CLAIMS

We claim:

1. A valve (100) comprising:

a valve body (102) comprising a flow bore (104) and a stem bore (158);

a flow control element (106) rotatably disposed in the flow bore;

a bracket (150) fixedly supported from the valve body and comprising a stem opening (162) aligned with the stem bore;

a valve stem (108) rotatably disposed in the stem bore and comprising a first end (160) disposed in a central bore (193) of a shear bushing (186) adjacent the bracket, a stem shoulder (182) to engage the shear bushing adjacent the first end, and a second end (156) engaging the flow control element; and

a bushing profile (187) of the shear bushing cooperating with an opening profile (163) of the stem opening for selective retention and release of the valve stem, wherein the shear bushing is rotatable between a stem release position (165), wherein the bushing profile is aligned with the opening profile and the shear bushing can pass through the stem opening, and a stem retention position (167), wherein the bushing profile is offset with respect to the opening profile and the bracket and stem shoulder engage opposite sides of the shear bushing to retain the valve stem in the stem bore.

2. The valve of claim 1, wherein:

the bushing profile comprises a minor outside diameter (OD) (190a), a major OD (192a), and one or more minor OD portions (190) along the minor OD alternated with one or more lobes (192) extending radially from the minor OD to the major OD;

the opening profile comprises a minor inside diameter (ID) (194a) larger than the minor OD, a major ID (194b) larger than the major OD, one or more minor ID portions (195a) along the minor ID alternated with one or more major ID portions (195b) along the major ID, and one or more opening passages (194) extending radially from the minor ID to the major ID;

preferably wherein the bushing profile and the opening profile comprise diametrically opposed pairs of the minor OD portions, the lobes, the minor ID portions, and the opening passages, wherein the lobes are smaller than the opening passages;

more preferably wherein the bushing profile and the opening profile comprise matching butterfly profiles.

3. The valve of claim 1 or claim 2, comprising a bushing retention member (196) securing the shear bushing in the stem retention position, preferably wherein the bushing retention member is elongated to extend through a first retaining bore (197A) formed in the bracket into or adjacent to the lobes, more preferably wherein the elongated bushing retention member is threaded and extends into a second retaining bore (197B) formed in one of the lobes.

4. The valve of any one of claims 1 to 3, comprising:

a packing bore (170) formed in the valve body coaxial with the stem bore;

one or more contiguous packing rings (168) disposed around the valve stem in the packing bore to form a seal between the valve stem and the valve body;

a packing gland (166) positioned around the valve stem;

a gland flange (174) in an open access area (154) between the bracket and the valve body secured to the valve body around the valve stem; and

one or more live loading springs (180, 180A, 180B) disposed between the gland flange and the packing gland to load the packing gland and the packing rings.

5. The valve of any one of claims 1 to 4, wherein the valve body is a single piece body, the bracket is integrally forged with the valve body, and the shear bushing is contiguous; preferably comprising clamping hubs (202, 204) formed on the valve body at inlet and outlet ends (116, 118) of the flow bore; preferably wherein:

the flow bore comprises a central bore (415) and first and second end bores (417, 412), wherein the central bore has an inside diameter (ID) larger than an ID of the first end bore and smaller than an ID of the second end bore;

a first seat (418) for sealing engagement between the flow control element and the valve body adjacent the first end bore comprising a first seat body (420) having a first sealing surface (421) for sealingly engaging the flow control element and an attachment end (422) releasably secured to the valve body;

a second seat (402) comprising a second seat body (404) having a second sealing surface (405) for sealingly engaging the flow control element;

a seat spring (406) to bias the second seat body against the flow control element, wherein the flow control element floats between the first seat and the second seat;

an annular plug (408) in sealing engagement with the valve body, the annular plug having an outer end (410) threadedly engaged in the second end bore and an inner end (411) in

engagement with the seat spring; and

an upstream seat land (430) between the second seat body and the inner end of the annular plug for sealingly engaging the second seat body and the inner end of the plug, wherein the inner end loads the seat spring against the second seat body to sealingly engage the first element when a fluid pressure is higher in the second end bore relative to the first end bore, and wherein the upstream seat land sealingly engages the second seat body and the inner end of the annular plug when a fluid pressure higher in the first end bore relative to the second end bore compresses the seat spring.

6. The valve of any one of claims 1 to 5, comprising:

valve trim (117) comprising the flow control element, a downstream seat (110) to form a seal between the valve body and the flow control element, and an upstream seat (112) that is spring-driven to bias the flow control element against the downstream seat, wherein the flow control element floats between the upstream seat and the downstream seat;

wherein the valve trim is insertable into the flow bore through one end of the flow bore;

wherein the upstream seat and the flow control element are removable through the one end; and

a retainer (132) having an annular structure in the one end to secure the valve trim in the flow bore, preferably a retaining ring in a groove (134) in the one end or a threaded member (408) threadedly engaged in the one end;

preferably wherein the valve trim comprises one of arrangements (A1), (B1), and (C1) as follows:

(A1) wherein the valve trim comprises a cartridge assembly (304, 353, 368, 612) comprising the flow control element, the upstream seat, and a sleeve (306, 352) to hold the flow control element and the upstream seat together in relative position for insertion through an inlet bore (116) of the flow bore into a main bore (118) of the flow bore, wherein the sleeve is expandable to release the flow control element to float between the upstream seat and the downstream seat;

preferably wherein the valve comprises:

an entry bore (128, 384) to an outlet bore (118) of the flow bore; and

either one of arrangements (X) and (Y) as follows:

(X) wherein the downstream seat comprises an annular seat body (600, 650) having a downstream sealing surface (124) to sealingly engage the flow control element and an attachment end (601, 653) for removably

securing the annular seat body in the entry bore;

wherein the attachment end and the entry bore are threaded for threaded engagement; and

wherein the annular seat body comprises internal notching (660) for installation with a square bar inserted through the inlet bore;

preferably (A) wherein the annular seat body comprises a seat body flange between the attachment end and the downstream seat element, and comprising a gasket for compression between the seat body flange and an annular surface of the valve body adjacent the outlet bore, more preferably wherein the attachment end comprises trapezoidal screw threads; or (B) wherein the entry bore comprises a threaded section adjacent the main bore receiving a threaded portion of the attachment end, a cylindrical section adjacent an ID of the outlet bore receiving a cylindrical portion of the attachment end, and a tapered section between the threaded section and the cylindrical section engaging a tapered portion of the attachment end, more preferably wherein the attachment end and the entry bore comprise a flare fitting profile;

(Y) wherein the downstream seat comprises an annular seat body (380, 550) comprising a downstream sealing surface (124) to sealingly engage the flow control element and an attachment end (381) for removably securing the annular seat body in the entry bore;

wherein the entry bore comprises a female machine tapered cone (384A) and the attachment end comprises a male machine tapered cone (385, 554), wherein the attachment end is received in the entry bore in an interference fit;

preferably wherein the male machine tapered cone comprises ridges (552) to form a labyrinthine seal;

(B1) wherein the downstream seat comprises a downstream seat land (702) secured in an entry bore (704) to an outlet bore of the flow bore and a seat body comprising a downstream seat element to sealingly engage the flow control element, wherein the seat land and the seat body have opposing lapped surfaces for sealing engagement, preferably wherein the seat land is press fit into the entry bore, preferably wherein the

downstream seat element comprises external notches (708) to facilitate lapping;

(C1) wherein the downstream seat comprises a threaded element (425A, 757, 814) threadedly received in an entry bore (423, 762, 810) to an outlet bore (114) of the flow bore, and an external polygonal cut profile (428, 770, 818), preferably a hex cut profile, for installation with a socket inserted through the inlet bore.

7. A method of inserting a valve stem in a valve according to any one of claims 1 to 6, comprising:

preferably integrally forging the bracket with the valve body, forming the stem opening through the bracket, and forming the stem bore through the valve body in alignment with the stem opening;

installing the flow control element in the flow bore through the valve body;

inserting the first end of the valve stem into the central bore of the shear bushing;

inserting the valve stem into the stem opening through the bracket fixedly supported from the valve body;

radially aligning the shear bushing with respect to the bracket in the stem release position wherein the bushing profile of the shear bushing cooperates with the opening profile of the stem opening for axial passage of the shear bushing through the stem opening;

axially positioning the shear bushing between the bracket and the stem shoulder on the valve stem;

preferably passing the second end of the valve stem through a packing gland in an open access area between the bracket and the valve body; positioning one or more contiguous packing rings on the second end of the valve stem in a packing bore, and securing a gland flange to the valve body and positioning live loading springs between the gland flange and the packing gland to bias the packing gland against the one or more packing rings;

inserting the second end of the valve stem into the stem bore through the valve body to engage the flow control element, preferably wherein the flow control element is installed in the flow bore prior to the engaging of the flow control element with the second end of the valve stem; and

rotating the shear bushing into the stem retention position wherein the bushing profile is offset from the opening profile and the bracket and a stem shoulder on the valve stem engage opposite surfaces of the shear bushing to retain the valve stem in the stem bore;

preferably securing the shear bushing from rotation to retain the shear bushing in the stem retention position; and

optionally comprising removing the valve stem from the valve, wherein removing the valve stem comprises:

rotating the shear bushing with respect to the bracket from the stem retention position into the stem release position;

passing the shear bushing axially through the stem opening away from the valve body;

disengaging the second end of the valve stem from the flow control element; and

removing the valve stem from the stem bore;

preferably wherein the method comprises:

after removing the valve stem from the valve bore, inspecting, replacing, or inspecting and replacing, one or more contiguous packing rings on the second end of the valve stem;

positioning the shear bushing in the stem release position and passing the shear bushing through the stem opening toward the valve body, positioning the shear bushing between the bracket and the stem shoulder, inserting the valve stem through the stem bore, engaging the flow control element with the second end of the valve stem, and positioning the one or more packing rings in the packing bore; and

rotating the shear bushing into the stem retention position;

preferably wherein the method comprises:

disengaging a gland flange from the valve body, prior to removing the valve stem from the stem bore; and

after inspecting, replacing, or inspecting and replacing one or more contiguous packing rings, inserting the valve stem through the stem bore and positioning the one or more packing rings in the packing bore, positioning live loading springs between the gland flange and a packing gland, and securing the gland flange to the valve body to bias the packing gland against the one or more packing rings.

8. A repairable valve assembled from a repairable valve assembly system comprising components for assembly together into the repairable valve, the components comprising:

a spherical flow control element (106) with a flow control bore (107) therethrough;

a valve stem (108) to engage the flow control element;

a valve body (102, 382) comprising a flow bore (104) to rotatably receive the flow control element and a stem bore (158) to rotatably receive the valve stem, the flow bore

comprising a main bore (114), an inlet bore (116), and an outlet bore (118);

a downstream seat (110) comprising a seat body (120) for sealing engagement with the valve body adjacent the outlet bore having a sealing surface 124 to sealingly engage the flow control element and an outwardly tapered surface (330) adjacent the downstream seat element;

an upstream seat assembly (302) comprising an upstream seat element (140) to engage the flow control element, a seat spring (136) to bias the upstream seat element, and an annular spacer (138) following the spring;

a cartridge assembly (304, 353) insertable into the inlet bore comprising a sleeve (306, 352) engaging the annular spacer and the flow control element to hold the upstream seat element and the seat spring between the annular spacer and the flow control element for insertion into the flow bore;

wherein the sleeve has a leading sleeve end to engage the outwardly tapered surface to expand the sleeve and release the flow control element to float between the upstream seat element and the downstream seat body; and

a retainer (132) having an annular structure for removable attachment in the inlet bore to secure the cartridge in the flow bore and load the seat spring;

preferably wherein the repairable valve assembly system comprises:

a bracket fixedly supported from the valve body;

a stem opening in the bracket aligned with the stem bore;

a shear bushing with a central bore to slidably receive a first end of the valve stem, wherein the valve stem has a second end comprising a tang to engage the flow control element, and wherein the sleeve comprises a space to receive the tang;

wherein the shear bushing is rotatably disposable between the bracket and a stem shoulder formed on the valve stem, wherein the shear bushing has a bushing profile to cooperate with an opening profile of the stem opening for selective retention of the valve stem by the bracket or release of the shear bushing and valve stem for axial passage through the stem opening.

9. A repairable valve assembled from a repairable valve assembly system comprising components for assembly together into the repairable valve, the components comprising:

a spherical flow control element with a flow control bore therethrough;

a valve stem engaging the flow control element;

a valve body comprising a flow bore rotatably receiving the flow control element and a stem

bore rotatably receiving the valve stem, the flow bore comprising a main bore, an inlet bore, an outlet bore, and an entry bore from the main bore into the outlet bore;

a downstream seat comprising a downstream seat land and a seat body having opposed lapped surfaces in sealing engagement between the downstream seat land and the seat body, wherein the downstream seat land has an attachment end sealingly received in the entry bore, wherein the seat body has a downstream seat element comprising a sealing surface sealingly engaging the flow control element;

an upstream seat assembly comprising an upstream seat element engaging the flow control element, a seat spring to bias the upstream seat element, and an annular spacer following the seat spring; and

a retainer having an annular structure securing the upstream seat assembly in the flow bore and loading the seat spring, wherein the flow control element floats between the seat body and the upstream seat element;

preferably wherein the repairable valve comprises:

a bracket fixedly supported from the valve body;

a stem opening in the bracket aligned with the stem bore;

a shear bushing with a central bore to slidably receive a first end of the valve stem, wherein the valve stem has a second end comprising a tang to engage the flow control element; and

wherein the shear bushing is rotatably disposable between the bracket and a stem shoulder formed on the valve stem, wherein the shear bushing has a bushing profile to cooperate with an opening profile of the stem opening for selective retention of the valve stem by the bracket or release of the shear bushing and valve stem for axial passage through the stem opening.

10. A repairable valve comprising:

a spherical flow control element with a flow control bore therethrough;

a valve stem engaging the flow control element;

a valve body, preferably a single piece valve body, comprising a flow bore rotatably receiving the flow control element and a stem bore rotatably receiving the valve stem, the flow bore comprising a main bore, an inlet bore, an outlet bore, and an entry bore from the main bore into the outlet bore;

a downstream seat comprising:

a seat body having a downstream seat element comprising a sealing surface sealingly

engaging the flow control element, and a threaded element threadedly received in the entry bore and having an external polygonal cut profile for installation with a socket inserted through the inlet bore;

an upstream seat assembly comprising an upstream seat element engaging the flow control element, a seat spring to bias the upstream seat element, and an annular spacer following the seat spring, wherein the flow control element floats between the seat body and the upstream seat element; and

a retainer having an annular structure in the inlet bore securing the upstream seat assembly in the flow bore and loading the seat spring;

preferably wherein the repairable valve comprises:

a bracket fixedly supported from the valve body;

a stem opening in the bracket aligned with the stem bore;

a shear bushing with a central bore to slidably receive a first end of the valve stem and wherein the valve stem has a second end comprising a tang to engage the flow control element;

wherein the shear bushing is rotatably disposable between the bracket and a stem shoulder formed on the valve stem, wherein the shear bushing has a bushing profile to cooperate with an opening profile of the stem opening for selective retention of the valve stem by the bracket or release of the shear bushing and valve stem for axial passage through the stem opening.

11. A repairable, bidirectional valve (400) comprising:

a spherical flow control element (106) with a flow control bore (107) therethrough;

a single piece valve body (416) comprising a flow bore (104) rotatably receiving the flow control element (106), the flow bore comprising a central flow bore (415) and first and second end bores (417, 412), wherein the central bore has an inside diameter (ID) larger than an ID of the first end bore and smaller than an ID of the second end bore;

a first seat (418) for sealing engagement between the flow control element and the valve body adjacent the first end bore comprising a first seat body (420) having a first sealing surface (421) for sealingly engaging the flow control element and an attachment end (422) releasably secured to the valve body;

a second seat (402) comprising a second seat body (404) having a second sealing surface (405) for sealingly engaging the flow control element;

a seat spring (406) to bias the second seat body against the flow control element, wherein the flow control element floats between the first seat and the second seat;

an annular plug (408) in sealing engagement with the valve body, the annular plug having an outer end (410) threadedly engaged in the second end bore and an inner end (411) in engagement with the seat spring; and

a seat land (430) between the second seat body and the inner end of the annular plug for sealingly engaging the second seat body and the inner end of the plug, wherein the inner end loads the seat spring against the second seat body to sealingly engage the first element when a fluid pressure is higher in the second end bore relative to the first end bore, and wherein the seat land sealingly engages the second seat body and the inner end of the annular plug when a fluid pressure higher in the first end bore relative to the second end bore compresses the seat spring (preferably wherein the seat land has a height in excess of a solid height of the seat spring);

preferably wherein the repairable, bidirectional valve comprises:

a bracket (150) fixedly supported from the valve body, [preferably wherein the bracket is integrally forged with the valve body];

a stem opening in the bracket aligned with the stem bore;

a shear bushing with a central bore receiving a first end of the valve stem (preferably wherein the shear bushing is contiguous), wherein the valve stem has a second end comprising a tang to engage the flow control element;

wherein the shear bushing is rotatably disposable between the bracket and a stem shoulder formed on the valve stem, wherein the shear bushing has a bushing profile to cooperate with an opening profile of the stem opening for selective retention of the valve stem by the bracket or release of the shear bushing and valve stem for axial passage through the stem opening.

12. A valve comprising:

a valve body with an axial fluid flow bore therethrough;

a spherical flow control element disposed in the flow bore and rotatable between open and closed positions;

a valve stem having a first end in engagement with the flow control element for rotation thereof, the valve stem removably passing through a stem bore formed through the valve body;

wherein the fluid flow bore comprises a main passage, an inlet end, and an outlet end, wherein the main passage has a diameter larger than a diameter of the flow control element, wherein one of the inlet and outlet ends has an innermost diameter equal to

or larger than the diameter of the main passage;

valve trim comprising a downstream seat and an upstream seat assembly, the downstream seat disposed between the outlet end and the flow control element for sealing between the flow control element and the valve body, wherein the downstream seat comprises a body seal to sealingly engage the valve body and a seat element having a sealing surface to sealingly engage the flow control element, wherein the upstream seat assembly, the flow control element, and at least the downstream seat element are removable from the valve body through one end of the flow bore;

the upstream seat assembly disposed in the main passage between the inlet end and the flow control element, the upstream seat assembly comprising a spring to bias an upstream seat element against the flow control element and the flow control element against the downstream seat element, wherein the flow control element floats between the upstream and downstream seat elements; and

a retainer removably attached to the valve body about the fluid flow bore and having one or more projections into the flow bore to secure the downstream seat, the flow control element, and the upstream seat assembly in the flow bore and load the spring;

preferably wherein the valve stem extends from the first end through the stem bore to a second end selectively retained by a bracket spaced laterally from the valve body on a support;

preferably wherein the innermost diameter of the inlet end is larger than the innermost diameter of the outlet end, wherein the innermost diameter of the outlet end is smaller than the main flow passage, and wherein the upstream seat assembly, flow control element, and the downstream seat element are removable through the inlet end.

13. A method of assembling the valve of claim 12, comprising the steps of:

installing the downstream seat into the main passage adjacent the outlet end for sealing engagement with the valve body;

installing the flow control element into the main passage against the downstream seat;

installing the upstream seat assembly into the main passage against the flow control element; and

installing the retainer and loading the spring to bias the upstream seat element against the flow control element and the flow control element against the downstream seat element.

14. A repairable valve assembled from a repairable valve assembly system comprising components adapted to be assembled together into the repairable valve, the components comprising:

a valve body with an axial fluid flow bore therethrough, wherein the fluid flow bore comprises a main passage, an inlet end, and an outlet end;

a downstream seat adapted to be inserted into the main passage through the inlet end and at least a portion of the downstream seat sealingly secured to the valve body adjacent the outlet end, wherein the downstream seat comprises a seat element having a sealing surface to sealingly engage a flow control element and a tapered outer surface adjacent the sealing surface, wherein at least the downstream seat element is removable from the valve body through the inlet end;

a cartridge assembly adapted to be inserted into the main passage through the inlet end, the cartridge assembly comprising:

the flow control element, wherein the flow control element has a diameter less than the diameter of the main passage;

an upstream seat assembly comprising an upstream seat element having a surface to engage the flow control element, an annular spacer having an outside diameter larger than the flow control element, and a spring disposed between the spacer and the upstream seat element; and

a sleeve receiving the flow control element and at least a portion of the spacer, wherein the sleeve comprises radially spaced arms extending axially from a base at a first end adjacent the spacer to a second end extending beyond the flow control element;

wherein the arms are positioned at a small angle with respect to a longitudinal axis to hold the flow control element in engagement with the upstream seat element, the upstream seat element in engagement with the spring, and the spring in engagement with the spacer in an installation configuration; and

wherein installation of the cartridge assembly in the installation configuration through the inlet end of the flow bore causes the second ends of the arms to contact the taper, spread the arms apart, and release the flow control element to float between the upstream and downstream seat elements;

a retainer adapted to be removably attached to the valve body about the fluid flow bore and having one or more projections into the flow bore to secure the downstream seat, the flow control element, and the upstream seat assembly in the flow bore and load the

spring; and

preferably a valve stem having a first end adapted to engage the flow control element for rotation thereof, the stem adapted to extend from the first end through a stem bore in the valve body to a second end away from the valve body; wherein the valve stem is selectively retainable in or removable from the stem bore.

15. A method of assembling the repairable valve of claim 14, comprising the steps of:

installing the downstream seat through the inlet end and securing at least a portion of the downstream seat in sealing engagement with the valve body;

inserting the cartridge assembly through the inlet end and into the main passage until the arms contact the taper of the downstream seat element;

advancing the cartridge assembly to spread the arms apart and release the flow control element and the upstream seat element; and

installing the retainer through the inlet end to load the spring and bias the upstream seat element against the flow control element and the flow control element against the downstream seat element.;

preferably wherein the valve comprises a valve stem having first and second ends, forming a stem bore through the valve body, engaging the flow control element with the first end of the valve stem for rotation of the flow control element, extending the valve stem from the first end through the stem bore to a second end away from the valve body, and selectively retaining or removing the valve stem in or from the stem bore.