

TITLE OF THE INVENTION:

LIMITED VOLUME COAXIAL VALVE BLOCK

CROSS-REFERENCE TO RELATED APPLICATIONS

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[0001] This application for a patent claims priority to U.S. Provisional Patent Application No. 62/987,128 filed on March 9, 2020, and U.S. Provisional Patent Application No. 63/055,869 filed on July 23, 2020.

BACKGROUND OF THE INVENTION

10 **[0002]** Various types of chemicals and processes are required in the semiconductor fabrication industry, all while continuous, pure chemical can be supplied at the semiconductor tool request. These requirements necessitate regular and safe chemical container change out processes within the chemical delivery system.

15 **[0003]** Large piping runs and the presence of deadlegs within the design increase purge time required to safely change these chemical containers while decreasing purging efficiency. Deadlegs refer to sections of chemical delivery system design where purge gas cannot effectively reach, therefore decreasing purging efficiency and safety of the system during chemical container change out and system servicing.

20 **[0004]** These drawbacks to the chemical delivery system design are amplified by the presence of chemicals with lower vapor pressure and high purity such as tetrakis(dimethylamido)titanium (TDMAT). Chemicals of this kind are historically purged with use of solvent chemical, as disclosed in U.S. Pat. No. 5,964,230 and U.S. Pat. No. 6,138,691.

25 **[0005]** The use of a low volume block valve, as described below, will have the ability to remove the solvent purge requirement and use high pressure, high velocity purge gas and internal coaxial line instead. The use of vacuum draw and purge gas evacuation is also included in the block valve design. This low volume block valve has virtually eliminated any deadleg within the purgeable piping design, allowing for improved purging efficiency during chemical container changeouts.

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BRIEF SUMMARY OF THE INVENTION

[0006] In one aspect, disclosed herein is a valve block comprising: a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114); a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the second portion (152) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) through a conduit via a bend portion (162); and an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188).

[0007] In another aspect, disclosed herein is a system comprising: a valve block comprising: a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118)

- comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114); a first valve control mechanism located the cylindrical depression (118) of the first side (116); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114); a second valve control mechanism located the cylindrical depression (130) of the third side (128); a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162); an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188); and a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158).
- [0008]** In yet another aspect, disclosed herein is a method of performing a purge step in a valve block after the valve block has undergone a fluid flow step, wherein the valve block is in fluid communication with a container, the valve block comprising: a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve

control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first
5 portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114); a first valve control mechanism located the cylindrical depression (118) of the first side (116); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical
10 depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening
15 (204) located on the fourth side (138) of the housing (114); a second valve control mechanism located the cylindrical depression (130) of the third side (128); a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162); an angled seventh side
20 (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with
25 an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188), wherein the opening (206) located on the second side (126) of the housing (114) is in fluid communication with a purge gas source
30 (159); and a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158); the method comprising the steps of: changing the container; engaging the second valve control mechanism to close the first opening (134) in the surface (132) of the cylindrical depression (130) in the third side (128) and to isolate the second opening (136) in the surface (132) of the cylindrical depression (130) in the third

side (128); disengaging the first valve control mechanism to open the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and to open the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116); disengaging the third valve control mechanism to open the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) and to open the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158); and flowing high pressure purge gas through the opening (206) located on the second side (126) of the housing (114) such that the purge gas flows through the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) then through the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) to exit the inner coaxial portion (183) of the coaxial conduit and back up the outer coaxial portion (185) of the coaxial conduit through the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and into the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116) to the vent opening (178) located on the second side (126) of the housing (114).

[0009] The embodiments of the invention can be used alone or in combinations with each other.

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BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0010] FIG. 1 illustrates a prior art solvent purge system comprising a solvent purge manifold to host container manifold system comprising two independent valves and a coax injector connection;

25 **[0011]** FIG. 2 illustrates a prior art high-pressure purge manifold to host container manifold system comprising two independent valves consisting of three independent valve control mechanisms and a coax injector connection;

[0012] FIG. 3 illustrates yet another prior art system comprising a valve block with dual valve control mechanisms;

30 **[0013]** FIG. 4 illustrates a valve block of the present invention;

[0014] FIG. 5 is an axial view of the valve block of FIG. 4;

- [0015] FIG. 6 is a view of the valve block of FIG. 5 cut along line A-A;
- [0016] FIG. 7 is a view of the valve block of FIG. 6 cut along line B-B;
- [0017] FIG. 8 is another view of the valve block of FIG. 4;
- [0018] FIG. 9 is a view of the valve block of FIG. 8 cut along line C-C;
- 5 [0019] FIG. 10 is a view of the valve block of FIG. 8 cut along line D-D; and
- [0020] FIG. 11 is an illustration of the valve block of the present invention in relation to its installation point on the container, underneath a chimering.

DETAILED DESCRIPTION OF THE INVENTION

- 10 [0021] The ensuing detailed description provides preferred exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the invention. Rather, the ensuing detailed description of the preferred exemplary embodiments will provide those skilled in the art with an enabling description for implementing the preferred exemplary embodiments of the invention. Various changes may be made in the
- 15 function and arrangement of elements without departing from the spirit and scope of the invention, as set forth in the appended claims.

[0022] For purposes of the present specification and accompanying claims, the term “high velocity purge” means a purge step using a purge gas that is delivered at a rate of 100 liters per minute or greater.

- 20 [0023] For purposes of the present specification and accompanying claims, the term “conduit” refers to one or more structures through which fluids can be transported between two or more components of a system. For example, conduits can include pipes, ducts, manifolds, and combinations thereof that transport liquids and/or gases at varying pressures throughout a system.

- 25 [0024] For purposes of the present specification and accompanying claims, the term “fluid flow communication” refers to the nature of connectivity between two or more components that enables liquids and/or gases to be transported between the components in a controlled fashion. Coupling two or more components such that they are in fluid flow communication with each other can involve any suitable method known
- 30 in the art, such as with the use of flanged conduits, gaskets, and/or bolts.

[0025] For purposes of the present specification and accompanying claims, the term "coax" or "coaxial" refers to an arrangement of tubing where there is an inner tube located inside of an outer tube in concentric fashion.

[0026] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (*e.g.*, "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention. The use of the term "comprising" in the specification and the claims includes the more narrow language of "consisting essentially of" and "consisting of."

[0027] Embodiments are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

[0028] As used herein, "about" is intended to correspond to $\pm 5\%$ of the stated value.

[0029] Disclosed herein is an improved valve block design and system therefor that can be used to improve the purging efficiency for drying all wetted surfaces that are

connected between either a chemical container and a manifold or between a pair of manifolds. The improved valve block design includes several features that can be used to significantly reduce the time required to purge all wetted surfaces within a system. The valve block design eliminates or introduces only minimal deadlegs and provides for full
5 impingement on any minimal deadlegs. It also allows for a substantial reduction in the length of the vent path, and therefore a substantial reduction in the total quantity of surface area of conduit that becomes wetted with liquid chemical.

[0030] The valve block disclosed herein comprises a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116)
10 comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a
15 second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface
20 (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114); a fifth side (140) and a sixth side (142) opposite the fifth side (140),
25 wherein the second portion (152) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) through a conduit via a bend portion (162); and an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the
30 cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the

second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188).

[0031] The valve block according to embodiments disclosed herein accomplishes these improvements by having a triad of valves located within a single valve block or housing, two of the valve seats being oriented at a 90 degree difference relative to each other (e.g., on adjacent surfaces of a housing that is in the shape of a rectangular prism) while the third is located independently on another side. When used in a system in which the valve block is connected to a host container, the presence of the triad of valves ensures that all deadlegs are fully impinged upon during a purge step, thereby permitting a more efficient purge process. Specifically, the conduit through which purge gas enters the system is coaxially aligned with the port opening that is in fluid flow communication with the container. Because this port opening is closed during the purge process, the minimal deadleg located coaxially to this port opening is fully impinged upon by the purge gas when said port opening is closed. Accordingly, less purge gas can be used, the purge process can occur more quickly, and energy savings can be realized. This is contrasted with known prior art systems (see FIGS. 1 and 2), in which the valve seats are further from the container opening. In addition, locating the valves in a single valve block allows the liquid (vent) path to be kept very short, thereby greatly reducing the quantity of conduit surface area that becomes wetted and therefore must be dried. This is contrasted with a known prior art system (see FIG. 2), which has a comparably much longer liquid (vent) path that must be dried.

[0032] Fig. 1 is a visual representation of a prior art system 10 comprising a solvent source 66 in fluid flow communication with a conduit 40 which is in fluid flow communication with valve 38. Valve 38 is in fluid flow communication with conduit 17 via connection 16 which is in fluid flow communication with conduit 15 via bend 26. Conduit 15 is in fluid flow communication with the internal coaxial portion of coax injector 36 and in fluid flow communication with container 30 via conduit 29.

[0033] A fluid flow outlet 60 in fluid flow communication with a conduit 59 which is in fluid flow communication with valve 68. Valve 68 is in fluid flow communication with conduit 47 via connection 46. Conduit 47 is in fluid flow communication with the external coaxial portion of coax injector 36 and in fluid flow communication with container 30 via conduit 29.

[0034] Fig. 2 is a visual representation of a prior art system 70 comprising a purge source 101 in fluid flow communication with a conduit 97 which is in fluid flow communication with valve 84 via bend 92. Valve 84 is in fluid flow communication with conduit 79 and is in fluid flow communication with the internal coaxial portion of coax injector 88 and in fluid flow communication with container 90 via conduit 89.

[0035] A fluid flow outlet 98 in fluid flow communication with a conduit 74 which is in fluid flow communication with valve 72 via connection 83. Valve 72 is dual actuated to control individual ports connections 82, 83 via actuators 99, 100. During this operation, actuator 99 is open and 100 is closed to allow fluid flow communication to connection 75 and is in fluid flow communication with conduit 93. Conduit 93 is in fluid flow communication with the external coaxial portion of coax injector 88 and in fluid flow communication with container 90 via conduit 89.

[0036] A vent 96 in fluid flow communication with a conduit 95 which is in fluid flow communication with valve 72 via connection 82. Valve 72 is dual actuated to control individual ports connections 82, 83 via actuators 99, 100. During this operation, actuator 100 is open and 99 is closed to allow fluid flow communication to connection 75 and is in fluid flow communication with conduit 93. Conduit 93 is in fluid flow communication with the external coaxial portion of coax injector 88 and in fluid flow communication with container 90 via conduit 89.

[0037] The valve block shown in prior art FIG. 3 is disclosed in U.S. Patent No. 10,663,072, which is incorporated herein by reference. The valve block shown in prior art FIG. 3 is a refill manifold to host container manifold system 110 comprising an improved valve block 112 according to the present invention will now be described in detail.

[0038] The valve block 112 according to the present invention comprises a housing 114 that is approximately a rectangular prism in shape, although other housing shapes are possible within the scope of this invention, including generally cubic, spherical, or ovoid shapes or irregular shapes. In this embodiment, the housing 114 comprises a first side 116 that includes a valve seat 117 comprising a cylindrical depression 118. The cylindrical depression 118 comprises a surface 120 at which openings 122, 124 terminate and a second side 126 that opposes the first side 116. The cylindrical depression 118 accommodates the placement of a valve control mechanism therein (not shown). The

valve control mechanism allows for selective opening and closing of the opening **122** via a diaphragm that is fully engageable with the opening **122**.

[0039] The opening **122** is connected in fluid flow communication to a conduit portion **144**, which is connected in fluid flow communication to a T-connection **146**. The T-connection **146** is also connected in fluid flow communication with a conduit portion **148** that comprises a first portion **150** and a second portion **152**. The valve block **112** further comprises a third side **128** that includes a valve seat **129** comprising a cylindrical depression **130**. The cylindrical depression **130** comprises a surface **132** at which openings **134,136** terminate, a fourth side **138** that opposes the third side **128**, a fifth side **140**, and a sixth side **142** that opposes the fifth side **140**. The cylindrical depression **130** accommodates the placement of a second valve control mechanism therein (not shown). The second valve control mechanism is used to selectively open and close the opening **134** via a diaphragm that is fully engageable with the opening **134**. Opening **134** is in fluid flow communication with the first portion **150** of the conduit portion **148** and opening **136** is in fluid flow communication with conduit portion **160**. In this embodiment, the cylindrical depressions **118,130** of the valve seats **117,129** that accommodate attachment of the valve control mechanisms are located on adjacent sides of the housing **114** (i.e., first side **116** and third side **128**), the openings **134,154** are axially aligned, i.e., the center points of the openings **134,154** are aligned along the same linear axis (via a line that could be drawn through the center of the volume of conduit portion **148**).

[0040] The second portion **152** of the conduit portion **148** is in fluid flow communication with an opening **154** located on the fourth side **138** of the valve block **112**, and the opening **154** is in fluid flow communication with both a refill manifold **158** and a purge gas source **159** via connection **156**. Conduit portion **160** is in fluid flow communication with conduit portion **164** via bend **162**, and conduit portion **164** is in fluid flow communication with opening **166** located on the second side **126** of the housing **114**. Opening **166** is in fluid flow communication with container **170** via connection **168**. Opening **124** located on surface **120** of cylindrical depression **118** is in fluid flow communication with conduit portion **172**, which is in fluid flow communication with conduit portion **176** via bend **174**. Conduit portion **176** is in fluid flow communication with opening **178** located on fifth side **140** of the housing **114** and opening **178** is in fluid flow communication with vent **182** via connection **180**. In this embodiment, T-connection **146** and bends **162,174** orient respective connected conduit portions at 90 degree angles. It should be understood that in alternate embodiments, the T-connection **146** and/or bends

162,174 need not orient respective connected conduit portions at **90** degree angles but could instead orient respective connected conduit portions at any angle from 30 to 135 degrees.

[0041] The valve block disclosed in U.S. Patent No. 10,663,072, however, still suffers from the drawback of only being move liquids or gas through three ports controlled by two actuators. While the current invention can move liquids or gas through four ports controlled by three individual actuators. In addition to the advanced port control, the present invention can feed purge gas directly in the container connection, the fluid flow path, and the vent due to the use of a coaxial tube within the valve block. The smaller tube inside of the coax portion of the valve concentrates the pressure of the purge gas to higher pressures which allows for quicker purging of the valve block. The present disclosure builds on that disclosed in U.S. Patent No. 10,663,072.

[0042] Referring now to FIGS. 4 to 10, a purge manifold to host container manifold system **110** comprising an improved valve block **112** according to the present invention will now be described in detail.

[0043] The valve block **112** according to the present invention comprises a housing **114** that is a multi-sided object, although other housing shapes are possible within the scope of this invention, including generally cubic, spherical, rectangular, ovoid shapes or other irregular shapes. In this embodiment, the housing **114** comprises a first side **116** that includes a valve seat **117** comprising a cylindrical depression **118**. The cylindrical depression **118** comprises a surface **120** at which openings **122, 124** terminate and a second side **126** that opposes the first side **116**. The cylindrical depression **118** accommodates the placement of a valve control mechanism therein (not shown). The valve control mechanism allows for selective opening and closing of the opening **122** via a diaphragm this is fully engageable with the opening **122**.

[0044] The opening **122** is connected in fluid flow communication to a conduit portion **144**, which is connected in fluid flow communication to at T-connection **146**. The T-connection **146** is also connected in fluid flow communication with a conduit portion **148** that comprises a first portion **150** and a second portion **152**. The valve block **112** further comprises a third side **128** that includes a valve seat **129** comprising a cylindrical depression **130**. The cylindrical depression **130** comprises a surface **132** at which openings **134, 136** terminate, a fourth side **138** that opposes the third side **128**, a fifth side **140**, and sixth side **142** that opposes the fifth side **140**. The cylindrical depression

130 accommodates the placement of the second valve control mechanism therein (not shown). The second valve control mechanism is used to selectively open and close the opening 134 with, for example, a diaphragm. Opening 134 is in fluid flow communication with the first portion 150 of the conduit portion 148 and opening 136 is in fluid flow communication with conduit portion 198. Conduit portion 198 is in fluid flow communication with opening 204 located on the fourth side 138 of the housing 114 and opening 204 is in fluid flow communication with fluid flow outlet 202 via connection 200. In this embodiment, the cylindrical depressions 118, 130 of the valve seats 117, 129 that accommodate attachment of the valve control mechanisms are located on adjacent (i.e., first side 116 and third side 128), instead of opposing sides of the housing of the valve block as shown in the prior art embodiments on FIG. 2.

[0045] Conduit portion 148 is in fluid flow communication with conduit portion 164 via bend 162, and conduit portion 164 is in fluid flow communication with opening 166 located on the fifth side 140 of the housing 114. Opening 166 is in fluid flow communication with a face seal fitting 187 via a reducing conduit 189 and is in fluid flow communication with coaxial conduit portion 185 which is in fluid flow communication with opening 208. Opening 208 is in fluid flow communication with container 170 via connection 168. Opening 124 located on surface 120 of cylindrical depression 118 is in fluid flow communication with conduit portion 172. Conduit portion 172 is in fluid flow communication with opening 178 located on the second side 126 of the housing 114 and opening 178 is in fluid flow communication with vent 182 via connection 180.

[0046] Additionally, the valve block 112 comprises of an angled seventh side 158 that includes a valve seat 131 comprising a cylindrical depression 154. The cylindrical depression 154 comprises a surface 184 at which openings 174, 176 terminate, the second side 126 that opposes the first side 116. The cylindrical depression 154 accommodates the placement of the third valve control mechanism therein (not shown). The third valve control mechanism is used to selectively open and close the opening 174. Opening 174 is in fluid flow communication with the conduit portion 192. Conduit portion 192 is in fluid flow communication with conduit portion 194 via bend 196. Conduit portion 194 is in fluid flow communication with outer coaxial conduit portion 185 (outer portion) and conduit portion 168 to the container 170 via the inner coaxial portion 183 (inner portion) located inside the face seal fitting 187. and opening 176 is in fluid flow communication with conduit portion 186. Conduit portion 186 is in fluid flow communication with conduit portion 188 via bend 190, and conduit portion 188 is in fluid

flow communication with opening **206** located on the second side **126** of the housing **114** and is in fluid flow communication with a purge gas source **159** via connection **156**.

[0047] In the system **110** of FIGS. 4 to 10 during normal fluid flow operation, valve control mechanism (not shown) in cylindrical depression **130** is open. This allows fluid to flow from container **170** through conduit **168** and through opening **208** into conduit **185**. Conduit **185** is the outer coaxial portion of face seal **187**, which allows fluid to flow through opening **166** and into conduits **164** and **148**. With the valve control mechanism open (not shown) fluid can flow through opening **134** and into opening **136** so it can make its way out of opening **204** to fluid flow outlet **202** via conduit **198** and **200**.

[0048] When container **170** is empty and needs to be changed. The valve control mechanism (not shown) in cylindrical depression **130** (third side) is closed. This closes opening **134** and isolates the wetted system from the area that is intended to be purged. Valve control mechanisms (not shown) in cylindrical depressions **154** and **118** both open to allow the purge cycle to begin. Purge gas source **159** feeds purge gas through opening **206** via conduit **156** and through conduits **188** and **186**. With the valve control mechanism open (not shown) fluid can flow through opening **174** and into opening **176** so it travel through conduit **192** and **196** to exit the inner coaxial portion **183**. The valve control mechanism (not shown) on the container will be closed and this purge step forces high pressure purge gas to blast fluid molecules off the connection of opening **208** and forces and back up the outer coaxial conduit **185**. Conduit **185** is the outer coaxial portion of face seal **187**, which allows purge gas and fluid particles to flow through opening **166** and into conduits **164** and **148**. With the valve control mechanism of cylindrical depression **118** open (not shown) purge gas and fluid particles can flow through opening **122** and into opening **124** so it can make its way out of opening **178** to vent **182** via conduit **172** and **180**.

[0049] Thus, disclosed herein is a system comprising: a valve block comprising: a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in

fluid communication with a vent opening (178) located on the second side (126) of the housing (114); a first valve control mechanism located the cylindrical depression (118) of the first side (116); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114); a second valve control mechanism located the cylindrical depression (130) of the third side (128); a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162); an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188); and a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158).

25 **[0050]** Thus, also disclosed herein is a method of performing a purge step in a valve block after the valve block has undergone a fluid flow step, wherein the valve block is in fluid communication with a container, the valve block comprising: a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid

communication with a vent opening (178) located on the second side (126) of the housing (114); a first valve control mechanism located the cylindrical depression (118) of the first side (116); a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114); a second valve control mechanism located the cylindrical depression (130) of the third side (128); a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162); an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with the opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188), wherein the opening (206) located on the second side (126) of the housing (114) is in fluid communication with a purge gas source (159); and a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158); the method comprising the steps of: changing the container; engaging the second valve control mechanism to close the first opening (134) in the surface (132) of the cylindrical depression (130) in the third side (128) and to isolate the second opening (136) in the surface (132) of the cylindrical depression (130) in the third side (128); disengaging the first valve control mechanism to open the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and to open the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116); disengaging the third valve control mechanism to open the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side

(158) and to open the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158); and flowing high pressure purge gas through the opening (206) located on the second side (126) of the housing (114) such that the purge gas flows through the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) then through the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) to exit the inner coaxial portion (183) of the coaxial conduit and back up the outer coaxial portion (185) of the coaxial conduit through the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and into the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116) to the vent opening (178) located on the second side (126) of the housing (114).

[0051] Unlike prior art system **10** shown in FIG. 1, when the system **110** of FIG. 4 needs to change the container, it does not need to use a dangerous solvent source. The use of high-pressure purge gas is to accomplish the same task reduces the change of hazardous chemical exposure in the system and reduces the waste stream of disposing of hazardous chemicals.

[0052] Also, unlike prior art system **70** shown in FIG. 2, system **110** of FIGS. 4 to 10 does not require the additional conduit, valves and a separate coaxial injector. System **110** of FIGS. 4 to 10 takes all these separate components and combines them into one small valve block. The advantage of this being a greatly reduced amount of wetted surfaces inside the valve block. This significantly decreases purge times and increases the rate at which a container can be changed.

[0053] Additionally, unlike prior art system **110** shown in FIG. 3, when system **110** of FIGS. 4 to 10 performs a container change, the coaxial injector portion **187** can blast the connection between the valve block **112** and the container **170** with high pressure purge gas. This allows the same valve to vent the gas in the same step, as well as, deliver fluid in another step once the can change is complete. This is completed by incorporating three separate valve control mechanisms (not shown) into a single valve block while also taking advantage of a coaxial high-pressure purge device.

CLAIMS

1. A valve block comprising:

5 a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are terminal ends of conduits, wherein the first opening is in fluid
10 communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114);

15 a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in
20 fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114);

25 a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the second portion (152) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) through a conduit via a bend portion (162); and

30 an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are

- terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with an opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188).
- 5
2. The valve block of claim 1 wherein the opening (204) in the fourth side (138) of the housing (114) is in fluid communication with a fluid flow outlet (202) via a connection (200).
- 10
3. The valve block of claim 2 wherein the opening (166) on the fifth side (140) is in fluid communication with a face seal fitting (187) via a reducing conduit (189) and is in fluid communication with the coaxial conduit (185), which is in fluid communication with the opening (208) located on the fifth side (140) of the housing (114).
- 15
4. The valve block of claim 3 wherein the opening (208) located on the fifth side (140) of the housing (114) is in fluid communication with a container (170) via a connection (168).
- 20
5. The valve block of claim 1 wherein the opening (206) located on the second side (126) of the housing (114) is in fluid communication with a purge gas source (159).
6. The valve block of claim 1 wherein the T-connection comprises a 90° angle.
7. The valve block of claim 1 wherein the T-connection comprises an angle from 30° to 135°.
8. A system comprising:
- 25
- a valve block comprising:
- a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are
- 30

terminal ends of conduits, wherein the first opening is in fluid communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114);

5 a first valve control mechanism located the cylindrical depression (118) of the first side (116);

a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism, wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening (204) located on the fourth side (138) of the housing (114);

10 15 a second valve control mechanism located the cylindrical depression (130) of the third side (128);

a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162);

20 an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second opening (176) is in fluid communication with an opening (206) located on

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the second side (126) of the housing (114) through conduit (186) via bend (190) and conduit portion (188); and

a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158).

- 5 9. The system of claim 8 wherein the opening (204) in the fourth side (138) of the housing (114) is in fluid communication with a fluid flow outlet (202) via a connection (200).
- 10 10. The system of claim 9 wherein the opening (166) on the fifth side (140) is in fluid communication with a face seal fitting (187) via a reducing conduit (189) and is in fluid communication with the coaxial conduit (185), which is in fluid communication with the opening (208) located on the fifth side (140) of the housing (114).
- 15 11. The system of claim 10 wherein the opening (208) located on the fifth side (140) of the housing (114) is in fluid communication with a container (170) via a connection (168).
12. The system of claim 8 wherein the opening (206) located on the second side (126) of the housing (114) is in fluid communication with a purge gas source (159).
13. The system of claim 8 wherein the T-connection comprises a 90° angle.
- 20 14. The system of claim 8 wherein the T-connection comprises an angle from 30° to 135°.
15. A method of performing a purge step in a valve block after the valve block has undergone a fluid flow step, wherein the valve block is in fluid communication with a container, the valve block comprising:
- 25 a housing (114) having a first side (116) and a second side (126) opposite the first side (116), wherein the first side (116) comprises a cylindrical depression (118) for receiving a valve control mechanism, wherein the cylindrical depression (118) comprises a surface (120) and a first opening (122) and a second opening (124) in the surface (120), each of which are
- 30 terminal ends of conduits, wherein the first opening is in fluid

communication with a T-connection (146) in fluid communication with a second conduit (148) having a first portion (150) and a second portion (152), wherein the second opening (124) is in fluid communication with a vent opening (178) located on the second side (126) of the housing (114);

5 a first valve control mechanism located the cylindrical depression (118) of the first side (116);

a third side (128) adjacent to the first side (116) and a fourth side (138) opposite the third side (128), wherein the third side (128) comprises a cylindrical depression (130) for receiving a valve control mechanism,
10 wherein the cylindrical depression (130) comprises a surface (132) and a first opening (134) and a second opening (136) in the surface, each of which are terminal ends of conduits, wherein the first opening (134) is in fluid communication with the first portion (150) of the second conduit (148) and the second opening (136) is in fluid communication with an opening
15 (204) located on the fourth side (138) of the housing (114);

a second valve control mechanism located the cylindrical depression (130) of the third side (128);

a fifth side (140) and a sixth side (142) opposite the fifth side (140), wherein the first portion (150) of the second conduit (148) is in fluid
20 communication with an opening (166) located on the fifth side (140) of the housing (114) via a bend portion (162);

an angled seventh side (158) adjacent to the first side (116) and the fourth side (138), wherein the angled seventh side (158) comprises a cylindrical depression (154) for receiving a valve control mechanism, wherein the
25 cylindrical depression (154) comprises a surface (184) and a first opening (174) and a second opening (176) in the surface (184), each of which are terminal ends of conduits, wherein the first opening (174) is in fluid communication with an opening (208) through conduit portion (194) via bend (196) located on the fifth side (140) of the housing (114), the second
30 opening (176) is in fluid communication with an opening (206) located on the second side (126) of the housing (114) through conduit (186) via bend

(190) and conduit portion (188), wherein the opening (206) located on the second side (126) of the housing (114) is in fluid communication with a purge gas source (159); and

5 a third valve control mechanism located the cylindrical depression (154) of the angled seventh side (158);

the method comprising the steps of:

changing the container;

10 engaging the second valve control mechanism to close the first opening (134) in the surface (132) of the cylindrical depression (130) in the third side (128) and to isolate the second opening (136) in the surface (132) of the cylindrical depression (130) in the third side (128);

15 disengaging the first valve control mechanism to open the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and to open the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116);

disengaging the third valve control mechanism to open the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) and to open the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158); and

20 flowing high pressure purge gas through the opening (206) located on the second side (126) of the housing (114) such that the purge gas flows through the second opening (176) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) then through the first opening (174) in the surface (184) of the cylindrical depression (154) in the angled seventh side (158) to exit the inner coaxial
25 portion (183) of the coaxial conduit and back up the outer coaxial portion (185) of the coaxial conduit through the first opening (122) in the surface (120) of the cylindrical depression (118) in the first side (116) and into the second opening (124) in the surface (120) of the cylindrical depression (118) in the first side (116) to the vent opening (178) located on the second side (126) of the housing (114).

16. The method of claim 15 wherein the opening (204) in the fourth side (138) of the housing (114) is in fluid communication with a fluid flow outlet (202) via a connection (200).

5 17. The method of claim 16 wherein the opening (166) on the fifth side (140) is in fluid communication with a face seal fitting (187) via a reducing conduit (189) and is in fluid communication with the coaxial conduit (185), which is in fluid communication with the opening (208) located on the fifth side (140) of the housing (114).

10 18. The method of claim 17 wherein the opening (208) located on the fifth side (140) of the housing (114) is in fluid communication with a container (170) via a connection (168).

19. The method of claim 15 wherein the T-connection comprises a 90° angle.

20. The method of claim 15 wherein the T-connection comprises an angle from 30° to 135°.

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