiments, the maximum rotation can be in the range of 5° to 15° inclusive or 5° to 10° inclusive.

It is noted that the portrayal herein of a pair of protrusions in the various depictions is non-limiting. A single protrusion can be utilized, as incidental rotation will, in any case, be less than one revolution. Also, knowing the direction of the incidental rotation, one can
20 position the single protrusion at a rotational location relative to the stop tab 62 so that only a small angle of travel is permitted before contact with the stop tab 62. Furthermore, more than two protrusions can also be utilized.

Referring to FIGS. 6 through 8, various clasping arrangements 116a, 116b and 116c are respectively depicted for coupling the free ends 112 and 114 together in
25 embodiments of the disclosure. The clasping arrangement 116a includes a radially protruding barb 132 that mates with an aperture 134. The clasping arrangement 116b includes a snap-on connector arrangement 142 having a male snap 144 and a female receptacle 146, wherein the male snap 144 is slid tangentially into the female receptacle 146. The clasping arrangement 116c is also a snap-on connector arrangement 152 having
30 a male snap 154 and a female receptacle 156; however, the male snap 154 and the female receptacle 156 are arranged so that the male snap 154 is inserted into the female receptacle 156 in the axial direction (i.e., parallel to the central axis 46).

Referring to FIG. 9, an open ended anti-rotation band 160 is depicted in a disclosed embodiment. The open ended anti-rotation band 160 includes many of the same aspects as the anti-rotation bands 36 described above, which are shown with like-numbered numerical references. The open ended anti-rotation band 160 includes free ends 162 and 164 that do not include clasp arrangements. Instead, an exterior surface 166 can include ridges 168 proximate the proximal and distal edges 90, 96 that define a tangential channel 172 therebetween. The tangential channel 172 can be used to capture a tying device (not depicted) such as a cord, a twist tie, or a conventional cable tie that loops around the open ended anti-rotation band 160. The tying device is tightened to secure the open ended anti-rotation band 160 to the female nut 34, with the protrusions 94 disposed in respective recesses 84.

Referring to FIGS. 10 and 11, an anti-rotation band 178 comprising a modified cable tie 180 is depicted in a disclosed embodiment. The modified cable tie 180 includes a band portion or cable tie portion 182 with the protrusions 94a and 94b extending laterally from a proximal edge 90 thereof. In one embodiment, the protrusions 94a and 94b are integrally formed with the cable tie portion 182. The protrusions 94a and 94b can be characterized as having a distal end 184 (i.e., the distal extremity of the base portion 102) that is integral with the cable tie portion 182. Thus, for the anti-rotation band 178, the base portion 102 can be, but is not required to be, mounted to an interior face 188 of the cable tie portion 182.

In assembly, the modified cable tie 180 is mounted so that the cable tie portion 182 is distal to the necked down portion 86 of the female nut 34, where the exterior surface 82 of the female nut 34 tangentially defines a right cylinder. At such a location, the interior face 188 of the cable tie portion 182 conforms to the female nut 34. The modified cable tie 180 is positioned on the female nut 34 so that the protrusions 94a and 94b extend proximally and mate within the recesses 84 on the necked down portion 86 of the female nut 34. In one embodiment, a spacing 186 between the centers of the protrusions 94a and 94b is dimensioned so that the protrusions 94a and 94b register in respective recesses 84 on the necked down portion 86 of the female nut 34 when the modified cable tie 180 is wrapped around the female nut 34 and cinched into place.

It is noted that, in some embodiments, the protrusions 94a and 94b of the anti-rotation band 178 may easily deflect radially outward. The junction between the distal end 184 of the protrusions 94a, 94b might not offer much resistance to bending. Even if the

coupling of the protrusion 94 to the cable tie portion 182 is enhanced by forming the protrusions 94a, 94b to the interior face 188 of the cable tie portion 182, the requisite flexibility of the cable tie portion 182 may cause it to roll away from the female nut 34 when the protrusions 94a, 94b are subject to an outward radial force. Accordingly, the connection verification structure 38 (or structure with similar features of the wall 122 and interior flange 124) may be required to capture the projecting portions 104 of the protrusions 94a and 94b to prevent them from rolling away from the female nut 32.

Referring to FIG. 12 and FIGS. 13A-13F, a three-protrusion anti-rotation band 190 with dual locking apertures 134a and 134b is depicted in an embodiment of the disclosure. The three-protrusion anti-rotation band 190 includes many of the same aspects as the anti-rotation band 36 described above, which are shown with like-numbered numerical references. In addition, the three-protrusion anti-rotation band 190 includes a third protrusion 94c. In one embodiment, the three protrusions 94a, 94b, and 94c are spaced at tangentially uniform locations along the band portion 88; that is, the tangential spacing between protrusions 94a and 94b are the same as between protrusions 94b and 94c. The tangential spacing between protrusions 94a, 94b, and 94c can be dimensioned to readily accommodate the tangential dimension of stop tab 62 while engaging the stop tab 62 after a desired angle of incidental rotation. In the depicted embodiment, the protrusions 94a, 94b, and 94c are centered at substantially 60° intervals (FIG. 13A). Herein, “substantially 60°” means 60° to within the manufacturing and assembly tolerance of the three-protrusion anti-rotation band 190.

In one embodiment, the clasping arrangement 116 of the three-protrusion anti-rotation band 190 includes two apertures 134a and 134b, each sized to accommodate the radially protruding barb 132 in a clasping arrangement. It is noted that the dual aperture arrangement is not limited to the three-protrusion anti-rotation band 190; that is, the dual aperture arrangement can be utilized with any of the embodiments disclosed herein that utilize clasping arrangements 116, such as depicted in FIGS. 6 through 8.

Functionally, for the embodiment of FIGS. 1 through 5 which includes two diametrically opposed stop tabs 62a and 62b, the provision of a third protrusion 94c enables the three-protrusion anti-rotation band 190 to be installed at six unique angular orientations uniformly distributed about the central axis 46. An advantage of having the flexibility of multiple angular orientations for installation is that the installer may be constrained to a narrow range of angular orientations within which the anti-rotation band

can be installed. The narrow range may be imposed, for example, by extraneous appurtenances and equipment proximate the hydraulic connector assembly 30 that preclude installation at certain orientations.

Illustration of this capability is depicted in FIGS. 13A through 13F. In each of the
5 FIGS. 13A through 13F, the male body 32 is arranged in the same orientation, with stop tabs 62a and 62b oriented in a 12:00 and 6:00 position, respectively. In reference to FIG. 13A, the clasp arrangement 116 is in substantial radial alignment with the stop tab 62a. By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the clockwise direction will cause protrusion 94c to engage stop tab 62b, whereas rotation in
10 the counterclockwise direction will cause protrusion 94a to engage with stop tab 62a. Either engagement will effectively halt the rotation (loosening) of the female nut 34 (to which the three-protrusion anti-rotation band 190 is coupled).

In reference to FIG. 13B the clasp arrangement 116 is rotationally offset at an angle θ_2 relative to the stop tab 62a. For embodiments where the protrusions 94a, 94b,
15 and 94c are spaced 60° apart, θ_2 is also centered substantially at 60° relative to stop tab 62a (i.e., relative to the 12:00 position). By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the clockwise direction will cause protrusion 94b to engage stop tab 62b, whereas rotation in the counterclockwise direction will cause protrusion 94c to engage with stop tab 62b, again effectively halting the loosening of the
20 female nut 34.

In reference to FIG. 13C the clasp arrangement 116 is rotationally offset at an angle θ_3 relative to the stop tab 62a. For embodiments where the protrusions 94a, 94b, and 94c are spaced 60° apart, θ_3 is centered substantially at 120° relative to the stop tab 62a. By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the
25 clockwise direction will cause protrusion 94a to engage stop tab 62b, whereas rotation in the counterclockwise direction will cause protrusion 94b to engage with stop tab 62b, again effectively halting the loosening of the female nut 34.

In reference to FIG. 13D the clasp arrangement 116 is rotationally offset at an angle θ_4 relative to the stop tab 62a. For embodiments where the protrusions 94a, 94b,
30 and 94c are spaced 60° apart, θ_4 is centered substantially at 180° relative to the stop tab 62a. By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the clockwise direction will cause protrusion 94c to engage stop tab 62a, whereas rotation in

the counterclockwise direction will cause protrusion 94a to engage with stop tab 62b, again effectively halting the loosening of the female nut 34.

In reference to FIG. 13E the clasp arrangement 116 is rotationally offset at an angle θ_5 relative to the stop tab 62a. For embodiments where the protrusions 94a, 94b, and 94c are spaced 60° apart, θ_5 is centered substantially at 240° relative to the stop tab 62a. By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the clockwise direction will cause protrusion 94b to engage stop tab 62a, whereas rotation in the counterclockwise direction will cause protrusion 94c to engage with stop tab 62a, again effectively halting the loosening of the female nut 34.

In reference to FIG. 13F the clasp arrangement 116 is rotationally offset at an angle θ_6 relative to the stop tab 62a. For embodiments where the protrusions 94a, 94b, and 94c are spaced 60° apart, θ_6 is centered substantially at 300° relative to the stop tab 62a. By this arrangement, rotation of the three-protrusion anti-rotation band 190 in the clockwise direction will cause protrusion 94a to engage stop tab 62a, whereas rotation in the counterclockwise direction will cause protrusion 94b to engage with stop tab 62a, again effectively halting the loosening of the female nut 34.

Accordingly, the three-protrusion anti-rotation band 190, as depicted in FIGS. 12 and 13A through 13F, can be oriented in increments of 60° —six unique positions—about the central axis 46, while providing substantially the same amount of play in the loosening rotation of the female nut 34 before engagement with one of the stop tabs 62a, 62b, regardless of mounted orientation. This can enable ready installation of the three-protrusion anti-rotation band 190 in any of the multiple orientations while providing substantially the same low angle of rotational play or loosening before engagement with the stop tab 62. For example, for the angular layout discussed above, wherein the spacing between adjacent protrusions 94a, 94b and 94b, 94c is on the order of 58° to 54° , and the stop tabs 62a, 62b each occupying an angular dimension on the order of 40° to 50° inclusive, the maximum rotation of the female nut 34 before one of the stop tabs 62a or 62b engages one of the protrusions 94a or 94b is on the order of 4° to 18° , regardless of whether one of the stop tabs 62a, 62b is within or outside the interval between the two of the protrusions 94a, 94b or 94b, 94c. Also, depending on the dimensions and arrangements of the stop tabs 62 and protrusions 94, the maximum rotation can be in the range of 3° to 25° inclusive for various embodiments; for some embodiments, the

maximum rotation can be in the range of 5° to 20° inclusive; for still other embodiments, the maximum rotation can be in the range of 5° to 15° inclusive or 5° to 10° inclusive.

Functionally, the dual apertures 134a and 134b of the three-protrusion anti-rotation band 190 can accommodate radial growth of the necked down portion 86 of the female nut 34 that can occur due to creep stress. The necked down portion 86 is more susceptible deformation, at least in part due to the reduced thickness of material relative to the main body of the female nut 34. In operation, when the female nut 34 is tightened onto the male body 32, the necked down portion 86 can deform radially outward. The radial growth can be permanent due to creep stresses, particularly when operating conditions entail elevated temperatures. Thus, the diameter of the female nut 34 at the necked down portion 86 may be larger after a period of service than for a new, unused female nut 34.

Accordingly, the dual apertures 134a and 134b can enable the three-protrusion anti-rotation band 190 to accommodate a new, unused female nut 34 or a used female nut 34 in a retrofit. The coupling barb 132 with aperture 134a can accommodate a first, larger diameter female nut 34 for retrofit situations, while coupling the barb 132 with aperture 134b can accommodate a second, smaller diameter for a new, unused female nut 34.

In one embodiment, the anti-rotation bands 36, 178, 190 are provided separately (i.e., without the male body 32 or the female nut 34) with instructions for installation. It is noted that certain aspects of the hydraulic connector assembly 30 are included in existing hydraulic connectors. For example, PRIMELOCK fittings typically include the male body 32 with stop tabs 62a and 62b and flange 48 that cooperate with the connection verification structure 38. PRIMELOCK fittings also typically include the female nut 34 with recesses 84 for engagement with a custom nut wrench. Accordingly, anti-rotation bands 36, 178, 190 can be configured as a retrofit for connector systems such as the PRIMELOCK, complete with instructions for installation.

In one embodiment, the instructions are provided on a tangible medium, such as paper, compact disc, or on a computer memory device, and can include the following steps:

- wrapping the anti-rotation band 36, 178, 190 around a female nut 34 of the hydraulic connector assembly 30;

- inserting the protrusion 94 in the recess 84, such that the projecting portion 104 of the protrusion 94 extends past the stop tab 62 located on the male body 32 of the hydraulic connector assembly 30; and
- securing the anti-rotation band 36, 178, 190 on the female nut 34.

5 In one embodiment, a standard cable tie is provided to secure the anti-rotation band 36 to the female nut 34.

Each of the additional figures and methods disclosed herein can be used separately, or in conjunction with other features and methods, to provide improved containers and methods for making and using the same. Therefore, combinations of features and methods
10 disclosed herein may not be necessary to practice the invention in its broadest sense and are instead disclosed merely to particularly describe representative and preferred embodiments of the instant invention.

Various modifications to the embodiments of the inventions may be apparent to one of skill in the art upon reading this disclosure. For example, persons of ordinary skill
15 in the relevant art will recognize that the various features described for the different embodiments of the inventions can be suitably combined, un-combined, and re-combined with other features, alone, or in different combinations, within the spirit of the invention. Likewise, the various features described above should all be regarded as example embodiments, rather than limitations to the scope or spirit of the inventions. Therefore, the
20 above is not contemplated to limit the scope of the inventions.

Persons of ordinary skill in the relevant arts will recognize that the inventions may comprise fewer features than illustrated in any individual embodiment described above. The embodiments described herein are not meant to be an exhaustive presentation of the ways in which the various features of the inventions may be combined. Accordingly, the
25 embodiments are not mutually exclusive combinations of features; rather, the inventions may comprise a combination of different individual features selected from different individual embodiments, as understood by persons of ordinary skill in the art.

Any incorporation by reference of documents above is limited such that no subject matter is incorporated that is contrary to the explicit disclosure herein. Any incorporation
30 by reference of documents above is further limited such that no claims included in the documents are incorporated by reference herein. Any incorporation by reference of

documents above is yet further limited such that any definitions provided in the documents are not incorporated by reference herein unless expressly included herein.

References to “embodiment(s)”, “embodiment(s) of the disclosure”, and “disclosed embodiment(s)” contained herein refer to the specification (text, including the claims, and
5 figures) of this patent application that are not admitted prior art.

For purposes of interpreting the claims for the embodiments of the inventions, it is expressly intended that the provisions of 35 U.S.C. 112(6) are not to be invoked unless the specific terms “means for” or “step for” are recited in the respective claim.

CLAIMS

What is claimed is:

1. A hydraulic connector assembly, comprising:
 - a male body threadably engaged with a female nut, said male body including a stop tab that extends radially outward therefrom, said female nut being concentric about a central axis and including a recess formed on an exterior surface thereof;
 - an anti-rotation band engaged with and extending tangentially around said female nut to define a proximal edge of said anti-rotation band, said anti-rotation band including a protrusion having a base portion and a projecting portion, said base portion extending radially inward from an interior surface of said anti-rotation band and being disposed within said recess of said female nut, said projecting portion of said protrusion extending beyond said proximal edge of said anti-rotation band in a direction parallel to said central axis,
 - wherein rotation of said female nut relative to said male body causes said anti-rotation band to rotate therewith and causes said projecting portion of said protrusion to engage with said stop tab of said male body, thereby preventing further rotation of said female nut.
2. The hydraulic connector assembly of claim 1, wherein said stop tab is arcuate
3. The hydraulic connector assembly of claim 1, wherein said recess is substantially parallel to said central axis
4. The hydraulic connector assembly of claim 1, wherein said recess is one of a plurality of recesses defined on said exterior surface and distributed about said central axis, each of said plurality of recesses being dimensioned to mate with said base portion of said protrusion.

5. The hydraulic connector assembly of claim 4, wherein said recesses are uniformly distributed about said central axis.
6. The hydraulic connector assembly of claim 1, wherein said anti-rotation band extends tangentially around the circumference of the exterior surface of the female nut.
7. The hydraulic connector assembly of claim 6, wherein said anti-rotation band includes free ends and complementary claspings arrangements for joining said free ends together.
8. The hydraulic connector assembly of claim 1, further comprising a retention ring coupled with said anti-rotation band, said retention ring maintaining said protrusion in an orientation for engagement with said stop tab.
9. The hydraulic connector assembly of claim 8, wherein said retention ring is a verification structure.
10. The hydraulic connector assembly of claim 1, wherein a maximum degree of rotation of said female nut relative to said male body before said protrusion engages said stop tab is between 60° and 90° inclusive.