[0010] Thus, in one aspect, the invention provides an apparatus for sealing an open end of a pipe comprising:

[0011] - a sealing plate sized to cover the open end of the pipe;

[0012] - a first compression ring and gripper ring assembly, sized to be provided over the outer surface of the pipe,

[0013] - a first means for connecting the first compression ring to the sealing plate and for urging the first compression ring towards the sealing plate;

[0014] - the first compression ring and the first gripper ring being provided in a cooperating arrangement, wherein urging of the first compression ring towards the sealing plate forces the first gripper ring against the outer surface of the pipe;

[0015] - a second compression ring and gripper ring assembly, sized to be provided within the diameter of the pipe;

[0016] - a second means for connecting the second compression ring to the sealing plate and for urging the second compression ring towards the sealing plate;

[0017] - the second compression ring and the second gripper ring being provided in a cooperating arrangement, wherein urging of the second compression ring towards the sealing plate forces the first gripper ring against the inner surface of the pipe; and,

[0018] - a backplate sized to be provided within the pipe, the backplate being connected to the sealing plate and being provided on an a side of the second compression ring opposite to the sealing plate.

[0019] In a further embodiment, the invention provides a method for sealing a section of a pipe having an open end, the method comprising:

[0020] - providing an apparatus having a first clamping means, for frictionally engaging the outer surface of the pipe, and a second clamping means, for frictionally engaging the inner surface of the pipe; and,

[0021] - forming a seal between the inner surface of the pipe and the second clamping means.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] These and other features of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings wherein:

[0023] Figure 1 is a cross sectional view of one embodiment of the apparatus of the present invention.

[0024] Figure 2 is a perspective view of the clamp of the apparatus of Figure 1.

[0025] Figure 3 is a cross sectional elevation of another embodiment of the clamp of Figure 1.

[0026] Figures 4, 4b, 5 and 6 are cross sectional views of further embodiments of the present invention.

[0027] Figures 7 to 9 are cross sectional views of an embodiment of the invention having an external clamp.

[0028] Figure 10 is a perspective view of another aspect of the invention shown in Figure 9.

[0029] Figure 11 is side view of another aspect of the invention shown in Figure 10.

[0030] Figure 12 is an end view of a clamp shown in Figures 10 and 11.

[0031] Figure 13 is a side cross-sectional view of another embodiment of the external clamp according to the invention.

[0032] Figure 14 is an end view of the embodiment shown in Figure 13.

[0033] Figure 15 is a side cross-sectional view of another embodiment of the external clamp according to the invention.

[0034] Figures 16 and 17 are front and side cross-sectional views of the compression ring shown in Figure 15.

[0035] Figures 18 and 19 are front and side cross-sectional views of the clamping ring shown in Figure 15.

[0036] Figures 20, 21 and 22 are front, side cross-sectional and detailed cross-sectional views of the gripper ring shown in Figure 15.

[0037] Figure 23 is a side cross-sectional view of an embodiment of the invention shown in Figure 15 wherein a plurality of external clamps are combined.

[0038] Figure 24 is a side cross-sectional view of an aspect of the invention comrpsing a combination external clamp and internal clamp.

[0039] Figures 25 and 26 are side cross-sectional and front views of the clamping plate shown in Figure 24.

[0040] Figures 27 and 28 are side cross-sectional and front views of the external compression ring shown in Figure 24.

[0041] Figures 29 and 30 are front and side cross-sectional views of the internal compression ring shown in Figure 24.

[0042] Figures 31 and 32 are front and side cross-sectional views of the backplate shown in Figure 24.

[0043] Figures 33, 34 and 35 are front, side cross-sectional and detailed cross-sectional views of the internal gripper ring shown in Figure 24.

DETAILED DESCRIPTION OF THE INVENTION

[0044] Throughout the description of the invention the following terms will be assumed to have the following associated meanings:

[0045] "Vessel" - will be understood to mean any equipment or apparatus to which a nozzle is attached. As such, the term "vessel" will include vessels per se, pipes, drums, and any other similar equipment. It will be understood that the term "vessel" is used herein simply as a convenient way to encompass all such equipment or apparatus.

[0046] "Annular" - this term is used to describe a body having at least one outer diameter and at least one inner diameter. Thus, an "annular tube" will be assumed to be a hollow tube with an inner and outer diameter. An "annular disc" will be assumed to be an object having an outer diameter and a central aperture thereby providing an inner diameter.

[0047] "Axial" - this term will be used to describe a direction taken along the longitudinal axis of a pipe or conduit. Thus, "axial force" or "axial stress" will be understood as being a force applied in a direction parallel to the longitudinal axis of the conduit. Similarly, the term "axially extending" will be understood to mean extending in a direction parallel to the longitudinal axis of the pipe.

[0048] "Proximal" and "distal" - these terms will be used to describe the positions of various components of the invention once positioned over a pipe having an open end. The term "proximal" will be used to describe a position closer to the open end of the pipe. The term "distal" will be used to describe a position away from the open end of the pipe.

[0049] Figure 1 illustrates one aspect of the invention wherein an internal sealing apparatus for a pipe is shown. The sealing apparatus 10 is preferably sized to fit within the lumen of a pipe (or tube) 12. The apparatus 10 comprises a sealing plate 14 having a diameter slightly less than the internal diameter of the pipe 12. The plate includes a first face 16 and a second face 18, wherein the second face is adjacent a clamp 20. The second face 18 of the sealing plate 14 is provided with beveled edge 22 for accommodating an O-ring 24 or other such resilient sealing means.

[0050] The clamp 20 generally comprises an annular ring having an outer diameter sized to fit within the pipe 12. An annular shape for the clamp 20 is preferred to minimize its weight. However, the clamp 20 may also comprise a solid body. As will be understood by persons skilled in the art having reviewed the present disclosure, the outer diameter of the clamp 20 is preferably slightly less than the internal diameter of the pipe 12 so as to permit axial placement of the clamp 20. The clamp 20 is provided with one or more recesses or pockets 26 into which are placed magnets 28. Preferably, the magnets 28 comprise electromagnets that can be activated when desired.

[0051] The magnets 28 provided on the clamp 20 are designed to magnetically attract the wall of the pipe 12, which, as is commonly known in the art, is formed from a ferrous metal. The magnets 28 are designed to form a strong clamping force with the interior wall of the pipe 12 and, thereby, to anchor the clamp in a fixed axial position within the pipe 12. In a preferred embodiment, at least two or more magnets 28 are provided on the clamp 20 with such magnets being placed circumferentially around the annular clamp 20. Such an arrangement will serve to evenly secure the clamp 20 within the pipe 12. Although the

Figure 23 is provided with a plurality of compression rings 202 and gripper rings 206. As will be understood, by providing a plurality of compression and gripper rings, 202 and 206, the amount of clamping force offered by the clamp 250 is increased. In the result, the clamp of Figure 23 is able to withstand higher pipe pressures than the clamp of Figure 15. The number of additional compression rings and clamping rings will vary based on the desired clamping force required and it will be understood that any number of such rings may be provided for any given clamp.

[00110] In order to ensure that each compression ring 202 acts upon a respective gripper ring 206, each of the compression rings 202 are separated by a separation ring 252. As will be understood, the separation rings 252 serve to prevent binding between each of the compression rings and to ensure that each of such compression rings act upon respective gripper rings 206. The separation rings 252 may comprise, for example, O-rings.

[00111] It will be understood that in situations where a given length of a pipe is to be tested, both ends of the pipe can be sealed using any of the sealing apparatus described above. In such case, the ends of the pipe will each be provided with the same or different ones of the apparatus of the invention. Each end of the pipe would thus be sealed and the interior of the pipe may then be pressurized for conducting an integrity test.

[00112] As described above, in some of the embodiments of the invention, the clamp includes a gripper plate (formed of two or more sections) that is provided with a ramped surface adapted to engage an oppositely ramped surface on another portion of the clamp. In some cases, such oppositely ramped surface is provided on the clamp body or on a compression or “squeeze” ring as described above. It will be noted in the described embodiments that the gripper plate is positioned so that the thinner portion of the gripper plate is oriented away from the pipe opening. As seen, for example in Figures 13 and 15, and as will be understood by persons skilled in the art, such an orientation would be preferred. Specifically, once the clamp is tightened against the exterior surface of the pipe, the clamp would be securely engaged and the sealing plate is then attached thereto so as to seal the open end of the pipe. Subsequently, when the interior of the pipe is pressurized (such as in cases where a pressure test is conducted on the pipe), it will be understood that such pressure will act to force the sealing plate of the apparatus away from the pipe opening in the axial direction. However, since the sealing plate is secured to the clamp by means of the sealing bolts (i.e. the bolts connecting the sealing plate to the clamp), the axial movement of the sealing plate would also exert an axial force on the clamp. In the result,

described internal reinforcement (such as shown at 110 in Figure 10) may be used in combination with any of the external clamps described herein. In addition, having the ability to axially position the clamp at any location along the length of the pipe allows for a desired amount of clearance in the event that a weld is located near the open end of the pipe.

[00115] It will be understood that the external clamp and sealing plate of the invention can also be used on pipes that include a bend. For example, in a pipe comprising an elbow, the clamp may be positioned on one side of the bend with the sealing plate covering the pipe opening on an opposite side of the bend. In such case, the connecting elements between the clamp and the sealing plate may be adapted or oriented to provide the same sealing force as described above. For example, the clamp may be provided with an extension for cooperating with the connecting elements to engage the sealing plate. Various other such modifications to the invention are also possible.

[00116] It will be understood by persons skilled in the art that any number of, and types of embodiments of, the clamp of the invention can be used in combination. Such combined use would depend upon the specific use being contemplated and the specific combination will be apparent to persons skilled in the art. For example, the embodiment of Figure 11 may be combined with the embodiment of Figure 23 etc. In this example, the embodiment of Figure 23 can form a downstream “anchor” while the embodiment of Figure 11 is used upstream.

[00117] As discussed above, the apparatus of the invention is preferably used for sealing an end of a pipe so that the interior of the pipe can be pressurized such as for testing the integrity of the pipe. In one example, the integrity test is used for testing a weld that may be present on the pipe. Such a weld may serve to connect two pipe segments or to connect the pipe to another apparatus.

[00118] It will be understood that the above discussion has used geometric terms such as annular, disc, circumference, etc., for ease of reference. However, these terms should not be construed as limiting the invention to any specific shape of nozzle or pipe and various modifications of the apparatus will be apparent to persons skilled in the art to adapt same to any shape or design.

[00119] A further embodiment of the invention is illustrated in Figures 24 to 35. In this embodiment, the invention comprises a combined internal and external clamp shown generally at 500. As shown in Figure 24, the combination clamp 500 includes an external

clamp 300, that is adapted to be secured to the outer surface of a pipe 12, and an internal clamp 400, that is secured to the inner surface of the pipe 12. The external clamp 300 functions in a similar manner to the clamp 200 discussed above. For this reason, elements of clamp 300 that are similar to previously described clamp 200 will be identified with similar reference numerals but starting with "3". As shown, the external clamp 300 comprises a first squeeze, or compression ring 302 and a second, clamping or sealing plate 304. As discussed above, the compression ring 302 and clamping plate 304 are preferably each unitary in structure. As discussed above, the compression ring 302 has an internal diameter and an external diameter. The internal diameter of the compression ring 302 is preferably sized to be slightly greater than the outer diameter of the pipe 12, whereby the compression ring 302 can be slidably provided over the pipe 12. Unlike the previously described clamping plate 204, the clamping plate 304 is designed to be positioned against the open end of the pipe 12 and, therefore, sized so as to have a diameter, or at least a portion thereof, that exceeds the diameter of the pipe 12. As shown in Figure 24, this arrangement serves to allow the clamping plate 304 to cover the outer rim of the pipe 12 opening. The clamping plate 304 may be provided with an internal diameter, as shown in Figures 24 - 26, so as to assume an annular disc shape as shown in Figure 24. In other embodiments, such as where the pipe 12 has a small diameter, the clamping plate 304 may simply comprise a solid plate. As also described above with respect to other embodiments, the clamping plate 304 may be provided with a groove or the like to receive the open end of the pipe 12. Such groove may similarly be provided with a sealing member to form a seal with the end of the pipe 12 as described above.

[00120] The external clamp 300 also includes an external gripper ring 306. As described above, the external gripper ring 306 in generally annular in shape and has an inner diameter that is sized to be provided over the outer circumference of the pipe 12, when the gripper ring 306 is in its initial state. The inner diameter of the external gripper ring 306 is reducible upon application of a suitable force, as discussed further below. Although the term "ring" is used for external gripper ring 306, such ring is preferably formed of two or more sections, which, when combined, form a ring over the pipe 12. It should also be noted that, as discussed above, the sections forming the external gripper ring 306 are preferably spaced apart so as to allow radial compression of its internal diameter, i.e. as the sections are brought together over the pipe 12 surface.

[00121] As also discussed above, the compression ring 302 and external gripper ring 306 have oppositely directed ramped surfaces that cooperate to achieve the desired clamping

force on the outer surface of the pipe 12. As shown, compression ring 302 includes a ramped surface 314 defined on the inner diameter thereof. As shown in Figure 24, the ramped surface is arranged so as to provide the compression ring 302 with a slightly larger internal diameter on the side of the ring 302 facing the opening of the pipe 12. Similarly, the external gripper ring 306 is provided with a ramped surface 316 that is similar to that shown in Figures 20-22. That is, the ramped surface 316 of the external gripper ring 306 is provided on the outer diameter of the external gripper ring 306 and is arranged oppositely to the ramped surface 314 of the compression ring 302. When the clamp 300 is in use, the gripper ring 306 is arranged so as to allow a portion of the ramped surface 316 to engage the ramped surface 314 of the compression ring 302, with the ramped surfaces 316 and 314 being oppositely directed as shown in Figure 24.

[00122] The external clamp 300 includes a number of clamping bolts 312 and cooperating nuts 314, which serve the same purpose as described above. Specifically, the nuts 314 and bolts 312 combine to urge the compression ring 302 and clamping plate 304 together, thereby causing the compression ring 302 to bear against the sections of the external gripper ring 306, thereby compressing the latter against the outer surface of the pipe. As shown in Figure 26, the clamping plate 304 is provided with a plurality of boltholes 310 through with the bolts 312 are passed. Similarly, as shown in Figure 28, the compression ring 302 is also provided with a plurality of boltholes 308 through which the bolts 312 are passed.

[00123] Figure 24 also illustrates an internal clamp 400 that also forms part of the apparatus of this embodiment. As will be understood by persons skilled in the art, the internal clamp 400 operates in a similar manner to the external clamp 300 just described. As shown, the internal clamp 400 includes a backplate 401 that has an outer diameter that is sized to allow the backplate 401 to be inserted into the pipe 12. An internal compression ring 402 is also provided adjacent to the backplate 401, when the apparatus is in use. As shown, the internal compression ring 402 is also sized to be inserted within the pipe 12. A resilient sealing member, such as an O-ring 403 is provided between the backplate 401 and internal compression ring 402. The purpose of the seal 403 will become apparent in the following description.

[00124] The internal compression ring 402 is preferably annularly shaped so as to result in an inner and outer diameter. As mentioned above, the outer diameter of the internal compression ring 402 is sized so as to be provided within the pipe 12. The outer diameter of

Alternatively, the bolts 412 may extend through the backplate 401 and secured thereto with nuts (not shown). In the latter case, it will also be understood that the bolts 412 would need to be secured to the backplate 401 prior to insertion into the pipe 12.

[00128] Simultaneously with forming the aforementioned seal, the internal gripper ring 406 is urged outwardly due to the advancing internal compression plate and the cooperating ramped surfaces 414 and 416. In the result, the sections forming the internal gripper ring 406 are pressed against the inner surface of the pipe 12 to form a clamping force therewith. As shown in Figure 35, the internal gripper ring 406 may be provided with a texture outer diameter surface 413, in order to enhance the frictional engagement of the internal gripper ring 406 against the inner surface of the pipe 12.

[00129] In operation, it will be apparent to persons skilled in the art that the external clamp 300 may be provided on a pipe first, followed by engagement of the internal clamp 400. With the two clamps 300 and 400 in place, it will be understood that the wall of the pipe 12 is essentially "pinched" from outside and inside, whereby the securing of the combined external and internal clamp is enhanced.

[00130] Once the combination clamp 500, comprising the external 300 and internal clamp 400, is in place, the interior of the pipe may be pressurized as described above. As described, the combination clamp 500 also serves to seal the end of the pipe 12. To assist in the pressurization, the backplate 401 may be provided with one or more pipes 420 through which the interior of the pipe 12 may be filled with the required pressurizing fluid. The backplate 401 is preferably provided with an aperture 422 to receive the pipe 420. It will be understood that various gauges, monitors etc. may also be used with the combination clamp 500.

[00131] Although the invention has been described with reference to certain specific embodiments, various modifications thereof will be apparent to those skilled in the art without departing from the purpose and scope of the invention as outlined in the claims appended hereto. Any examples provided herein are included solely for the purpose of illustrating the invention and are not intended to limit the invention in any way. Any drawings provided herein are solely for the purpose of illustrating various aspects of the invention and are not intended to be drawn to scale or to limit the invention in any way. The disclosures of all prior art recited herein are incorporated herein by reference in their entirety.

We Claim:

1. An apparatus for sealing an open end of a pipe comprising:

- a sealing plate sized to cover the open end of the pipe;

- a first compression ring and gripper ring assembly, sized to be provided over the outer surface of the pipe,

- a first means for connecting the first compression ring to the sealing plate and for urging the first compression ring towards the sealing plate;

- the first compression ring and the first gripper ring being provided in a cooperating arrangement, wherein urging of the first compression ring towards the sealing plate forces the first gripper ring against the outer surface of the pipe;

- a second compression ring and gripper ring assembly, sized to be provided within the diameter of the pipe;

- a second means for connecting the second compression ring to the sealing plate and for urging the second compression ring towards the sealing plate;

- the second compression ring and the second gripper ring being provided in a cooperating arrangement, wherein urging of the second compression ring towards the sealing plate forces the first gripper ring against the inner surface of the pipe; and,

- a backplate sized to be provided within the pipe, the backplate being connected to the sealing plate and being provided on an a side of the second compression ring opposite to the sealing plate.

2. The apparatus as claimed in claim 1, wherein the first compression ring and first gripper ring have cooperating ramped surfaces, wherein the ramped surface of the first gripper ring is urged between the first compression ring and the outer surface of the pipe upon urging of the first compression ring towards the sealing plate.

3. The apparatus as claimed in claim 1, wherein the second compression ring and second gripper ring have cooperating ramped surfaces, wherein the ramped surface of the second gripper ring is urged between the second compression ring and the inner surface of the pipe upon urging of the second compression ring towards the sealing plate.

4. The apparatus of claim 1, further comprising a resilient sealing member provided between the backplate and second compression plate.

5. The apparatus of any one of claims 1 to 4, wherein the first and second means for connecting comprise combinations of nuts and bolts.

6. The apparatus of any one of claims 1 to 5, wherein the backplate includes at least one port for connection to a pressurizing means, a monitoring means or a combination thereof, for pressurizing, venting or monitoring the interior of the pipe.

7. The apparatus of any one of claims 1 to 6, wherein the sealing plate includes at least one port for connection to a pressurizing means, a monitoring means or a combination thereof, for pressurizing, venting or monitoring the interior of the pipe.

8. The apparatus of any one of claims 1 to 7, wherein the sealing plate includes a groove for receiving the open end of the pipe.

9. The apparatus of claim 8, wherein the groove includes a sealing means for forming a seal between the groove and the open end of the pipe.

10. The apparatus of any one of claims 1 to 9, wherein the first and second gripper rings are formed of two or more sections.

11. A method for sealing a section of a pipe having an open end, the method comprising:

- providing an apparatus having a first clamping means, for frictionally engaging the outer surface of the pipe, and a second clamping means, for frictionally engaging the inner surface of the pipe; and,
- forming a seal between the inner surface of the pipe and the second clamping means.

12. The method of claim 11, further comprising pressurizing the interior of the pipe.

[0010] Thus, in one aspect, the invention provides an apparatus for closing and sealing the bore of an open end of a pipe comprising:

[0011] - a front plate for abutting the end face of the pipe end;

[0012] - an outer clamping means for frictionally and circumferentially engaging the external surface of the pipe end, said means comprising a segmental outer gripper ring positionable on the external surface and an outer compression ring mountable on the gripper ring, said rings having cooperating contacting ramped surfaces,

[0013] - means for connecting and urging the front plate and compression ring together so that the compression ring compresses the gripper ring against the pipe end's external surface;

[0014] -an inner clamping means for frictionally and circumferentially engaging the internal surface of the pipe end, said inner clamping means comprising a segmental inner gripper ring positionable against the internal surface and an inner compression ring mountable within the inner gripper ring, said inner rings having cooperating contacting ramped surfaces;

[0015] - a movable back plate for transversely positioning within the bore of the pipe end adjacent the inner end of the inner clamping means;

[0016] - an annular deformable resilient seal means for positioning between the back plate and the inner compression ring;

[0017] - means for connecting and urging the back plate and inner compression ring together so that they may compress and deform the seal means into sealing engagement with the pipe end's internal surface and so that the inner compression ring may also compress the inner gripper ring against the internal surface;

[0017a] - means, connecting the black plate with the front plate for urging the back plate toward the front plate when in use; and

[0018] - whereby the back plate, seal means, inner clamping means and front plate may combine to close and seal the pipe bore when tightened together.

[0019] In a further embodiment, the invention provides a method for sealing a section of a pipe having an open end, the method comprising:

[0020] - providing an apparatus having a first clamping means, for frictionally engaging the outer surface of the pipe, and a second clamping means, for frictionally engaging the inner surface of the pipe; and,

[0021] - forming a seal between the inner surface of the pipe and the second clamping means.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] These and other features of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings wherein:

[0023] Figure 1 is a cross sectional side view of one embodiment of the inner clamp assembly positioned within a pipe.

[0024] Figure 2 is a perspective view of part of the clamp assembly of the apparatus of Figure 1.

[0025] Figure 3 is a cross sectional side elevation of another embodiment of part of the clamp of Figure 1.

[0026] Figures 4a and 4b are cross sectional side views of further embodiments of the inner clamp assembly positioned within a pipe.

[0026a] Figure 5 is a cross sectional side view of a front plate and inner clamp assembly associated with a pipe end.

[0026b] Figure 6 is a cross sectional side view showing an embodiment of inner and outer clamp assemblies associated with a pipe.

[0027] Figures 7 to 9 are cross sectional views of embodiments having an outer clamp assembly and a front plate positioned at a pipe end.

[0028] Figure 10 is a perspective view of another embodiment for sealing a pipe end.

[0029] Figure 11 is a side view of embodiment showing an outer clamp assembly and front plate.

[0030] Figure 12 is an end view of the outer clamp assembly shown in Figures 10 and 11.

[0031] Figure 13 is a side cross-sectional view of another embodiment of the outer clamp assembly.

[0032] Figure 14 is an end view of the embodiment shown in Figure 13.

[0033] Figure 15 is a side cross-sectional view of another embodiment of an outer clamp assembly and front plate associated with a pipe end.

[0034] Figures 16 and 17 are front and side cross-sectional views of the compression ring shown in Figure 15.

[0035] Figures 18 and 19 are front and side cross-sectional views of the clamping ring shown in Figure 15.

[0036] Figures 20, 21 and 22 are front, side cross-sectional and detailed cross-sectional views of the segmental gripper ring shown in Figure 15.

[0037] Figure 23 is a side cross-sectional view of the outer clamp assembly and front plate wherein a plurality of clamp assemblies are combined.

[0038] Figure 24 is a side cross-sectional view of an embodiment of the invention comprising, in combination, a front plate and inner and outer clamp assemblies.

[0039] Figures 25 and 26 are side cross-sectional and front views of the front plate shown in Figure 24.

[0040] Figures 27 and 28 are side cross-sectional and front views of the outer compression ring shown in Figure 24.

[0041] Figures 29 and 30 are front and side cross-sectional views of the inner compression ring shown in Figure 24.

[0042] Figures 31 and 32 are front and side cross-sectional views of the backplate shown in Figure 24.

[0043] Figures 33, 34 and 35 are front, side cross-sectional and detailed cross-sectional views of the inner gripper ring shown in Figure 24.

DETAILED DESCRIPTION OF THE INVENTION

[0044] Throughout the description of the invention the following terms will be assumed to have the following associated meanings:

[0045] “Vessel” - will be understood to mean any equipment or apparatus to which a nozzle is attached. As such, the term “vessel” will include vessels per se, pipes, drums, and any other similar equipment. It will be understood that the term “vessel” is used herein simply as a convenient way to encompass all such equipment or apparatus.

[0046] “Annular” - this term is used to describe a body having at least one outer diameter and at least one inner diameter. Thus, an “annular tube” will be assumed to be a hollow tube with an inner and outer diameter. An “annular disc” will be assumed to be an object having an outer diameter and a central aperture thereby providing an inner diameter.

[0047] “Axial” - this term will be used to describe a direction taken along the longitudinal axis of a pipe or conduit. Thus, “axial force” or “axial stress” will be understood as being a force applied in a direction parallel to the longitudinal axis of the conduit. Similarly, the term “axially extending” will be understood to mean extending in a direction parallel to the longitudinal axis of the pipe.

[0048] “Proximal” and “distal” - these terms will be used to describe the positions of various components of the invention once positioned over a pipe having an open end. The term “proximal” will be used to describe a position closer to the open end of the pipe. The term “distal” will be used to describe a position away from the open end of the pipe.

[0048a] The pairs of terms 'sealing plate' and 'front plate', 'clamp' and 'clamping assembly', 'internal' and 'inner', 'external' and 'outer' are used interchangeably herein.

[0049] Figure 1 illustrates one aspect of the invention wherein an internal sealing apparatus for a pipe is shown. The sealing apparatus 10 is preferably sized to fit within the lumen of a pipe (or tube) 12. The apparatus 10 comprises a sealing plate 14 having a diameter slightly less than the internal diameter of the pipe 12. The plate includes a first face 16 and a second face 18, wherein the second face is adjacent a clamp 20. The second face 18 of the sealing plate 14 is provided with beveled edge 22 for accommodating an O-ring 24 or other such resilient sealing means.

[0050] The clamp 20 generally comprises an annular ring having an outer diameter sized to fit within the pipe 12. An annular shape for the clamp 20 is preferred to minimize its weight. However, the clamp 20 may also comprise a solid body. As will be understood by persons skilled in the art having reviewed the present disclosure, the outer diameter of the clamp 20 is preferably slightly less than the internal diameter of the pipe 12 so as to permit axial placement of the clamp 20. The clamp 20 is provided with one or more recesses or pockets 26 into which are placed magnets 28. Preferably, the magnets 28 comprise electromagnets that can be activated when desired.

[0051] The magnets 28 provided on the clamp 20 are designed to magnetically attract the wall of the pipe 12, which, as is commonly known in the art, is formed from a ferrous metal. The magnets 28 are designed to form a strong clamping force with the interior wall of the pipe 12 and, thereby, to anchor the clamp in a fixed axial position within the pipe 12. In a preferred embodiment, at least two or more magnets 28 are provided on the clamp 20 with such magnets being placed circumferentially around the annular clamp 20. Such an arrangement will serve to evenly secure the clamp 20 within the pipe 12. Although the

Figure 23 is provided with a plurality of compression rings 202 and gripper rings 206. As will be understood, by providing a plurality of compression and gripper rings, 202 and 206, the amount of clamping force offered by the clamp 250 is increased. In the result, the clamp of Figure 23 is able to withstand higher pipe pressures than the clamp of Figure 15. The number of additional compression rings and clamping rings will vary based on the desired clamping force required and it will be understood that any number of such rings may be provided for any given clamp.

[00110] In order to ensure that each compression ring 202 acts upon a respective gripper ring 206, each of the compression rings 202 are separated by a separation ring 252. As will be understood, the separation rings 252 serve to prevent binding between each of the compression rings and to ensure that each of such compression rings act upon respective gripper rings 206. The separation rings 252 may comprise, for example, O-rings.

[00111] It will be understood that in situations where a given length of a pipe is to be tested, both ends of the pipe can be sealed using any of the sealing apparatus described above. In such case, the ends of the pipe will each be provided with the same or different ones of the apparatus of the invention. Each end of the pipe would thus be sealed and the interior of the pipe may then be pressurized for conducting an integrity test.

[00112] As described above, in some of the embodiments of the invention, the clamp includes a gripper ring (formed of two or more sections) that is provided with a ramped surface adapted to contact and cooperate with or engage an oppositely ramped surface on another portion of the clamp. In some cases, such oppositely ramped surface is provided on the clamp body or on a compression or “squeeze” ring as described above. It will be noted in the described embodiments that the gripper ring is positioned so that its thinner portion is oriented away from the pipe opening. As seen, for example in Figures 13 and 15, and as will be understood by persons skilled in the art, such an orientation would be preferred. Specifically, once the clamp is tightened against the exterior surface of the pipe, the clamp would be securely engaged and the sealing plate is then attached thereto so as to seal the open end of the pipe. Subsequently, when the interior of the pipe is pressurized (such as in cases where a pressure test is conducted on the pipe), it will be understood that such pressure will act to force the sealing plate of the apparatus away from the pipe opening in the axial direction. However, since the sealing plate is secured to the clamp by means of the sealing bolts (i.e. the bolts connecting the sealing plate to the clamp), the axial movement of the sealing plate would also exert an axial force on the clamp. In the result,

described internal reinforcement (such as shown at 110 in Figure 10) may be used in combination with any of the external clamps described herein. In addition, having the ability to axially position the clamp at any location along the length of the pipe allows for a desired amount of clearance in the event that a weld is located near the open end of the pipe.

[00115] It will be understood that the external clamp and sealing plate of the invention can also be used on pipes that include a bend. For example, in a pipe comprising an elbow, the clamp may be positioned on one side of the bend with the sealing plate covering the pipe opening on an opposite side of the bend. In such case, the connecting elements between the clamp and the sealing plate may be adapted or oriented to provide the same sealing force as described above. For example, the clamp may be provided with an extension for cooperating with the connecting elements to engage the sealing plate. Various other such modifications to the invention are also possible.

[00116] It will be understood by persons skilled in the art that any number of, and types of embodiments of, the clamp of the invention can be used in combination. Such combined use would depend upon the specific use being contemplated and the specific combination will be apparent to persons skilled in the art. For example, the embodiment of Figure 11 may be combined with the embodiment of Figure 23 etc. In this example, the embodiment of Figure 23 can form a downstream “anchor” while the embodiment of Figure 11 is used upstream.

[00117] As discussed above, the apparatus of the invention is preferably used for sealing an end of a pipe so that the interior bore of the pipe can be pressurized such as for testing the integrity of the pipe. In one example, the integrity test is used for testing a weld that may be present on the pipe. Such a weld may serve to connect two pipe segments or to connect the pipe to another apparatus.

[00118] It will be understood that the above discussion has used geometric terms such as annular, disc, circumference, etc., for ease of reference. However, these terms should not be construed as limiting the invention to any specific shape of nozzle or pipe and various modifications of the apparatus will be apparent to persons skilled in the art to adapt same to any shape or design.

[00119] A further embodiment of the invention is illustrated in Figures 24 to 35. In this embodiment, the invention comprises combined internal and external clamps shown generally at 500. As shown in Figure 24, the combination clamp 500 includes an external

clamp 300, that is adapted to be secured to the outer surface of a pipe 12, and an internal clamp 400, that is secured to the inner surface of the pipe 12. The external clamp 300 functions in a similar manner to the clamp 200 discussed above. For this reason, elements of clamp 300 that are similar to previously described clamp 200 will be identified with similar reference numerals but starting with "3". As shown, the external clamp 300 comprises a first squeeze, or compression ring 302 and a second, clamping or sealing plate 304. As discussed above, the compression ring 302 and clamping plate 304 are preferably each unitary in structure. As discussed above, the compression ring 302 has an internal diameter and an external diameter. The internal diameter of the compression ring 302 is preferably sized to be slightly greater than the outer diameter of the pipe 12, whereby the compression ring 302 can be slidably provided over the pipe 12. Unlike the previously described clamping plate 204, the clamping plate 304 is designed to be positioned or abut against the open end of the pipe 12 and, therefore, sized so as to have a diameter, or at least a portion thereof, that exceeds the diameter of the pipe 12. As shown in Figure 24, this arrangement serves to allow the clamping plate 304 to cover the end face of the pipe 12 opening. The clamping plate 304 may be provided with an internal diameter, as shown in Figures 24 - 26, so as to assume an annular disc shape as shown in Figure 24. In other embodiments, such as where the pipe 12 has a small diameter, the clamping plate 304 may simply comprise a solid plate. As also described above with respect to other embodiments, the clamping plate 304 may be provided with a groove or the like to receive the open end of the pipe 12. Such groove may similarly be provided with a sealing member to form a seal with the end of the pipe 12 as described above.

[00120] The external clamp 300 also includes an external segmental gripper ring 306. As described above, the external gripper ring 306 is generally annular in shape and has an inner diameter that is sized to be provided over the outer circumference of the pipe 12, when the gripper ring 306 is in its initial state. The inner diameter of the external gripper ring 306 is reducible upon application of a suitable force, as discussed further below. Although the term "ring" is used for external gripper ring 306, such ring is preferably formed of two or more sections, which, when combined, form a ring over the pipe 12. It should also be noted that, as discussed above, the sections forming the external gripper ring 306 are preferably spaced apart so as to allow radial compression of its internal diameter, i.e. as the sections are brought together over the pipe 12 surface.

[00121] As also discussed above, the compression ring 302 and external gripper ring 306 have oppositely directed ramped surfaces that cooperate to achieve the desired clamping

force on the outer surface of the pipe 12. As shown, compression ring 302 includes a ramped surface 314 defined on the inner diameter thereof. As shown in Figure 24, the ramped surface is arranged so as to provide the compression ring 302 with a slightly larger internal diameter on the side of the ring 302 facing the opening of the pipe 12. Similarly, the external gripper ring 306 is provided with a ramped surface 316 that is similar to that shown in Figures 20-22. That is, the ramped surface 316 of the external gripper ring 306 is provided on the outer diameter of the external gripper ring 306 and is arranged oppositely to the ramped surface 314 of the compression ring 302. When the clamp 300 is in use, the gripper ring 306 is arranged so as to allow a portion of the ramped surface 316 to engage the ramped surface 314 of the compression ring 302, with the ramped surfaces 316 and 314 being oppositely directed as shown in Figure 24.

[00122] The external clamp 300 includes a number of clamping bolts 312 and cooperating nuts 314, which serve the same purpose as described above. Specifically, the nuts 314 and bolts 312 combine to urge the compression ring 302 and clamping plate 304 together, thereby causing the compression ring 302 to bear against the sections of the external gripper ring 306, thereby compressing the latter against the outer surface of the pipe. As shown in Figure 26, the clamping plate 304 is provided with a plurality of boltholes 310 through with the bolts 312 are passed. Similarly, as shown in Figure 28, the compression ring 302 is also provided with a plurality of boltholes 308 through which the bolts 312 are passed.

[00123] Figure 24 also illustrates an internal clamp 400 that also forms part of the apparatus of this embodiment. As will be understood by persons skilled in the art, the internal clamp 400 operates in a similar manner to the external clamp 300 just described. As shown, the internal clamp 400 includes a backplate 401 that has an outer diameter that is sized to allow the backplate 401 to be inserted into the pipe 12. An internal compression ring 402 is also provided adjacent to the backplate 401, when the apparatus is in use. As shown, the internal compression ring 402 is also sized to be inserted within the pipe 12. A resilient deformable sealing member, such as an O-ring 403 is provided between the backplate 401 and internal compression ring 402. The purpose of the seal 403 will become apparent in the following description.

[00124] The internal compression ring 402 is preferably annularly shaped so as to result in an inner and outer diameter. As mentioned above, the outer diameter of the internal compression ring 402 is sized so as to be provided within the pipe 12. The outer diameter of

Alternatively, the bolts 412 may extend through the backplate 401 and secured thereto with nuts (not shown). In the latter case, it will also be understood that the bolts 412 would need to be secured to the backplate 401 prior to insertion into the pipe 12.

[00128] Simultaneously with forming the aforementioned seal, the internal gripper ring 406 is urged outwardly due to the advancing internal compression plate and the cooperating ramped surfaces 414 and 416. In the result, the sections forming the internal gripper ring 406 are pressed against the inner surface of the pipe 12 to form a clamping force therewith. As shown in Figure 35, the internal gripper ring 406 may be provided with a textured or serrated outer diameter surface 413, in order to enhance the frictional engagement of the internal gripper ring 406 against the inner surface of the pipe 12.

[00129] In operation, it will be apparent to persons skilled in the art that the external clamp 300 may be provided on a pipe first, followed by engagement of the internal clamp 400. With the two clamps 300 and 400 in place, it will be understood that the wall of the pipe 12 is essentially “pinched” from outside and inside, whereby the securing of the combined external and internal clamp is enhanced.

[00130] Once the combination clamp 500, comprising the external 300 and internal clamp 400, is in place, the interior of the pipe may be pressurized as described above. As described, the combination clamp 500 also serves to seal the end of the pipe 12. To assist in the pressurization, the backplate 401 may be provided with one or more pipes 420 through which the interior of the pipe 12 may be filled with the required pressurizing fluid. The backplate 401 is preferably provided with an aperture 422 to receive the pipe 420. It will be understood that various gauges, monitors etc. may also be used with the combination clamp 500.

[00131] Although the invention has been described with reference to certain specific embodiments, various modifications thereof will be apparent to those skilled in the art without departing from the purpose and scope of the invention as outlined in the claims appended hereto. Any examples provided herein are included solely for the purpose of illustrating the invention and are not intended to limit the invention in any way. Any drawings provided herein are solely for the purpose of illustrating various aspects of the invention and are not intended to be drawn to scale or to limit the invention in any way. The disclosures of all prior art recited herein are incorporated herein by reference in their entirety.

CLAIMS

1. An apparatus for closing and sealing the bore of an open end of a pipe, comprising:

a) a front plate for abutting the end face of the pipe end;

b) an outer clamping means for frictionally and circumferentially engaging the external surface of the pipe end, said means comprising a segmental outer gripper ring positionable on the external surface and an outer compression ring mountable on the gripper ring, said rings having cooperating contacting ramped surfaces;

c) means for connecting and urging the front plate and compression ring together so that the compression ring compresses the gripper ring against the pipe end's external surface;

d) an inner clamping means for frictionally and circumferentially engaging the internal surface of the pipe end, said inner clamping means comprising a segmental inner gripper ring positionable against the internal surface and an inner compression ring mountable within the inner gripper ring, said inner rings having cooperating contacting ramped surfaces;

e) a movable back plate for transversely positioning within the bore of the pipe end adjacent the inner end of the inner clamping means;

f) an annular deformable resilient seal means for positioning between the back plate and the inner compression ring; and

g) means for connecting and urging the back plate and inner compression ring together so that they may compress and deform the seal means into sealing engagement with the pipe end's internal surface and so that the inner compression ring may also compress the inner gripper ring against the internal surface;

h) means, connecting the backplate with the front plate, for urging the backplate toward the front plate when in use;

i) whereby the back plate, seal means, inner clamping means and front plate may combine to close and seal the pipe bore when tightened together.

2. The apparatus as set forth in claim 1 wherein:

the means c) and g) each comprises threaded nut and bolt assemblies.

3. The apparatus as set forth in claim 2 comprising:

means for introducing pressurized liquid into the bore of the pipe through the front and back plates.

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4. The apparatus as set forth in claim 1 wherein each gripper ring has a textured inner surface for engaging the pipe.