PROJECT REPORT

ASSEMBLY PROPOSAL DRAFT-I

COMPONENT ASSEMBLY OF LOW COST VENTILATION SYSTEM

REPORT BY:

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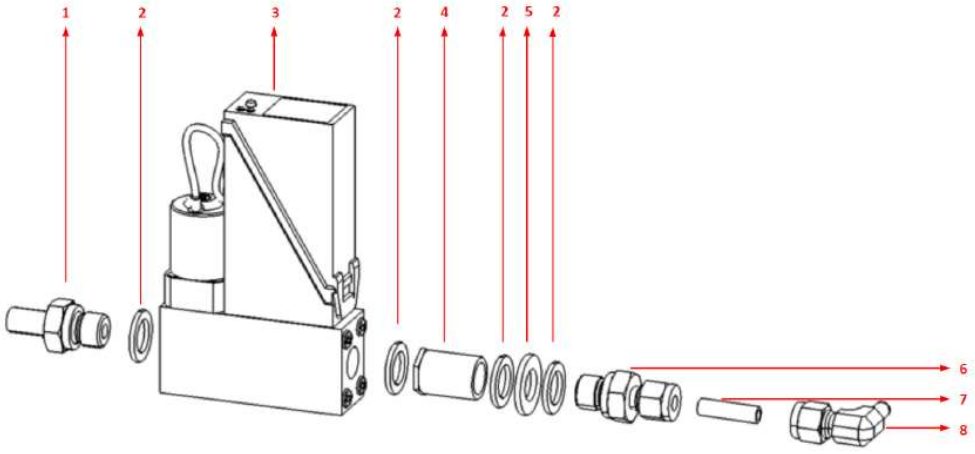
REPORT SUMMARY

The following design is an adaptation of the open source ventilator “OperationAir” developed by TU Delft. Upon further examination of the design published by the group, flaws in the design were discovered and solutions were integrated in the original schematic to ensure proper functionality. Since several project milestones have already been covered by the group, adapting their design and optimizing it would significantly reduce the project duration and allow the team to divert their attention towards the development of a better UI and hence make the device more robust. Software aspects shall be discussed further.

INTRODUCTION

For simplification, the assembly of the device may be broken up into smaller sub-sections as following:

- **SUB-ASSEMBLY #1 – MASS FLOW CONTROLLER – AIR**: The MFC assembly for air shall control the flow of compressed medical air into the device and then into the accumulator tank. The main component of the assembly is a Mass Flow controller. The specifications of the mass flow controller have been mentioned in the report titled "Schematic Diagram of Ventilator".

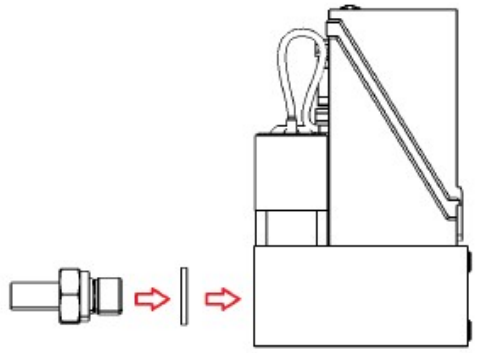


Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

Part	Supplier	Quantity
1: G1/4" to 3/8" tube fitting	Swagelok	1
2: Ring G 1/4" (rubber)	Swagelok	4
3: MFC (Air)	Bronkhorst	1
4: Pressure regulator (4 bar)	Kramp	1
5: Ring M12 (steel)		1
6: G1/4" to 1/4" tube fitting	Swagelok	1
7: Tube fitting 1/4"	Swagelok	.
8: Elbow 1/4"	Swagelok	1

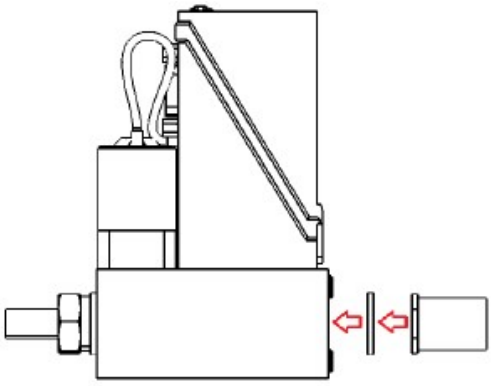
The direction of assembly are as follows:

- ✓ Check whether the MFC is labelled ‘Air’ on its side
- ✓ On the side that will be connected to the mixing chamber (where the flow arrow on the side of the MFC is pointing towards), a G1/4” to 3/8" metal tube fitting needs to be inserted.
- ✓ In between these parts, a 1/4" rubber ring needs to be inserted (see figure 1.1)
  - 1/4” rubber ring: SS-4-RS-2V.
  - G 1/4” to 3/8 metal en buis :- SS-6-TA-4-RS.



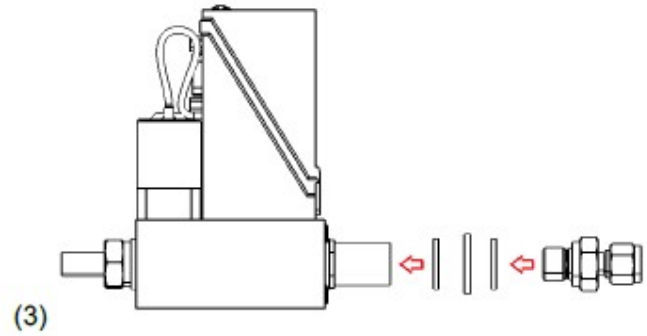
(1)

- ✓ On the other side of the MFC, a pressure regulator needs to be turned in. In reality, the pressure regulator has a male fitting, which is not in accordance with figure 1.2
- ✓ In between these parts, a 1/4" rubber ring needs to be inserted (see figure 1.2).
  - 1/4” rubber ring: SS-4-RS-2V.



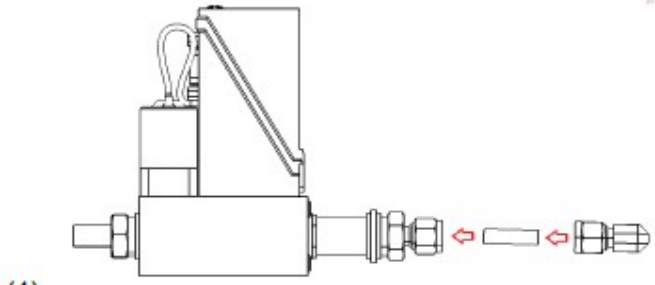
(2)

- ✓ In the pressure regulator, a G1/4” to 1/4” tube fitting needs to be inserted. This part needs to be closed off with multiple rings.
- ✓ This is done by inserting 2 rubber rings (1/4") and a metal ring (to separate the rubber rings). De metal ring should be inserted in between the two rubber rings (see figure 1.3).
  - 1/4” rubber ring: SS-4-RS-2V.
  - G 1/4" to 1/4: SS-400-1-4 RS



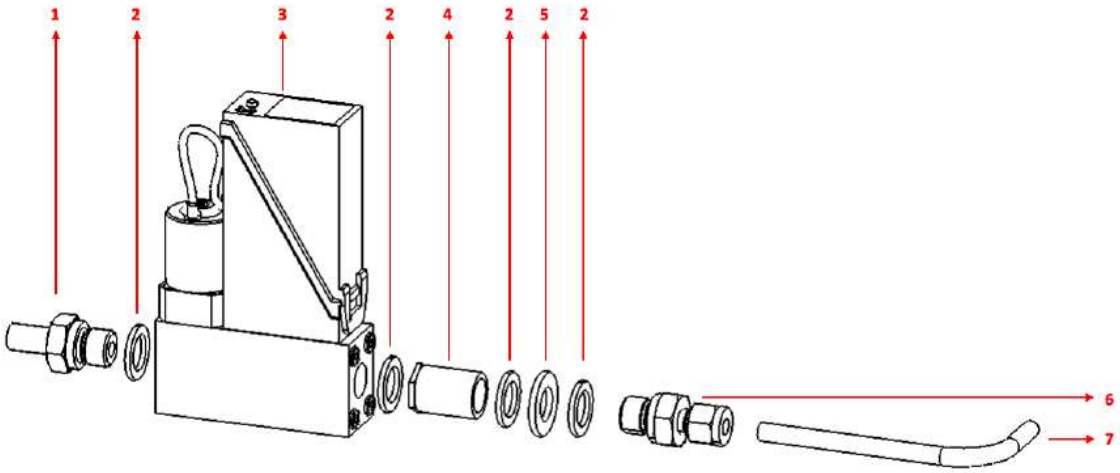
(3)

- ✓ A 1/4" tube fitting (length ± 4.8 cm) should be mounted to the connection shown instep 3. For this, the above mentioned connection can be used (see figure 1.4).
- ✓ On the other end of the tube fitting, an elbow 1/4" should be connected.
  - Elbow 1/4": SS-400-2R-4.



(4)

- **SUB-ASSEMBLY #2 – MASS FLOW CONTROLLER – OXYGEN**: The MFC assembly for oxygen shall control the flow of compressed medical oxygen into the device and then into the accumulator tank. The main component of the assembly is a Mass Flow controller. The specifications of the mass flow controller have been mentioned in the report titled "Schematic Diagram of Ventilator".

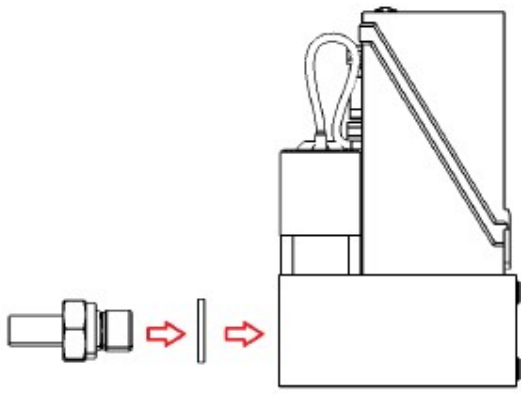


Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

Part	Supplier	Quantity
1: G1/4" to 3/8" tube fitting	Swagelok	1
2: G1/4" gasket (rubber)	Swagelok	4
3: MFC (O_2)	Bronkhorst	1
4: Pressure regulator (4 bar)	Kramp	1
5: Ring M12 (steel)	-	1
6: G 1/4" to 1/4" tube fitting	Swagelok	1
7: Tube 1/4"	Swagelok	n.a.

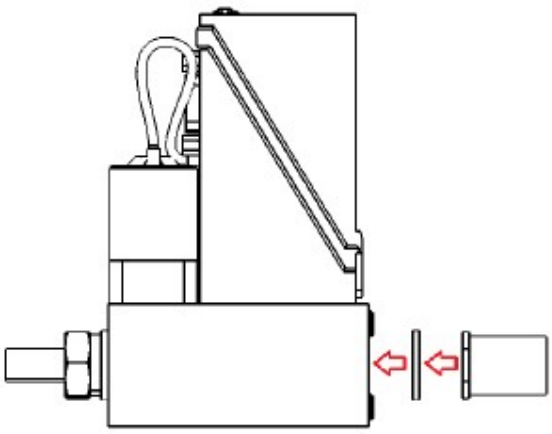
The direction of assembly are as follows:

- ✓ Check the label on the Mass Flow Controller (MFC) used for this assembly, it should have the label 'O2'
- ✓ A G1/4" to 3/8" tube fitting must be mounted to the side of the MFC going to the mixing chamber (the flow arrow points towards this side).
- ✓ Between the fitting and the MFC, a G1/4" gasket must be placed (figure 1)
  - G1/4" gasket: SS-4-RS-2V.
  - G1/4" to 3/8" tube fitting: SS-6-TA-4-RS.



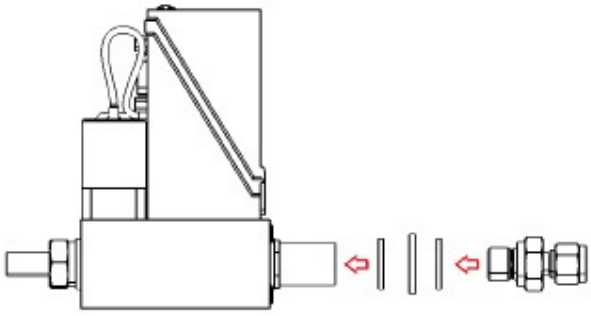
(1)

- ✓ A pressure regulator must be turned into the other side of the MFC. (The pressure regulator used has a male connector, which is not in accordance with the figure.)
- ✓ A G1/4" gasket must be placed between the pressure regulator and the MFC (see figure 2)
  - G1/4" gasket: SS-4-RS-2V.



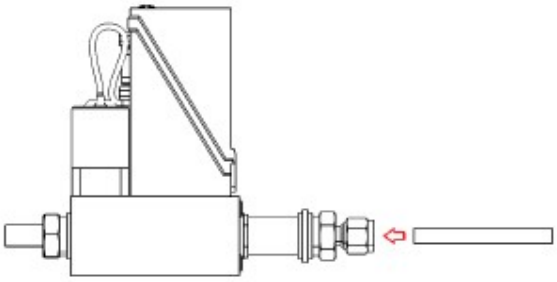
(2)

- ✓ A G1/4” to 1/4" tube fitting must be mounted into the other side of the pressure regulator.
- ✓ Two G1/4” gaskets and a M12 metal ring must be used for this connection. The metal ring must be placed in between the two gaskets (see figure 3).
  - G1/4” gasket: SS-4-RS-2V.
  - G 1/4" to 1/4" tube fitting: SS-400-1-4RS.



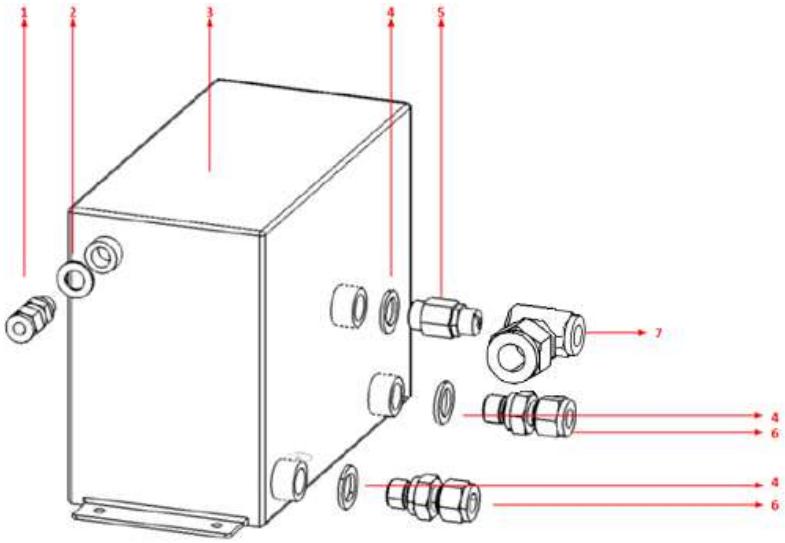
(3)

- ✓ A 1/4" tube of ±13.9 cm length must be connected to the fitting from step 3 (see figure 4).



(4)

- **<u>SUB-ASSEMBLY #3 –MIXING CHAMBER AND PRV</u>**: In this sub-assembly the mixing chamber with its connections will be described, thereby the pressure relief valve will be connected on this system. Please note: not all pressure relief valves are already calibrated to 1 bar! This has to be measured before the pressure relief valve is used and assembled. For the Swagelok components used every step, the product name is mentioned to ensure the right component is used.

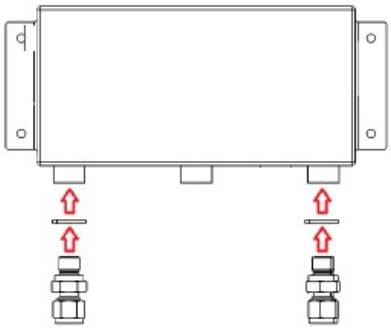


Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

part	supplier	quantity
1: 1/8" to 6 mm fitting	Swagelok	1
2: Ring 1/8" (rubber)	Swagelok	1
3: Tank	RPP	1
4: Ring 1/4" (rubber)	Swagelok	3
5: PRV (1 bar)	Landefeld	1
6: 1/4" to G 3/8" fitting	Swagelok	2
7: Gas Mixing T	Swagelok	3

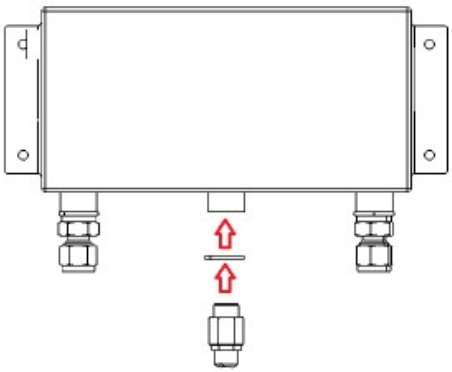
The direction of assembly are as follows:

- ✓ The mixing chamber contains 5 openings. 4of these are sized G ¼ ", the remaining one is sized G ⅛"
- ✓ On locations 1-3, a G ¼" to ⅜" fitting needs to be attached (Figure 1)
- ✓ Therefore, a rubber gasket needs to be placed between the connections (¼ ")
  - G 1/4" to 3/8": SS-600-1-4RS.
  - 1/4" rubber gasket: SS-4-RS-2V.

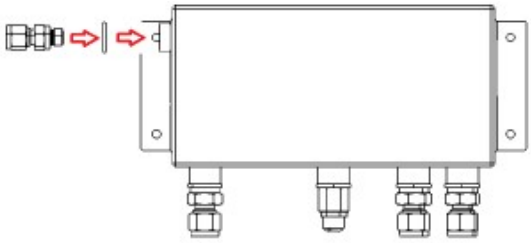


- ✓ In the opening at location 4 (Figure 2), a pressure relief valve (calibrated to 1 bar) needs to be attached.

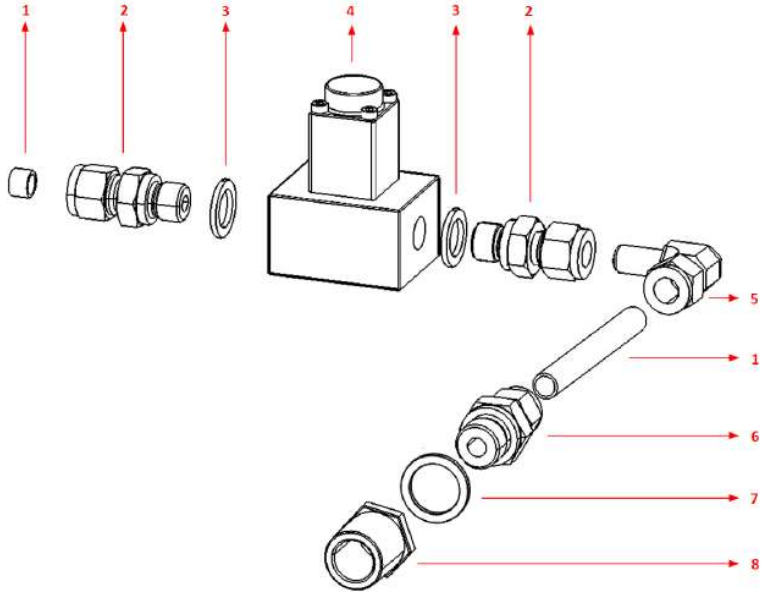
- ✓ The attachment to the bottom plate needs to be done at the end of the assembly line.
- ✓ Therefore, a rubber gasket needs to be placed between the connections (¼").
  - 1/4" rubber gasket: SS-4-RS-2V.



- ✓ At location 5, a G1/8" to 6mm fitting needs to be attached (Figure 3).
- ✓ Therefore, a rubber gasket needs to be placed between the connections (⅛").
  - G 1/8" to 6 mm: SS-6M0-1-2RS.
  - 1/8" rubber gasket: SS-2-RS-2V



- **<u>SUB-ASSEMBLY #4 –INPIRATORY TRACK</u>**: This subassembly describes the assembly of the mixing chamber and the inspiratory 3D-complex. This assembly together with subassembly 4B forms the inspiratory part. The Swagelok components that are used in every step are named explicitly to ensure correct component placement.

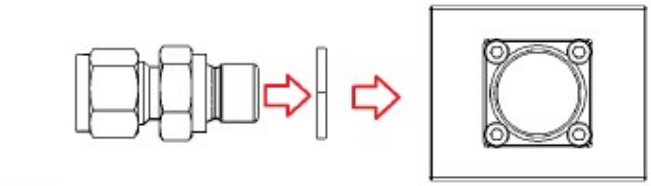


Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

Part	Supplier	Quantity
1: 3/8" tube	Swagelok	n/a
2: G1/4" to 3/8" tube fitting	Swagelok	2
3: G1/4" Gasket	Swagelok	2
4: Proportional Inhalation Valve	Pressure Control Solutions	1
5: Elbow 3/8"	Swagelok	1
6: G3/8" to 3/8" tube fitting	Swagelok	1
7: G3/8" Gasket	Swagelok	1
8: Connector G3/8" - 22 mm	Heemskerk	1

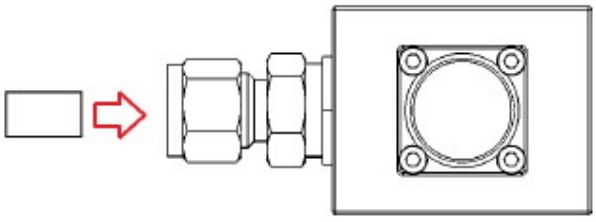
The direction of assembly are as follows:

- ✓ On the side of the proportional inhalation valve, which is connected to the mixing chamber (receiving flow side, also annotated on the valve), a G1/4" to 3/8"tube fitting should be placed (see figure 1)
- ✓ In between these parts, a rubber ring (G1/4" Gasket) should be place do G1/4" to 3/8": SS-600-1-4-RS.1
  - G1/4" Gasket: SS-4-RS-2V.



(1)

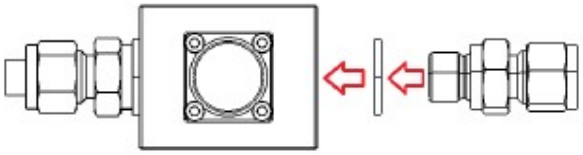
- ✓ Attach a 3/8" tube fitting (length ± 4 cm) to the tube fitting of step 1 (see figure 2).



(2)

- ✓ On the other side of the proportional inhalation valve, leading to the remainder of the inspiratory part, attach a G1/4" to 3/8" tube fitting (see figure 3).
- ✓ In between these parts, a rubber ring (G1/4" Gasket) should be place do G1/4" to 3/8" tube fitting: SS-600-1-4-RS.

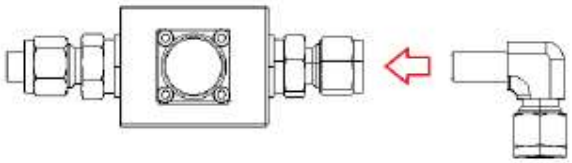
- G1/4" Gasket: SS-4-RS-2V.



(3)

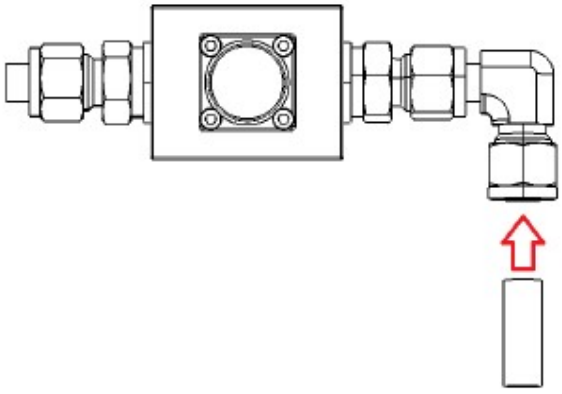
✓ An elbow 3/8” should be placed in between (see figure 4).

- Elbow 3/8”: SS-600-2R6.



(4)

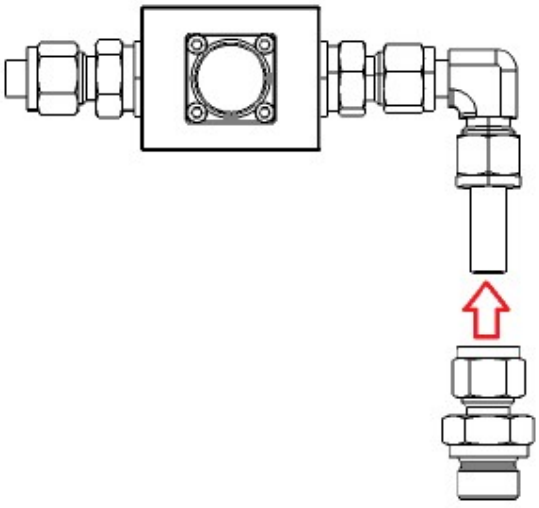
✓ Attach the 3/8” tube (length ± 12.4 cm) to the elbow described in step 4 (see figure 5).



(5)

✓ A G3/8” to 3/8” tube fitting should be attached to the tube described in step 5(see figure 6).

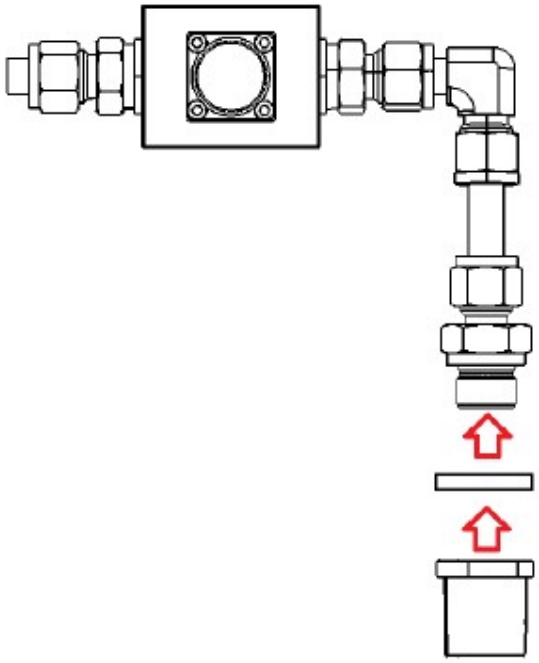
- G3/8” to 3/8: SS-600-1-6RS.



(6)

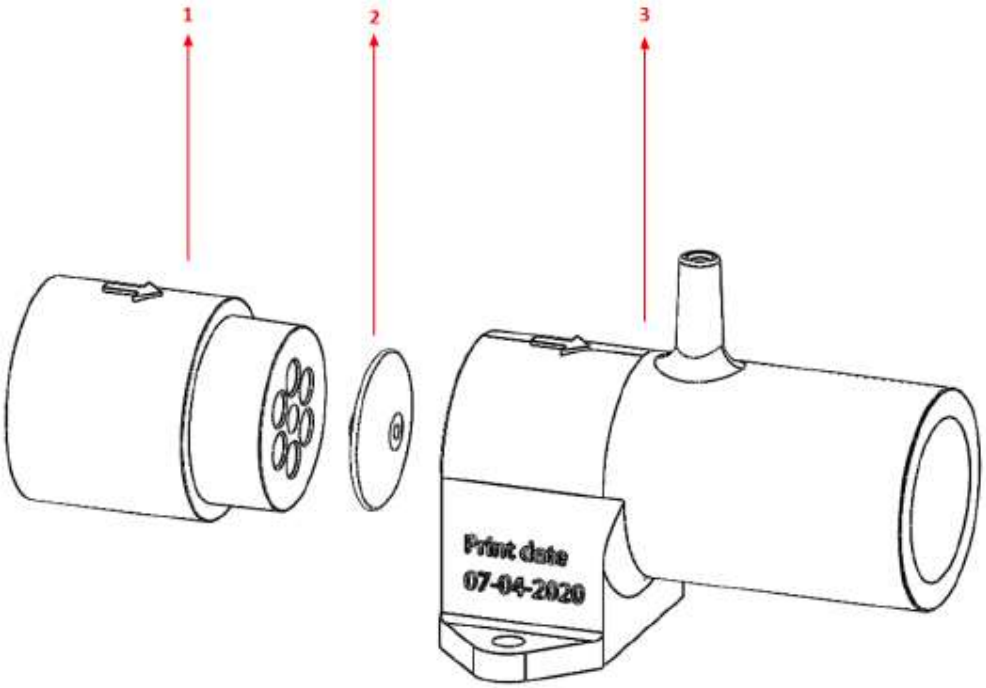
✓ A connector G3/8" - 22 mm should be attached to the tube fitting described in step 6. This is not a Swagelok part, but a custom made part (see figure 7).

✓ A rubber ring (G3/8” Gasket) should be placed in between.



(7)

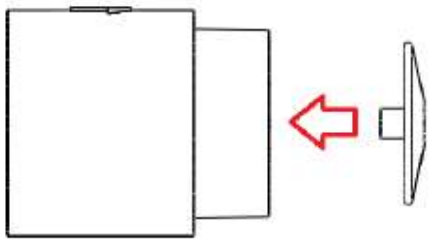
- **<u>SUB-ASSEMBLY #5 –INPIRATORY TRACK:</u>** This subassembly describes the assembly of the mixing chamber and the inspiratory 3D printed-complex. This assembly together with subassembly 4A forms the inspiratory part. The Swagelok components that are used in every step are named explicitly to ensure correct component placement.



Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

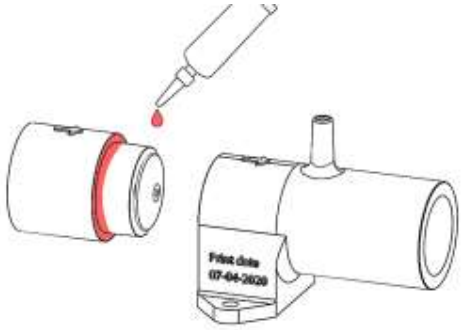
Part	Supplier	Quantity
1: SLS 3D print: Check valve mount	Shell	1
2: Umbrella valve	Minivalve	1
3: SLS 3D print: Patient IN	Shell	1

- ✓ The inspiratory 3D complex consists of two parts: Patient IN and check valve mount.
- ✓ The umbrella valve has a protruding part which should be attached to the smallest part of the 3D-complex (see figure 1).

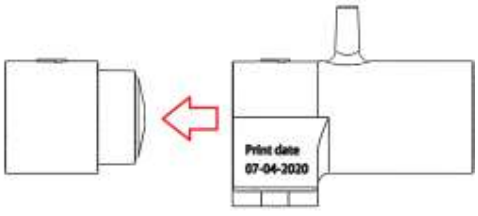


(1)

- ✓ The two parts should be connected manually. Dimensions of the parts play a decisive role in a good fitting of the parts (see figure 2.1).
- ✓ To ensure a good connection, the use of biocompatible glue is necessary (Loctite4601).
  - Apply a thin layer of glue as described in figure 2.2.



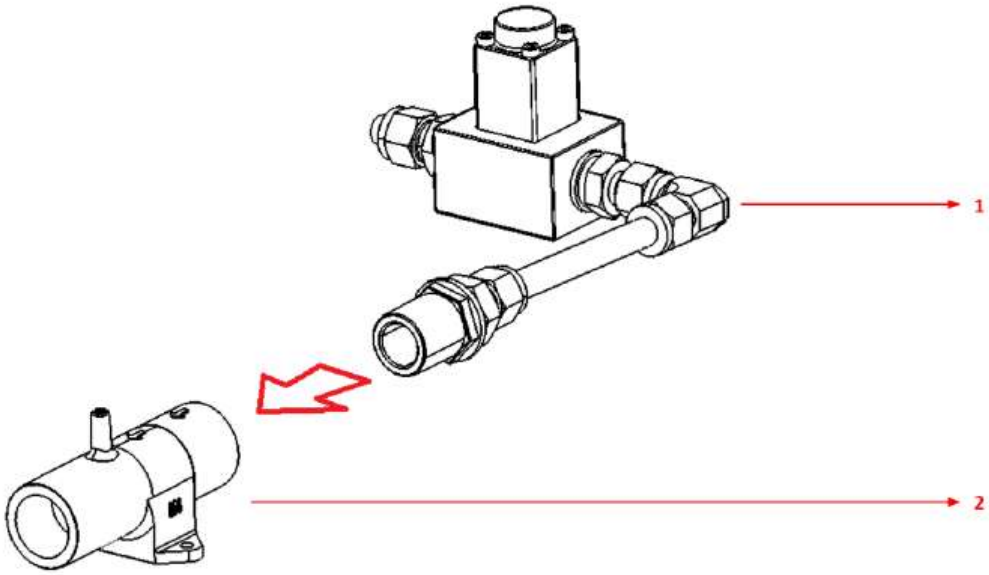
(2.1)



(2.2)

- ✓ On the protruding parts of the inspiratory 3D complex, a tube (6 mm) should be attached. This can be difficult bus has to be done with care.

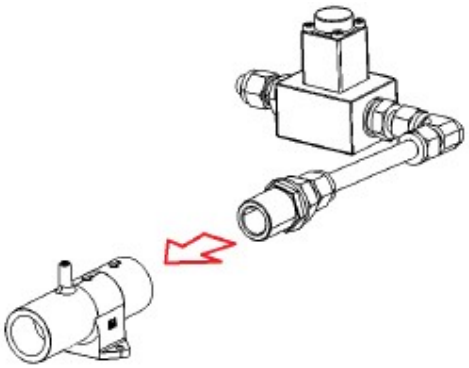
- **<u>SUB-ASSEMBLY #6 –INPIRATORY TRACK</u>**: This subassembly describes the assembly of the mixing chamber and the inspiratory 3D printed-complex. This assembly together with subassembly 4A forms the inspiratory part. The Swagelok components that are used in every step are named explicitly to ensure correct component placement.



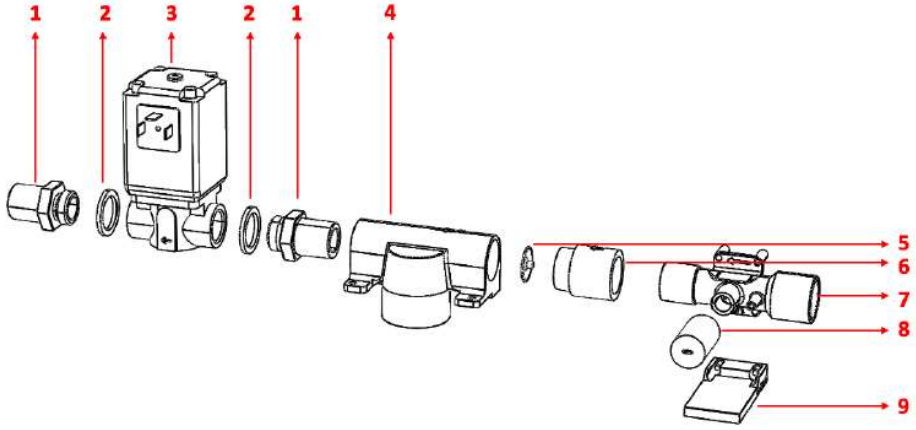
Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

Part	Supplier	Quantity
1: Result subassembly 4A	-	1
2: Result subassembly 4B	-	1

✓ The result of subassembly 4A should be attached to the result subassembly 4B. As a whole, this assembly forms the inspiratory tract (see figure 1).



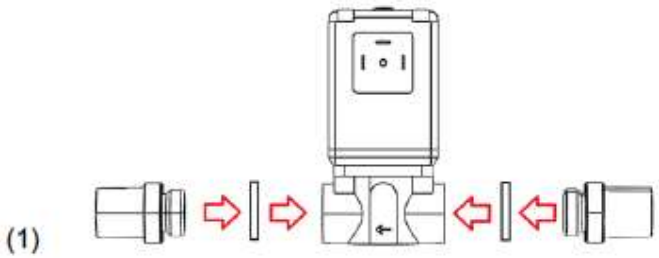
- **<u>SUB-ASSEMBLY #7 –EXPIRATORY TRACK</u>**: This sub-assembly describes the montage between the tube mounting and the discharge of air to the ambient air. Caution: not all pressure relief valves are set at 80 mbar. Before adding the valve to the assembly, the settings should be checked and, if necessary, corrected. The product name of each Swagelok component will be mentioned per montage step to ensure the correct components are used. As mentioned previously, the flow sensor should be turned 90°. This quarter turn has not been included in all the images of the sub-assemblies.



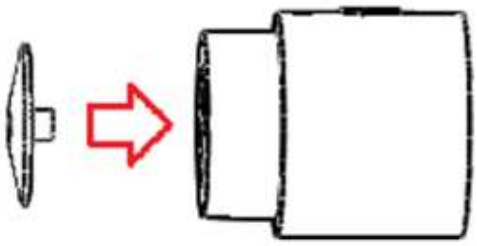
Though the supplier in the case of LCV shall be different, the following manufacturers may be used as a benchmark for specifications of the parts hence making it easier to purchase the components from local supplier.

Part	Supplier	Quantity
1: Connector G 1/2" - 22M	Heemskerk	2
2: G1/2" gasket	Swagelok	2
3: Solenoid control valve	Bürkert	1
4: 3D-print Patient OUT	Shell	1
5: Umbrella valve	Minivalve	1
6: 3D-print Check valve mount	Shell	1
7: 3D-print Flow sensor holder	Shell	1
8: 3D-print Flow sensor protection	MTB3D	1
9: 3D-print Flow sensor basket	MTB3D	1

- ✓ The solenoid control valve has an entrance and exit size of G1/2". Connectors fromG1/2" to 22mm should be placed on both sides. These connectors are produced by Heemskerk (See figure 1).
- ✓ In between the connectors, a G1/2" gasket rubber should be placed.
  - G1/2" gasket: SS-8-RS-2V.

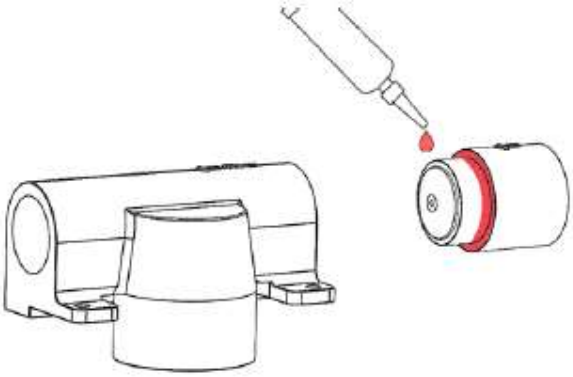


- ✓ Before connecting the other pieces, a 3Dcomplex of the umbrella valve, the 3D print Check valve mount and 3D print Patient OUT is composed.
- ✓ First place the umbrella valve on the small circular shaft (see figure 2.1).



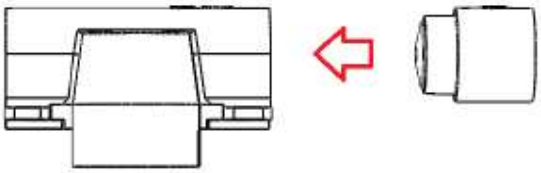
(2.1)

- ✓ The 3D print Patient OUT and the 3D print Check valve mount should be connected. For ensuring proper connection, use of biocompatible glue is mandatory (Loctite4601).
  - Cover the highlighted parts with a thin glue layer (see figure 2.2)



(2.2)

- ✓ Then, connect the two compartments. (See Figure 2.3).



(2.3)