CBRN Escape Respirator

Breathing Gas Control

Concept Requirement:

- **CO₂** – Maximum Average Inhaled
  - Concentration of 2.5% Max
  - 42 CFR, Part 84

- **O₂** – Minimum Inhaled
  - Concentration of 19.5%
  - 42 CFR, Part 84
CBRN Escape Respirator

Breathing Gas Control

- Human Subject Testing
  - Greater than 80 kg, 2 subjects
  - Less than 60 kg, 2 subjects
- Work Rate:
  - Standing, 2.5 and 3.5 mph: treadmill
- Test for Duration of Each Respirator
CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing
  - Simulate Six Work Rates
    - Low Work Rate – 0.5 l/min VO₂
      - Work Rate – 1.0 l/min VO₂
      - Work Rate – 1.5 l/min VO₂
      - Work Rate – 2.0 l/min VO₂
      - Work Rate – 2.5 l/min VO₂
      - Work Rate 2.5 l/min VO₂
    - High Work Rate – 3.0 l/min VO₂
CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing (ABMS):
  - Commercially Available Escape Sets
  - Multiple ABMS Tests with Each Respirator
  - Carbon Dioxide Levels > 4% Common
  - Oxygen Concentrations < 19.5% Common

- Non Conclusive Results

CDC Workplace Safety and Health
NIOSH
CBRN Escape Respirator

Breathing Gas Control

- Benchmark Testing (Human Subject)
  - Testing 7 Test Subjects
  - 4 Males, 3 Females
  - Work Rates:
    - Standing
    - Treadmill @ 2.5 mph
    - Treadmill @ 3.5 mph
CBRN APR Escape Respirator

- Benchmark Testing - Human Subjects
  - $\text{CO}_2$ - 5.5% Maximum
  - $\text{O}_2$ - 14.8% Minimum
  - Both $\text{CO}_2$ and $\text{O}_2$ Exceed NIOSH Expected Limits
  - Physiological Consequences
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<th>Time Frame (min)</th>
<th>Estimated VO&lt;sub&gt;2&lt;/sub&gt; (pL/min)</th>
<th>Time Completed (min)</th>
<th>Incident</th>
<th>F&lt;sub&gt;2&lt;/sub&gt;CO&lt;sub&gt;2&lt;/sub&gt; ppm (%)</th>
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CBRN Air Escape Respirator

- Benchmark Testing - Human Subject
  - Human Factors Issues Observed
    - Neck Seal Excessively Tight
      - Neck Constriction
      - Sensation of Strangulation
    - Mouth-Bit/ Gagging Reflex
      - Expel Mouth - Bit
    - Difficulties Donning Over Head
      - Insufficient Arm Strength to Stretch Over Head