National Institute for Occupational Safety and Health
National Personal Protective Technology Laboratory
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DETERMINATION OF POSITIVE PRESSURE, CLOSED-CIRCUIT, PRESSURE-DEMAND, SELF-CONTAINED BREATHING APPARATUS STANDARD TESTING PROCEDURE (STP)

1. PURPOSE

This test establishes the procedures for ensuring that the level of protection provided by the positive pressure test requirements on Closed-Circuit, Pressure-Demand, Self-Contained Breathing Apparatus (SCBA) submitted for Approval, Extension of Approval, or examined during Certified Product Audits, meet the minimum certification standards set forth in 42 CFR, Part 84, Subpart G, Section 84.63(a)(c)(d), Subpart H, Section 84.70(a)(1); Volume 60, Number 110, June 8, 1995, and Federal Register, Volume 50, No. 222, November 18, 1985.

2. GENERAL

This STP describes the Determination of Positive Pressure, Closed-Circuit, Pressure-Demand, Self-Contained Breathing Apparatus test in sufficient detail that a person knowledgeable in the appropriate technical field can select equipment with the necessary resolution, conduct the test, and determine whether or not the product passes the test.

3. EQUIPMENT/MATERIALS

3.1. The list of necessary test equipment and materials follows:

3.1.1. Two channel thermal tip recording system (Gould Model No. RS3200) with carrier amplifier (Model No. 13-4615-35) or equivalent.

Approvals:	1st Level	2nd Level	3rd Level

3.1.2. Mechanical Breather with 622 Kg.m/min. Cam as per U.S. BOM Drawings C-1748 (3/17/69) Breathing Machine and B-1198 (3/6/69) Breathing Cam or equivalent.

3.1.3. ISI anthropometric test head with tube for measuring breathing resistance (International Safety Instruments - Model SR-085) or equivalent.

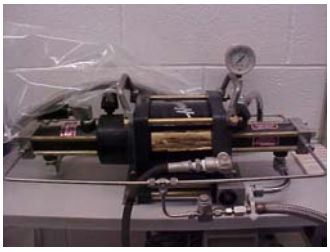
3.1.4. Temperature compensated pressure transducer (Validyne Engineering Model No. DP45) or equivalent.

3.1.5. Electric Timer, calibrated to hundredths of a minute (Precision Scientific Company) or equivalent.

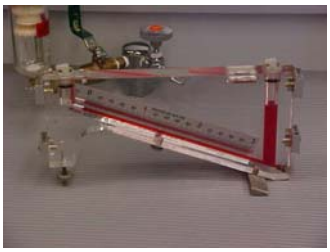
3.1.6. Wet Test - Gas Meter (American Meter Company - Model AL17-1), 1 liter per rev. or equivalent.

3.1.7. Check Valve.

3.1.8. Flow Control Valve (Gas Valve).



3.1.9. Haskel Oxygen Pump (6000psig) - Model 17495-AGD-30 or equivalent.



3.1.10. Dwyer Slant Manometer 0-3", F. W. Dwyer Manufacturing Co., Michigan City, Indiana or equivalent.

4. TESTING REQUIREMENTS AND CONDITIONS

4.1. Prior to beginning any testing, all measuring equipment to be used must have been calibrated in accordance with the manufacturer's calibration procedure and schedule. At a minimum, all measuring equipment utilized for this testing must have been calibrated within the preceding 12 months using a method traceable to the National Institute of Standards and Technology (NIST).

4.2. The compressed gas cylinder must meet all applicable Department of Transportation requirements for cylinder approval as well as for retesting/requalification.

4.3. Normal laboratory safety practices must be observed. This includes all safety precautions

described in the current ALOSH Facility Laboratory Safety Manual.

4.3.1. Safety glasses, lab coats, and hard-toe shoes must be worn at all times.

4.3.2. Work benches must be maintained free of clutter and non-essential test equipment.

4.3.3. When handling any glass laboratory equipment, lab technicians and personnel must wear special gloves which protect against lacerations or punctures.

5. PROCEDURE

Note: Reference Section 3 for equipment, model numbers and manufacturers. For calibration purposes use those described in the manufacturer's operation and maintenance manuals.

Test Procedure for Inhalation Breathing Resistance of Closed-Circuit, and Exhalation Breathing Resistance of Closed-Circuit and Closed-Circuit Positive Pressure

5.1. Turn on recorder and allow at least 30-minutes warmup.

PRE-TEST BALANCING OF TRANSDUCER AND RECORDER

5.1.1. Connect the transducer to be used during testing in parallel with a manometer. Attach the manometer and transducer to a pressure regulated air. A pinch clamp, used for slight pressure changes, is placed inline with two equal lengths of tubing for the manometer and transducer connections.

5.1.2. Connect the transducer cable to the carrier amplifier in the chart. Calibrate the recorder and carrier amplifier per instruction manual. Press the 5 mm/sec chart speed button. With no load applied to the transducer/manometer system, adjust the “POSITION” potentiometer on the chart recorder until the pen is at the mid-scale position. Press the STOP button on the chart recorder.

5.1.3. Apply a pressure of 0.5 inches of water to the transducer/manometer system. Press the 5 mm/sec chart speed button. Adjust the “CAL” potentiometer on the carrier amplifier until the pen on the chart recorder is at the next bold line left of mid-scale position. This represents 0.5 inches of water. Press the STOP button on the chart recorder.

5.1.4. Reduce the pressure to 0.0 inches of water to the transducer/manometer system. Press the 5 mm/sec chart speed button and check the chart recorder pen is at zero mid-scale position. Make any necessary adjustments. Press the STOP button on the chart recorder.

5.1.5. Repeat steps 5.1.3 and 5.1.4 with a pressures of 1.0 , 1.5, and 2.0 inches of water until no adjustments are necessary at the “CAL” potentiometer on the carrier amplifier.

5.1.6. After the calibration sequence is complete remove the pressure source from the

system.

5.2. Assemble the apparatus as shown in Figure 1. Mount the pressure transducer where shock and vibration are minimal.

5.3. Fill SCBA cylinder with oxygen to the DOT certified pressure (as stamped on bottle). A "+" indicates that the DOT pressure may be exceeded by 10%.

5.4. Assemble respirator. Mount facepiece on anthropometric head, taking care not to block resistance port below and left of nose, particularly if a nosecup is used. Make sure that the face seal is leak tight by blocking-off inhalation port of facepiece and inhaling through the breathing tube port exiting back of head. After building up several inches of negative pressure hold breath several seconds, which will enable you to determine if a leak is present. If there is a leak, readjust headstraps and facepiece position and repeat leak test until a seal is obtained.

5.5. Connect regulator or breathing tube to facepiece. Do not connect head to breathing machine. Turn on breathing machine and use a timer to determine that the cam is operating at 24 rpm. (This will give a 40 lpm volume). Stop breathing machine so that it is ready to begin on inhalation stroke.

5.6. Empty respirator breathing bag completely so that the demand valve will activate when the breathing machine is turned on. This will give maximum negative component of inhalation phase of breathing cycle. Do not use the first or second breathing cycles for inhalation resistance measurement.

5.7. Zero the recorder base-line to mid point of chart paper. (while this is being done the transducer should be connected to the recorder but the transducer should not have any load on it).

5.8. Connect head to breathing machine. Connect transducer to resistance port with a short length of tubing.

5.9. Open cylinder valve full and open main line valve full. Make sure the by-pass valve is closed.

5.10. Record all attenuation and speed settings directly on chart. Turn on breathing machine and recorder simultaneously. Operate recorder at change chart speed of 20 mm/sec. Cycle respirator from initial emission valve activation until the bag is full and the relief valve is operating. This will give the entire range of breathing resistance; i.e., from emission valve activation (maximum negative peak to relief valve operation (maximum positive peak). This may take several minutes.

5.11. When tracings are complete - Turn off breathing machine, recorder, and cylinder valve on SCBA and bleed down high-pressure air trapped in breathing circuit by removing the tubing from the transducer.

5.12. Retrieve the tracings on chart paper for data analysis.

Test Procedure for Inhalation Resistance of Positive Pressure Closed-Circuit

5.13. Follow steps (5.1., 5.2., 5.4., 5.5., 5.7., and 5.8.) from the procedure above.

5.14. Place a "T" between the Anthropometric Head and Breathing Machine.

5.15. Connect the open end to:

a) a one way exhalation check valve

b) a variable flow control valve

c) a wet test meter (1-3 LP revolution)

sequentially, with Tygon tubing.

5.16. Pressurize the oxygen cylinder to approximately 30 percent of service pressure.

5.17. Turn on the SCBA oxygen cylinder.

5.18. Set the exhalation portion flow thru the wet test meter to 2.5 $\pm$ 0.5 lpm by using the variable flow control valve with the breathing machine in operation at a 40 lpm volume at 24 RPM.

5.19. Once adjustment is complete, recharge the oxygen cylinder to approximately 30% of service pressure and replace in unit.

5.20. a) turn on SCBA oxygen cylinder (fully open),
b) turn on recorder (set to desired chart speed),
c) turn on breathing machine (as calibrated).

5.21. Cycle breathing machine as required until the admission/demand valve is activated. Continue until the admission valve has been activated three times.

5.22. When tracings are complete - Turn off breathing machine, recorder, and cylinder valve on SCBA and bleed down high-pressure air trapped in breathing circuit by removing the tubing from the transducer.

5.23. Retrieve the tracings on chart paper for data analysis.

5.24. Data Analysis

5.24.1. The recorder produces a trace showing the inhalation (negative) and exhalation (positive) breathing resistance. The inhalation and exhalation phase are the components for analysis. With a chart speed of 20 mm/sec., one complete cycle phase (inhale and exhale) should measure approximately 50 mm (See Figure 2.).

5.24.2. Looking at the tracing will show that the first spike of the inhalation phase is the result of the admission valve opening. The final spike in the exhalation phase will show the relief valve in operation; i.e., dumping excess oxygen since the breathing bag is full (see step 5.1.10. in test procedure).

5.24.3. The peak values of the inhalation tracing and the exhalation tracing[1] are in inches of water column height on the chart tracings. (See Figure 2.) These peak values should be examined at the beginning cycle and ending cycle.

5.24.4 For pressure-demand apparatus all exhalation values may not exceed 2.0 inches of water column height and the inhalation values may not drop below ambient pressure with and without emission valve in operation[2]. Exhalation resistance as with demand units is determined at maximum deflection ignoring the relief valve pressure spike.

Note: [1]When reading the inhalation tracing for a positive pressure closed circuit the exhalation portion of the breathing curve should be discarded as the test set up will give erroneous readings.

Note: [2]Discard first and second cycles to allow for apparatus system (breathing circuit) to equalize.

Note: This test should be done on a minimum of two respirators, or more if additional testing is required (42 CFR, Part 84, Sections 84.12, 84.30, and 84.60).

6. PASS\FAIL CRITERIA

6.1. The criterion for passing this test is set forth in 42 CFR, Part 84, Subpart G, Section 84.63(a)(c)(d), Subpart H, Section 84.70(a)(1); Volume 60, Number 110, June 8, 1995, and Federal Register, Volume 50, No. 222, November 18, 1985.

6.2. This test establishes the standard procedure for ensuring that:

84.63 Test requirements; general.

(a) Each respirator and respirator component shall when tested by the applicant and by the Institute, meet the applicable requirements set forth in subparts H through L of this part.

(c) In addition to the minimum requirements set forth in subparts H through L of this part, the Institute reserves the right to require, as a further condition of approval, any additional requirements deemed necessary to establish the quality, effectiveness, and safety of any respirator used as protection against hazardous atmospheres.

(d) Where it is determined after receipt of an application that additional requirements will be required for approval, the Institute will notify the applicant in writing of these additional requirements, and necessary examinations, inspections, or tests, stating generally the reasons for such requirements, examinations, inspections, or tests.

84.70 Self-contained breathing apparatus; description.

(a) Self-contained breathing apparatus, including all completely assembled, portable, self-contained devices designed for use as respiratory protection during entry into and escape from or escape only from hazardous atmospheres, are described as follows:

(1) Closed-circuit apparatus. An apparatus of the type in which the exhalation is rebreathed by the wearer after the carbon dioxide has been effectively removed and a suitable oxygen concentration restored from sources composed of:

(i) Compressed oxygen; or
(ii) Chemical oxygen; or
(iii) Liquid-oxygen.

Federal Register, Volume 50, No. 222, November 18, 1985.

The positive-pressure closed circuit self-contained breathing apparatus will maintain a positive pressure in the facepiece during all pressure and flow tests.

6.3. The inhalation resistance of closed-circuit pressure-demand apparatus shall not drop below ambient pressure with and without the emission valve in operation.

7. RECORDS\TEST SHEETS

7.1. All test data will be recorded on the SPECIAL TEST - POSITIVE-PRESSURE TEST - CLOSED-CIRCUIT, SELF-CONTAINED BREATHING APPARATUS test data sheet.

7.2. All videotapes and photographs of the actual test being performed, or of the test equipment shall be maintained in the task file as part of the permanent record.

7.3. All equipment failing any portion of this test will be handled as follows;

7.3.1. If the failure occurs on a new certification application, or extension of approval application, send a test report to the RCT Leader and prepare the hardware for return to the manufacturer.

7.3.2. If the failure occurs on hardware examined under an Off-the-Shelf Audit the hardware will be examined by a technician and the RCT Leader for cause. All equipment failing any portion of this test may be sent to the manufacturer for examination and then returned to NIOSH. However, the hardware tested shall be held at the testing laboratory until authorized for release by the RCT Leader, or his designee, following the standard operating procedures outlined in Procedure for Scheduling, and Processing Post-Certification Product Audits, RB-SOP-0005-00.

SPECIAL TEST - POSITIVE-PRESSURE TEST - CLOSED-CIRCUIT, SELF-CONTAINED BREATHING APPARATUS

Project No. : _____ Date: _____

Company : _____

Respirator Type: _____

Reference: 42 CFR, Part 84, Subpart G, Section 84.63(a)(c)(d), Subpart H, Section 84.70(a)(1); and Federal Register, Volume 50, No. 222, November 18, 1985.

Requirement: The positive pressure closed-circuit self-contained breathing apparatus will maintain a positive pressure in the facepiece during all pressure and flow tests.

Procedure: A breathing machine with a 622 Kg-n/min. cam operating at 24 RPM is connected to a tee. One leg of the tee is connected to an anthropometric head form. A pressure tap in the head form is connected to a transducer which in turn is connected to a strip chart recorder for recording the pressure tracing for calibration and record purposes. The check valve, then a variable flow control valve, then a wet test meter. The O_2 cylinder on the unit to be tested is pressurized to approximately 30%. While the breathing machine is operating the variable flow control valve is adjusted to give a flow on the wet test meter 2.5± 0.5 lpm. The breathing machine will be operated until the admission/demand valve has been activated a minimum of three times.

Results:

Facepiece pressure

Unit #1 > or = ambient _____ ; < ambient _____ ;

Unit #2 > or = ambient _____ ; < ambient _____ ;

Comments:

_____

_____

_____

_____

_____

Test Engineer: _____ PASS_____ FAIL_____

Figure 1.

Test Set-up for Measuring Inhalation and Exhalation Breathing Resistance.

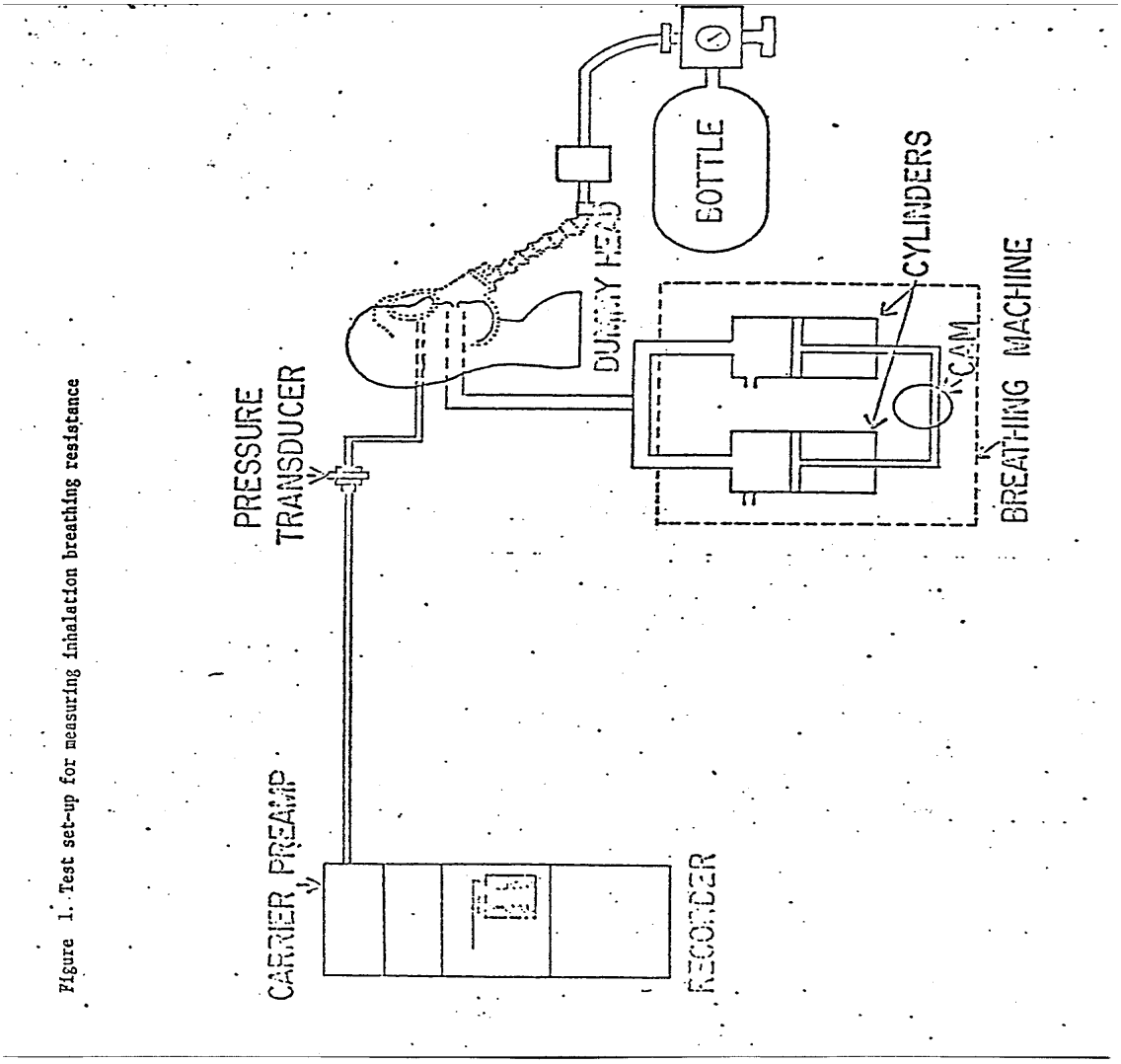
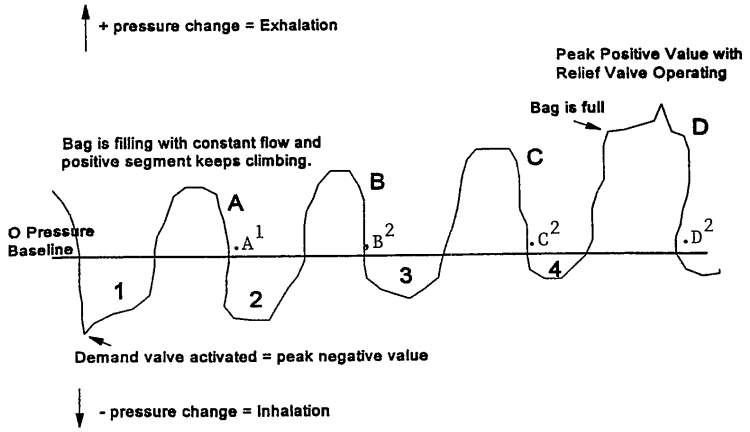


Figure 1. Test set-up for measuring inhalation breathing resistance

Figure 2.

Breathing Resistance Trace.



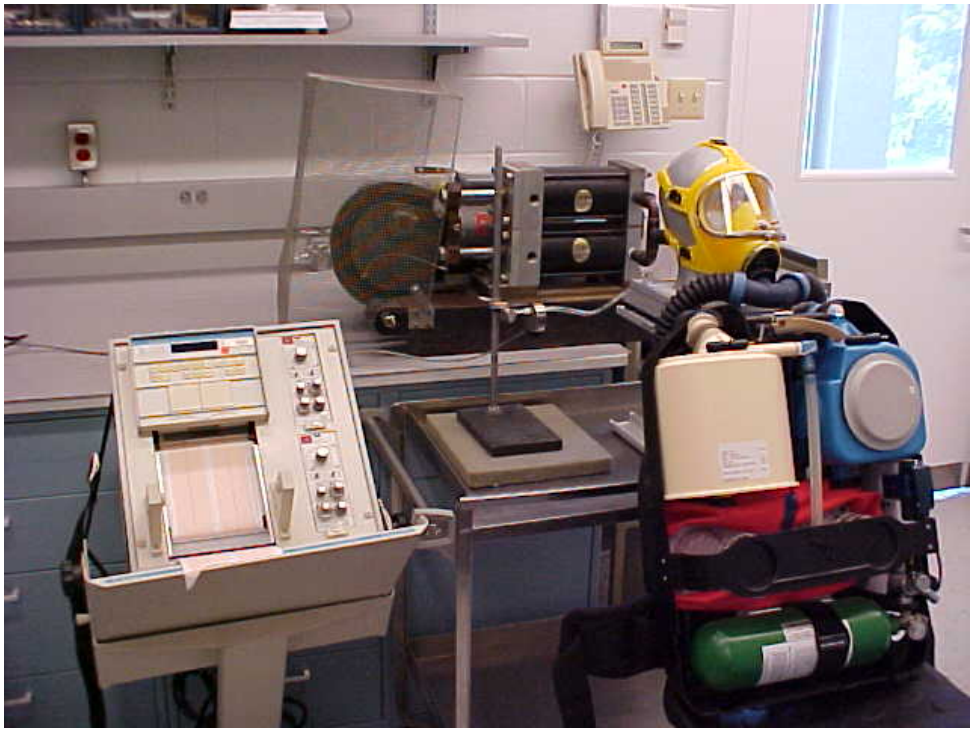
towards the baseline.

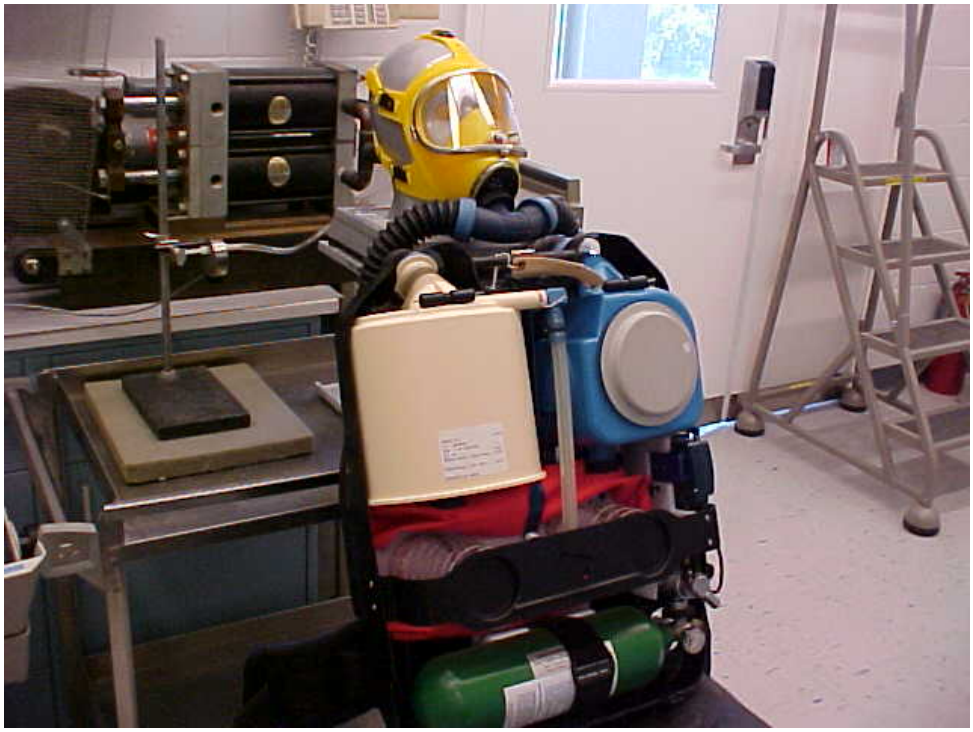
the zero pressure baseline.

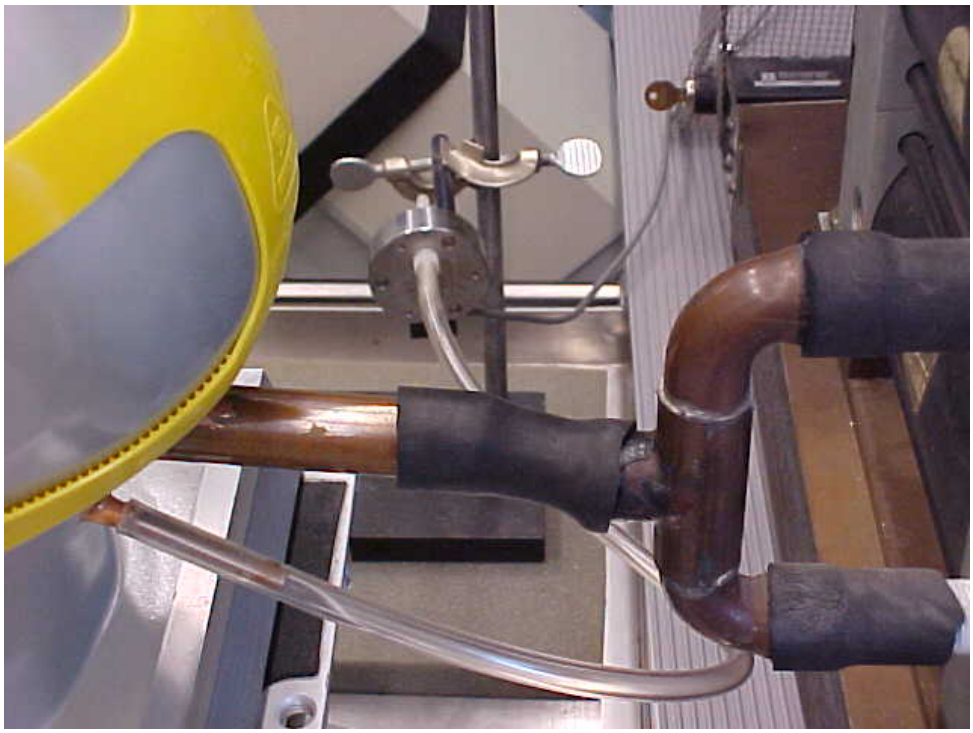
Note: This figure relates to the demand operation while the inserted points on the baseline, A^1, B^2, C^2, D^2 relates to the pressure demand operation and represents the maximum deflection allowable for this type of apparatus.

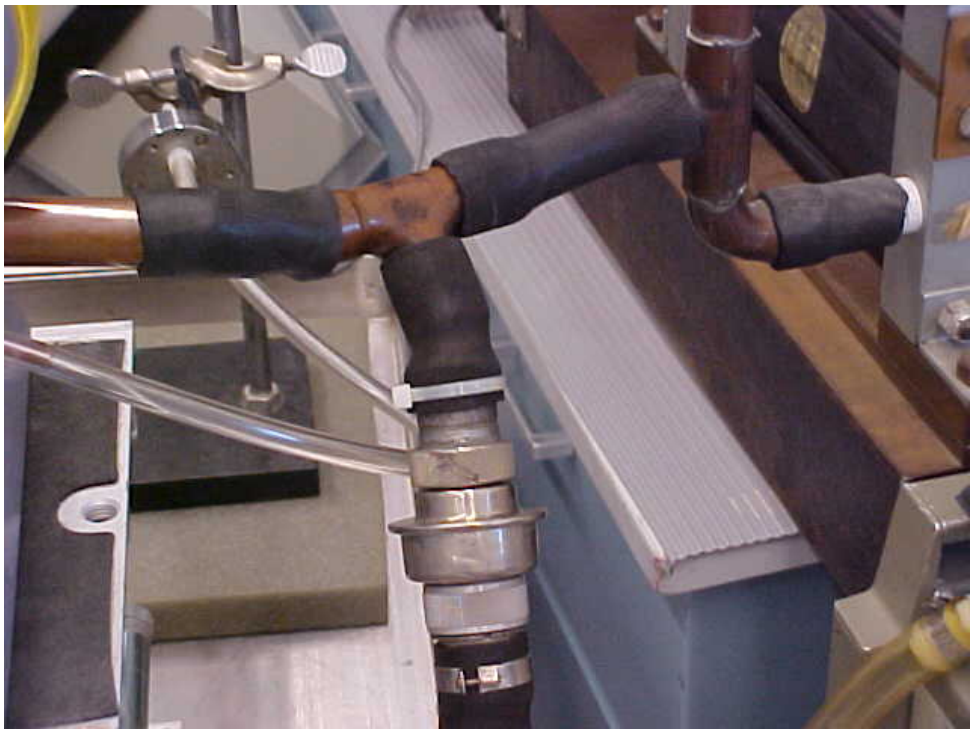
APPENDIX C--Figure 2

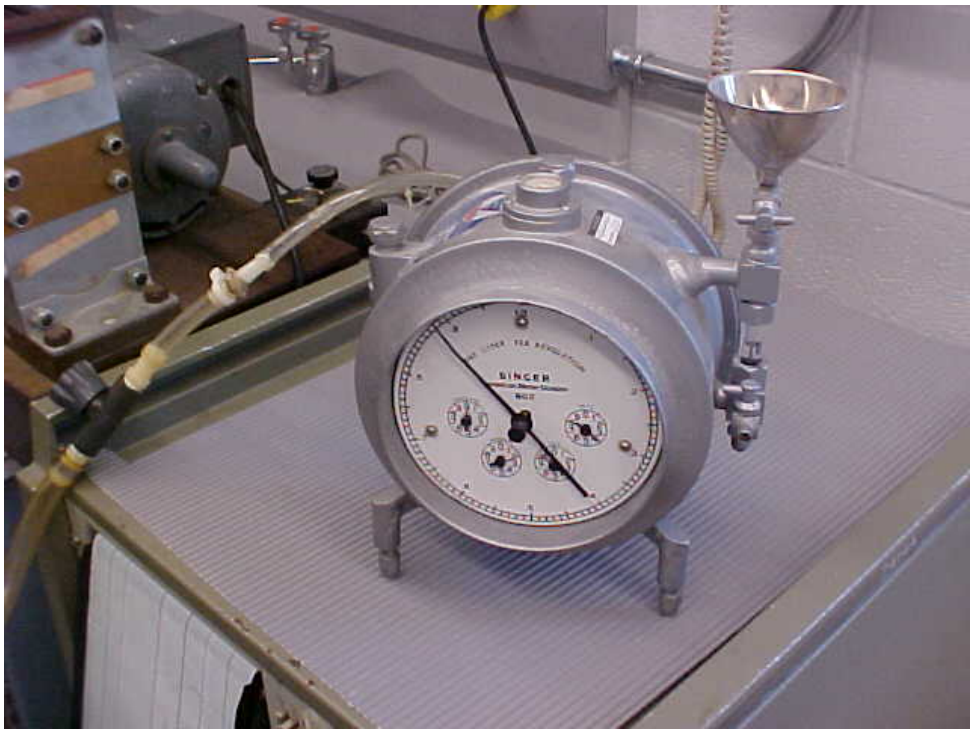
Breathing Resistance Trace







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Revision History

Revision	Date	Reason for Revision
1.0	24 May 2001	Historic document
1.1	21 September 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method