National Institute for Occupational Safety and Health National Personal Protective Technology Laboratory P.O. Box 18070 Pittsburgh, PA 15236			
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Level 1	Level 2	Level 3	Level 4

STANDARD TEST PROCEDURE (STP) FOR CAPACITY TEST OF CLOSED-CIRCUIT ESCAPE RESPIRATORS (CCER) AT MANUFACTURER's RECOMMENDED MINIMUM TEMPERATURE

1. PURPOSE

1.1 This procedure establishes the test for ensuring that the level of protection provided by the breathing gas capacity at the manufacturer-recommended minimum temperature on Closed-Circuit Escape Respirators (CCER) submitted for Approval, Extension of Approval, or examined during Certified Product Audits, meet the minimum certification standards set forth in Sections 84.303 and 84.304, of Subpart O−Closed Circuit Escape Respirators updated requirements to 42 CFR, Part 84, Volume 60, Number 110, June 8, 1995 as published in Federal Register / Vol. 77, No. 46 / Thursday, March 8, 2012 / Rules and Regulations pp. 14168-14197.

2. GENERAL

2.1 This Standard Procedure describes the Determination of Breathing Gas Capacity at the manufacturer recommended minimum temperature for Closed-Circuit Escape Respirators test in sufficient detail such 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/INSTRUMENTS AND MATERIALS

3.1 The equipment and materials necessary to perform the following measurements are specified in Section 3 of Standard Operating Procedure for a Breathing and Metabolic Simulator when Performing Capacity and Performance Tests on Closed-Circuit Escape Respirators.

3.2 Environmental chamber:

3.2.1 Russells Technical Products Temp/Humidity Chamber, model RDV100-705 or equivalent

3.2.2 Research, Inc. Micristar Controller model 828E or equivalent

3.2.3 Envirotronics Temp/Humidity Chamber model EVH-100-2-705 S/N 04911590 or equivalent

3.2.4 Research, Inc. Micristar Controller model 828-E11 S/N 11522 or equivalent

3.2.5 Honeywell Truline Chart Recorder model 910-80714 or equivalent

3.3 Note: The Breathing and Metabolic Simulator (BMS) must be located adjacent to the Environmental chamber so that the CCER to be tested may be placed inside the chamber and through an appropriate connection attached to the BMS for this test.

4. TEST REQUIREMENTS AND CONDITIONS

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

4.2 Normal laboratory safety practices must be observed. These include safety precautions given in the current *NIOSH-Pittsburgh Health and Safety Manual*, Job Hazard Analysis (JHA), work instruction documents and test equipment manufacturer recommended practices.

4.3 Any laboratory using this procedure to supply certification test data to NPPTL will be subject to the provisions of the NPPTL Supplier Qualification Program (SQP). This program is based on the tenets of ISO/IEC 17025, the NIOSH Manual of Analytical Methods and other NIOSH guidelines. An initial complete quality system audit and follow-on audits are requirements of the Program. Additional details of the Program and its requirements can be obtained directly from NPPTL.

4.4 Additional test requirements and conditions necessary to perform the following measurements are specified in Standard Operating Procedure for a Breathing and Metabolic Simulator when Performing Capacity and Performance Tests on Closed-Circuit Escape Respirators.

4.5 Conduct the capacity test at manufacturer recommended minimum temperature on two units submitted for approval.

4.6 Prior to beginning the Capacity Test Procedure, the CCER will be opened and visually inspected using manufacturer’s and NIOSH inspection criteria. This inspection will include:

4.6.1 Applying a -300mm H_2O vacuum to assess the integrity of the breathing tube and associated parts.

4.6.2 A phenolphthalein swab to detect alkaline chemicals present in the CCER user interface.

5. PROCEDURE

5.1 Storage at manufacturer-recommended minimum temperature

5.1.1 The CCER unit to be tested will be readied for use and placed inside the environmental chamber.

5.1.1.1 The respiratory inlet covering (typically a mouth bit) will be sealed air-tight (typically with a stopper).

5.1.2 The controlled temperature of the chamber will be adjusted to the manufacturer-recommended cold temperature limit specified under 42 CFR, Part 84 Subpart O Section 84.302 (h) (1) (v).

5.1.3 The CCER unit to be tested will first be maintained in the chamber at the cold temperature limit for at least 24 hours.

5.1.4 Just before the capacity test is begun, the stopper is removed from the respiratory inlet covering which is then attached to the BMS.

5.1.5 The controlled temperature of the chamber is maintained at the cold temperature limit throughout the capacity test.

5.2 Capacity Test Requirements and Conditions

5.2.1 Capacity tests will continuously monitor the stressors listed in Table 1. The stressors will be measured at the interface between the CCER and the BMS "mouth" by instruments capable of breath-by-breath measurement. Stressor measurements will be evaluated as one-minute averages. The operating (overall) averages of each stressor will be calculated upon the completion of each test as the average of the one-minute measurements of the stressor recorded during the test.

Table 1: Monitored Stressors and their Acceptable Ranges

Stressor	**Acceptable Range Operating Average**	**Acceptable Range Excursion**
Average inhaled CO_2	<1.5%	≤4%
Average inhaled O_2	>19.5%	≥15%
Peak Breathing Pressures	$\Delta P \leq 200$ mm H_2O	$-300 \leq \Delta P \leq 200$ mm H_2O
Wet-bulb temperature	<43˚C	≤50˚C

5.2.2 Capacity tests will conclude when the stored breathing gas supply has been fully expended.

5.2.3 Each unit will be tested at a constant work rate, depending on the capacity specified by the manufacturer, according to the requirements specified in Table 2.

Table 2: Capacity Test Requirements (All volumes are given at standard temperature (0°C) and pressure (760 mm Hg), dry)

Capacity Rating	**Capacity (L)**	$\dot{V}O_2$ **(L/min)**	$\dot{V}CO_2$ **(L/min)**	$\dot{V}e$ **(L/min)**	**RF (Breaths/min)**
Cap 1	$20 \leq L \leq 59$	2.50	2.50	55	22
Cap 2	$60 \leq L \leq 79$	2.00	1.80	44	20
Cap 3	$L \geq 80$	1.35	1.15	30	18

$\dot{V}O_2$=volume of oxygen consumed/min; $\dot{V}CO_2$=volume of carbon dioxide produced/min

$\dot{V}e$ = ventilation rate; RF = respiratory frequency

5.3 Capacity Test with BMS

5.3.1 The procedure is specified in Section 5 of Standard Operating Procedure for a Breathing and Metabolic Simulator when Performing Capacity and Performance Tests on Closed-Circuit Escape Respirators.

5.3.2 The protocol used must correspond to the capacity test requirements in § 84.304 of subpart O, Table 2 for the capacity rating specified by the CCER manufacturer which is either Cap 1, Cap 2, or Cap 3.

5.4 Data analysis

5.4.1 Determine the achieved capacity for the test as follows:

5.4.1.1 Determine the completion time as the time elapsed from test start to when the gas supply is fully expended. Expended gas supply is usually indicated when the breathing bag is empty, or (if present) the O_2 cylinder is empty, and (as a result) the peak inhalation pressure begins to spike below -300 mm H_2O.

5.4.1.2 Calculate the achieved capacity as the product of the completion time (in minutes) and the VO_2 (L/minute) used in the test protocol.

5.4.2 Calculate the overall average for each of the stressor measurements using the one-minute average values from the test start to when the gas supply is fully expended.

6. PASS/FAIL CRITERIA

6.1 The apparatus fails the test and certification if:

6.1.1 Any average stressor measurement (as the overall average from test start to when the gas supply is fully expended) is outside the acceptable operating average range shown in Table 1 (middle column).

6.1.2 If from the test start up to the completion time any one-minute average stressor measurement is outside the acceptable excursion range shown in Table 1 (last column).

6.2 The apparatus fails certification if the achieved capacity is below the minimum capacity indicated for the rating in Table 2.

7. RECORDS AND TEST SHEETS

7.1 Test summary

Device ID	**Test**	**Test date**	**Completion time**	**Calculated capacity**		**Indicate minimum capacity**
	Capacity at cold temperature limit					
	Capacity at cold temperature limit					

8. APPENDICES

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9. REVISION HISTORY

Revision	Date	Reason for Revision
00	18 August 2011	Initial Review
1.0	22 December 2011	Administrative changes – Document number changed
2.0	3 April 2012	Administrative changes were made to include information for the release of the proposed rule