DRAFT FOR DISCUSSION

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

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 during 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
- 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

2.2. 42 CFR, Part 84, Subpart H; the following paragraphs apply

84.70 Self-contained breathing apparatus; description, paragraphs (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] 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
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
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; exhalation a and c
84.91	Breathing resistance test; exhalation e
84.92	Exhalation valve leakage test
84.94	Gas flow test; closed-circuit apparatus
84.96	Service time test; closed circuit
84.97	Test for carbon dioxide in inspired gas; open- and closed-circuit apparatus; maximum allowable limits 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. Breathing Gas Performance

The CC-SCBA shall meet or exceed the breathing gas requirements identified in Table 1 for each of the parameters for the entire duration of the test. The NIOSH Automated Breathing and Metabolic Simulator (ABMS) shall be used to test the breathing gas requirements at the two work load conditions at the prescribed parameters and protocol defined in Table 2. 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 that 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. Test conditions of the breathing gas performance test are as follows:

Ambient temperature:	22 °C ± 3 °C (72 °F ± 5 °F)
Relative humidity:	50% ± 25%
Barometric pressure:	725 +50/-70 mm Hg (28.54 +1.97/-2.75 in. Hg)

Table 1—Performance requirements

Parameter	Requirement

CO_2 concentration of dry breathing gas during inhalation	≤ 2% by volume
O_2 concentration of dry breathing gas during inhalation	≥ 19.5% by volume
Wet-bulb temperature of breathing gas during inhalation	≤ 45°C
Maximum breathing gas pressure	≤ 89 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	24.0
Oxygen consumption rate, liters/min, STPD	3.2	1.6
Carbon dioxide production rate, liters/min, STPD	3.4	1.6

Table 2.b.—Protocol

Apparatus rated period	Work load	Starting time (minutes)	Duration (minutes)
	A	0	12
Hour 1	B	12	43
	A	55	5
	B	60	25
Hour 2	A	85	5
	B	90	25
	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 stated in Table 1 during each of the environmental conditions indicated in Table 3. The environmental sequence test conditions shall start with the first environmental condition list 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 °C ± 3 °C (72 °F ± 5 °F) with a relative humidity of 50 percent ± 25 percent for a minimum of a 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 °C ± 1 °C (-25 °F ± 2 °F)	Cold soak for a minimum of 12 hours	Perform test at -32 °C ± 5 °C (-25 ± 10 °F)
Hot	71 °C ± 1 °C (160 °F ± 2 °F)	Hot soak for a minimum of 12 hours	Perform test at 71 °C ± 5 °C (160 °F ± 10 °F)
Cold temperature shock	71 °C ± 1 °C (160 °F ± 2 °F) transferred to -32 °C ± 1 °C (-25 °F ± 2 °F); Test temperature shall be -32 °C ± 5 °C (-25 °F ± 10 °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 °C ± 1 °C (-25 ± 2 °F) transferred to 71 °C ± 1 °C (160 °F ± 2 °F); Test temperature shall be 71°C ± 5°C (160 °F ± 10 °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 hold chamber

3.3. Vibration Endurance Requirement

3.3.1. The CC-SCBA shall meet the performance requirements stated in Table 1 after being subjected to vibration endurance testing. The vibration testing shall be conducted in accordance with MIL-STD 810F, Method 514.5.

The vibration exposure shall be performed as described in Table 514.5C-VII, U.S. highway truck vibration exposures, in the vertical, transverse and longitudinal positions, as indicated on Figure 514.5C-1. The CC-SCBA shall be placed in a holding box that encases the complete apparatus during the vibration test but shall be unrestrained. The CC-SCBA regulators and hoses shall remain attached to the apparatus, except for the facepiece and the components that attach to the facepiece, and excluding the regulators. The facepiece and the components that attach to the facepiece, excluding the regulators, shall be vibration tested under the same conditions as the apparatus, but in a secondary holding box. The total test duration is 180 minutes consisting of two 90-minute periods for each orientation of the apparatus.

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 Federal Test Method Standard 191A, Textile Test Methods, with Method 5903.1, Flame Resistance of Cloth, Vertical.

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 length (305 mm) and shall be tested in the width specified by Method 5903.1. However, if the width is not specified in the method, a minimum width of 12 inches shall be used for each specimen.

3.5. Fabric Heat Resistance Requirement

3.5.1. The fabric used to secure the CC-SCBA to the wearer shall not melt or ignite when tested for heat resistance in a forced circulating air oven capable of achieving and maintaining an air stream temperature of 260 °C to 265 °C (500 °F to 510 °F).

3.5.2. Five specimens of each fabric component of the CC-SCBA shall be tested for fabric heat resistance. Each specimen shall be suspended by a metal hook at the top of the oven and be exposed for 5 minutes +15/-0 seconds.

3.5.3. Prior to testing, the specimens of each fabric component of the CC-SCBA 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.

3.6. Thread Heat Resistance Requirement

3.6.1. The thread used in the components of the CC-SCBA shall not melt or ignite when thread specimens are tested in accordance with Federal Test Method Standard 191A, Method 1534, Melting Point of Synthetic Fibers at a temperature of 260 °C +5/-0 °C (500 °F +10/-0 °F).

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 accelerated corrosion. In addition, the CC-SCBA shall meet the breathing gas performance 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 °C ± 2 °C (95 °F ± 3 °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 ± 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 °C ± 2 °C (95 °F ± 3 °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 breathing gas performance 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 mannequin, including the test head form, shall be rotated on the vertical axis 180 degrees midway through the test. The test duration shall be 1 hour, and the ABMS shall be in operation throughout the entire test. The test shall be permitted to be interrupted to replace components typically expended during normal use, according to manufacturer's user instructions.

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:

- Air velocity: 533.4 m/min ± 76.2 m/min (1750 ft/min ± 250 ft/min)
- Temperature: 23 °C ± 3 °C (72 °F ± 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 National Fire Protection Association (NFPA) 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Emergency Services, 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 performance 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, except that the NIOSH ABMS shall be used instead of the NFPA simulator. In addition, the test mannequin used to mount the CC-SCBA during the test shall meet the apparatus requirements prescribed in Section 8.11.4 of NFPA 1981:

3.11.1.1. The CC-SCBA shall be tested for heat and flame resistance performance by meeting the breathing gas performance in Section

3.1 of this document, except for the maximum wet-bulb temperature of breathing gas during inhalation for the entire duration of the test.

3.11.1.2. 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.

3.11.1.3. 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.

3.11.1.4. 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.

3.12. 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 designated air flow-rates for various time frames, which are indicated in Table 2. 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/m3)	Maximum breakthrough (concentration integrated over minimum service life) (mg-min/m3)	Number of systems tested	Minimum service life (hours)
HD-Vapor	300 mg/m3	30*	See Table 2	0.60‡	6.0§	3	6†
HD-Liquid	0.86 mL	360					

* Vapor challenge concentration 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/m^3 will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

§ The cumulative C_i including all peak data points must not be exceeded for the duration of the 6-hour test.

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) ($mg\text{-}min/m^3$)	Number of systems tested	Minimum service life (hours)
GB	2,000 mg/m^3	30*	See Table 2	0.087‡	2.1§	3	6†

* The vapor challenge concentration 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/m^3 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 6-hour test.

3.13. Laboratory Respiratory Protection Level (LRPL) Test Requirement

3.13.1. The measured laboratory respiratory protection level (LRPL) for each closed-circuit SCBA shall be 10,000 when the SCBA is worn by a human test volunteer in the operational mode in accordance with the manufacturer's user instructions in an atmosphere containing 20 to 40 mg/m^3 corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 μm.

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.

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.