

SYSTEM, METHOD AND APPARATUS FOR PLUMBING FITTING WITH REMOVABLE SAMPLING VALVE

TECHNICAL FIELD

The invention generally relates to valves and, in particular, to a system,
5 method and apparatus for a plumbing fitting with a removable and replaceable
sampling valve.

BACKGROUND ART

Sampling valves are commonly used in fluid plumbing systems to provide
samples of the fluid flowing within the system without disrupting the fluid flow.
10 Conventional sampling valves typically comprise units that have completely
integrated and permanently mounted components. Such sampling valves are
permanently installed in the plumbing. When any component on a sampling valve
unit fails, the entire sampling valve must be replaced. Replacing such a sampling
valve requires all conduits connected to the sampling valve to be cut and reattached to
15 a new unit. This replacement process requires a significant interruption in fluid flow,
which adds to the cost of replacement.

Thus, improved systems, methods and devices for replacing sampling valves
continue to be of interest.

20 BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the features and advantages of the embodiments
are attained and can be understood in more detail, a more particular description briefly
summarized above may be had by reference to the embodiments thereof that are
illustrated in the appended drawings. However, the drawings illustrate only some
25 embodiments and therefore are not to be considered limiting of its scope as the
invention may admit to other equally effective embodiments.

FIG. 1 includes an isometric view of a plumbing assembly in accordance with a particular embodiment.

FIG. 2 includes a rear plan view of a plumbing assembly in accordance with a particular embodiment.

5 FIG. 3 includes a side plan view of a plumbing assembly in accordance with a particular embodiment.

FIG. 4 includes a top plan view of a plumbing assembly in accordance with a particular embodiment.

10 FIG. 5 includes a cross-sectional view of a plumbing assembly in accordance with a particular embodiment taken along line 5-5 in FIG. 4.

FIG. 6 includes an isometric view a plumbing assembly in accordance with another particular embodiment.

FIG. 7 includes a side plan view of a plumbing assembly in accordance with another particular embodiment.

15 FIG. 8 includes a top plan view of a plumbing assembly in accordance with another particular embodiment.

FIG. 9 includes a cross-sectional view of a plumbing assembly in accordance with another particular embodiment taken along line 9-9 in FIG. 8.

20 FIG. 10 includes an isometric view a plumbing assembly in accordance with yet another particular embodiment.

FIG. 11 is a schematic diagram of an embodiment of a plumbing system.

The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 Referring to FIG. 1 through FIG. 5, a first embodiment of a plumbing assembly with a replaceable sampling valve is shown and is generally designated 20.

The plumbing assembly 20 can include a plumbing fitting 21 and a sampling valve assembly 41. As indicated, the plumbing fitting 21 can be generally T-shaped and can include a body 22 having a generally cylindrical main body portion 23 and a generally cylindrical peripheral body portion 24 extending from the main body portion 23 at an angle. In a particular aspect, the peripheral body portion 24 can extend perpendicularly from the main body portion 23.

As most clearly illustrated in FIG. 5, the main body portion 23 can include a first flared end 26 and a second flared end 28. Each flared end 26, 28 can be chamfered, or formed with a beveled, or flared, face 26', 28'. The beveled faces 26', 28' face are angled from the inner wall of the main bore 25 to the outer wall of the main body portion 23 such that a ramp is formed to facilitate the installation of a tube, or conduit, onto, or around, the first flared end 26 and the second flared end 28.

As indicated in FIG. 5, the main body portion 23 can also include a main bore 25 along the length of the main body portion 23, e.g., from the first flared end 26 of the main body portion 23 to the second flared end 28 of the main body portion 23 along a main axis 27. The main bore 25 can define a first port 29 that is circumscribed by the first flared end 26 of the main body portion 23 and a second port 30 that is circumscribed by the second flared end 28 of the main body portion 23.

The main body portion 23 can include a first threaded portion 26'' adjacent to the first flared end 26 of the main body portion 23 and a second threaded portion 28'' adjacent to the second flared end 28 of the main body portion 23. Each threaded portion 26'', 28'' can include an outer diameter, OD_{TP} , and each flared end 26, 28 can include an outer diameter, OD_{FE} . In a particular aspect, OD_{FE} can be $< OD_{TP}$.

For example, OD_{FE} can be $\leq 95\% OD_{TP}$, $\leq 90\% OD_{TP}$, or $\leq 85\% OD_{TP}$. Further, OD_{FE} can be $\geq 70\% OD_{TP}$, such as $\geq 75\% OD_{TP}$, or $\geq 80\% OD_{TP}$. In another aspect, OD_{FE} can be within a range between and including any of the $\% OD_{TP}$ values described herein.

For example, OD_{FE} can be $\leq 95\% OD_{TP}$ and $\geq 70\% OD_{TP}$, $\leq 95\% OD_{TP}$ and $\geq 75\% OD_{TP}$, or $\leq 95\% OD_{TP}$ and $\geq 80\% OD_{TP}$. OD_{FE} can be $\leq 90\% OD_{TP}$ and $\geq 70\% OD_{TP}$, $\leq 90\% OD_{TP}$ and $\geq 75\% OD_{TP}$, or $\leq 90\% OD_{TP}$ and $\geq 80\% OD_{TP}$. OD_{FE} can be

$\leq 85\% OD_{TP}$ and $\geq 70\% OD_{TP}$, $\leq 85\% OD_{TP}$ and $\geq 75\% OD_{TP}$, or $\leq 85\% OD_{TP}$ and $\geq 80\% OD_{TP}$.

As illustrated, the first threaded portion 26'' can be distanced from the first beveled face 26' of the first flared end 26 in order to define, or establish, a first
 5 conduit engagement area 26''' around the first flared end 26 of the main body portion 23 between the first beveled face 26' and the first threaded portion 26''. The second threaded portion 28'' can be distanced from the second beveled face 28' of the second flared end 28 in order to define, or establish, a second conduit engagement area 28''' around the first flared end 28 of the main body portion 23 between the second beveled
 10 face 28' and the second threaded portion 28''.

Each conduit engagement area 26''', 28''' can have a length, L_{CEA} , and each threaded portion can have a length, L_{TP} . As illustrated in FIG. 5, L_{CEA} , can be $< L_{TP}$. For example, L_{CEA} , can be $\leq 95\% L_{TP}$, such as $\leq 90\% L_{TP}$, or $\leq 85\% L_{TP}$. Further, L_{CEA} , can be $\geq 70\% L_{TP}$, such as $\geq 75\% L_{TP}$, or $\geq 80\% L_{TP}$. In a particular aspect,
 15 L_{CEA} can be within a range between and including any of the $\% L_{TP}$ values described herein. For example, L_{CEA} can be $\leq 95\% L_{TP}$ and $\geq 70\% L_{TP}$, such as $\leq 95\% L_{TP}$ and $\geq 75\% L_{TP}$, or $\leq 95\% L_{TP}$ and $\geq 80\% L_{TP}$. Further, L_{CEA} can be $\leq 90\% L_{TP}$ and $\geq 70\% L_{TP}$, such as $\leq 90\% L_{TP}$ and $\geq 75\% L_{TP}$, or $\leq 90\% L_{TP}$ and $\geq 80\% L_{TP}$. Moreover, L_{CEA} can be $\leq 85\% L_{TP}$ and $\geq 70\% L_{TP}$, such as $\leq 85\% L_{TP}$ and $\geq 75\% L_{TP}$, or $\leq 85\% L_{TP}$ and $\geq 80\% L_{TP}$.
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FIG. 5 further indicates that a first flare nut 31 can be threadably engaged with the first threaded portion 26'' around the first flared end 26 of the main body portion 23. Further, a second flare nut 32 can be threadably engaged with the second threaded portion 28'' around the second flared end 28 of the main body portion 23.

25 In a particular aspect, a first conduit 33, i.e., and end thereof, can be installed around the first flared end 26 of the main body portion 23 at least partially along, or around, the first conduit engagement area 26''' so that the first conduit engagement area 26''' that circumscribes the first flared end 26 extends at least partially into the end of the first conduit 33. The first flare nut 31 can be installed over the first
 30 conduit 33 and engaged with the first threaded portion 26''. As the first flare nut 31 is tightened onto the first threaded portion 26'', the end of the first conduit 33 can be

captured between an inner surface of the first flare nut 31 and an outer surface of the first flared end 26 of the main body 24.

Similarly, an end of a second conduit 34 can be installed around the second flared end 28 of the main body portion 23 at least partially along the second conduit engagement area 28''' so that the second conduit engagement area 28''' formed around the second flared end 28 extends at least partially into the end of the second conduit 34. The second flare nut 32 can be installed over the first conduit 34 and engaged with the second threaded portion 28''. As the second flare nut 32 is tightened onto the second threaded portion 28'', the end of the second conduit 34 can be captured between an inner surface of the second flare nut 32 and an outer surface of the second flared end 28 of the main body 24.

As an alternative to using the flare nuts 31, 32 to connect the conduits 33, 34, the conduits 33, 34 can be permanently attached to the main body 24 of the plumbing fitting 21 by using a fuse bond, a chemical weld, or some other appropriate method of forming a permanent bond or weld.

Returning to FIG. 5, the peripheral body portion 24 of the body 22 of the valve fitting 21 can be formed with a sampling bore 35 that can extend from the main bore 25 formed in the main body portion 23 and the sampling bore 35 can be in fluid communication with the main bore 25. In a particular aspect, the sampling bore 35 can extend along a sampling axis 37 that is substantially perpendicular to the main axis 27. Further, the sampling bore 35 can include a first portion 36 and a second portion 38.

As illustrated, the first portion 36 of the sampling bore 35 can have an inner diameter, ID_{sb1} , and the second portion 38 of the sampling bore 35 can have an inner diameter, ID_{sb2} . In a particular aspect, ID_{sb1} can be $< ID_{sb2}$ and a flared face 45 can be formed in the inner wall of the peripheral body portion 24 at the interface between the first portion 36 of the sampling bore 35 and the second portion 38 of the sampling bore 35. For example, ID_{sb1} can be $< 80\% ID_{sb2}$, such as $< 75\% ID_{sb2}$, or $< 70\% ID_{sb2}$. Further, ID_{sb1} can be $> 50\% ID_{sb2}$, such as $> 55\% ID_{sb2}$, or $> 60\% ID_{sb2}$.

In another aspect, ID_{sb1} can be with a range between and including any of the % ID_{sb2} values described herein. For example, ID_{sb1} can be $< 80\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 80\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 80\% ID_{sb2}$ and $> 60\% ID_{sb2}$. In another aspect, ID_{sb1} can be $< 75\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 75\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 75\% ID_{sb2}$ and $> 60\% ID_{sb2}$. Moreover, ID_{sb1} can be $< 70\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 70\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 70\% ID_{sb2}$ and $> 60\% ID_{sb2}$.

In another aspect, the main bore 25 of the main body portion 23 can have a substantially uniform inner diameter, ID_{mb} , along the length of the main bore 25. Further, in this aspect, ID_{sb1} can be $< ID_{mb}$. For example, ID_{sb1} can be $\leq 40.0\% ID_{mb}$, such as $\leq 37.5\% ID_{mb}$, $\leq 35.0\% ID_{mb}$, or $\leq 30\% ID_{mb}$. Further, ID_{sb1} can be $\geq 15.0\% ID_{mb}$, such as $\geq 20.0\% ID_{mb}$, or $\geq 25.0\% ID_{mb}$.

In another aspect, ID_{sb1} can be within a range between and including any of the % ID_{mb} values described herein. For example, ID_{sb1} can be $\leq 40.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 40.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 40.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$. In another aspect, ID_{sb1} can be $\leq 37.5\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 37.5\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 37.5\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$. Further, ID_{sb1} can be $\leq 35.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 35.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 35.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$. Moreover, ID_{sb1} can be $\leq 30.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 30.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 30.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$.

As indicated in FIG. 5, the peripheral body portion 24 of the body 22 can include a first outer diameter, OD_{P1} , measured through the first portion 36 of the sampling bore 35 and a second outer diameter, OD_{P2} , measured through the second portion 38 of the sampling bore 35. In a particular aspect, as illustrated in FIG. 5, OD_{P1} can be $< OD_{P2}$. For example, OD_{P1} can be $< 85\% OD_{P2}$, such as $< 80\% OD_{P2}$, or $< 75\% OD_{P2}$. Further, OD_{P1} can be $> 60\% OD_{P2}$, such as $> 65\% OD_{P2}$, or $> 70\% OD_{P2}$.

In another aspect, OD_{P1} can be within a range between and including any of the % OD_{P2} values described herein. For example, OD_{P1} can be $< 85\% OD_{P2}$ and $> 60\% OD_{P2}$, such as $< 85\% OD_{P2}$ and $> 65\% OD_{P2}$, or $< 85\% OD_{P2}$ and $> 70\% OD_{P2}$. In another aspect, OD_{P1} can be $< 80\% OD_{P2}$ and $> 60\% OD_{P2}$, such as $< 80\% OD_{P2}$ and $> 65\% OD_{P2}$, or $< 80\% OD_{P2}$ and $> 70\% OD_{P2}$. Further, OD_{P1} can be $< 75\%$

OD_{P2} and $> 60\% OD_{P2}$, such as $< 75\% OD_{P2}$ and $> 65\% OD_{P2}$, or $< 75\% OD_{P2}$ and $> 70\% OD_{P2}$.

FIG. 5 indicates that the peripheral body portion 24 of the body 22 can include a distal end 46 that can be formed with a flared, or beveled, face 47. Moreover, a
 5 third threaded flare nut 39 can be installed around the distal end 46 of the peripheral body portion 24 of the body 22. A sampling valve assembly 41 can be threadably engaged with the third flare nut 39 to engage the sampling valve assembly 41 with the body 22 of the plumbing fitting 21.

Specifically, the sampling valve assembly 41 can include a valve body 60. An
 10 inlet tube 61 can extend from the valve body 60. An outlet tube 63 can extend from the valve body 60 substantially perpendicular to the inlet tube 61. The inlet tube 61 can include a first portion 65 that is sized and shaped to fit into the second portion 38 of the sampling bore 35 formed in the peripheral body portion 24 of the body 22 of the plumbing fitting 21. The inlet tube 61 of the sampling valve assembly 41 can also
 15 include a threaded second portion 66 adjacent to the first portion 65 of the inlet tube 61 and the threaded second portion 66 can be sized and shaped to threadably engage the third flare nut 39 that is disposed around the peripheral body portion 24 of the body 22 of the plumbing fitting 21.

As shown in FIG. 5, the first portion 65 of the inlet tube 61 can have an outer
 20 diameter, OD_{IT1} , and the threaded second portion 66 can have an outer diameter, OD_{IT2} . In a particular aspect, OD_{IT1} can be $< OD_{IT2}$. For example, OD_{IT1} can be $< 85\% OD_{IT2}$, such as $< 80\% OD_{IT2}$, or $< 75\% OD_{IT2}$. Further, OD_{IT1} can be $> 60\% OD_{IT2}$, such as $> 65\% OD_{IT2}$, or $> 70\% OD_{IT2}$.

In another aspect, OD_{IT1} can be within a range between and including any of
 25 the $\% OD_{IT2}$ values described herein. For example, OD_{IT1} can be $< 85\% OD_{IT2}$ and $> 60\% OD_{IT2}$, such as $< 85\% OD_{IT2}$ and $> 65\% OD_{IT2}$, or $< 85\% OD_{IT2}$ and $> 70\% OD_{IT2}$. In another aspect, OD_{IT1} can be $< 80\% OD_{IT2}$ and $> 60\% OD_{IT2}$, such as $< 80\% OD_{IT2}$ and $> 65\% OD_{IT2}$, or $< 80\% OD_{IT2}$ and $> 70\% OD_{IT2}$. Further, OD_{P1} can be $< 75\% OD_{IT2}$ and $> 60\% OD_{IT2}$, such as $< 75\% OD_{IT2}$ and $> 65\% OD_{IT2}$, or $< 75\%$
 30 OD_{P2} and $> 70\% OD_{IT2}$.

As shown in FIG. 5, a flared face 47 can be formed in the outer surface of the inlet tube 61 at the interface between the first portion 65 and the second portion 66 of the inlet tube 61. Further, the inlet tube 61 can include a distal end 67 that can be also formed with a flared face 47.

5 When the sampling valve assembly 41 is engaged with the plumbing fitting 21, as shown in FIG. 5, the first portion 65 of the inlet tube 61 of the sampling the valve 42 fits into the second end 38 of the sampling bore 35 of the peripheral body portion 24 of the body 22 of the plumbing fitting 22 and the flared face 47 of the distal end 67 inlet tube 61 can seat against the flared face 45 formed within the
10 sampling bore 35. Moreover, the flared face 47 formed between the first portion 65 and the second portion 66 of the inlet tube 61 can seat against the flared face 45 formed on the distal end 46 of the peripheral body portion 24 of the body 22 of the plumbing fitting 22.

FIG. 5 indicates that the sampling valve assembly 41 can include an internal
15 fluid chamber 70. An inlet bore 75 that can extend along the entire length of the inlet tube 61, through the valve body 60 adjacent to the inlet tube 61, and can terminate at the internal fluid chamber 70 so that the inlet bore 75 is in fluid communication with the internal fluid chamber 70. The inlet bore 75 can have an inner diameter, ID_I , and in a particular aspect, ID_I can be the same as ID_{sb1} .

20 The sampling valve assembly 41 can also include an outlet bore 77 formed along the outlet tube 63. The outlet bore 77 extends through the valve body 60 of the sampling valve assembly 41 so that the outlet bore 77 is in fluid communication with the internal fluid chamber 70. The outlet tube 63 can include a distal end 90 that can circumscribe a sampling port 51.

25 As illustrated, the inlet bore 75 can include a distal end 78 that can terminate at the distal end 67 of the inlet tube 61. The inlet bore 75 can also include a proximal end 79 that can terminate at an inner wall of the valve body 60. The proximal end 79 of the inlet bore 75 can be circumscribed by a valve seat 81. A valve 42 having a stem 82 and a head 83 can be installed within the sampling valve assembly 41 such
30 that the valve 42 is aligned with the inlet bore 75. The head 83 of the valve 42 can be biased toward the valve seat 81, by one or more springs, in order to engage the valve

seat 81 and establish a seal with the valve seat 81 in order to block fluid flow through the inlet bore 75. During operation, the valve 42 can move linearly within the sampling valve assembly 41 away from the valve seat 81 so that the head 83 of the valve 42 is unseated, and distanced, from the valve seat 81 to allow fluid flow through the inlet bore 75 and to permit fluid communication between the inlet bore 75, the internal fluid chamber 70, and the outlet bore 77.

Accordingly, when the sampling valve assembly 41 is actuated, or otherwise opened, a sample of fluid moving through the main bore 25 of the main body portion 23 of the body 22 of the plumbing fitting 21 fluid communication is permitted between the plumbing fitting 21 and the sampling valve assembly 41. Further, a sample can flow through the sampling bore 35 of the peripheral body portion 24 of the body 22 of the plumbing fitting 21, through the inlet bore 75 of the sampling valve assembly 41, through the internal fluid chamber 70 of the sampling valve assembly 41, and through the outlet bore 77 of the sampling valve assembly 41.

In a particular aspect, the sampling valve assembly 41 can include, for example, a high pressure valve (HPV) or a compact diaphragm valve (CDV). The sampling valve assembly 41 can include an operating pressure, P_O , and P_O can be ≥ 60 psi, such as ≥ 65 psi, ≥ 70 psi, ≥ 75 psi, or ≥ 80 psi. Further, P_O can be ≤ 120 psi, such as ≤ 110 psi, or ≤ 100 psi. In a particular aspect, P_O can be within a range between and including any of the values of P_O described herein. For example, P_O can be ≥ 60 psi and ≤ 120 psi, such as ≥ 60 psi and ≤ 110 psi, or ≥ 60 psi and ≤ 100 psi. P_O can be ≥ 65 psi and ≤ 120 psi, such as ≥ 65 psi and ≤ 110 psi, or ≥ 65 psi and ≤ 100 psi. Moreover, P_O can be ≥ 70 psi and ≤ 120 psi, such as ≥ 70 psi and ≤ 110 psi, or ≥ 70 psi and ≤ 100 psi. P_O can be ≥ 75 psi and ≤ 120 psi, such as ≥ 75 psi and ≤ 110 psi, or ≥ 75 psi and ≤ 100 psi. Further, P_O can be ≥ 80 psi and ≤ 120 psi, such as ≥ 80 psi and ≤ 110 psi, or ≥ 80 psi and ≤ 100 psi.

The sampling valve assembly can be a pneumatically actuated valve assembly 41 as shown in FIG. 1 through FIG. 5 and FIG. 6 through FIG. 9. Alternatively, the sampling valve assembly can be a manually actuated valve assembly as illustrated in FIG. 10. In either case, a plunger, or valve, can be actuated to release fluid through the sampling valve and out a sampling port 51 circumscribed by a distal end 90 of the outlet tube 62 of the sampling valve assembly 41.

In a particular aspect, the distal end 90 of the outlet tube 63 can be circumscribed by a fourth flare nut 53. The fourth flare nut 53 can be used to connect a third conduit 91 to the plumbing assembly 20.

In another particular aspect, the outlet bore 77 and the sampling port 51 of the outlet bore 77 can have an inner diameter, ID_O , and, as described above, the inlet bore 75 can have an inner diameter ID_I . In this aspect, ID_O can be $\leq ID_I$. For example, ID_O can be $\leq 70\% ID_I$, such as $\leq 65\% ID_I$, $\leq 60\% ID_I$, or $\leq 50\% ID_I$. Further, ID_O can be $\geq 20\% ID_I$, such as $\geq 25\% ID_I$, or $\geq 30\% ID_I$. ID_O can be within a range between and including any of the $\%ID_I$ values described herein. For example, ID_O can be $\leq 70\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 70\% ID_I$ and $\geq 25\% ID_I$, or $\leq 70\% ID_I$ and $\geq 30\% ID_I$. ID_O can be $\leq 65\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 65\% ID_I$ and $\geq 25\% ID_I$, or $\leq 65\% ID_I$ and $\geq 30\% ID_I$. In another aspect, ID_O can be $\leq 60\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 60\% ID_I$ and $\geq 25\% ID_I$, or $\leq 60\% ID_I$ and $\geq 30\% ID_I$. Moreover, ID_O can be $\leq 50\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 50\% ID_I$ and $\geq 25\% ID_I$, or $\leq 50\% ID_I$ and $\geq 30\% ID_I$.

In each of the embodiments shown, no portion of the sampling valve assembly 41, e.g., the inlet tube 61 of the sampling valve assembly 41, extends into the main bore 25 formed in the main body portion 23 of the body 22 of the plumbing fitting 21. As such, the main bore 25 is completely unimpeded. Additionally, use of the sampling valve assembly 41 imparts substantially no pressure drop in fluid flowing through the main bore in the main bore 25 (e.g., between the first port 29 and the second port 30).

In a particular aspect, the fluid flowing through the plumbing fitting 21 can have an operating pressure, P , and the pressure drop, P_d , caused by sampling valve can be $\leq 1.0\% P$, such as $\leq 0.75\% P$, or $\leq 0.5\% P$. In another aspect, P_d may be $\geq 0.05\% P$, $\geq 0.1\% P$, or $\geq 0.25\% P$. Further, P_d can be within a range between and including any of the $\% P$ values described herein. P_d can be $\leq 1.0\% P$ and $\geq 0.05\% P$, such as $\leq 1.0\% P$ and $\geq 0.1\% P$, or $\leq 1.0\% P$ and $\geq 0.25\% P$. P_d can be $\leq 0.75\% P$ and $\geq 0.05\% P$, such as $\leq 0.75\% P$ and $\geq 0.1\% P$, or $\leq 0.75\% P$ and $\geq 0.25\% P$. Moreover, P_d can be $\leq 0.5\% P$ and $\geq 0.05\% P$, such as $\leq 0.5\% P$ and $\geq 0.1\% P$, or $\leq 0.5\% P$ and $\geq 0.25\% P$.

In a particular aspect, each of the flare nuts 31, 32, 39, and 53 can include external textures 55 (e.g., axial ribs, etc.) to facilitate manual rotation. In some applications, the ribbed nuts may comprise Teflon® PFA materials that interface with a tool to ensure no chemical leakage under flow pressure.

5 It can be appreciated that in a particular aspect, while the third flare nut 39 can be threadably engaged with the inlet tube 61 of the valve assembly 41, the third flare nut 39 is free to rotate about the peripheral body portion 24 of the body 22 of the plumbing fitting 21. As such, when the sampling valve assembly 41 is engaged with the plumbing fitting 21, the sampling valve assembly 41 can be rotated about the
10 sampling axis 37 so that an outlet axis 100 extending through the outlet bore 77 and the sampling port 51 can form a sampling angle with respect to the main axis 27. As shown in FIG. 4, the sampling angle can be any angle between and including 0° to 360°.

 For example, at 0°, the outlet axis 100 can be parallel to the main axis 27 and
15 the sampling port 51 of the sampling valve 41 can face a first direction that is parallel to the main axis 27. At 180°, the sampling port 51 of the sampling valve 41 can face a second direction that is also parallel to the main axis 27, but opposite the first direction. At 90°, the sampling port 51 of the sampling valve 41 can face a third direction that is perpendicular to the main axis 27. At 270°, the sampling port 51 of
20 the sampling valve 41 can face a fourth direction that is also perpendicular to the main axis 27, but opposite the third direction. Further, as stated above, the outlet port 51 can be rotated at any angle with respect to the main axis 27 in a range between and including 0° to 360°. As such, the sampling valve 41 can be repositioned during use to facilitate sampling.

25 Referring now to FIG. 11, a plumbing system is illustrated and is generally designated 101. As shown in FIG. 11, the plumbing system 101 may comprise a valve (e.g., a shut-off valve) 103, a plumbing fitting 21 having a sampling valve 41 connected thereto, as described herein, a conduit 104 extending from the shut-off valve 103 to the plumbing 21, and from the plumbing fitting 21 downstream thereof.
30 In a particular aspect, closure of the shut-off valve 103 can permit the sampling valve assembly 41 to be removed from the body 22 of the plumbing fitting 21, and replaced by another implement.

The other implement may comprise another sampling valve assembly 41. This configuration also permits purging of the system 101, such as flushing by a fluid like deionized water or nitrogen gas.

However, still other embodiments of implements may comprise at least one of
5 a pressure gage, a static mixer, a thermometer, a velocimeter, a densimeter, and a
plug. Each of these implements may be threaded to threadably engage the third flare
nut 39 of the plumbing fitting 21 when the sampling valve assembly 41 is removed
therefrom. Forms of such implements are known to those of ordinary skill in the art,
but they are not interchangeably connectable with a T-shaped plumbing fitting having
10 a readily removable or replaceable sampling valve, as described in detail herein.

This written description uses examples to disclose the embodiments, including
the best mode, and also to enable those of ordinary skill in the art to make and use the
invention. The patentable scope is defined by the claims, and may include other
examples that occur to those skilled in the art. Such other examples are intended to be
15 within the scope of the claims if they have structural elements that do not differ from
the literal language of the claims, or if they include equivalent structural elements
with insubstantial differences from the literal languages of the claims.

Note that not all of the activities described above in the general description or
the examples are required, that a portion of a specific activity may not be required,
20 and that one or more further activities may be performed in addition to those
described. Still further, the order in which activities are listed are not necessarily the
order in which they are performed.

In the foregoing specification, the concepts have been described with
reference to specific embodiments. However, one of ordinary skill in the art
25 appreciates that various modifications and changes can be made without departing
from the scope of the invention as set forth in the claims below. Accordingly, the
specification and figures are to be regarded in an illustrative rather than a restrictive
sense, and all such modifications are intended to be included within the scope of
invention.

As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other
5 features not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

10 Also, the use of “a” or “an” are employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

15 Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

20 After reading the specification, skilled artisans will appreciate that certain features are, for clarity, described herein in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, references to values
25 stated in ranges include each and every value within that range.

WHAT IS CLAIMED IS:

1. A plumbing assembly, comprising:
 - a plumbing fitting having a body, the body of the plumbing fitting comprising:
 - a main body portion comprising a first end and a second end opposite the first end, a main bore extending through the main body from the first end to the second end, a first flare nut around the first end of the main body portion, and a second flare nut around the second end of the main body portion, wherein the first end circumscribes a first port and the second end circumscribes a second port, wherein the first flare nut is configured to connect a first conduit to the first end of the main body, and wherein the second flare nut is configured to connect a second conduit to the second end of the main body; and
 - a peripheral body portion extending from the main body portion, the peripheral body portion including a distal end, a third flare nut circumscribing the distal end of the peripheral body portion, and a sampling bore extending through the peripheral body such that the sampling bore is in fluid communication with the main bore;
 - a sampling valve threadably coupled to the peripheral body portion of the plumbing fitting and extending at least partially into the sampling bore without extending into the main bore, such that the main bore is unimpeded by the sampling valve and use of the sampling valve imparts substantially no pressure drop in a fluid passing through the main bore of the plumbing fitting, wherein the sampling valve comprises an outlet tube that includes a sampling port.
2. A plumbing fitting, comprising:
 - a body, comprising:
 - a main body portion comprising a first end and a second end opposite the first end, a main bore extending through the main body from the first end to the second end, a first flare nut around the first end of the main body

portion, and a second flare nut around the second end of the main body portion, wherein the first end circumscribes a first port and the second end circumscribes a second port, wherein the first flare nut is configured to connect a first conduit to the first end of the main body, and wherein the second flare nut is configured to connect a second conduit to the second end of the main body; and

a peripheral body portion extending from the main body portion, the peripheral body portion including a distal end, a third flare nut circumscribing the distal end of the peripheral body portion, and a sampling bore extending through the peripheral body such that the sampling bore is in fluid communication with the main bore, wherein the peripheral body portion is configured to threadably receive a sampling valve, such that the main bore is unimpeded by the sampling valve and use of the sampling valve imparts substantially no pressure drop in a fluid passing through the main bore during operation of the plumbing fitting, wherein the sampling valve comprises an outlet tube that includes a sampling port.

3. A plumbing system, comprising:

a plumbing fitting having a body, the body comprising:

a main body portion comprising a first end and a second end opposite the first end, a main bore extending through the main body from the first end to the second end, a first flare nut around the first end of the main body portion, and a second flare nut around the second end of the main body portion, wherein the first end circumscribes a first port and the second end circumscribes a second port, wherein the first flare nut is configured to connect a first conduit to the first end of the main body, and wherein the second flare nut is configured to connect a second conduit to the second end of the main body; and

a peripheral body portion extending from the main body portion, the peripheral body portion including a distal end, a third flare nut circumscribing the distal end of the peripheral body portion,

and a sampling bore extending through the peripheral body such that the sampling bore is in fluid communication with the main bore;

a sampling valve threadably coupled to the peripheral body portion of the plumbing fitting and extending at least partially into the sampling bore without extending into the main bore, such that the main bore is unimpeded by the sampling valve and use of the sampling valve imparts substantially no pressure drop in a fluid passing through the main bore during operation of the plumbing fitting, wherein the sampling valve comprises an outlet tube that includes a sampling port; and

a shut-off valve coupled to the plumbing fitting upstream from plumbing fitting via a conduit, wherein closure of the shut-off valve permits the sampling valve to be removed from the plumbing fitting, and replaced by another implement.

4. The plumbing system according to claim 3, wherein the other implement comprises another sampling valve or a pressure gage, static mixer, thermometer, velocimeter, densimeter and plug, each of which is threaded to threadably engage the threaded port of the sampling bore when the sampling valve is removed therefrom.

5. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling valve is a high pressure valve (HPV) or a compact diaphragm valve (CDV).

6. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling valve is manual or pneumatic.

7. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling bore has a first portion having an inner diameter, ID_{sb1} , and a second portion having an inner diameter, ID_{sb2} , wherein $ID_{sb1} < ID_{sb2}$.

8. The plumbing assembly according to claim 7, wherein $ID_{sb1} < 80\% ID_{sb2}$, such as $< 75\% ID_{sb2}$, or $< 70\% ID_{sb2}$.
9. The plumbing assembly according to claim 8, wherein $ID_{sb1} > 50\% ID_{sb2}$, such as $> 55\% ID_{sb2}$, or $> 60\% ID_{sb2}$.
10. The plumbing assembly according to claim 7, wherein $ID_{sb1} < 80\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 80\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 80\% ID_{sb2}$ and $> 60\% ID_{sb2}$.
11. The plumbing assembly according to claim 7, wherein $ID_{sb1} < 75\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 75\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 75\% ID_{sb2}$ and $> 60\% ID_{sb2}$.
12. The plumbing assembly according to claim 7, wherein $ID_{sb1} < 70\% ID_{sb2}$ and $> 50\% ID_{sb2}$, such as $< 70\% ID_{sb2}$ and $> 55\% ID_{sb2}$, or $< 70\% ID_{sb2}$ and $> 60\% ID_{sb2}$.
13. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling bore has a first portion having an inner diameter, ID_{sb1} , and the main bore has an inner diameter, ID_{mb} , and wherein $ID_{sb1} < ID_{mb}$.
14. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 10, wherein $ID_{sb1} \leq 40.0\% ID_{mb}$, such as $\leq 37.5\% ID_{mb}$, $\leq 35.0\% ID_{mb}$, or $\leq 30\% ID_{mb}$.
15. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 11, wherein $ID_{sb1} \geq 15.0\% ID_{mb}$, such as $\geq 20.0\% ID_{mb}$, or $\geq 25.0\% ID_{mb}$.
16. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 13, wherein $ID_{sb1} \leq 40.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 40.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 40.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$.

17. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 13, wherein $ID_{sb1} \leq 37.5\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 37.5\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 37.5\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$.
18. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 13, wherein $ID_{sb1} \leq 35.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 35.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 35.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$.
19. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 13, wherein $ID_{sb1} \leq 30.0\% ID_{mb}$ and $\geq 15.0\% ID_{mb}$, such as $\leq 30.0\% ID_{mb}$ and $\geq 20.0\% ID_{mb}$, or $\leq 30.0\% ID_{mb}$ and $\geq 25.0\% ID_{mb}$.
20. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling valve comprises an inlet tube having a first portion and a threaded second portion adjacent to the first portion, wherein the first portion of the inlet tube extends into the second portion of the sampling bore and the third flare nut threadably engages the threaded second portion of the inlet tube to secure the sampling valve to the plumbing fitting.
21. The plumbing assembly, the plumbing fitting, or the plumbing system according to claim 20, wherein the peripheral body portion includes a flared face within the sampling bore between the first portion and second portion of the sampling bore, and the inlet tube of the sampling valve includes a distal end formed with a flared face that is configured to engage and seat against the flared face within the sampling bore.
22. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, where each of the flare nuts have external textures to facilitate manual rotation.
23. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, further comprising at least one of a pressure gage, a static mixer, a thermometer, a velocimeter, a densimeter, and a plug, each of

which is threaded to threadably engage the third flare nut when the sampling valve is removed therefrom.

24. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling valve further comprises a fourth flare nut that circumscribes a distal end of the outlet tube.

25. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the outlet bore and the sampling port have an inner diameter, ID_O , and the inlet tube includes an inlet bore having a diameter, ID_I , wherein $ID_O \leq ID_I$.

26. The plumbing assembly according to claim 25, wherein $ID_O \leq 70\% ID_I$, such as $\leq 65\% ID_I$, $\leq 60\% ID_I$, or $\leq 50\% ID_I$.

27. The plumbing assembly according to claim 26, wherein $ID_O \geq 20\% ID_I$, such as $\geq 25\% ID_I$, or $\geq 30\% ID_I$.

28. The plumbing assembly according to claim 25, wherein $ID_O \leq 70\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 70\% ID_I$ and $\geq 25\% ID_I$, or $\leq 70\% ID_I$ and $\geq 30\% ID_I$.

29. The plumbing assembly according to claim 25, wherein $ID_O \leq 65\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 65\% ID_I$ and $\geq 25\% ID_I$, or $\leq 65\% ID_I$ and $\geq 30\% ID_I$.

30. The plumbing assembly according to claim 25, wherein $ID_O \leq 60\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 60\% ID_I$ and $\geq 25\% ID_I$, or $\leq 60\% ID_I$ and $\geq 30\% ID_I$.

31. The plumbing assembly according to claim 25, wherein $ID_O \leq 50\% ID_I$ and $\geq 20\% ID_I$, such as $\leq 50\% ID_I$ and $\geq 25\% ID_I$, or $\leq 50\% ID_I$ and $\geq 30\% ID_I$.

32. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the sampling valve is rotatably connected to the peripheral body portion of the body of the plumbing fitting, such that

the sampling valve can be rotated about a sampling axis extending through the sampling bore.

33. The plumbing assembly, the plumbing fitting, or the plumbing system according to any of claims 1, 2, or 3, wherein the fluid flowing through the main body portion of the body of the plumbing fitting includes a pressure, P , and a pressure drop, P_d , caused by sampling valve is $\leq 1.0\% P$, such as $\leq 0.75\% P$, or $\leq 0.5\% P$.

34. The plumbing assembly according to claim 33, wherein $P_d \geq 0.05\% P$, $\geq 0.1\% P$, or $\geq 0.25\% P$.

35. The plumbing assembly according to claim 33, wherein $P_d \leq 1.0\% P$ and $\geq 0.05\% P$, such as $\leq 1.0\% P$ and $\geq 0.1\% P$, or $\leq 1.0\% P$ and $\geq 0.25\% P$.

36. The plumbing assembly according to claim 33, wherein $P_d \leq 0.75\% P$ and $\geq 0.05\% P$, such as $\leq 0.75\% P$ and $\geq 0.1\% P$, or $\leq 0.75\% P$ and $\geq 0.25\% P$.

37. The plumbing assembly according to claim 33, wherein $P_d \leq 0.5\% P$ and $\geq 0.05\% P$, such as $\leq 0.5\% P$ and $\geq 0.1\% P$, or $\leq 0.5\% P$ and $\geq 0.25\% P$.