May 15, 2003
DRAFT FOR DISCUSSION

Concept for CBRN Escape Respirator Standard

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 the Automated Decision Aid System for Hazardous Incidents (ADASHI) modeling program developed by the U.S. Army Soldier and Biological Chemical Command. This 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, challenge concentrations for sarin gas, GB, and sulfur mustard, HD were determined to be 2000 mg/m3 for GB and 300 mg/m3 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/m3 GB and 2.7 mg/m3 HD, based on Acute Exposure Guideline Levels (AEGL's), AEGL 2 values at 30 minutes. Also, high concentrations of some TICs will cause displacement of oxygen in the contaminated area, thus resulting in an IDLH condition where the oxygen content falls below 19.5%.

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 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 (General). 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 low concentrations of CWA's and TIM's (CBRN Protection) plus high concentrations of specific TIM's .

LOW (General): Air Purifying Escape Respirator for low concentrations of CWA's and TIM's (CBRN Protection).

Part 1 of this concept paper addresses the SPECIFIC and LOW (General) categories for air purifying escape respirators. The HIGH category, self-contained escape respirator, is addressed in Part 2 of the concept paper.

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 (General) (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 (General) 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	1250	150
Cyanogen Chloride	300	0.4
Cyclohexane	2600	10
Formaldehyde	250	10
Hydrogen Cyanide	470	10 [1]
Hydrogen Sulfide	500	30
Nitrogen Dioxide	100	1 ppm NO_2
Phosgene	125	0.2
Phosphine	150	0.5
Sulfur Dioxide	750	3

(1) Sum of HCN and C2N2

2(c) Escape Respirator Multi Gas/Vapor/Particulate LOW (General) 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: Test Concentration – 3600 ppm; Breakthrough Concentration – 350 ppm.

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

Escape respirators intended for use at the specific hazard threat category conditions shall meet the gas/vapor/particulate testing at identified conditions of paragraph 2(b) Escape Respirator Multi Gas/Vapor/Particulate Requirements LOW (General) Category .

Additional specific test agent protections can be added to the minimum as specified by the applicant for: Ammonia, Cyclohexane, Cyanogen Chloride, Formaldehyde, Hydrogen Cyanide, Nitrogen Dioxide, Hydrogen Cyanide, Sulfur

Dioxide, Phosgene, Phosphine, and Carbon Monoxide.

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

In addition to the test requirements of paragraph 2(b) Escape Respirator Multi Gas/Vapor/Particulate Requirements LOW (General) Category test concentrations for additional specific test agent protections shall be as specified by the manufacturer.

2(d)2 Breakthrough Concentration for Specific Category: Test breakthrough concentrations for the specific category shall be Breakthrough concentrations identified in Section 2(b) Escape Respirator Multi Gas/Vapor/Particulate Requirements LOW (General) Category .

(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 duration 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) Duration Rating: Escape respirators will be rated for 15, 30, 45 or 60 minute duration as specified by the manufacturer.

(4) Gas Life Test Requirements:

4(a) Test Duration: Test duration will be 15, 30, 45 or 60 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.

(5) Environmental Conditioning Requirements:

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.

Environmental conditioning shall be performed in accordance with the following Table:

Durability Test Matrix: Environmental, Transportation and Drop Tests

Test	Test Method	Test Condition	Duration
Hot Constant	Mil-Std-810F, 501.4	71°C (160°F), Constant	5 Weeks
Cold Constant	Mil-Std-810F, 502.4	Basic Cold, -32 °C (-24 °F), Constant	3 Days
Humidity	Mil-Std-810E, 507.3	Realistic, Natural Cycle Humidity Profiles in the U.S.	5 Days "quick look" Mil-Std-810E Table 507.3-II
Transportation Vibration	MIL-STD-810F, 514.5	U. S. Roadway Vibration, Unrestrained	12 hours/axis, 3 Axes; Total Duration = 36 hours = 12,000 miles
Drop	Adopted from NIOSH, CBRN APR Standard	Height of 3 Feet	1 Drop on each of the 3 Axes per Unit

(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 (General) and 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:

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

Agent	Challenge Concentration (1)	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m^3)	Maximum Breakthrough Concentration integrated over Minimum Service Life ($mg\text{-}min/m^3$)	Number of Systems Tested	Minimum Service Life (minutes)
HD - Vapor	50 mg/m^3	15/30/45/60 (1,5)					
HD - Liquid	0.86 ml (2)	60	40	0.60 (3)	6.0 (4)	3	30/60/90/120 (6)

(1) Vapor challenge concentration will start immediately after the liquid drops have been applied and the test chamber has been sealed.
(2) Liquid volume applied as 25 drops of equal size..
(3) 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.
(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the test.
(5) 15, 30, 45 or 60 minutes, equal to the tested duration.
(6) 30, 60, 90 or 120 minutes, twice the tested duration.

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

Table: Vapor Challenge of Escape Respirator 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 (minutes)
GB	210	15/30/45/60 (1,5)	40	0.087 (3)	2.1 (4)	3	30/60/90/120 (2,6)

(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/m3 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, 30, 45 or 60 minutes, equal to the tested duration.
(6) 30, 60, 90 or 120 minutes, twice the tested duration.

6(c) Breathing Resistance:
The resistance of airflow 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_2O and the exhalation resistance shall not exceed 20 mm H_2O.

6(d) Breathing Gas::
The carbon dioxide content shall not exceed 2.5% by volume and the oxygen concentration shall not be less than 19.5% by volume when tested on an Automated Breathing Metabolic Simulator (ABMS) operated per the requirements of the following table:

Metabolic Variables for the ABMS Breathing Gas Test

Work Rate	f (breath/min)	Vt (Liters, STPD)	VE (L/min, STPD)	VO2 (L/min, STPD)	VCO2 (L/min, STPD)	R	ABMS Waveform	Approx. Peak Flows (L/min, BTPS
1	12	0.8	10.0	0.5	0.4	0.80	BS1210	45.0
2	19.5	1.30	25.3	1.0	0.8	0.82	BS1925	96.6
3	28.0	1.35	38.0	1.5	1.3	0.87	BS2838	149.5
4	32.6	1.90	62.0	2.0	1.9	0.95	BS3362	243.8
5	34.2	2.00	70.0	2.5	2.5	1.00	BD3470	209.3ex 241.5in
6	36.4	2.20	80.0	3.0	3.15	1.05	BD3680	246.1ex 276.0in

Test time at each work rate shall be 10 minutes.

6(e) Communications (Speech Intelligibility):

The Communication (Speech Intelligibility) capability is an optional feature for the AP Escape Respirator. The manufacturer will inform NIOSH whether they want their respirator certified with the Communication (Speech Intelligibility) Endorsement. If the manufacturer declines to have the Communication Endorsement, then the manufacturer's AP Escape Respirator will not be required to meet the Communication Performance Requirement. If the manufacturer informs NIOSH that they want the Communication Endorsement, then the respirator must meet or exceed the Communication Performance Requirement.

Communication Performance Requirement is based upon performance using a Modified Rhyme Test (MRT). The Communications Performance Requirement is met if the overall performance rating is greater than or equal to seventy (70) percent when tested in accordance with NIOSH Standard Test Procedure CET-APRS-STP-CBRN-0313. The MRT will be performed with a steady background noise of 60 dBA consisting of a broadband "pink" noise. The distance between the listeners and speakers shall be 10 feet (3 m).

6(f) Field of View:

The CBRN AP Escape Respirator shall obtain a Visual Field Score (VFS) of 70 or greater when tested in accordance with NIOSH Standard Test Procedure CET-APRS-STP-CBRN-0314. The VFS shall be obtained by using a medium size respirator or equivalent that is sized to fit the Head Form described in Figure 14 of EN 136, Respiratory protective devices – Full face masks – Requirements, testing, marking; January 1998 or equivalent.

The VFS is determined by using a VFS grid (Dots on visual field) as defined in the American Medical Association *Guides to the Evaluation of Permanent Impairment*, 5th Edition (2000) that is overlaid on the diagram of the visual field plot obtained using the spherical shell of EN 136 apertometer or equivalent. The VFS score is the average of three fittings of the same respirator on the specified head form.

From Table-7, Ranges of Field Loss and O&M (Orientation and Mobility) Ability of the Visual Standards Report, Aspects and Ranges of Vision Loss with Emphasis on Population Surveys, International Council of Ophthalmology at the 29th International Congress of Ophthalmology Sydney Australia, April 2002, the VFS score of 70 points is the minimum value which falls into the Mild Visual Impairment category. This category translates to a functional ability of Normal O&M Performance that needs more scanning, occasionally surprised by events on the side. If the visual field is mildly impaired, the user has scanning capability.

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:

The AP Escape Respirator shall demonstrate an average Visual Acuity Score (VAS) of greater or equal to 70 points for all measurements for each individual. The wearer shall not experience undue discomfort because of restrictions to breathing or other physical or chemical changes to the respirator.

The respirator shall be donned by the test subject in an indoor ambient temperature of approximately 72°F +/- 2° F at 30% RH +/- 5% and then shall enter into a simulated outdoor extreme temperature chamber where the visual acuity tests shall be administered. The APR Escape Respirator shall be tested for fogging in the hot/humid condition of 90 ° F/ 60% RH and the cold condition of 13.1°F.

From Table-5, Ranges of Reading Ability, of the Visual Standards Report, Aspects and Ranges of Vision Loss with Emphasis on Population Surveys, International Council of Ophthalmology at the 29th International Congress of Ophthalmology Sydney Australia, April 2002, the VAS score of 70 points indicates Statistical estimates of Reading Ability that borderlines between the Normal Reading Speed/Reduced Reading Distance and the Near-Normal with Appropriate Reading Aids Category.

6(i) Flammability and Heat Resistance:

LOW (General) and SPECIFIC Category Escape Respirator shall be tested for Flammability and Heat Resistance using the test equipment specified in EN 136, Respiratory Protective Devices, Full Face Masks, Requirements, testing, Marking, 1998 Edition. No component of the respirator shall have an afterflame after 5 seconds. No component of the escape respirator shall drip, melt, or develop a visible hole or damaged in any manner that compromises the breathing protection provided by the respirator.

The distance between the outer surface of the escape respirator and the burner tips shall be adjusted to 250 mm ± 6.4 mm. The pressure reducer shall be adjusted to 2.1 bar ± .05 psi. The temperature of the flame positioned 250 mm ± 6.4 mm above the burner tip shall be 800 °C ± 50 ° C. The respirator shall be rotated once through the flame at a velocity of 6 ± 0.5 cm/s. Where components of the respirator such as valves, filters, etc. are arranged on the respirator, the test shall be repeated with these components at the appropriate height of 250 mm ± 6.4 mm.

6(k) Laboratory Respirator Protection Level:

The measured laboratory respirator 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^3 corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 micrometers.

	Small	Medium	Large
Head Circumference	NA	NA	576 - 600
Neck Circumference	307 - 350	351 - 375	376 - 409
Face Length	NA	NA	124 – 133.5

Five respirators shall be tested with test subjects from each cell of the above table with dimensions identified. Each cell is uniquely tested.

(7) Design Considerations:

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 vision and shall be compatible with wearing of glasses.

7(c) Respiratory Protection System:

The respiratory protection system shall consist of 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 cannot be degraded by the carbon dioxide and humidity of the exhaled gas.

(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 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

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
84.180 Non-powered air purifying particulate filter efficiency

(9) Service and Maintenance:

TBD

(10) Training:

TBD

(11) Cautions and Limitations:

TBD

Part 2: Concept for CBRN Self-Contained Escape Respirator Standard

(1) General:

The concept for escape respirator performance requirements to address the wide range of variables is segmented into three categories: HIGH, SPECIFIC, and LOW (General). 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 CWA's and specific TIM's.

LOW (General): Air Purifying Escape Respirator for low concentrations of CWA's and TIM's.

The standard discussed in Part 2 of this concept paper addresses the HIGH category for self-contained escape respirators. The SPECIFIC and LOW (General) Categories are discussed in Part 1 of the Escape Respirator Concept.

(2) Requirements for the HIGH Category Self-Contained Escape respirator are identified as a three tier set of requirements:

- 42 CFR, Part 84, Subpart H Escape Respirator Approval
- Enhanced Escape Respirator Performance Requirements
- CBRN Requirements.

(3) 42 CFR, Part 84, Subpart H Approval:

The HIGH Category Escape Respirator must be NIOSH approved as a self-contained escape respirator for a service life of 15, 30, 45 minutes duration in accordance with the requirements of 42 CFR, Part 84, Subpart H.

(4) Enhanced Escape Respirator Performance Requirements:
Escape respirators will be environmentally conditioned prior to conducting test and evaluations specified in sections 4 and 5.

(4.1) 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.

Environmental conditioning shall be performed in accordance with the following Table:

Durability Test Matrix: Environmental, Transportation and Drop Tests

Test	Test Method	Test Condition	Duration
Hot Constant	MIL-STD-810F, 501.4 ,	71 0C (160 0F)	Constant 5 Weeks
Cold Constant	MIL-STD-810F, 502.4	Basic Cold, -32 0C (-24 0F),	Constant 3 Days
Humidity	MIL-STD-810E, 507.3	Realistic, Natural Cycle Humidity Profiles in the U.S.	5 Days "quick look" Mil-Std-810E Table 507.3-II
Transportation Vibration	MIL-STD-810F, 514.5	U. S. Roadway Vibration, Unrestrained	12 hours/axis, 3 Axes; Total Duration = 36 hours = 12,000 miles
Drop	Adopted from NIOSH, CBRN APR Standard	Height of 3 Feet	1 Drop on each of the 3 Axes per Unit

(4.2) Hood:

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 glasses. 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.

(4.3) Respiratory Protection System:

The respiratory protection system shall consist of an oral/nasal cup or mouthpiece. If a mouthpiece is employed a method of preventing nasal breathing must be provided.

(4.4) Dermal Protection:

The HIGH Category Escape Respirator shall include a means of full body protection in the form of a cape, apron or coat that may be packaged separate from the respirator. The cape, apron or coat shall cover the shoulders, arms, upper body and legs

(4.5) Donning Time:

The HIGH Category Escape Respirator shall be fully donned and activated from its stored configuration in less than 30

seconds.

(4.6) Flammability and Heat Resistance:

HIGH Category Escape Respirator shall be tested for Flammability and Heat Resistance using the test equipment specified in EN 136, Respiratory Protective Devices, Full Face Masks, Requirements, testing, Marking, 1998 Edition. No component of the respirator shall have an afterflame after 5 seconds. No component of the escape respirator shall drip, melt, or develop a visible hole or damaged in any manner that compromises the breathing protection provided by the respirator.

The distance between the outer surface of the escape respirator and the burner tips shall be adjusted to 250 mm ± 6.4 mm. The pressure reducer shall be adjusted to 2.1 bar ± .05 psi. The temperature of the flame positioned 250 mm ± 6.4 mm above the burner tip shall be 80° 0 C ± 50°C. The respirator shall be rotated once through the flame at a velocity of 6 ± 0.5 cm/s. Where components of the respirator such as valves, filters, etc. are arranged on the respirator, the test shall be repeated with these components at the appropriate height of 250 mm ± 6.4 mm. If compressed oxygen is used in the escape respirator this requirement will be tested using a surrogate oxygen pressure vessel.

(4.7) Field of View:

The CBRN Self Contained Escape Respirator shall obtain a Visual Field Score (VFS) of 70 or greater when tested in accordance with NIOSH Standard Test Procedure CET-APRS-STP-CBRN-0314. The VFS shall be obtained by using a medium size respirator or equivalent that is sized to fit the Head Form described in Figure 14 of EN 136, Respiratory protective devices – Full face masks – Requirements, testing, marking; January 1998 or equivalent.

The VFS is determined by using a VFS grid (Dots on visual field) as defined in the American Medical Association Guides to the Evaluation of Permanent Impairment, 5th Edition (2000) that is overlaid on the diagram of the visual field plot obtained using the spherical shell of EN 136 apertometer or equivalent. The VFS score is the average of three fittings of the same respirator on the specified head form.

From Table-7, Ranges of Field Loss and O&M (Orientation and Mobility) Ability of the Visual Standards Report, Aspects and Ranges of Vision Loss with Emphasis on Population Surveys, International Council of Ophthalmology at the 29th International Congress of Ophthalmology Sydney Australia, April 2002, the VFS score of 70 points is the minimum value which falls into the Mild Visual Impairment category. This category translates to a functional ability of Normal O&M Performance that needs more scanning, occasionally surprised by events on the side. If the visual field is mildly impaired, the user has scanning capability.

(4.8) Fogging:

The CBRN Self Contained Escape Respirator shall demonstrate an average Visual Acuity Score (VAS) of greater or equal to 70 points for all measurements for each individual. The wearer shall not experience undue discomfort because of restrictions to breathing or other physical or chemical changes to the respirator.

The respirator shall be donned by the test subject in an indoor ambient temperature of approximately 72°F +/- 2° F at 30% RH +/- 5% and then shall enter into a simulated outdoor extreme temperature chamber where the visual acuity tests shall be administered. The APR Escape Respirator shall be tested for fogging in the hot/humid condition of 90 0F/ 60% RH and the low temperature use limit for which the respirator is approved as part of 42 CFR, Part 84, Subpart H.

From Table-5, Ranges of Reading Ability, of the Visual Standards Report, Aspects and Ranges of Vision Loss with Emphasis on Population Surveys, International Council of Ophthalmology at the 29th International Congress of Ophthalmology Sydney Australia, April 2002, the VAS score of 70 points indicates Statistical estimates of Reading Ability that borderlines between the Normal Reading Speed/Reduced Reading Distance and the Near-Normal with Appropriate Reading Aids Category.

(4.9) Breathing Gas Concentrations:

The inhaled CO2 concentration shall be less than 1.5% by volume and the O2 concentration greater than 19.5% by volume when tested with human test subjects in accordance with Man Test 1, 42 CFR, Subpart H, Paragraph 84.100 work activities. The concentration of CO2 and O2 in the inspired gas at the mouth will be measured continuously throughout the test. Human subject tests will be performed with two test subjects at each work rate, one weighing 60 kilograms or less and one weighing 80 kilograms or more. Tests shall be performed for the rated duration of the

respirator as determined by 3(c) Duration Rating for each work rate specified.

NIOSH will also perform machine tests with an Automated Breathing Metabolic Simulator (ABMS) prior to performing human subject testing to assess the function of the respirator to determine it's suitability for human subject testing. The ABMS tests will be performed at the following conditions:

Work Rate	f (breath/min)	Vt (Liters, STPD)	VE (L/min, STPD)	VO2 (L/min, STPD)	VCO2 (L/min, STPD)	R	ABMS Waveform	Approx. Peak Flows (L/min, BTPS
1	12	0.8	10.0	0.5	0.4	0.80	BS1210	45.0
2	19.5	1.30	25.3	1.0	0.8	0.82	BS1925	96.6
3	28.0	1.35	38.0	1.5	1.3	0.87	BS2838	149.5
4	32.6	1.90	62.0	2.0	1.9	0.95	BS3362	243.8
5	34.2	2.00	70.0	2.5	2.5	1.00	BD3470	209.3ex 241.5in
6	36.4	2.20	80.0	3.0	3.15	1.05	BD3680	246.1ex 276.0in

Test time at each work rate shall be the rated duration of the respirator.

(5.0) CBRN Requirements:

(5.1) Laboratory Respiratory Protection Level (LRPL):

The measured laboratory respirator protection level (LRPL) for each High Category Escape Respirator 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^3 corn oil aerosol of a mass median aerodynamic diameter of 0.4 to 0.6 micrometers.

	Small	Medium	Large
Head Circumference	NA	NA	576 - 600
Neck Circumference	307 - 350	351 - 375	376 - 409
Face Length	NA	NA	124 – 133.5

Five respirators shall be tested with test subjects from each cell of the above table with representative dimensions. Each cell is uniquely tested.

5.2) Live Agent Test:

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

Open-circuit, positive-pressure SCBAs, including all components and accessories except the air cylinder (shell), 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 Table 1.

Table 1: Simultaneous Liquid and Vapor Challenge of SCBA with Distilled Sulfur Mustard (HD)

Agent	Challenge Concentration [1]	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m^3)	Maximum Breakthrough (concentration integrated over Minimum Service Life) ($mg\text{-}min/m^3$)	Number of Systems Tested	Minimum Service Life (minutes)
HD - Vapor	300 mg/m^3	Stated Duration [1,5]	40	0.60 [3]	6.0 [4]	3	Twice Stated Duration [2, 6]
HD - Liquid	0.86 ml [2]	360					

(1) Vapor challenge concentration will start immediately after the liquid drops have been applied and the test chamber has been sealed.
(2) The test period begins upon start of initial vapor generation.
(3) 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.
(4) The cumulative Ct including all peak data points must not be exceeded for the duration of the 6-hour test.
(5) For a duration period equal to the stated duration life.
(6) For a duration period equal to twice the stated service life.

Test requirements for sarin (GB) agent are shown in Table 2.

Table 2: 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 (minutes)
GB	2,000 mg/m3	Stated Duration [1,5]	40	0.087 [3]	2.1 [4]	3	Twice Stated Duration [2,6]

(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/m3 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 6-hour test.
(5) For a duration period equal to the stated duration life.
(6) For a duration period equal to twice the stated service life.