National Personal Protective Technology Laboratory

Battery Requirements

Sheraton Station Square, Pittsburgh, PA

Ted Klemetti

December 15, 2004
Battery Test Requirements

Public Comment

- Difficult tests to perform, consider standardizing
- Test low flow indicator against both conditions (battery and clogging)
- Change in work rates changes battery life

Disposition

- Test will be performed in standardized conditions using equipment submitted
- Both conditions will be tested if appropriate
- Testing to a standard minimum, explanation of the effects of changing work rates on battery life required
<table>
<thead>
<tr>
<th>Public Comment</th>
<th>Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Require only one indicator; low flow or low battery</td>
<td>Both required to alert user to more fault conditions</td>
</tr>
<tr>
<td>Manufacturer should provide data on extreme temperature use and other pertinent issues</td>
<td>Will be required as well as some minimum testing</td>
</tr>
<tr>
<td>Indicator signaling method should be optional</td>
<td>Method of indicator signaling not specified, but minimum of one method is mandatory</td>
</tr>
</tbody>
</table>
Battery Test Requirements

- Battery Performance Test
  - Tested at minus 30°C to insure the functionality of the system at this temperature

- Low Battery Indicator Test
  - Evaluates the PAPR ability to alert the user to a low battery condition, enabling the user to egress

- Low Flow Alarm Test
  - Evaluates units ability to alarm user prior to negative pressure
<table>
<thead>
<tr>
<th>Battery Test Requirement</th>
<th>Benchmark Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Flow Alarm</td>
<td>-30°C</td>
</tr>
<tr>
<td>Low Battery Indicator</td>
<td>-30°C</td>
</tr>
<tr>
<td>Breathing Performance</td>
<td>25°C</td>
</tr>
<tr>
<td>Battery Performance</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>High</td>
</tr>
<tr>
<td>PAPR</td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Low Temperature Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25°C</td>
</tr>
<tr>
<td></td>
<td>11:43</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>10:12</td>
</tr>
<tr>
<td>A</td>
<td>Ran 72 hr cold soak</td>
</tr>
<tr>
<td>B</td>
<td>Ran 72 hr cold soak</td>
</tr>
<tr>
<td>C</td>
<td>Ran 12 hr cold soak</td>
</tr>
<tr>
<td>D</td>
<td>Ran 12 hr cold soak</td>
</tr>
</tbody>
</table>
Battery Performance Test

- **Concept Criteria**
  - Must maintain positive pressure in the breathing zone while breathing at the manufacturer selected breathing performance rate (40 or 103 L/min)
  - Each PAPR must maintain positive pressure for at least 35% of the manufacturer’s specified operational battery life
  - The average life of all trials must be at least 40%
  - Tested at -30°C
  - PAPR will be cold soaked for 4 hours prior to test
Battery Performance Test

• Benchmark Results
  - Breathing performance benchmark testing has been performed at 25°C, both breathing rates, on multiple PAPR systems, and using both the Posicheck and NIOSH breathing machines
  - Preliminary testing of ability to work in low temperature conditions have been performed
Battery Performance Test

- Future Direction
  - Perform benchmark testing on several PAPR systems
  - Finalize standard test procedure
  - Perform verification testing once the standard testing procedure is completed
Low Battery Indicator

- Concept Criteria
  - Moderate or high performance (25°C)
    - Passively alarms the user at least 15 minutes prior to negative pressure, but no more than 45 minutes
  - Moderate or high performance (-30°C)
    - Passively alarms the user prior to negative pressure, minimum and maximum duration after alarm are not evaluated
Low Battery Indicator

- Test Conditions
  - At $25^\circ C \pm 5^\circ C$
  - Relative Humidity 50% ± 5%
  - At $-30^\circ C \pm 5^\circ C$
  - Relative Humidity 20% ± 5%

- Breathing machine operated at either 40 or 102 L/min
Low Battery Indicator

- Benchmark Results
  - Performed tests at 25°C on multiple PAPRs
    - PAPRs with built-in alarms showed ability to pass test
      - Dependent on when alarm activates
    - PAPRs without built-in alarms could be designed to perform the same task
Low Battery Indicator

Benchmark Results

Mild FLOW (40), BENCHMARK Breathing Machine
5 hours 50 minutes - 6 hours 6 minutes

Time (3000 Samples = 5 minutes)

Pressure (in H2O)

-1.7 -1.2 -0.7 -0.3 0.3 0.8 1.3
Low Battery Indicator

- Future Direction
  - Perform benchmark testing at low temperature
  - Finalize the standard test procedure
  - Perform verification testing
Low Flow Alarm

Test Conditions

- Part One, the PAPR is tested in same manner as the breathing performance and battery performance at both temperatures under the same environmental conditions and equipment.
- Part Two, the PAPR is tested by adding additional resistance to simulate loading or clogging at both environmental conditions.
Low Flow Alarm

- Concept Criteria
  - Alarms the user upon or just prior to negative pressure in the breathing zone
Low Flow Alarm

* Benchmark Results *

- Initial evaluation of PAPRs with low flow indicators have shown the ability to provide the required warning
- Further testing will be performed
- Eliminate the need for both fault modes to indicate simultaneously for integrated alarm systems
Low Flow Alarm

Benchmark Results

MODERATE FLOW(40), BENCHMARK 3
Low Flow Alarm

Time (600 samples = 1 minute)

Pressure (in H₂O)
Low Flow Alarm

- Future Direction
  - Evaluate the effects of instantaneous negative peaks in the breathing pattern
  - Perform low flow testing at the low temperature condition
  - Finalize the standard test procedure
  - Perform verification testing
National Personal Protective Technology Laboratory

Carbon Dioxide Requirements
Sheraton Station Square, Pittsburgh, PA

Ted Klemetti
December 15, 2004
<table>
<thead>
<tr>
<th>Public Comment</th>
<th>Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify the standard test procedure used for this test</td>
<td>The STP for the CBRN PAPR requirements will be referenced in the final standard and will be completed with the standard</td>
</tr>
<tr>
<td>What flow rate will be used for this test</td>
<td>The PAPR will be tested at a breathing rate of 10.5 L/min</td>
</tr>
<tr>
<td>Will the PAPR be tested in the power off mode (blower off)</td>
<td>The PAPR will not be tested in the blower off mode</td>
</tr>
</tbody>
</table>
CO₂ Machine Test

- **Concept Criteria**
  - The average carbon dioxide inhalation level must be less than 1%
  - The average oxygen level must be greater than 19.5%
  - The PAPR will be required to pass both levels to receive a passing result for this test
  - Test will be performed with the blower operating
CO$_2$ Machine Test

- Test Conditions
  - Temperature range will be 68°F–80°F during testing.
  - The gas levels will be averaged for at least 5 breathing cycles.
  - The breathing machine will run at 10.5 L/min.
  - The exhalation air from the breathing machine will contain 5% CO$_2$.
  - Equipment used will be as received.
CO$_2$ Machine Test

• Benchmark Results
  - Preliminary testing performed using carbon dioxide analyzer without oxygen analyzer and pressure sensor
  - Tested four different PAPRs
### CO$_2$ Machine Test

#### Benchmark Results

<table>
<thead>
<tr>
<th>PAPR</th>
<th>Blower On</th>
<th>Blower Off*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.20</td>
<td>2.69</td>
</tr>
<tr>
<td>2</td>
<td>0.00</td>
<td>2.36</td>
</tr>
<tr>
<td>3</td>
<td>0.00</td>
<td>1.27</td>
</tr>
<tr>
<td>4</td>
<td>0.00</td>
<td>1.46</td>
</tr>
</tbody>
</table>

* Currently not part of concept criteria

PAPR not sized to fit headform
**CO₂ Machine Test**

- Future direction
  - Perform additional testing with equipment to determine repeatability and equivalency to current testing procedures
  - Finalize standard test procedure
Human Subject CO₂ Test

- Concept Criteria
  - The average carbon dioxide inhalation level must be equal to or less than 2%.
  - The average oxygen level must be greater than 19.5%.

- The PAPR will be required to pass both levels to receive a passing result for this test.
- Test will be performed with the blower operating...
Human Subject CO₂ Test

- **Test Conditions**
  - Temperature range will be 68°F–80°F during testing
  - The gas levels will be averaged for at least 5 breathing cycles
  - Two trials, one stationary and one walking briskly at 3.5 mph
  - Equipment used will be as received
Human Subject CO$_2$ Test

• Future Direction
  - Perform benchmark testing
  - Establish standard test procedure based on STP 0454
  - Perform verification testing