SAMPLE PROBE

USER MANUAL

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SAMPLE PROBE

PROBE DESCRIPTION

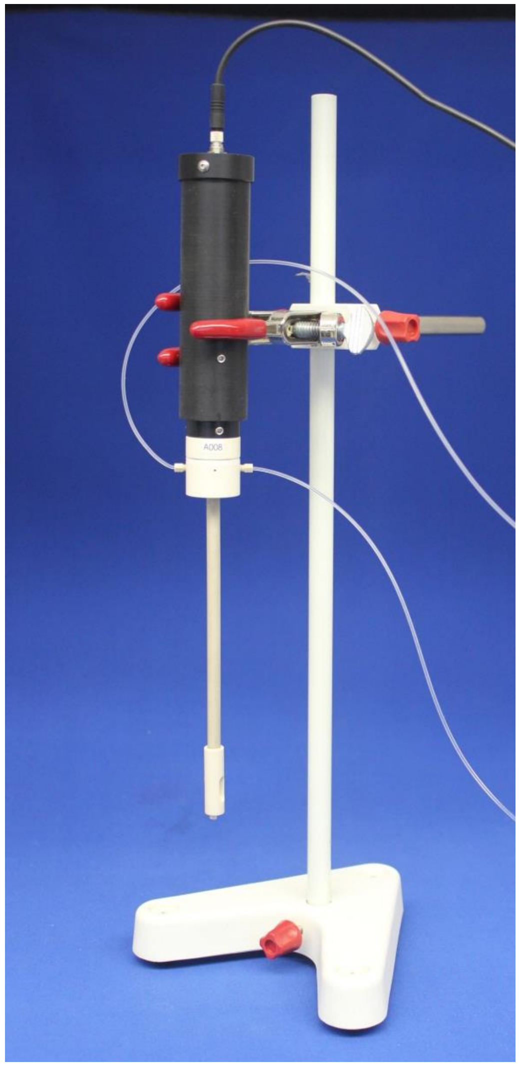

Figure 1: Sample Probe

Global FIA has developed and patented[1] a versatile sample probe shown in Figure 1 to allow the withdrawal of sample from a range of process and experimental environments. This sample probe is

[1] Wolcott D. K. and Marshall G.D. *Sampling probe for solutions containing soluble solids or high concentrations of dissolved solids*, **USP: 8,365,616**, (2013)

suited for sampling in the pharmaceutical, petrochemical, mineral processing, biochemical, fermentation, food handling, and environmental fields.

Various accessories and attachments allow sampling from:

- Batch reactors
- Homogenous room temperature reactors
- Heterogeneous room temperature reactors where the liquid phase or sample containing solids is required
- Reactors at elevated temperatures containing supersaturated solutions
- Miniature reactors where probe size is a constraint
- Flow through reactors
- The headspace of reactors

What distinguishes this probe from many others is that it includes a stream switching device. This device is either a two-position three-port valve or a two position four-port switching valve. This valve allows the design of fluid handling systems with certain sample manipulations carried out in close proximity to the sampling point. This feature is vital in the handling of heterogeneous samples or super-saturated solutions. It allows sample manipulation unit operations such as dilution, solvent modification, and enrichment. Our thinking in developing this probe was to transform the sample into a form that is easier to handle as close to the sampling point as possible. In this way we have been able to simplify many tedious and troublesome sampling projects and expand the degree of automation achievable for real-time at-line analysis.

SAMPLE PROBE COMPONENTS

The sample probe comprises of the following components which are identified in Figure 2 :

a. A two-position selection valve
    - Three port version
    - Four port version
b. Motor for activating the valve
c. Valve controller
d. Motor-valve coupler and limit switches
e. Power and control cable
f. Probe shaft – $^3/_8$”, ¼”, $^1/_8$” OD standard length is 7” (180 mm) - custom lengths are available
g. Sampling probe tips – in addition to custom probe tips the following standard tips are available
    - No filter
    - Coarse mesh (75µm) screen
    - Large volume 25µm pore size filter
    - Small volume 2µm filter
    - Flat bottom 1 -25µm filter

- Sterile 0.2µm filter
- Disposable syringe filter
- Flow through cell

h. Mounting hardware
- Teflon adapter for 24/40 tapered ground glass joint
- Mounting bracket
- Mounting rod

i. Connecting tubing and fittings

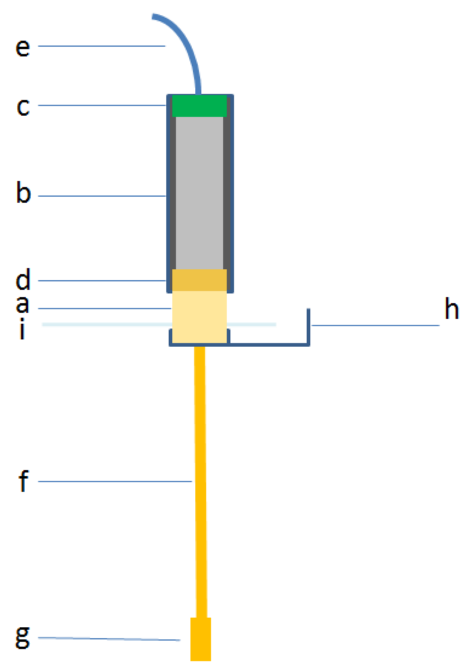

Figure 2: Sample probe components

THREE-PORT SELECTION VALVE

The three-port selection valve (depicted in Figure 4) has a common port and two selectable ports. The common port is one of the side ports and the probe shaft is connected to one of the selectable ports. The rotor has a T-shaped cut-out which interfaces with a stator plate with ports connected to the three valve ports. The motor switches between two positions 90° apart. With this arrangement the side common port can be connected to either the other side port or the probe shaft port.

The two side ports have a 6-40 thread detail which allows connection of 1/16" or 1/32" OD tubing using Valco miniature 6-40 flange-free fittings (P/N: 640FF-16 or 640FF-32). The shaft port is a standard flat bottom ¼-28 port. Shafts are equipped with mating ¼-28 threaded ends. Alternatively, standard Valco

¼-28 flange free fittings can be used to couple up either 1/16” or 1/8” OD tubing to act as the probe shaft (P/N FF1428-16N, FF1428-8N).

Figure 3 shows cutaway drawings of the valve with the rotor in its two positions. In the left picture, the fluid path indicated in red passes from the common port through the valve and exists to waste. In the right picture, the rotor has been rotated 90 degrees so that the common port is connected to the probe shaft. The diagrams provide a realistic representation of the actual fluid pathway.

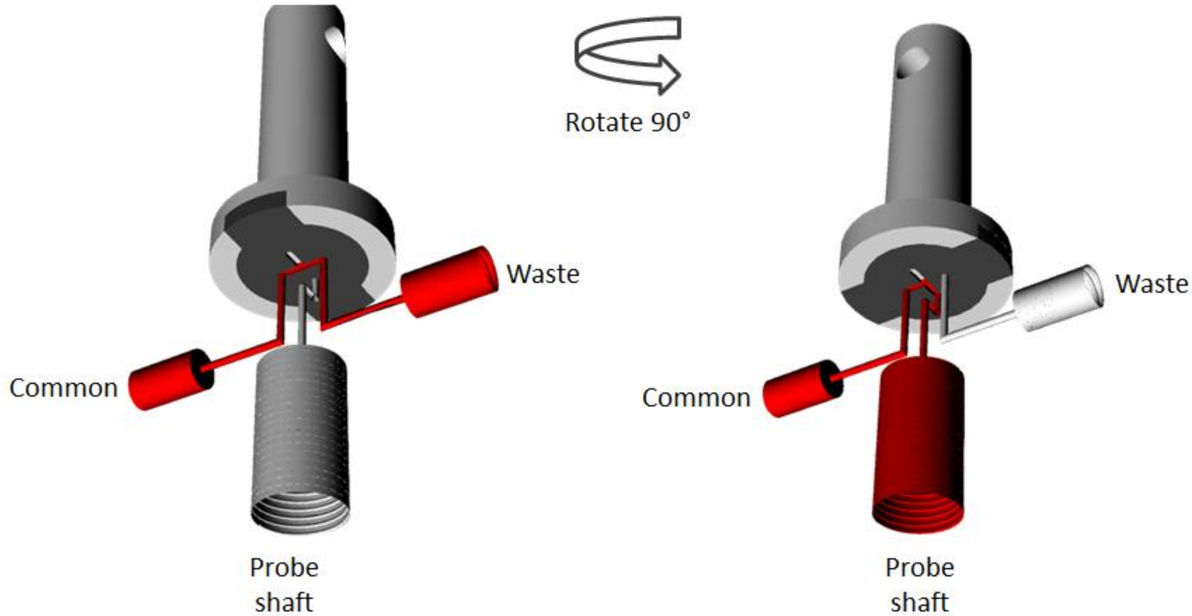

Figure 3: Cut-away drawings showing fluid path through the valve

Details of how this valve is used are given below in the section “Using the sample probe”.

Figure 4: Three-port selection valve

FOUR-PORT SWITCHING VALVE

The four-port switching valve (depicted in Figure 5) has two side ports and two shaft ports. By switching the valve, the side ports can be connected to either of the two shaft ports, i.e. side port **a** is connected to shaft port **1** while side port **b** is connected to shaft port **2** and then after switching, side port **a** is connected to shaft port **2** while side port **b** is connected to shaft port **1**. With this arrangement, the sample probe can function in as a self-cleaning sample probe. Details of how this valve is used are given below in the section "Self-cleaning filter probe".

Figure 5: Four port switching valve

VALVE MOTOR AND CONTROLLER

PROBE TIPS

The sample probe can be fitted with one of the probe tips developed to meet different sampling needs. Custom tips can be developed to meet specific sampling needs.

The simplest probe tip provides no sample conditioning and is a straightforward 0.03" ID inlet (A in Figure 6). This tip can be equipped with a stainless steel 75 µm screen (B in Figure 6). Several filter elements have been developed. Each filter element is replaceable. The large volume filter element is equipped with a 2cm long 25µm porous Teflon filter (C in Figure 6). The small volume filter is equipped with a 7mm 2µm filter (D in Figure 6). The flat bottom filter tip allows sampling from shallow reactors (E in Figure 6) and has a filter surface area of 30 mm^2 and can be equipped with any filter disk. The sterile barrier filter is equipped with a 7mm 0.2µm filter (F in Figure 6). Syringe filters can be attached to the luer fitting tip (G in Figure 6). Part numbers for each of these tips are given in Table 2.

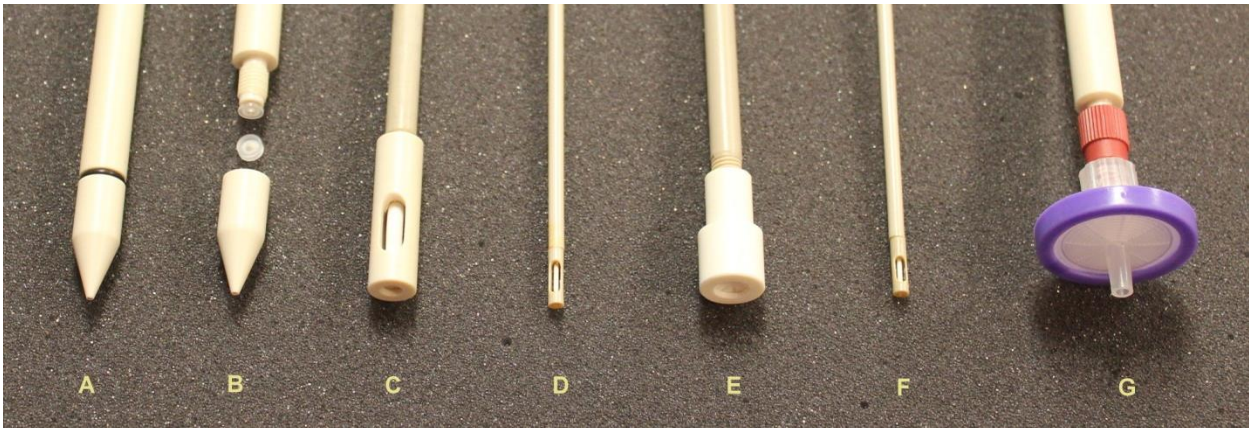

Figure 6: Batch sampling tips

A flow through cell with sample probe (Figure 7) has been developed that is usually equipped with the large volume filter element.

Figure 7: Flow through sampling head

MOUNTING HARDWARE

Three mounting options are provided; the shaft can be gripped in a Teflon 24/40 adapter for ground glass joints (Figure 8). Alternatively, a mounting rod convenient for clamping the sample probe to a racking system can be attached to the sampling valve (Figure 9). The third mounting option is a mounting bracket to provide a secure mounting option (Figure 10).

Figure 8: Glass slip joint mounting

<Picture needed>

Figure 9: Mounting rod

<Picture needed>

Figure 10: Probe mounting bracket

MATERIALS OF CONSTRUCTION

The wetted components of the sample probe are constructed from PPS, PTFE, and UHMWPE. Certain accessories may include O-ring seals made from Viton. Where Viton seals are not compatible with the fluids used, Kalrez O-rings can be substituted. Filter material is porous PTFE, porous polyethylene, or porous polypropylene. The course screen is made from stainless steel. Connecting tubing is PFA.

CHEMICAL COMPATIBILITY OF WETTED MATERIALS

PPS

The valve body, probe shaft and certain probe tips are constructed from PPS (trade name Ryton®).

Poly (p-phenylene sulfide) (PPS) is a polymer made up of alternating sulfur atoms and phenylene rings in a *para*-substitution pattern. The highly stable chemical bonds of its molecular structure impart a remarkable degree of molecular stability toward both thermal degradation and chemical reactivity. PPS has not been found to dissolve in any solvent at temperatures below about 200°C. Non-oxidizing, water-based acid, base, and salt solutions do not have a significantly different effect on PPS than water alone, except under very acidic conditions. Non-oxidizing organic chemicals generally have little effect on PPS, but amines, aromatic compounds, and halogenated compounds may cause some swelling and softening over extended periods of time at elevated temperatures. Avoid exposure of PPS to oxidizing chemicals except at low concentrations or for very brief periods. Exposure to light causes PPS to discolor over time from a cream color to more of light brown color. This change in color has no adverse effect to the component's mechanical performance.

PTFE

The valve rotor and stator plate are made from PTFE. Porous PTFE is used in some of the filters.

Polytetrafluoroethylene is the generic name for the class of materials known as Teflon®. It offers superior chemical resistance and lends itself to good sealing characteristics. Volatile compounds of low molecular weight can permeate PTFE. Fumes of strong acids such as hydrochloric acid can permeate the PTFE and should be constantly purged from the internals of the valve by blowing instrument air in through one of the leak ports. A barbed fitting (Cat No.: P-N) is available to allow convenient hookup of an air-line. A special order valve is required to allow connection of the barbed fitting.

UHMWPE

UHMWPE can be used as the valve rotor or stator and provides longer life time.

Ultra-high-molecular-weight polyethylene (UHMWPE, UHMW) is a subset of the thermoplastic polyethylene and has extremely long chains which serve to transfer load more effectively to the polymer backbone by strengthening intermolecular interactions. It is highly resistant to corrosive chemicals except oxidizing acids; has extremely low moisture absorption and a very low coefficient of friction; is self-lubricating; and is highly resistant to abrasion.

PAEK

Historically PEEK has been used for certain probe components. Future probes will use PPS in place of PEEK.

Polyaryletherketone is the generic name for the family of polyketone compounds. PAEK includes PEK, PEEK, PEKK, and PEKEKK, which differ in physical properties and, to a lesser degree, in inertness. PEEK is known to resist all common HPLC solvents and dilute acids and bases. However, concentrated or prolonged use of halogenated solvents may cause the polymer to swell. Avoid concentrated sulfuric or nitric acids (over 10%).

VALCON P

Certain valve components may be constructed from Valcon P® in the future.

This composite, the majority of which is PTFE and carbon, has been used extensively in many analytical applications that use Valco valves. It is routinely used in other applications at 1000 psi, 75°C, and can also be used at temperatures approaching 200°C with decreased sealing tension.

VITON®

Viton® O-rings are used to seal some of the joints in the sample probe.

Besides its excellent mechanical properties, Viton® provides the best proven fluid and chemical resistance of the commercial non-fluorinated elastomers.

KALREZ®

Kalrez® O-rings can be used instead of Viton and must be special ordered.

Kalrez® perfluoro elastomer parts and seals resist over 1,800 different chemicals while offering the high temperature stability of PTFE (327°C). Advanced properties help maintain seal integrity

POROUS POLYPROPYLENE

Porous polypropylene (PP) is used as a filter material in some of the filter tips

Polypropylene is highly resistant to most acids and alkalis. It is resistant to most organic solvents below 176°F (80°C). Its use at high temperatures depends on conditions in addition to heat, but as a rule, PP may be used at temperatures ranging from 200 to 300° F (93°C to 149°C) if not stressed.

POROUS POLYETHYLENE

Porous polyethylene (PE) is used as a filter material in some of the filter tips.

Polyethylene is highly resistant to most acids and alkalis. Certain oxidizing acids and chlorinated organic solvents could have an adverse effect on filter elements when exposure is for extended periods or at elevated temperatures.

SAMPLE PROBE CONTROL

The sample probe valves are driven by a simple DC motor. The motor is powered by 5VDC and is controlled using a single TTL level digital output. The control circuitry applies power to the motor turning it until an internal limit switch is contacted. At this point the power to the motor is removed. When the control line is switched, the motor turns in the opposite direction until the limit switch is reached and then the motor stops.

ASSEMBLY

VALVE REPLACEMENT

The following steps describe the procedure for replacing the valve:

1. Disconnect the power / control cable.
2. Disconnect all fluid lines.
3. Unscrew the sample probe shaft.
4. Loosen the three set screws that clamp the valve to the probe holder.

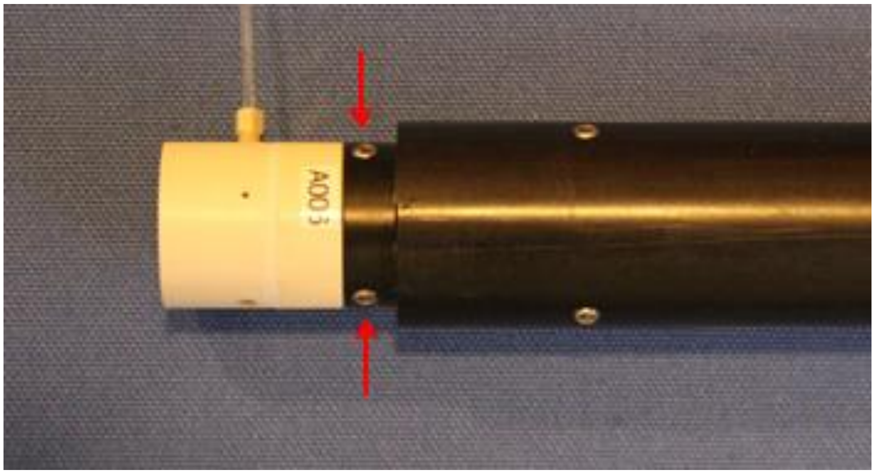

Figure 11: Valve clamping set screws

5. Carefully pull the valve away from the probe holder.

To install a new valve:

1. Ensure that the motor is in the position corresponding to the control off output this will be the fully CCW position when viewed from the valve end of the actuator.
2. Rotate the valve drive shaft by hand so that the stem of the marked T (on older valves) or dimple on the side of the valve drive shaft is 180° from the orientation dot on the side of the valve. The drive shaft cross pin should line up with the two side ports of the valve. Note - If you inadvertently line the stem of the marked T or dimple on the side of the valve drive shaft <u>with</u> the orientation dot on the side of the valve then in the digital output “off” position, all three ports will be connected. This is not a useful or intended arrangement.

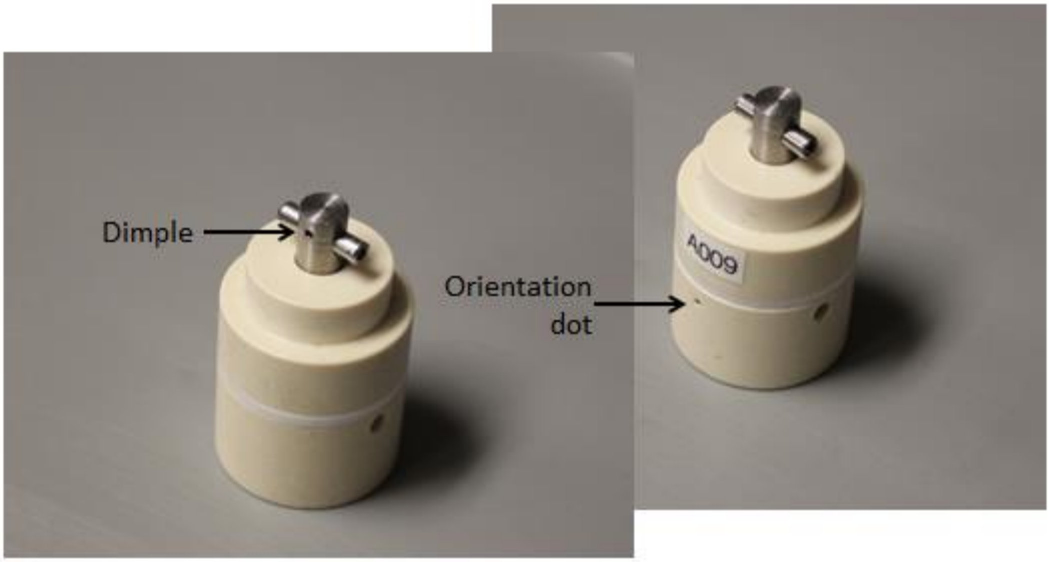

Figure 12: Correct orientation of the valve drive shaft

3. Slide the valve into the sample probe holder being careful to align the drive shaft cross pin with the motor coupler. Be careful not to turn the valve drive shaft while positioning the valve in the probe holder.
4. Tighten the set screws that clamp the valve to the sample probe holder.
5. Attach the fluid lines.
6. Screw in the desired sample probe shaft.
7. Connect up the power / control cable.
8. Test operation by switching the valve.
9. Ensure that there is flow through the valve in both positions. If either of the two ports is blocked or partially blocked then remove the valve and begin again being careful to align the orientation dimple (or stem of the marked T) 180° from the orientation dot.

ROTOR REPLACEMENT

If the valve is sucking air and you have checked all the fluid connections it may be necessary to replace the rotor and stator. To replace the rotor and stator:

1. Disconnect the fluid lines and probe shaft.
2. Loosen the four screws in the port body that hold the valve parts together (Figure 13).

Figure 13: Valve screws in valve port body

3. Remove the stator disk.
4. Remove the rotor for the rotor cup.
5. Install a new rotor in the rotor cup so that the stem of the T in the rotor faces the dimple on the drive shaft.
6. Orientate the new stator disk so that the three holes are facing the rotor and the channel on the back side of the stator disk points at the orientation dot on the side of the valve and faces the valve port body (Figure 14).

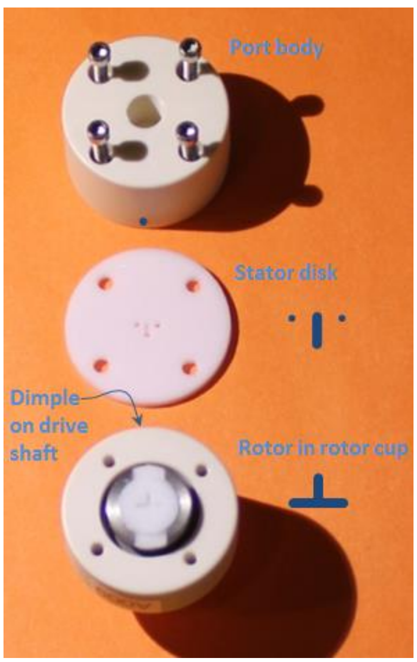

Figure 14: Orientation of stator disk and rotor

7. Insert the four screws and tighten them in a cross pattern so that the valve components come together evenly. Be careful not to over tighten the screws – simply tighten till there are no gaps between the layers of the valve

PROBE EXCHANGE

Before removing the sample probe or probe tip ensure that all process fluids have been well flushed from the system. Then ensure that all connections are tight and do not leak air. The probe shaft and probe tip can be finger tightened. Use the 6-40 finger-nut wrench to tighten the 6-40 fittings.

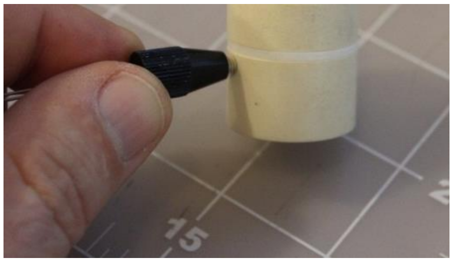

Figure 15: Tightening 6-40 fittings using the 6-40 finger-nut wrench

ELECTRICAL CONNECTIONS

The sampling probe valve is powered and controlled using a three wire cable. The hookup of this cable is shown in Figure 16 and detailed in Table 1.

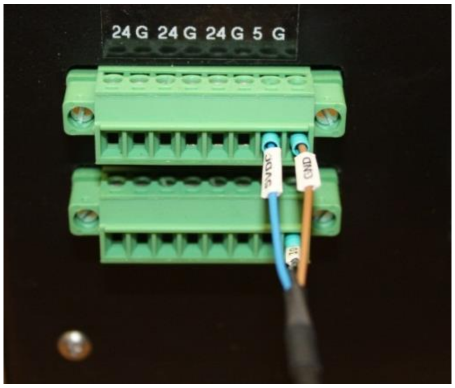

Figure 16: Electrical connections

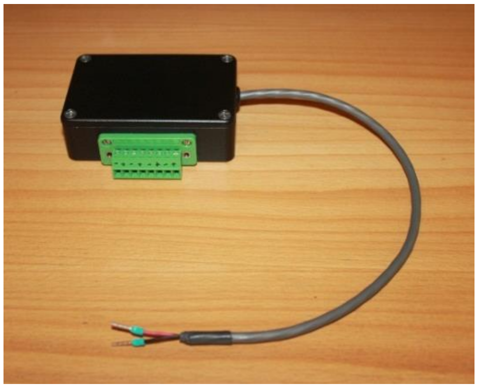

Figure 17: 5VDC expansion box

Table 1: Electrical connections

Conductor	Label	Description
Blue	5V	5 VDC
Brown	Gnd	Ground
Black	IO	Digital IO port

The IO port is a current sinking output port. This IP port is controlled via FloZF (Global FIA's device control and data acquisition software) and selects between the two positions (logic 0-V_{IL}< 0.8V logic 1-V_{IH}> 2.2V) of the valve. Typically we use the digital output ports on the MDrive controller that is used to control device B; B1 for sample probe 1, B2 for sample probe 2, etc.

Figure 18 shows the setup box for a sample probe connected to digital output B1 on a device that is coupled to COM 9.

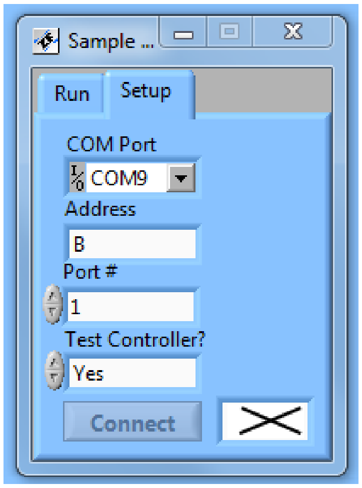

Figure 18: Digital output setup for sample probe

Each valve also required 5VDC power. Where multiple sample probes are connected, an extension box (Figure 17) that provides up to 4 pairs of 5VDC connection points is available.

USING THE SAMPLE PROBE

The sampling probe can be used in a number of different sampling applications. The following sections describe the basic Zone Fluidics (ZF) manifolds and associated fluid handling sequence. ZF manifolds (see Figure 19) typically comprise of a bi-directional positive displacement pump (P) such as Global FIA's milliGAT pump and one or more multi-position selection valves (SV-A and SV-B). These valves have a single common port that can be sequentially coupled to one of the surrounding ports. These surrounded ports are typically plumbed with narrow bore PFA tubing to reagent reservoirs or fluid handling unit operations (U). By appropriate port selection and pump action, fluids can be shunted around the manifold to achieve the desired sample transformations and manipulations. A holding coil (HC) is typically positioned between the pump and the primary selection valve (SV-A) so that fluids aspirated are not drawn into the pump; the pump typically is only exposed to the carrier solution (C). A pressure relief valve (PRV) immediately downstream of the pump ensures that in the event of a blockage or dead head, fluid pumped will be diverted to waste instead of entering the internals of the pump or valves. The devices are controlled using Global FIA's FloZF (ZF) device control and data acquisition software typically installed on a PC or laptop computer.

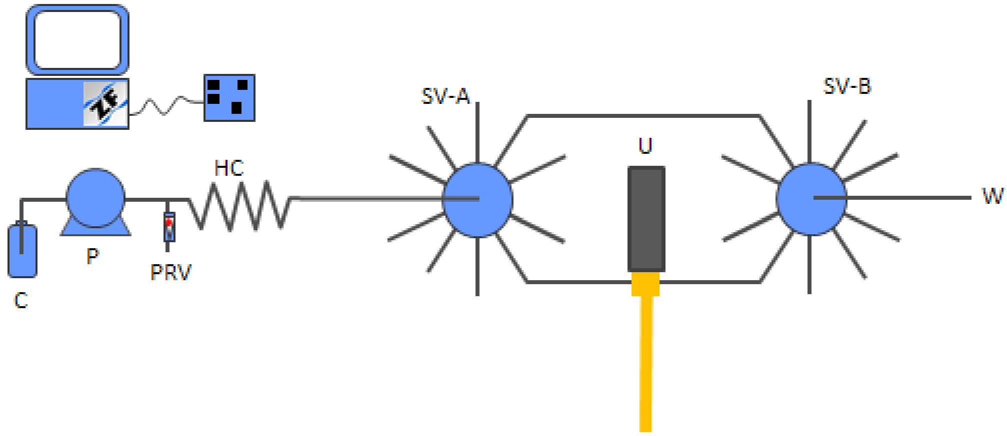

Figure 19: Zone Fluidics Manifold

SAMPLING WITH NO DILUTION

Figure 20 shows the Zone Fluidics flow manifold for sampling with no dilution. The sequence is the same as for dilution except that the diluent is replaced with air zones. The air zones bracket the sample and prevent mixing of the sample with the carrier.

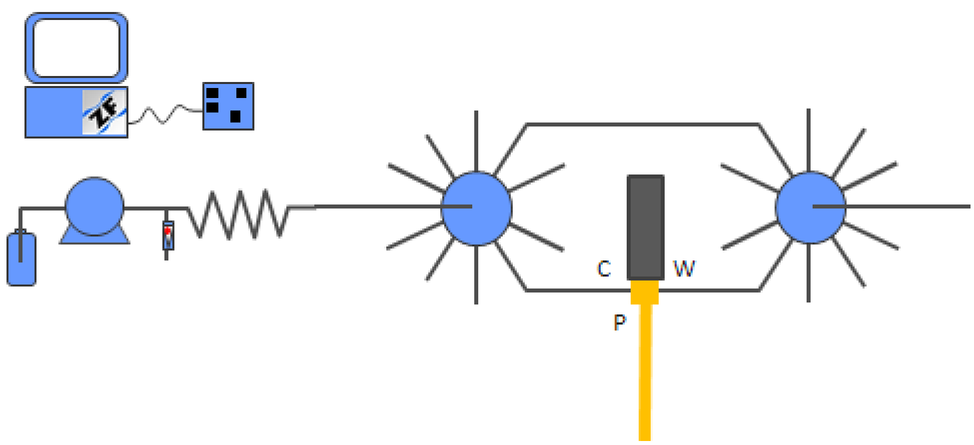

Figure 20: Flow manifold for Sampling with No Dilution

SAMPLING WITH DILUTION

Figure 21 shows the Zone Fluidics flow manifold for sampling with dilution. The sample probe has three ports; a common port (C) that is plumbed back to the primary selection valve (SV-A), a waste port that is plumbed to the secondary selection valve (SV-B) and the sample port that that is in fluid contact with the process to be sampled. The sequence to sample and dilute process solution involves the following steps:

1. A zone of diluent typically 100-200µL is aspirated into the holding coil (HC) and bracketed with two air bubbles to keep it from dispersing into the carrier solution.
2. This zone is then dispensed to the sample probe with the waste port selected so that the zone straddles the valve, i.e. half the diluent volume is upstream of the sample probe valve and half is downstream of the sample probe valve.
3. The sample probe valve is then switched so that the sample port is selected.
4. The diluent upstream of the valves is dispensed so that it reaches the tip of the sample probe to dispense old sample back into the process.
5. Fresh sample is aspirated being led by the diluent. Mutual dispersion and mixing of the sample zone and diluent zone begins immediately lowering the concentration of the sample elements.
6. When the desired volume of sample has passed through the sample probe valve, the sample probe valve is switched to waste so that the diluent parked downstream can be aspirated.
7. As the sample is now drawn back towards the holding coil, it is sandwiched between the two bubble bracketed diluent zones.
8. Dispersion and Taylor flow ensure thorough mixing of the sample with the diluent thus diluting the sample in close proximity to the sampling point.

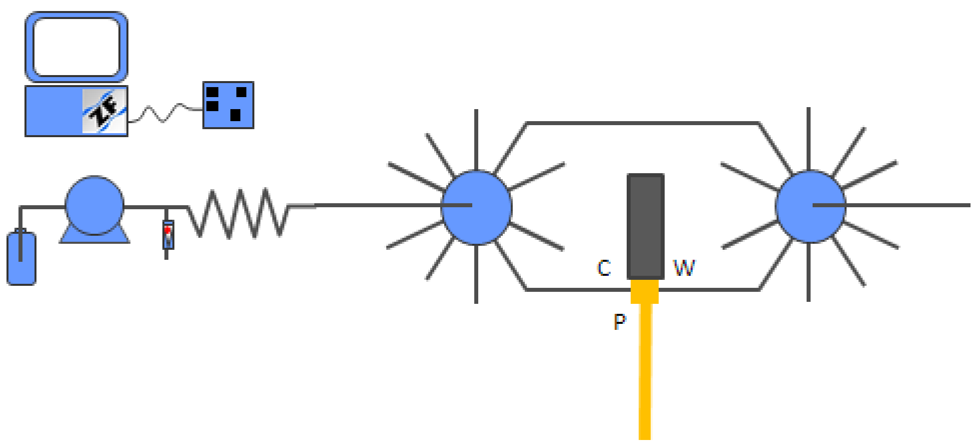

Figure 21: Flow manifold for Sampling with Dilution

SAMPLING WITH SOLVENT MODIFICATION

Figure 22 shows the Zone Fluidics flow manifold for sampling with solvent modification. The sequence is the same as for dilution except that the diluent is comprised of a different solvent to that employed in the process. As the sample mixes with this diluting solvent, the matrix of the sample is altered. In this way the pH, polarity, or solvent composition can be altered.

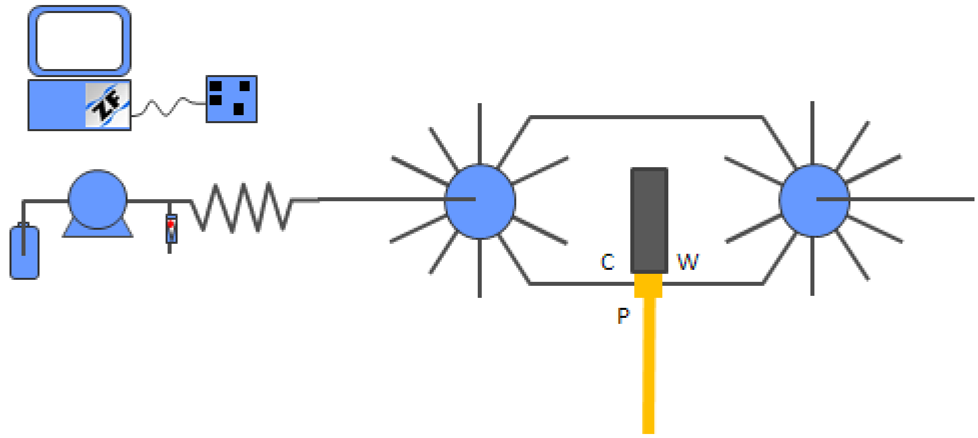

Figure 22: Flow manifold for Sampling with Solvent Modification

SAMPLING WITH FILTRATION

Figure 23 shows the Zone Fluidics flow manifold for sampling with filtration. If the sample must be filtered, then the sampling tip is changed to include one of the filters described above. The fluid sequence could be any of those described above. Depending on the solids loading in the process, it may be necessary to add filter washing steps and perhaps slow the rate at which the sample is aspirated.

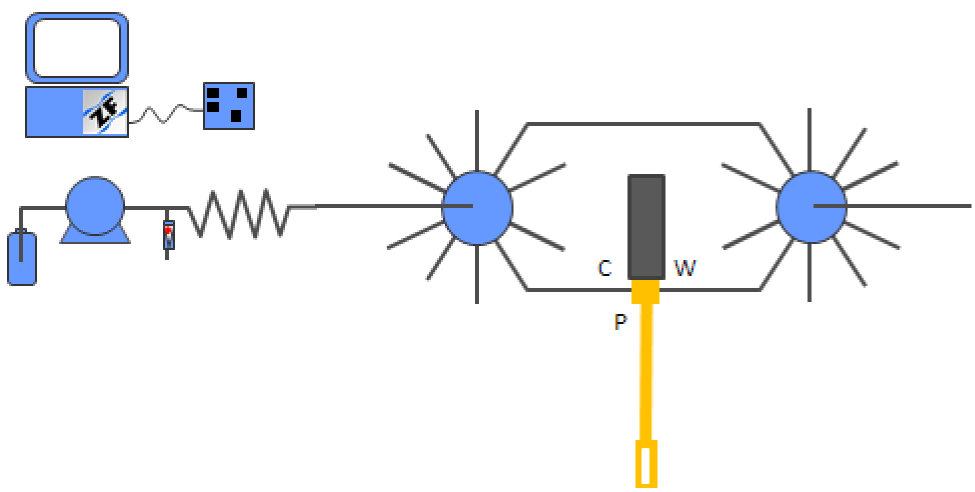

Figure 23: Flow manifold for Sampling with Filtration

SAMPLING WITH ANALYTE ENRICHMENT

Figure 24 shows the Zone Fluidics flow manifold for sampling with analyte enrichment. This manifold has not been tested but is presented as potential application of the sample probe. A small solid phase extraction column is placed immediately upstream of the sample probe. For this to work the sample must be in a form in the process that will allow strong binding to the solid phase extractant. The sequence to enrich the process solution involves the following steps:

1. A zone of eluent is aspirated into the holding coil (HC) and bracketed with two air bubbles to keep it from dispersing into the carrier solution.
2. This zone is then dispensed to the sample probe with the waste port selected so that the eluent zone is positioned downstream of the sample probe valve.
3. The sample probe valve is then switched so that the sample port is selected.
4. Fresh sample is aspirated and passes through the extraction column. The analyte is adsorbed onto the column.
5. When the desired volume of sample has been passed over the solid phase extraction column, the sample probe valve is switched to waste so that the parked eluent can be aspirated.
6. As the eluent passes over the column, the analyte is extracted and is drawn back towards the holding coil for further processing.

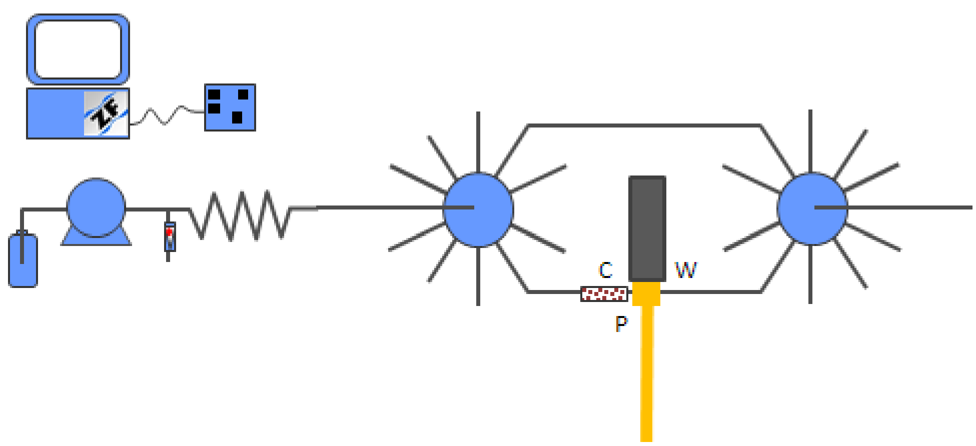

Figure 24: Flow manifold for Sampling with Analyte Enrichment

STERILE SAMPLING

Sterile sampling is accomplished by equipping the sample probe with a filter element with a pore size <0.45µm. The ZF manifold also presents opportunities for chemically sterilizing the manifold components. More test work is needed for this application of the sample probe.

SELF-CLEANING FILTER PROBE

Figure 25 shows the Zone Fluidics flow manifold using a self-cleaning filter probe. For this manifold, the second embodiment of the sample probe valve is used. This two-position valve has four ports. In one position, port **a** is connected to filter **1** and port **b** is connected to filter **2**. When the valve is switched, port **a** is connected to filter **2** and port **b** is connected to filter **1**. The probe is plumbed as indicated below with a second pump that withdraws sample from one filter probe and returns it to the other probe. A fraction of the circulating fluid is withdrawn from a de-bubbler for further analysis. The rest of the sample back flushes the downstream filter probe. When the valve is switched the probe that had been back flushed becomes the filtering probe and the filtering probe is back-flushed. By switching the valve periodically, the probes are kept clean.

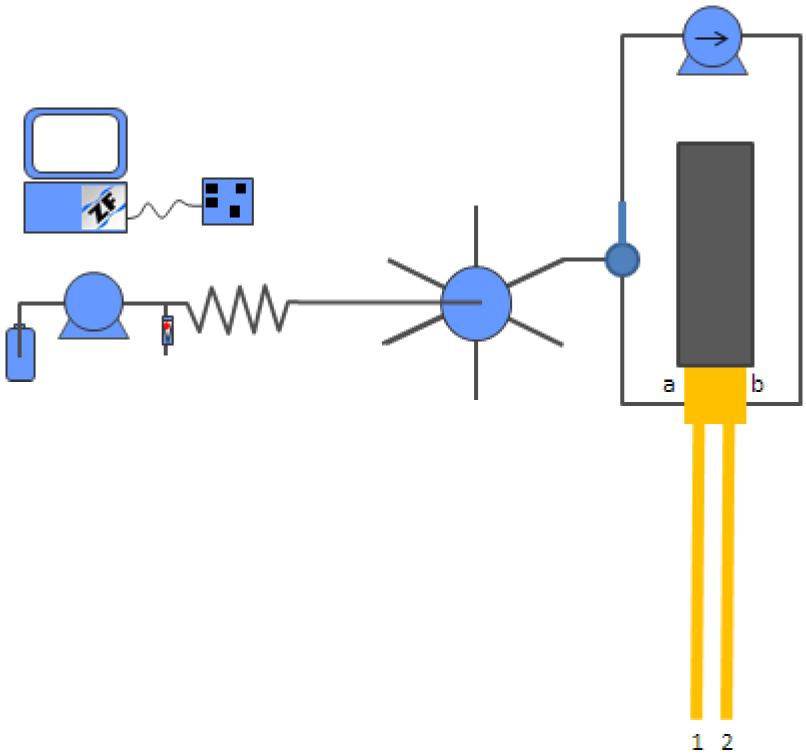

Figure 25: Flow manifold for Self Cleaning Filter Probe

PREVENTATIVE CARE

- When not in use, ensure that the sample probe has been thoroughly flushed with clean solvent or DI water. Displace all fluid from the sample probe and store dry with all ports blocked to prevent dust from getting into the valve and fouling it.
- When removing a filter probe tip from a process, back flush the filter by pushing an appropriate solvent or wash solution through the filter using a syringe equipped with a luer to ¼-28 male fitting as illustrated in Figure 26.

Figure 26: Back flushing a sample probe filter tip

- When not in use soak filter probe tips in an appropriate solvent or wash solution to dissolve solids which may have accumulated on the surface or in the pores of the filter.
- The motor and controller contain parts vulnerable to corrosion. An air purge or extraction of corrosive fumes will help to minimize corrosion of these parts.
- Do not pick up or handle the sample probe by the cable. If additional strain relief is required, use a cable tie to fasten the cable to the probe motor enclosure as shown in Figure 27.

Figure 27: Additional strain relief for the probe cable

- Wipe off solvent or process solution splashes.

MINIMIZING BLOCKAGES

Typically, fluid channels in the sample probe have an ID of 0.03”. If solution with high dissolved solids content is left in the sample probe, the solids will crystalize out and could block the narrow bore channels. It is therefore a good practice to flush the sample probe when it is not in use.

If a blockage occurs:

1. Determine whether the blockage is in the sampling tip, probe shaft or sample probe valve.
2. If it is in the sampling tip, replace the filter.
3. If it is in the probe shaft, use a syringe to attempt to dislodge the blockage. If it remains blocked, replace the probe shaft.
4. If it is in the valve and the valve has been disassembled, ensure that the valve has been properly assembled (refer to Figure 14). When the motor is in the digital output "0" or off state, the dimple on the drive shaft should be 180° from the orientation dot on the side of the valve and the channel on the back of the stator disk should be pointing away from the orientation dot on the side of the valve. The stator disk has the side with the three holes (no slot) orientated towards the rotor.
5. If it is in the valve, disconnect the fluid lines and use a syringe to push fluid through the valve. If this does not dislodge the blockage, open the valve and clean out the channels in the rotor and stator disk. Examine the ports to see if you can see where the blockage is. If this does not remove the blockage, replace the valve.

The channels in the valve are shown in the following cross section.

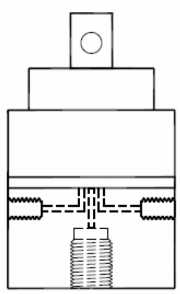

Figure 28: Valve cross section showing channel geometry

TROUBLESHOOTING

VALVE DOES NOT SWITCH

1. Ensure that the cable is correctly connected as indicated in Table 1.
2. Ensure that the cable is securely plugged into the back of the probe – tighten the connector lock collar.
3. Check that the digital output port that is being activated in FloZF is the one to which the control wire is connected. The first sample port is typically connected to port B1.
4. Using a digital voltmeter, check the 5VDC power line.
5. Using a digital voltmeter, check that the control digital output is switching when commanded to do so.
6. Ensure that the valve is properly seated and coupled to the valve motor.

7. Remove the valve from the motor and manually rotate the drive shaft to ensure that it has not jammed. Be sure to orientate the drive shaft as described in Figure 12 when re-coupling the valve to the motor.

BUBBLES EMERGE FROM THE SAMPLE PROBE

1. Tighten all fluid connections.
2. Replace the filter in the sampling tip.
3. Replace the rotor and stator disk.

VALVE PORTS APPEAR TO BE PARTIALLY BLOCKED

1. Re-align the valve on the valve motor making sure that the dimple on the side of the valve drive shaft is 180° to the orientation dot on the side of the valve (refer Figure 12).

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Engineers at Valco have also played a key role in turning our ideas into commercial products.

PART NUMBERS

Table 2 provides the part numbers for the various Sample Probe options and accessories.

Table 2: Sample Probe Part Numbers

Part Number	Description	UoM	Comment
SP	Complete sample probe with basic no-filter probe tip	Ea	
SP-3P	Sample probe three port valve	Ea	
SP-4P	Sample probe four port valve	Ea	
SP-VM-L	Sample probe valve motor	Ea	
M5-W-3	Sample probe power and control cable	Ea	
IO-8M	Phoenix (green) connectors for sample probe cable	Ea	
VR-3	Sample probe rotor for three port valve	Ea	
VS-3	Sample probe stator disk for three port valve	Ea	
VR-4	Sample probe rotor for four port valve	Ea	
VS-4	Sample probe stator disk for four port valve	Ea	
FPS-3/8-7	Sample probe shaft, 0.375"x 7", PPS	Ea	Custom-enquire
PT-NF	Probe tip no filter	Ea	Fig. 5 type A
ILF-75	Screen mesh, 75µm	10 pack	For fig. 5 type B
PT-F-20	Large volume filter holder with disposable filter	Ea	Fig. 5 type C
RF-20	Large volume disposable filters	5 pack	For fig. 5 type C
PT-F-2	Small volume filter holder with disposable filters	5 pack	Fig. 5 type D
PT-FB	Flat bottom filter	Ea	Fig. 5 type E
RF-30	Disposable filter for flat bottom filter, 30-60 µm	10 pack	For fig. 5 type E
RF-5	Disposable filter for flat bottom filter, 5-10 µm	10 pack	For fig. 5 type E
PT-STER	Sterile filter	Ea	Fig. 5 type F
PT-LUER	Disposable syringe filter holder	Ea	Fig. 5 type G
PT-FC	Flow-through cell (excludes valve)	Ea	Fig. 6