NASA Developments in Personnel Protective Equipment

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Air Quality Technologies Event
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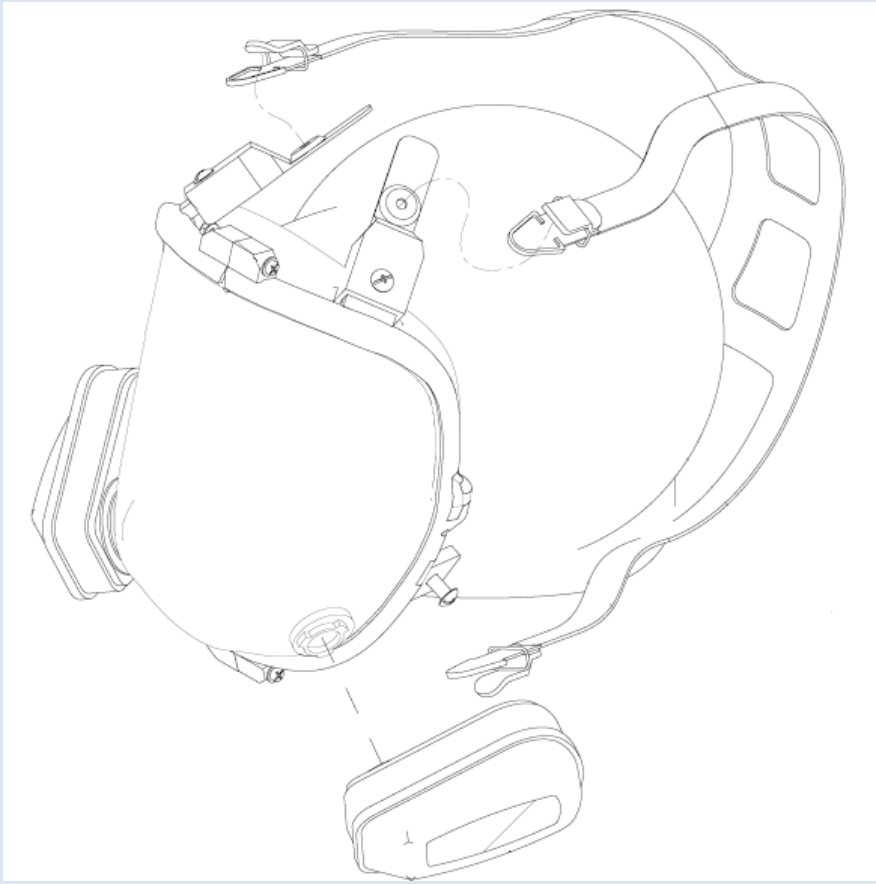
Summary: NASA has some unique and challenging PPE needs: there are credible threats to air quality (fire, ammonia leak, hydrazine leak) that require a contingency breathing apparatus that operates for many hours – but there is not enough space or up-mass to provide supplied air tanks. We cannot use "Scott Air Tanks" commonly used by firefighters and other first responders. NASA has developed a respirator based emergency breathing device. It uses a "one size fits everybody in the astronaut corps" hooded mask with excellent chemical permeability and fire resistance properties, and a filtering respirator cartridge that protects the wearer from ammonia leaks, hydrazine leaks, or products of combustion. If you need a small, lightweight emergency breathing system that lasts longer than a supplied air system, we should meet and learn if NASA sponsored technology development can help.

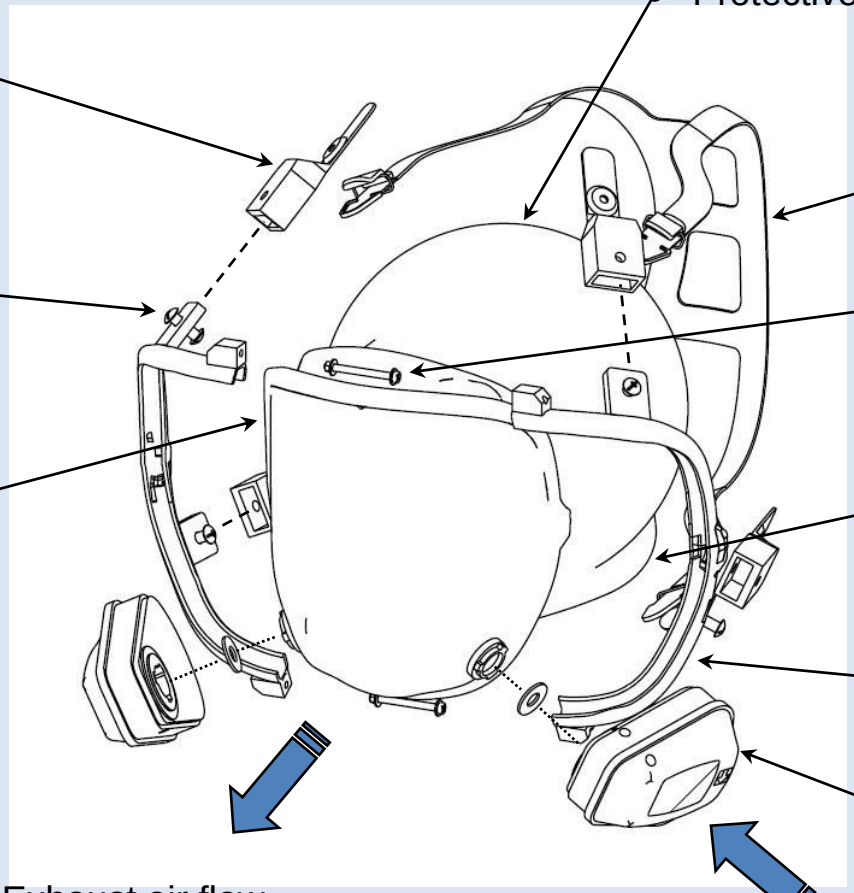
Astronauts Butch Wilmore and Terry Virts don protective respirator masks in January 2015, in response to a “false alarm” indicating a possible ammonia leak. There was no leak, and no exposure to the crew.

First Generation Respirator: For Ammonia Only

Dual Seal Ammonia Respirator



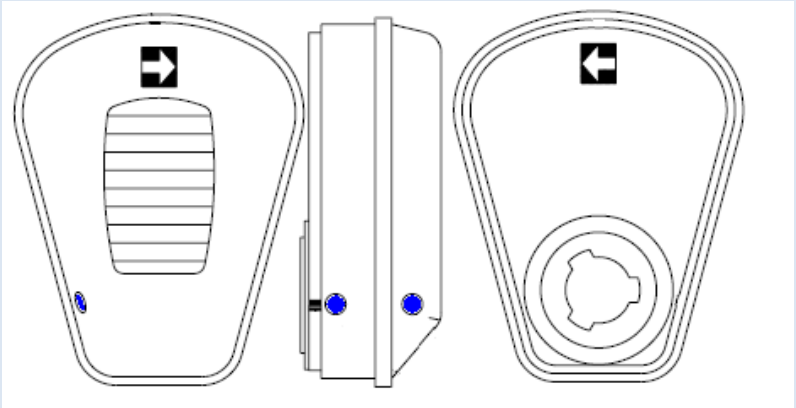
First Generation Ammonia Respirator: Components



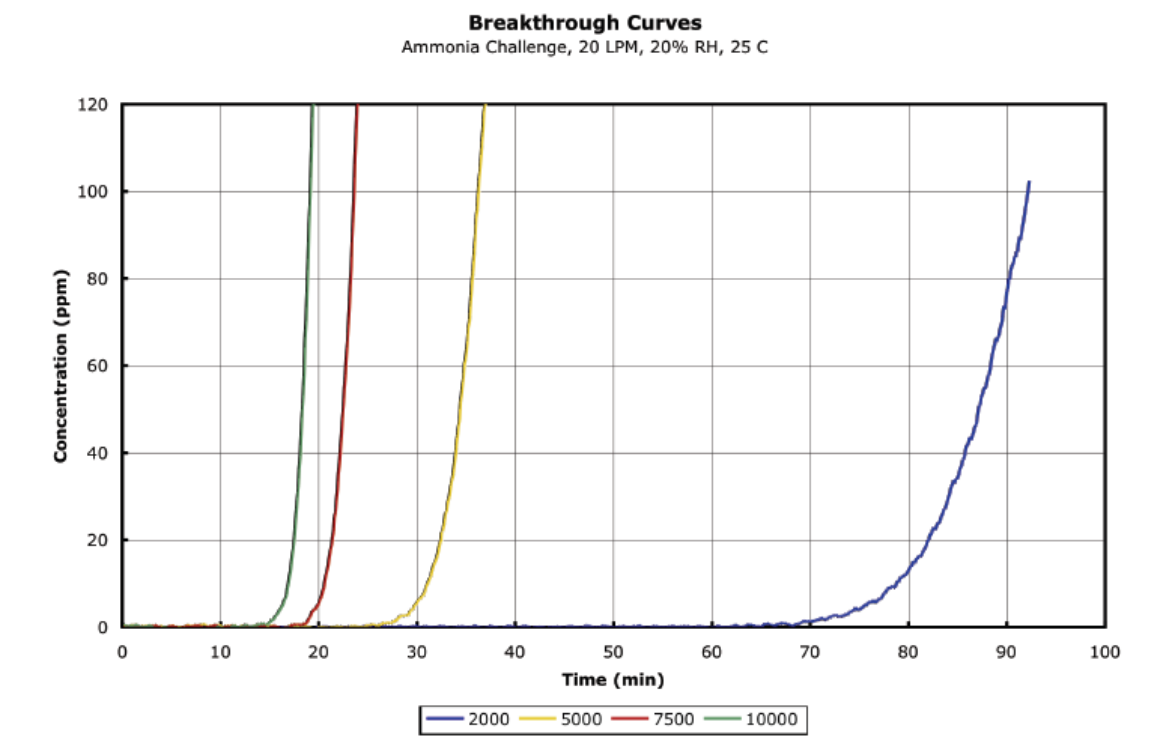
Astronaut Chris Hadfield wearing the ammonia respirator in a training exercise

Ammonia Respirator uses a COTS cartridge

- 3M Ammonia Cartridge
  - P/N SEG33119910-301
  - Weight ≈ 4 oz ea.
  - Volume ≈ 3.75” x 4.50” x 1.75”
  - Cartridge equipped with a particulate filter
  - 3M quality assurance testing is preformed on several units throughout the time of production
    - Test run with 1000 ppm Ammonia
    - Min break through to 25ppm after 50 minutes
    - Rate of 32 lpm & 64 lpm
    - 3M has no reports of any defective ammonia cartridges ever being sold
  - Active scrubbing particulate is Carbon treated Zinc Chloride
  - Toxicity of the Ammonia Cartridges was determined to be Tox. level one before and after use
- How we are altering 3M design
  - Dots will be added to assist proper alignment with the Ammonia Respirator
  - Arrow labels will be added to show proper direction for instillation
  - Cartridges packed in foil laminate
  - Single cartridge in a single pack
  - Labeled baggies will be provided for used cartridge disposal

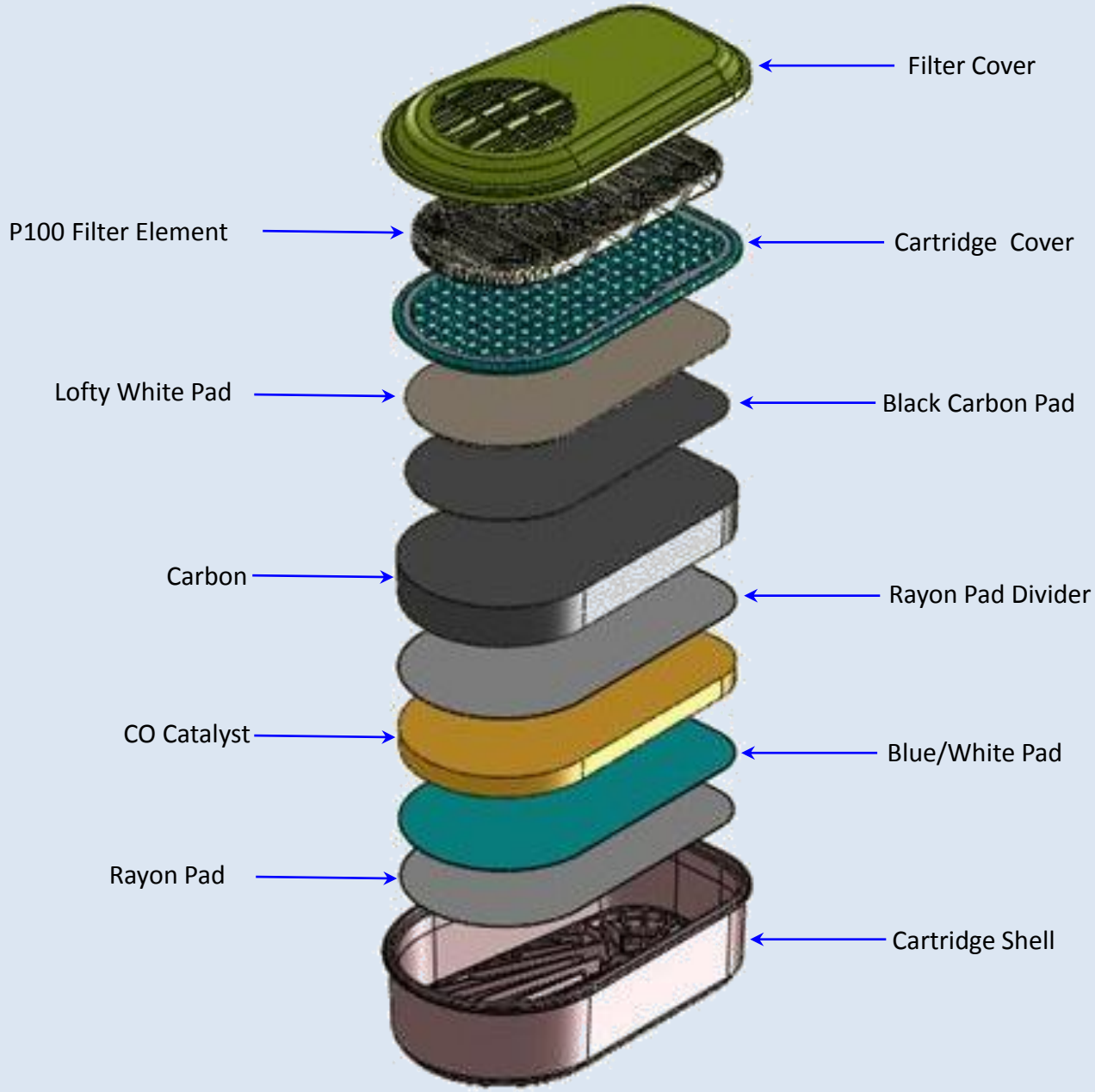


Testing of cartridge capacity and replacement time



Development of a custom built cartridge to protect the crew from products of combustion

Expanded view of cartridge



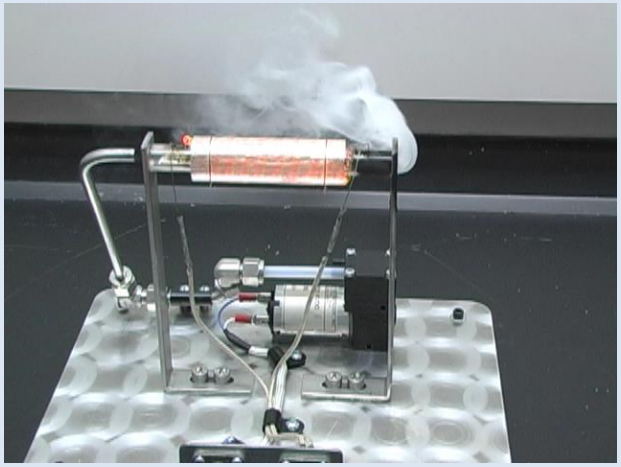
Testing: EN 136 Flammability and molten drip testing, NASA-STD-6001 flammability and offgassing

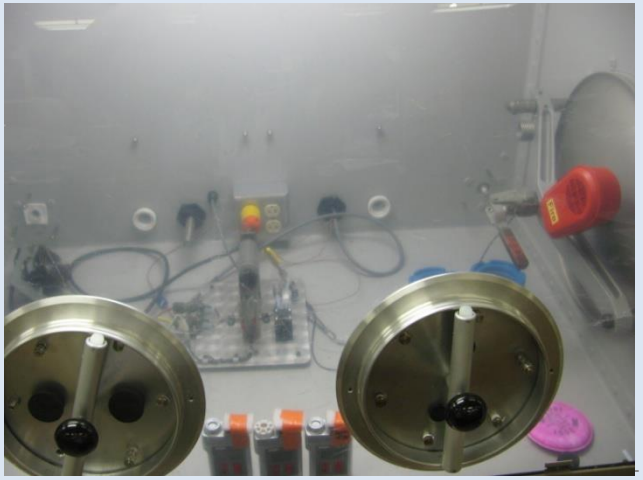
Figure 15. FRRC After Flammability Test


Figure 16. FRRC After Molten Drip Test

Performance testing in a fire environment

- Fire Challenges at White Sands Test Facility (WSTF)
  - Objective: Meet functional requirements when tested at WSTF
  - Approach: Utilize a in-house developed smoke generator to produce smoke particulate and gaseous combustion products that could be formed in a spacecraft fire
  - Fire Challenge A
    - Worst-case production of volatile organic compounds from the thermal decomposition of the polymer fuel mix followed by CO production
  - Fire Challenge B
    - Worst-case carbon monoxide
    - Volatile organics and smoke are produced in the initial heating followed by oxidation of the solid ash to form CO
  - Fire Challenge C
    - Worst-case particulate/flaming combustion
    - Smoldering fire followed by a flame event in which the effluent of the smoke is ignited to produce flaming combustion



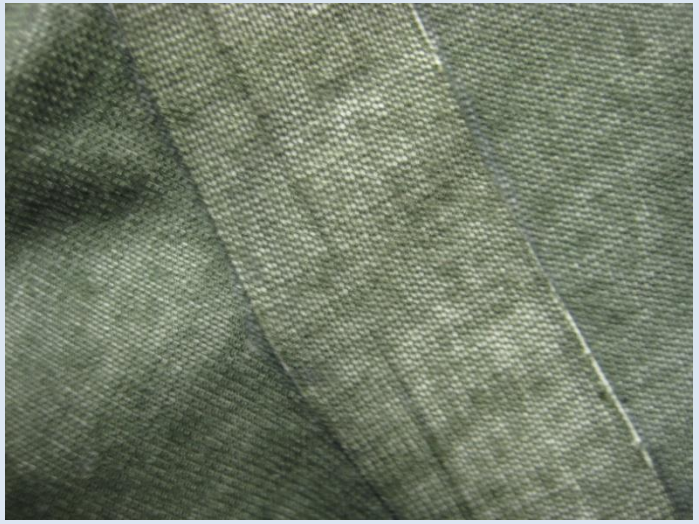


Development of a hooded mask with “one size fits every astronaut” and good chemical permeability properties, and good flame resistance peroperties

Fabric and face shield details

Fabric:

- Selected fabric is approved for military use
- Fabric meets ammonia permeability reqts
- Fabric meets ANSI flame impingement reqts



Face Shield:

- Polycarbonate face shield used for military application
- Shield material meets ANSI fire reqts
- Face shield is coated to meet military vision reqts if condensation occurs

Neck dam is strong, flexible, has good leakage performance, and is relatively comfortable to wear.

Summary

- If you are looking for an emergency breathing system that is small, and lasts longer than a supplied air system, we should talk
- If you are looking for a filtering respirator that can protect the wearer from ammonia, hydrazine, or products of combustion, we should talk

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