

UCD IMPROVE Technical Instruction #226D

Denuders

*Interagency Monitoring of Protected Visual Environments
Air Quality Research Center
University of California, Davis*

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DOCUMENT HISTORY

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05/10/21	SRS	All	Separated TI: A-H doc into individual TIs
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TABLE OF CONTENTS

1. Purpose and Applicability.....	4
2. Summary of the Method	4
3. Definitions.....	4
4. Health and Safety Warnings	4
5. Cautions	4
6. Interferences.....	4
7. Personnel Qualifications	4
8. Equipment and Supplies	5
9. Procedural Steps.....	6
9.1 Assigning an Inventory Number	6
9.2 Updating the Inventory.....	6
9.3 Cleaning the Denuders	6
9.3.1 Preparing and Using the Ultrasonic Bath.....	6
9.3.2 Rinsing the Denuders	7
9.4 Coating the Denuders.....	7
9.4.1 Preparing the Solution.....	7
9.4.2 Coating the Denuders.....	7
9.4.3 Updating the Inventory	7

1. PURPOSE AND APPLICABILITY

The purpose of this technical instruction (TI) is to describe the function of the denuders used in 2B modules and to detail how they are cleaned and coated for reuse after returning from the field.

2. SUMMARY OF THE METHOD

Denuders are used in 2B modules to remove nitric acid vapor from the air before it binds to the nylon filter. All denuders are assigned an inventory number for record-keeping. Denuders stay in B modules for approximately one to two years and are switched out with a fresh one during field maintenance. The “dirty” denuders are brought back to the Air Quality Research Center shop, where they are cleaned and coated. The denuders are then ready to be sent out to another site.

3. DEFINITIONS

- Denuder: a series of concentric aluminum tubes that is placed within the 2B module stack at sampling sites. The denuder serves to remove nitric acid vapor from the air stream before it binds to the nylon filter. The goal is to collect nitrate particles (which affect visibility) and not nitric acid (which does not).

4. HEALTH AND SAFETY WARNINGS

Always be cautious when handling chemicals. Wear gloves and safety goggles when preparing the solutions to clean and coat the denuders.

5. CAUTIONS

When coated, denuders easily attract dust, dirt and oils. Take care to only handle denuders with clean hands, and be cautious not to set them down on unclean surfaces.

6. INTERFERENCES

It is important to leave the denuders to dry at an angle to properly drain excess solution. If excess solution does not drain properly, the coating will not be even and can clog the air paths. This leads to lowering the surface area and therefore the effectiveness of the denuder.

7. PERSONNEL QUALIFICATIONS

Field technicians and trained shop assistants are responsible for cleaning and coating denuders in preparation for them to be sent out into the field.

8. EQUIPMENT AND SUPPLIES

Supplies for Cleaning Denuders:

- Household grade ammonia
- Glass cleaner
- Balance
- 1L graduated cylinder
- 2L Flask
- Ultrasonic bath
- Deionized water
- Denuder drying bucket-rack
- Paper
- “Dirty” denuder bin
- “Clean” denuder bin
- Safety glasses and gloves

Supplies for Coating Denuders:

- 1L graduated cylinder
- Balance
- 2L flask
- 1L plastic bottle
- Deionized water
- Glycerol
- Sodium carbonate (Na_2CO_3)
- Paper
- “Coated” denuder bin

Miscellaneous Supplies:

- Computer
- Engraver

All of the necessary supplies can be found in the IMPROVE shop. The chemical materials are found with the cart of supplies, kept in the chem lab.

If any of the solution ingredients have run out, chemical supplies can be obtained in the Chem 149 storeroom. See the field manager or shop supervisor for the billing number, which is

required for making purchases. Make sure to obtain a receipt for billing purposes. Sign and date the receipt and then submit it to the shop supervisor or field manager.

9. PROCEDURAL STEPS

9.1 Assigning an Inventory Number

All denuders must be assigned an inventory number. The inventory number should be etched on either the top or the bottom end of the denuder. If a denuder does not have an inventory number, go into the denuder inventory file, find the next available sequential ID number, and assign it to the denuder. This inventory file can be found in the U:\ Drive. All denuder inventory numbers are in the format "D####." Use the engraver to inscribe the next sequential number onto the end of the denuder.

9.2 Updating the Inventory

A denuder is classified as being in one of four states: dirty, coated, scrapped, or currently installed at a field site. If a denuder has just returned from the field, it is considered "dirty" and should be classified as such. To inventory a denuder, first pull up the denuder inventory on the shop computer. Sort according to denuder ID and find the line that corresponds to the last known location of the denuder. Insert a new line into the spreadsheet. Fill out the columns for the denuder ID, the site in which it was last installed, and the date it arrived in the shop. Change the status to "dirty" in the "Status" column. Clear the "Date Coated", "Site Sent To", and "Date Sent" columns.

9.3 Cleaning the Denuders

All "dirty" and brand-new denuders must be cleaned before being coated. "Dirty" denuders can be found in a designated bin.

9.3.1 Preparing and Using the Ultrasonic Bath

The ultrasonic bath is on the denuder cart, which is located directly outside of the AQRC shop, near the sink. Fill the bath with seven liters of deionized water. If unsure of where to locate the deionized water, ask shop personnel for assistance. Then, put on gloves and safety goggles. Take the graduated cylinder and add 10 mL of household grade ammonia. Pour the ammonia into the bath. Take a two-liter flask and fill it with one liter of deionized water. Next, take a piece of paper and make it into a cup. Put the cup on the balance in the shop. Tare the balance, and then scoop 80 g of glass cleaner into the cup. Pour the glass cleaner into the flask and stir until it dissolves. Add the solution to the bath.

Place up to eight denuders in the bath and run the bath for 30 minutes. If additional denuders need to be washed, the bath may be reused an additional three times for 32 denuders. If more than 32 denuders need to be cleaned, a new bath must be made. Discard all bath solution in the sink when the bath is complete.

9.3.2 Rinsing the Denuders

After the denuder bath is complete, remove the denuders promptly and rinse them thoroughly with the deionized water hose for several minutes. This can be done using the deionized water source outside AQRC shop. Allow as much water as possible to drain from the denuders, and then place them in the denuder drying bucket-rack. Allow them to dry overnight. Once the denuders are dry, place them in the “cleaned” denuder bucket. They are now ready to be coated.

9.4 Coating the Denuders

After being cleaned, denuders need to be completely immersed in a sodium carbonate (Na_2CO_3) solution. The coating solution enhances the ability of the denuder to remove nitric acid from the air stream.

9.4.1 Preparing the Solution

First, put on gloves and safety goggles. Locate the 2L flask, which is the vessel that the solution will be mixed in. Find the graduated cylinder and fill it with 100 mL of deionized water. Then, measure out 30 mL of glycerol into the graduated cylinder, on top of the water. Pour the solution into the flask. Measure out another 900 mL of deionized water into the graduated cylinder and add it to the solution.

Next, prepare to weigh the sodium carbonate. Use an empty weighing dish and place it on the balance. Tare the balance and then measure out 71g of sodium carbonate. Add it to the flask and agitate the solution until all of the sodium carbonate is dissolved. The solution is now prepared and should be placed into a 1L plastic bottle for storage.

9.4.2 Coating the Denuders

Obtain the graduated cylinder. Add 860 mL of the sodium carbonate solution to the graduated cylinder. This level will ensure that the solution will not spill over once the denuder is placed into the cylinder. Take a clean denuder and submerge it into the solution. Pull the denuder out, turn it over, and submerge the other side. Remove the denuder from the solution and allow it to dry in the bucket-rack. Repeat this procedure for up to ten denuders. After ten denuders have been coated, the solution must be discarded. Take the solution to the sink and dilute it with hot water before pouring it down the drain. Allow the denuders to dry overnight and then place them in the “coated” denuder bin.

9.4.3 Updating the Inventory

Once the denuders are coated, their statuses must be updated in the inventory. Open the Access inventory file and change the appropriate lines with the “Dirty” status in the “Status” column. Change the status to “Coated”. Fill in the date in the “Date Coated” column.