

Draft for Discussion

June 20, 2005

Concept Standard for
Chemical, Biological, Radiological, and Nuclear (CBRN),
Full Facepiece, Closed-Circuit,
Self-Contained Breathing Apparatus (SCBA)

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1.0 Purpose

The purpose of this standard is to specify minimum requirements to determine the effectiveness of a full facepiece, closed-circuit, self-contained breathing apparatus (CC-SCBA) used for entry into chemical, biological, radiological, and nuclear (CBRN) atmospheres that are immediately dangerous to life or health (IDLH). The CC-SCBA must meet the minimum requirements identified in the following paragraphs:

- Paragraph 2.0 - Requirements Specified in Title 42 Code of Federal Regulations (CFR), Part 84;
- Paragraph 3.0 - Special Requirements for CBRN Use;
- Paragraph 4.0 - Quality Assurance Requirements; and
- Paragraph 5.0 - General Requirements

2.0 Title 42 Code of Federal Regulations (CFR), Part 84

The following paragraphs of 42 CFR, Part 84 are applicable:

2.1 42 CFR, Part 84, Subparts A, B, D, E, F, and G

Subpart A: General Provisions

Subpart B: Application for Approval

Subpart D: Approval and Disapproval

Subpart E: Quality Control

Subpart F: Classification of Approved Respirators

Subpart G: General Construction and Performance Requirements

2.2 42 CFR, Part 84, Subpart H (Self-Contained Breathing Apparatus); the following paragraphs apply

- 84.70 Self-contained breathing apparatus; description. paragraph (a)(1).
- 84.71 Self-contained breathing apparatus; required components.
- 84.72 Breathing tubes; minimum requirements. Flexible breathing tubes used in conjunction with breathing apparatus shall be designed and constructed to prevent: (a) Restriction of free head movement; (b) Disturbance of the fit of facepieces and mouthpieces; (c) Interference with the wearer's activities; and (d) Shutoff of airflow due to kinking, or from chin or arm pressure.
- 84.73 Harness; installation and construction; minimum requirements.
- 84.74 Apparatus containers; minimum requirements.
- 84.75 Half-mask facepiece, full facepiece, mouthpieces; fit; minimum requirements. [full facepiece only] paragraphs (a), (b), and (d).
- 84.76 Facepiece; eyepieces; minimum requirements.
- 84.77 Inhalation and exhalation valves; minimum requirements.
- 84.78 Head harnesses; minimum requirements.
- 84.79 Breathing gas; minimum requirements.
- 84.80 Interchangeability of oxygen and air prohibited.

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- 84.81 Compressed breathing gas and liquefied breathing gas containers; minimum requirements.
- 84.82 Gas pressure gages; minimum requirements.
- 84.83 Timers; elapsed time indicators; remaining service life indicators; minimum requirements.
- 84.84 Hand-operated valves; minimum requirements.
- 84.85 Breathing bags; minimum requirements.
- 84.86 Component parts exposed to oxygen pressures; minimum requirements.
- 84.87 Compressed gas filters; minimum requirements.
- 84.88 Breathing bag test.
- 84.89 Weight requirement.
- 84.90 Breathing resistance test; inhalation. paragraphs (a) and (c).
- 84.91 Breathing resistance test; exhalation. paragraph (e).
- 84.92 Exhalation valve leakage test.
- 84.94 Gas flow test; closed-circuit apparatus.
- 84.96 Service time test; closed-circuit apparatus.
- 84.97 Test for carbon dioxide in inspired gas; open- and closed-circuit apparatus; maximum allowable limits. paragraph (b).
- 84.98 Tests during low temperature operation.
- 84.99 Man tests; testing conditions; general requirements
- 84.100 Man tests 1, 2, 3, and 4; requirements.
- 84.101 Man test 5; requirements.
- 84.102 Man test 6, requirements.
- 84.103 Man tests; performance requirements.

3.0 Special Requirements for CBRN Use:

3.1 Operational Performance Requirement

When tested on the NIOSH Automated Breathing and Metabolic Simulator (ABMS) performing the protocol described in Table 2.b. composed of the workloads in Table 2.a., the CC-SCBA shall not exceed the ranges of stressor levels listed in Table 1. The facepiece of the CC-SCBA being tested shall be mounted on the ABMS headform such that an initial pressure of 25.4 ± 2.5 mm, w.g. (1.0 ± 0.1 in, w.g.) below ambient shall not decay by more than 5.1 mm, w.g. (0.2 in, w.g.) in 5 seconds. The remaining components shall be mounted on a mannequin torso to simulate the wearing position during the test. The CC-SCBA shall be fully charged and ready to use as defined by the manufacturer's instructions. The CC-SCBA, including the facepiece, shall be mounted on the headform and mannequin torso in accordance with the manufacturer's specifications of the apparatus. Ambient test conditions of the operational performance test are as follows:

Ambient temperature: $22 \text{ }^\circ\text{C} \pm 3 \text{ }^\circ\text{C}$ ($72 \text{ }^\circ\text{F} \pm 5 \text{ }^\circ\text{F}$)

Relative humidity: $50\% \pm 25\%$

Barometric pressure: $725 \text{ }^{+50/-70}$ mm Hg ($28.54 \text{ }^{+1.97/-2.75}$ in. Hg)

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Table 1—Performance requirements

Parameter	Requirement
CO ₂ concentration of dry breathing gas during inhalation	≤ 4% by volume
O ₂ concentration of dry breathing gas during inhalation	≥ 15 % by volume
Wet-bulb temperature of breathing gas during inhalation	≤ 50°C
Maximum breathing gas pressure	≤ 200 mm, w.g.
Minimum breathing gas pressure	≥ 0 mm, w.g.

Table 2.—Test regimen

Table 2.a.—Parameters

Parameter	Work load A	Work load B
Ventilation rate, liters/min, at T _{lung} , P _{local} and 100% RH	100	40
Respiratory frequency, breaths/min	30.0	18.0
Oxygen consumption rate, liters/min, STPD	3.2	1.35
Carbon dioxide production rate, liters/min, STPD	3.4	1.15

Table 2.b.—Protocol

Apparatus rated period	Work load	Starting time (minutes)	Duration (minutes)
Hour 1	A	0	12
	B	12	43
Hour 2	A	55	5
	B	60	25
Hour 3	A	85	5
	B	90	25
Hour 3	A	115	5
	B	120	25
Hour 3	A	145	5
	B	150	30
Hour 4 and beyond	B	180	60

3.2 Environmental Temperature Operational Performance Requirement

- 3.2.1 The CC-SCBA shall be tested for environmental operational performance and meet the requirements in Table 1 except for the Wet-bulb temperature breathing gas requirement during each of the environmental conditions indicated in Table 3. The environmental sequence test conditions shall start with the first environmental condition listed at the top of Table 3, and end with the last test listed at the bottom of Table 3. After conducting the operational performance test

in each environmental condition, the CC-SCBA shall be placed in an ambient environment of $22\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ ($72\text{ }^{\circ}\text{F} \pm 5\text{ }^{\circ}\text{F}$) with a relative humidity of 50 percent ± 25 percent for a minimum 12-hour dwell.

- 3.2.2 The facepiece of the CC-SCBA being tested shall be mounted on the ABMS headform and the other components shall be mounted on a mannequin torso to simulate a typical wearing position, both of which shall be in the environmental chamber. The CC-SCBA, including the facepiece, shall be mounted on the headform and mannequin torso in accordance with the manufacturer's specifications of the apparatus.
- 3.2.3 The dwell period between environmental test conditions shall be used for replacing those components or materials expended during normal CC-SCBA operation, and for visually inspecting the apparatus for any gross damage that could cause an unsafe test condition.

Table 3.—Environmental test conditions

Environment	Temperature	Test duration	Test procedure
Cold	$-32\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($-25\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$)	Cold soak for a minimum of 12 hours	Perform test at $-32\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($-25 \pm 10\text{ }^{\circ}\text{F}$)
Hot	$71\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($160\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$)	Hot soak for a minimum of 12 hours	Perform test at $71\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($160\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$)
Cold temperature shock	$71\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($160\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$) transferred to $-32\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($-25\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$); Test temperature shall be $-32\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($-25\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$)	Hot soak for a minimum of 12 hours; initiate test within 3 minutes in cold chamber	Initiate test within 3 minutes after transferring apparatus to cold chamber
Hot temperature shock	$-32\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($-25 \pm 2\text{ }^{\circ}\text{F}$) transferred to $71\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ ($160\text{ }^{\circ}\text{F} \pm 2\text{ }^{\circ}\text{F}$); Test temperature shall be $71\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ ($160\text{ }^{\circ}\text{F} \pm 10\text{ }^{\circ}\text{F}$)	Cold soak for a minimum of 12 hours; initiate test within 3 minutes in hot chamber	Initiate test within 3 minutes after transferring apparatus to hot chamber

3.3 Vibration Endurance Requirement

- 3.3.1 The CC-SCBA shall meet the performance requirements of Table 1 after being subjected to the vibration endurance testing. The vibration testing shall be conducted in accordance with Section 8.3.5.3 of National Fire Protection Association (NFPA) 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Emergency Services, 2002 Edition. The holding box shall be constructed with a minimum of 1 large compartment and 1 smaller compartment. The sides and base of the holding box shall be constructed of 6 mm (1/4 inch) stainless steel and the top of the compartments shall remain open. The compartment size shall not be less than that would allow a minimum distance of

25.4 mm (1 inch) between the sidewall and any component of the test item and shall not exceed a maximum distance that would allow the test item to rotate from the original axis of intended orientation. The SCBA facepiece and those components that attach directly to the facepiece, excluding regulators, shall be placed in the smaller compartment of the holding box unrestrained with the facepiece looking up. The SCBA including the regulators and hoses shall be placed in the larger compartment unrestrained with the SCBA back-plate resting on the bottom of the holding box. The test shall be conducted with the specimens in smaller and larger compartments oriented in each of the following two positions: SCBA and facepiece axes perpendicular to direction of tester movement and SCBA and facepiece axes parallel to direction of tester movement. The total test duration is 180 minutes consisting of two 90-minute periods for each orientation of the apparatus. The oxygen cylinder shall be replaced by a surrogate cylinder during the vibration test.

3.4. Fabric Flame Resistance Requirement

- 3.4.1 The fabric used to secure the CC-SCBA to the wearer shall have an average char length of no more than 4.0 inches (101.6 mm), an average after-flame of no more than 2 seconds, and shall not melt or drip when testing specimens in accordance American Society for Testing and Materials (ASTM) D 6413, Standard Test Method for Flame Resistance of Textiles (Vertical Test). A Wire Lattice Test Frame specified in Section 8.4.8.2. of the NFPA 1981, 2002 Edition shall be used to hold test specimens that not do not comply with Section 3.4.3. of this standard.
- 3.4.2 Five specimens of each fabric component of the apparatus shall be tested for fabric flame resistance. Prior to testing, the specimens of each fabric component of the apparatus shall first be conditioned by five wash and drying cycles in accordance with procedures specified in Machine Cycle 1, Wash Temperature V, Drying Procedure Ai, of AATCC 135, Dimensional Changes in Automatic Home Laundering of Woven and Knit Fabrics.
- 3.4.3 The test specimens shall be a minimum of 12 inches in length (305 mm) and 3 inches (75mm) in width.

3.5 Fabric Heat Resistance Requirement

The fabric used to secure the CC-SCBA to the wearer shall not melt or ignite when tested for heat resistance in accordance with NFPA 1981, 2002 Edition Section 8.5, Fabric Heat Tests.

3.6 Thread Heat Resistance Requirement

The thread used in the components of the CC-SCBA shall not melt or ignite when thread specimens are tested in accordance with NFPA 1981, 2002 Edition, Section 8.6, Thread Heat Tests.

3.7 Accelerated Corrosion Resistance Requirement

- 3.7.1 The CC-SCBA shall be tested for Accelerated Corrosion and any corrosion shall not prohibit the proper use and function as specified in the manufacturer's user instructions of any control or operating feature of the apparatus when tested for

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accelerated corrosion. In addition, the CC-SCBA shall meet the operational performance requirements described in Section 3.1 of this document.

3.7.2 The CC-SCBA and one set of consumable components, each in the stowed configuration according to the manufacturer's user instructions, shall be tested for accelerated corrosion in accordance with MIL-STD-810F, Environmental Test Methods, Method 509.4, Salt Fog.

3.7.2.1 The CC-SCBA and components shall be mounted on a test mannequin to simulate a typical wearing position as specified by the manufacturer's user instructions. The mannequin shall then be placed in the test chamber equalized at a temperature $35\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($95\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$). The CC-SCBA mounted on the mannequin shall be equalized to the test chamber for a minimum of 2 hours before initiating the salt fog.

3.7.2.2 The CC-SCBA and consumable components shall be exposed to a 5 percent \pm 1 percent salt fog for 24 hours. After the 24-hour salt fog exposure, the SCBA shall be removed from the salt fog chamber and be placed in a drying chamber set at $35\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($95\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$) for 24 hours.

3.7.2.3 The CC-SCBA and consumable components shall then be exposed to a second 24-hour cycle of salt fog and drying period as previously described.

3.7.3 After the two 24-hour periods of salt fog exposure and drying periods, the CC-SCBA shall be made operationally ready to use and shall meet the accelerated corrosion resistance requirement described in Section 3.7.1.

3.8 Particulate Resistance Requirement

3.8.1 The CC-SCBA shall meet the operational performance requirements described in Section 3.1 of this document while being exposed to dust and sand in accordance with MIL-STD-810F, Method 510.4, Procedure I – Blowing Dust. When testing the CC-SCBA for the particulate resistance requirement, the apparatus and components shall be mounted on a test mannequin in a manner typical of a user configuration that is integrated with the NIOSH ABMS, in accordance with the ABMS instruction manual. The CC-SCBA facepiece shall be mounted on a test headform in accordance with the CC-SCBA's user instructions that shall be connected to the test mannequin.

3.8.2 The simulator shall be operated at work load B as defined in Table 2. The test duration shall be 1 hour, and the ABMS shall be in operation throughout the entire test.

3.8.3 The particulate resistance requirement shall be tested in accordance with MIL-STD-810F, Method 510.4, Procedure I – Blowing Dust at the following conditions:

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- Air velocity: 533.4 m/min \pm 76.2 m/min (1750 ft/min \pm 250 ft/min)
- Temperature: 23 °C \pm 3 °C (72 °F \pm 5 °F)

3.9 Facepiece Lens Haze, Luminous Transmittance and Abrasion Resistance Requirement

3.9.1 The SCBA primary facepiece lens specimens shall not exhibit an average increase in haze greater than 14 percent when tested in accordance with the test procedures prescribed in NFPA 1981, 2002 Edition, for the facepiece lens abrasion resistance performance requirement.

3.10 Communications Performance Requirement

3.10.1 The SCBA shall meet or exceed the communications performance requirement identified in NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Emergency Services, 2002 Edition, when tested in accordance with the associated test procedures prescribed within NFPA 1981.

3.11 Heat and Flame Resistance Performance Requirement

3.11.1 The CC-SCBA and its accessories shall meet the following Heat and Flame Resistance requirements when tested in accordance with the procedure prescribed in Section 8.11.5 of NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Emergency Services, 2002 Edition and meet the breathing pressure requirement in Table 1 of Section 3.1:

3.11.1.1 When the CC-SCBA and its accessories are tested for heat and flame resistance performance, the components of either the SCBA or its accessories shall have an after-flame no greater than 2.2 seconds.

3.11.1.2 When the CC-SCBA and its accessories are tested for heat and flame resistance performance, no components of either the SCBA or its accessories shall separate or fail in such a manner that would cause the SCBA to be worn and used in a position not specified by the manufacturer's user instructions.

3.11.1.3 When the CC-SCBA and its accessories are tested for heat and flame resistance performance, the facepiece lens shall not obscure vision below the 20/100 vision criteria.

3.11.2 After performing the Heat and Flame Resistance requirements of Section 3.11.1., the CC-SCBA shall meet the performance requirements of Section 3.1 of this document.

3.12 Chemical Agent Permeation and Penetration Resistance Against Distilled Mustard (HD) and Sarin (GB) Agent Test Requirement

3.12.1 The SCBA, including all components and accessories, shall resist the permeation and penetration of distilled sulfur mustard (HD) and Sarin (GB) chemical agents when tested on an upper-torso mannequin connected to the NIOSH ABMS operating at a breathing rate of 30 L/min ($VO_2 = 1.35$ L/min; 18 Breaths per minute). The test requirements and test conditions for HD are shown in Table 4 and for GB are shown in Table 5.

Table 4.—Simultaneous liquid and vapor challenge of SCBA with distilled sulfur mustard (HD)

Agent	Challenge concentration	Duration of challenge (min)	Breathing machine airflow rate (L/min)	Maximum peak excursion (mg/m ³)	Maximum breakthrough (concentration integrated over minimum service life) (mg-min/m ³)	Number of systems tested	Minimum service life (hours)
HD-Vapor	300 mg/m ³	30*	30 L/min	0.60‡	6.0§	3	† ††
HD-Liquid	0.86 mL	Minimum Service Life					

* Vapor challenge generation will start immediately after the liquid drops have been applied and the test chamber has been sealed.

† The test period begins upon start of initial vapor generation.

‡ Three consecutive sequential test data points at or exceeding 0.6 mg/m³ will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

§ The cumulative C_t including all peak data points must not be exceeded for the duration of the Minimum Service Life.

†† Minimum Service Life is equal to applicant's identified duration plus 1 hour.

Table 5.—Vapor challenge of SCBA with Sarin (GB)

Challenge agent	Vapor concentration (mg/m ³)	Vapor challenge time (minutes)	Breathing machine airflow rate (L/min)	Maximum peak excursion (mg/m ³)	Maximum breakthrough (concentration integrated over minimum service life) (mg-min/m ³)	Number of systems tested	Minimum service life (hours)
GB	2,000 mg/m ³	30*	30 L/min	0.087‡	2.1§	3	†† †

* The vapor challenge generation will be initiated immediately after test chamber has been sealed.

† The test period begins upon initial generation of vapor concentration.

‡ Three consecutive sequential test data points at or exceeding 0.087 mg/m³ will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

§ The cumulative C_t including all peak data points must not be exceeded for the duration of the Minimum Service Life.

†† Minimum Service Life is equal to applicant's identified duration plus 1 hour

3.13 Laboratory Respiratory Protection Level (LRPL) Test Requirement

- 3.13.1 The measured LRPL for each CC-SCBA system when worn by a human test volunteer in the operational mode in accordance with the manufacturer's user instructions shall be greater than or equal to 10,000 in an atmosphere containing 20 to 40 mg/m³ corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 µm. A minimum of eight CC-SCBA systems shall be tested to fulfill the small, medium, and large designations of facial size – 2 small, 4 medium, and 2 large.
- 3.13.2 The measured LRPL for the CC-SCBA facepiece shall be greater than or equal to 500 when the facepiece is worn by a human test volunteer in accordance with the manufacturer's user instructions in an atmosphere containing 20 to 40 mg/m³ corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 µm. Applicants shall provide enough facepieces (approximately 11-25 facepieces) and adapters that contain a P100 filter to meet the LRPL requirements of the NIOSH CBRN Standard for Open-Circuit Self-Contained Breathing Apparatus, December 2001.

4.0 Quality Assurance Requirements

4.1 Quality Control Plan

Respirators submitted for CBRN closed-circuit self-contained breathing apparatus approval shall be accompanied by a complete quality control plan meeting the requirements of Subpart E of 42 CFR, Part 84.

4.2 Sampling/Test/Inspection Plan

The applicant shall specify a sampling/test/inspection plan for respirator parts and materials to ensure the construction and performance requirements of this standard are established through the manufacturing process. As a minimum, specific attributes to be addressed are:

- Materials of construction used for respirator parts that form a barrier between the user and ambient air.
- Integrity of mechanical seals that comprise a barrier between the user and ambient air.

4.3 Test Sequence and Quantity

Testing of the CC-SCBA shall follow Table 6:

Table 6.- Required Sequence and Standard Test Procedure for CBRN CC-SCBA Concept

Test Order	SCBA #1 Initial Qualifier	SCBA #2	SCBA #3	SCBA #4 Initial Qualifier	SCBA #5	SCBA #6	SCBA #s 7, 8, 9, 10, 11 and 12	* Component Tests (As Required by Test Procedures)
1.		Cold Para. 3.2. STP-611	Cold Para. 3.2. STP-0611		Communication Performance Para. 3.10. STP-0613			Fabric Flame Resistance Para. 3.4. ASTM F1891 AATCC 135
2.		Hot Para. 3.2. STP-0611	Hot Para. 3.2. STP-0611		Laboratory Respirator Protection Level Requires an Additional 11-25 Facepieces and adapters with only P100 Filters			Fabric Heat Resistance Para. 3.5 NFPA 1981, 2002, Sec 8..5 AATCC 135
3.		Cold Shock Para. 3.2. STP-0611	Cold Shock Para. 3.2. STP-0611		Corrosion Para. 3.7. STP-0612	Heat and Flame Para. 3.11. STP- 0615	Return to Manufacturer	Thread Heat Resistance Para. 3.6 ASTM D 276
4.		Hot Shock Para. 3.2. STP-0611	Hot Shock Para. 3.2. STP-0611		Particulate Para. 3.8. STP-0613			Facepiece Lens Para. 3.9 NFPA 1981, 2002, Sec 10.5
5.		Vibration Para. 3.3 STP-0611	Vibration Para. 3.3 STP-0611		Operational Performance Para. 3.1. STP-06??			
6.		Operational Performance Para. 3.1. STP-06??	Operational Performance Para. 3.1. STP-06??					
7.	GB Chemical Agent Para. 3.12.1. STP-:0650	GB Chemical Agent Para. 3.12.1. STP-:0651	HD Chemical Agent Para. 3.12.1. STP-:0651				Return to Manufacturer	

* Different specimens required for each test

5.0 General Requirements

In addition to the requirements of Title 42, CFR, Subpart G – General Construction and Performance Requirements, the following requirements apply:

Prior to making or filing any application for approval or modification of approval, the applicant shall conduct, or cause to be conducted, examinations, inspections, and tests of respirator performance, which are equal to or exceed the severity of those prescribed in the standard. Chemical Agent Penetration and Permeation Resistance Against Distilled Sulfur Mustard (HD) and Sarin (GB) tests, Paragraph 4.2, are excluded from this requirement.