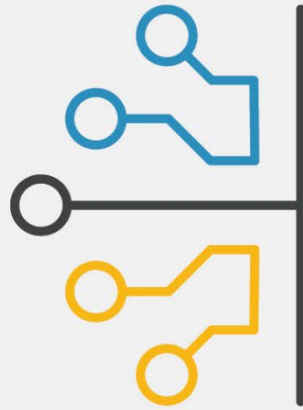


Welcome to



**EMERGING
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CONFERENCE at Advanced Textiles
EXPO

Textiles in Space: Ensuring Safety and Functionality

Speaker: Mary Walker, NASA Johnson Space Center

September 23, 2024

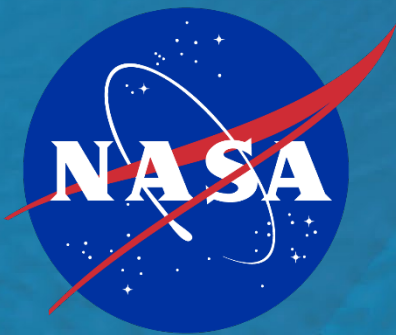
Speaker Introduction

Mary Walker: Project Manager, Crew and Thermal Systems Division,
Engineering Directorate, NASA Johnson Space Center

Current projects:

- Crew Cabin Softgoods for Human Landing Systems
- Clothing and Clothes Cleaning Logistics Reduction

mary.walker@nasa.gov



Two Environmental Categories:



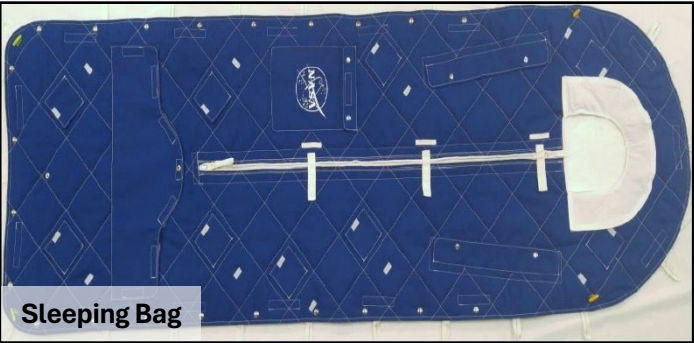
Extravehicular Activity (**EVA**) – Outside spacecraft or planetary environment



Intravehicular Activity (**IVA**) – Inside spacecraft environment

Examples of IVA Textiles

Crew Quarters/Interior



Crew Clothing



Containers and Bags



Restraints

Space Vehicle Cabin Environments

Vehicle	Oxygen Concentration	Pressure
Apollo (1961-1972)	100%	5 psi
Skylab (1973-1979)	70%	5 psi
Shuttle (1981-2011)	21%*	14.7 psi*
International Space Station (ISS) (1998-present)	21%*	14.7 psi*
Orion (2022-present)	21%*	14.7 psi*
	26.5% (max 30%)	10.2 psi
Exploration (beyond Low Earth Orbit) (2026+)	34% (max 37%)	8.2 psi

**same as Earth's atmosphere*

Enriched Oxygen Cabin Environments

- NASA is sending astronauts back to the Moon with the Artemis Program
- The suggested lunar lander cabin maximum oxygen concentration is **37% O₂** (including margin)
- The main benefit of enriched oxygen cabin environments (>30% O₂) is a shorter spacewalk preparation process (“pre-breathe”)
 - **Minimizing risk of decompression sickness**
 - **Maximizing time on a spacewalk**



Non-Flammable Textiles

- Flammable material creates fire and safety hazards
- Non-flammable textiles are necessary to ensure large-scale flame propagation events do not occur
- There is an immediate need for improved non-flammable textiles for oxygen-enriched environments **up to 40% O₂** to ensure mission safety



Apollo 1 Crew

IVA Textile Challenges – Flammability

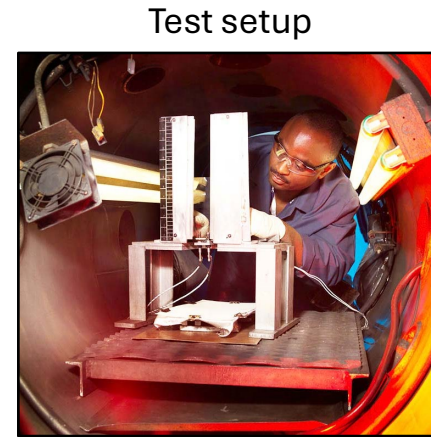
- IVA materials are required to pass flammability testing at the applicable test environment
 - NASA-STD-6001, Test 1
- Recent flammability testing shows that all textile components (i.e. zipper, thread, Velcro), **not just the outermost layer**, must have good flame-resistance performance
 - Textile fibers that fail flammability testing at >30% O₂ could be blended with higher-performing fibers to balance flammability and other functionality

Textile Fibers	Earth 21 % O ₂	ISS Airlock/ Orion Cabin 30 % O ₂	Future Spacecraft > 34 % O ₂
Cotton ((Limited Oxygen Index (LOI) ~19%)	✗	✗	✗
Polyester (LOI ~ 22%)	✗	✗	✗
Wool (LOI ~ 22%)	✓	✗	✗
Modacrylic (LOI ~ 26%)	✓	✗	✗
Nomex (LOI ~ 31%)	✓	✓	✗
P84 (LOI ~ 33%)	✓	✓	✗
FR Cotton (LOI ~ 34%)	✓	✓	✗
Durette (LOI ~ 38%)	✓	✓	✓
PBI (LOI >50%)	✓	✓	✓
Carbon (LOI > 55%)	✓	✓	✓
Teflon (LOI > 95%)	✓	✓	✓
Fiberglass (LOI ~ 100%)	✓	✓	✓

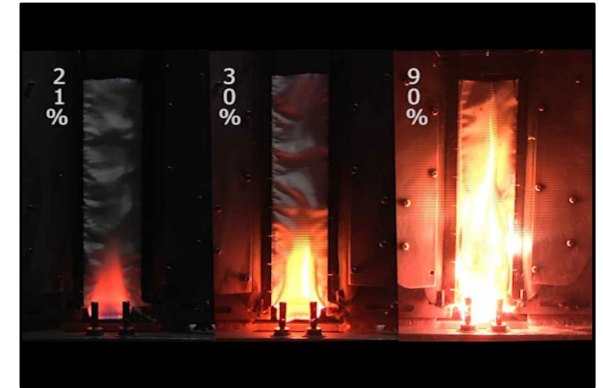
Flammability results of common textile fibers in various oxygen environments

Flammability Testing Process

- NASA-STD-6001, Test 1
 - Bottom ignition upward flame propagation test
 - Burn length < 6”
 - No transfer of burning debris (melt and drip)



Textile being tested at various O₂ concentrations



- Typical textile flammability test plan (abridged):



Post-test examination of textile

Unique Challenges

- Along with safety, textile **functionality** is crucial for mission success
- Desirable textile properties for various IVA spaceflight applications:
 - **Durability**
 - **Reusability**
 - **Low toxicity**
 - **Comfort** (for garments)
 - **Dust-resistance** (avoid contamination of IVA cabin and equipment)

IVA Textile Challenges – Availability

- Flame-resistant fibers and textiles were developed during Apollo and Skylab due to their enriched oxygen cabin environments
- These specialized fibers and textiles (i.e. Beta glass, PBI, Durette, Astro Velcro) are no longer commercially available due to discontinuation of raw materials and closure of the original manufacturers
- Recent development efforts have found very limited existing Commercial Off The Shelf (COTS) textiles that can be certified for use in up to 40% O₂ environment

**WE WANT
YOU**



HELP US DEVELOP
NON-FLAMMABLE
TEXTILES FOR SPACE



Call to Action

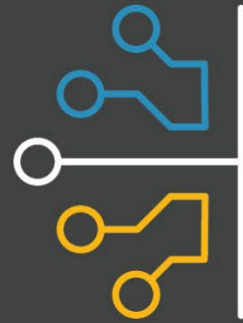
- **Immediate need:** non-flammable textiles in oxygen-enriched environments up to 40% O₂ for use inside space vehicle cabins
 - Durable woven fabric
 - Sewing thread
 - Felt
 - Elastics
 - Seam tape
 - Hook and loop fasteners
- Come talk to us at **Booth #: E1856**

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See you next year!



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