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O-G LIFE SUPPORT FOR SPACE STATION FREEDOM

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ABSTRACT

Optimal design of spacecraft environmental control and life support systems (ECLSS) for long-duration missions requires an understanding of microgravity and its long-term influence on ECLSS performance characteristics. This understanding will require examination of the fundamental processes associated with air revitalization and water recovery in a microgravity environment. Short-term testing can be performed on NASA's reduced gravity aircraft (a KC135), but longer tests will need to be conducted on the shuttle or Space Station Freedom.

Conceptual designs have been prepared for ECLSS test beds that will allow extended testing of equipment under microgravity conditions. Separate designs have been formulated for air revitalization and water recovery test beds. In order to allow testing of a variety of hardware with minimal alteration of the beds themselves, the designs include storage tanks, plumbing, and limited instrumentation that would be expected to be common to all air (or water) treatment equipment of interest. In the interest of minimizing spacecraft/test bed interface requirements, the beds are designed to recycle process fluids to the greatest extent possible. In most cases, only cooling water and power interfaces are required.

A volume equal to that of two SSF lockers was allowed for each design. These bed dimensions would limit testing to equipment with a 0.5- to 1.5-person-equivalent throughput. The mass, volume, and power requirements for the air revitalization test bed are estimated at 125-280 kg, 1.0-1.4 m3, and 170-1070 W. Corresponding ranges for the water recovery test bed are 325-375 kg, 1.0-1.1 m3, and 350-850 W. These figures include individual test articles and accompanying hardware as well as the tanks, plumbing, and instrumentation included in the bed designs. Process fluid weight (i.e. water weight) is also included.

C-5

ZERO - G LIFE SUPPORT RESEARCH

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RATIONALE

- Optimal design of spacecraft ECLSS for long-duration missions requires an understanding of microgravity and its long-term influence on ECLSS performance.

- Such understanding requires examination of fundamental processes associated with air revitalization and water recovery in a microgravity environment.

- Short-term testing can be performed on NASA's reduced-gravity aircraft (KC135), but longer tests will need to be conducted on the shuttle or SSF.

CONSTRAINTS

- Bed must fit in two adjacent station lockers, each with dimensions 0.91 m x 0.99 m x 1.83 m.
  - Limited space available means that full-scale (i.e. 4-person) hardware cannot be tested.
- SSF-test bed interfaces limited to
  - electric power
  - cooling water at 4°C
  - air

COMMONALITY

- Separate beds have been designed for testing ARS and WRMS equipment.
  - Vastly different flow rates and compressibilities require dissimilar equipment, line sizing, and instrumentation.
    - A common test bed would require parallel flow paths and equipment to allow circulation of gases and liquids.
  - Many air revitalization processes are continuous, while most water recovery subsystems include batch processes.

TEST BED CLOSURE

- Due to limited SSF- test bed interfacing, test bed should be closed to the greatest extent possible.
- In some cases, full closure may be unrealistic.
  - Example: Bosch reactor
    - To close bed with respect to carbon, solid carbon would have to be recovered and oxidized to CO_2.
    - To close bed with respect to hydrogen, product water would have to be electrolyzed.
    - Equipment necessary to close test bed would drive mass, volume, and power requirements beyond limits of bed.

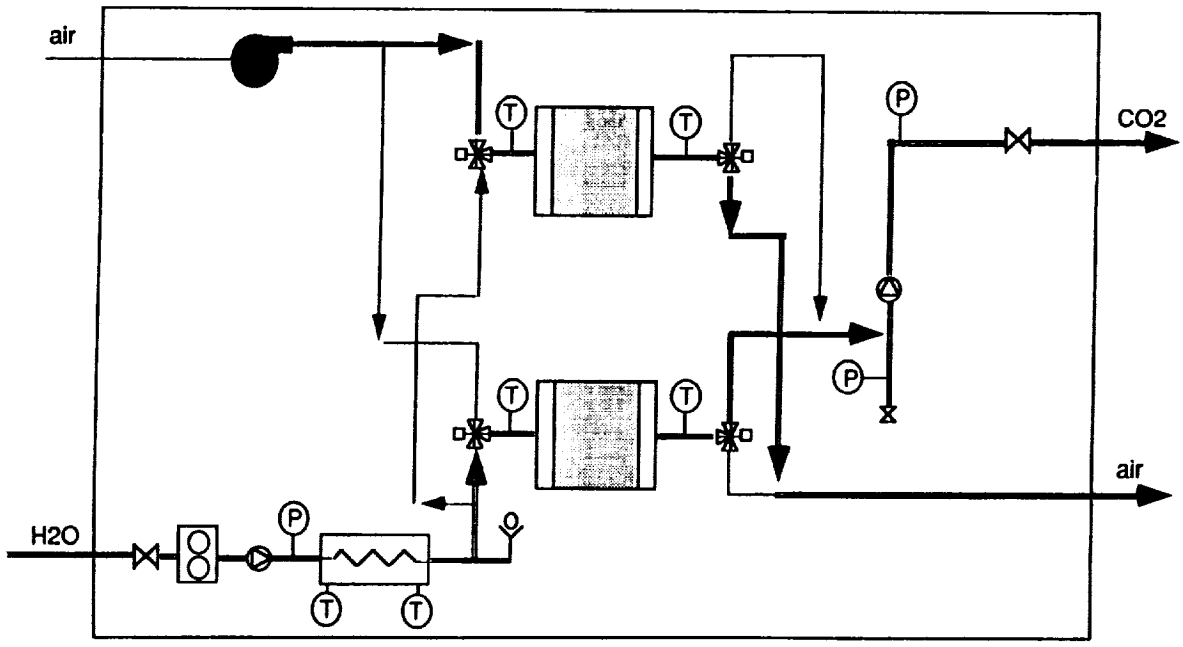
BED DESIGN PHILOSOPHY

- Test beds have been designed in a modular fashion in order to allow testing of a variety of equipment.
- To allow testing of different hardware with minimal bed modification, bed designs include storage tanks, plumbing, and limited instrumentation expected to be common to all equipment of interest.
- Each bed allows space for insertion of "experiment packages", which will include test articles as well as instrumentation, plumbing, and controls specific to test articles.

ARS TEST BED HARDWARE

- surge/storage tank
- CO_2 and O_2 sensors
- condensing heat exchanger
- humidifier
- adsorbent bed
- fan
- electric heater
- control package

SCHEMATIC OF POSSIBLE EXPERIMENT PACKAGE



adapted from final report on SAWD II, SVHSER 10634

ARS TEST BED MASS, VOLUME, AND POWER SUMMARY

	Mass (kg)	Volume (m3)	Power (W)
test bed	93	0.8	129
experiment package	32 - 187	0.2 - 0.6	41 - 941
TOTAL	125 - 280	1.0 - 1.4	170 - 1070

WRMS TEST BED HARDWARE

- feed/product tank
- pretreatment storage
- posttreatment
- two heat exchangers **OR**
- control package

- feed pump
- pretreatment pump
- filter
- temperature control bath

SUMMARY

- Long-term testing of life support hardware under microgravity conditions is essential for design of optimal life support systems.
- Separate test beds have been designed to enable testing of ARS and WRMS hardware on SSF.
- ARS test bed requirements are estimated at 125 - 280 kg, 1.0 - 1.4 m3, and 170 - 1070 W.
- WRMS test bed requirements are estimated at 325 - 375 kg, 1.0 - 1.1 m3, and 350 - 850 W.
- The above estimates include test articles and accompanying hardware in addition to tanks, plumbing, and instrumentation contained in bed infrastructure.