

PPE CASE



Personal Protective Equipment Conformity Assessment Studies and Evaluations

Evaluation of a Self-Contained Breathing Apparatus Involved in a Fatality While Operating at a Structure Fire

Watertown Fire Department Request for a MSA Model G1, 45 minute, 4500 psi unit

The National Institute for Occupational Safety and Health (NIOSH) conducts a Fire Fighter Fatality Investigation and Prevention Program, which is executed by its Division of Safety Research (DSR). In support of this Program, NIOSH's National Personal Protective Technology Laboratory (NPPTL) inspects and evaluates the self-contained breathing apparatus (SCBA) used by the fire fighter during a fatality.

This report provides a summary of NPPTL's inspection and evaluation methods as well as findings for testing related to an SCBA that was being used by the Watertown Fire Department fire fighter during a fatal event. The SCBA used was an MSA Model G1, 45 minute, 4500 psi unit. NIOSH DSR and the Watertown Fire Department were advised that NIOSH NPPTL would provide a written report of the investigation and any applicable test results.

What NIOSH Did to Protect the Worker

Upon receipt of the SCBA, NPPTL managed the custody of evidence throughout the entire inspection and evaluation process at its Morgantown, West Virginia, facility. NPPTL staff inspected all SCBA components and documented their findings with written and photographic evidence. NIOSH assigned Task Number TN-24882 to identify the unit. NPPTL also tested the SCBA to determine conformance to NPPTL's approval requirements as outlined in Title 42, Code of Federal Regulations, Part 84 (42 CFR 84). Further testing was conducted to provide an indication of the conformance of the SCBA to the National Fire Protection Association (NFPA) Airflow Performance requirements of NFPA 1981, Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service, 2013 Edition. If the inspection or evaluation data suggested that the SCBA unit may have contributed to the fatal event, NPPTL would have engaged in corrective action to ensure that no other users of the product would experience a fatal event. In this case, no such corrective action was necessary. NPPTL then managed the disposition of the SCBA.

NIOSH received an SCBA used by a fire fighter involved in a fatality. The tested components of the SCBA were not found to contribute to the fatality.

A qualified service technician must inspect, repair, test, clean, and replace damaged components of any SCBA involved in an incident before it may be returned to service.

Chain of Custody

The SCBA unit was delivered by the NIOSH DSR investigators assigned to investigate the Watertown Fire Department fatal event. They delivered the unit to Lab H1513 for secure storage at the NIOSH facility in Morgantown, West Virginia, on April 21, 2021. The SCBA unit remained in secure storage in Lab H1513 throughout the inspection and testing process.

SCBA Inspection

On May 26, 2021, NPPTL employees Jay Tarley and Angela Andrews inspected the SCBA unit. These employees identified the SCBA as a Watertown Fire Department SCBA and visually examined the device, component by component, in the condition received to determine the conformance of the unit to the NIOSH-approved configuration. The unit was an MSA Model G1, 45 minute, 4500 psi with NIOSH Approval Numbers TC-13F-0787CBRN.

As-received (pictured below) SCBA unit

- SCBA unit was hand delivered to Lab H1513 by NIOSH DSR investigators
- Cylinder was received with less than 1000 psi and was closed
- Bypass was closed
- Mask-mounted regulator (MMR) was securely connected to the low-pressure line
- Facepiece was included with blackout cover



Figure 1: SCBA as received

Components and Observations for SCBA (“right” or “left” are from the user’s perspective; “good” means functional and may show signs of dirt/soot; “fair” means functional, but signs of some damage; “bad” means not functional, needs to be inspected by technician to possibly replace part(s)) (see **Figures in Appendix**)

Facepiece (Figures 2-5)

- Facepiece seal P/N: 10161810; M/N: 7-2771-1
- Nosecup MFG date: 10/2016
- Overall condition was good condition
- Lens was in good condition
- Upper lens ring was in good condition
- Lens retaining ring was intact
- MMR housing was clean and in good condition; M/N 7-2774-1; 10144213
- HUD was present and intact
- Hairnet was in good condition with dirt present
- All straps and buckles functioned properly
- Blackout cover for facepiece was present

Mask-Mounted Regulator (MMR) (Figures 6-8)

- MMR label on front: MSA; M/N: 7-2779-1
- Overall condition was good with signs of dirt
- MMR was secured to low-pressure line
- Bypass closed
- Inside flange had normal wear and in good condition
- Sealing area was good and slightly dirty
- Regulator could be attached and removed
- Outer rubber in good condition
- RFID stamp

Low-Pressure Regulator Hose (Figures 8-9)

- Secured at all attachment points
- Line was in good condition
- Line passed through the shoulder strap to the reducer

Pressure Reducer Assembly (Figure 10-11)

- Overall condition was good
- All airline connections were secure
- All lines going to the pressure reducer were in good condition
- 4500 psi; 0817750

PASS Control Module (Figures 12-14)

- Lines to control module looked good
- Gauge lens was readable
- Protective casing was good and in place
- M/N 7-2816-1

High-Pressure Hose and Cylinder Attachment (Figures 15-18)

- High-pressure M/N: 7-2844-1 (cylinder attachment #) 10149679 hose
- High-pressure line good condition with some signs of wear; M/N 7-2844-1

- Cylinder quick connect attachments WO 11082108, 02/17-U 4500/5500 psi, 10149700 were in good condition

Quick-Fill line (18)

- Protective cover and sleeve in good condition

PASS Power Module (Figures 19-21)

- SEI label:02-2017; 10148687 4500 psi; RFID
- PASS met requirements of NFPA 1982: Standard on Personal Alert Safety Systems (PASS) 2013 edition
- FCC ID P9R 10154953, RPN 10069330
- Overall condition was good
- Li-ion Rechargeable Battery Pack 7-2814-1
- Held securely to backframe
- Power module battery was attached

Backframe Assembly (Figures 22-25)

- SEI label 1981-2013 edition
- NIOSH Approval Number label: TC-13F-0787CBRN
- FD label with 470262
- Overall condition was good
- Shoulder straps were attached to the frame

Straps and Buckles (Figures 23-24)

- Overall condition of straps was good
- Hose lines passed through shoulder straps
- All adjustable buckles moved and held in place
- Waist area buckle latched

Compressed Air Cylinder and Cylinder Valve Assembly (Figures 26-32)

- DOT-SP 10915-4500; TC-3CCM -310
- Luxfer R388; ACU258211; REE: 126
- MSA M/N 7-1348-1
- Hydrostatic date: 3/2017; 45-minute, 4500 PSI
- Received with less than 1000 psi
- Overall condition was good
- Gauge was readable
- Threads were good
- O-ring was present and in good condition
- Rubber bumper at base of cylinder valve was in good condition
- FD labels 7-3 and City Watertown 17-012

SCBA Testing

The SCBA unit was tested using six NIOSH test methods and one NFPA test method as described in **Table 1**.

Table 1. Summary of results from testing SCBA unit.

NIOSH Tests	Description of Results	PASS/ FAIL
<p>Positive Pressure Test - NIOSH Standard Test Procedure Number 120, 42 CFR Part 84 Reference: Subpart H, § 84.70 (a)(2)(ii) Requirement: <i>The pressure inside the facepiece in relation to the immediate environment is positive during both inhalation and exhalation.</i> Procedure: A breathing machine with a 622 kg-m/min cam operating at 24 RPM with a 40 liters per minute flow rate (115 liters per minute peak flow) is connected to an anthropometric head for cycling. A pressure tap in the head is connected to a transducer which in turn is connected to a strip chart recorder for determining the pressure in the facepiece.</p>	<p>The unit met the test requirement. The inhalation breathing resistance did not become negative during the test.</p> <p>Inhalation Breathing Resistance: (inches of water column) = 0.36</p>	<p>PASS</p>
<p>Rated Service Time Test - NIOSH Standard Test Procedure Number 121, 42 CFR Part 84 Reference: Subpart F, § 84.53 (a) and Subpart H, § 84.95 (a) and (b) Requirement: <i>Service time will be measured while the apparatus is operated by a breathing machine as described in § 84.88. The open-circuit apparatus will be classified according to the length of time it supplies air or oxygen to the breathing machine. Classifications are listed in § 84.53.</i> Procedure: A breathing machine with a 622 kg-m/min cam operating at 24 RPM with a 40 liters per minute flow rate is connected to an anthropometric head for cycling. A pressure tap in the head is connected to a transducer which in turn is connected to a strip chart recorder for determining the pressure in the facepiece. The breathing machine is run until the inhalation portion of the breathing curve falls below the minimum requirement.</p>	<p>The unit met the test requirements. The measured service time (adjusted to correspond with the recorded breathing cycles) was more than the rated service time of 45 minutes. The SCBA did not go negative on inhalation; therefore, maintained positive pressure was maintained in the facepiece</p> <p>Measured Service Time: 51 Minutes 20 Seconds</p>	<p>PASS</p>

<p>Static Pressure Test - NIOSH Standard Test Procedure Number 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (d)</p> <p>Requirement: <i>The static pressure (at zero flow) in the facepiece shall not exceed 38 mm (1.5 inches) water column height.</i></p> <p>Procedure: The facepiece is fitted to an anthropometric head for testing. A pressure tap in the head is connected to a calibrated manometer. Full cylinder pressure is applied to the unit at zero flow and a reading from the manometer is recorded.</p>	<p>The SCBA met the test requirement.</p> <p>Facepiece Static Pressure:(inches of water column) = 1.12</p>	<p>PASS</p>						
<p>Gas Flow Test - NIOSH Standard Test Procedure Number 123, 42 CFR Part 84 Reference: Subpart H, § 84.93 (b) and (c)</p> <p>Requirement: <i>The flow from the apparatus shall be greater than 200 liters per minute when the pressure in the facepiece of demand apparatus is lowered by 51 mm (2 inches) water column height when full container pressure is applied. Where pressure demand apparatus are tested, the flow will be measured at zero gauge pressure in the facepiece.</i></p> <p>Procedure: A pressure tap in the anthropometric head is connected to a manometer for determining when the pressure inside the facepiece is at zero. A mass flow meter is connected in line between the anthropometric head and an adjustable vacuum source to measure flow. The SCBA cylinder is replaced by a test stand which is adjusted initially to full cylinder pressure. The vacuum source is adjusted during the test to maintain the desired pressure inside the facepiece. Once the proper facepiece pressure has stabilized, a flow reading is recorded. The procedure is then repeated with the test stand adjusted to 500 psig.</p>	<p>The SCBA met the test requirement.</p> <table border="0"> <tr> <td>Applied Pressure</td> <td>Airflow (liters per minute)</td> </tr> <tr> <td>4500 psig</td> <td>331.3</td> </tr> <tr> <td>500 psig</td> <td>325.6</td> </tr> </table>	Applied Pressure	Airflow (liters per minute)	4500 psig	331.3	500 psig	325.6	<p>PASS PASS</p>
Applied Pressure	Airflow (liters per minute)							
4500 psig	331.3							
500 psig	325.6							
<p>Exhalation Resistance Test - NIOSH Standard Test Procedure Number 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (c)</p> <p>Requirement: <i>The exhalation resistance of pressure-demand apparatus shall not exceed the static pressure in the facepiece by more than 51 mm (2 inches) water column height.</i></p> <p>Procedure: The facepiece is mounted on an anthropometric headform. A probe in the headform is connected to a slant manometer for measuring exhalation breathing resistance. The airflow through the apparatus is adjusted to a rate of 85 liters per minute and the exhalation resistance is recorded.</p>	<p>The SCBA met the test requirement.</p> <p>Exhalation Breathing Resistance: (inches of water column) = 2.20 Static Pressure: (inches of water column) = 1.12 Difference: (inches of water column) = 1.08</p>	<p>PASS</p>						

<p>Remaining Service Life Indicator Test - NIOSH Standard Test Procedure Number 124, 42 CFR Part 84 Reference: Subpart H, § 84.83 (f) and Subpart G, § 84.63 (c)</p> <p>Requirement: <i>Each remaining service life indicator or warning device shall give an alarm when the remaining service life of the apparatus is reduced within a range of 33 to 37 percent of its rated service time or pressure.</i> <i>This requirement is modified under § 84.63(c) as follows: For apparatus which do not have a method of manually turning off remote gauge in the event of a gauge or gauge line failure the remaining service life indicator is required to be set at 33% + 4% of the rated service time or pressure.</i></p> <p>Procedure: A calibrated gauge is connected in line between the air supply and the first stage regulator. The unit is then allowed to gradually bleed down. When the low air alarm is activated, the pressure on the gauge is recorded. This procedure is repeated six times. The average of the six readings is calculated and recorded.</p>	<p>The test requirement was identified on the label as 33% - 37% of its remaining rated service time.</p> <table border="1" data-bbox="1318 227 1915 552"> <thead> <tr> <th>Run #</th> <th>Electrical Alarm Point (psi)</th> <th>Bell Alarm Point (psi)</th> </tr> </thead> <tbody> <tr><td>1</td><td>1570</td><td>1570</td></tr> <tr><td>2</td><td>1565</td><td>1560</td></tr> <tr><td>3</td><td>1580</td><td>1570</td></tr> <tr><td>4</td><td>1570</td><td>1560</td></tr> <tr><td>5</td><td>1570</td><td>1580</td></tr> <tr><td>6</td><td>1590</td><td>1580</td></tr> <tr><td>Average:</td><td>1574</td><td>1570</td></tr> </tbody> </table>	Run #	Electrical Alarm Point (psi)	Bell Alarm Point (psi)	1	1570	1570	2	1565	1560	3	1580	1570	4	1570	1560	5	1570	1580	6	1590	1580	Average:	1574	1570	<p>PASS PASS</p>
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Average:	1574	1570																								

National Fire Protection Association (NFPA) Test (in accordance with NFPA 1981, 2013 Edition):

NFPA Test	Description of Results	PASS/ FAIL
<p>NFPA Airflow Performance Test - NFPA 1981 (2013 Edition) Reference: Chapter 8, Performance Requirements, Sec. 8-1.1</p> <p>Requirement: <i>SCBA shall be tested for airflow performance as specified in Section 8.1, Airflow Performance Test, and the SCBA facepiece pressure shall not be less than 0.0 in (0.0 mm) water column and not greater than 3½ in (89 mm) water column above ambient pressure from the time the test begins until the time the test is concluded.</i></p> <p>Procedure: The required equipment specified in the NFPA standards were used to conduct the tests on this unit. A pressure tap in the head is connected to a transducer which in turn is connected to a flatbed chart recorder for determining the pressure in the facepiece.</p>	<p>The SCBA passed this test.</p> <p><i>*During initializing the PosiChek, a message popped up stating exhalation valve could be sticky</i></p> <p>Maximum Facepiece Pressure: (inches of water column) = 2.35 Minimum Facepiece Pressure: (inches of water column) = 0.15</p>	<p>PASS PASS</p>

Disposition of SCBA

Following testing on May 26, June 7, and June 8, 2021, the SCBA unit was returned to secure storage in Lab H1513 at the NIOSH facility in Morgantown, West Virginia.

Synopsis of Findings

The SCBA unit inspected and evaluated by NPPTL was identified as an MSA Model G1, 45 minute, 4500 psi unit with NIOSH Approval Numbers TC-13F-0787CBRN. The fire fighter was wearing the unit when the event occurred. The corresponding facepiece and cylinder were provided with the unit. The testing team determined a replacement facepiece was needed because they were unable to achieve a passing static pressure test with the facepiece provided after the Gas Flow Test. Therefore, the remainder of the testing was conducted utilizing an NPPTL facepiece. Overall, the SCBA was in good condition. The NFPA approval label was present and readable. The PASS, HUD, and alarm systems functioned as designed during the inspection and during the remaining service life indicator testing completed on 5/26/2021. However, it seems as though the battery is no longer charged. The unit passed all the NIOSH tests as well as meeting the requirements for the NFPA “Airflow Performance” test.

The information obtained during this investigation does not suggest that the components tested contributed to the fatality. The SCBA was returned to the shipping container to be shipped back to the Watertown Fire Department.

CASE Conclusion

No evidence was identified to suggest that the SCBA unit inspected and evaluated contributed to the fatality. NIOSH determined that there was no need for corrective action with regards to the approval holder or end user of SCBA manufactured under the approval numbers granted to this product.

Actions to be Taken by the Fire Departments with SCBAs Involved in an Incident

- Any SCBA unit involved in an incident may not be placed back in service until the SCBA has been repaired, tested, cleaned, and any damaged components replaced and inspected by a qualified service technician, including such testing and other maintenance activities as prescribed by the schedule from the SCBA manufacturer.
- All SCBA units, even those not involved in an incident, must undergo a flow test on at least an annual basis.

Actions PPE Users, Selectors, and Purchasers May Take to Further Protect Themselves and Others from Hazards

- Sign up for [NPPTL's Listserv](#) to receive email notifications relevant to PPE.

To request additional information about this report, contact NPPTL at ppeconcerns@cdc.gov, and reference NIOSH Task Number 24882 in your request.

For more information related to personal protective equipment, visit the NIOSH website <https://www.cdc.gov/niosh/npptl/>

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Appendix Photographs to Support Inspection Findings for SCBA

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Figure 2: Front of facepiece



Figure 3: Inside facepiece and HUD



Figure 4: Facepiece hairnet and straps



Figure 5: Blackout cover for facepiece



Figure 6: Mask-mounted regulator



Figure 7: Inside of mask-mounted regulator



Figure 8: Mask-mounted regulator and low-pressure line connected to SCBA



Figure 9: Low-pressure line in protective sleeve



Figure 10: Pressure reducer, RIC UAC with primary low-pressure warning device (bell)

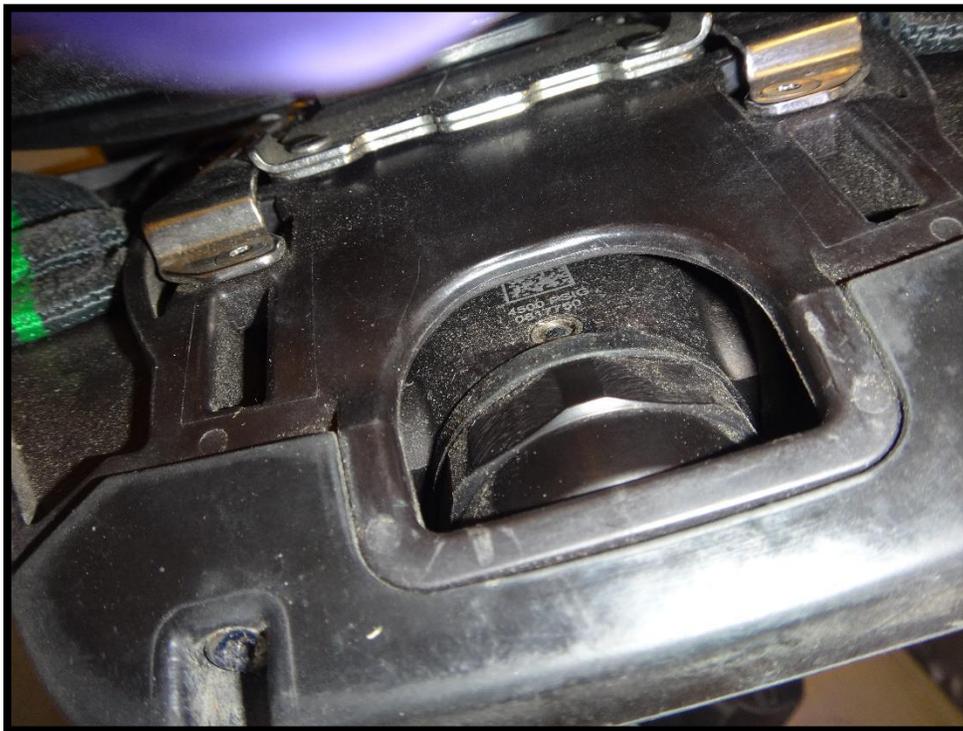


Figure 11: Bottom view of pressure reducer assembly



Figure 12: Front of PASS control module



Figure 13: Back of PASS control module



Figure 14: Labeling on PASS control module



Figure 15: High-pressure hose and cylinder attachment



Figure 16: Top view of high-pressure hose



Figure 17: Quick Connect adapter cover



Figure 18: Quick Connect adapter



Figure 19: PASS power module SEI label



Figure 20: Power module



Figure 21: Power module MSA label



Figure 24: Overview of waist belt, straps, and buckles



Figure 25: Backframe with cylinder holder



Figure 26: Top view of cylinder with labeling



Figure 27: Top view of cylinder with labeling



Figure 28: Top view of cylinder with labeling



Figure 29: Cylinder gauge



Figure 30: Cylinder valve and rubber bumper



Figure 31: Threaded CGA connector attached to cylinder



Figure 32: Threaded CGA connector removed to show cylinder threads

Disclaimer

The purpose of this effort was to determine the conformance of a respirator to the NIOSH approval requirements found in Title 42, *Code of Federal Regulations*, Part 84. A number of performance tests are selected from the complete list of Part 84 requirements and each respirator is tested in its “**As received**” condition to determine its conformance to those performance requirements. Each respirator is also inspected to determine its conformance to the quality assurance documentation on file at NIOSH.

In order to gain additional information about its overall performance, each respirator may also be subjected to other recognized test parameters, such as National Fire Protection Association (NFPA) consensus standards. While the test results give an indication of the respirator’s conformance to the NFPA approval requirements, NIOSH does not actively correlate the test results from its NFPA test equipment with those of certification organizations which list NFPA-compliant products. Thus, the NFPA test results are provided for information purposes only.

Selected tests are conducted only after it has been determined that each respirator is in a condition that is safe to be pressurized, handled, and tested. Respirators whose condition has deteriorated to the point where the health and safety of NIOSH personnel and/or property is at risk will not be tested.

