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Custom Textile Development for Space Vehicles with Elevated Oxygen Environments

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NASA Johnson Space Center Engineering, Technology, and Science (JETS) II contract

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Background

Artemis missions planning elevated oxygen cabin environments (>30% O_2)

- Oxygen-enriched cabin exploration atmospheres (>30% O2) are preferred to shorten prebreathing time and maximize the duration of EVAs
- The proposed Artemis IV+ atmosphere is 8.2 psia and 34±2% O2 (testing at 37% O2 for contingency)
- Greatly increases flammability risk

Significant need for improved non-flammable textiles

- Selection of fire-resistant textiles is a key part of NASA's fire prevention strategy to ensure large-scale flame propagation events do not occur
- Very limited existing commercial off-the-shelf (COTS) textiles can be certified for use in up to 37% O2 environments
- Most of the fibers and textiles developed during Apollo (100% O2) and Skylab (70% O2) (i.e., beta glass, PBI, Durette, Astro Velcro) that are no longer commercially available due to discontinuation of raw materials and closure of the original manufacturers

Flammability Testing Overview

- **NASA-STD-6001, Test 1**
  - Coupon secured to test stand inside chamber at set pressure and O_2 concentration
  - Bottom ignition upward flame propagation test
  - Burn length < 6”
  - No transfer of burning debris (melt / drip)

Test setup



Textile being tested at various O_2 concentrations



- **Typical textile flammability test process:**

START → **Fabric-Level Test** → pass → **Lay Up Test** → pass → **Configuration Test** (w/ Thread, Zipper, Velcro, etc.) → pass → **Final Assembly Verification**

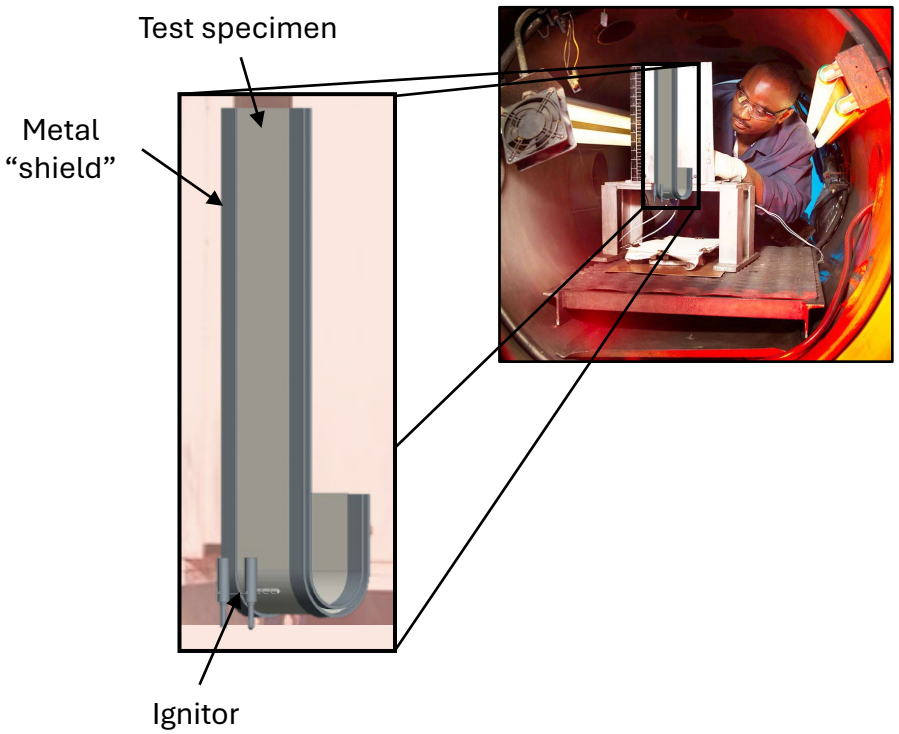


Post-test examination of sample

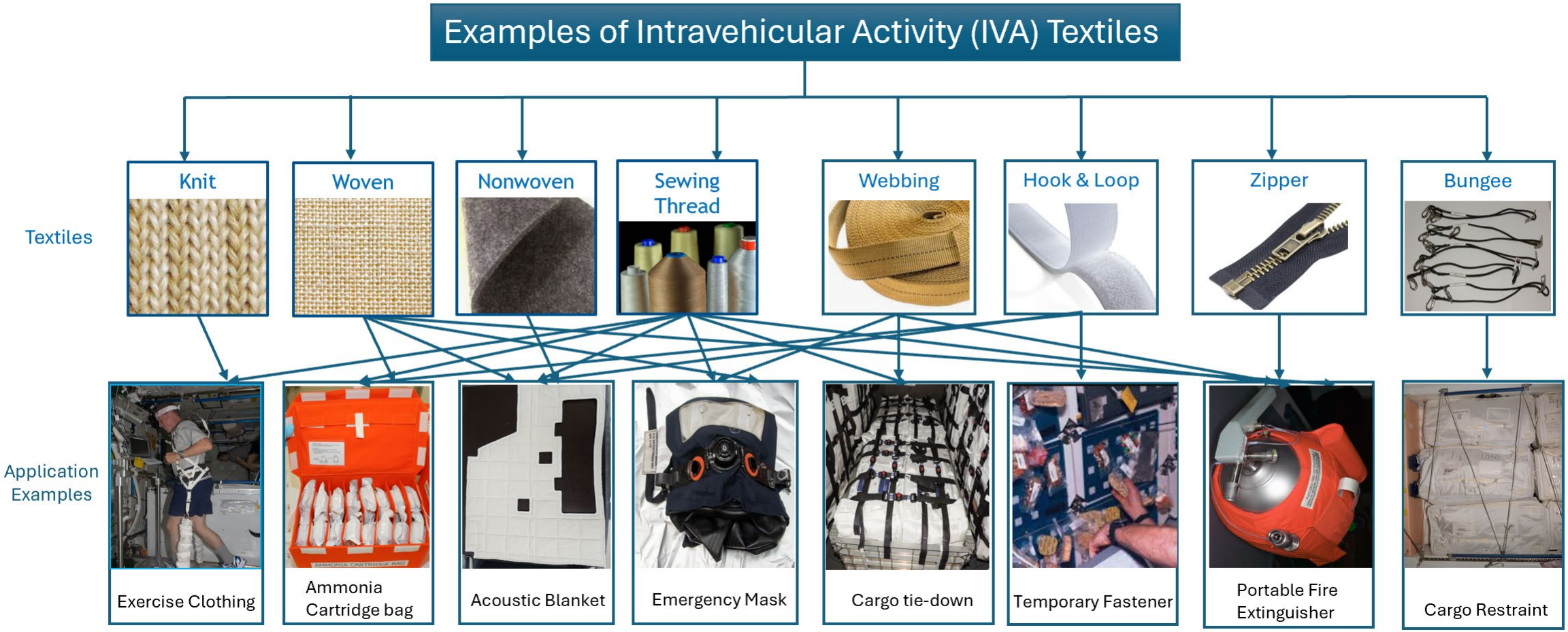
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Testing Methodology

- The typical test configuration is Standard Edge Ignition (most conservative)
- Most textiles are tested in a “J-configuration”
  - Ignitor placed at bottom of “J” to ignite surface of the specimen
  - Metal fixture can be used to shield the vertical raw edges
  - Suitable for test specimens of materials that won’t have any exposed raw edges in usage applications



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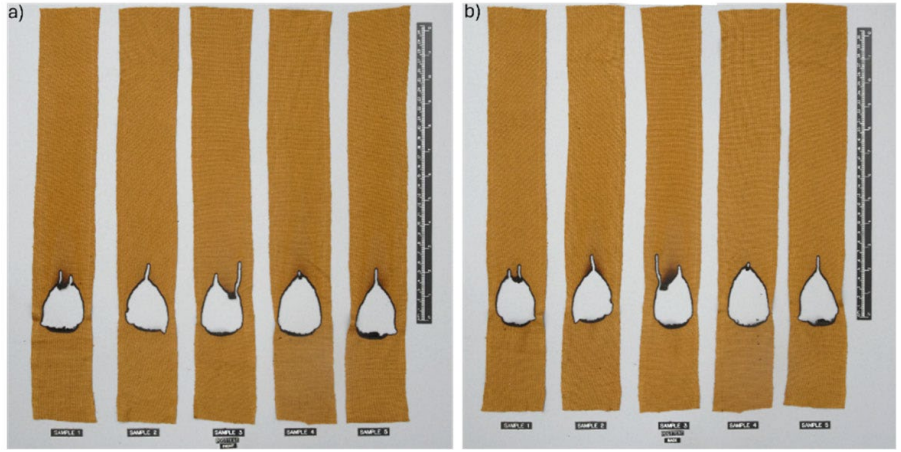


- Fire-resistant textiles must be available to fabricate the end soft goods
- Coupon-level flammability testing at 37% O_2 shows increased propagation with configuration and layup testing as compared with single material tests

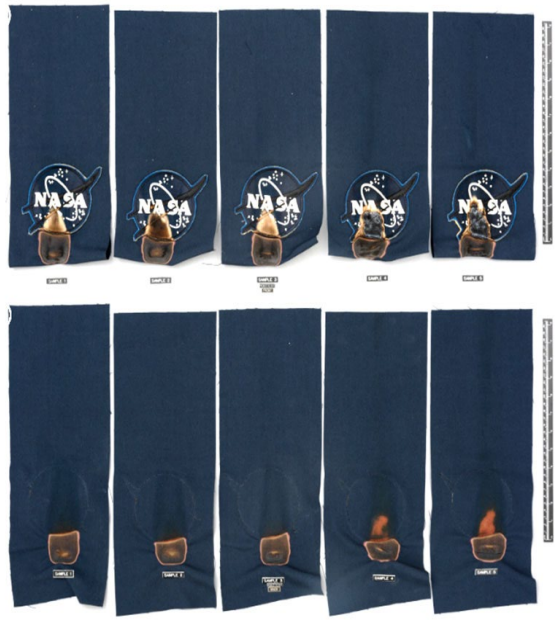
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COTS Solutions

- NASA's textile engineering and development team has been sourcing existing COTS textile products, modifying COTS textiles, and developing custom fire-resistant solutions
- Some NASA-developed Artemis Softgoods items will utilize COTS solutions:
  - Crew clothing outer jacket and pants
  - Cargo Transfer Bags
  - Sleeping Bags
- Developed fire-resistant textile solutions:
  - 100% PBI knit fabric for crew clothing next-to-skin shirt
  - Fire-resistant patches



100% PBI knit fabric coupons tested at 48% O_2 and 8.2 psia



Custom fire-resistant patches sewn to outer jacket fabric tested at 37% O_2 and 8.2 psia

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Fire-resistant Textile Assessment

- NASA Engineering and Safety Center (NESC) was requested to conduct an assessment and develop a strategy for the development of high priority fire-resistant textiles for softgoods applications within a vehicle cabin at a minim um of 37% O2 at 8.2 psia
- Agency-wide Assessment:
    1. Identify stakeholders and collect data including key performance and safety parameters/metrics
    2. Determine material requirements, applications, and NASA program priorities
    3. Comprehensively assess the NASA and industry current state of the art and opportunities for fire-resistant textiles
    4. Develop a prioritized strategy and implementation plan

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Fire-resistant Textile Strategy

Phase 1

Baseline Testing of Available COTS Products

- Evaluate and confirm whether COTS materials are available that can be certified for use at 37% O2/8.2 psia for each textile type
- Certification testing will be performed at White Sands Test Facility (WSTF)

Phase 2

Incremental Improvement over COTS Solutions

- If no COTS solution can meet NASA-STD-6001B Test 1 but a relatively low effort can be done to modify the COTS and increase the chance of passing, it is recommended to pursue the incremental improvement/modification on the COTS solution and assess the performance again

Phase 3

Custom Textile Development

- If no COTS solution can meet NASA-STD-6001B Test 1 and it is not possible to do incremental improvement over COTS solutions, a custom major development effort is required with an industrial partner to design and develop a suitable solution that can meet NASA's specific needs

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Conclusion

- **Fire-resistant Textile Development:**
  - Critical priority for NASA to buy down flammability risk
  - NASA's textile engineering and development team is actively implementing the NESC's 3-phase strategy
  - Systematically mature materials that enable safer and more sustainable human exploration missions




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