National Institute for Occupational Safety and Health
National Personal Protective Technology Laboratory
P.O. Box 18070
Pittsburgh, PA 15236

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DETERMINATION OF SAFETY RELIEF VALVE OPERATION - CLOSED-CIRCUIT, DEMAND AND 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 relief valve requirements on Closed-Circuit, Demand and 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), and Subpart H, Section 84.84(i)(1)(2)(3); Volume 60, Number 110, June 8, 1995.

2. GENERAL

This STP describes the Determination of Safety Relief Valve Operation - Closed-Circuit, Demand and 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. ISI Anthropometric Test heads with tube for measuring breathing resistance and air flows - Model SR-085 or equivalent.

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

3.1.4. Air pump of most any type (low flow capability) or house air source.

3.1.5. Haskel Oxygen Pump (6000psig) - Model 17495-AGD-30 used for pumping high pressure oxygen 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 during all testing.

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.

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 pressure as noted in the instruction manual. Make sure the pressure is within the DOT certified pressure range. 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 five 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 to determine that the cam is operating at 24 rpm. (This will give a 40 lpm volume).

5.6. 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).

5.7. Connect the anthropocentric head with the facepiece to the breathing machine. Connect transducer to resistance port with a short length of tubing for all compressed oxygen systems which have a constant flow orifice. For all others including liquid air or oxygen, solid chemical oxygen generators (KO2, chlorate candles), demand only regulators et al., a positive flow pump is connected with a "T" between the transducer and anthropometric head.

5.8. Empty breathing bag completely by compressing bag by hand which dumps all bag volume through relief valve.

5.9. Record all attenuation and speed settings directly on chart paper. Turn on breathing machine and recorder simultaneously, and let operate at 5 mm/sec. and set attenuator to a low value which may have to be increased as bag inflates. Chart speed and attenuator settings may have to be changed to cover pressure range and to accentuate or null sensitivity desired for tracing since each unit's relief valve has response characteristics different from other unit's relief valve.

5.10. Turn on unit (oxygen cylinder) to activate the respirator constant dosage flow to approximately 1.5 lpm and allow several minutes for the bag to fill (approximately 5 - 6 liters) and the relief valve to open fully, which process can be determined by observing the pressure tracing on the recorder paper. If the respirator does not have a constant flow/dosage capability then turn on the pump placed in line and adjust for a low flow (i.e. less than 2 lpm) which can be monitored with a low capacity flow meter in line. If the pump has too high a flow rate capacity, it may be necessary to place a "T" in line between the pump tubing connection and the "T" in line between transducer and dummy head. The open end of the "T" will dump excess flow overboard and a piece of Tygon tubing with screw clamp may be installed to gain fine control of flow rate.

5.11. A series of five or more tracings should be obtained for analysis since spring loaded valves tend to take set. Such cycling will relax valve and results of additional tracings will be reproducible within a narrow range.

5.12. When tracings are complete - Turn off breathing machine, recorder, and cylinder valve (or pump if used) and bleed down high pressure oxygen trapped in breathing hose and/or regulator lines by opening by-pass valve, shut by-pass off.

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

5.14. Data Analysis

5.14.1. The recorder produces a trace showing the bag pressure increase with time and flow.

5.14.2. The tracing will be different from respirator to respirator since bag/ relief valve characteristics are specific to unit design and operations. Generally most tracings fall into two curve types (see Figure 2).

a. Trace A shows a curve type in which the bag fills and bag folds pop out at points such as B, C and D. In order to obtain the bag full point a small ruler should be laid on the trace at point E where the relief valve is opening and follow the final slope until departure from that slope occurs. This point F is where the bag is considered full. Point G is the point at which the relief valve is fully open. The segment E to G is not used in final slope determination since the relief valve is opening gradually giving a rounded segment.

b. Trace B shows a curve type in which the bag full point and relief valve open point as well as slope rise points are relatively sharply defined. The bag is filling at points A to B. This point is determined by laying a ruler on the slope and determining the departure location from this slope. This point B is where the bag is full, while line D is the relief valve fully open point. Segments B-B1 and C-C1 are not used in slope determination since they are rounded segments and not specifically definable with reference to actual slope.

5.14.3. The first and second tracing may be eliminated if cycling indicates need for

reproducibility.

5.14.4. All values may not exceed 69 mm for relief valve fully open operation and the difference between the bag full point and relief valve fully open level must be 13 mm for acceptance.

5.14.5. The range allowed after a test tolerance is 0.28" H_2O to 0.75"H_2O. All values must fall within this range.

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), and Subpart H, Section 84.84(i)(1)(2)(3); Volume 60, Number 110, June 8, 1995.

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

84.84 Hand-operated valves; minimum requirements.

(i) Safety relief valves or systems, designed and constructed to release excess pressure in the breathing circuit, shall be provided on closed-circuit apparatus, and shall meet the following requirements:

(1) The relief valve or system shall operate automatically when the pressure in the breathing circuit on the inhalation side of the breathing bag reaches 13 mm. (one-half inch) water-column height of pressure above the minimum pressure required to fill the breathing bag, within the breathing resistance requirements for the apparatus.

Note: The range allowed after a test tolerance is 0.28" H_2O to 0.75"H_2O. All values must fall

within this range.

(2) The relief valve or system shall be designed to prevent external atmospheres from entering the breathing circuit.

(3) The relief valve or system shall be designed to permit manual overriding for test purposes and in the event of a failure in the valve or system.

7. RECORDS\TEST SHEETS

7.1. All test data will be recorded on the SAFETY RELIEF VALVE OPERATION, CLOSED-CIRCUIT, SELF-CONTAINED BREATHING APPARATUS test data sheet.

7.2. All videotapes and photographs of the actual test being performed, or of the tested 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.

SAFETY RELIEF VALVE OPERATION, CLOSED-CIRCUIT, SELF-CONTAINED BREATHING APPARATUS

Project No : _____ Date: _____

Company : _____

Respirator Type: _____

Reference: 42 CFR, Part 84, Subpart H, 84.84(i)(1)(2)(3).

Requirement: The relief valve or system shall operate automatically when the pressure in the breathing circuit on the inhalation side of the breathing bag reaches 13 mm. (one-half inch) water-column height of pressure above the minimum pressure required to fill the breathing bag, within the breathing resistance requirements for the apparatus.

Results: Unit #1

Test #	Bag Full (inches H_2O)	Release (inches H_2O)	Difference (inches H_2O)
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____
5.	_____	_____	_____
6.	_____	_____	_____

Comments :

_____

_____

_____

_____

_____

Results: Unit #2

Test #	Bag Full (inches H_2O)	Release (inches H_2O)	Difference (inches H_2O)
1.			
2.			
3.			
4.			
5.			
6.			

Comments :

Test Engineer: _____ PASS_____ FAIL_____

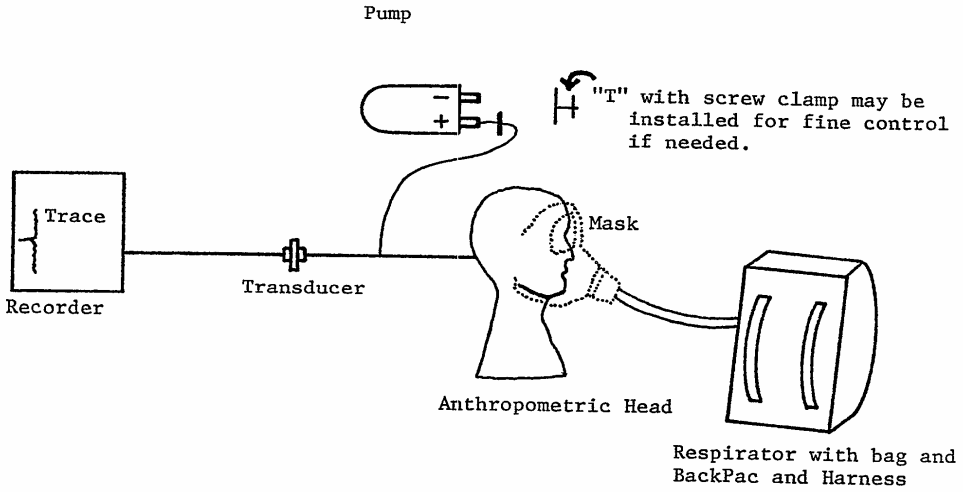
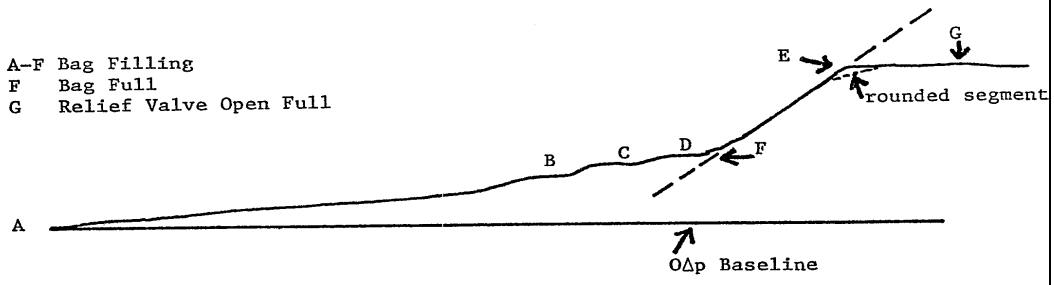
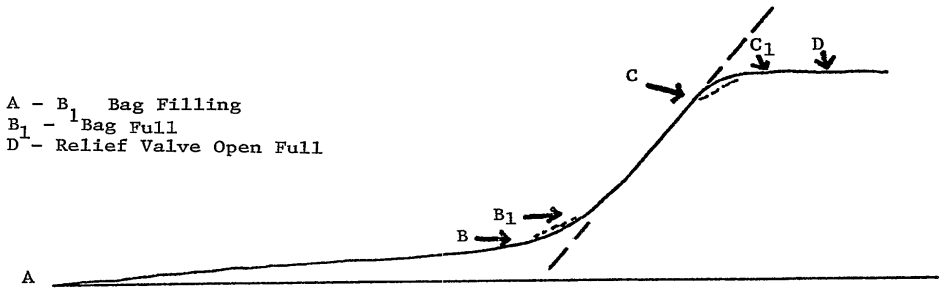


Figure 1. Test Setup

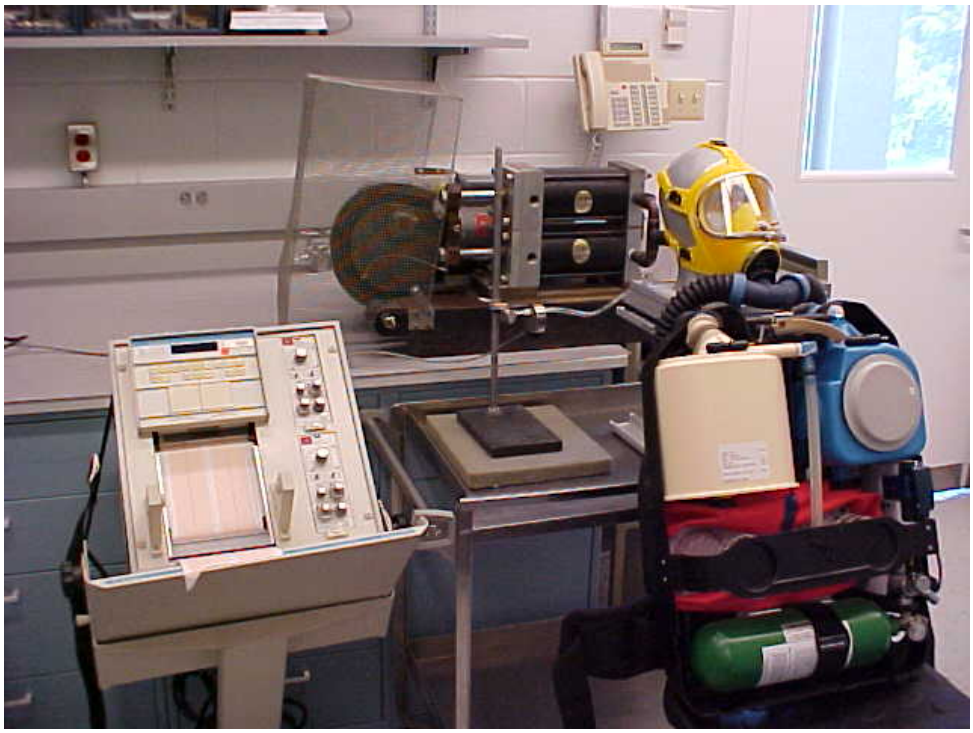


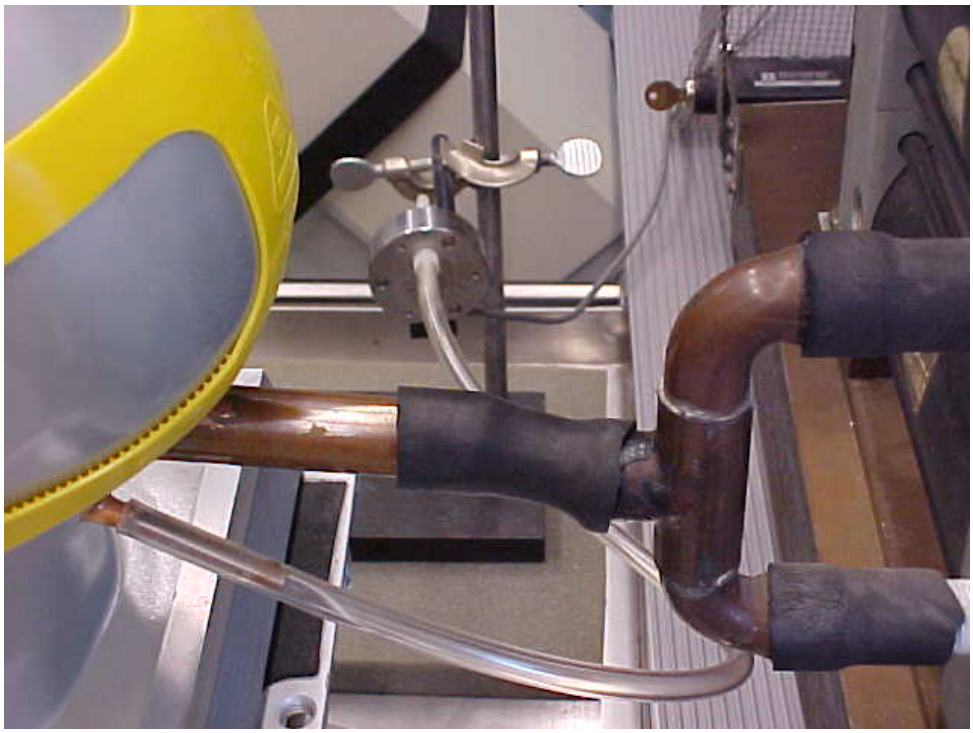
Trace A



Trace B

Figure 2. Relief Valve Trace



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OXYGEN ON

Revision History

Revision	Date	Reason for Revision
1.0	21 February 2000	Historic document
1.1	26 September 2005	Update header and format to reflect lab move from Morgantown, WV No changes to method