

# Concept for CBRN Air-Purifying Escape Respirator Standard

## DRAFT FOR DISCUSSION

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### Part 1: Concept for CBRN Air-Purifying Escape Respirator Standard

#### (1) Goal:

Develop a NIOSH standard for escape only air-purifying respirators that addresses CBRN materials identified as inhalation hazards from possible terrorist events for use by the general working population.

#### (2) Hazard Categories:

Defining appropriate hazard levels for escape from a possible chemical, biological, radiological and nuclear (CBRN) terrorist event is a complex problem. Analysis of possible escape scenarios indicates the range of possible hazard concentrations at and between levels typically identified by emergency responders as the Hot Zone and the Warm Zone. The Hot Zone is ground zero and can be characterized as the hazard levels associated with a likely terrorist event, "Most Credible Event" (MCE). MCE's for chemical warfare agents (CWA's) and toxic industrial materials (TIM's) expected at a terrorist event are determined using a modeling process (US ARMY). The MCE model considers several parameters associated with the potential event. These parameters include the means used to transport the CWA or TIM to the scene, the method of dissemination of the hazard, properties of the hazard, the quantity of the CWA or TIM used, the availability of the CWA or TIM, and physical characteristics of the area such as room size and the degree of ventilation present. Using this approach MCE's for sarin gas, GB, and sulfur mustard, HD were determined to be 2000 mg/m<sup>3</sup> for GB and 300 mg/m<sup>3</sup> for HD. Similar modeling techniques are currently being employed for TIM's that have also been identified as high threat possibilities.

Warm Zone analysis of the CWA's and TIM's are determined by the immediately dangerous to life or health, IDLH, concentrations or equivalent for the identified hazards. For GB and HD the equivalent warm zone concentrations can be set at 0.19 mg/m<sup>3</sup> GB and 2.7 mg/m<sup>3</sup> HD, based on Acute Exposure Guideline Levels (AEGL's), AEGL 3 values at 30 minutes.

Based on the Hot Zone / Warm Zone GB and HD concentrations it can be expected that respirator performance requirements for escape from the Hot Zone are different from those requirements for escape from or near Warm Zone concentrations. In addition, the characteristics of the diverse hazards and buildings or site characteristics vary significantly. No two are expected to be identical. Because of this a wide range of escape strategies is expected. Certain conditions may involve a dual response strategy: use of an escape respirator and/or shelter in place. Escape only air-purifying respirators designed for specific hazards at levels between the Hot and Warm Zones may be appropriate for specific escape scenarios but do not represent a universal escape respirator solution for protecting all or the

majority of workers. Furthermore, requirements for acceptable escape respirator performance for a skyscraper are most likely different than acceptable escape respirator performance from a 3-level building. The threat for a metropolitan area located near a major industrial complex, a chemical plant or oil refinery is not the same as the threat for metropolitan areas removed from industry.

The concept for escape respirator performance requirements to address the wide range of variables is segmented into three categories: HIGH, SPECIFIC, and LOW. The categories are associated with a level of protection as follows:

**HIGH:** Self-Contained Escape Respirator for unknown conditions and oxygen deficiency.

**SPECIFIC:** Air Purifying Escape Respirator for high concentrations of CWAs and specific TIMs.

**LOW:** Air Purifying Escape Respirator for low concentrations of CWAs and TIMs.

The standard discussed in this concept paper addresses the SPECIFIC and LOW categories for air purifying escape respirators. The HIGH category, self-contained escape respirator, is part of the standards development program scheduled for 2004.

**2(a) Category vs. Hazard vs. Escape Respirator Type:**

Table 1. Escape Respirator Categories

Category	Hazard Description	Respirator Type
HIGH (Hot & Warm Zones)	CWA & TIM Hazard Threats at High Concentrations and/or Oxygen Deficiency	Self Contained Escape Respirator
SPECIFIC (Hot & Warm Zones)	CWA + Specific TIM Hazard Threats at High Concentrations	Specific Gas/Vapor + CWA Air Purifying Escape Respirator
LOW (Warm Zone)	CWA & Multiple Hazard Threats at Low Concentrations	Multi Gas/Vapor/Particulate Air Purifying Escape Respirator

**2(b) Escape Respirator Multi Gas/Vapor/Particulate Requirements LOW Category:**

Multi Gas/Vapor/Particulate Escape respirators for use at low hazard threat conditions shall meet the gas/vapor test challenge concentrations as follows:

	Test Concentration (ppm) Draft	Breakthrough Concentration (ppm) Draft
Ammonia	2500	TBD
Cyanogen Chloride	300	TBD
Cyclohexane	3900	TBD
Formaldehyde	500	TBD

Hydrogen Cyanide	940	TBD
Hydrogen Sulfide	1000	TBD
Nitrogen Dioxide	200	TBD
Phosgene	250	TBD
Phosphine	300	TBD
Sulfur Dioxide	1500	TBD

**2(c) Escape Respirator Multi Gas/Vapor/Particulate LOW Category with Carbon Monoxide Requirements:**

Escape respirators intended for use at low hazard threat conditions with carbon monoxide protection shall meet the requirements of paragraph 2(b) plus carbon monoxide as follows:

To Be Determined, TBD

**2(d) Escape Respirator Specific Gas/Vapor/Particulate Plus CWA Requirements SPECIFIC Category:**

Escape respirators intended for use at the specific hazard threat conditions shall meet the gas/vapor/particulate testing at identified concentrations. Minimum test agents are as follows:

	Test Concentration (ppm) Draft	Breakthrough Concentration (ppm) Draft
Cyclohexane	Section 2(d)1.	TBD
Sulfur Dioxide	Section 2(d)1.	TBD
Cyanogen Chloride	Section 2(d)1.	TBD
Hydrogen Cyanide	Section 2(d)1.	TBD
Hydrogen Sulfide	Section 2(d)1.	TBD

Additional specific test agent protections can be added to the minimum as specified by the applicant for: Ammonia, Formaldehyde, Nitrogen Dioxide, Sulfur Dioxide, Phosphine and Carbon Monoxide.

**2(d) 1. Test Concentrations for Specific Category:**

Test concentrations will be determined as follows:

Test Concentration = (Multiplying Factor, TBD) X Escape Use Concentration,

Where the Escape Use Concentration is specified by the applicant as the intended level of protection provided by the respirator.

**(3) Respirator Use:**

**3(a) Escape Only:** Escape respirators are intended to be one time use for escape only from terrorist events.

**3(b) Panic Demand:** Each escape respirator shall provide a minimum service life of 5 minutes when tested at a flow rate of 100 ±10 liters per minute, 50 ±5 percent relative humidity and 25 ±5°C for each of the gases/vapors identified in Section 2.

**3(c) Service Life Rating:** Escape respirators will be rated for 15 minute or 30 minute service life.

**(4) Gas Life Test Requirements:**

**4(a) Test Duration:** Test duration will be 15 or 30 minutes as specified by the applicant.

**4(b) Gas Life:** Gas life tests are performed at room temperature, 25 ±5°C; 25 ±5 percent relative humidity, and 80 ±5 percent relative humidity. Three filters will be tested at each specified humidity with a flow rate of 64 liters per minute, continuous flow. Tests will be conducted to the minimum specified service time. Gas testing shall be performed following environmental conditioning and rough handling. Service Life testing is performed to the minimum specified service time. The breakthrough concentration must be no greater than the specified breakthrough for each tested gas. Testing is terminated after the minimum specified service time is achieved.

**4(c) Particulate Filtration:** The filter shall meet the requirements of a P100 particulate filter as described in 42 CFR, Part 84 paragraphs 84.170, 84.179 and 84.181. In addition to the 20 filters required by 42 CFR, Part 84, paragraph 84.181.

**(5) Environmental Conditioning:**

Environmental conditioning will be performed on escape respirators in the ready-to use configuration. The ready-to-use configuration is the operational packaging state prior to use such that immediately upon opening allows the user to don the respirator.

5(a) Environmental Conditioning Requirements : Environmental conditioning shall be performed in accordance with the following Table :

**Table: Environmental Conditioning**

Test	Test Method	Condition	Duration
Hot Diurnal	Mil-Std-810F, 501.4	71°C max, cyclical	3 Weeks
Cold Constant	Mil-Std-810F, 502.4	Basic Cold, -32 °C	3 Days
Humidity	Mil-Std-810E, 507.3	Table 507.3-II, Natural Cycle, Cycle 1	5 Days, Quick Look
Vibration	TBD	TBD	TBD
Drop	3 foot drop onto bare concrete surface	Filter Only, In package 3 Axis	N/A

**5(b) Service life testing conditioned Respirators:** Service life testing will be done on environmentally conditioned respirators.

## (6) Performance Requirements:

Escape respirator performance requirements considered will include the following:

### 6(a) Chemical Agent Permeation and Penetration Resistance Against Distilled Mustard (HD) and Sarin (GB) Agent Requirement, LOW Category:

The escape respirator system shall resist the permeation and penetration of distilled sulfur mustard (HD) and Sarin (GB) chemical agents when tested on an upper-torso manikin connected to a breathing machine operating at an air flow rate of 40 liters per minute (L/min), 36 respirations per minute, 1.1 liters tidal volume. Test requirements for distilled sulfur mustard (HD) are shown in the following Table:

#### Simultaneous Liquid and Vapor Challenge of Escape Respirator with Distilled Sulfur Mustard (HD)

Agent	Challenge <sup>(1)</sup> Concentration	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m <sup>3</sup> )	Maximum Breakthrough Concentration integrated over Minimum Service Life (mg- min/m <sup>3</sup> )	Number of Systems Tested	Minimum Service Life (minutes)
HD - Vapor	300mg/m <sup>3</sup>	15/30 (1,5)					
HD - Liquid	0.46 ml <sup>(2)</sup>	60	40	0.60 <sup>(3)</sup>	6.0 <sup>(4)</sup>	3	60

(1) Vapor challenge concentration will start immediately after the liquid drops have been applied and the test chamber has been sealed.

(2) Liquid volume is TBD

(3) Three consecutive sequential test data points at or exceeding 0.6 mg/m<sup>3</sup> will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the test.

(5) 15 minutes for a 15 minute respirator, 30 minutes for a 30 minute respirator.

Test requirements for Sarin (GB) agent are shown in the following Table:

### Vapor Challenge of Escape Respirator with Sarin (GB).

Challenge Agent	Vapor Concentration (mg/m <sup>3</sup> )	Vapor Challenge Time (minutes)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m <sup>3</sup> )	Maximum Breakthrough Concentration integrated over Minimum Service Life (mg-min/m <sup>3</sup> )	Number of Systems Tested	Minimum Service Life (minutes)
GB	210	15/30 <sup>(1,5)</sup>	40	0.087 <sup>(3)</sup>	2.1 <sup>(4)</sup>	3	60 <sup>(2)</sup>

(1) The vapor challenge concentration generation will be initiated immediately after test chamber has been sealed.

(2) The test period begins upon initial generation of vapor concentration.

(3) Three consecutive sequential test data points at or exceeding 0.087 mg/m<sup>3</sup> will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the test.

(5) 15 minutes for a 15 minute respirator, 30 minutes for a 30 minute respirator.

### 6(b) Chemical Agent Permeation and Penetration Resistance Against Distilled Mustard (HD) and Sarin (GB) Agent Requirement, SPECIFIC Category:

The escape respirator system shall resist the permeation and penetration of distilled sulfur mustard (HD) and Sarin (GB) chemical agents when tested on an upper-torso manikin connected to a breathing machine operating at an air flow rate of 40 liters per minute (L/min), 36 respirations per minute, 1.1 liters tidal volume.

Test requirements for distilled sulfur mustard (HD) are shown in the following Table:

### Simultaneous Liquid and Vapor Challenge of Escape Respirator with Distilled Sulfur Mustard (HD)

Agent	Challenge <sup>(1)</sup> Concentration	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m <sup>3</sup> )	Maximum Breakthrough Concentration integrated over Minimum Service Life (mg-min/m <sup>3</sup> )	Number of Systems Tested	Minimum Service Life (minutes)
HD - Vapor	TBDmg/m <sup>3</sup>	TBD					
HD - Liquid	TBD ml <sup>(2)</sup>	TBD	40	0.60 <sup>(3)</sup>	6.0 <sup>(4)</sup>	3	TBD

(1) Vapor challenge concentration will start immediately after the liquid drops have been applied and the test chamber has been sealed.

(2) Liquid volume is TBD

(3) Three consecutive sequential test data points at or exceeding  $0.6 \text{ mg/m}^3$  will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the test.

Test requirements for Sarin (GB) agent are shown in the following Table :

**Vapor Challenge of Escape Respirator with Sarin (GB).**

Challenge Agent	Vapor Concentration ( $\text{mg/m}^3$ )	Vapor Challenge Time (minutes)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion ( $\text{mg/m}^3$ )	Maximum Breakthrough Concentration integrated over Minimum Service Life ( $\text{mg-min/m}^3$ )	Number of Systems Tested	Minimum Service Life (minutes)
GB	TBD	TBD <sup>(1)</sup>	40	0.087 <sup>(3)</sup>	2.1 <sup>(4)</sup>	3	TBD <sup>(2)</sup>

(1) The vapor challenge concentration generation will be initiated immediately after test chamber has been sealed.

(2) The test period begins upon initial generation of vapor concentration.

(3) Three consecutive sequential test data points at or exceeding  $0.087 \text{ mg/m}^3$  will collectively constitute a failure where each test value is based on a detector sample time of approximately 2 minutes.

(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the test.

**6(c) Breathing Resistance:**

The resistance to air flow shall be measured at the breathing zone (nosecup or mouthpiece) of a hood mounted on a head form test apparatus operated at a continuous airflow rate of 85 liters per minute. The inhalation resistance shall not exceed 70 mm H<sub>2</sub>O and the exhalation resistance shall not exceed 20 mm H<sub>2</sub>O.

**6(d) Carbon Dioxide:**

The carbon dioxide content shall not exceed 2.5% by volume when tested on an Automated Breathing Metabolic Simulator (ABMS) operated at an oxygen consumption rate of 3.0 liters per minute and a ventilation rate of 80 liters per minute.

**6(e) Communications ( Speech Intelligibility):** TBD

**6(f) Field of View:**

The full facepiece shall be designed so that the effective field of vision shall be not less than 70% related to the natural field of vision. The applicant shall provide test data demonstrating compliance with the Field of View requirement when tested in accordance with EN 136: 1998, Respiratory Protective Devices-Full facemasks-Requirements, testing, marking, paragraph 8.17 Field of Vision.

**6(g) Donning:**

The time to fully don the respirator from the ready-to use configuration shall be no greater than 30 seconds. The ready-to-use configuration is the operational packaging state prior to use such that immediately upon opening allows the user to don the respirator.

**6(h) Fogging:**

Two persons with a visual acuity of 20/70 or better will perform the tests described in paragraph (a) and (b) of this section. The escape respirator shall meet the requirements of paragraph (c) of this section.

**(a).** The respirator shall be cold soaked in an environmental chamber at minus 21°C (- 6°F) for 4 hours.

At the start of each cold temperature wear trial a test participant shall enter the test chamber (maintained at -21°C) and sit quietly for five minutes. Once the five minute rest period transpires, subjects shall self-don their assigned respirator.

At the start of each cold temperature wear trial a test participant shall enter the test chamber (maintained at -21°C) and sit quietly for five minutes. Once the five minute rest period transpires, subjects shall self-don their assigned respirator.

A visual acuity test shall then be administered to quantify the impact of any lens fogging on vision. The test participant shall then complete a 12-minute work-rest-work regimen comprised of five minutes of exercise, 2 minutes of rest, and an additional five minutes of exercise with the exercise periods consisting of treadmill walking at 4.8 km/hr (3 mph) on a level grade.

Visual acuity tests shall be repeated at the end of each walk period (i.e., after five minutes of walking and at the end of the 12 minute period immediately following the treadmill walk).

**(b).** The respirator shall be conditioned in an environmental chamber at 15.5°C (60°F), 75% RH for 4 hours.

At the start of each cool/humid temperature wear trial a test participant shall enter the test chamber (maintained at 15.5°C) and sit quietly for five minutes. Once the five minute rest period transpires, subjects shall self-don their assigned respirator.

A visual acuity test shall then be administered to quantify the impact of any lens fogging on vision.

The test participant shall then complete a 12-minute work-rest-work regimen comprised of five minutes of exercise, 2 minutes of rest, and an additional five minutes of exercise with the exercise periods consisting of treadmill walking at 4.8 km/hr (3 mph) on a level grade.

Visual acuity tests shall be repeated at the end of each walk period.

**(c) 1.** The respirator shall function satisfactory throughout the test. The wearer shall not experience undue discomfort because of restrictions to breathing or other physical or chemical changes to the respirator.

**(c) 2.** Visual acuity scores obtained during each environmental test with the respirator shall be divided by a subject's visual acuity score obtained with the mask prior to testing to calculate a performance rating using the following equation:

Performance Rating (%) =  $VA_{\text{CHAMBEREX}} / VA_{\text{INITIAL}} \times 100$  (1)

where  $VA_{\text{chamber } x}$  = visual acuity score during chamber test at time x and  $VA_{\text{initial}}$  = visual acuity score obtained with the mask prior to testing.

**6(i) Heat Exposure:** TBD.

**6(j) Flamability of Materials:** TBD.

**6(k) Laboratory Respirator Protection Level:**

The measured laboratory respiratory protection level (LRPL) for each air purifying escape respirator shall be 2000, when the respirator is tested in a negative pressure mode in an atmosphere containing 20-40 mg/m<sup>3</sup> corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 micrometers.

**(7) Design Considerations: The following design features will be considered:**

**7(a) General:** The escape respirator shall provide a barrier from ambient conditions for the wearer's entire head, eyes and respiratory system. The escape respirator shall not require the use of hands to maintain the respirator position to ensure proper function of the respirator when fully donned.

**7(b) Hood Type Device:** The escape respirator shall be designed as a hooded device. The hood shall include an area for field of vision and shall be compatible with wearing of glasses.

**7(c) Respiratory Protection System:** The respiratory protection system shall consist of a an oral / nasal cup or mouthpiece. If a mouthpiece is employed a method of preventing nasal breathing must be provided. The respiratory protection system shall be designed such that the air purifying filter can not be degraded by the carbon dioxide and humidity of the exhaled gas.

**7(d) Dermal Protection:** Dermal protection required for escape respirators intended for Hot Zone Hazard levels, TBD.

**7(e) Weight:** TBD

**(8) 42 CFR Applicable Sections:**

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

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

Subpart A: General Provision

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

42 CFR, Part 84 Subpart K; the following paragraphs apply:

84.170 Non-powered air purifying particulate respirators; description

84.179 Non-powered air purifying particulate respirators; filter identification

84.181 Non-powered air purifying particulate filter efficiency

**(9) Service and Maintenance:**

TBD

**(10) Training:**

TBD

**(11) Cautions & Limitations:**

TBD

**(12) Quality Assurance Provisions:**

TBD