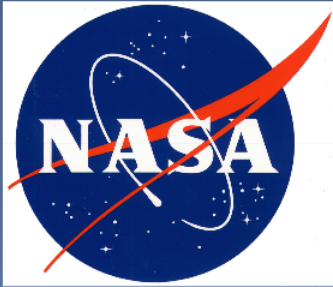


ADVANCED LIFE SUPPORT WATER RECYCLING TECHNOLOGIES CASE STUDIES: VAPOR PHASE CATALYTIC AMMONIA REMOVAL AND DIRECT OSMOTIC CONCENTRATION

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Design for microgravity has traditionally not been well integrated early on into the development of advanced life support (ALS) technologies. NASA currently has a many ALS technologies that are currently being developed to high technology readiness levels but have not been formally evaluated for microgravity compatibility. Two examples of such technologies are the Vapor Phase Catalytic Ammonia Removal Technology and the Direct Osmotic Concentration Technology. This presentation will cover the design of these two systems and will identify potential microgravity issues.



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Advanced Life Support

Water Recycling

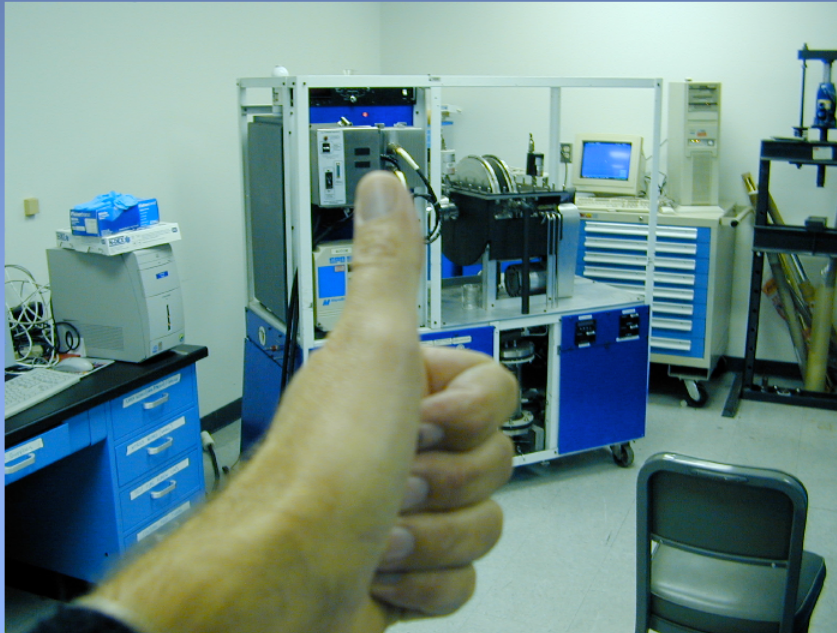
- One of the “tall poles” in the development of a viable human Mars Exploration program is the development of applicable Advanced Life Support System.
- Of all the metabolic requirements water is the most significant
- Water accounts for 89% of the total metabolic resupply requirements to keep an astronaut alive in space.
- Using the Mars Reference Mission as a baseline and Mars Pathfinder launch cost data, the cost of supplying water for this mission in the open loop case is over \$11 Billion.

Assumptions: 6 astronauts, flow=3.18kg/hr, duration=960 days, launch Cost= \$150,000/kg

Advanced Life Support

- The ALS program supports fundamental research into the development of new technologies.
- It supports the development of these technologies to high technology readiness levels (TRL 5-6).
- It has not adequately supported the validation of the microgravity performance of these technologies (TRL 7 to 8).

Rule of Thumb Approach



Alternative Approaches?

- Integrate technology development and microgravity design early on in the design process.
- Complete a set of fundamental microgravity fluid physics experiments that will have broad applicability to ALS.
 - Workshop on Critical Issues in Microgravity Fluids, Transport and Reaction Processes in Advanced Human Support Technology
- Form teams with microgravity community to begin to generate answers to questions associated with existing technologies.

Case Study Examples

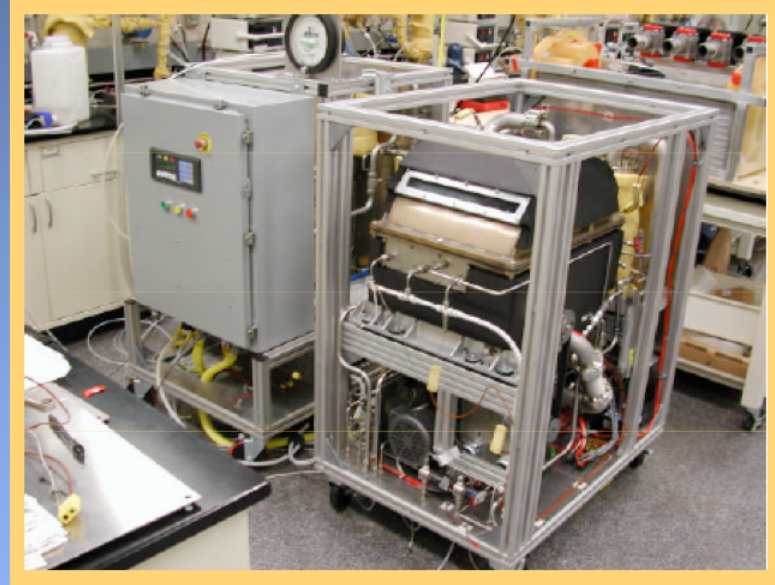
- Vapor Phase Catalytic Ammonia Removal
 - Currently a TRL 5 technology being developed for advancement to TRL 6
- Direct Osmotic Concentration
 - Currently a TRL 3 technology being developed for advancement to TRL 6

Vapor Phase Catalytic Ammonia Removal (VPCAR)

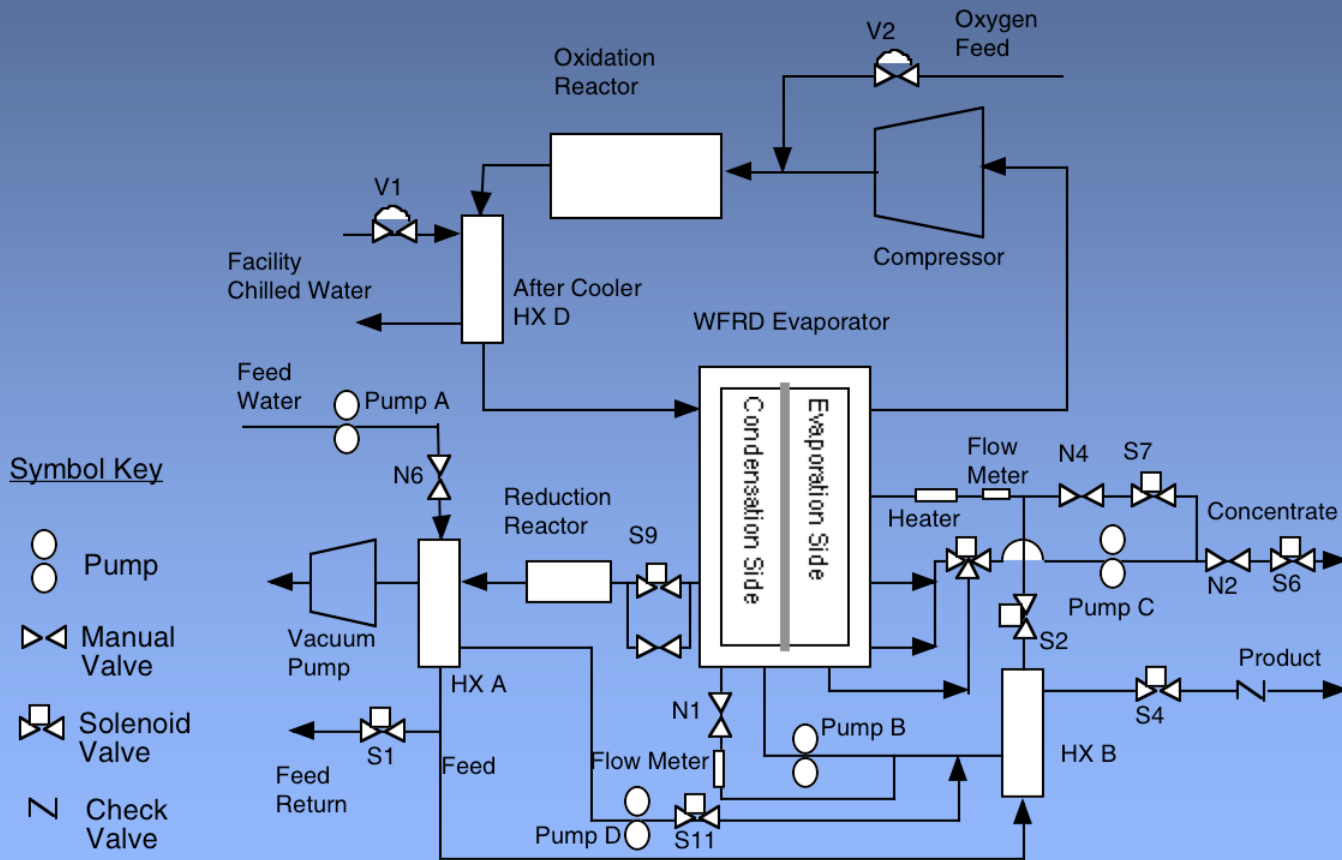


Vapor Phase Catalytic Ammonia Reduction

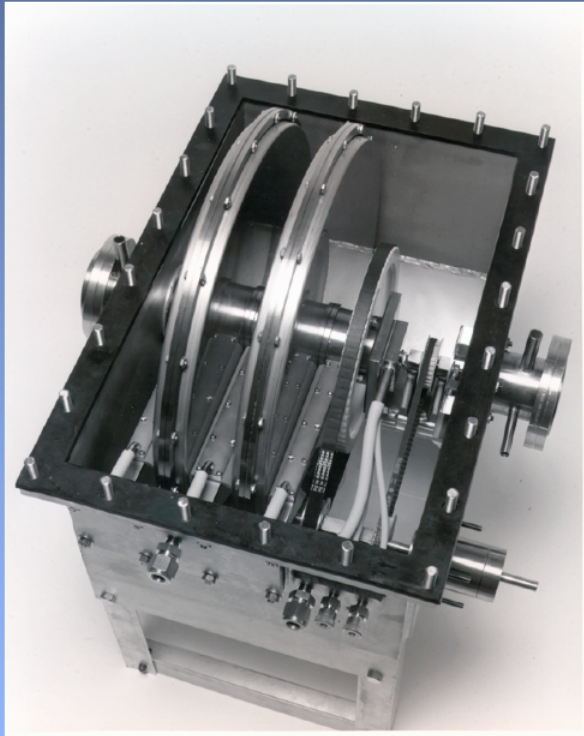
- The VPCAR is designed to accept a combined waste stream (urine, condensate, and hygiene) and produce potable water in a single step.
- The system is designed to require no re-supply or maintenance.
- The technology is modular and can be packaged to fit into a volume comparable to a single Space Station rack.
- The technology has been the subject of many NASA trades studies and peer reviews.



VPCAR Flow Diagram



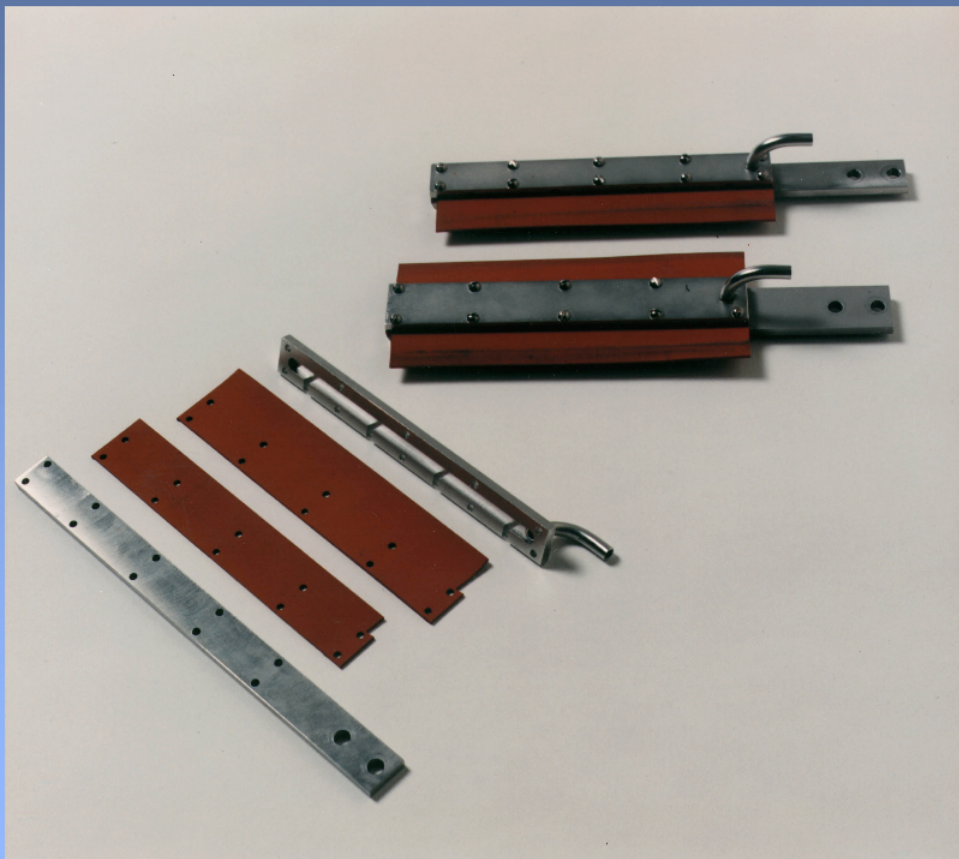
WFRD Components

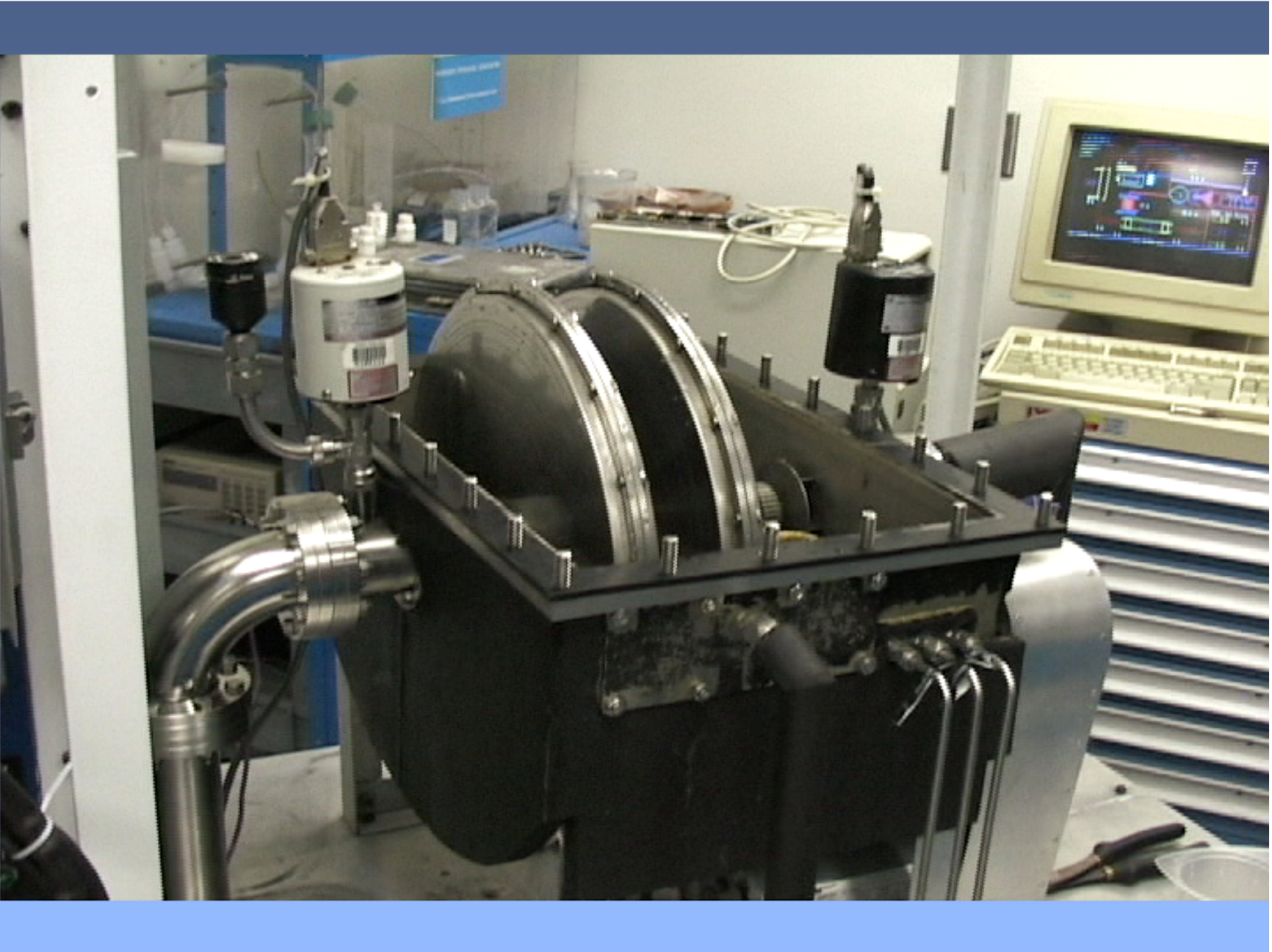


Rotor Assembly



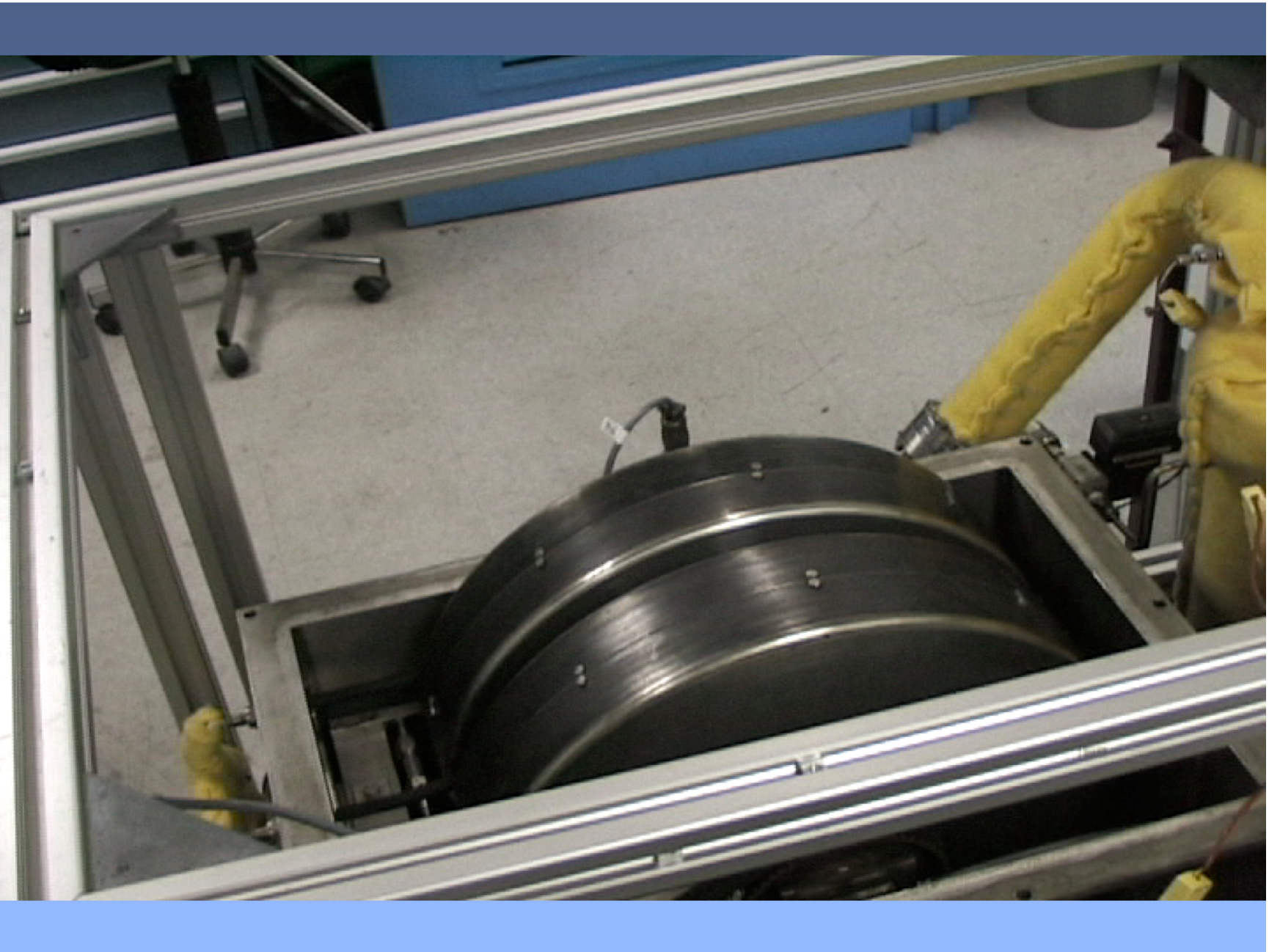
Wiper Blades





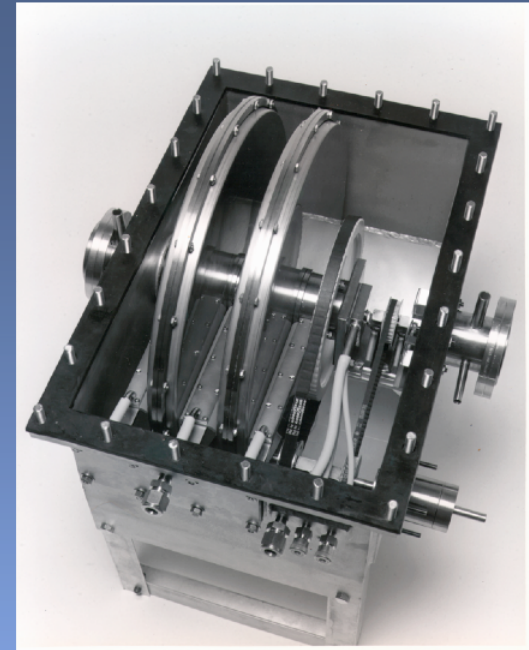
Microgravity Evaporator

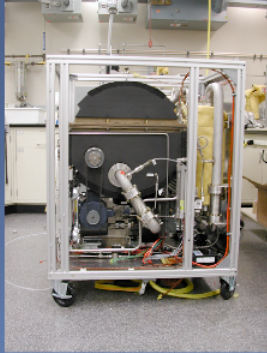




VPCAR Systems Flight Verification Topics

- Thermal properties of thin fluid films
- Two phase flow in open chambers
- Three phase flow
- Splashing in liquid/gas boundaries
- Centrifugal separations, what occurs during start and stop events
- Wiper blade fluid application



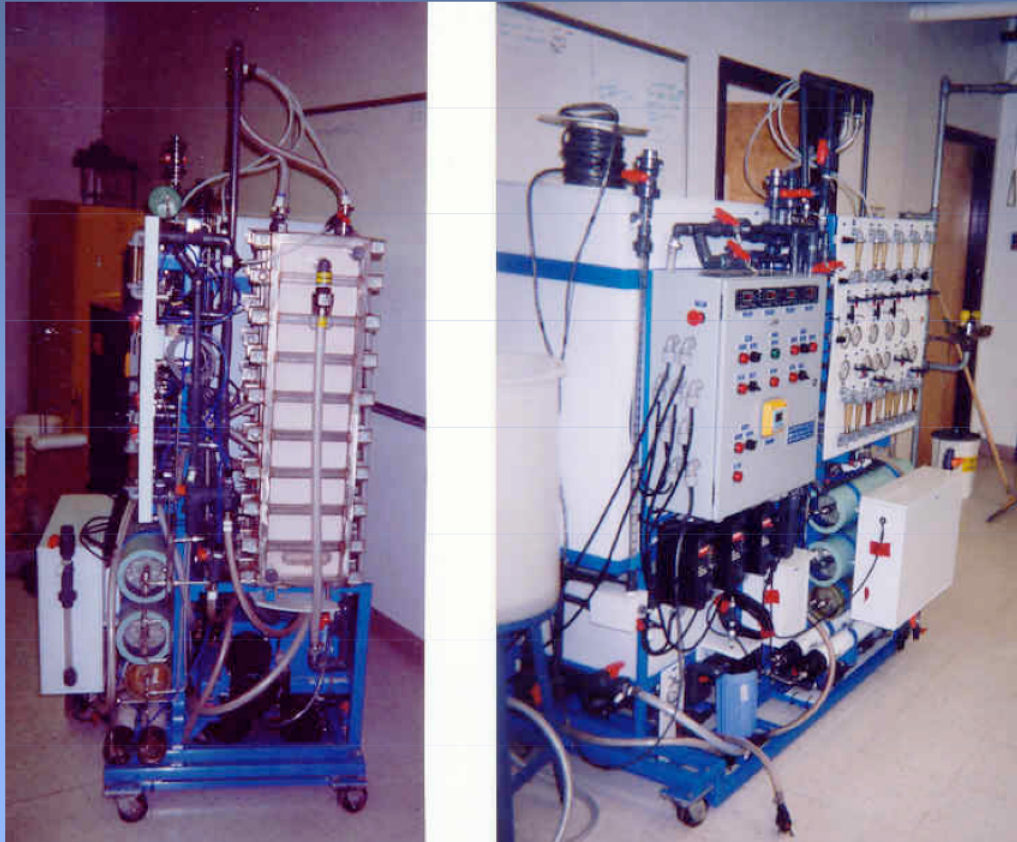


VPCAR Systems Flight Verification Topics (Cont.)



- Pumping of saturated fluids
- Surface tension directed flow stability
- Reaction kinetics in packed beds, effects of channeling and condensation
- Stability of packed beds during launch
- Deterioration of packed beds during operation
- Lubrication of rotating gears

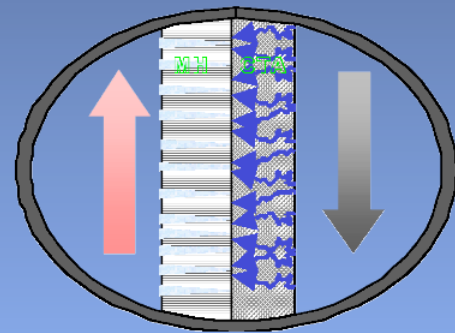
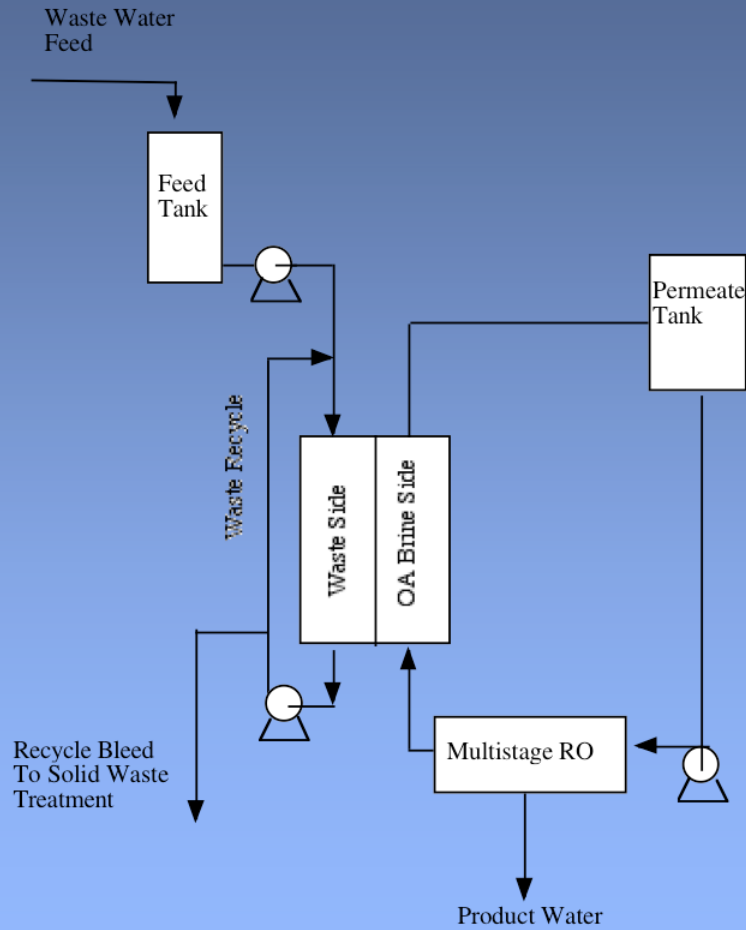
Direct Osmotic Concentration (DOC)



DOC Description

- The DOC technology is a highly integrated membrane / distillation / oxidation based water processor.
- It incorporates a novel direct osmosis step, an osmotic distillation step, a reverse osmosis step, and a catalytic reactor post treatment step.
- The DOC technology is designed to accept separate hygiene and urine + condensate streams and produces potable water while requiring little re-supply or maintenance for a 3 year mission.

DOC Simplified Flow Diagram



DOC Flight Verification Topics

- Three phase flow
- Two and three phase flow in membrane elements
- Stability of packed beds
- Two phase flow in packed beds
- Multi Phase flow separation and mixing
- Cavitation control