Water: A Critical Material Enabling Space Exploration

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Presentation Outline

- Where is NASA going?
- Why is water critical to NASA’s mission?
- Recovering water from wastewater
- Water quality for humans and hardware
- Technology needs for exploration
Acronym Primer

- **ISS** = International Space Station
- **WRS** = Water recovery system
- **EVA** = Extravehicular activity
So what is NASA really doing?

HUMAN EXPLORATION
NASA’s Path to Mars

EARTH RELIANT
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

Learning fundamentals aboard the International Space Station
U.S. companies provide access to low-Earth orbit

PROVING GROUND
MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

Expanding capabilities by visiting an asteroid in a lunar distant retrograde orbit
Traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

MARS READY
MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

Exploring Mars, its moons and other deep space destinations
Recovery of water from wastewater is an enabling technology to explore beyond low Earth orbit
Open-loop life support system resupply mass
12,000 kg/person-year
(26,500 lbs/person-year)

- Water 89%
- Oxygen 2.5%
- Food (dry) 2.2%
- Crew Supplies 2.1%
- Gases lost to space 2.1%
- Systems Maintenance 2.1%

10,680 kg
(23,545 lbs)
(2827 gallons)
**Human mass balance**

### SOLID
- **FOOD**
  - ~0.620kg/p/day
- **FECAL**
  - ~0.110kg/p/day

### LIQUID
- **WATER**
  - ~3.530kg/p/day
- **URINE/SWEAT/RESPIRATION**
  - ~3.870kg/p/day
- **CO2 + O2**
  - ~1.130kg/p/day

### GAS
- **OXYGEN**
  - ~0.830kg/p/day
- **ATMOSPHERIC COMPOSITION**
  - 51711Pa < P tot ≤ 103421Pa
  - 128mm Hg < ppO2 ≤ 178mm Hg
  - ≤ 5mm Hg ppCO2

### REGULATION (Metric)
- **Temp & Humidity**
  - ~18°C - ~ 27°C
  - ~25% - ~75% H2O

### REGULATION (English)
- **Temp & Humidity**
  - ~64°F - ~ 81°C
  - ~25% - ~75% H2O

- **Atmospheric Composition**
  - 7.5psia < P tot ≤ 15.0psia
  - 2.48psia < ppO2 ≤ 3.44psia
  - ≤ .096 Hg ppCO2
Water requirements change as mission matures
Wastewater on ISS

International Space Station

Recovered Wastewater

Urine

Humidity Condensate

8/12/14

Separation Science and Technology as a Convergence Platform for SusCHEM
Wastewater on a planetary surface

- Shower Water
- Laundry
- Hand Wash
- Food
- Oral Hygiene
- Shave
RECOVERING WATER FROM WASTEWATER
International Space Station

- **Recycle urine and humidity condensate**
  - Distillation
  - Adsorption
  - Ion exchange
  - Catalytic oxidation
  - Disinfection

Separation Science and Technology as a Convergence Platform for SusChem
ISS Life Support Systems

Separation Science and Technology as a Convergence Platform for SusChEM
On-orbit work with water containers
Technology for Exploration
WATER QUALITY FOR HUMANS AND HARDWARE
Drinking Water Quality on ISS

ISS WPA Product Water TOC
In-Flight TOCA and Archive Data

U.S. Segment Specification for TOC = 3000 µg/L

WPA TOC
Archive TOC
PWD TOC
WPA PFU2

IX Bed R&R
Cat Rx /MF R&R
PFU1 MDL

PFU2 MDL

Date

6/21/10 7/28/10 8/22/10 9/17/10 10/17/10 11/17/10 12/17/10 1/18/11 2/18/11 3/18/11 4/18/11 5/18/11 6/18/11 7/18/11 8/18/11 9/18/11 10/18/11 11/18/11 12/18/11 1/19/12 2/19/12 3/19/12 4/19/12 5/19/12 6/19/12 7/19/12 8/19/12 9/19/12 10/19/12 11/19/12 12/19/12 1/20/13 2/20/13 3/20/13 4/20/13 5/20/13 6/20/13 7/20/13 8/20/13 9/20/13 10/20/13 11/20/13 12/20/13 1/21/14 2/21/14
Contaminant identification

- Dimethylsilanediol (DSMD)
- trimethylsilanol
- dimethylsulfone
- Metal silicate coating
- Polydimethylsiloxane (PDMS)
Urine and solubility
What happens when you DON’T stabilize
Tear Down and Inspection

Silicate Blockage

Unused Drum for Comparison

Corroded Braze Joint
Conclusions

- Water impacts human health and safety in space
- Hardware developers need help defining WHAT water quality is required for their hardware
- Water recovery enables American’s future space exploration
Thank you

QUESTIONS