Closed-Circuit Breathing Apparatus
Development of Performance Requirements

Concept

Evaluation of CCBA requires three areas of scrutiny:

CAPACITY - How far will this apparatus carry me? How many liters of usable oxygen are in it?
PERFORMANCE - What are its characteristics in terms of stressors; i.e., levels of CO_2 and O_2, temperature and pressure?
WEARABILITY - Human interface; i.e., if I bend over, will it cut or burn me? Does it interfere with my activities?

Any testing protocol addressing these three levels of scrutiny must include:

- A quantitative work load
- Continuously monitored stressor levels
- Test termination only when oxygen supply is expended or if a stressor exceeds a safe limit
- Apparatus classified by quantity of usable oxygen

Old versus New

Current tests:

- specify activities rather than work load;
- provide for monitoring stressors only occasionally;
- end at predetermined times;
- classify apparatus by duration, affected by user's weight and activity.

Proposed tests:

- specify quantitative workload;
- provide for continuous monitoring of stressors;
- terminate only when oxygen supply is expended or if stressor limits are exceeded;
- classify apparatus by liters of usable oxygen.

Three tests - three areas of scrutiny

Capacity
- Run at a constant, moderately high work-rate.
- Run until empty.

Performance
- Monitor apparatus performance at high and low work rates while various components are operating.
- Evaluate performance of entire apparatus, not individual components.
- Repeat 30-minute, 50-L, cycle until empty.

Wearability
- Evaluate ergonomics.

Stressor limits based on physiology

- Continuously monitored physiology-based stressor limits shall not be exceeded for longer than one minute in any test.
- Most presently certified CCBA exceed the proposed one-minute limits when monitored continuously.

Monitored Stressors, Acceptable Ranges

Stressor limits are given as permissible averaged over entire test and over any one-minute period.

Stressor	Acceptable Range Operating Average	Acceptable Range Excursion
Average inhaled CO_2	< 1.5%	≤ 4.0%
Average inhaled O_2	> 19.5%	≥ 15.0%
Peak Breathing Pressures	Pex - Pin ≤ 200 mm H_2O	-300 ≤ ΔP ≤ 200 mm H_2O
End-of-breath wet-bulb temperature[1]	< 43°C (109.4 °F)	≤ 50°C (122.0 °F)

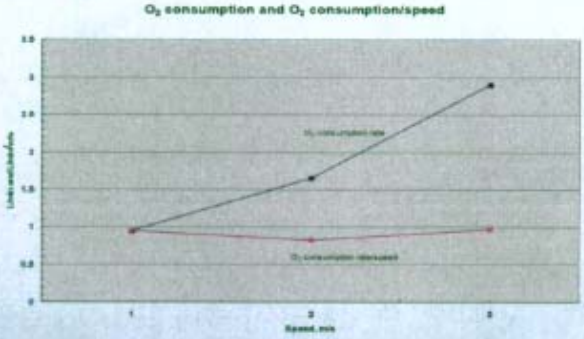
Capacity Test

VO_2 (L/min)	VCO_2 (L/min)	Ve (L/min)	RF (Breaths/min)
1.35	1.15	30	18

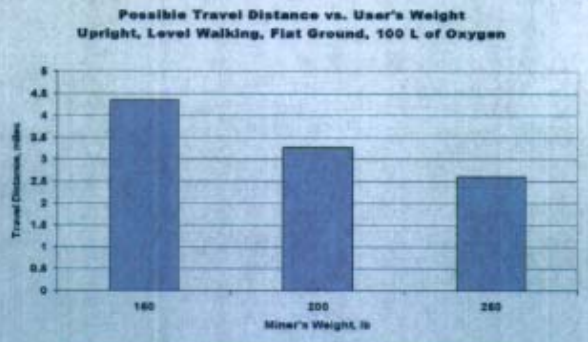
•The capacity rating will be determined by multiplying the lowest duration obtained in any of the Capacity tests by the oxygen consumption rate, 1.35 L/min, rounded down to the nearest 5-L increment. In addition to the capacity rating, in parentheses on the label shall be given the lowest duration obtained in the Capacity test as an expected duration for a user of average weight at a moderately high work rate.

Advantages of rating by capacity rather than by duration

-The duration obtained from a CCBA is inversely proportional to the use rate. Capacity is largely unaffected by use rate.



- Users are not mislead into thinking that the apparatus will last them a certain duration no matter how much they weigh or what they do while wearing it.



Performance Test

Work-Rate Test Sequence	Duration per cycle	VO_2 (L/min)	VCO_2 (L/min)	Ve (L/min)	RF (breaths/min)
Peak	5 min.	3.00	3.20	65	25
High	15 min.	2.00	1.80	44	20
Low	10 min.	0.50	0.40	20	12

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Closed-Circuit Self-Contained Breathing Apparatus (CC-SCBA) Program

Frank Palya Jr.

Goal

Develop new performance requirements for the Closed-Circuit Self-Contained Breathing Apparatus (CC-SCBA) and promulgate them as regulations into Title 42 CFR Part 84 which includes the following:

- Based on latest creditable human physiological factor limits and ergonomics
- Allow latest technology and innovative designs be tested and have flexibility to accommodate future technology
- Ensure NIOSH-certified apparatus provides adequate protection to the wearer and are "safe-to-use"
- Incorporate into Standard Test Procedures (STPs) the required use of test equipment that employs state-of-the-art technology to test the performance requirements
- Provide Chemical, Biological, Radiological and Nuclear (CBRN) protection (optional requirements)
- Provide fire resistant protection: high radiant heat and flame resistance (optional requirements)

Partners

U.S. Army Research, Development and Engineering Command (RDECOM), Occupational Safety and Health Administration (OSHA), Respirator Manufacturers and Mine Safety and Health Administration (MSHA)

Stakeholders

User groups and manufacturing organizations including United Mine Workers of America (UMWA), International Association of Fire Fighters (IAFF), International Association of Fire Chiefs (IAFC), InterAgency Board (IAB) for Equipment Standardization, Bituminous Coal Operators Association (BCOA), National Mining Association (NMA), United Steel Workers of America (USWA) and Internal Safety Equipment Association (ISEA)

Milestones

3QFY08	Post the concept paper containing the draft CC-SCBA performance requirements on the NIOSH website
	Present and discuss the draft performance requirements at NIOSH Public Meeting
4QFY08	Post on the NIOSH website a revised concept paper developed on comments received at the 3QFY08 Public Meeting and information sent to Dockets #039 and #123

Summary of Conceptual Changes, CC-SCBA, Subpart Q

Description	Subpart Q is a new module that contains exclusively the requirements of Pressure Demand and Demand types of Closed-Circuit SCBA designed for entry and escape from Immediately Dangerous to Life and Health (IDLH) atmospheres
Facepiece	Add a Laboratory Respiratory Protection Level (LRPL) performance requirement intended to be replaced by a Total Inward Leakage test
Eye Piece	Add field of view, fogging resistance, haze and luminous transmittance, and abrasion resistance performance requirements, and update impact resistance performance
Breathing Bag	Add a kerosene and toluene vapor permeation resistance performance requirement
Breathing Performance	Implement the use of an Automated Breathing and Metabolic Simulator (ABMS) to test the breathing performance of the apparatus for human stressor needs of CO_2, O_2, breathing pressures and wet-bulb temperature outputs. Breathing performance includes Capacity, Performance and Wearability requirements which will be tested with both the ABMS and human subjects. Replace service time rating with a Capacity rating
Operational Performance	Update Operational performance requirements tested both at ambient temperature and at a manufacturer's recommended low temperature
CBRN Performance	Include optional CBRN performance requirements: – Human stressor to be compliant with NFPA requirements – Temperature-Extreme Operational Performance – Durability of vibration endurance, corrosion resistance and dust resistance – Communication Performance – Chemical agent resistance to Sulfur Mustard (HD) and Sarin (GB)
Fire Fighter Protection	Include optional high heat and flame resistance performance requirements: – Operational performance of the apparatus when exposed to the high heat and open flame test specified in Section 8.11 of NFPA1981-2007. Other performance requirements include the following: – Fabric flame resistance – Fabric heat resistance – Thread heat resistance

Expected Outputs

- Elimination of obsolete requirements with new regulation
- Update or add STPs and Standard Operating Procedures (SOPs) for testing current, new, CBRN, and high heat and flame resistance performance requirements
- Allow for flexibility for greater variety of CC-SCBA designs to be certified
- Certified CBRN CC-SCBA with optional high heat and flame resistance properties
- Availability of CC-SCBA for use in CBRN and high radiant heat and flame environments (If current limitation on CC-SCBA use in high heat and flame environments is repealed)
- Final rule stated in Title 42 CFR Part 84, Subpart Q

Expected Outcomes

Improve CC-SCBA performance for traditional users such as mine rescue teams and for potential new users such as the military, first responder and fire service communities

Poster Topic Sequence

The following topics are covered in the remaining CC-SCBA posters:

(1) Base Performance Requirements

(2) Development of Capacity, Performance, and Wearability Requirements

(3) Chemical, Biological, Radiological and Nuclear (CBRN) Optional Requirements

(4) CBRN (continued) and Firefighter Protection Optional Requirements

(5) NIOSH O_2 Prohibition

(6) Standard Test Procedures

(1) CC-SCBA - Base Performance Requirements

Timothy Rehak

Goal

Develop new performance requirements for the Closed-Circuit Self-Contained Breathing Apparatus (CC-SCBA) and promulgate them as regulations into Title 42 CFR Part 84.

Partners

U.S. Army RDECOM, NIOSH, NFPA and MSHA

Stakeholders

User groups and manufacturing organizations including UMWA, IAFF, IAFC, IAB, BCOA, NMA, USWA and ISEA

Full facepiece - LRPL

- The CC-SCBA shall have a measured LRPL value greater than or equal to 10,000 when the entire CC-SCBA is tested (minimum of 8 tested).
- The measured LRPL value for the CC-SCBA facepiece shall be greater than or equal to 500 when the CC-SCBA facepiece is tested using an adapter and P-100 filter (approximately 11-25 tested).

Facepiece Lens

Shall be designed and constructed to be impact and penetration resistant by meeting the requirements of ANSI Z87.1-2003.

Permeability resistance

CC-SCBAs shall be tested for 8-hour durations in:
•one unit in a gasoline saturated atmosphere;
•one unit in a kerosene saturated atmosphere; and
•one unit in a toluene saturated atmosphere.

The CC-SCBA shall be operated during these tests by a breathing machine set at 24 revolutions per minute (rpm), 40 liter minute-volume, and a work rate of 622 kg - m/minute.

The breathing air in the CC-SCBA shall not contain more than:
•100 parts per million (ppm) of gasoline vapor,
•14 ppm of kerosene vapor,
• 50 ppm of toluene vapor at the conclusion of each of the respective tests.

Monitored Stressors and their Acceptable Operating Averages and Excursions

Stressor	Acceptable Operating Averages	Acceptable Excursions
Average inhaled CO_2	< 1.5%	≤ 4.0%
Average inhaled O_2	> 19.5%	≥ 15.0%
Peak Breathing Pressures	Pex - Pin ≤ 200 mm H_2O	-300 ≤ ΔP ≤ 200 mm H_2O
End-of-breath wet-bulb temperature	< 43°C (109.4 °F)	≤ 50°C (122.0 °F)

Notes:
•An excursion is considered to be going outside an acceptable range for more than one minute.
•Operating averages are minute averages averaged over the entire duration of the test.

Capacity Test Requirements

Four (4)CC-SCBAs will be tested as follows:
•Two (2) each on a NIOSH automated breathing and metabolic simulator (ABMS)
•One (1) each on an ABMS after being cold soaked, for a minimum of 24 hours, at the cold-temperature limit recommended by the applicant.
• One (1) each by a human subject on a treadmill.

The capacity rating will be determined by multiplying the lowest duration obtained in any of the Capacity tests by the oxygen consumption rate, 1.35 L/min, rounded down to the nearest 5-L increment. In addition to the capacity rating, in parentheses on the label shall be given the corresponding duration obtained in the Capacity test as an expected duration for a user of average weight at a moderately high work rate.

Metabolic Parameters for the Capacity Tests

VO_2 (L/min)	VCO_2 (L/min)	Ve (L/min)	RF (Breaths/min)
1.35	1.15	30	18

VO_2 = Volume of oxygen consumed/minute **VCO_2 = Volume of carbon dioxide produced/minute**
Ve = Volume of gas exhaled/minute **RF = Respiratory frequency**

Performance Test Requirements

Four (4) CC-SCBAs will be tested as follows:
•Two (2) each on a NIOSH automated breathing and metabolic simulator (ABMS)
•One (1) each on an ABMS after being cold soaked, for a minimum of 24 hours, at the cold-temperature limit recommended by the applicant.
• One (1) each by a human subject on a treadmill.

Performance Test Sequence

Work-Rate Test Sequence	Duration per cycle	VO_2 (L/min)	VCO_2 (L/min)	Ve (L/min)	RF (breaths/min)
Peak	5 min.	3.00	3.20	65	25
High	15 min.	2.00	1.80	44	20
Low	10 min.	0.50	0.40	20	12

Wearability Test Requirements

•Three (3) human subjects will be tested at ambient temperature:
  •2-males
  •1-female
(Note: Human subjects will be selected at various heights and weights.)

•One (1) human subject (of any weight and height) will be tested in a cold chamber at the lowest temperature recommended for use by the applicant.

Activity	Minimum Duration
Sitting	1 min.
Stooped walking	1 min.
Crawling	1 min.
Lying on left side	1 min.
Lying on right side	1 min.
Lying on back	1 min.
Bending over to touch toes	1 min.
Turning head from side to side	1 min. (at least 10 times)
Nodding head up and down	1 min. (at least 10 times)
Climbing steps or a laddermill	1 min. (1 step/sec)
Carrying 22.68 kg (50-lb) bag on treadmill at 5 km/hr (3.11 mph)	1 min.
Lifting 9.07 kg (20-lb) weight from floor to an upright position	1 min. (at least 10 times)
Running on treadmill at 10 km/hr (6.21 mph)	1 min.

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(2) CC-SCBA - Development of Capacity, Performance, and Wearability Requirements

Nicholas Kyriazi

Concept

Evaluation of CC-SCBA requires three areas of scrutiny:

CAPACITY - How far will this apparatus carry me? How many liters of usable oxygen are in it?

PERFORMANCE - What are its characteristics in terms of stressors; i.e., levels of CO_2 and O_2, temperature and pressure?

WEARABILITY - Human interface; i.e., if I bend over, will it cut or burn me? Does it interfere with my activities?

Any testing protocol addressing these three areas of scrutiny must include:

- A quantitative work load
- Continuously monitored stressor levels
- Test termination only when oxygen supply is expended or if a stressor exceeds a safe limit
- Apparatus classified by quantity of usable oxygen

Old versus New

Current tests:

- specify activities rather than work load;
- provide for monitoring stressors only occasionally;
- end at predetermined times;
- classify apparatus by duration, affected by user's weight and activity.

Proposed tests:

- specify quantitative workload;
- provide for continuous monitoring of stressors;
- terminate only when oxygen supply is expended;
- classify apparatus by liters of usable oxygen.

Three tests - three areas of scrutiny

Capacity

- Run at a constant, moderately high work-rate.
- Run until useable oxygen is expended.

Performance

- Monitor apparatus performance at high and low work rates.
- Evaluate performance of entire apparatus, not individual components.
- Repeat 30-minute, 50-L, cycle until useable oxygen is expended.

Wearability

- Evaluate ergonomics.

Stressor limits based on physiology

- Continuously monitored physiology-based stressor limits shall not be exceeded for longer than one minute in any test.
- Most presently certified CC-SCBA exceed the proposed one-minute limits when monitored continuously.

Monitored Stressors, Acceptable Ranges

Stressor limits are given as permissible averaged over entire test and over any one-minute period.

Stressor	Acceptable Range Operating Average	Acceptable Range Excursion
Average inhaled CO_2	< 1.5%	≤ 4.0%
Average inhaled O_2	> 19.5%	≥ 15.0%
Peak Breathing Pressures	Pex - Pin ≤ 200 mm H_2O	-300 ≤ ΔP ≤ 200 mm H_2O
End-of-breath wet-bulb temperature(1)	< 43°C (109.4 °F)	≤ 50°C (122.0 °F)

(1) Wet-bulb temperature is a measurement of the temperature of a wet surface. It represents the temperature of the inhaled breathing gas in the CC-SCBA user's trachea

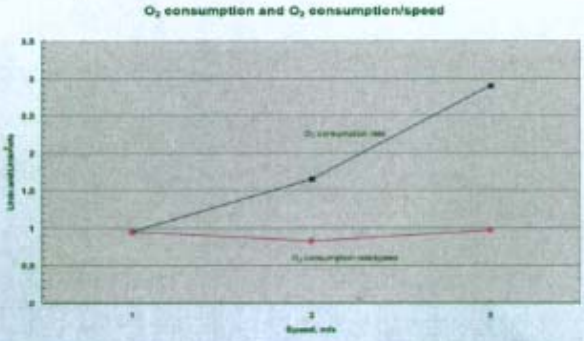
Capacity Test

O_2 consumption rate (VO_2) (L/min)	CO_2 production rate (VCO_2) (L/min)	Ventilation rate (Ve) (L/min)	Respiratory frequency (RF) (Breaths/min)
1.35	1.15	30	18

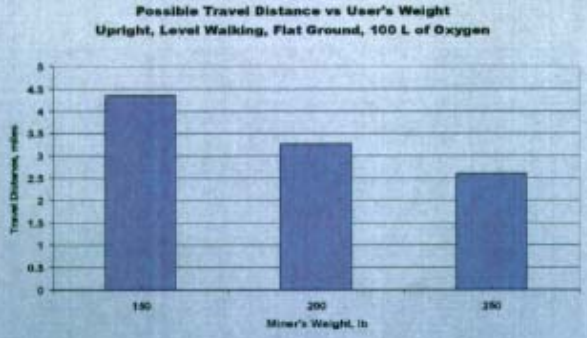
•The capacity rating will be determined by multiplying the lowest duration obtained in any of the Capacity tests by the oxygen consumption rate, 1.35 L/min, rounded down to the nearest 5-L increment. In addition to the capacity rating, in parentheses on the label shall be given the corresponding duration obtained in the Capacity test as an expected duration for a user of average weight at a moderately high work rate.

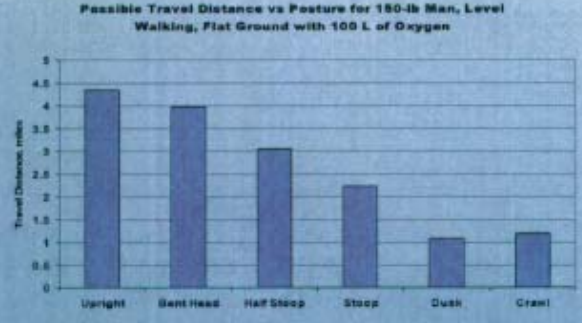
Advantages of rating by capacity rather than by duration

-The duration obtained from a CC-SCBA is inversely proportional to the use rate. Capacity is largely unaffected by use rate.



- Users are not mislead into thinking that the apparatus will last them a certain duration no matter how much they weigh or what they do while wearing it.





Performance Test Sequence

Work-Rate	Duration per cycle	VO_2 (L/min)	VCO_2 (L/min)	Ve (L/min)	RF (breaths/min)
Peak	5 min.	3.00	3.20	65	25
High	15 min.	2.00	1.80	44	20
Low	10 min.	0.50	0.40	20	12

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(3) CC-SCBA - Chemical, Biological, Radiological and Nuclear (CBRN) Optional Requirements

Jonathan Szalajda

CBRN Requirements

§84.521 Chemical, biological, radiological, and nuclear (CBRN) CC-SCBA; Optional requirements; for Use Against CBRN Agents.

(a) A CC-SCBA designed for use as respiratory protection during entry into IDLH CBRN hazardous atmospheres shall meet or exceed the optional performance requirements specified in §84.521 through §84.526 of Subpart Q.

(b) NIOSH approval is obtained for CBRN Protection after it has been determined by NIOSH that the device has met the minimum performance requirements in §84.500 through §84.520.

§84.522 Additional Requirements for CBRN CC-SCBA:

(a) Operational Performance test is to evaluate the performance of the CC-SCBA and not the capacity.

(b) The CC-SCBA shall not exceed the ranges of human stressors listed in Table 5. An excursion is considered to be going outside an acceptable range for more than one minute. Operating averages are minute averages averaged over the entire duration of the test.

(1) The CC-SCBA shall be tested on an automated breathing and metabolic simulator (ABMS) in accordance with the Test Regimen of Table 6 that consists of the Test Parameters and Workloads described in Table 6a and the Test Time Duration per Assigned Workload described in Table 6b.

Refer to Draft Subpart Q: Closed-Circuit Self-Contained Breathing Apparatus-May 28, 2008 for other requirements and test conditions of this section.

Table 5: Human Stressors and Acceptable Range Requirements

Human Stressors	Acceptable Operating Average Requirement	Acceptable Excursion Requirement
Average inhaled CO_2	<1.5% by volume	≤ 4.0% by volume
Average inhaled O_2	>19.5% by volume	≥ 15.0% by volume
End-of-Inhalation wet-bulb temperature(1)	< 43°C (109.4 °F)	≤ 45 °C (113.0 °F)
Peak Exhalation Pressure (PEP)	≤ 200 mm, H_2O	≤ 200 mm, H_2O
Peak Inhalation Pressure (PIP)	≥ 0 mm, H_2O	≥ 0 mm, H_2O

(1) Wet-bulb temperature is a measurement of the temperature of a wet surface. It represents the temperature of the inhaled breathing gas in the CC-SCBA user's trachea

Table 6: Test Regimen

Table 6a: Test Parameters and Workloads

Parameter	Work load A	Work load B
Ventilation rate, liters/min, absolute volume displacement	100	40
Respiratory frequency, breaths/min	30	18
Oxygen consumption rate, liters/min, * STPD	3.2	1.35
Carbon dioxide production rate, liters/min, * STPD	3.4	1.15

* Standard temperature [0oC (32.0°F)] and Pressure (760 mm Hg), Dry

Table 6b: Test Time Duration per Assigned Workload Sequence

Starting time (minutes)	Work load	Duration (minutes)
0	A	12
12	B	43
55	A	5
60	B	25
85	A	5
90	B	25
115	A	5
120	B	25
145	A	5
150	B	30
180	B	60

§84.523 Temperature-Extreme Operational Performance Requirements.
The CC-SCBA shall be tested for Temperature-Extreme Operational Performance and meet the requirements in paragraph 84.522(a), (b)(1), b(2) and b(3) except for the wet-bulb temperature breathing gas requirement in Table 5 during the hot and hot temperature shock conditions when tested in accordance with the following:
(1) The Temperature-Extreme sequence shall start with the Cold condition listed at the top of Table 7, and end with the Hot Temperature Shock condition listed at the bottom of Table 7.
(2) The cold temperature shall be the same minimum temperature specified by the applicant in accordance with Section § 84.502(e)(8).
(3) The apparatus shall be placed in an ambient environment of 22°C ± 3°C (71.6°F ± 5.4°F) with a relative humidity of 50 percent ± 25 percent for a minimum 12-hour dwell after being tested in each environmental condition.
(i) Those components or materials expended during normal apparatus operation shall be replaced after the dwell period between environmental test conditions.

Table 7: Temperature-Extreme Sequence Test Conditions, Temperature, Duration and Procedures

Environment	Temperature	Test duration	Test procedure
Cold (*RBA)	* RBA Temp ± 2°C (RBA Temp °F ± 3.6°F)	Cold soak for a minimum of 12 hours	Perform test at * RBA Temp ± 2°C (* RBA Temp °F ± 3.6°F)
Hot	71°C ± 2°C (159.8°F ± 3.6°F)	Hot soak for a minimum of 12 hours	Perform test at 71°C ± 5°C (159.8°F ± 9°F)
Cold Temperature Shock	71°C ± 2°C (159.8°F ± 3.6°F) transferred to * RBA Temp ± 2°C (* RBA Temp °F ± 3.6°F); Test temperature shall be * RBA Temp ± 2°C (* RBA Temp °F ± 3.6°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	* RBA Temp ± 2°C (* RBA Temp °F ± 3.6°F) transferred to 71°C ± 1°C (159.8°F ± 3.6°F); Test temperature shall be 71°C ± 5°C (159.8°F ± 9°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

* RBA - Cold temperature limit Recommended By Applicant (RBA) under § 84.502(e)(8).

§84.524 Environmental Test Requirements for CBRN Use.
The CC-SCBA shall meet the Operational Performance requirements of §84.522(a), (b)(1), b(2) and b(3) and all control or operating features of the apparatus shall properly function, as specified in the apparatus' User's Instructions, after being subjected to the following Environmental test conditions:

(1) The unrestrained vibration shock with the CC-SCBA placed in a holding box that meets the compartment dimensional requirements of Section 8.3.4.2 of NFPA 1981- 2007 Edition. The vibration movement on the test table bed of a 25.4 mm (1 inch) orbital path operating in synchronous mode at 250 rpm, ± 5 rpm for a period of 3 hours.

(2) The accelerated corrosion test conditions shall be performed in accordance with MIL-STD-810F, Environmental Test Methods, Method 509.4, Salt Fog.
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 ± 3.6°F) for 24 hours; then exposed to a second 24-hour cycle of salt fog and drying period.

(3) The particulate test conditions shall be performed in accordance with MIL-STD-810F, Method 510.4, Procedure I – Blowing Dust as described:
(a) The CC-SCBA and components shall be mounted on a test manikin integrated with the NIOSH ABMS.
(b) The ABMS shall be operated at work load B as defined in Table 6a. The test duration shall be one hour.
(i) Air velocity: 533.4 m/min ± 76.2 m/min (1750 ft/min ± 250 ft/min)
(ii) Temperature: 22°C ± 3°C (71.6°F ± 5.4°F)

(4) CC-SCBA – CBRN (continued) and Firefighter Protection Optional Requirements

Timothy R. Rehak

Chemical, Biological, Radiological and Nuclear (CBRN) Requirements

§ 84.525 Communications Performance Requirement for CBRN Use.
(a) The CC-SCBA shall have a means of communication capable of achieving an average calculated value of not less than 80 percent when tested in accordance with Section 8.10 of the National Fire Protection Association (NFPA) 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Emergency Services- 2007 Edition.
(b) Under the authority stated in § 84.63(c), NIOSH will make the determination in the future whether to require the performance requirement stated in § 84.525(a) and § 84.528(a) through § 84.531(a) be tested in accordance with the NFPA 1981- 2007 Edition or a later Edition of NFPA 1981 for new applications when NIOSH deems the later Edition of NFPA 1981 serves as a more thorough test or is more beneficial to establish the quality, effectiveness and safety of the CC-SCBA. The test method described in the later Edition shall be equal to or more stringent as the test described in the current NFPA 1981-2007 Edition. If deemed necessary, NIOSH will revise the Edition in this document by Policy Letter and will inform all interested parties by writing a Letter to All Interested Parties.

§ 84.526 Chemical Agent Permeation and Penetration Resistance Against Distilled Mustard (HD) and Sarin (GB) Agent Test Requirement for CBRN Use.
The CC-SCBA model, including all components and accessories, shall resist the permeation and penetration of distilled sulfur mustard (HD) and Sarin (GB) chemical agents by meeting the requirements and test conditions specified in Table 8 for HD and Table 9 for GB.

Table 8: Test Parameters Simultaneous Liquid and Vapor Challenge of SCBA with Distilled

Agent	Challenge	Duration of challenge (min)	Breathing machine airflow rate (L/min)	Maximum peak excursion (mg/m^3)	Maximum breakthrough (concentration integrated over minimum Test Duration) ($mg\text{-}min/m^3$)	Number of systems tested	Minimum Test Duration (hours)
HD-Vapor	300 mg/m^3 [3]	30 [1]	40 [6]	0.60 [3]	6.0 [4]	3	6 [2]
HD-Liquid	0.86 ml	360					

[1] Vapor challenge generation shall start immediately after the liquid drops have been applied and the test chamber has been sealed.
[2] The test period begins upon the start of initial vapor generation.
[3] Three consecutive sequential test data points at or exceeding 0.6 mg/m^3 shall 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, shall not be exceeded for the duration of the six (6) hour test.
[5] Decay rate of vapor challenge shall follow the same profile as the decay rate of the NIOSH CBRN Standard for Open-Circuit SCBA.
[6] Absolute volume with the air parameters being the following: Temperature = 32°C ± 1°C (89.6°F ± 1.8°F), Atmospheric Pressure At Sea Level = 760 mm Hg and saturation = 100%.

Table 9—Test Parameters of Vapor Challenge of SCBA with Sarin (GB)

Agent	Vapor challenge 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 Test Duration) ($mg\text{-}min/m^3$)	Number of systems tested	Minimum Test Duration (hours)
GB	2,000 [5]	30 [1]	40 [6]	0.087 [3]	2.1 [4]	3	6 [2]

[1] The vapor challenge generation shall 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^3 shall 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 shall not be exceeded for the duration of the of the six (6) hour test.
[5] Decay rate of vapor challenge shall follow the same profile as the decay rate of the NIOSH CBRN Standard for Open-Circuit SCBA.
[6] Absolute volume with the air parameters being the following: Temperature = 32°C ± 1°C (89.6°F ± 1.8°F), Atmospheric Pressure At Sea Level = 760 mm Hg and saturation = 100%.

Firefighter Protection Requirements

§ 84.527 Firefighter Protection Requirements for CBRN Use (Optional and in addition to Section § 84.521 through § 84.526 of Subpart Q).
A NIOSH prohibition exists, as stated in Federal Register (50 FR 47456), for entry into high radiant heat and open flame environments while wearing a pure oxygen, positive-pressure CC-SCBA. However, optional testing may be obtained. In the event that this prohibition is lifted sometime in the future, approval could then be granted without additional testing. Sections § 84.527 through § 84.531 specifies minimum requirements to ensure that the CC-SCBA possesses some features of high radiant heat and open flame resistance characteristics. These requirements are not meant to sanction its use in high radiant heat and open flame environments unless NIOSH repeals the prohibition.

§ 84.528 Heat and Flame Resistance Performance Requirement.
(a) The CC-SCBA and its accessories shall meet the following requirements when tested in accordance with Section 8.11 of NFPA 1981- 2007 Edition with modifications made to the test apparatus and procedure to accommodate a CC-SCBA:
(1) The peak exhalation pressure shall be ≤ 200 mm H_2O and the peak inhalation pressure ≥ 0 mm, H_2O when measured as described in § 84.517(a).
(2) The components of either the SCBA or its accessories shall have an after-flame no greater than 2.2 seconds.
(3) The components of either the CC-SCBA or its accessories shall not separate or fail in such a manner that would cause the CC-SCBA to be worn and used in a position not specified by the apparatus' User Instructions.
(4) The facepiece lens shall not obscure vision below the 20/100 vision criteria.
(5) The CC-SCBA remaining capacity indicators shall meet the performance requirements in § 84.511.
(b) As described in § 84.525(b), NIOSH will make the determination whether to revise the Edition of NFPA 1981 to test the performance requirement stated §84.528(a).

§ 84.529 Fabric Flame Resistance Requirement.
(a) All apparatus fabric used to secure the CC-SCBA to the wearer shall meet the performance requirement of Section 7.4 of NFPA 1981- 2007 Edition.
(b) As described in § 84.525(b), NIOSH will make the determination whether to revise the Edition of NFPA 1981 to test the performance requirement stated §84.529(a).

§ 84.530 Fabric Heat Resistance Requirement.
(a) All fabric components of the CC-SCBA shall meet the performance requirement of Section 7.5 of NFPA 1981- 2007 Edition.
(b) As described in § 84.525(b), NIOSH will make the determination whether to revise the Edition of NFPA 1981 to test the performance requirement stated § 84.530(a).

§ 84.531 Thread Heat Resistance Requirement.
(a) All thread used in the CC-SCBA shall meet the performance requirement of Section 7.6 of NFPA 1981- 2007 Edition.
(b) As described in § 84.525(b), NIOSH will make the determination whether to revise the Edition of NFPA 1981 to test the performance requirement stated §84.531(a).

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(5) NIOSH Oxygen (O_2) Prohibition

Timothy R. Rehak

Existing Prohibition

Available information does not demonstrate to the satisfaction of NIOSH that positive-pressure closed-circuit self-contained breathing apparatus (CC-SCBA) which use a breathing gas of pure oxygen can be used during direct exposure to open flames and/or high radiant heat and assure the wearer's safety. Therefore, NIOSH has determined that until it has been demonstrated to the satisfaction of NIOSH that those devices can be worn under such conditions, it is prudent to presently limit the use of positive-pressure closed-circuit self-contained breathing apparatus which use pure oxygen breathing gas to atmospheres which do not involve exposure to open flames or high radiant heat.

Partners

NIOSH, NFPA, IAFF, IAFC, MSHA, and Manufacturers.

Stakeholders

User groups and manufacturing organizations including UMWA, IAFF, IAFC, BCOA, NMA, and USWA

Proposed Fire Resistant Protection for Closed-Circuit Self-Contained Breathing Apparatus

Include optional Heat and Flame Resistance Protection performance requirements:

- Operational performance of the apparatus when exposed to the high heat and open flame test specified in Section 8.11 of NFPA1981-2007.

Other heat and flame resistance performance requirements included the following:

- Fabric flame resistance
- Fabric heat resistance
- Thread heat resistance

NIST Research

Objective - to develop a computational fluid dynamics (CFD) simulation of the outward leakage of oxygen around the facepiece of a closed circuit breathing device .

Conclusions

- Oxygen expelled through leak in respirator is propelled away from head region through advection and dissipates through diffusion.
- Risk of flammable mixture near head is observed in 10 % propane environment.
  - This is an extreme environment (fuel-rich, near flammable mixture).
- In case of flammable environment, oxygen leak results in small fuel-lean region near head.
- In fuel-lean environment, oxygen further decreases fuel concentration.
- NIST Technical Note 1484, "A Computational Model of Dissipation of Oxygen from an Outward Leak of a Closed-Circuit Breathing Device" available at this link, http://fire.nist.gov/bfrlpubs/fire07/PDF/f07024.pdf, chronicles the research work completed by NIST.

Heat and Flame Testing Conducted

Intertek, June 2005

Treatment - Section 8.11.5 of NFPA 1981, 2002 Edition (tested without live oxygen).

Problems noted:

- After flame beyond 2.2 seconds:
  - Hose
  - Harness
  - Facepiece hose connector
- Hole burnt through the hose.
- Hole burnt through the facepiece hose connector.
- Backpack fell off the mannequin.
- Bypass valve was fused shut.
- Oxygen bottle strap was burnt through.

Note: Tested CC-SCBAs were not hardened for the heat or flame test.

Automated Breathing and Metabolic Simulator (ABMS) Testing after retrofitting – no difference from untreated units.

Dekra Exam, July 2007

Treatment - Department 8 of the Association for the Promotion of German Fire Safety, Guideline 0802 (tested with oxygen).

Problems noted:

None – met requirements of EN137, Section 6.11.2.2, Flame Engulfment.

Note: CC-SCBA was hardened for the heat and flame test.

Intertek, March 2008

Treatment - Section 8.11.5 of NFPA 1981, 2007 Edition (tested with live oxygen).

Problems noted:

- One unit had a small flame on the lower left side of the facepiece. This caused a leak into the mask, which engulfed the unit eventually into flames during the post test airflow.
- Second unit had a slight afterflame after the 2.2 seconds. Follow-up test on an ABMS revealed no difference from untreated units.

Expected Outputs

- Data to support the reevaluation of the current Prohibition.

Expected Outcomes

Maintain or revise policy on the use of positive-pressure closed-circuit self-contained breathing apparatus which use pure oxygen breathing gas when exposed to open flames or high radiant heat atmospheres.

(6) CC-SCBA - Standard Test Procedures

W. P. King

Goal

For Proposed Subpart Q, ensure up-to-date standard test procedures (STPs) are available for new, revised and current (continued) performance requirements for closed-circuit breathing apparatus (CC-SCBA). STP development includes:

- Incorporating state-of-the-art technology into performance requirement testing
- Benchmarking new procedures
- Elimination of tests for obsolete requirements

New Standard Test Procedures

Topic	STP Number	Proposed paragraph	Status
Breathing bag toluene and kerosene permeation	PSD-ASR-STP-0134	84.516	Draft
Capacity determination*	PSD-ASR-STP-0117	84.518	Benchmark
Performance*	PSD-ASR-STP-0129	84.519	Benchmark
Wearability	PSD-ASR-STP-0130	84.520	Draft

*Color matches that of superseded STPs in last table

Capacity and performance testing with automated breathing and metabolic simulator (ABMS) benchmarking

Current Standard Test Procedures

Topic/Title	Current STP Number	Proposed paragraph
LRPL for full facepiece CC-SCBA	CET-CBRN-CC-SCBA-STP-0652	84.506(b)
Facepiece field of view	CET-APRS-STP-CBRN-0312	84.507(b)
Lens fogging	CET-APRS-STP-CBRN-0314	84.507(c)
Haze, luminous-transmittance, and abrasion-resistance	CET-APRS-STP-CBRN-0316	84.507(d)
Gauge accuracy	RCT-ASR-STP-0128	84.511
Breathing bag gasoline permeation	RCT-ASR-STP-0134	84.516
CBRN environmental temperature operational performance	CET-CBRN-CC-SCBA-STP-0611	84.523
Vibration endurance	CET-CBRN-CC-SCBA-STP-0610	84.524(a)
Salt fog/ accelerated corrosion	CET-CBRN-CC-SCBA-STP-0612	84.524(b)(3)
Blowing dust	CET-CBRN-CC-SCBA-STP-0618	84.524 (c)
Communication performance	CET-APRS-STP-CBRN-0313	84.525
Sarin (GB) vapor agent test	CET-CBRN-CC-SCBA-STP-0650	84.526
Distilled sulfur mustard (HD) vapor and liquid agent test	CET-CBRN-CC-SCBA-STP-0651	84.526

STPs in blue are for optional requirements for CBRN CC-SCBA

Blowing dust benchmarking

Referenced Standards

Standard	Topic/Title	Proposed paragraph
ANSI Z87.1-2003	Lens impact and penetration resistance	84.507(a)
ASTM D 1003-00	Lens optical requirements	84.507(d)
ASTM D 1044-99	Test specimen requirements	84.507(d)
United States Pharmacopoeia (USP)	Breathing gas	84.508
CGA V-1 -2005	Compressed gas cylinder valve outlet and inlet connections	84.510 (d)
NFPA 1981- 2007 Edition [section]	[8.3.4.2] Vibration shock	84.524(a)
	[8.10] Communications performance	84.525(a)
	[8.11] Heat and flame resistance	84.528 (a)
	[7.4] Fabric flame resistance	84.529
	[7.5] Fabric heat resistance	84.530
	[7.6] Thread heat resistance	84.531
MIL-STD-810F, Environmental Test Methods	Method 509.4 salt fog	84.524(b)
	Method 510.4 blowing dust	84.524(c)

Vibration endurance benchmarking

CC-SCBA Standard test procedures not proposed for Subpart Q

Topic/Title	Current STP Number	Ref. 42CFR paragraph
Det. of positive pressure-CC-SCBA	RCT-ASR-STP-0117	84.70(a)(1), 84.90(a), FR v 50 222,11/18/85
Det. of rated service time	RCT-ASR-STP-0121A	84.96, 84.97(d), 84.99, 84.100, 84.103
Det. of alarm pressure	RCT-ASR-STP-0124A	84.84.83(e)(f), 84.96(a)(b)
Gas-tightness with isoamyl acetate	RCT-ASR-STP-0125	84.104(a)(b)
By-pass valve flow	RCT-ASR-STP-0127	84.63(a)(c)(d)
Det. of breathing resistances	RCT-ASR-STP-0135	84.90
Det. of demand gas flow	RCT-ASR-STP-0136	84.94(c), FR v 50 222,11/18/85
Det. of cont. gas flow with demand flow	RCT-ASR-STP-0137	84.94(b)(c)
Safety relief valve operation	RCT-ASR-STP-0138	84.84(i)(1)(2)(3)
Facepiece carbon dioxide	RCT-ASR-STP-0139	84.97
Man tests 1,2,3,4	RCT-ASR-STP-0140	84.100
Man test 5	RCT-ASR-STP-0141	84.101
Vibration (Ro-Tap test)	RCT-ASR-STP-0142	84.63(c)
Det. of low-temperature operation	RCT-ASR-STP-0143	84.98
Det. of cont. gas flow on const. flow	RCT-ASR-STP-0144	84.94(a)
Man test 6	RCT-ASR-STP-0155	84.102

Color corresponds to that of the STP (in the above table) which subsume this aspect.

Supplied-Air Respirator (SAR) Program

Jeffrey D. Palcic

Goal

Develop new performance requirements for the SAR and promulgate them as regulations into 42 CFR Part 84 which includes the following:

- Revise and update minimum requirements used to determine the effectiveness of SAR during entry into and escape from atmospheres not Immediately Dangerous to Life or Health (non-IDLH)
- Base on latest creditable human physiological factor limits and ergonomics
- Allow the latest technology and innovative designs to be tested and have sufficient flexibility to accommodate future technology
- Ensure that NIOSH certified SAR provide adequate protection to the wearer and operate safely
- Incorporate into the standard test procedures (STP) the required use of test equipment that employs state of the art technology to test the performance requirements
- Develop minimum requirements to determine the effectiveness of combination SAR/self-contained breathing apparatus (SCBA) used for escape from chemical, biological, radiological, and nuclear (CBRN) (optional requirements) atmospheres that are Immediately Dangerous to Life or Health (IDLH)

Partners

U.S. Army RDECOM, Respirator Manufacturers, and OSHA

Stakeholders

OSHA, Respirator Manufacturers, Employers, Labor Unions, Respirator Users

Milestones

3QFY08	Post draft SAR requirements to the NIOSH website Present the new SAR requirements at public meeting
4QFY08	Post the revised draft of SAR requirements to NIOSH website

Expected Outputs

- Update requirements to align with current technology
- Update STPs and standard operating procedures (SOP) for current, new, and CBRN requirements
- Facilitate development of a greater variety of SAR designs
- CBRN Certified SAR
- Publish final rule in 42 CFR Part 84, Subpart J

Expected Outcomes

- Improve SAR performance for general industrial workers, and emergency responders
- Availability of SAR for use in CBRN environments

Poster Topic Sequence

The following topics are covered in the remaining SAR posters. The posters are displayed in the order that they are discussed in the draft SAR standard of July 1, 2008:

Supplied-Air Respirators (SAR) Base Requirements

(1) Descriptions of Airline and Airsource Respiratory Systems

(2) Non-Respiratory Requirements

(3) Respiratory Requirements

(4) Airsource Portable Blower/Air Compressors and Air Supply Hose

Supplied-Air Respirators (SAR) Enhanced Requirements

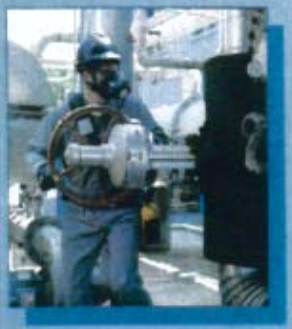
(5) Combination SAR/SCBA Requirements

(6) Chemical, Biological, Radiological, and Nuclear (CBRN) Requirements

Supplied-Air Respirators (SAR) Reference Posters

(7) Work Rate and Escape Cylinder Capacity

(8) Standard Test Procedures



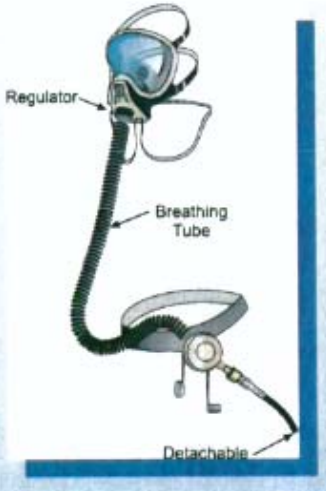
(1) SAR Base Requirements

Descriptions of Airline and Airsource Respiratory Systems

William Hoffman

Airline System

Supplied-Air Respirator – Airline: A respirator equipped with a pressurized air hose which is used for entry into atmospheres not immediately dangerous to life or health, which utilizes a source of respirable breathing air and consists of an Airline hose, detachable coupling(s), control valve, orifice, pressure demand valve, an arrangement for attaching the hose to the wearer, and a respiratory inlet covering usually consisting of a tight facepiece, loose hood, or helmet.



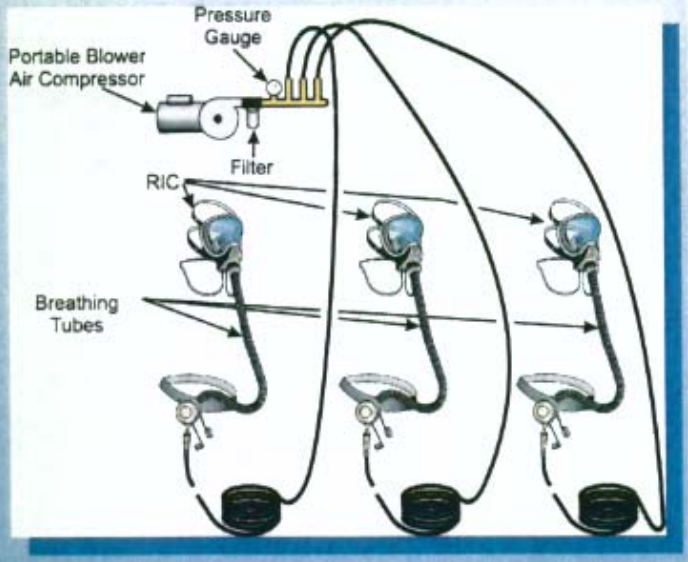
Supplied-air respirator-Airline with Shield: An Airline respirator equipped with additional accessories designed to protect the wearer's head and neck against impact and abrasion from rebounding abrasive particulate or toxic material, and with shielding material such as plastic, glass, woven wire, sheet metal, or other suitable resistant material to protect the lenses of respiratory inlet coverings which do not unduly interfere with the wearer's breathing zone or vision and while permitting easy access to the external surface of such lenses for cleaning.

Airsource System

Supplied-Air Respirator – Airsource: SAR, for entry into atmospheres not immediately dangerous to life or health, which requires a portable blower/air compressor, air hose, detachable coupling(s), an arrangement for attaching the hose to the wearer and respiratory inlet covering usually consisting of a facepiece, hood, or helmet. Systems capable of supplying respirable air to four or more users are considered "industrial plant or site-wide systems" and are not within the scope of this subpart.

Supplied-Air Respirator – Airsource with Shield: An Airsource SAR equipped with additional accessories designed to protect the wearer's head and neck against impact and abrasion from rebounding particulate and toxic material. Designed with shielding material such as plastic, glass, woven wire, sheet metal, or other suitable material to protect respiratory inlet covering lens which does not unduly interfere with the wearer's breathing zone or vision while permitting easy access to the external surface of such lenses for cleaning.

Typical Portable Airsource System



(2) SAR Base Requirements

Non-Respiratory Requirements

Jeffrey D. Palcic

For Use in Industrial Non-IDLH Atmospheres

Required Components

- Airline SAR – Respiratory inlet covering, air supply valve or orifice, air supply hose, detachable couplings, flexible breathing tube, and harness
- Airsource SAR – Respiratory inlet covering, air supply valve or orifice, air supply hose, detachable couplings, flexible breathing tube, harness, and portable blower or air compressor

General Construction

Must meet subpart G of 42 CFR Part 84

Harness; Minimum Requirements

Body Harness

- Must hold the components of the respirator in position against wearer's body
- Designed for easy removal and replacement of respirator parts and hold the facepiece in the ready position when not in use
- Protect the pressure reducer
- Ergonomically designed for multiple shapes and sizes of users
- Shoulder strap test increased from 250 lb to 300 lb for 30 minutes
- Belt and rings increased from 300 lb to 500 lb for 30 minutes
- Life lines or safety harness shall meet applicable standards
- Hose pull test remains unchanged: 250 lb for 30 minutes
- Maximum length and diameter (heaviest hose configuration) must be dragged over a concrete floor without compromising the harness or exerting a pull of the respiratory inlet covering

Head Harness

- Head harness shall be adjustable, replaceable, and provide adequate tension during use
- Rigid head covering shall be required to assist in holding the covering in place

Respiratory Inlet Covering Requirements

Remain unchanged from 42 CFR Part 84, Section 84.132, and 84.135 with the following exceptions:

- Helmets shall meet the requirements of ANSI Z89.1-2003 Type I or Type II protective cap standards. Head gear not designed to provide head protection shall be prominently labeled to indicate that they are not impact and penetration resistant
- Neck seal designs shall provide a seal around the neck without causing discomfort to the user and permit easy donning and doffing

Visors/Lenses of Respiratory Inlet Coverings

Remain unchanged from 42 CFR Part 84, Section 84.136 with the following exceptions:

- Respiratory inlet coverings shall obtain an average Visual Field Score of 90 or greater following the VFS method described by the American Medical Association (AMA)
- Lens shall be designed to be impact and penetration resistant per the requirements of ANSI Z87.1-2003

Noise Levels

- Noise levels generated by the respirator during normal operation shall be measured at maximum airflow obtainable within pressure and hose length requirements and shall be less than 80 dBA at both ear canals

Failure Mode Effects Analysis (FMEA)

- Manufacturers shall demonstrate that reliability is assessed and controlled within their quality assurance plan by conducting a system FMEA on their device or component
- Manufacturer shall provide a written declaration that the FMEA was completed
- Manufacturer shall maintain a copy of the FMEA in their records

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(3) SAR Base Requirements

Respiratory Requirements

Gary Walbert

For Use in Industrial Non-IDLH Atmospheres

Continuous Flow Class

Unchanged from 42 CFR Part 84, Section 84.148

Pressure Demand Class

Unchanged from 42 CFR Part 84, Section 84.149

Demand Class

Eliminated

Breathing Air for Airline SAR

Breathing air supply shall meet the applicable minimum grade requirements for Type I-Grade D breathing air set forth in the Compressed Gas Association Commodity Specification for Air, G-7.1, 5th Edition, 2004 (Grade D or higher quality)

Breathing Air for Airsource SAR

- Blowers/air compressors for Airsource SAR shall be equipped with a CO alarm to warn the user if the CO concentration in the air supply is ≥ 10 ppm of CO
- The temperature of the air produced by the blower/air compressor for all Airsource respirators shall not exceed 6 degrees Celsius above ambient as measured at the air entrance point of the respiratory inlet covering
- Must maintain positive pressure in the breathing zone of the respiratory inlet covering(s) at the manufacturer's specified work rate(s)
- Airsource SAR shall be equipped with a filter between the portable blower/air compressor and the respiratory inlet covering(s) to effectively remove 95% of the particles from the breathing air
- The filter between the blower/air compressor and the respiratory inlet covering shall be easily replaceable by the user. The manufacturer's filter change-out scheduled should be followed
- Compressors used to supply breathing air to respirators are constructed and situated to meet the requirements set forth in the 29 CFR 1910.134.i "Breathing air quality and use"

Inhalation and Exhalation Valves

Unchanged from 42 CFR Part 84, Section 84.137

Exhalation Valve Leakage

Valve and valve seats will continue to be subject to a suction of 25 mm water column but the allowable leakage between the valve and valve seat has been lowered from 30 ml to 15 ml per minute

Breathing Resistance

Inhalation and exhalation resistance shall be measured inside the respiratory inlet coverings in the breathing zone

Respirator Type	Respirator Class	Minimum Inhalation Pressure	Maximum Exhalation Resistance	Test Air Flow Rate
Airline/Airsource	Continuous Flow	Positive Press. In the Breathing Zone	25 mm (H_2O)	@Manuf. Spec. Work Rate
	Pressure Demand	Positive Press. In the Breathing Zone	51 mm (H_2O) Above Static Pressure	@Manuf. Spec. Work Rate

Breathing Rates, Low, Moderate, and/or High Rates

Refer to poster "Supplied-Air Respirator (SAR) Work Rate and Escape Cylinder Capacity"

Carbon Dioxide Machine Test

Verification that inhalation carbon dioxide concentration in the breathing zone of the SAR does not exceed one percent when properly mounted on a headform connected to a breathing machine

Human Subject Testing

Upon successful completion of the carbon dioxide machine test human testing may be conducted in order to ensure that users are not exposed to elevated levels of carbon dioxide or a deficiency of oxygen. This would consist of monitoring carbon dioxide and oxygen concentrations in the breathing zone of test subjects while standing and while walking at 3.5 miles per hour. Carbon dioxide shall not exceed two percent and oxygen shall not fall below 19.5 percent

Laboratory Respiratory Protection Level (LRPL)

Shall be determined with the respirator operating in the candidate approved design mode as described in the applicable user instructions at the manufacturer's specified work rate. The minimum LRPL values are in the following table:

Respiratory Inlet Covering	LRPL – Minimum Value
Loose-Fitting Respiratory Inlet Covering	2,000
Tight-Fitting Respiratory Inlet Covering	10,000
Tight-Fitting Half Mask	2,000

Practical performance shall also evaluate human interface issues with the use of the respirator

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(4) SAR Base Requirements

Airsource Portable Blowers/Air Compressors and Air Supply Hose

William Hoffman

Airsource Portable Blower/Air Compressor

Shall be designed and constructed to maintain positive pressure in the breathing zone of the respiratory inlet covering(s) at the manufacturer's specified work rate(s)

Shall undergo a performance evaluation by operation at their specified running parameters for 8 hours a day for a total of 15 days in the most demanding configuration for which the device is to be approved. This testing will be conducted in a laboratory with the maximum number of respirators mounted on head forms and coupled to breathing machines set at the manufacturer's maximum approved work rate

Noise levels shall be ≤ 85 dBA at any point within a three foot diameter of the system

Any system component exceeding 60 degrees Celsius shall be protected against incidental user contact

Multiple user systems, whereby more than one user is supplied by a single portable blower/air compressor, may be approved, if each hose line is connected directly to a manifold (requires pressure gauge and regulator) at the blower/air compressor

Multiple user systems shall be designed such that air shall not back flow from one line to another

Multiple user systems shall be designed such that air in each line shall flow properly regardless of occurrences in other lines (such as total blockage or disconnected free flow)

Air Supply Hose

All air supply hose length restrictions have been eliminated and the hose lengths will be specified by the manufacturers. The system must maintain positive pressure in the respiratory inlet covering. The following requirements are based on the current 42 CFR Part 84, Table 8

Airline Supply Hose

Air flow - shall maintain positive pressure in the respiratory inlet covering at the manufacturer's specified work rate(s) through the maximum length of hose and greatest number of connections for which approval is sought and the minimum specified air supply pressure

Air-Regulating – unchanged with the exception that the tests will be conducted at the manufacturer's specified work rate and shall maintain positive pressure in the respiratory inlet covering

Airsource Supply Hose

Air flow - Using the blower/air compressor as the supply, the air supply hose shall maintain positive pressure in the respiratory inlet covering at the manufacturer's specified work rate(s) through the maximum length of hose and greatest number of connections for which approval is sought and the minimum specified air supply pressure

Airline and Airsource Supply Hose

Non-collapsibility -unchanged with the exception that the tests will be conducted at the manufacturer's specified work rate and shall maintain positive pressure in the respiratory inlet covering

Non-kinkability - unchanged with the exception that the tests will be conducted at the manufacturer's specified work rate and shall maintain positive pressure in the respiratory inlet covering

Strength of hose and couplings - unchanged

Tightness – unchanged

Hose permeation – unchanged for gasoline; additional proposed permeation tests using kerosene and toluene

Detachable coupling – unchanged with the exception that all couplings shall be constructed to prevent unintentional disconnection requiring at least two different motions for disconnection

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(5) SAR Enhanced Requirements

Combination SAR/SCBA

Jay Parker

Performance Requirements Beyond Base for use in IDLH Atmospheres

Airline and/or Airsource SAR with integrated escape cylinder

Includes all completely assembled respirators with an integrated escape breathing gas cylinder and accessories meeting the following requirements:

- Tight fitting respiratory inlet coverings offer positive pressure, pressure demand protections designed to seal to the face or neck
- Incorporation of a 5 minute or longer duration escape air cylinder based on the high work rate, with air hose supply used during entry
- Incorporation of a 15 minute or longer duration escape air cylinder base on the high work rate, allowing not more than 20 percent of the rated cylinder capacity of air supply to be used during entry into a hazardous area
- If the connection to air supply hose occurs in a hazardous atmosphere zero dead volume connectors must be used
- The connection between the air hose and the rest of the respirator, including the escape air cylinder shall incorporate a check valve or other means such that no contaminated air shall reach the wearer in the event of disconnection, severing, or damage to the air hose and no back flow of the cylinder air through the disconnected air supply hose shall occur
- The connection between the air hose and the rest of the respirator shall be such that breathing air from the cylinder shall only flow to the tight fitting respiratory inlet covering and shall not flow back through the supply air hose or pneumatic tool connection if so equipped
- The unit must automatically switch to the escape cylinder if the air supply hose is disconnected, severed, catastrophically fails or cannot supply adequate breathing air

  Supplied breathing air will be disconnected and the respirator will automatically switch to the available SCBA integrated breathing air cylinder source in the event of loss of air hose supplied air. This shall occur without loss of air pressure to the user and with no detectable inward leakage of contaminants
- An alarm providing an indication that the system is on cylinder air shall be readily visible (via light) or detectable (via sound or vibration) to the user without manipulation of the respirator and without affecting protection and performance
- These respirators must also meet the applicable criteria for subpart H- SCBA

Lens material haze, luminous transmittance and abrasion resistance

- Lens Material Haze: The haze value of the primary lens material shall be 3% or less when tested in accordance with ASTM D 1003-00
- Lens material luminous transmittance: The luminous transmittance value of the primary lens material shall be 88% or greater when tested in accordance with ASTM D 1003-00
- Lens material abrasion resistance: The haze and luminous transmittance of the primary lens material shall be determined in accordance with ASTM D 1003-00 before and after subjecting the lens material to the abrasion test. The abrasion test shall be conducted in accordance with ASTM D 1044-99 using a CS10F calibrase wheel at a minimum of 70 revolutions under a 500-gram weight. After the residue is removed from the test specimens, the test specimens shall not exhibit an increase of haze greater than 4% and a decrease of luminous transmittance greater than 4%

Impact and penetration resistance

- All lenses of respiratory inlet coverings shall be designed and constructed to be impact and penetration resistant per the requirements of ANSI Z87.1-2003, American National Standard for Occupational and Educational Personal Eye and Face Protection Devices.

Low temperature fogging

- The respirator shall demonstrate an average Visual Acuity Score (VAS) of greater or equal to 75 points for all measurements of acuity. The respirator shall be cold soaked and tested in an environmental chamber at minus 21°C or lower if requested by the manufacturer for four (4) hours. The wearer shall not experience undue discomfort because of restrictions to breathing or other physical or material changes to the respirator outfitted with accessories

Communications

- Communications are based upon performance using a modified rhyme test (MRT). The communications requirement is met if the overall performance rating is greater than or equal to seventy (70) percent. The MRT shall 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 3 meters (9.8 feet)

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(6) SAR Enhanced Requirements

Chemical, Biological, Radiological, and Nuclear (CBRN)

Tim Rehak

Performance Requirements Beyond Base and SAR/SCBA for use in CBRN Atmospheres

Airline and/or Airsource CBRN SAR/SCBA

Includes all completely assembled respirators with an integrated escape cylinder, meeting the following requirements:

- Tight fitting respiratory inlet coverings offer positive pressure, pressure demand protection
- 15 minute or longer duration escape air cylinder based on high work rate
- Connection of the SAR portion of the CBRN SAR/SCBA to the portable Airsource or Airline must occur in the non-contaminated atmosphere prior to entry
- No half-mask SAR shall be approved for CBRN protection
- Must meet criteria for subpart H: SCBA and those for CBRN SAR/SCBA in this subpart

Conditioning Requirements

CBRN SAR/SCBA and the required components shall be subject to environmental conditioning prior to testing in the manufacturer specified minimum packaging configuration as per the following table:

Test	Test Method	Test Conditions	Duration
Hot Diurnal	Mil-Std-810F 501.4	35°C to 71°C, 24 Hour cycle	3 Weeks Diurnal Cycle
Cold Constant	Mil-Std-810F 502.4	Basic Cold, -32°C, Constant	3 Days
Humidity	Mil-Std-810E 507.3	Natural Cycle, Cycle 1, Diurnal Cycle, 31°C(88°F) RH 88% to 41°C(105°F) RH 59%	5 Day, Quick Look
Vibration	Mil-Std-810F 514.5	U.S. Highway Vibration, Unrestrained Figure 514.5C-1	12 Hours/Axis, 3 Axis; Total Duration = 36 Hours, equivalent to 12,000 miles

Chemical Agent Permeation and Penetration Resistance

Chemical agent permeation and penetration resistance against sulfer mustard (HD) and sarin (GB) requirements:

- Includes all respirator components and accessories
- Test on an upper torso manikin connected to a breathing machine operating at an air flow rate of 40 Lpm, 36 respirations per minute, and 1.1 liter tidal volume
- Respirator tested in normal operating mode with the CBRN SAR/SCBA breathing from the air supply hose for a minimum of six hours
- Breathing air from the air supply hose will be terminated and the SAR must switch automatically to the escape air cylinder

Simultaneous liquid and vapor challenge of CBRN SAR/SCBA with HD

Agent	Challenge Conc.	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m³)	Maximum Breakthrough Mg-min/m³)	Number of Systems Tested	Minimum Service Life (hours)
HD-Vapor	300 mg/m³	30[1]	40	0.60[3]	6.0[4]	3	6[2]
HD-Liquid	0.86 ml	360					

(1) Vapor challenge concentration shall 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 test data points at or exceeding 0.6 mg/m³ shall 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

Vapor challenge of CBRN SAR/SCBA with GB

Agent	Challenge Conc.	Duration of Challenge (min)	Breathing Machine Airflow Rate (L/min)	Maximum Peak Excursion (mg/m³)	Maximum Breakthrough Mg-min/m³)	Number of Systems Tested	Minimum Service Life (hours)
GB-Vapor	2000 mg/m³	30[1]	40	0.087[3]	2.1[4]	3	6[2]

(1) Vapor challenge concentration shall start immediately after the test chamber has been sealed

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

(3) Three consecutive test data points at or exceeding 0.087 mg/m³ shall 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

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(7) SAR Reference Poster

Work Rate and Escape Cylinder Capacity

Rich Vojtko

Multiple Work Rate Approvals

NIOSH has tentatively defined low, moderate and high work rates as described in the table below. These designations are not meant to imply that they cover the full range of human physiological limits. They represent three sustainable work rates. Table #1 includes average tidal volumes and respiration rates that NIOSH will use for positive pressure tests using a breathing machine.

Table#1 Proposed NIOSH Work Rates

Work Rate	Minute Volume	Tidal Volume and Respirations
Low	25 Lpm	1.30 liters @ 19.2 respirations per minute
Moderate	40 Lpm	1.67 liters @ 24 respirations per minute
High	57 Lpm	1.95 liters @ 29.1 respirations per minute

The manufacturer shall specify the highest work rate from Table #1 for the intended use of the SAR system. During testing, the SAR must maintain positive pressure in the breathing zone of the respiratory inlet covering while properly mounted on a headform coupled with a breathing machine operating at the specified work rate. The SAR must be operated at the manufacturer's minimum supply pressure and maximum hose resistance configuration at each of the rates desired for approval.

Escape Cylinder Capacity Comparison

The current version of the Draft SAR Standard allows optional approval for an enhanced SAR with integrated escape cylinder. In addition to meeting all base requirements, this enhanced SAR/SCBA must meet additional requirements to ensure safe escape from hazardous atmospheres. For escape only, the manufacturer may choose a five minute or longer duration cylinder capacity based on the high work rate (57Lpm) shown to the left. For systems to be used for both entry and escape, the manufacturer may choose a 15 minute or longer duration cylinder based on the same high work rate. No more than 20 percent of the air supply should be used for entry into the hazardous area. NIOSH is considering amending these capacity designations from cylinder duration to actual volumes. This does not change the actual requirement, only the capacity designations. Table #2 describes currently proposed time designations and their volumetric equivalents.

Table #2 Escape Cylinder Capacities

Capacity Designation	Capacity				
	Escape Only			Entry and Escape	
Time Basis (min)	5	10	>10*	15	>15*
Volume Basis (liter)	285	570	>570*	875	>875*

*Actual capacity specified by manufacturer

The purpose of the proposed change in capacity designation is to prevent confusion among end users. Specification of an exact time could lead to over estimation of the remaining air supply in cases of high exertion. A knowledge of the quantity of air available and the factors that affect the rate of consumption should give a trained user the best tools to pace activities and escape from a hazardous atmosphere in a timely fashion.

(8) SAR Reference Poster

Standard Test Procedures

William P. King

Goal

Update standard test procedures (STPs) and standard operating procedures (SOP) to reflect current, new, and CBRN performance requirements for supplied-air respirators (SAR).

New Standard Test Procedures

The following standard test procedures will be added to fulfill the testing requirements for the SAR. Several of these procedure already exist for testing other respiratory protective devices and will be modified to meet the SAR performance standards. The remainder will be developed and validated.

Topic	Draft Reference Section
Harness Test	4.1.3.3
Determination of Field of View	4.1.5.1
Lens Impact and Penetration Resistance	4.1.5.2
Airsource CO Alarm Test	4.2.4.1
Airsource Breathing Gas Temperature Test	4.2.4.2
Airsource Filter Efficiency Test	4.2.4.4
Exhalation Valve Leakage	4.2.6
Positive Pressure in the Breathing Zone @ Work Rate	4.2.8
Facepiece Carbon Dioxide Machine Test	4.2.9
Facepiece Oxygen And Carbon Dioxide Levels	4.2.10
Laboratory Respirator Protection Level (LRPL)	4.2.11
Airsource Performance Evaluation Test	4.3.2
Airsource Noise Test	4.3.3
Airsource Component Surface Temperature Test	4.3.4
Airsource System Backflow Test for Multiple Users	4.3.6-7
Air Hose Non-Collapsibility	4.4.3.1
Hose & Coupling Kerosene Permeation	4.4.3.6
Hose & Coupling Toluene Permeation	4.4.3.7
Haze, Luminous Transmittance, and Abrasion Resistance	5.2
Low Temperature Fogging	5.2.3
Communication Test	5.2.4
SAR/SCBA Escape Cylinder	6
Durability Conditioning	6.3.4
Live Agent Tests	6.4
Pneumatic Tool Take-off Line Test	7.2
Drinking Tube Leakage	7.5

Standard Test Procedures Requiring Revision

The following standard test procedures will be revised to include the new respiratory performance standards and methods.

Topic	STP Number	STP Status	Draft Reference Section
Noise Levels	RCT-ASR-STP-0111	Orig.	4.1.6
Inhalation Air Flow Resistance-Pressure Demand	RCT-ASR-STP-0106	Orig.	4.2.7
Airflow Resistance-Continuous Flow	RCT-ASR-STP-0113	Orig.	4.2.7
Exhalation Air Flow Resistance-Pressure Demand	RCT-ASR-STP-0107	Orig.	4.2.7
Regulating Valve Cycle Performance	RCT-ASR-STP-0104	Orig.	4.4.1.2
Hose & Coupling Gasoline Permeation	RCT-ASR-STP-0103A	Orig.	4.4.3.5
Air Flow Resistance	RCT-APR-STP-0065	Orig.	4.4.2.1
Hose Kinkability	RCT-ASR-STP-0102	Orig.	4.4.3.2
Hose & Coupling Strength	RCT-ASR-STP-0100	Orig.	4.4.3.3
Hose & Coupling Tightness	RCT-ASR-STP-0101	Orig.	4.4.3.4

Obsolete Standard Test Procedures

The following test procedures will be eliminated from the existing SAR requirements due to changes in the performance requirements and the methods that will be used to evaluate SAR.

Topic	STP Number
Inhalation Air Flow Resistance-demand	RCT-ASR-STP-0108
Exhalation Air Flow Resistance-demand	RCT-ASR-STP-0109
Continuous Flow Air Flow	RCT-ASR-STP-0105
Demand & Pressure Demand Air Flow	RCT-ASR-STP-0105A
Determination Of Gas Tightness Test	RCT-SAR-STP-0110

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