CLAIMS

1. A nozzle for a pressure vessel that is sized for being welded to a wall of the vessel, the nozzle comprising:

a barrel attached to an annular lip, the barrel defining an inner passageway that is in fluid communication with a vessel interface opening defined by the lip at a first end of the nozzle, a second end of the nozzle opposite the first end of the nozzle having an interface opening in communication with the inner passageway;

the lip having a distal side that is opposite a proximate side, the proximate side being positionable around an inner end of the barrel to define the vessel interface opening; and

the proximate side of the lip being spaced apart from the distal side of the lip by a first distance that is between 4 times a thickness of the wall (t) and 0.75t such that a joint of the weld between the wall and the distal side of the lip is a distance of between 4t and 0.75t from the proximate side of the lip.

2. The nozzle of claim 1, wherein the nozzle has an inner curved transition that is positioned to extend between the proximate side of the lip and the inner passageway of the barrel, the inner curved transition extending a distance of between 0.5t and 2t;

optionally wherein the nozzle has an outer curved transition that is positioned to extend between the proximate side of the lip and the barrel, the outer curved transition extending a distance that is between 0.5t and 3t;

further optionally wherein an annular wall of the barrel that defines the inner passageway has a thickness at an intermediate portion of the barrel that is located between the vessel interface opening and the interface opening of the second end of the nozzle, the thickness at the intermediate portion of the barrel being between 0.5t and 3t;

even further optionally wherein an outer surface of the barrel extends from the outer curved transition to the intermediate portion of the barrel is a distance that is between 0.5t and 6t; and

yet even further optionally the barrel tapers from the intermediate portion to the interface opening of the second end of the nozzle.

3. The nozzle of claim 1, wherein the nozzle has an outer curved transition that is positioned to extend between the proximate side of the lip and the barrel, the outer curved transition extending a distance that is between 0.5t and 3t;

optionally wherein an outer surface of the barrel extends from the outer curved transition to an intermediate portion of the barrel at a distance that is between 0.5t and 6t, the intermediate portion of the barrel being located between the vessel interface opening and the interface opening of the second end of the nozzle; and

further optionally wherein the barrel tapers from the intermediate portion to the interface opening of the second end of the nozzle.

4. The nozzle of claim 1, wherein the lip is contoured to substantially match a contour of a portion of a head of the end of the vessel that was removed to form a hole in which the nozzle is positionable.

5. The nozzle of claim 1, wherein the proximate side of the lip is spaced apart from an inner surface of the barrel defining the inner passageway at the first end of the nozzle by a distance that is between 2t and 6t such that a joint of the weld between the wall and the distal side of the lip is a distance of between 2t and 6t from the inner surface of the barrel defining the inner passageway at the first end of the nozzle.

6. The nozzle of claim 1, wherein the first distance is at least 2.5 cm.

7. The nozzle of claim 1, wherein the wall of the vessel is a wall of a vessel head having a thickness of at least 2.5 cm.

8. A vessel for an apparatus configured to utilize cyclic pressurization, the vessel comprising:

a body having a first end and a second end, the first end having an opening defined therein, the first end having a wall, the body of the vessel defining a chamber within the vessel;

a first nozzle positioned within the opening defined in the first end of the body, the first nozzle including:

a barrel attached to an annular lip, the barrel defining an inner passageway that is in fluid communication with a vessel interface opening defined by the lip at a first end of the first nozzle, a second end of the first nozzle opposite the first end of the first nozzle having an interface opening in communication with the inner passageway;

the lip having a distal side that is opposite a proximate side, the proximate side being positionable around an inner end of the barrel to define the vessel interface opening; and

the proximate side of the lip being spaced apart from the distal side of the lip by a first distance that is between 4 times a thickness of the wall (t) and 0.75t such that a joint of a weld between the wall and the distal side of the lip is a distance of between 4t and 0.75t from the proximate side of the lip.

9. The vessel of claim 8, wherein the second end of the body has an opening defined therein, the second end having a wall, the vessel also comprising:

a second nozzle positioned within the opening defined in the second end of the body, the second nozzle including:

a barrel attached to an annular lip, the barrel of the second nozzle defining an inner passageway that is in fluid communication with a vessel interface opening defined by the lip of the second nozzle at a first end of the second nozzle, a second end of the second nozzle opposite the first end of the second nozzle having an interface opening in communication with the inner passageway of the barrel of the second nozzle;

the lip of the second nozzle having a distal side that is opposite a proximate side, the proximate side of the lip of the second nozzle being positionable around an inner end of the barrel of the second nozzle to define the vessel interface opening of the second nozzle; and

the proximate side of the lip of the second nozzle being spaced apart from the distal side of the lip of the second nozzle by a distance that is between 4 times a thickness of the wall of the second end (t') and 0.75t' such that a joint of a weld between the wall of the second end and the distal side of the lip of the second nozzle is a distance of between 4t' and 0.75t' from the proximate side of the lip of the second nozzle.

10. The vessel of claim 8, wherein the first nozzle has an inner curved transition that is positioned to extend between the proximate side of the lip and the inner passageway of the barrel, the inner curved transition extending a distance of between 0.5t and 2t;

optionally wherein the first nozzle has an outer curved transition that is positioned to extend between the proximate side of the lip and the barrel, the outer curved transition extending a distance that is between 0.5t and 3t;

further optionally wherein an annular wall of the barrel that defines the inner passageway has a thickness at an intermediate portion of the barrel that is located between the vessel interface opening and the interface opening of the second end of the first nozzle, the thickness at the intermediate portion of the barrel being between 0.5t and 3t;

even further optionally wherein an outer surface of the barrel extends from the outer curved transition to the intermediate portion of the barrel is a distance that is between 0.5t and 6t; and

yet even further optionally wherein the barrel tapers from the intermediate portion to the interface opening of the second end of the first nozzle.

11. The vessel of claim 8, wherein the proximate side of the lip is spaced apart from an inner surface of the barrel defining the inner passageway at the first end of the first nozzle by a distance that is between 2t and 6t such that a joint of the weld between the wall and the distal side of the lip is a distance of between 2t and 6t from the inner surface of the barrel defining the inner passageway at the first end of the first nozzle.

12. The vessel of claim 8, wherein the apparatus configured to utilize cyclic pressurization is a pressure swing adsorption (PSA) system, a PSA system utilized for carbon dioxide capture, or is a buffer tank.

13. The vessel of claim 8, wherein the vessel has a diameter of at least 1.2 meters.

14. A process for providing at least one vessel, comprising:

forming a body of a vessel having a first head end, the body of the vessel defining a chamber;

cutting away a portion of an apex of a first end of the body of the vessel;

attaching a first nozzle to the first end of the body within a hole of the first end of the body formed via the cutting away of the portion of the apex of the first end of the body via

welding that forms a weld joint between a distal side of an annular lip of the first nozzle and a wall of the first end of the body of the vessel, the wall of the first end of the body of the vessel having a thickness (t);

wherein the first nozzle is attached to the first end of the body such that a barrel defining an inner passageway that is attached to the lip of the first nozzle is in fluid communication with a vessel interface opening defined by the lip at a first end of the first nozzle, a second end of the first nozzle opposite the first end of the first nozzle having an interface opening in communication with the inner passageway;

the distal side of the lip being opposite a proximate side of the lip, the proximate side being positioned around an inner end of the barrel to define the vessel interface opening; and

the proximate side of the lip being spaced apart from the distal side of the lip by a first distance that is between 4 times a thickness of the wall (t) and 0.75t such that a joint of a weld between the wall and the distal side of the lip is a distance of between 4t and 0.75t from the proximate side of the lip;

optionally wherein the first nozzle is forged such that the lip and the barrel are integral to each other and the first nozzle does not include an inner projection; and

optionally wherein the proximate side of the lip being spaced apart from an inner surface of the barrel defining the inner passageway at the first end of the first nozzle by a distance that is between 2t and 6t such that the weld joint is a distance of between 2t and 6t from the inner surface of the barrel defining the inner passageway at the first end of the first nozzle.

15. A system for purification of a fluid comprising:

at least one vessel, each of the at least one vessel having:

a body having a first end and a second end, the first end having an opening defined therein, the first end having a wall, the body of the vessel defining a chamber within the vessel, at least one layer of adsorbent material being positioned within the chamber;

a first nozzle positioned within the opening defined in the first end of the body, the first nozzle including:

a barrel attached to an annular lip, the barrel defining an inner passageway that is in fluid communication with a vessel interface opening defined by the lip

at a first end of the first nozzle, a second end of the first nozzle opposite the first end of the first nozzle having an interface opening in communication with the inner passageway;

the lip having a distal side that is opposite a proximate side, the proximate side being positionable around an inner end of the barrel to define the vessel interface opening;

the proximate side of the lip being spaced apart from the distal side of the lip by a first distance that is between 4 times a thickness of the wall (t) and 0.75t such that a joint of a weld between the wall and the distal side of the lip is a distance of between 4t and 0.75t from the proximate side of the lip;

optionally wherein the at least one vessel includes a plurality of vessels and the system is configured as a pressure swing adsorption system.