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DETERMINATION OF CAPACITY TEST OF CLOSED-CIRCUIT ESCAPE RESPIRATORS (CCER) AT MANUFACTURER's RECOMMENDED MINIMUM TEMPERATURE

1. PURPOSE

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

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

Approvals: First Level	Second Level	Third Level	Fourth Level

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 to allow the CCER to be tested while inside the chamber using appropriate means of connection.

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 placed inside the environmental chamber.

5.1.2. The controlled temperature of the chamber will be adjusted to the manufacturer-recommended cold-temperature operating limit specified in the application and provided in the users instructions.

5.1.3. The CCER unit to be tested will then 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, using care not to activate the unit prematurely, the sample unit will be opened and deployed into the as-worn configuration and 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.

Note: Stressor measurements will be evaluated as one-minute averages. The overall operating averages for 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, excursion pressure limits are exceeded, average inhaled carbon dioxide reaches 4%, or average inhaled oxygen falls below 15%.

5.2.3. Each unit will be tested at a constant work rate, which depends 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)**	**CO_2 (L/min)**	**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

O_2=volume of oxygen consumed/min; CO_2=volume of carbon dioxide produced/min

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 meet the capacity test requirements Table 2 corresponding to the capacity rating specified by the CCER manufacturer which is 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, or the time when any of the monitored stressors in Table 1 exceed allowable limits.

Note: Expended gas supply can be indicated by an empty breathing bag, an empty O_2 cylinder (if present), and (as a result) peak inhalation pressure at or below -300 mm H_2O, or a combination of these.

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. ATTACHMENTS

8.1. None

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
		Former document number - STP-00001-PSDB-0009
0.1	4 April 2014	New document number to reflect numbering in the approval library, normalization of format. The only changes made in the procedure are in section 5.1. The order of events has been changed to reflect the fact that that the CCER sample will undergo the 24-hour, cold soak in the as-carried (packaged) configuration. Notes have been added at sections 5.2.1. and 5.4.1.1. to clarify termination criteria and data evaluation. The cold operating temperature has been clarified in section 5.1.2. Document accessibility enhancements affected. Other minor grammatical edits have been applied for clarity, but there are no changes to procedure from historical document.