

# PPE CASE



## *Personal Protective Equipment Conformity Assessment Studies and Evaluations*

### **Evaluation of a Self-Contained Breathing Apparatus Involved in a Fatality in the Fire Service**

**Worcester Fire Department requested the evaluation of a Scott® Safety Air-Pak® Model 4.5, 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. 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, and findings for a SCBA that was used by the Worcester Fire Department firefighter during a fatal event. The SCBA was the Scott® Safety Air-Pak® Model 4.5, 45 minute, 4500 psi unit. The NIOSH Division of Safety Research (NIOSH DSR) and the Worcester Fire Department was 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 staff managed the custody of evidence throughout the inspection and evaluation process at its Morgantown, West Virginia facility. NPPTL staff inspected all the SCBA components and documented their findings with written and photographic evidence. They also tested the SCBA to determine conformance to the NIOSH 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 SCBA's conformance to the National Fire Protection Association (NFPA) Air Flow 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 fatality, NPPTL would have engaged in corrective action to ensure

*NIOSH received an SCBA used by a firefighter 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.*

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that no other users of the product would experience an incident. In this case, no such corrective action was necessary. NPPTL then managed the disposition of the SCBA.

## Chain of Custody

NIOSH DSR submitted the Worcester Fire Department SCBA unit to NIOSH NPPTL for evaluation. The SCBA unit was delivered via FedEx in a plastic box to Lab H1513 in the NIOSH facility in Morgantown, West Virginia on December 18, 2019.

On December 31, 2019, NPPTL employees Jay Tarley and Angie Andrews inspected the SCBA unit. The SCBA unit remained in Lab H1513 throughout the inspection and testing process.

The SCBA was identified as belonging to the Worcester Fire Department and was visually examined, component by component, in the condition received to determine the conformance of the unit to the NIOSH-approved configuration. The unit was identified as the Scott® Safety Air-Pak® Model 4.5, 45 minute, 4500 psi unit, with NIOSH Approval Number TC-13F-212CBRN.

## SCBA Inspection

On December 31, 2019, NPPTL employees Angie Andrews and Jay Tarley inspected the SCBA unit. The SCBA was identified as belonging to the Worcester, MA Fire Department and was visually examined, component by component, in the condition received to determine the conformance of the unit to the NIOSH-approved configuration. The unit was identified as the Scott® Safety Air-Pak® Model 4.5, 45-minute, 4500 psi unit, with NIOSH Approval Number TC-13F-212CBRN.

### As Received

- SCBA was delivered by FedEx ground in a plastic container to off-site warehouse and later delivered to Lab H1513
- SCBA was in fair condition
- A cylinder was included with the unit
- A facemask was included with the unit
- The donning switch on mask mounted regulator was in the off position
- Bypass was closed on unit



**Figure 1: SCBA in plastic container as received**



**Figure 2: SCBA as received**

[Components and Observations for SCBA L5-1](#) (“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 AV 3000 (Figures 3-5)**

- Facepiece seal P/N: 31001739; Size: Medium; MFG date: 05/2018
- Nosecup P/N: 201127; Size: Medium; MFG date: 2nd Q 20158
- Retaining ring top MFG date: 12/2016; P/N: NA; bottom MFG date 3/2018, PN: NA
- Lens P/N: 805337-12/-32/-35/38; MFG date: 1/2018
- Overall condition good; extremely sooty
- Lens was good, extremely dirty, with minimal scratches, molten material on lens
- Hairnet was in good condition, but dirty
- Hairnet straps good, straps moved freely and held in place by buckle, held securely to facepiece
- Attachment points for straps was good
- The facepiece seal was in good condition
- Regulator interface area was in good condition
- Voice amplifier/speaker present; PN: 10110026; model: 200260

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

- Easy Flo Vibralert and with Heads-Up Display (HUD)
- Regulator assembly P/N, S/N not readable MFG date: not readable
- Overall condition, fair
- Outer case good and front label fair
- Donning switch was off
- Bypass was closed, towards user
- Sealing area good
- Locking assembly functioned
- HUD fully intact

**Low Pressure Regulator Hose (Figures 9-10)**

- No markings
- Overall condition is sooty; one area compromised (burnt through above first stage regulator)
- No quick disconnect

**Pressure Reducer Assembly (Figures 11-12)**

- Position marking: L5-1
- P/N: not readable
- S/N: not readable
- MFG date: not readable
- Overall condition was good, very dirty, labels burnt off

- All airline connections were secure

**High Pressure Hose and Cylinder Attachment (Figures 13-15)**

- Overall condition was good. Hose extremely sooty.
- High pressure hose marking 1830P
- Markings on cylinder attachment: 802228-15; 0910
- Soot covered
- Cylinder attachment threads good, but dirty and “O” ring in place
- RIC/UAC system connector markings: Eaton FD17-1002-10-04; 23010
- RIC/UAC system connector cover was burnt

**PASS Console Assembly (Figures 16-17)**

- Scott label: not readable
- Overall condition sooty
- Lines were good
- Gauge lens sooty; not readable
- Attachment present
- SEI not present
- HUD US Patent#: 5097826

**PASS Control Module with PAK-Alert (Figure 18)**

- Labels/markings were not readable
- Overall condition dirty with heat damage
- Held securely to backframe
- Wire connected to PASS device; heat damage
- Wire held secure to backframe and connected to console assembly

**Backframe Assembly (Figures 19-20)**

- SEI label present, 2007 ed
- NIOSH label TC-13F-212CBRN
- Other marking: L5-1, Industrial protection services flow tested 12/13
- Overall condition good, no bends/cracks in wire frame, or plate
- Shoulder straps were attached to the frame; left shoulder had heat damage
- Cylinder strap melted, but functional

**Straps and Buckles (Figures 21-24)**

- Overall strap condition good
- Both shoulder straps attached at the top of the backframe
- Hose lines and wires passed through right shoulder strap, but not on the left side

- All adjustable buckles moved and held in place
- Waist area buckle (left side) was not attached
- Lumbar strap had heat damage

#### **Compressed Air Cylinder and Cylinder Valve Assembly**

##### **(Figures 25-27)**

- Minute Duration: 45 minutes
  - DOT –Number: DOT-SP 10915-4500
  - TC-SU5134-310
  - IL 704099
  - REE: 99
  - Scott Part number: 805588-AC0841
  - Scott logo visible (partially)
  - Luxfer
  - Manufacture date: 2/2012
  - Overall condition was bad; outside layer had been compromised
- Gauge was not readable
  - Threads clean
  - As received, cylinder valve fully closed with no air remaining
  - Rubber bumper at base on cylinder valve was burnt
  - Rehydro label burnt off
  - Info on stem: Not readable

## SCBA Testing

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

**Table 1. Summary of results from testing SCBA Unit L5-1.**

NIOSH Tests	Description of Results	PASS/ FAIL
<p><b>Positive Pressure Test - NIOSH Standard Test Procedure No. 120, 42 CFR Part 84 Reference: Subpart H, § 84.70 (a)(2)(ii)</b>  <b>Requirement:</b>  <i>The pressure inside the facepiece in relation to the immediate environment is positive during both inhalation and exhalation.</i>  <b>Procedure:</b>            A breathing machine with a 622 kg-m/min cam operating at 24 RPM with a 40-liter 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>*The Vibralert and HUD both functioned</p> <p><b>Inhalation Breathing Resistance: (inches of water column) = 0.05</b></p>	<p><b>PASS</b></p>
<p><b>Rated Service Time Test - NIOSH Standard Test Procedure No. 121, 42 CFR Part 84 Reference: Subpart F, § 84.53 (a) and Subpart H, § 84.95 (a) and (b)</b>  <b>Requirement:</b>  <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>  <b>Procedure:</b>            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 in the facepiece</p> <p><b>Measured Service Time: 49 minutes 80 seconds</b></p>	<p><b>PASS</b></p>

<p><b>Static Pressure Test - NIOSH Standard Test Procedure No. 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (d)</b>  <b>Requirement:</b>  <i>The static pressure (at zero flow) in the facepiece shall not exceed 38 mm. (1.5 inches) water column height.</i>  <b>Procedure:</b>  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><b>Facepiece Static Pressure: (inches of water column) = 0.95</b></p>	<p><b>PASS</b></p>						
<p><b>Gas Flow Test - NIOSH Standard Test Procedure No. 123, 42 CFR Part 84 Reference: Subpart H, § 84.93 (b) and (c)</b>  <b>Requirement:</b>  <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 is tested, the flow will be measured at zero gauge pressure in the facepiece.</i>  <b>Procedure:</b>  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 requirements.</p> <table border="0"> <tr> <td><b>Applied Pressure</b></td> <td><b>Air Flow (liters per min.)</b></td> </tr> <tr> <td><b>4500 psig</b></td> <td><b>475.73</b></td> </tr> <tr> <td><b>500 psig</b></td> <td><b>668.28</b></td> </tr> </table>	<b>Applied Pressure</b>	<b>Air Flow (liters per min.)</b>	<b>4500 psig</b>	<b>475.73</b>	<b>500 psig</b>	<b>668.28</b>	<p><b>PASS</b></p>
<b>Applied Pressure</b>	<b>Air Flow (liters per min.)</b>							
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<p><b>Exhalation Resistance Test - NIOSH Standard Test Procedure No. 122, 42 CFR Part 84 Reference: Subpart H, § 84.91 (c)</b>  <b>Requirement:</b>  <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>  <b>Procedure:</b>  The facepiece is mounted on an anthropometric head form. A probe in the head form is connected to a slant manometer for measuring exhalation breathing resistance. The air flow 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><b>Exhalation Breathing Resistance: (inches of water column) = 1.88</b>  <b>Static Pressure: (inches of water column) = 0.95</b>  <b>Difference: (inches of water column) = 0.93</b></p>	<p><b>PASS</b></p>						

<p><b>Remaining Service Life Indicator Test - NIOSH Standard Test Procedure No. 124, 42 CFR Part 84</b>  <b>Reference: Subpart H, § 84.83 (f) and Subpart G, § 84.63 (c)</b>  <b>Requirement:</b>  <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 20 to 25 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 gage in the event of a gage or gage line failure the remaining service life indicator is required to be set at 25% ± 2% of the rated service time or pressure.</i>  <b>Procedure:</b>  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>As these SCBA models do not have a remote gauge shutoff, the test requirement is 25% +2, -2, which is between 1215 psig and 1035 psig.</p> <table border="1" data-bbox="1333 227 1890 552"> <thead> <tr> <th>Run #</th> <th>Electronic Alarm Point (psi)</th> <th>Vibralert Alarm Point (psi)</th> </tr> </thead> <tbody> <tr><td>1</td><td>1130</td><td>1100</td></tr> <tr><td>2</td><td>1120</td><td>1070</td></tr> <tr><td>3</td><td>1140</td><td>1070</td></tr> <tr><td>4</td><td>1140</td><td>1070</td></tr> <tr><td>5</td><td>1140</td><td>1070</td></tr> <tr><td>6</td><td>1150</td><td>1070</td></tr> <tr><td><b>Avg:</b></td><td><b>1140</b></td><td><b>1075</b></td></tr> </tbody> </table> <p>Electronic = PASS  Vibralert = PASS</p>	Run #	Electronic Alarm Point (psi)	Vibralert Alarm Point (psi)	1	1130	1100	2	1120	1070	3	1140	1070	4	1140	1070	5	1140	1070	6	1150	1070	<b>Avg:</b>	<b>1140</b>	<b>1075</b>	<p><b>PASS</b></p>
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**National Fire Protection Association (NFPA) Test** (in accordance with NFPA 1981, 2013 Edition):

<b>NFPA Test</b>	<b>Description of Results</b>	<b>PASS/ FAIL</b>
<p><b>NFPA Air Flow Performance Test—NFPA 1981 (2013 Edition) Reference: Chapter 8, Performance Requirements, Section 8-1.1</b>  <b>Requirement:</b>  SCBA shall be tested for air flow performance as specified in Section 8.1, Air flow 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.  <b>Procedure:</b>  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. Vibralert, HUD, and alarm systems were functional.</p> <p><b>Maximum Facepiece Pressure: (inches of water column) = 2.5</b></p> <p><b>Minimum Facepiece Pressure: (inches of water column) = 0.5</b></p>	<p><b>PASS</b></p>

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## Disposition of SCBA

Following testing on January 22 and 24, 2020, the SCBA 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 a Scott® Safety Air-Pak® Model 4.5, 45 minute, 4500 psi unit with NIOSH Approval Number TC-13F-212CBRN. The firefighter was wearing the unit when the event occurred. A corresponding facepiece was provided with the unit. The provided cylinder was not suitable for testing; therefore, we used one of NPPTL's cylinders for testing. Overall, the SCBA was in fair condition. The NFPA approval label was present and readable. The PASS, HUD, and Vibralert all functioned.

The SCBA unit leaked air from the high pressure hose until approximately 3500 psig during the NIOSH Positive Pressure Test and still met the test requirements, as the SCBA maintained a positive pressure for the 45 minute minimum duration of the test. The unit passed all the other NIOSH tests, as well as met 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 Worcester Fire Department.

## CASE Conclusion

No evidence was identified to suggest that the SCBA unit inspected and components 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 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 manufacturer.
- All SCBA units, even those not involved in an incident, must undergo a flow test on at least an annual basis.

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## 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](mailto:ppeconcerns@cdc.gov), and reference NIOSH Task Number 23616 in your request.

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

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

Telephone: 1-800-CDC-INFO (1-800-232-4636)

TTY: 1-888-232-6348

CDC INFO: [www.cdc.gov/info](http://www.cdc.gov/info)

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# Appendix: Photographs to Support Inspection Findings for SCBA

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**Figure 3: Front view of facepiece**



**Figure 4: Rear view of facepiece**



**Figure 5: Voice amplifier/speaker**



**Figure 6: Front view of Mask Mounted Regulator**



**Figure 7: Inside flange of Mask Mounted Regulator**



**Figure 8: Remnants of label on Mask Mounted Regulator**



**Figure 9: Low pressure hose**



**Figure 10: Low pressure hose sheath heat damage**



**Figure 11: Side of first stage regulator**



**Figure 12: Side of first stage regulator**



**Figure 13: High pressure hose and cylinder attachment**



**Figure 14: O-ring and threads of cylinder attachment**



**Figure 15: RIC/UAC connector**



**Figure 16: Front of PASS console**



**Figure 17: Back of PASS console**



**Figure 18: PASS control module heat damage**



Figure 19: Interior side of backframe assembly



Figure 20: Exterior side of backframe assembly



**Figure 21: Melted cylinder strap**



**Figure 22: Straps and buckles**



**Figure 23: Left side shoulder strap heat damage**



**Figure 24: Left side waist strap heat damage**



**Figure 25: Overall of cylinder**



**Figure 26: Gauge, rubber bumper and valve**



**Figure 27: Heat damage to cylinder**

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## 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.



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