OPERATION, MAINTENANCE, AND MODIFICATION
OF THE CHAPEL HILL FACILITY

FILTERED FACE ENCLOSURE ACCEPTANCE TEST

Prepared for
The Environmental Protection Agency
Research Triangle Park, NC 27711

In Response To
Contract 68HERC22C0056, Special Project Request #244

Prepared by
TRC Environmental Corporation
1429 Rock Quarry Road, Suite 116
Raleigh, NC 27610

March 20, 2025

Document Number
68HERC22C0056-0046AT

1.0 INTRODUCTION

1.1 Overview

The U.S. Environmental Protection Agency has contracted with TRC to operate, maintain, and modify specific components of the EPA Human Studies Facility located in Chapel Hill, North Carolina. Included are systems associated with human exposure chambers, subject test rooms, the Medical Station, and the *in vitro* exposure system. Other tasks include computer operations, data management, safety assurance, quality assurance, system documentation, and preparation of technical reports. The specific services to be provided by TRC are those identified in EPA Contract 68HERC22C0056 Attachment 1, *Performance Work Statement*.

This Acceptance Test describes the test criteria for verifying that the filtered face enclosure, developed under Special Projects Request (SPR) #244, meets all requirements set forth in the original SPR directive and in the project Supplemental Work Plan. The work performed is in accordance with Contract Task 5, Upgrading of Systems.

1.2 Organization of this Document

This document describes the Acceptance Test Plan for the filtered face enclosure developed for the MASKON study. Section 2.0 describes tasks that must be completed prior to beginning the Acceptance Test, Section 3.0 describes general procedures for performing the test, and Section 4.0 describes the method of documenting results. Section 5.0 contains recommendations for post-test activities to further ensure data integrity. Detailed procedures for performing the tests are found in Section 6.0. Issues that arise during system integration may necessitate modifications to these tests; modifications will be reflected in the revision number associated with each procedure.

2.0 PRE-TEST PREPARATIONS

The following activities must be completed prior to performing the test procedures contained in this document:

- As-built drawings and operational manuals and procedures must be completed and available during the test.
- The condensation particle counter used for monitoring must be calibrated within 12 months of the acceptance test.
- Characterization tests must be completed prior to the final acceptance test. At a minimum, characterization tests will include the following:

    1. Test for plumbing leaks
    2. Test for adequate flow to the subject
    3. Test for function in the chamber space with no interference to communication
    4. Test of the modified CAPR system using a model VOC to demonstrate accurate representation

Results of these tests will be available for review during the acceptance test and will be delivered along with acceptance test results at the end of the project.

3.0 GENERAL TEST PROCEDURES

The complete set of test procedures required to demonstrate acceptability of the filtered face enclosure is contained in this acceptance test document. All tests will be performed by TRC and witnessed by an EPA representative with authority to accept the test results. Should an EPA representative not be available, documentation of the tests will be reviewed and certified by the TRC QA staff and delivered to the Contracting Officer's Representative (COR) for final acceptance.

4.0 DOCUMENTATION OF TEST RESULTS

Most steps of the test procedures are followed by one or more questions regarding system impact directly resulting from the performance of that step in the procedure. Each question is accompanied by a check box. When conducting the test, the tester is expected to place a mark in the check box if the answer to the question is in the affirmative.

In addition, each test procedure is followed by an evaluation section where EPA and TRC evaluators judge the final test results. If the system is judged to have failed a test, a complete and formal repeat of the test will be performed once the problems are corrected. It is possible, however, for the system to pass a specific test even though minor potential deficiencies are noted. In such a case, evaluators can specify whether a complete repeat of the test is required. Each potential deficiency, whether major or minor, will be documented with a Finding Report (Figure 1), which will be attached to the completed test procedures, along with any tabular or graphical reports that were generated during the test. Each Finding Report will be analyzed by TRC, and the results of that analysis and any corrective or re-test action taken will be delivered to the EPA as part of the test results. Test results will be delivered within two weeks of test completion.

5.0 POST-TEST RECOMMENDATIONS

The test procedures contained in this document adequately verify that the filtered face enclosure satisfies the requirements outlined in the original SPR directive and as updated and clarified in the project Supplemental Work Plan. However, because research questions and results are based on exposure levels, the following activities are additionally recommended prior to using the filtered face enclosure in actual research conditions:

1. EPA users conduct one or more practice runs to ensure that operators are adequately trained and familiar with system characteristics and performance.

2. A copy of the test results that document performance claims should be filed such that they are readily available to answer questions about research conducted using the filtered face enclosure.

Date:	Time:
FINDING REPORT	
Report Number:	Test Number:
Operator:	Observer:
FINDING: (Attach any hard copy tabular or graphical output that illustrates the potential problem. Include any information that can help engineers reproduce the problem.)	
REPEATABLE? YES NO UNKNOWN	
RESOLUTION:	

Figure 1. Finding Report

6.0 SYSTEM TESTS

Test procedures in this section will be performed by TRC and witnessed by an EPA representative authorized to judge the results. TRC will provide the EPA COR with a tentative schedule of these test activities when characterization tests of the system are nearing completion.

FILTERED FACE ENCLOSURE INSPECTION

This procedure verifies that documentation of the filtered face enclosure accurately represents the as-built system, and that the enclosure is suitable for a subject to wear during a two-hour exposure session. This test requires that the chamber support and console equipment be running and that two volunteers, preferably members of the MASKON study staff, are available to participate in donning the filtered face enclosure in the chamber.

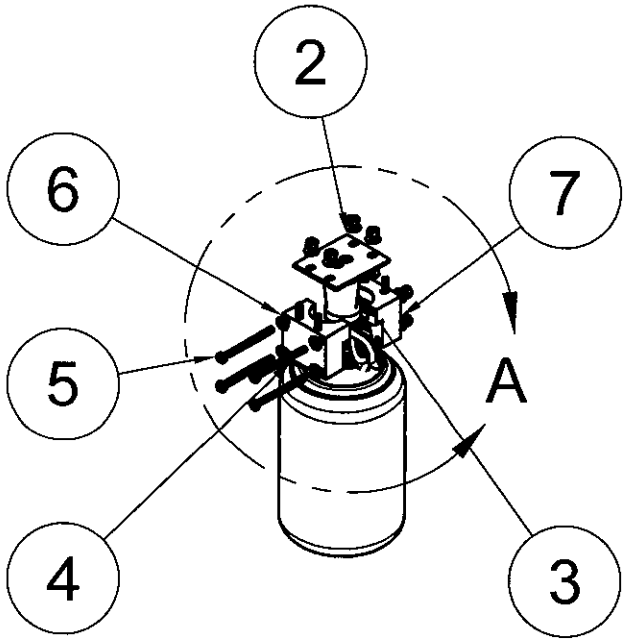
PROCEDURE	RESULTS
1. Inspect the filter manifolds, helmet support, and modifications to the CAPR. Review as-built drawings for the system.	☑ Drawings accurately represent the as-built system?
2. Turn on the pumps. When the system has stabilized, escort a volunteer into the chamber and assist in installing the enclosure onto the volunteer's head. Place a sound meter inside the enclosure.	☑ Sound meter shows 70 dB or less?
3. Remove the sound meter. Leave the volunteer in the chamber alone and close the door. From the chamber console, have a two-way conversation with the volunteer.	☑ Volunteer can clearly hear staff seated at the console? ☑ Staff seated at the console can clearly hear the volunteer?

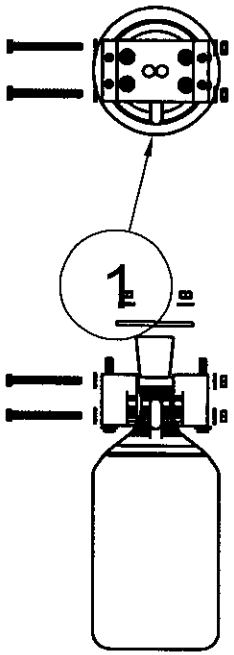
EVALUATION	
Overall evaluation:	☑ PASS ☐ FAIL
Possible deficiencies observed?	☐ YES ☑ NO If yes, list associated Finding Report numbers below:
Re-test necessary?	☐ YES ☑ NO
Comments?	

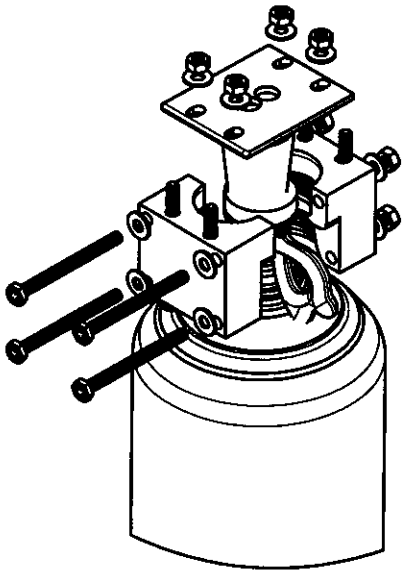
SIGNATURES

TRC QA Manager: Janet Bunta (Signature) 4/3/2025 (Date)

EPA Representative: (Signature) April 2, 2025 (Date)







PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	SPR244- 1 GALLON JUG WITH HANDLE
2	1	SPR244- 1 GALLON TOP PLATE
3	1	SPR244- COLE PALMER STOPPER
4	4	SPR244- 3" BOLT TB
5	4	SPR244- 3.5" BOLT LR
6	1	SPR244- LEFT MOUNTING BODY
7	1	SPR244- RIGHT MOUNTING BODY

NOTE: All units are in inches unless otherwise specified.

TRC
1429 ROCK QUARRY RD, SUITE 116
RALEIGH, NC 27610
919-828-3150

PROJECT

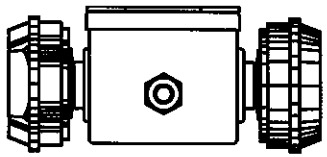
Filtered Face Enclosure

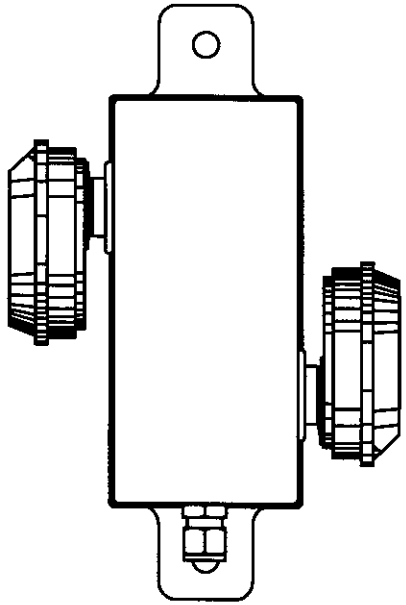
TITLE

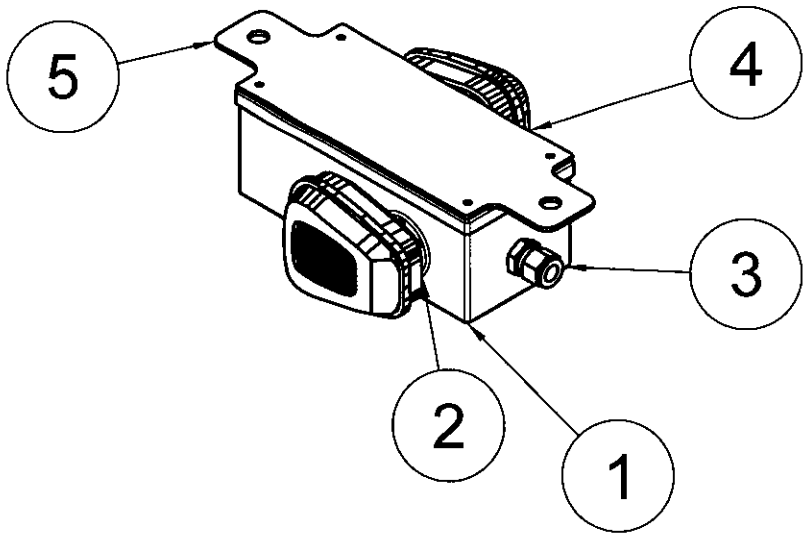
Baffle 1 Gallon Exploded View Assembly

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	A	SPR 244	202500101	
DRAWN Thomas Austin 3/27/2025	SCALE 1:8	WEIGHT	SHEET 1/8	

PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	PART1
2	2	FLITER MOUNT 4MM
3	1	PRODUCT_ID_1
4	2	3M FILTER
5	1	FILTER BOX MOUNTING PLATE







NOTE: All units are in inches unless otherwise specified.

TRC
1429 ROCK QUARRY RD, SUITE 116
RALEIGH, NC 27610
919-828-3150

PROJECT

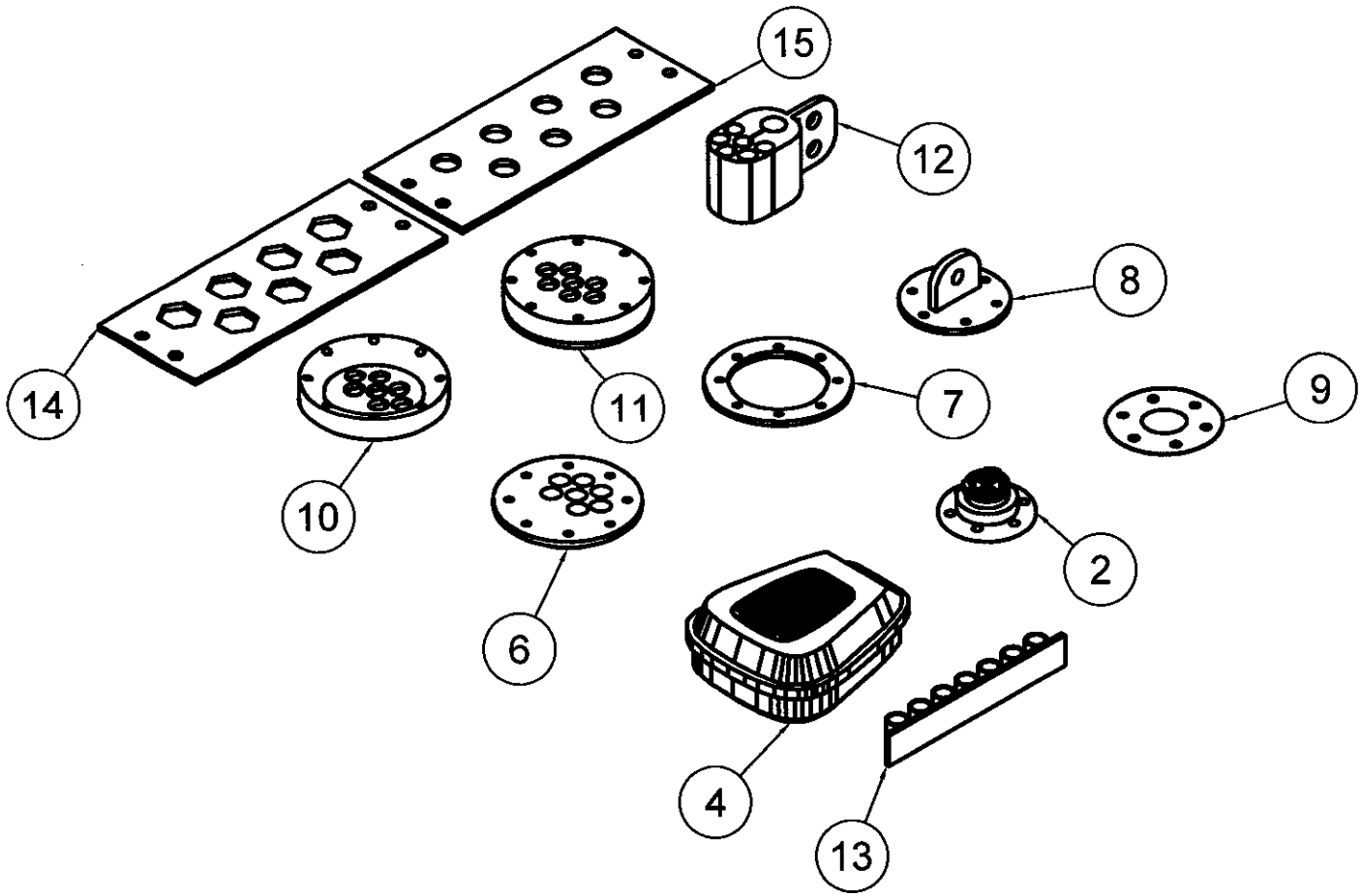
Filtered Face Enclosure

TITLE

Filter Box Assembly Support View Assembly

APPROVED				
CHECKED				
DRAWN Thomas Austin 3/28/2025	SCALE 1:5	WEIGHT	SHEET 2/8	

SIZE	CODE	DWG NO	REV
A	SPR 244	202500101	



PARTS LIST		
ITEM	QTY	PART NUMBER
2	1	FLITER MOUNT 4MM
4	1	3M FILTER
6	1	SPR244- 7 TUBE BULKHEAD- INSIDE OUTTER BASE MODC-A
7	1	SPR244- 7 TUBE BULKHEAD- OUTER FLANGE
8	1	SPR244- FRONT PIVOT MOUNT
9	1	SPR244- GASKET
10	1	SPR244- TUBE BULKHEAD DUAL INNER RACE- TOP MODB
11	1	SPR244- TUBE BULKHEAD DUAL INNER RACE MODB
12	1	SPR244- TUBE BUNDLE MOUNT LR TOP WITH STOP
13	1	TUBING MANIFOLD
14	1	SPR244- 7X TOP PLATE
15	1	SPR244- 7X MOUNTING PLATE

Note: All units are in inches unless otherwise specified.

TRC
1429 ROCK QUARRY RD, SUITE 116
RALEIGH, NC 27610
919-876-3150

PROJECT

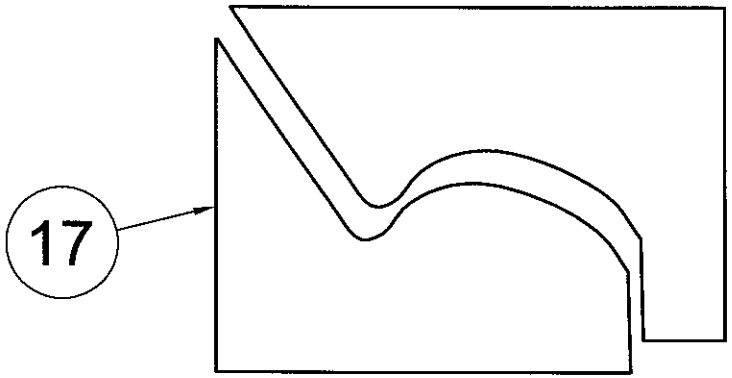
Filtered Face Enclosure

TITLE

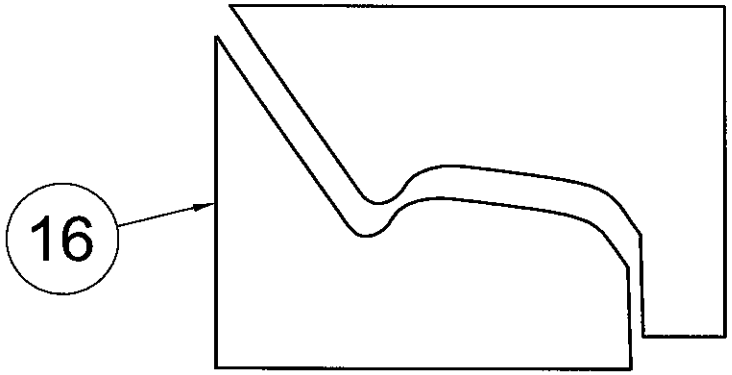
Filter Box Assembly Support View Assembly

APPROVED	SIZE	CODE	DWG NO	REV
CHECKED	B	SPR 244	202500101	
DRAWN Thomas Austin 3/28/2025	SCALE 1:3	WEIGHT	SHEET 3/8	

Template- H



Template- F



PARTS LIST		
ITEM	QTY	PART NUMBER
16	1	SPR244- TUBING TEMPLATE REV F
17	1	SPR244- TUBING TEMPLATE REV H

NOTE: All units are in inches unless otherwise specified.

TRC
1429 ROCK QUARRY RD, SUITE 116
RALEIGH, NC 27610
919-828-3150

PROJECT

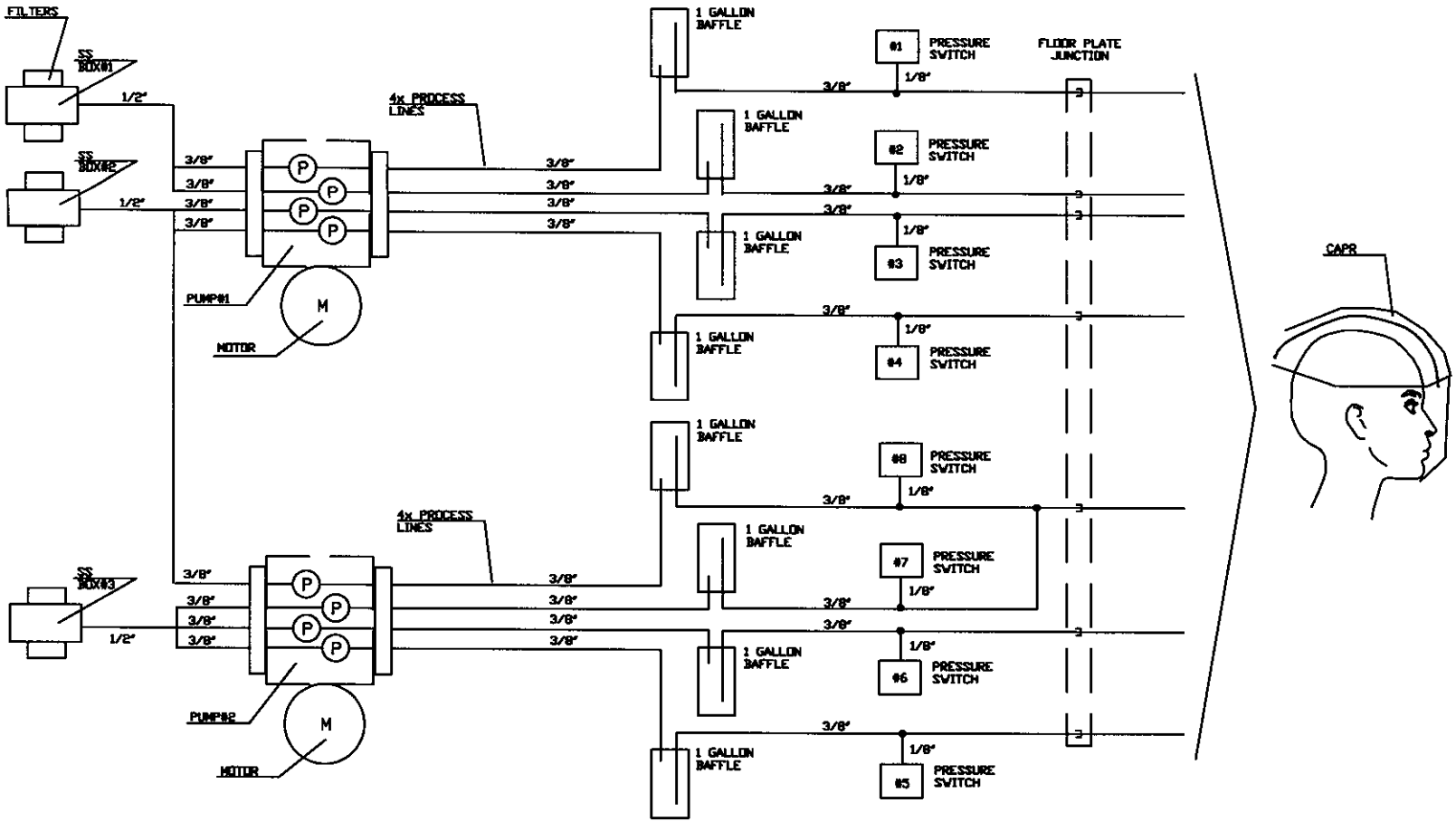
Filtered Face Enclosure

TITLE

Tube Bending Templates Detail

APPROVED				
CHECKED				
DRAWN	Thomas Austin 3/28/2025	SCALE 1:5.5	WEIGHT	SHEET 4/8

SIZE	CODE	DWG NO	REV
A	SPR 244	202500101	



EPA Human Studies Facility

Chapel Hill, NC

Grd Floor Testing Areas CAPR Delivery System Layout

Revisions

Initial Release Date 03-24-25

Project Number 429577.2000

Project Mgr.

Designed

Drawn T AUSTIN

Checked

TRC

1429 ROCK QUARRY RD, SUITE 110
RALEIGH, NC 27610
919-828-3150

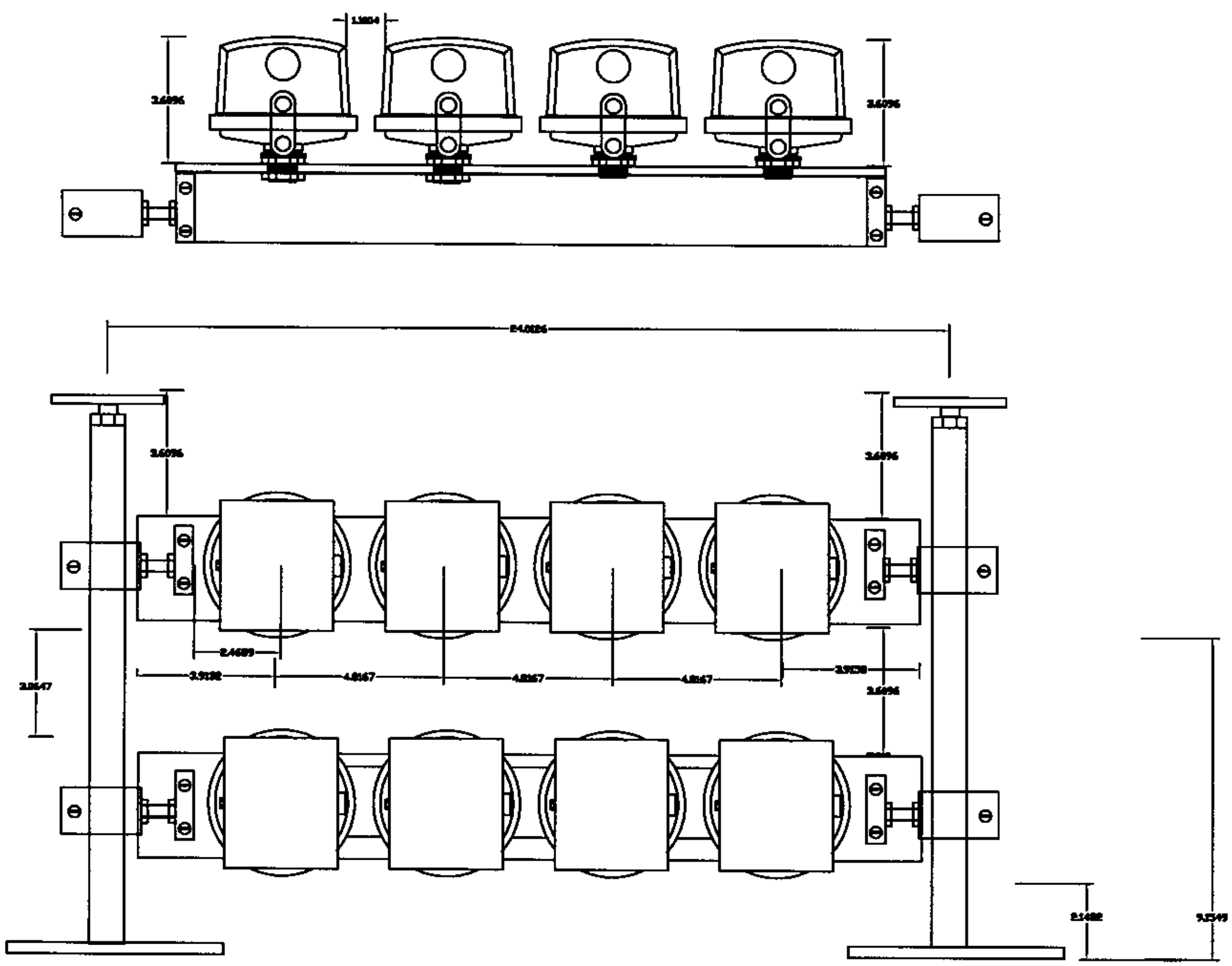
SPR 244

SIZE D

All units are in inches unless otherwise specified.

Drawing Number 202500101 Rev. P5

Scale: NA



REVISIONS

PARTS LIST

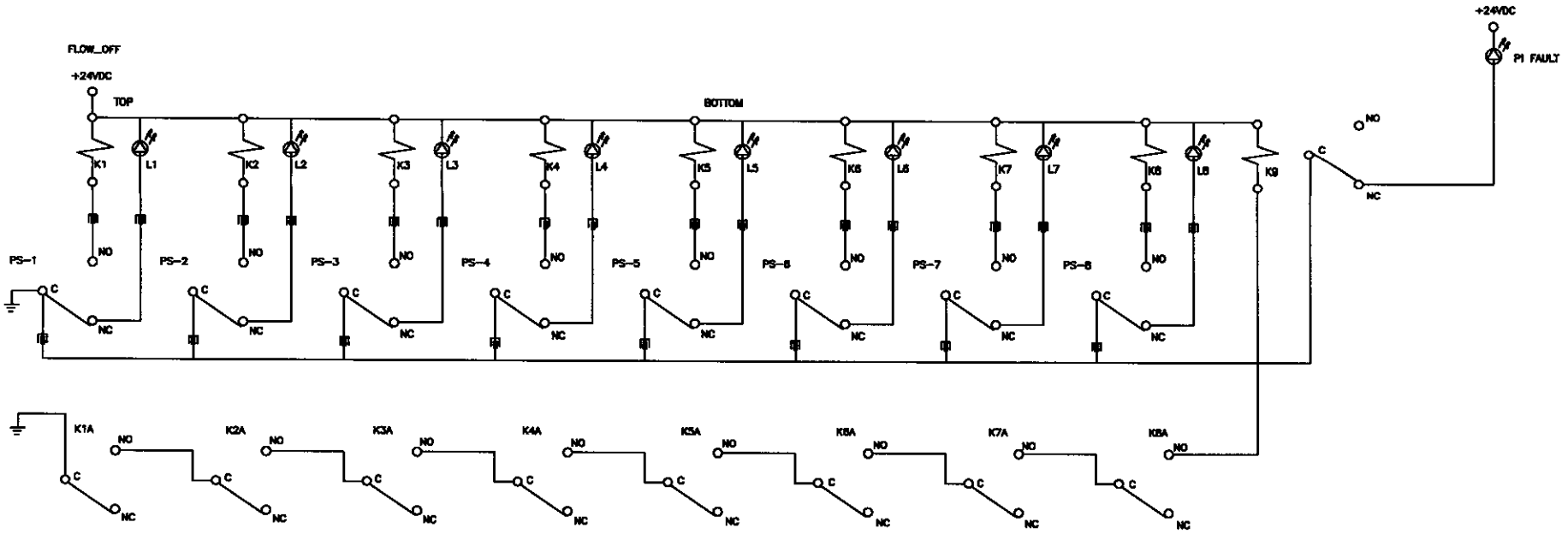
CLIENT/PROJECT NAME	
E.P.A. HUMAN STUDIES FACILITY	
PROJECT LOCATION	HUMAN STUDIES LABS U.N.C., Chapel Hill, N.C.
	420577-0602-00000
DR. BY	T AUSTIN 03/24/25

TRC

PARTICLE CHAMBER
PRESSURE LAYOUT
SPR244 MODIFICATION

SIZE D — 202500101

SCALE NONE — SHEET 6 OF 8



REVISIONS

ECR	DESCRIPTION	DATE	DRN	APP

PARTS LIST

TRC
The Environmental Corporation

CLIENT/PROJECT NAME
E.P.A.
HUMAN STUDIES FACILITY

PROJECT LOCATION
HUMAN STUDIES LABS
U.N.C. Chapel Hill, N.C.

TRC PROJECT NO.
42867-0802-00000

DR. BY	T AUSTIN	03/24/25
CHK BY		
APP BY		

PARTICLE CHAMBER PRESSURE LAYOUT\WIRING SPR244 MODIFICATION

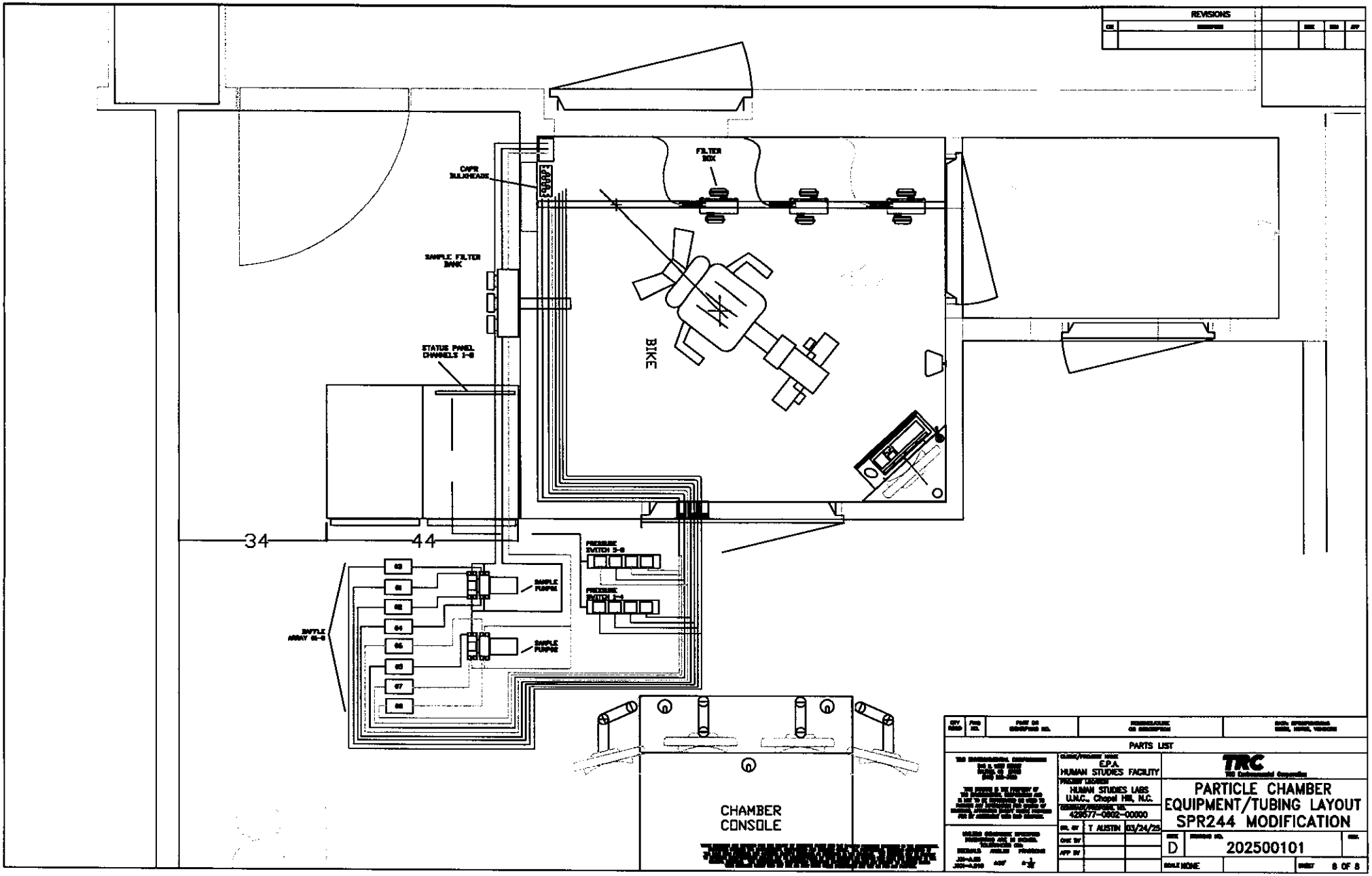
SIZE D

DRAWING NO. 202500101

REV.

SCALE NONE

SHEET 7 OF 8


REVISIONS
CAPR BULKHEADS
FILTER BOX
SAMPLE FILTER BANK
STATUS PANEL CHANNELS 1-8
BIKE
34
44
PRESSURE SWITCH 5-8
PRESSURE SWITCH 1-4
SAMPLE PUMPS
SAMPLE PUMPS
MANIFOLD ASSY 01-8
CHAMBER CONSOLE
PARTS LIST
E.P.A.
HUMAN STUDIES FACILITY
HUMAN STUDIES LABS
U.N.C., Chapel Hill, N.C.
4206577-0802-00000
T AUSTIN 03/24/25
TRC
PARTICLE CHAMBER
EQUIPMENT/TUBING LAYOUT
SPR244 MODIFICATION
D
202500101
SCALE NONE
SHEET 8 OF 8

GAS FLOW DELIVERY

This procedure demonstrates that the system delivers adequate air flow to the filtered face enclosure and that disruption to the air flow (*e.g.*, pump failure) creates an alarm condition noticeable to study staff seated at the console. This test requires that the chamber support equipment be running and the Chamber PC81 Minute Ventilation System be available and recently calibrated.

PROCEDURE	RESULTS
1. Start the pumps for the filtered face enclosure. After the system stabilizes, connect the in-chamber pneumotach to each of the seven tubes providing air flow to the filtered face enclosure and begin sampling. Record the flows.	Flow (1): 26.5 L/min Flow (2): 27.5 L/min Flow (3): 26.1 L/min Flow (4): 47.4 L/min Flow (5): 26.1 L/min Flow (6): 27.5 L/min Flow (7): 26.5 L/min
2. Calculate the total flow.	Total Flow: 207.6 ☑ Flow ≥ 180 lpm?
3. Turn off one pump.	☑ Flow error light illuminated on the chamber console? ☑ Status panel accurately reflects which pump heads were turned off?

EVALUATION	
Overall evaluation:	☑ PASS ☐ FAIL
Possible deficiencies observed?	☐ YES ☑ NO If yes, list associated Finding Report numbers below:
Re-test necessary?	☐ YES ☑ NO

Comments?

SIGNATURES

TRC QA Manager: Janet Bunta (Signature) 4/3/2025 (Date)

EPA Representative: (Signature) April 2, 2025 (Date)

SYSTEM LEAK CHECK

This procedure demonstrates that the system is free of leaks, thus ensuring that particulates from a woodsmoke exposure will not infiltrate the face enclosure. This test requires that the chamber support equipment be running and a calibrated low flow calibrator be available.

PROCEDURE	RESULTS
1. Install manifold caps to plug each of the lines from the filter holder manifolds. Connect the low flow calibrator to each of the port entering the face enclosure. Record the flows. Calculate the totals.	Flow (1): 160 sccm Flow (2): 0 sccm Flow (3): 0 sccm Flow (4): 0 sccm Flow (5): 0 sccm Flow (6): 104 sccm Flow (7): 77.8 sccm Total Flow: 341.8 sccm ☑ Flow ≤ 1 lpm?
3. Unplug the lines from the filter holder manifold and record the flow at each. Calculate the total.	Flow (1): 69.5 L/min Flow (2): 50.5 L/min Flow (3): 72.4 L/min Total Flow (manifold): 192.4 L/min
3. Connect the low flow calibrator to measure the flow from each of the ports entering the face enclosure. Record the flows. Calculate the total.	Flow (1): 20.5 Flow (2): 24.4 Flow (3): 21.8 Flow (4): 42.3 Flow (5): 23.4 Flow (6): 24.8 Flow (7): 22.7

	Total Flow (enclosure): 179.9 L/min
4. Calculate the mean of the total flow from the filter holder manifold and the total flow into the face enclosure. Record the mean.	Mean Flow: 186.15 L/min
5. Calculate the percentage difference of the combined manifold flow from the mean flow recorded in step 4 and record the absolute value of the difference. Do the same for the flow into the enclosure.	%Difference (manifolds): +3.36 % %Difference (enclosure): −3.36 % ☑ Both differences ≤ 5%?

EVALUATION	
Overall evaluation:	☑ PASS ☐ FAIL
Possible deficiencies observed?	☐ YES ☑ NO If yes, list associated Finding Report numbers below:
Re-test necessary?	☐ YES ☑ NO
Comments? Flow from manifold lines was reduced due to the need for a vibration dampening bottle. Normal operation would have higher flows. Enclosure flows were measured w/ appropriate manifold lines in the vibration dampening bottle	

SIGNATURES

TRC QA Manager: Janet Benton (Signature) 4/3/2025 (Date)

EPA Representative: (Signature) April 2, 2025 (Date)

VOC Representation Accuracy

This procedure demonstrates that there is negligible absorption of VOCs in the system, thus ensuring that the concentration of VOCs measured during a woodsmoke exposure is representative of the VOCs presented to the subject in the face enclosure. This test requires that the chamber support equipment be off and a Pollutant Control System (PCS) total hydrocarbon (HC) analyzer be recently calibrated and configured to monitor the chamber.

PROCEDURE	RESULTS
1. Inside the chamber, place the filtered face enclosure on the mannequin head fitted with a 2-inch diameter tube through the back of its neck such that the tube inlet is slightly protruding from its mouth. Turn on the pumps.	
2. Using an acetone gas cylinder and piped nitrogen, create a delivery rig with ambient vent where the mixture is delivered to a measurement point inside the chamber and to the sample manifold line. The concentration at the ambient vent should be approximately 5 ppm as measured by the PCS HC analyzer.	
3. Place the analyzer sample line at the measurement point inside the chamber. Record the start time. After approximately four minutes, record the end time.	Start Time (C1): 10:11 End Time (C1): 10:15
4. Place the analyzer sample line through the mannequin head inlet tube. Record the start time. After at least four minutes, record the end time.	Start Time (H1): 10:21 End Time (H1): 10:25
5. Repeat step 3.	Start Time (C2): 10:30 End Time (C2): 10:34
6. Repeat step 4.	Start Time (H2): 10:38 End Time (H2): 10:42
7. Repeat step 3.	Start Time (C3): 10:44 End Time (C3): 10:48

8. Repeat step 4.	Start Time (H3): 10:51 End Time (H3): 10:55
9. Use the PCS Report Analog command to obtain hardcopy reports showing the mean concentration during the time periods recorded in steps 3 through 8.	☑ Attach the reports to these test results.
10. For each of the three measurement periods, calculate the mean of the reported mean concentration measured in the chamber and the mean concentration measured inside the face enclosure. Record the values.	Chamber / Face enclosure / Overall average Mean (1): 4.95 ppm / 4.84 ppm / 4.9 Mean (2): 5.00 ppm / 4.82 ppm / 4.91 Mean (3): 4.98 ppm / 4.75 ppm / 4.87
11. Calculate the percentage difference of the individual mean concentrations from the overall mean for each measurement period.	☑ All individual means within ±5% of overall average for corresponding measurement period?

EVALUATION	
Overall evaluation:	☑ PASS ☐ FAIL
Possible deficiencies observed?	☐ YES ☑ NO If yes, list associated Finding Report numbers below:
Re-test necessary?	☐ YES ☑ NO
Comments?	

SIGNATURES

TRC QA Manager: Janet Bernstein — Signature — 4/3/2025 — Date

EPA Representative: [signature] — Signature — April 2, 2025 — Date

Mnemonic SHC2 from 03/25/2025 10:11:38 to 03/25/2025 10:13:38

2 samples	0 have no data	0 out-of-limits	
average =	4.9459E+00	standard deviation =	1.2108E-02
minimum =	4.9373E+00	maximum =	4.9545E+00

Mnemonic SHC2 from 03/25/2025 10:21:38 to 03/25/2025 10:23:38

2 samples	0 have no data	0 out-of-limits	
average =	4.8402E+00	standard deviation =	1.4543E-02
minimum =	4.8299E+00	maximum =	4.8505E+00

Mnemonic SHC2 from 03/25/2025 10:31:38 to 03/25/2025 10:33:38

2 samples	0 have no data	0 out-of-limits	
average =	5.0031E+00	standard deviation =	1.5266E-02
minimum =	4.9924E+00	maximum =	5.0139E+00

Mnemonic SHC2 from 03/25/2025 10:39:38 to 03/25/2025 10:41:38

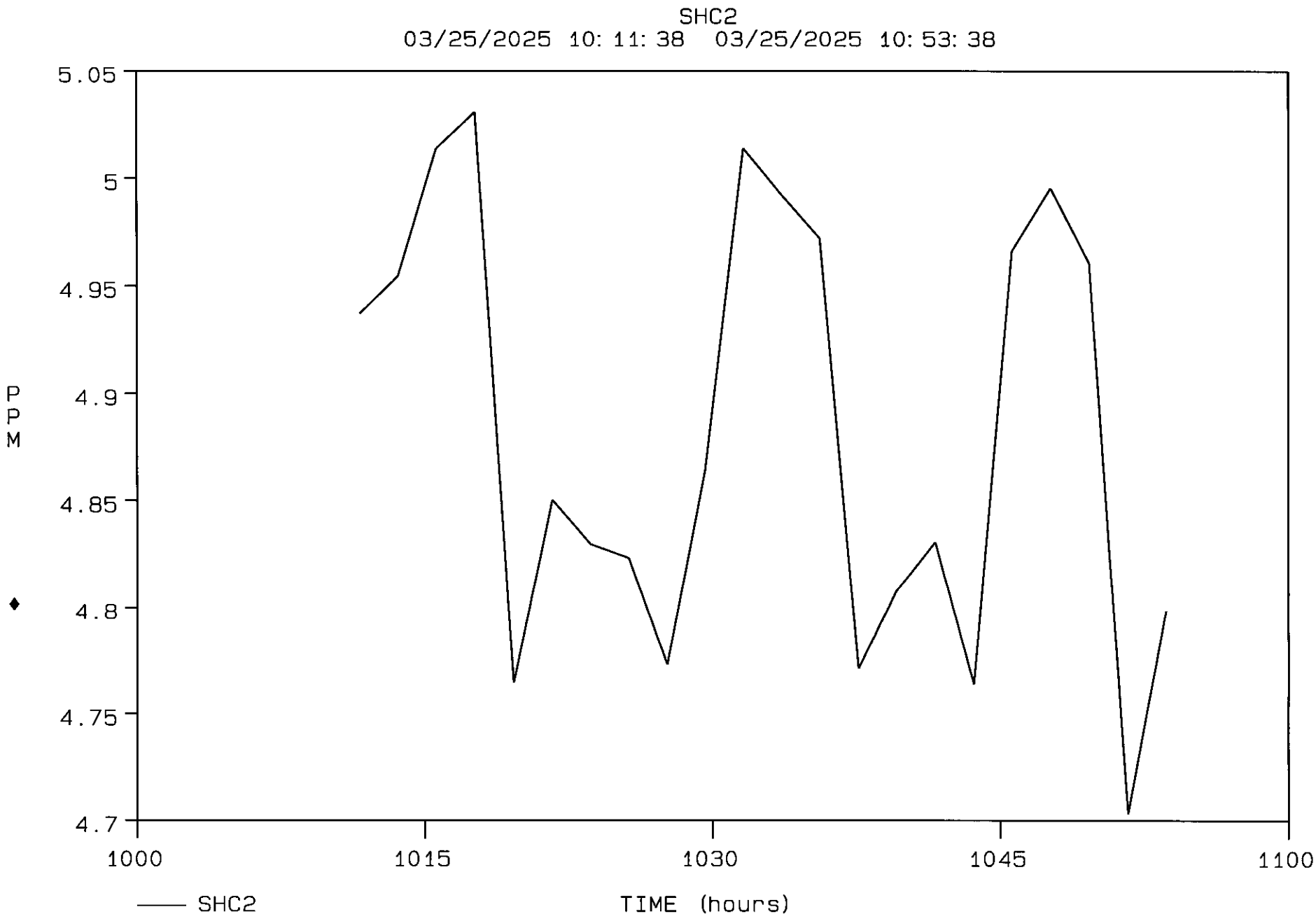
2 samples	0 have no data	0 out-of-limits	
average =	4.8194E+00	standard deviation =	1.6185E-02
minimum =	4.8080E+00	maximum =	4.8309E+00

Mnemonic SHC2 from 03/25/2025 10:45:38 to 03/25/2025 10:47:38

2 samples	0 have no data	0 out-of-limits	
average =	4.9808E+00	standard deviation =	2.0626E-02
minimum =	4.9662E+00	maximum =	4.9954E+00

Mnemonic SHC2 from 03/25/2025 10:51:38 to 03/25/2025 10:53:38

2 samples	0 have no data	0 out-of-limits	
average =	4.7509E+00	standard deviation =	6.7462E-02
minimum =	4.7032E+00	maximum =	4.7986E+00


SHC2
03/25/2025 10: 11: 38 03/25/2025 10: 53: 38
5.05
5
4.95
4.9
4.85
4.8
4.75
4.7
PPM
1000
1015
1030
1045
1100
SHC2
TIME (hours)

Particulate Removal Efficiency

This procedure demonstrates that the system with filter cartridges installed effectively prevents woodsmoke particles from entering the filtered face enclosure. This test requires that the chamber support equipment be running, two condensation particle counters (CPCs) be configured within the Pollutant Control System (PCS) to monitor Chamber PC81, and the PCS be configured for a 500 µg/m^3 woodsmoke exposure.

PROCEDURE	RESULTS
1. Inside the chamber, install filter cartridges on the manifolds and place the filtered face enclosure on the mannequin head. Insert the nonconductive or grounded stainless tubing CPC sample line into the enclosure's breathing zone. Turn on the pumps.	
2. Initiate delivery of woodsmoke to the chamber. Once the concentration has stabilized at the target concentration, record the time.	Start Time: 10:16
3. Allow the woodsmoke exposure to continue for at least 10 minutes before terminating woodsmoke delivery. Record the end time.	End Time: 10:27
4. Use the PCS Report Analog command to obtain hardcopy reports showing the mean particle count measured by both CPCs during the time period.	☑ Attach the report to these test results.
5. Calculate the percentage difference of the CPC mean particle count (enclosure) from the PCS mean particle count (chamber).	☑ Enclosure particle count <5% of chamber particle count.

EVALUATION	
Overall evaluation:	☑ PASS ☐ FAIL

Possible deficiencies observed?	☐ YES ☑ NO If yes, list associated Finding Report numbers below:
Re-test necessary?	☐ YES ☑ NO
Comments?	

SIGNATURES

TRC QA Manager: [signature] Signature 4/3/2025 Date

EPA Representative: [signature] Signature April 2, 2025 Date

Mnemonic SCP4 from 03/27/2025 10:17:38 to 03/27/2025 10:25:38

03/27/2025 10:17:38	3.5764E+04	03/27/2025 10:19:38	4.0347E+04
03/27/2025 10:21:38	3.6994E+04	03/27/2025 10:23:38	3.0180E+04
03/27/2025 10:25:38	2.6239E+04		

Mnemonic SCP4 from 03/27/2025 10:17:38 to 03/27/2025 10:25:38

5 samples	0 have no data	0 out-of-limits	
average =	3.3905E+04	standard deviation =	5.6378E+03
minimum =	2.6239E+04	maximum =	4.0347E+04

Mnemonic SCP5 from 03/27/2025 10:17:38 to 03/27/2025 10:25:38

03/27/2025 10:17:38	6.0199E+01	03/27/2025 10:19:38	5.9794E+01
03/27/2025 10:21:38	5.6239E+01	03/27/2025 10:23:38	5.2841E+01
03/27/2025 10:25:38	6.5138E+01		

Mnemonic SCP5 from 03/27/2025 10:17:38 to 03/27/2025 10:25:38

5 samples 0 have no data 0 out-of-limits

average =	5.8842E+01	standard deviation =	4.6143E+00
minimum =	5.2841E+01	maximum =	6.5138E+01