Development of a Wardrobe for Life in Space Vehicles and Habitats

Evelyne S. Orndoff
Textiles Research & Development, Lead
Engineering Directorate
NASA, Johnson Space Center
O₂, In The Beginning...

- Mercury: ~3 days
- Gemini: ~3 days
- Apollo: ~6 days
- Skylab: ~28 days
- Shuttle: 6-16 days
- ISS: ~6 month average

Flammability:
- Short-term wear/disposable
- Long-term wear/disposable

Ambient oxygen levels:
- High flamability

O₂ %
100% 90% 80% 70% 60% 50% 40% 30% 20% 10%
The Future is Somewhere in the Middle

- **Flammability, short-term wear/disposable**
  - Mercury
  - Gemini
  - Apollo
  - ~3 days
  - ~3 days
  - ~6 days

- **Flammability, Long-term wear/disposable**
  - Skylab
  - ~28 days

- **Mass, Volume, Comfort**
  - Shuttle
  - ISS
  - ~6 months average
  - ~6 months average

- **Oxygen (O₂)**
  - 100%
  - 90%
  - 80%
  - 70%
  - 60%
  - 50%
  - 40%
  - 30%
  - 20%
  - 10%

- **Reusability**
  - Toxicity
  - Human factors

- **Gateway**
  - 30 days

- **Mars**
Design Parameters

- Human factors
- Reusability
- Functionality
- Toxicity
- Mass
- Flamability
- Volume
- Long-term wear
Still in the study phase of development

- **Blind study:** Acceptance of wool vs. cotton
- **Length of wear study:** Odor (exercise clothing)
- **Lint study:** wool vs. other fibers
- **Microbial study:** packaging and storage
Blind Study

Most participants could not tell the difference -or- preferred wool over other fibers
Length of Wear Study

4+ Hours longer than other fibers tested
Current Studies: Usage Rate

Understanding usage rate and wear pattern of clothing in a space station

- shirts ~15 days
- Pants ~30 days
- socks ~7 days
- undergarments ~2 days
- Athletic clothing ~7 days
Current Study: Cleaning/life of garment

Evaluate cleaning and sanitation techniques to use in microgravity

- Clean with soap and water
- Stretch and twist results
- Clean with hydrogen peroxide (fade results)
- Clean with ozone (odor results)
Completed Study: Lint Study

ISS cotton crew socks and anklets compared to other type of crew socks with respect to lint production.

No difference

Lint makers
Completed Study: Microbial Study

Fiber integrity did not change when packaged in a clean environment
Work in Progress: Logistics Tracking

• ISS and Gateway clothing experiments
  • Tracking of RFID tags on clothing
Near-term Work: Continuation

• ISS and Gateway clothing experiments
  • Water based clothes cleaning in microgravity in combination with oxidative and physical methods of sanitation
GOAL

• Our goal is logistics reduction for long-duration space travel
  • Flammability issues
  • Toxicity issues
  • Long wear
  • Low odor development/bacterial growth
  • Human factors appeal
  • Moisture management
  • Lint management
  • Logistic process efficiency

https://ntrs.nasa.gov/search.jsp?R=20160010481&hterms=Adavanced+Clothing+Ground+Study&qs=N%3D0%26Ntk%3DAll%26Ntt%3DAdavanced%2520Clothing%2520Ground%2520Study%26Ntx%3Dmode%2520matchallpartial