National Personal Protective Technology Laboratory

Determination of Air Flow for CBRN Tight Fitting Powered Air-Purifying Respirators

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July 20, 2005
Objective

- Assess current PAPR flow measurement techniques
- Derive a new flow measurement method that will allow both constant flow and demand response flow PAPRs to be evaluated utilizing the same test method and equipment
Current Method for Measuring Flow Through Constant Flow PAPR

- The flow through a PAPR is measured using the following method
  - Mount the facepiece on a head form and leak test
  - Place the head form with the facepiece mounted in a sealed Lexan enclosure
  - Switch PAPR blower “On”
  - Apply a vacuum to the enclosure until zero inches of water column is reached
  - Record flow
Evaluating the Current PAPR Flow
Evaluating the Purposed PAPR Flow Measurement Method

- A flow curve was developed for each PAPR tested using the following method
  - Mount the facepiece on a head form and leak test
  - Install a pressure tap at the PAPR manifold outlet
  - Plug the pressure tap in the head form
  - Connect the head form breathing tube to a flowmeter and vacuum blower
  - PAPR switched “Off”
Evaluating the Purposed PAPR Flow Measurement Method (Cont.)

- Incrementally increase the vacuum flow through the PAPR and record the corresponding manifold pressures
- Collect points from zero flow to 500 Lpm in increments of 50 Lpm
- Create a pressure vs. flow graph
Example of a PAPR Flow Curve

\[ y = -79.856x^2 + 370.43x + 14.742 \]

\[ R^2 = 0.9971 \]
Evaluating the Purposed PAPR Flow Measurement Method
PAPR Evaluation Using a Breathing Machine

- Each PAPR was tested using the following procedure
  - Mount the facepiece on a head form and leak test
  - Connect the breathing tube from the head form to the breathing machine
  - Monitor both the pressure at the PAPR manifold and facepiece
  - Increase the breathing rate until zero inches of water column is achieved in the facepiece during inhalation
PAPR Evaluation Using a Breathing Machine (Cont.)

- Record the maximum manifold pressure
- Based on the previously derived flow curve this pressure will correlate to a flow rate
(Example) Mask Pressure During a Breathing Machine Test
(Example) Manifold Pressure During a Breathing Machine Test
Evaluating the Purposed PAPR Flow Measurement Method
Flow Comparison

- Low Capacity Breathing Machine (1.67 Tidal Vol.)
- High Capacity Breathing Machine (4.0 Tidal Vol.)

Flow (lpm)

<table>
<thead>
<tr>
<th>PAPR</th>
<th>Flow</th>
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<tbody>
<tr>
<td>A</td>
<td>118.5</td>
</tr>
<tr>
<td>B</td>
<td>130.6</td>
</tr>
<tr>
<td>C</td>
<td>175.8</td>
</tr>
<tr>
<td>D</td>
<td>182.8</td>
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<tr>
<td></td>
<td>141.7</td>
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<tr>
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<td>146.5</td>
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<td>402.9</td>
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Conclusion

- Model D was unable to be tested using the low capacity breathing machine due to the higher flows required by this PAPR.

- The high capacity breathing machine can be used to measure flow in both constant flow and demand response flow PAPRs.

- Constant flow and demand response flow PAPRs will be tested using the same test method and equipment.
PAPR Flow Measurement

Remaining Work

- Evaluation of the purposed PAPR flow measurement method using the new variable tidal volume and respirations per minute breathing machine
PAPR Flow Measurement

Questions?