

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

Lower Merion Fire Department, PA, Requested the Evaluation of a MSA Model G1, 30-minute, 4500 psi unit

National Institute for Occupational Safety and Health (NIOSH)

National Personal Protective Technology Laboratory (NPPTL)

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November 3, 2022

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 firefighter 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 a firefighter from the Lower Merion Fire Department during a fatal event. The SCBA used was an MSA Model G1, 30-minute, 4500 psi unit.

NIOSH received an SCBA used by a firefighter involved in a fatality. The SCBA was 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.

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-25965 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. This unit was certified to the 2013 Edition, therefore was evaluated to the 2013

Edition – there is no difference between the NFPA Airflow Performance requirements of NFPA 1981 2019 Edition and the 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 a SCBA with NIOSH Approval Number TC13F-0786CBRN would experience a fatal event. In this case, no such corrective action was necessary. NPPTL then managed the disposition of the SCBA.

Chain of Custody

The SCBA unit was delivered via FedEx in cardboard boxes to Lab H1513 for secure storage in the NIOSH facility in Morgantown, West Virginia, on June 23, 2022. The SCBA unit remained in secure storage in Lab H1513 throughout the inspection and testing process.

SCBA Inspection

On June 28, 2022, NPPTL employees Jay Tarley and Angie Andrews inspected the SCBA unit. The SCBA was identified as belonging to the Lower Merion Fire Department and was visually examined, component by component, in the condition received to determine the conformance of the unit to its NIOSH-approved configuration. The unit was an MSA Model G1, 30-minute, 4500 psi with NIOSH Approval Number TC-13F-0786CBRN.

As-received

- The SCBA unit was delivered by FedEx.
- The cylinder was received empty and was closed.
- The bypass was closed.
- The mask-mounted regulator (MMR) was securely connected to the medium-pressure hose.



Figure 1: SCBA as-received



Figure 2: SCBA as-received out of packaging

Components and Observations for the SCBA

The “right” or “left” are from the user’s perspective; “good” means functional and may show signs of dirt/soot; “fair” means functional, but with signs of some damage; “bad” means not functional, needs to be inspected by technician to possibly replace part(s). **(See Figures in Appendix 2)**

Facepiece (Figures 3-6)

- Facepiece seal P/N: 10161810; M/N: 7-2771-1 (1)
- Nosecup MFG date: 8/2018
- Overall condition was good condition
- Lens was scratched yet 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; 10144170 VMQ
- HUD was present and intact
- Head harness was in good condition with dirt present
- Bottom facepiece lug broken; top right head harness strap not hooked to mask

Mask-Mounted Regulator (MMR) (Figures 7-9)

- MMR label on front: MSA; M/N: 7-2779-1 TEC
- Overall condition was good with signs of dirt
- MMR was secured to medium-pressure hose; electrical line not attached
- Bypass closed
- Inside flange had normal wear and was in good condition
- Sealing area was good and slightly dirty
- Regulator could be attached and removed
- Outer rubber in good condition
- RFID stamp was present

Medium-Pressure Regulator Hose (Figures 9-10)

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

Pressure Reducer Assembly (Figures 11-12)

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

PASS Control Module (Figures 13-15)

- Lines to control module looked good
- Gauge lens was not readable
- Protective boot was good and in place
- M/N 7-3006-1

High-Pressure Hose and Cylinder Attachment (Figures 16-17)

- High-pressure line was in good condition; M/N: 7-2844-1, 0619
- Cylinder quick connect attachments 4500/5500 psi, P/N 10149702-SP, some heat damage and dirty

Quick-Fill line (Figures 18-19)

- Protective cover and sleeve in good condition

PASS Power Module (Figures 20-23)

- SEI label:02-2019; 10148686 4500 psi; RFID
- SEI label states this PASS met requirements of NFPA 1982: Standard on Personal Alert Safety Systems (PASS), 2013 edition
- Overall condition was good
- Li-ion Rechargeable Battery Pack 7-2814-1
- Held securely to backplate, signs of heat damage
- Power module battery; M/N 7-2814-1; P/N 10148741

Backplate Assembly (Figure 24)

- SEI label indicated unit met NFPA 1981 2013 edition
- NIOSH Approval Number label: TC-13F-0786CBRN
- FD label with SCBA 09
- Overall condition was good
- Shoulder straps were attached to the frame

Straps and Buckles (Figures 25-26)

- Overall condition of straps was good
- Hose lines passed through shoulder straps
- All adjustable buckles moved and held in place
- Lumbar strap not attached
- Waist area buckle latched

Compressed Air Cylinder and Cylinder Valve Assembly (Figures 27-31)

- DOT-SP 10915-4500; TC-3CCM-310
- Luxfer L45R-52; ACT193169; REE: 86
- MSA M/N 7-947-1
- Manufacturer date: 12/2018; 30-minute, 4500 PSI
- Received with no air
- Overall condition was good with signs of heat damage to label
- Gauge had heat damage; not sure if functional
- Threads were good
- O-ring was present and in good condition
- Rubber boot at base of cylinder valve was in good condition
- FD labels 21 09

SCBA Testing

The SCBA unit was tested using six NIOSH standard testing procedures and one NFPA test method as described in **Table 1** and **Table 2**.

Table 1. Summary of results from NIOSH standard testing procedures.

NIOSH Tests	Description of Results	PASS/ FAIL
<p>Positive Pressure Test - NIOSH Standard Testing 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 LabVIEW 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) = 0.05</p>	<p>PASS</p>
<p>Rated Service Time Test - NIOSH Standard Testing 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 LabVIEW 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 30 minutes. The SCBA did not go negative on inhalation; therefore, positive pressure was maintained in the facepiece</p> <p>Measured Service Time: 34 Minutes 53 Seconds</p>	<p>PASS</p>

<p>Exhalation Resistance Test - NIOSH Standard Testing Procedure Number 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (c) 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> 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) = 1.93 Static Pressure: (inches of water column) = 0.75 Difference: (inches of water column) = 1.18</p>	<p>PASS</p>						
<p>Static Pressure Test - NIOSH Standard Testing Procedure Number 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (d) Requirement: <i>The static pressure (at zero flow) in the facepiece shall not exceed 38 mm (1.5 inches) water column height.</i> 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) = 0.75</p>	<p>PASS</p>						
<p>Gas Flow Test - NIOSH Standard Testing Procedure Number 123, 42 CFR Part 84 Reference: Subpart H, § 84.93 (b) and (c) 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> 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="1" data-bbox="1325 911 1908 1013"> <thead> <tr> <th>Applied Pressure</th> <th>Airflow (liters per minute)</th> </tr> </thead> <tbody> <tr> <td>4500 psig</td> <td>410.6</td> </tr> <tr> <td>500 psig</td> <td>280.3</td> </tr> </tbody> </table>	Applied Pressure	Airflow (liters per minute)	4500 psig	410.6	500 psig	280.3	<p>PASS PASS</p>
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<p>Remaining Service Life Indicator Test - NIOSH Standard Testing 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 must give an alarm when the remaining service life is reduced to a minimum of 25 percent of its rated service time, or any higher minimum percent value or values as specified in the approval. Open-circuit demand and pressure-demand respirators must alarm continuously until depletion of the breathing air supply. The percent value set for indicator activation must be identified by labels and/or markings on each respirator unit.</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 4500 psi remaining rated service time. Could not test electrical alarm due to disconnected wire from the MMR.</p> <table border="1" data-bbox="1318 300 1915 625"> <thead> <tr> <th></th> <th>Electrical</th> <th>Bell</th> </tr> <tr> <th>Run #</th> <th>Alarm Point (psi)</th> <th>Alarm Point (psi)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>-</td> <td>1585</td> </tr> <tr> <td>2</td> <td>-</td> <td>1553</td> </tr> <tr> <td>3</td> <td>-</td> <td>1562</td> </tr> <tr> <td>4</td> <td>-</td> <td>1585</td> </tr> <tr> <td>5</td> <td>-</td> <td>1554</td> </tr> <tr> <td>6</td> <td>-</td> <td>1581</td> </tr> <tr> <td>Average:</td> <td>-</td> <td>1570</td> </tr> </tbody> </table>		Electrical	Bell	Run #	Alarm Point (psi)	Alarm Point (psi)	1	-	1585	2	-	1553	3	-	1562	4	-	1585	5	-	1554	6	-	1581	Average:	-	1570	<p>PASS</p>
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Table 2. 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>Maximum Facepiece Pressure: (inches of water column) = 2.55</p> <p>Minimum Facepiece Pressure: (inches of water column) = 0.17</p>	<p>PASS</p> <p>PASS</p>

Disposition of SCBA

At all times, except for testing on the dates of June 30, 2022, and July 12, 2022, the SCBA unit was securely stored 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, 30-minute, 4500 psi unit with NIOSH Approval Number TC-13F-0786CBRN. The firefighter was wearing the unit when the event occurred. The corresponding facepiece and cylinder were provided with the unit. The testing team determined to use the replacement cylinder provided by the Lower Merion Fire Department due to damage to the cylinder involved in the event. Overall, the SCBA was in good condition. The NFPA approval label was present and readable. The mechanical alarm system functioned as designed during the inspection and during the remaining service life indicator testing completed on June 30, 2022. However, it seems as though the electrical system was not working properly since the PASS would not respond to “shaking the unit” to deactivate the alarm once sounded while idle and with a full cylinder. This may be due to the electrical wire being disconnected from the MMR. For this reason, the testing team was not able to test the electrical system during the Remaining Service Life Indicator Test NIOSH Standard Testing Procedure Number 124. The unit passed all other NIOSH tests. The unit was tested on the NFPA “Airflow Performance” test on July 12, 2022 and met all requirements.

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 Lower Merion 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 users of the SCBA manufactured under the approval number 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 approval holder.
- 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 25965 in your request.

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

To receive documents or other information about occupational safety and health topics, contact NIOSH:

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Appendix 1: Acronyms and Abbreviations

CBRN	Chemical, Biological, Radiological, and Nuclear
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
DOT	Department of Transportation
FD	Fire Department
HUD	Heads-Up Display
kg-m/min	Kilogram Meter per Minute
L/min	Liters per Minute
M/N	Manufacturer Number
MFG	Manufacturing Date
mm	Millimeters
mmH2O	Millimeters of Water
MMR	Mask-Mounted Regulator
MSA	Mine Safety Appliances
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPPTL	National Personal Protective Technology Laboratory
P/N	Part Number
PASS	Personal Alert Safety System
PSI	Pounds per Square Inch
PSIG	Pounds per Square Inch Gauge
RFID	Radio Frequency Identification
RIC/UAC	Rapid Intervention Crew/Universal Air Connection
RPM	Revolutions per minute
SCBA	Self-Contained Breathing Apparatus
SEI	Safety Equipment Institute
STP	Standard Testing Procedure

Appendix 2: Photographs to Support Inspection Findings for the SCBA

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Figure 3: Front of facepiece



Figure 4: Inside facepiece and HUD



Figure 5: Facepiece head harness and straps



Figure 6: Bottom left lug broken on facepiece



Figure 7: Mask-mounted regulator with HUD wire not connected



Figure 8: Inside of mask-mounted regulator



Figure 9: Mask-mounted regulator and medium-pressure hose connected to SCBA



Figure 10: Medium-pressure hose in protective sleeve

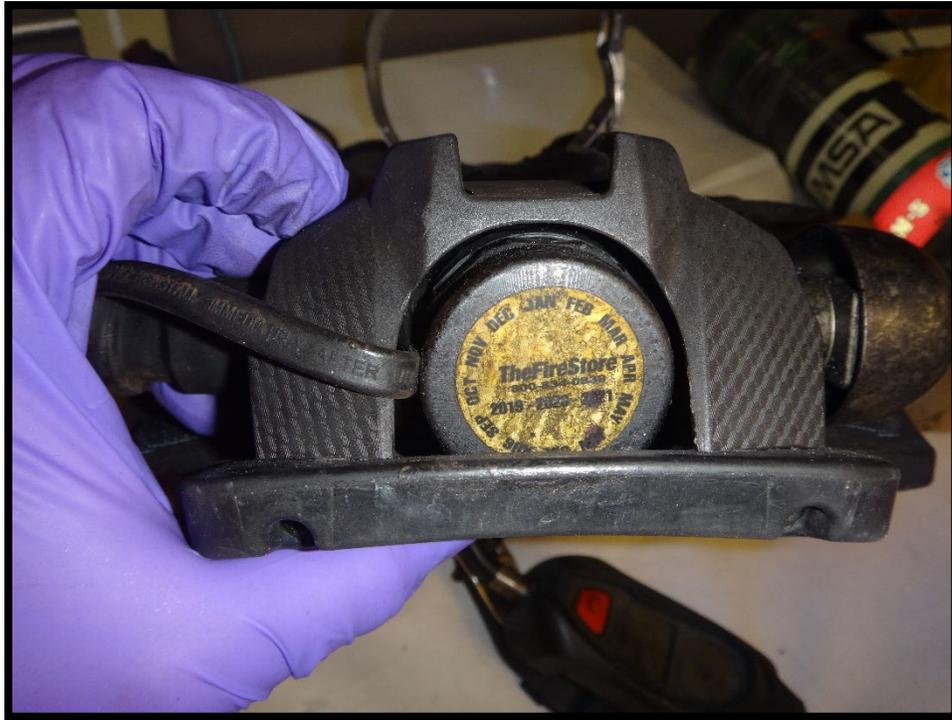


Figure 11: Pressure reducer, RIC/UAC with primary low-pressure warning device (bell)



Figure 12: Bottom view of pressure reducer assembly



Figure 13: Front of PASS control module



Figure 14: Protective boot of PASS control module



Figure 15: Labeling on PASS control module



Figure 16: High-pressure hose and cylinder attachment



Figure 17: Top view of high-pressure hose

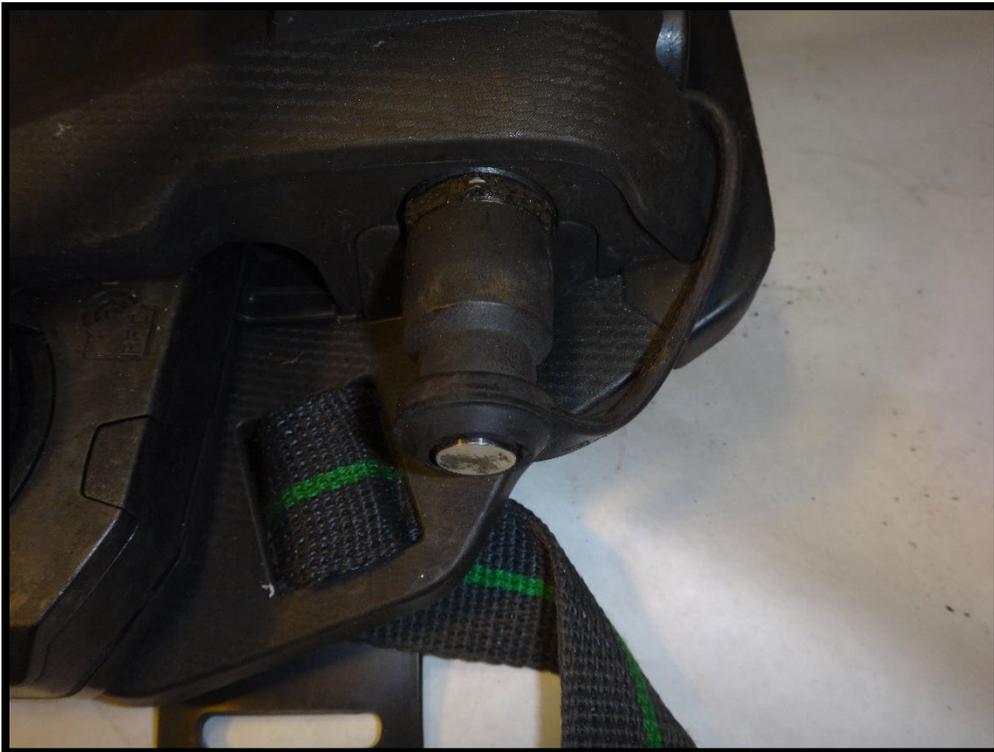


Figure 18: RIC/UAC rubber dust cap



Figure 19: RIC/UAC fitting



Figure 20: PASS power module SEI label



Figure 21: Power module

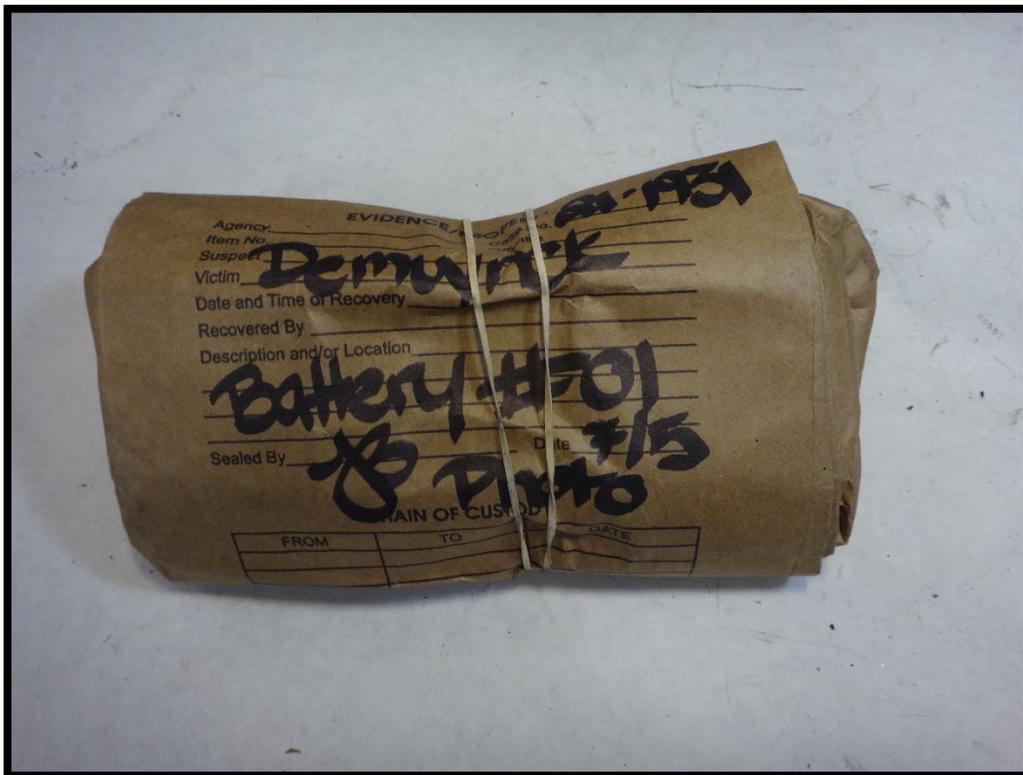


Figure 22: Battery as received



Figure 23: Battery out of packaging



Figure 24: Overview of backplate, straps, and buckles



Figure 25: Waist belt not attached to backplate



Figure 26: Backplate with cylinder holder



Figure 27: Top view of cylinder with labeling

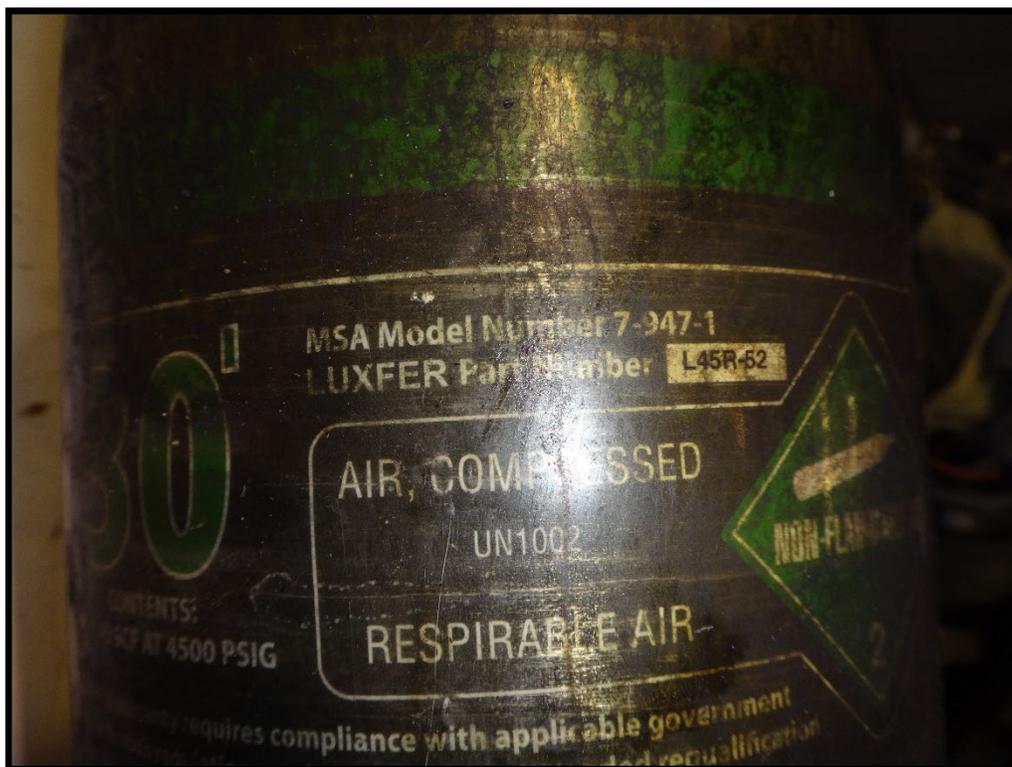


Figure 28: Top view of cylinder with labeling



Figure 29: Cylinder gauge



Figure 29: Cylinder valve and rubber boot



Figure 31: Threaded CGA quick-connect adapter attached to cylinder

Disclaimer

These evaluations are done to determine if the SCBA was a contributing factor to the incident. A number of performance tests are selected from the complete list of 42 CFR Part 84 requirements and each respirator is tested in its “**as received**” condition to determine its conformance to those performance requirements.

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.

Suggested Citation

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Centers for Disease Control
and Prevention
National Institute for Occupational
Safety and Health