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Fumigation Chambers (28.32 L) and Manifold System for Laboratory-Scale, Multi-Chamber Experiments

by

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Introduction

Historically, the primary reference work for basic principles of fumigation for insect control are found in two books by the same title: “Manual of Fumigation for Insect Control” by H.A.U. Monro, FAO Agric. Studies No. 79, 1969 and the second by E.J. Bond, F.A.O. Plant Production and Protection Paper No. 54 published in 1984. The modern compilation of fumigation procedures, facilities, chamber certification, and treatment schedules is found in the loose leaf or online edition of the Treatment Manual published by A.P.H.I.S. of the U.S.D.A. (see References below).

In general, to conduct a basic fumigation treatment safely, one needs a gas-tight chamber, a safe method to handle and introduce the fumigant into the chamber at the proper dose, a circulation fan or piping system to assure even distribution of the fumigant inside the chamber and throughout the load, and an exhaust fan and piping system to flush the chamber with fresh air at the end of the exposure period and for the safe removal and dilution of the fumigant or a method to recapture the fumigant.

This paper describes the components and details of construction for a small fumigation chamber and manifold system has been used at our research facility since ca. 1975. Although improvements have been incorporated as better materials or components have become available, the basic and original design of the system has remained essentially unchanged. The system is adaptable for use with one to many fumigation chambers.

The chamber is a modification of the 1 cu. ft. (28.32 L) Labconco® vacuum desiccator cabinet (Figure 1; Part # 5530000). The manifold will be highly variable in actual design or dimensions depending upon conditions and configuration of the structure available for housing the system. The manifold described here supports twelve 28.32 L fiberglass chambers (Figure 2) or three 242 L steel chambers (not shown). The entire system is housed inside a stainless steel (SS) controlled atmosphere room with temperature and humidity controls (600 ft³; 17 m³; not shown). The fumigation room is sheltered and shaded beneath an open-sided building.

Description of the Fumigation Chamber

The chamber is a modified fiberglass vacuum desiccator cabinet (Labconco® # 5530000; Figure 1). A diagrammatic representation of the modified version is shown in Figure 3. The chamber comes equipped with a 3-way vacuum release valve, a side-hinged door, a stainless steel (SS) pan, and two removable aluminum shelves each with twelve 7/8" (22 mm) holes. Modifications to the chamber serve to allow connection to the manifold, introduction and sampling of the fumigant, air circulation inside the chamber, installation of a vacuum gauge, and the addition of an air inlet port for use during the aeration period following the exposure period of the treatment schedule. This port may also be modified to allow for the use of a needle syringe to inject the fumigant dosage.

Construction of the Fumigation Chamber

Refer to Figure 4 and Table 1 for part and tool numbers (P# and T#) and for clarification of description or application.

Circulation Fan/Shelf Assembly (T1, 2, 3, 4; P5, 6, 7, 8, 9, 10)

Using the Greenlee® hole punch (T1), screw the 2 1/2" punch through the front-right corner hole of the shelf (P5) and tighten the punch to make a 2 1/2" hole. Align the fan (P7) in the center of the hole marking the four corners. Drill a 1/8" hole through the shelf at each corner of the fan and mount the fan to the shelf using a 1/8" pop rivet and washer (T2) through each hole. Be sure the fan is mounted so that air flow is upward from the bottom of the chamber.

The electrical feed-through (P8) consists of a bulkhead fitting with two Teflon® ferrules and two wires (black and red) passing through two holes drilled in each ferrule. First, drill a 3/8" hole at the back-bottom-right corner of the chamber and then tap the hole using a 7/16-20 NF tap (T3). Screw the male end of the bulkhead fitting into the hole. Leave about 12" of wire inside the chamber. Apply a bead of gasket compound (T4) to the chamber wall ringing the base of the fitting both inside and outside the chamber and tighten the bulkhead fitting. Slide the bulkhead nuts over the wire and ferrules and tighten.

Strip the insulation from the wires from both the fan and the electrical feed through. Attach the electrical connector (P6) and join the male and female ends of the connector. Slide the shelf with the fan into one of the molded-in shelf support slots.

On the outside of the chamber, connect the wires from the feed through to a two-conductor extension cord (P9; not shown) and secure connections with wire nuts (not shown). The power cord(s) are plugged into a surge-protected power strip (P10; not shown).

Gas Introduction/Exhaust Assembly (P2, 3, 4, 11, 12)

The three-way valve and one hose connect (P4) is included with the vacuum desiccator (P1). First, remove the valve (P2) and install a second P4 to the other end of the valve. Apply a bead of gasket compound (T4) on the chamber wall ringing the base of the fitting both inside and outside the chamber. Remount the valve to the chamber and tighten so that the valve is parallel with the chamber and hose connects (P4) face front and rear.

The exhaust end of the unit is simply a connection using a piece of Tygon® tubing (P12) cut to an appropriate length and connected from the rear-facing connector (P4) to the exhaust manifold (Figure 1).

The gas introduction and sampling port consists of two lengths of Tygon® tubing (P12) cut to about 2” and 12” and a glass stopcock (P11). Connect tubing to both ends of the stopcock and then connect the longer tubing to the frontward hose connect.

Vacuum Gauge (P13)

Drill a 7/16” hole through the chamber at the top-front-right corner and then tap the hole with a 1/4 – 18 NPT tap (T5). Place a bead of gasket sealant (T4) ringing the hole on top of the chamber and mount the vacuum gauge into the hole and align it to be facing forward.

Air Inlet Valve or Needle Injection Port Assembly (P14, 15a, or 15b, respectively)

First, the air inlet valve assembly consists of a bulkhead fitting (P14) with a spring-loaded needle valve (P15a) attached. Drill a 3/8” hole through the chamber at the top-front-left corner and then tap the hole with a 7/16 – 20 NF tap (T3). Apply a bead of gasket sealant (T4) ringing the hole both inside and outside the chamber and mount and tighten the bulkhead fitting in place. Connect the valve (P15a) to the bulkhead fitting.

Modification of this assembly is necessary if using a needle syringe to dose the chamber. Remove valve P15a. Replace it with a 3/8” blue rubber septum (P15b) held in place with a 1/4” Swagelok® nut. It may be possible to make a needle injection directly through the valve and avoid this modification.

Sealing Leaks

Use a high vacuum grease (T6) to seal the stopcocks and door gaskets.

Manifold, Exhaust Fan, and Vacuum Pump:

Actual dimensions and configuration of the manifold system will be highly variable depending on the dimensions of the room of residence. Our manifold is shown in Figure 2. It is constructed almost entirely from Schedule 40 PVC plastic pipe. The manifold from the chambers and across the rear wall is 3/4” PVC. A ball valve has been inserted along the rear wall into each of the four manifold lines to allow any or all lines to be open or closed. The pipe transitions from 3/4” to 1” PVC on the rear wall at the vertical riser to the 3-way valve. Beyond this point it increases to 1 1/2” PVC vertically through the roof to the exhaust fan. Thick-walled, wire-reinforced, vacuum hose (1 1/2” ID) runs vertically from the 3-way valve through the roof to the vacuum pump. All PVC slip-joints are joined by first applying blue primer followed by PVC glue. Any threaded joints are covered with Teflon® tape before being connected.

The aeration/exhaust fan (Gast Mfg. Co., Regenair®, Model 4110-2) and the vacuum pump (Edwards Mfg. Co., Model XDS-10) are mounted on the roof of the temperature controlled treatment room. Ventilation pipe (1 1/2” Schedule 40 PVC) from both pumps goes through a T-connector to a single vent pipe that passes through the roof of the building and extends to a height no less than 10 feet above the level of the roof. The vent pipe ends with a 90° street elbow fitting turned opposite from the direction of the prevailing winds for the area.

References:

Bond, E.J. "Manual of Fumigation for Insect Control", F.A.O. Plant Production and Protection Paper No. 54, 1984.

Monro, H.A.U. "Manual of Fumigation for Insect Control", F.A.O. Agric. Studies No. 79, 1969.

U.S.D.A., A.P.H.I.S., "Treatment Manual", website:

http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

CAUTION: Fumigants by nature are toxic gases and must be handled with extreme caution. Avoid inhalation and exposure to skin, eyes, and mucous membranes. Fumigants should be handled by authorized personnel only who are trained and qualified to work with this class of chemicals safely under strict guidelines, designed to eliminate any possible exposure.

Figure 1. Labconco® Vacuum Desiccator # 5530000



Figure 2. Manifold system for 28.32 L fumigation chambers. The system is located in a 600 cu. ft. stainless steel controlled-atmosphere room (temperature/humidity).

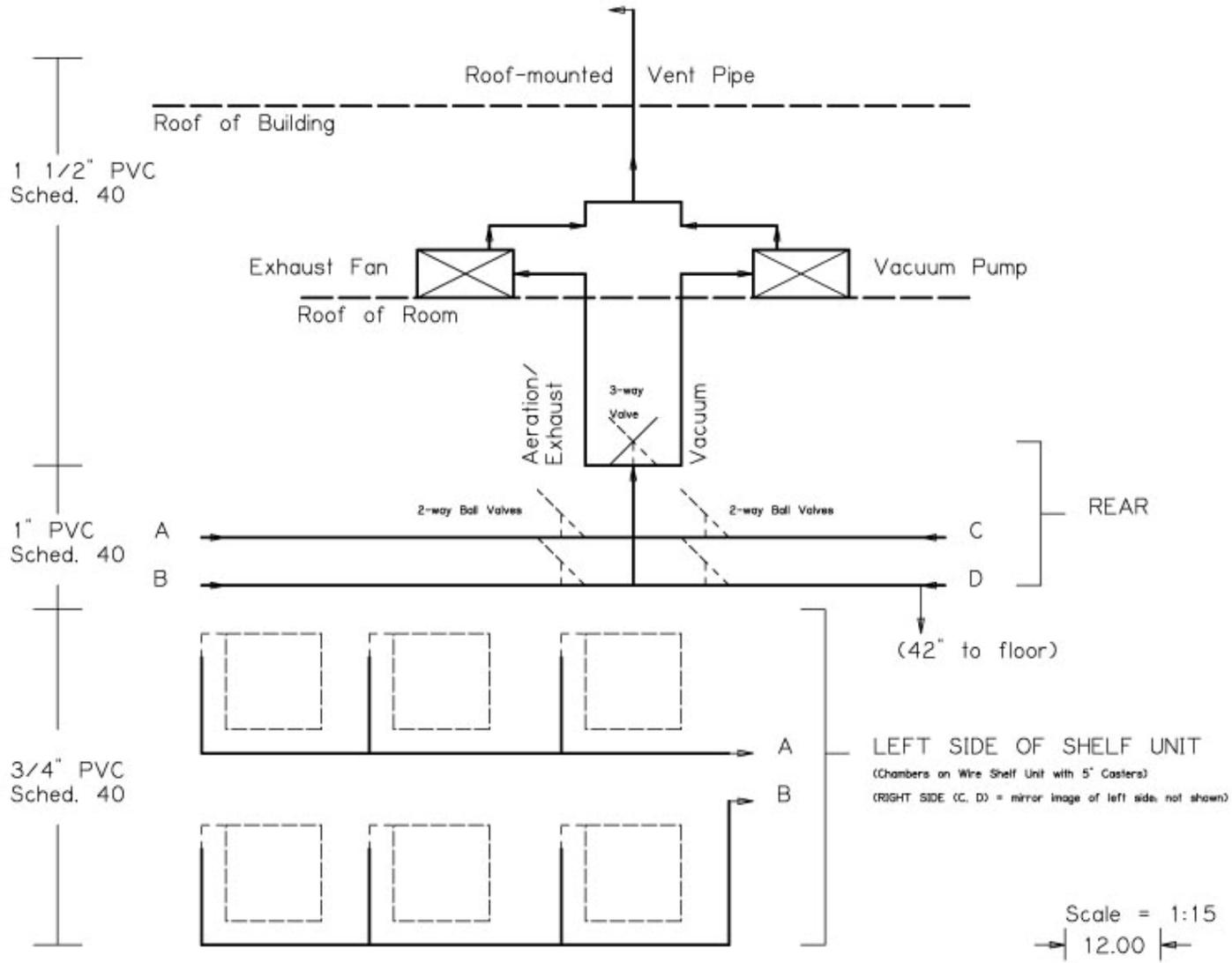


Figure 3. Diagrammatic representation of the 28.32 L fumigation chamber.

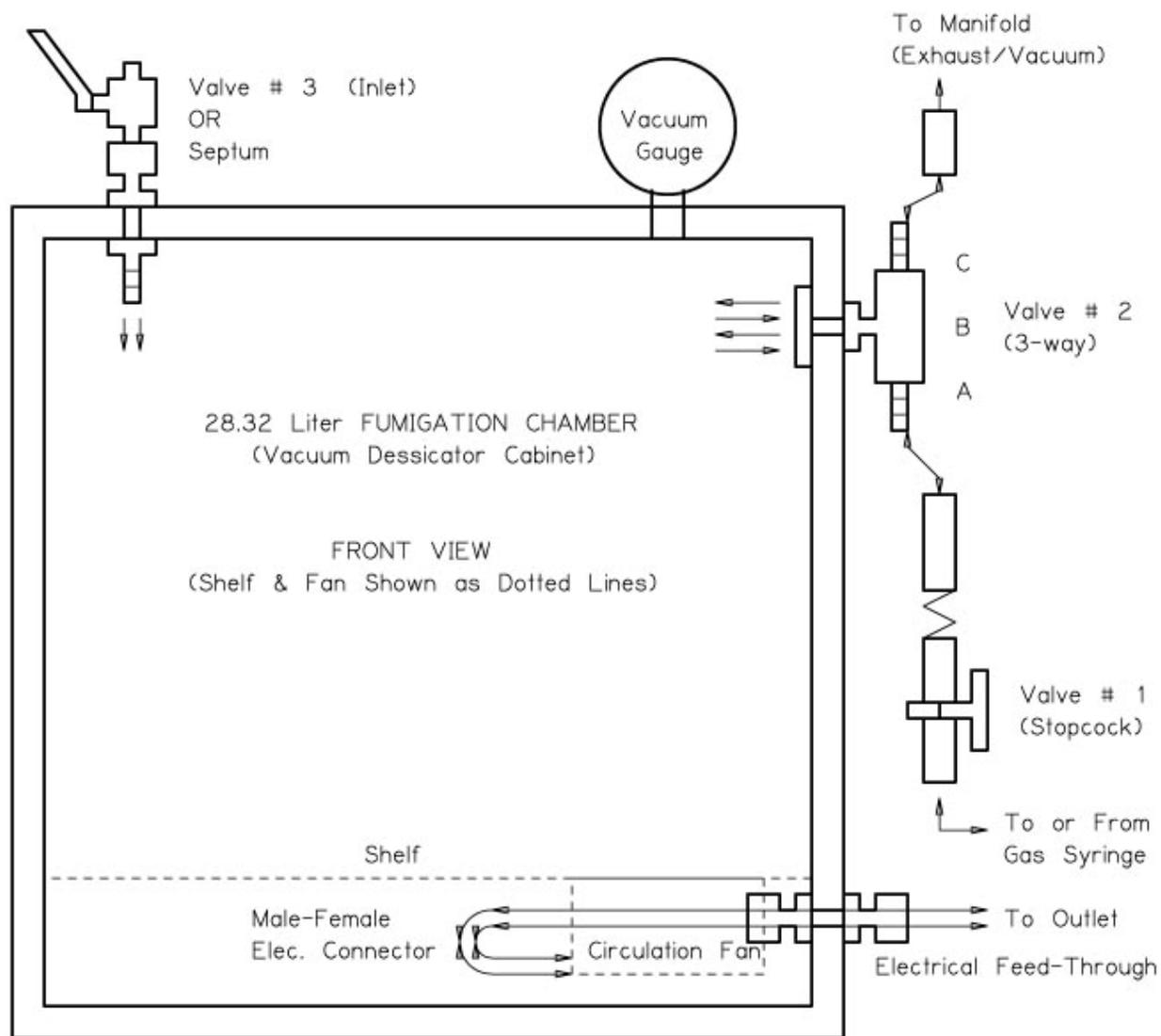


Figure 4. Illustration showing part numbers as described in text and as listed in Table 1.

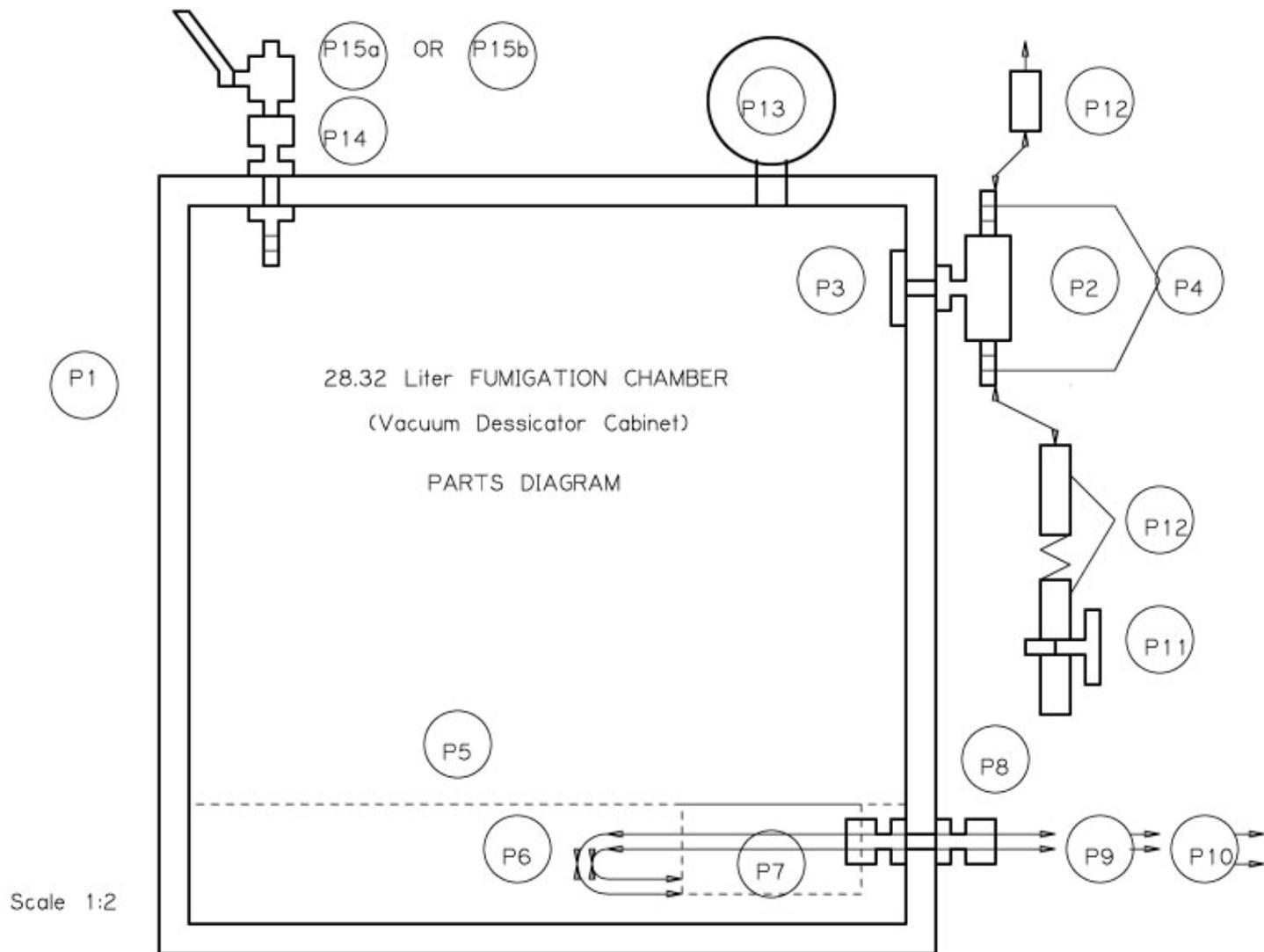


Table 1. Description of parts (P) and tools (T). Refer to Figure 4 and text.

Chamber	Part Code	Part Description	Part Number	Manufacturer
Tools	T1	Metal Hole Punch	2 ½” conduit 500-4177	Greenlee®
	T2	Pop Rivet Tool w/ 1/8” drill bit	1/8” rivets; 1/8” x 3/8” washers	Misc.
	T3	Drill and tap	3/8” drill; 7/16 – 20 NF tap	Misc.
	T4	Gasket compound/sealant	High Temp Red RTV Silicone Gasket Maker #81160-26BR	Permatex®
	T5	Drill and tap	7/16” drill; ¼ - 18 NPT tap	Misc.
	T6	High vacuum grease	N/A	Dow Corning®
Parts	P1	Chamber, Vacuum Desiccator Cabinet	5530000; 28.3 L	Labconco®
	P2 ¹	3-way Valve	B-42XF2-K	Swagelok®
	P3 ¹	Multi-hole inlet (a) w/ ring gasket (b)	5532400 (a) 1641900 (b)	Labconco®
	P4 ²	¼” hose connect	B-4-HC-1-2	Swagelok®
	P5	Shelf (included with P1)	Incl. with P1	Labconco®
	P6	Male-female electrical connector	Sta-Kon # LD2	Thomas Betts®
	P7	Air Circulating Fan; 30 CFM @ 0 SP	4WT40	Dayton®
	P8	Bulkhead fitting (a) w/ ¼” Teflon ® ferrules (b)	SS-400-61 or SS-400-61BT (a) CR2144XX (b)	Swagelok®
	P9	Electrical wire; # 18 gauge	Misc.	Misc.
	P10	Electrical extension cord	Misc.	Misc.
	P11	Stopcock; ¼” stems cut to 1 ¼” L	7280	Pyrex®
	P12	Clear Tubing; ¼” ID; 5/8” OD	R-3603	Tygon®
	P13	Gauge, Vacuum; ¼” NPT	5WH53	Ashcroft®
	P14	Bulkhead fitting	SS-400-R1-4	Swagelok®
	P15a	Toggle Valve; ¼” tubing	B- or SS-1GS4	Swagelok®
P15b	3/8” blue septa #6514 for needle injections; placed into P14	Misc.	Misc.	

¹ Included with Labconco desiccator cabinet #5530000

² One included with Labconco desiccator cabinet #553000; second purchased separately