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# Procedure for Building the Coaxial Needle Atomizing System

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At the time this work was performed, the U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC; Aberdeen Proving Ground, MD) was known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

Note: U.S. Patent no. 9,016,671 for the coaxial needle atomizing system was granted to David McCaskey (DEVCOM CBC) on 28 April 2015.

**14. ABSTRACT**

Inhalation research requires the generation of a steady and reproducible concentration of particles in a respirable range. When aerosols with highly toxic, precious fluids are generated, it is essential that a minimal amount of material be used to ensure safety and cost effectiveness. For this reason, a coaxial needle atomizing system was developed, and its construction is described herein.

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## PREFACE

The work described in this report was authorized under project no. CB10704. The work was started in December 2001 and completed in April 2015. At the time this work was performed, the U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC; Aberdeen Proving Ground, MD) was known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

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# PROCEDURE FOR BUILDING THE COAXIAL NEEDLE ATOMIZING SYSTEM

## 1. INTRODUCTION

Inhalation research requires the generation of a steady and reproducible concentration of particles in a respirable range. When aerosols with highly toxic, precious fluids are generated, a minimal amount of material is used to ensure safety and cost effectiveness. For this reason, we developed a coaxial needle atomizing (CNA) system.* Its construction process is described in this report.

The CNA system is built with precision. The work area must be wiped free of any dust or debris. Most CNA system parts are commercially available; however, one part is manufactured, and several commercially available parts are altered. To ensure the CNA system is assembled and operated properly, some parts are assembled in a specific sequence.

## 2. MATERIALS

The syringe adapter is the most important part of the CNA system. A diagram of the system is shown in Figure 1.

The following components were used to manufacture the syringe adapter:

1. 32 gauge (G) stainless steel (SS) hypodermic stock;
2. 1/16 in. outer diameter (OD), 0.01 in. inner diameter (ID) polytetrafluoroethylene (PTFE) tubing (Alltech Associates; Deerfield, IL);
3. SS chromatograph union (Swagelok Company; Solon, OH; no. SS-1F0-6GC);
4. SS chromatograph tee (Swagelok no. SS-1F0-3GC);
5. 1/16 in. SS ferrule sets (Swagelok no. SS-100-SET);
6. 1/16 in. OD, ≥0.03 in. ID SS tubing;
7. 1/4 in. stem by 1/16 in. SS reducer (Swagelok no. SS-100-R-4);
8. SS Male Luer lock to 10-32 adapter (Popper and Sons; New Hyde Park, NY; no. 6523);
9. 22 G Luer lock blunt tip non-disposable needle (3 in. is preferred to extend into sight glass when used);
10. 1/2 in. OD, 3/8 in. ID PTFE tubing; and
11. 1/2 in. SS bored-through union (Swagelok no. SS-810-6 BT).

* McCaskey, David A. Coaxial Needle Atomizing System. U.S. Patent 9,016,671 B1, 28 April 2015.

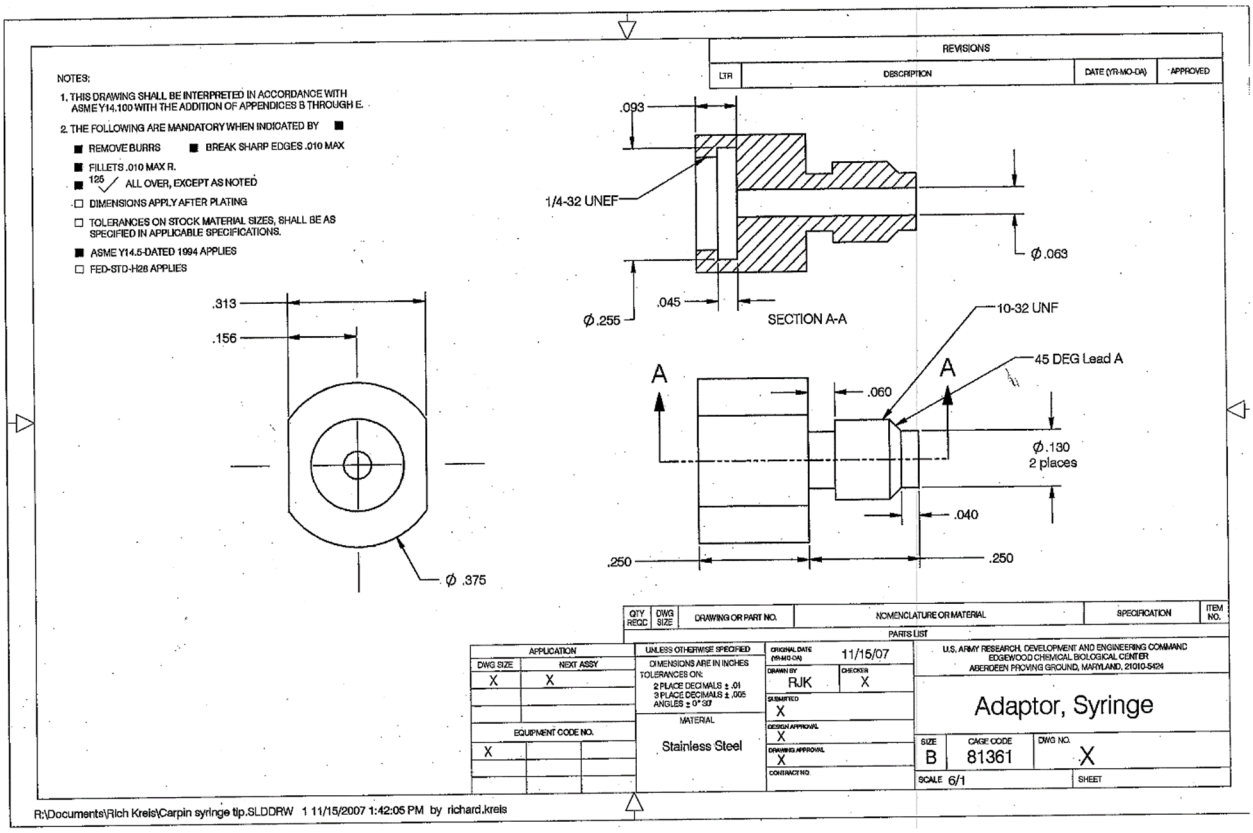


Figure 1. Syringe adapter.

## 3. TOOLS AND EQUIPMENT

The following tools were used to develop the CNA system:

1. non-crimping cutting device (e.g., grinding wheel),
2. stereo microscope (SM),
3. micro file,
4. 22 G disposable needle,
5. headband magnifier 3.5× (HBM),
6. 18 G disposable needle,
7. bench vise,
8. tongue and groove pliers,
9. 2 × 1/4 in. box end wrenches,
10. 5/16 in. box end wrench,
11. sharp cutting device (razor knife, scalpel, X-Acto knife [Elmer's Products; Westerville, OH], or razor blade), and
12. 7/8 in. box end wrench.

## 4. BUILDING THE CNA SYSTEM

The diagram in Figure 2 was used to determine orientation of items during CNA system assembly to ensure proper component alignment. As mentioned previously, it is extremely important to ensure that the work area is free of any dust or debris.

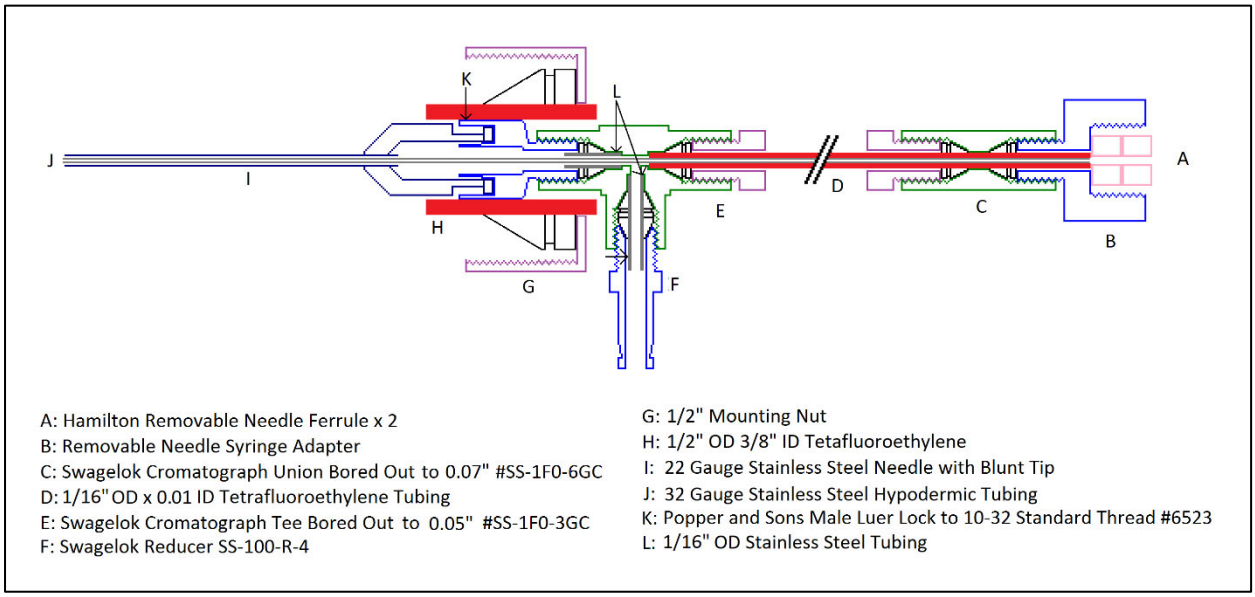


Figure 2. CNA system.

### 4.1 Assembling Materials, Tools, and Equipment

### 4.2 Contouring Materials

The materials were prepared for assembly in the following manner:

1. 32 G hypodermic stock (J in Figure 2).

   Determine the desired length of the 32 G hypodermic stock (distance from the end of a syringe [on syringe drive] to tip of atomizer). Cut 32 G hypodermic needle stock with a cutting wheel. Using a micro file and SM, gingerly flatten both ends to 90 degrees and deburr the OD. If any part of the needle stock bends or kinks, cut that portion off or start again. Using an SM, open the ID of the ends with the point of a disposable 22 G needle.

   **Note:** 14 in. is a good length for the hypodermic stock. It is long enough to reach a nearby syringe drive, long enough to attach and detach a syringe without pulling or tugging on the feed line, and short enough to avoid causing too much pressure drop.

2. SS chromatograph union and tee (C and E, respectively, in Figure 2).

   The chromatograph fittings must be bored: the union should be bored to 0.07 in. to allow the feed line PTFE tubing (D in Figure 2) to pass through, and the tee should be bored to slightly under 1/16 in. to make assembly easier and not impede the gas flow.

3. 1/16 in. OD, ≥0.03 in. ID SS tubing (L in Figure 2).

   a. To form a gas-tight seal, ferrules must be oriented properly, not only in relation to one another but also in relation to the fitting to which the tubing is connected (Figure 3). The beveled side of the back ferrule must be against the front ferrule, and the tapered end of the front ferrule must face away from the back ferrule. Ensure the front ferrule is inserted into the fitting first.

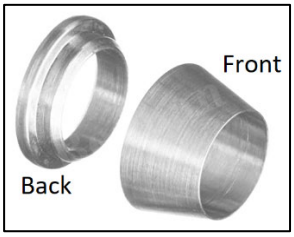


Figure 3. Ferrule set showing proper orientation.

   b. Using a micro file and HBM, flatten one end of the tubing to 90 degrees and deburr the OD. Again, using an HBM, open and bevel the ID of the end with the point of a disposable 18 G needle. Insert the shaped end into a 1/16 in. SS chromatograph fitting and lock a ferrule set onto it. Remove the tube from the fitting and cut it to 1/4 in. past the ferrule. Shape this end as before. Repeat this step again to yield two pieces of tubing (~1/2 in. long) with a ferrule set locked onto them.

   **Note:** After the boring and contouring are completed, the chromatograph fittings, 1/16 in. SS tubing pieces, and syringe adapter must be sonicated in hot soapy water, rinsed, and dried. This will remove all oils, waxes, and filings left behind from the manufacturing, drilling, or filing process. These contaminants could block the liquid feed line or gas pathway if they are not removed. After rinsing, each piece should be inspected using an SM to ensure no defects or debris could present a problem.

### 4.3 Assembling CNA Body Portion (E–I and K–L in Figure 2) of Liquid System (D and J in Figure 2)

The CNA body portion of the liquid system is assembled as follows:

1. Method for inserting the 32 G stock (J in Figure 2) into the 1/16 in. PTFE tubing (D in Figure 2).

   First, grasp the tip of a 1/16 in. PTFE tubing, then grasp the 32 G hypodermic stock near the tip and insert it into the PTFE tubing. In very small increments, gently slide the SS stock into the PTFE tubing until ~4.5 in. of the stock is sticking out of the PTFE. If you kink or bend the 32 G stock, you will have to cut that section out and reshape that end or contour a new piece of hypodermic tubing.

2. Assembly of the CNA body:

   Insert a 1/16 in. SS tubing (L in Figure 2) with a ferrule set and Luer-lock adapter (K in Figure 2) into the proper port of the chromatograph tee (E in Figure 2). Tighten the Luer-lock adapter into the chromatograph tee with a wrench and pliers. First place a 1/16 in. chromatograph male nut and then a ferrule set onto the 32 G stock (J in Figure 2), in that order, and slide them onto the PTFE tubing (D in Figure 2). Feed the 32 G stock through the chromatograph tee and Luer-lock fitting as before. Finger-tighten the male nut. Lightly pull on the PTFE tubing and see if there is any friction from the ferrule set. If not, reinsert the PTFE tubing and tighten the male nut 1/4 turn with a wrench. Continue this process until the PTFE is held lightly by the ferrule set. With an HBM, thread the 22 G needle (I in Figure 2) over the 32 G stock and use a wrench to tighten; be careful not to overtighten the needle into the Luer-lock fitting. You may have to loosen the male nut and pull the tubing slightly out of the body until the 32 G stock can be accessed. Push stock into PTFE tubing to adjust and reseat. When the 32 G stock barely extends past the tip of the 22 G needle and the male nut is secure enough to hold the PTFE in place, carefully push the tip of the 32 G stock flush with the tip of the 22 G needle. Now tighten the male nut with a wrench. As the male nut is tightened, it will compress the PTFE tubing slightly within the tee and force the 32 G stock to extend past the 22 G needle tip slightly. This is what you want. The 32 G stock should extend past the 22 G needle tip 1–2 mm. For the CNA to function properly, the 32 G stock must stick out slightly past the 22 G needle tip.

### 4.4 Attaching Syringe Adapter (B in Figure 2) to Feed Line (D and J in Figure 2) and Testing the CNA System

Attach the feed adapter to the CNA system in the following manner and then test the system to ensure it works:

1. With the aid of an SM, use a razor-sharp tool to trim off the excess 1/16 in. PTFE (D in Figure 2) as close as possible to the tip of the 32 G stock (J in Figure 2) without touching it. If you catch the end of the 32 G stock, you will damage it. The stock will have to be repaired or replaced.

2. In the following order, slide a male nut, ferrule set, chromatograph union (C in Figure 2), ferrule set, and syringe adapter on to the feedline. Lightly tighten the male nut and syringe adapter.

3. Orient the PTFE tubing of the feed line so it is ~1.5 mm below the sealing surface (inside flat of the female nut end) of the syringe adapter. Use a tool to tighten the syringe adapter. Visually inspect to see if the PTFE tubing is sticking out above the sealing surface of the syringe adapter. If it is, remove the syringe adapter, slide the chromatograph union down the PTFE tubing, and trim the PTFE tubing again, as described in step 1. Replace and tighten the syringe adapter with tools. Use tools to tighten the male nut onto the tee.

4. Attach a removable needle syringe loaded with filtered water to the syringe adapter via two Hamilton Company (Reno, NV) removable needle ferrules (A in Figure 2). Firmly depress the plunger of the syringe to inject water through the CNA. Water should shoot out of the end of the 32 G needle stock. If it does not, troubleshoot.

### 4.5 Attaching Gas Connector (F in Figure 2) to Chromatograph Tee

Place the remaining 1/16 in. piece of SS tubing into the open port of the chromatograph tee. Fit a ferrule front over the tubing with the bevel facing out. Screw in and tighten the SS reducer (F in Figure 2) using tools.

### 4.6 Affixing CNA Mounting Nut (G in Figure 2) to Luer-Lock Adapter (K in Figure 2)

Lock the body of the 1/2 in. bored-through PTFE tubing and fit into a bench vise. Insert the 1/2 in. PTFE tubing onto the fitting until it bottoms out. Slice the tubing flush with the fitting's nut. Carefully insert the needle of the CNA system through the 1/2 in. PTFE tubing and push the Luer-lock fitting into the PTFE as far as possible (i.e., the PTFE should be almost touching the gas inlet of the tee). Use a wrench to tighten the mounting nut, thereby locking the ferrule set onto the PTFE tubing and subsequently, the Luer-lock fitting. Finally, loosen the mounting nut from the union and remove the completed CNA system.

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CNA | coaxial needle atomizer |
| HBM | headband magnifier |
| ID | inner diameter |
| OD | outer diameter |
| PTFE | polytetrafluoroethylene |
| SM | stereo microscope |
| SS | stainless steel |

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