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CREW APPLIANCE CONCEPTS

CREW APPLIANCE STUDY

THE BOEING COMPANY
HOUSTON, TEXAS

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CREW APPLIANCE CONCEPTS

APPENDIX B

SHUTTLE ORBITER APPLIANCES

SUPPORTING ENGINEERING DATA

PREFACE

A study of crew appliances for advanced spacecraft is being performed for NASA JSC by the Boeing Aerospace Company under Contract NAS 9-13965. A large number of appliance concepts for the galley, personal hygiene, housekeeping, and other areas have been investigated for application to the Shuttle Orbiter and Modular Space Station missions. This document presents the background to and results of trade studies to determine the optimum appliance systems for these two vehicles.

An index file containing abstracts for 299 appliance-related documents was developed during the initial literature search for this study. The original file will be delivered to and retained by NASA.

Due to the large volume of library references and appliance engineering data used for the trade studies, it was necessary to present the supporting information to the concept report in separate appendices as follows:

<u>APPENDIX A</u> - In this appendix, the complete bibliography used for the appliance study is listed in three forms: numbered, alphabetized, and sorted by subject matter.

<u>APPENDIX B</u> - This appendix contains the supporting engineering data used for all appliance concepts considered for Shuttle Orbiter, including plotted and tabulated trade study results for each appliance function.

APPENDIX C - This appendix contains the supporting engineering data used for all appliance concepts considered for Modular Space Station, including plotted and tabulated trade study results for each appliance function.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION PAGE

VOLUME I OF V (Continued)

APPENDIX A - BIBLIOGRAPHY

VOLUME II OF V

APPENDIX B - SHUTTLE ORBITER APPLIANCES SUPPORTING ENGINEERING DATA

VOLUME III OF V

APPENDIX B (Continued) - SHUTTLE ORBITER APPLIANCES SUPPORTING ENGINEERING DATA

TABLE OF CONTENTS (Concluded)

SECTION PAGE

VOLUME IV OF V

APPENDIX C - SPACE STATION APPLIANCES ENGINEERING DATA

VOLUME V OF V

APPENDIX C (Continued) - SPACE STATION APPLIANCES ENGINEERING DATA

ILLUSTRATIONS

TABLES

1.0 INTRODUCTION

A large number of crew appliance concepts have been studies for applicability to the Modular Space Station and Shuttle Orbiter spacecraft, and detailed trade studies of the various concepts were conducted to choose the optimum appliance systems for both vehicles. Due to the volume of data used for the appliance trade studies, it was necessary to present the supporting information to the concept report in separate appendices. In this appendix are included all the engineering data collected for the appliances considered for Shuttle Orbiter, as well as plotted and tabulated trade study results for each appliance function.

A crew appliance system organization chart was constructed, Figure B1-1, to thoroughly and orderly establish an appliance system. The appliance concepts considered for Shuttle Orbiter were categorized within this system as listed in Figure B1-2. The engineering data and trade study results for the appliance concepts evaluated are presented in this appendix in the order given in Figure B1-2. All the appliance data apply to a four-man mission, with the baseline mission ground rules and assumptions given in Figure B1-3. The basic mission considered for Shuttle Orbiter was 20.5 days. The Shuttle Orbiter timeline used is illustrated in Figure B1-4.

The data used for trading alternate appliance concepts are presented in Section 2 of this appendix. The format used in the data presentation is as follows:

Top Sheet Description. This data sheet gives a description of the appliance function with the assumptions made for computing appliance size and penalties.

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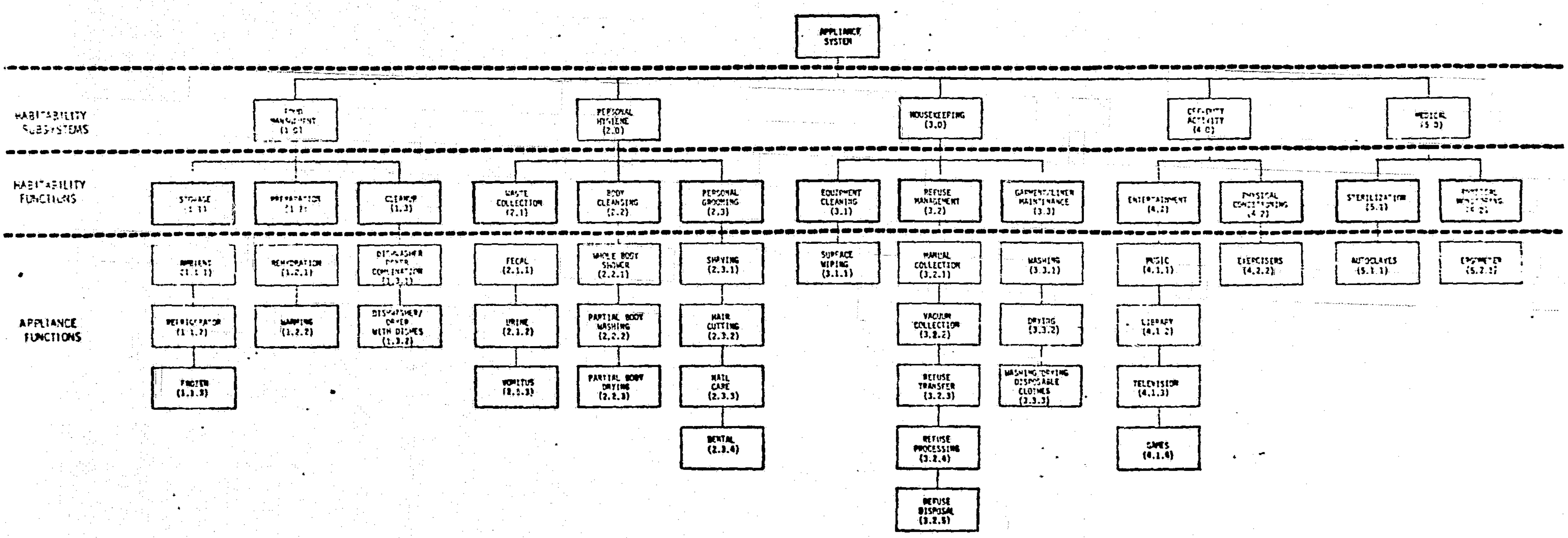

Figure B1-1. Crew Appliance System Organization

1.0 FOOD MANAGEMENT

1.1 FOOD STORAGE

1.1.1 Ambient Food Storage

1.1.1.1 Rigid Containers
1.1.1.2 Flexible Containers

1.1.2 Refrigerated Food Storage

1.1.2.1 Space Radiator
1.1.2.2 Thermoelectric
1.1.2.3 Air Cycle Turbine/Compressor

1.1.3 Frozen Food Storage

1.1.3.1 Space Radiator
1.1.3.2 Thermoelectric
1.1.3.3 Air Cycle Turbine/Compressor

1.2 FOOD PREPARATION

1.2.1 Food Rehydration

1.2.2 Food Warming

1.2.2.1 Heating Trays (Skylab)
1.2.2.2 Oven - Hot Air Convention (Electric Heat)
1.2.2.3 Oven - Microwave

1.3 GALLEY CLEANUP

1.3.1 Dishwasher/Dryer Combination

1.3.1.1 Hot Water Spray - Centrifuge Drying
1.3.1.2 Hot Water Spray - Air Spray Dry
1.3.1.3 Hot Water Spray Wash - Force Hot Air Electric Heat Dry
1.3.1.4 Hot Water Spray Wash - Forced Cold Air Desiccant
1.3.1.5 Hot Water Spray Wash - Forced Hot Air Dry - Thermal Storage
1.3.1.6 Ultrasonic Wash - Centrifuge Drying
1.3.1.7 Ultrasonic Wash - Forced Hot Air Electric Dry
1.3.1.8 Ultrasonic Wash - Force Cold Dry Air - Desiccant, Electrically Desorbed
1.3.1.9 Ultrasonic Wash - Force Hot Air Dry - Thermal Storage
1.3.1.10 Manual Wash - Manual Wipe Dry

1.3.2 Dishwasher/Dryer with Dishes

1.3.2.1 Hot Water Spray - Centrifuge Drying
1.3.2.2 Hot Water Spray - Forced Hot Air Electric Heat Drying
1.3.2.3 Hot Water Spray - Forced Air/Desiccant/ Electrically Heated
1.3.2.4 Manual Wash - Manual Wipe
1.3.2.5 Disposable Cups - Reusable Metallic Utensils and Dishes
1.3.2.6 Disposable Cups and Nonmetallic Dishes - Reusable Metallic Utensils
1.3.2.7 Disposable Cups and Nonmetallic Utensils - Reusable Metallic Dishes
1.3.2.8 Disposable Cups and Nonmetallic Utensils and Dishes
1.3.2.9 Reusable Cups and Metallic Utensils and Dishes
1.3.2.10 Reusable Cups and Metallic Utensils - Disposable Nonmetallic Dishes
1.3.2.11 Reusable Cups and Metallic Dishes - Disposable Nonmetallic Utensils
1.3.2.12 Reusable Cups-Disposable Nonmetallic Utensils and Dishes

2.0 PERSONAL HYGIENE

2.1 WASTE COLLECTION/TRANSFER

2.1.1 Fecal Collection/Transfer

Figure B1-2. Crew Habitability and Appliance Functions and Concepts

2.1.1.1 Dry John
2.1.1.2 Dry John - Anal Wash
2.1.1.3 Germicide - Wet John
2.1.1.4 Integrated Vacuum Decomposition
2.1.1.5 Flush Flow O_2 Incineration
2.1.1.6 Pyrolysis/Batch Incineration
2.1.1.7 Wet Oxidation
2.1.1.8 Semiautomatic Bag System (Skylab)
2.1.1.9 Dry Bags (Apollo)

2.1.2 <u>Urine Collection/Transfer</u>

2.1.2.1 Standup Urinal
2.1.2.2 Commode Urinal
2.1.2.3 Intimate Male Adapter Urine (Skylab)
2.1.2.4 Aperture Urinal
2.1.2.5 Liquid/Gas Flow Cuff Type (Apollo)

2.1.3 <u>Vomitus Collection/Transfer</u>

2.1.3.1 Disposable Intimate Personal Adapter (Mates with Commode)
2.1.3.2 Reusable Intimate Personal Adapter, Lined (Mates with Commode)
2.1.3.3 Disposable Portable Collector
2.1.3.4 Reusable Portable Collector

2.2 BODY CLEANSING

2.2.1 <u>Whole Body Shower</u>

2.2.1.1 Vacuum Pickup
2.2.1.2 Air Drag (Evaporative)
2.2.1.3 Mechanical (Towel Pickup)
2.2.1.4 Collapsible

2.2.2 <u>Partial Body Washing</u>

2.2.2.1 Disposable Wet Wipes
2.2.2.2 Reusable Wet Wipes
2.2.2.3 Disposable Wipes (Prepackaged)
2.2.2.4 Automatic Sponge
2.2.2.5 Reusable Washcloths
2.2.2.6 Disposable Washcloths (Skylab)

2.2.3 <u>Partial Body Drying</u>

2.2.3.1 Reusable Dry Wipes
2.2.3.2 Disposable Dry Wipes
2.2.3.3 Electric Dryer

2.3 PERSONAL GROOMING

2.3.1 <u>Shaving</u>

2.3.1.1 Wet Shave - Safety Razor and Cream
2.3.1.2 Dry Shave - Electric Razor/Vacuum Collection
2.3.1.3 Dry Shave - Windup Razor (Skylab)
2.3.1.4 Dry Shave - Vacuum Motor-Driven Razor
2.3.1.5 Wet Shave - Safety Razor/Vacuum Collection

2.3.2 <u>Hair Cutting</u>

2.3.2.1 Electric Clipper/Vacuum Collection
2.3.2.2 Razor-Comb/Vacuum Collection

2.3.3 <u>Nail Care</u>

2.3.3.1 Manual Nail Clipper/Bag Collection
2.3.3.2 Metal Nail File/Vacuum Collection

2.3.4 <u>Dental</u>

2.3.4.1 Toothbrush with Dentifrice
2.3.4.2 Water Pix
2.3.4.3 Electric Toothbrush with Dentifrice

3.0 <u>HOUSEKEEPING</u>

3.1 EQUIPMENT CLEANING

3.1.1 <u>Surface Wiping</u>

3.1.1.1 Disposable Wet/Dry Wipes

Figure B1-2. Crew Habitability and Appliance Functions and Concepts (continued)

3.1.1.2 Reusable Wet/Disposable Dry Wipes
3.1.1.3 Disposable Wet/Dry Wipes (Prepackaged)
3.1.1.4 Automatic Mop
3.1.1.5 Reusable Cleaning Cloths/ Disposable Dry Wipes
3.1.1.6 Disposable Cleaning Cloths/Disposable Dry Wipes
3.1.1.7 Disposable Wet Wipes/Reusable Dry Wipes
3.1.1.8 Reusable Wet/Dry Wipes
3.1.1.9 Reusable Cleaning Cloths/Dry Wipes
3.1.1.10 Disposable Cleaning Cloths/Reusable Dry Wipes
3.1.1.11 Sponges
3.1.1.12 Sponges/Skylab Wetting Unit

3.2 REFUSE MANAGEMENT

3.2.1 <u>Manual Collection</u>

3.2.1.1 Waste/Trash Bags
3.2.1.2 Waste Receptacles/Reusable
3.2.1.3 Waste Receptacles/Disposable

3.2.2 <u>Vacuum Collection</u>

3.2.2.1 Portable Vacuum/Electric (Skylab)
3.2.2.2 Portable Vacuum/Electric (Commercial)
3.2.2.3 Portable Vacuum/Space Venting

3.2.3 <u>Refuse Transfer</u>

3.2.4 <u>Refuse Processing</u>

3.2.4.1 Compactor
3.2.4.2 Shredder
3.2.4.3 Incinerator
3.2.4.4 Integrated Vacuum Decomposition
3.2.4.5 Flush Flow O_2 Incineration
3.2.4.6 Pyrolysis/Batch Incineration
3.2.4.7 Wet Oxidation

3.2.5 <u>Refuse Disposal/Storage</u>

3.2.5.1 Vacuum Storage
3.2.5.2 Storage Bin/Container
3.2.5.3 Restorage/Biological Stabilized
3.2.5.4 Trash Rocket

3.3 GARMENT/LINEN MAINTENANCE

3.3.1 <u>Garment/Linen Washing</u>

3.3.1.1 Mechanical Oscillations
3.3.1.2 Fluidic Agitation
3.3.1.3 Piston Agitation
3.3.1.4 Cyclic Valve and Pump
3.3.1.5 Diaphragm Actuated - One Directional Squeeze
3.3.1.6 Diaphragm Actuated - Two Directional Squeeze
3.3.1.7 Water Spray Agitated
3.3.1.8 Ultrasonic
3.3.1.9 Manual Washboard
3.3.1.10 Plain Recirculation

3.3.2 <u>Garment/Linen/Drying</u>

3.3.2.1 Forced Hot Air - Electric
3.3.2.2 Forced Hot Air - Heat from Thermal Storage Unit
3.3.2.3 Force Cold Dry Air - Desiccant - Vacuum Regenerable
3.3.2.4 Force Cold Dry Air - Desiccant - Heat Regenerable
3.3.2.5 Vacuum Dry
3.3.2.6 Thermal Vacuum Dry - Electric Heat
3.3.2.7 Thermal Vacuum Dry - Thermal Storage/ Radiant Heat
3.3.2.8 Clothesline - Forced Convection
3.3.2.9 Clothesline - Forced Convection plus Electric Heat

3.3.3 <u>Garment/Linen Washer/Dryer-Disposable Clothes</u>

3.3.3.1 Fluidic Agitation/Forced Hot Air - Electric Heater

Figure B1-2. Crew Habitability and Appliance Functions and Concepts (continued)

3.3.3.2 Fluidic Agitation/Forced Hot Air - Thermal Storage Heated
3.3.3.3 Fluidic Agitation/Forced Air Drying - Clothesline
3.3.3.4 Fluidic Agitation/Forced Air Drying - Clothesline
3.3.3.5 Water Spray Agitation/Forced Hot Air - Electric Heater
3.3.3.6 Water Spray Agitation/Forced Hot Air - Thermal Storage Heater
3.3.3.7 Water Spray Agitation/Forced Air Drying - Clothesline
3.3.3.8 Water Spray Agitation/Electrically Heated - Clothesline
3.3.3.9 Disposable Clothes

3.4 WASH WATER PROCESSING

4.0 <u>OFF-DUTY ACTIVITIES</u>

4.1 ENTERTAINMENT

4.1.1 <u>Music</u>

4.1.1.1 Cassette Player/Recorder

4.1.2 <u>Library</u>

4.1.2.1 Books

4.1.3 <u>Television</u>

4.1.4 <u>Games</u>

4.1.4.1 Handball
4.1.4.2 Dart Board
4.1.4.3 Cards

4.2 PHYSICAL CONDITIONING

4.2.1 <u>Exer-gym</u>

4.2.2 <u>Hand Exerciser</u>

5.0 <u>MEDICAL</u>

5.1 STERILIZATION

5.1.1 <u>Autoclaves</u>

5.1.1.1 Moist Heat
5.1.1.2 Dry Heat
5.1.1.3 Ethylene Oxide

5.2 PHYSICAL MONITORING

5.2.1 <u>Ergometer</u>

Figure B1-2. Crew Habitability and Appliance Functions and Concepts (concluded)

SHUTTLE MISSION BASELINE

- o 150,000 POUND ORBITER
- o BASELINE MISSION
  - 42 MAN-DAYS (3-6 MALE/FEMALE CREW FOR 7 DAYS)
  - 4 MAN NOMINAL MISSION
- o VEHICLE SYSTEM CAPABILITY
  - 42 MAN-DAYS + 96-HOUR CONTINGENCY FOR UP TO 10 CREWMEN (40 MAN-DAYS)

SHUTTLE IMPOSED REQUIREMENTS ON THE APPLIANCE SYSTEM

- o ALL MISSIONS WILL USE SAME HABITABILITY FUNCTIONS
- o GRAVITY - ZERO TO ONE EARTH GRAVITY
- o ATMOSPHERE
  - PRESSURE — 14.7 PSIA
  - COMPOSITION — 3.2 PSIA O_2; 11.5 PSIA N_2
  - CO_2 CONCENTRATION — 0-7.6 mm Hg
- o TEMPERATURE
  - RANGE (DRY BULK) — 65°-80° F
    - 4 MEN (DESIGN PT.) — 70° F
    - 10 MEN (DESIGN PT.) — 80° F
  - DEWPOINT — 39°-61° F
- o OPERATIONAL LIFE
  - 10 YEARS/100 ORBITAL MISSIONS/REPLACEABLE UNIT CONCEPT
- o GENERAL
  - GAS VENTING ALLOWED/NONPROPULSIVE
  - LIQUID VENTING SHALL BE MINIMIZED/NONPROPULSIVE
  - JETTISON OF SOLIDS/SOLID WASTES SHALL NOT BE ALLOWED.
  - NO MEDICAL SAMPLING REQUIRED OF FECES/URINE

SHUTTLE TIMELINE

- o NOMINAL CREW TIMELINE (SEE FIGURE B1-4)
  - WORK (INCLUDING OFF-DUTY) - 13 HOURS
  - EAT - 3 HOURS
  - SLEEP - 8 HOURS

REFERENCE MSC 07896, "SPACE SHUTTLE SYSTEM BASELINE REFERENCE MISSIONS-VOLUME II"

Figure B1-3. Shuttle Orbiter Baseline Mission

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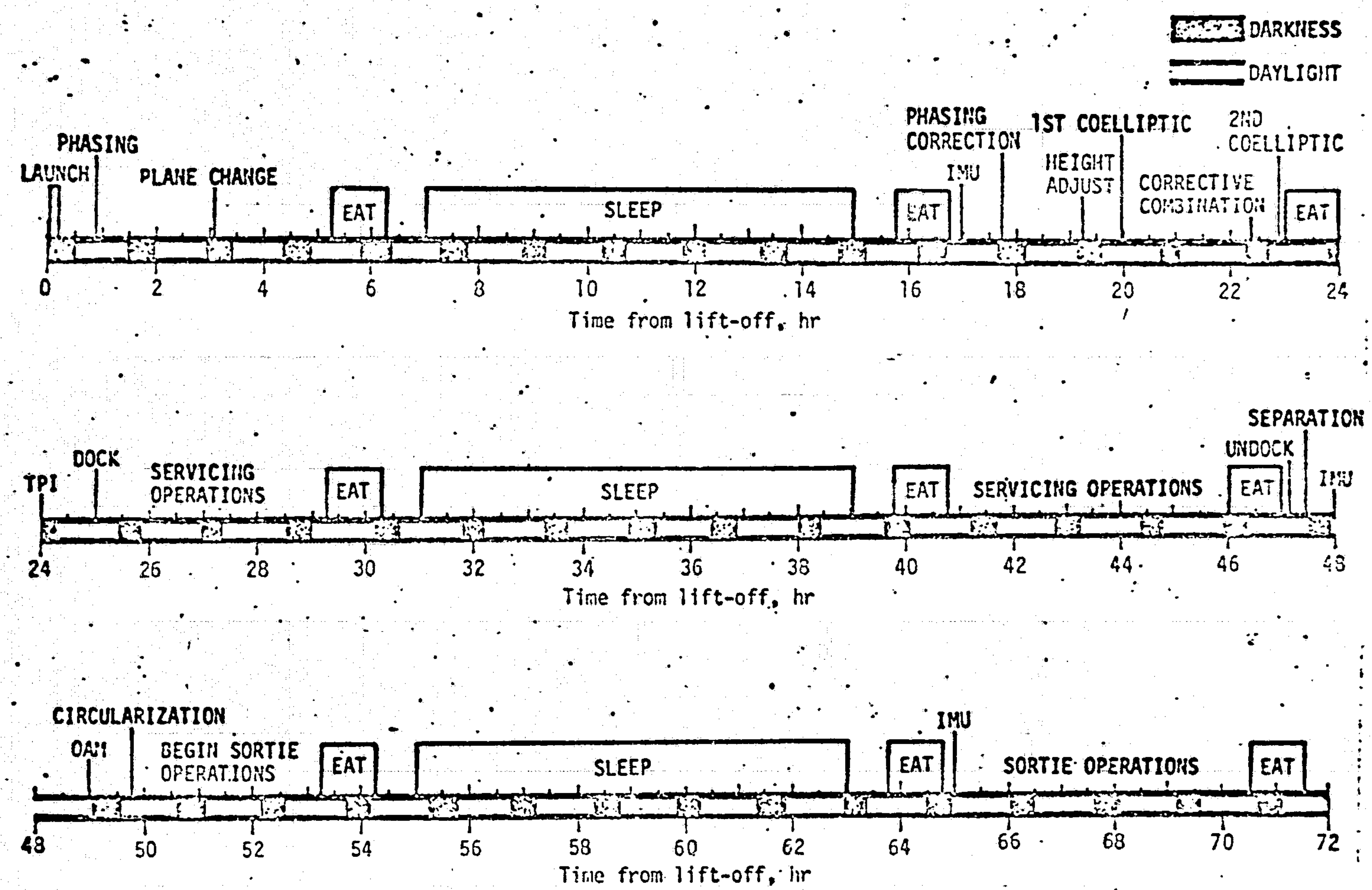


(a) Launch to 72 hours.

Figure B1-4. Shuttle Orbiter Timeline

1.0 (Continued)

Appliance Function Matrix. This table lists the following engineering data used for trading each appliance concept for a given appliance function:

- o Appliance usage time
- o Fluid consumables usage (e.g., amount of air or water lost to space)
- o Fluid interface requirements (type of fluid, flow rate, temperature, pressure)
- o Thermal requirement for maximum heat leak to cabin atmosphere and directly to the coolant circuit
- o Average and peak AC and DC electrical power requirement
- o Appliance total weight/volume penalty
- o Development cost indicator based on state-of-the-art rating and concept complexity

The thermal, electrical, weight, and volume requirements listed in the table represent the total penalties assumed for the appliance and used to trade against alternate concepts. For example, the weight tabulated for reusable washcloths for partial body washing includes an appropriate weight charge for a clothes washer and dryer assumed to clean the cloths. To see the detailed itemized breakdown of each of these penalties, the data worksheets, described later, should be consulted.

Alternate Appliance Concept Rating Plots. In this figure is plotted the rating (based on zero minimum and 100 maximum points) for each appliance concept traded for a particular appliance function. These plots were

1.0 (Continued)

generated by the TRADE computer program described in the concept report. Higher ratings indicate a more favorable concept based on the penalties considered and the weighting factors assumed. A curve is given for each appliance function.

Appliance Concept Selection Matrix. Four tables are included here giving the results of the computer trade and sensitivity analysis. These tables include the following:

- Selection matrix for a 20.5-day mission. This lists the weight, power, volume, etc. rating and the summed total points for each of the concepts. The total points are adjusted proportionally to a scale of zero to 100 maximum points to yield the final comparative rating for each concept.

- Sensitivity analysis for a 20.5-day mission. This table lists the comparative rating for each appliance concept assuming the weighting factor for each trade parameter (e.g., weight, power, volume, etc.) is increased or decreased individually by 50 percent while holding all other weighting factors constant. Thus, the sensitivity of the above trade to any single weighting factor may be seen.

Component Reliability/Maintenance/Safety List. This table itemizes the types and number of components used for each appliance concept and the number of items considered to be safety critical. Each component is numbered to identify it in the component reliability list given in

1.0 (Continued)

Table B1-1. This list itemizes the reliability data used for each component in the computer selection trades.

Appliance Concept Description. Each concept is described verbally and a drawing presented where available.

Appliance Concept Data Worksheets. Two data sheets are included here which itemize the weight, volume, power, thermal, and consumables penalties associated with each appliance concept.

TABLE B1-1

COMPONENT FAILURE RATE AND REPAIR TIMES

COMPONENT NUMBER	COMPONENT DESCRIPTION	REFERENCE NUMBER	FAILURE RATE (λx10^{-6}) FAILURES/ MILLION HOURS	REFERENCE NUMBER	REPAIR TIMES (MTTR) HRS/REPAIR
1	MOTOR	252	3.8	-	0.5+.2=.7
2	PUMP	100	6.0	254	0.2+.25=.45
3	SOLENOID VALVE	100	0.72	254	0.1+.2=.3
4	ACCUMULATOR	100	0.01	-	0.5+.2=.7
5	ACCUMULATOR/ BLADDER	251	1.77	-	0.5+.4=.9
6	WATER SEPARATOR	100	1.20	254	0.2+.2=.4
7	TRANSMISSION	251	1.50	-	0.5+.1=.6
8	FLUIDIC SWITCH	251	1.61	-	1.0+.1=1.1
9	FILTER	251	0.16	-	0.1+.2=.3
10	ELECTRIC SWITCH	252	5.74	-	0.2+.1=.3
11	PRESSURE REGULATOR	100	2.94	254	0.1+.1=.2
12	VALVE (GN_2)	100	0.72	254	0.1+.2=.3
13	CONTROLLER	251	2.5	254	0.1+.3=.4
14	HIGH FREQUENCY CONTROLLER	-	UNK	-	UNK
15	ELECTROACOUSTIC TRANSDUCER	252	86.2	254	0.1+.2=.3
16	HEAT EXCHANGER	251	0.23	254	0.2+.5=.7
17	HEATER-DC	251	1.0	-	0.2+.1=.3
18	BLOWER-AIR	251	10.89	254	0.2+.1=.3
19	CONTROLLER/ TIMER	251	2.5	254	0.1+.3=.4
20	THERMAL STORAGE UNIT (WAX)	251	0.23	-	0.2+.5=.7
21	DESICCANT CANISTER	251	0.21	-	0.2+.5=.7
22	CHECK VALVE	251	0.312	-	0.1+.2=.3
23	MANUAL VALVE	251	0.776	-	0.1+.2=.3
24	TEMPERATURE CONTROL VALVE	251	7.183	-	0.1+.2=.3
25	RELIEF VALVE	251	0.312	-	0.1+.2=.3
26	RF GENERATOR (MAGNETON TUBE)		UNK		UNK
27	ACTUATOR	252	.024		0.2+.5=.7
28	PRESSURE SWITCH	251	3.57	-	0.1+.2=.3

SECTION 2

TECHNICAL DATA

HABITABILITY SUBSYSTEM 1.0 Food Management

APPLIANCE FUNCTIONS CONSIDERED

1.1.1 Ambient Storage
1.1.2 Refrigerated Storage
1.1.3 Frozen Storage
1.2.2 Food Warming
1.3.1 Dishwasher/Dryer Combination
1.3.2 Dishwasher/Dryer w/Dishes

DESCRIPTION

The food management subsystem supplies all of the necessary functions for the storage and preparation of foods as well as the equipment required for the galley cleanup. Disposable dishes and utensils were considered as alternates to cleanup equipment. The three types of food storage were identified as ambient (dry or liquid), refrigerated, and frozen. The requirements for the food mix between these three categories are discussed later in this description.

Food preparation functions include rehydration of dry food and warming of frozen food. No considerations were made for the preparation of food mixes or cooking of food.

The cleanup equipment necessary to provide clean dishes and eating utensils for each crewmember for each meal was determined by first identifying the best mechanical cleaning systems and then comparing them against disposable dishes and utensils.

A large variety of spacecraft foods are available for crew consumption. These are typically divided into two major categories: wet (more than 5% moisture content) and dry (less than 5% moisture content). The dry food is considered to be shelf stable at ambient temperatures. The wet food is divided into three categories: (1) shelf stable at ambient temperature, (2) refrigerated, and (3) frozen. Obviously, a large variation in food mix could be chosen from these basic types. The Apollo wet/dry food mix was 20/80. For Skylab, it was 30/70. The crew requirement for drinking water from the potable water system will vary depending on the amount of water in the food mix. Also, the vehicle weight/volume/power penalty will depend on the type of food storage used--ambient, refrigerated, and frozen. To do a detailed optimization of the food system was beyond the scope of this study. Many of the decisions regarding food types depend on crew preference and psychological factors rather than strict weight/volume/power penalties. Consequently, it was decided to perform all the trades of food storage appliances based on the food mix used for Skylab. The weight and volume of frozen, refrigerated, and ambient storage food for Skylab is given in Table B2-1.

HABITABILITY SUBSYSTEM 1.0 Food Management (Continued)

TABLE B2-1

PLANNED SKYLAB FOOD WEIGHT AND VOLUME (INCLUDING PACKAGING AND RESTRAINT) FOR 420 MAN-DAYS

Food Type	Total Food Size: Weight kg (lb)	Total Food Size: Volume cum (cu ft)	Number of Units	Food Size Per Unit: Weight kg (lb)	Food Size Per Unit: Volume cum (cu ft)
Frozen	121 (266)	0.299 (10.56)	5	24.1 (53.2)	0.0598 (2.11)
Refrigerated	24.1 (53.2)	0.0598 (2.11)	1	24.1 (53.2)	0.0598 (2.11)
Ambient Storage	955. (2106.)	2.60 (91.7)	11	87 (192.)	0.236 (8.34)

These are the initial launch values for a planned 420 man-days. These values were multiplied by 82/420 to adjust for the 82 man-days for Shuttle assumed in this study. (Note that no contingency is accounted for in this ratio since the Skylab food weights already include the actual contingency used for the Skylab mission.) The resulting size required for Shuttle food storage is shown in Table B2-2.

TABLE B2-2

REQUIRED SHUTTLE FOOD WEIGHT AND VOLUME (INCLUDING PACKAGING AND RESTRAINT) FOR 82 MAN-DAYS

Food Type	Total Food Size: Weight kg (lb)	Total Food Size: Volume cu m (cu ft)	Number of Shuttle Units Required	Actual Number of Units Assumed	Assumed Food Size per Unit: Weight kg (lb)	Assumed Food Size per Unit: Volume cu m (cu ft)
Frozen	23.6 (52.0)	0.0583 (2.06)	0.976	1	23.6 (52.0)	0.0583 (2.06)
Refrigerated	4.72 (10.4)	0.0116 (0.41)	0.195	1	4.72 (10.4)	0.0116 (0.41)
Ambient Storage	186. (411.)	0.507 (17.9)	2.15	2	93.2 (205.5)	0.253 (8.95)

A number of different refrigeration systems were found discussed in the literature reviewed, including dry ice, water sublimation, cryogenic storage, precooled heat sink, vapor compression, space radiator, thermoelectric, and air-cycle turbine/compressor. These concepts were all reviewed for missions of 84 to 2250 man-days, and only two (space radiator and thermoelectric) were found to be practical for space missions. Consequently, only the space radiator and thermoelectric concepts were examined in this study; and also, the air-cycle turbine/compressor was included for comparison since it represents a typical commercial aircraft system. Other types of refrigeration systems are available, such as Stirling and Brayton cycles. However, no information was found on application of these to spacecraft food chillers, so they were not included in the study.

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.1 Food Storage

APPLIANCE FUNCTION 1.1.1 Ambient Food Storage

NUMBER OF CONCEPTS CONSIDERED 2

ASSUMPTIONS

The ambient food storage capacity assumed in this study was as follows (see food management description):

Number of units		2
Individual unit packaged food weight	93.2 kg	205.5 lbs
Individual unit packaged food volume	0.253 cu m	8.95 cu ft
Total packaged food weight	186.4 kg	411. lbs
Total packaged food volume	0.507 cu m	17.9 cu ft

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.1.1 .... AMBIENT FOOD STORAGE (SHUTTLE)

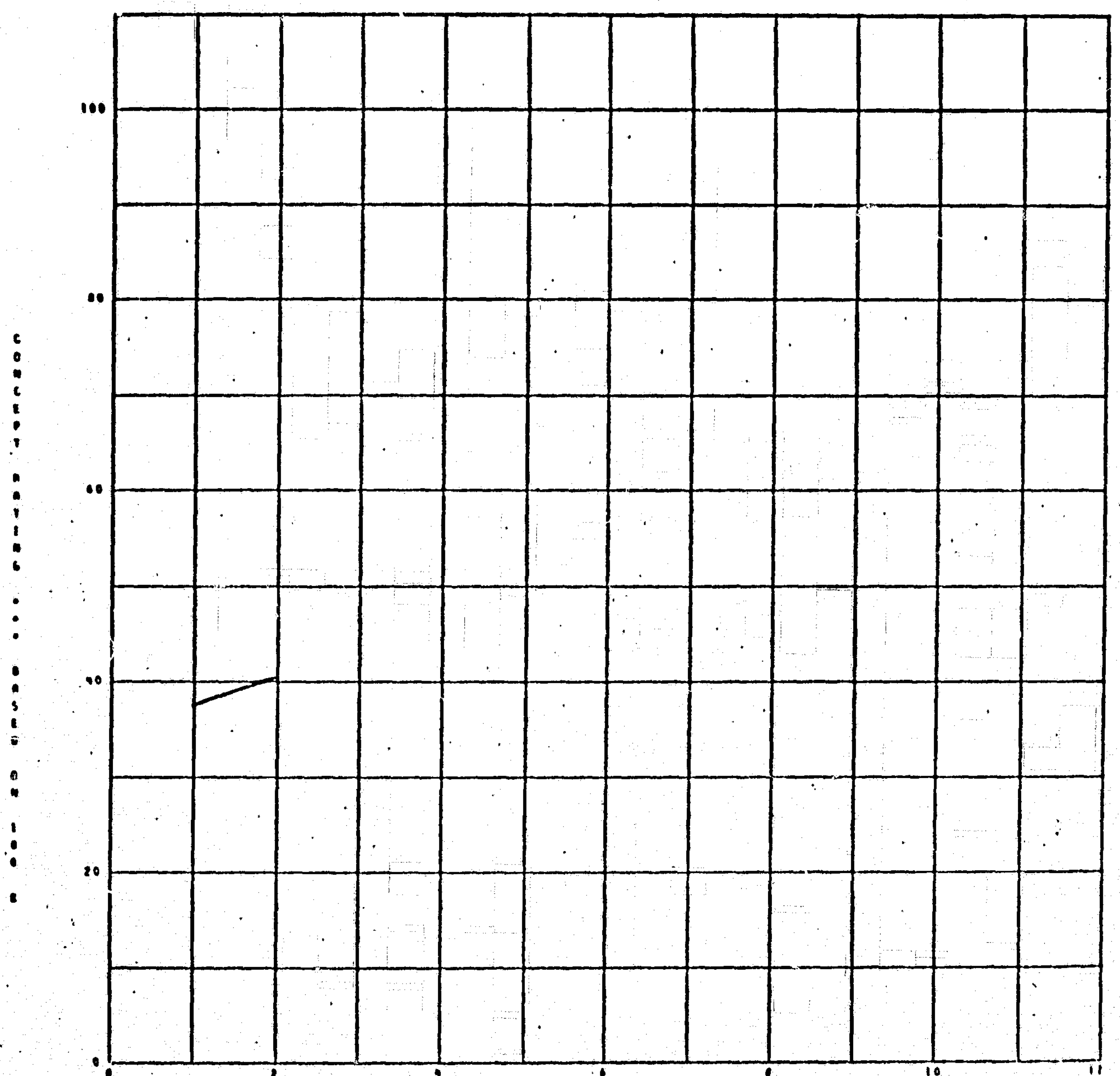
CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	.000 .000						0. (0.)	0. (0.)	.0 .0	.0 .0	7.1 (15.6)	.79 (27.90)	1	0	.0 (.0)
2	.000 .000						0. (0.)	0. (0.)	.0 .0	.0 .0	.0 (1.6)	.00 (20.30)	1	10	.0 (.0)

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	RIGID
2 -	FLEXIBLE

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 =	RIGID
2 =	FLEXIBLE



CONCEPT NUMBER

Ambient Food Storage (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 0
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300

SELECTION MATRIX . . . . . AMBIENT FOOD STORAGE (SHUTTLE)
(12/15/74)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	CONCEPT 2
WEIGHT	1.6000	15.600	15	.00	13.46
VOLUME	20.300	27.900	10	.00	2.72
DEV COST	.00000	10.000	15	15.00	.00
TOTAL PT	.00000	40.000	40	15.00	16.19
RATING	.00000	100.00	100	37.50	40.46

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	CONCEPT 2
NORMAL	37.50	40.46
WEIGHT	31.58	48.24
VOLUME	33.33	38.99
DEV COST	47.37	34.07

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	CONCEPT 2
NORMAL	37.50	40.46
WEIGHT	46.15	29.09
VOLUME	42.86	42.35
DEV COST	23.08	49.80

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.1.1-AMBIENT FOOD STORAGE

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS																NUMBER OF SAFETY CRITICAL ITEMS
NO.																	
	NO MECHANICAL/ELECTRICAL COMPONENTS																

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

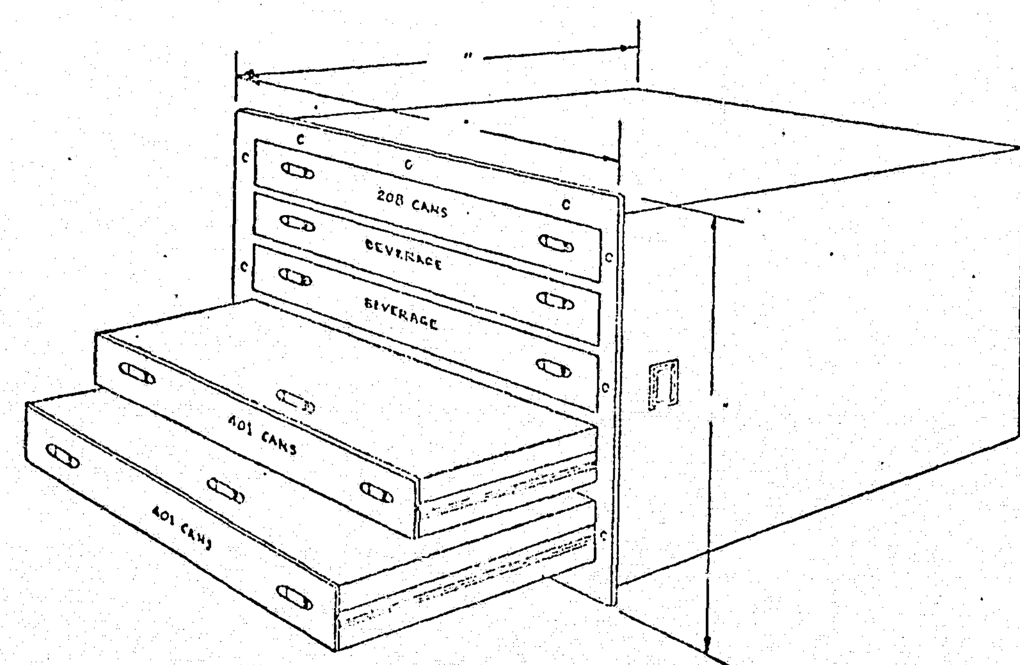
APPLIANCE FUNCTION Ambient Food Storage

APPLIANCE CONCEPT NO./TITLE 1/Rigid Container

INDEX NO. 1.1.1.1 REF. NO. 177

DESCRIPTION

In this concept, ambient food is contained in a rigid box-like container with shelves to retain the food. A structural weight of 26.3 kg per kg of food capacity was used from Reference 177. Volume was estimated on the basis of each individual storage locker being cubical in shape with 5.08 cm (2.0 inch) effective wall thickness on all sides.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/ Rigid container

INDEX NUMBER 1.1.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	AC POWER (3) AVERAGE (WATTS)	AC POWER (4) DEMAND (WATT-HR/CYCLE) (1)X(3)	DC POWER (5) PEAK (WATTS)	DC POWER (6) AVERAGE (WATTS)	DC POWER (7) DEMAND (WATT-HR/CYCLE) (1)X(7)
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1 / Rigid Container INDEX NUMBER 1.1.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Total storage module-empty (177)	15.6	27.9
TOTAL	7.08 (15.6) KG (LBS)	0.790 (27.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB)   Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______   Σ④ ______

TOTAL WT. MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Ambient Food Storage

APPLIANCE CONCEPT NO./TITLE 2/Flexible Container

INDEX NO. 1.1.1.2 REF. NO. 177

DESCRIPTION

In this concept, an elastic netting material is used to retain the ambient food within retractable guides. Structural weight is assumed, according to Reference 177, to be 10 percent of the weight for the rigid concept. Volume was estimated on the basis of each individual storage locker being cubical in shape with 1.27 cm (0.5 inch) effective wall thickness on all sides.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2./ Flexible container INDEX NUMBER 1.1.1.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A.C. POWER ② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	D.C. POWER ⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/Flexible Container

INDEX NUMBER 1.1.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Total storage module - empty (177)	1.6	20.3
TOTAL	0.726 (1.6) KG (LBS)	0.575 (20.3) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Σ①			Σ④	

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.1 Storage

APPLIANCE FUNCTION 1.1.2 Refrigerated Storage

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

The Shuttle refrigeration capacity assumed in this study was as follows (see food management description):

Number of units			1
Individual unit packaged food weight	4.71	kg	(10.4 lbs)
Individual unit packaged food volume	0.0116	cu m	(0.41 cu ft)
Total packaged food weight	4.71	kg	(10.4 lbs)
Total packaged food volume	0.0116	cu m	(0.41 cu ft)

Refrigerator box insulation thickness was assumed to be 10.16 cm (4.0 in) for all concepts.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.1.2 .... REFRIGERATED FOOD STORAGE (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	.000	8	.0000	.00	.0	4.4	9.	41.	50.0	.0	8.9	.04	1	0	.0
	.000		(.0000)	(.00)	(.0)	(40.0)	(30.)	(141.)	.0	.0	(19.6)	(1.44)			(.0)
2	.000						68.	14.	.0	.0	14.1	.10	2	25	.0
	.000						(233.)	(48.)	100.0	.0	(31.0)	(3.40)			(.0)
3	.000						373.	1060.	10200.0	.0	72.6	1.19	3	70	.0
	.000						(1274.)	(3620.)	.0	.0	(160.0)	(42.00)			(.0)

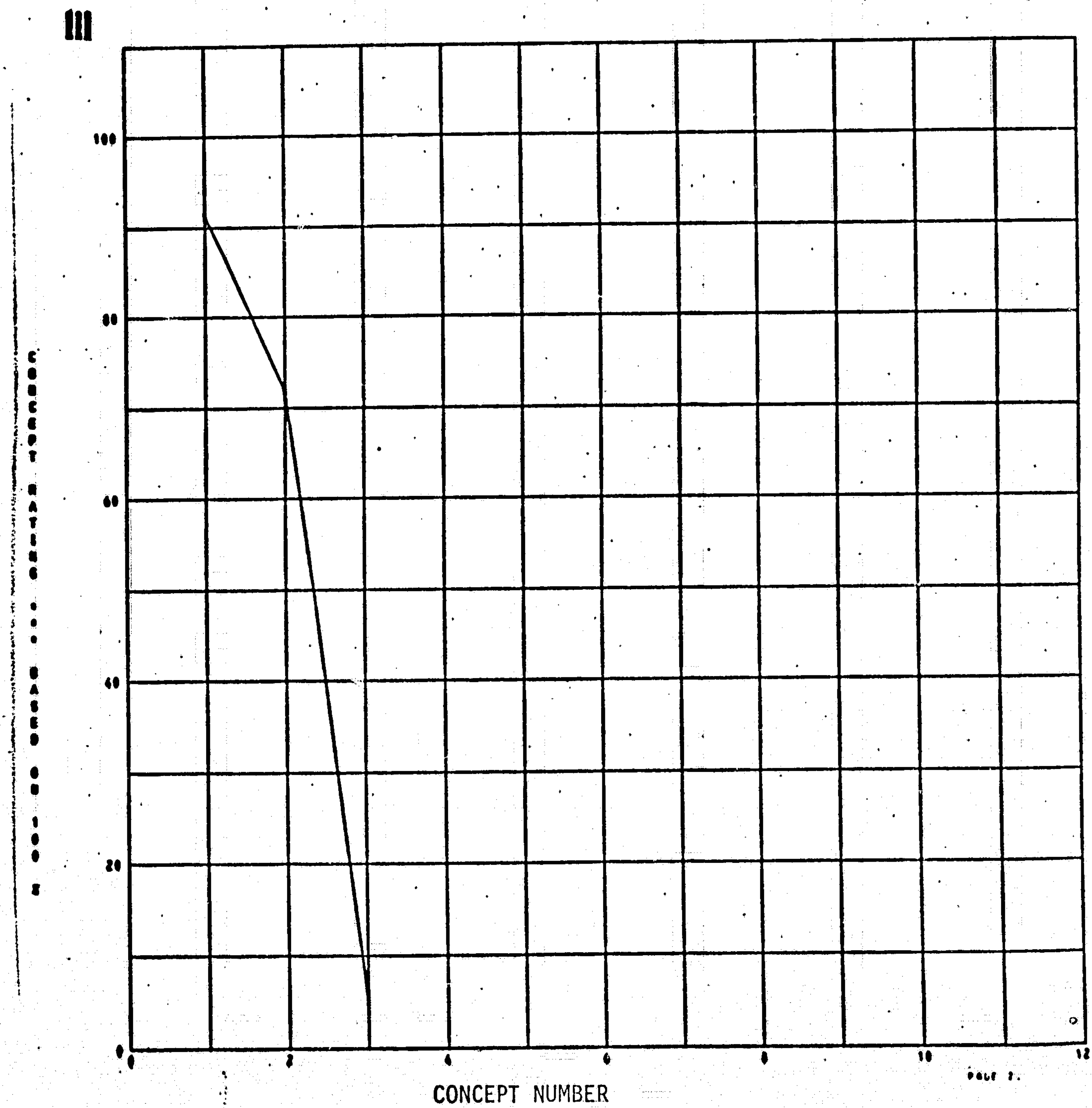
APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	SPACE RADIATOR
2 -	THERMOELECTRIC
3 -	AIR CYCLE-TURBINE/COMPRESSOR

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST), KG/HR (LB/HR)
3 - OXYGEN (LOST), KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST), KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED), KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED), KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

ok

APPLIANCE CONCEPT NO.		CONCEPT NAME
1	-	SPACE RADIATOR
2	-	THERMOELECTRIC
3	-	AIR CYCLE-TURBINE/COMPRESSOR



Refrigerated Food Storage (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 0
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • REFRIGERATED FOOD STORAGE (SHUTTLE)
(01/14/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3
WEIGHT	19.600	160.00	15	13.16	12.09	.00
POWER	26.500	5406.0	15	14.93	14.88	.00
VOLUME	1.4400	42.000	10	9.66	9.19	.00
THERMAL	8.4650	230.95	15	14.45	14.45	.00
RELIAB-Y	.98379	.99304	5	2.85	.20	.00
MAINTENC	.99998	.99999	5	2.65	.76	.00
SAFETY	.00000	1.0000	5	5.00	.00	5.00
DEV. COST	.00000	70.000	15	15.00	9.64	.00
TOTAL PT	.00000	85.000	85	77.70	61.22	5.00
RATING	.00000	100.00	100	91.41	72.02	5.88

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	91.41	72.02	5.88
WEIGHT	91.11	72.72	5.41
POWER	92.07	74.22	5.41
VOLUME	91.70	73.12	5.56
THERMAL	91.81	73.99	5.41
RELIAB-Y	90.43	70.07	5.71
MAINTENC	90.31	70.39	5.71
SAFETY	91.66	69.96	8.57
DEV COST	92.11	71.39	5.41

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	91.41	72.02	5.88
WEIGHT	91.76	71.19	6.45
POWER	90.63	69.39	6.45
VOLUME	91.09	70.78	6.25
THERMAL	90.93	69.66	6.45
RELIAB-Y	92.45	74.08	6.06
MAINTENC	92.57	73.74	6.06
SAFETY	91.15	74.20	3.03
DEV COST	90.58	72.77	6.45

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.1.2-REFRIGERATORS

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS																NUMBER OF SAFETY CRITICAL ITEMS
	MOTOR	PUMP	SOLENOID VALVE	HEAT EXCHANGER	CONTROLLER	BLOWER											
NO.	1	2	3	16	13	18											
SPACE RADIATOR	1	1	2	2	1	-											0
THERMOELECTRIC	2	-	-	-	1	2											1
AIR CYCLE TURBINE/COMPRESSOR	2	2	-	1	1	1											0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Refrigerated Storage

APPLIANCE CONCEPT NO./TITLE 1/Space Radiator

INDEX NO. 1.1.2.1 REF. NO. 184, 255

DESCRIPTION

This concept is simply an insulated food storage box, with coolant from the spacecraft ECS radiators routed through tubing within the refrigerator walls. This concept was used for the Skylab refrigerator, which had the following size:

	WEIGHT		VOLUME	
	kg	lb	cu m	cu ft
Food capacity (packaged and restrained)	24.1	53.2	0.0598	2.11
Total refrigerator (empty)	45.8	101	0.210	7.41

The Shuttle refrigerator was sized proportional to the above Skylab data based on the refrigerator food capacity. The wall insulation was 10.16 cm (4.0 in) thick. It was assumed that the radiator coolant would be of sufficiently low temperature for this concept to be feasible.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Space radiator refrigerator (Ref # 184 p4.1-4.5) INDEX NUMBER 1.1.2.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Controls, valves, sensors, illumination		50					
		50 MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	0	-30	30
Electrical	0	171	171	0
TOTAL	0 WATT (BTU/HR)	(171) WATT (BTU/HR)	(141) WATT (BTU/HR)	(30) WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Space radiator refrigerator INDEX NUMBER 1.1.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Refrigerator (total)	19.6	1.44
TOTAL	(19.6) KG (LBS)	(1.44) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ① ______ Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

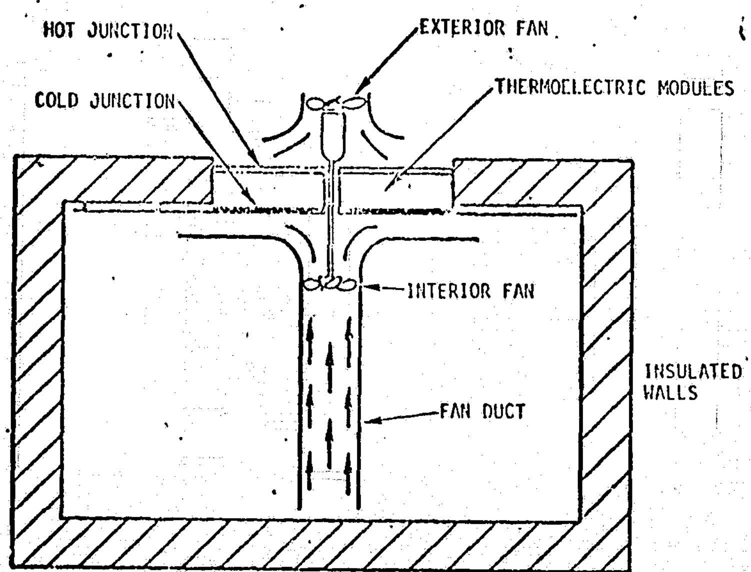
HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Refrigerated Storage

APPLIANCE CONCEPT NO./TITLE 2/Thermoelectric

INDEX NO. 1.1.3.2 REF. NO. 184, 177

DESCRIPTION: In this concept, the refrigerator has a self-contained cooling unit operating on the thermoelectric principle. Direct electrical current is passed through staged semi-conductor junctions arranged such that heat is removed at one set of junctions (providing the cooling) and rejected at the other. The freezer engineering data used were taken from Reference 184 and 177, which were obtained from catalogue data for commercial units. The reference weight and volume were given separately for the freezer locker and the thermoelectric devices. To keep the concepts on a common basis, the weight and volume of the locker were assumed equal to the locker for the space radiator concept #1.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Thermoelectric refrigerator INDEX NUMBER 1.1.2.2

(Ref. # 184 p 4.6 - 4.12)

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Thermoelectric devices, fans, illumination					100		
		MAXIMUM		TOTAL	100 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	-30	-30	0
Electrical power	0	311	78	233
TOTAL	0	(281)	(48)	(233)
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Thermoelectric refrigerator INDEX NUMBER 1.1.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Thermoelectric devices	11.4	2.0
Refrigerator locker only	19.6	1.44
TOTAL	(31.0) KG (LBS)	(3.4) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ① ______ Σ④ ______

TOTAL WT. / MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

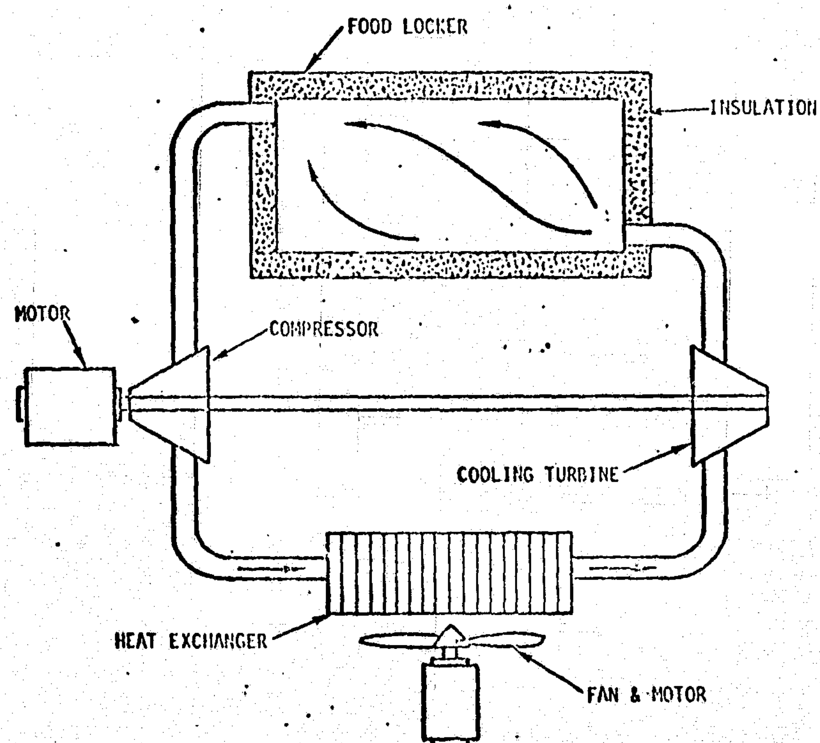
HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Refrigerated Storage

APPLIANCE CONCEPT NO./TITLE 3/Air-cycle turbine/compressor

INDEX NO. 1.1.2.3 REF. NO. 184

DESCRIPTION: In this concept, air is alternately compressed and expanded in a closed refrigeration cycle. This concept was included for comparison since it represents a typical commercial aircraft system. In an aircraft, ram air is used to cool the heated working fluid, whereas in the spacecraft system a motor and fan are used.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Air cycle turbine/compressor refrigerator (Ref. # 184 pp 4.13-4.16, A.34 - A.46)

INDEX NUMBER 1.1.2.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Compressor & fan		10,200					
		10,200 MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	-30	-30	0
Electrical power	0	4924	3650	1274
TOTAL	0 WATT (BTU/HR)	(4894) WATT (BTU/HR)	(3620) WATT (BTU/HR)	(1274) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS. (CONCLUDED)

CONCEPT Air cycle turbine/compressor refrigerator INDEX NUMBER 1.1.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Refrigerator (total)	160	42
TOTAL	(160) KG (LBS)	(42) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Σ①			Σ④	

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.1 Storage

APPLIANCE FUNCTION 1.1.3 Frozen Storage

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

The Shuttle freezer capacity assumed in this study was as follows (see food management description):

Number of Units		1
Individual unit packaged food weight	23.6 kg	52. lbs
Individual unit packaged food volume	.058 cu m	2.06 cu ft
Total packaged food weight	23.6 kg	52. lbs
Total packaged food volume	.058 cu m	2.06 cu ft

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.1.3 **** FROZEN FOOD STORAGE (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	.000	8	.0000	.00	.0	-23.3	55.	-5.	50.0	.0	44.8	.21	1	0	.0
	.000		(.0000)	(.00)	(.0)	(-10.0)	(188.)	(-17.)	.0	.0	(98.7)	(7.25)			(.0)
2	.000						389.	78.	.0	.0	96.2	.39	2	25	.0
	.000						(1327.)	(268.)	570.0	.0	(212.0)	(13.80)			(.0)
3	.000						2328.	1540.	15200.0	.0	328.0	3.82	3	70	.0
	.000						(7950.)	(5260.)	.0	.0	(723.0)	(135.00)			(.0)

APPLIANCE CONCEPT NO. — CONCEPT NAME

1 - SPACE RADIATOR
2 - THERMOELECTRIC
3 - AIR CYCLE-TURBINE/COMPRESSOR

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

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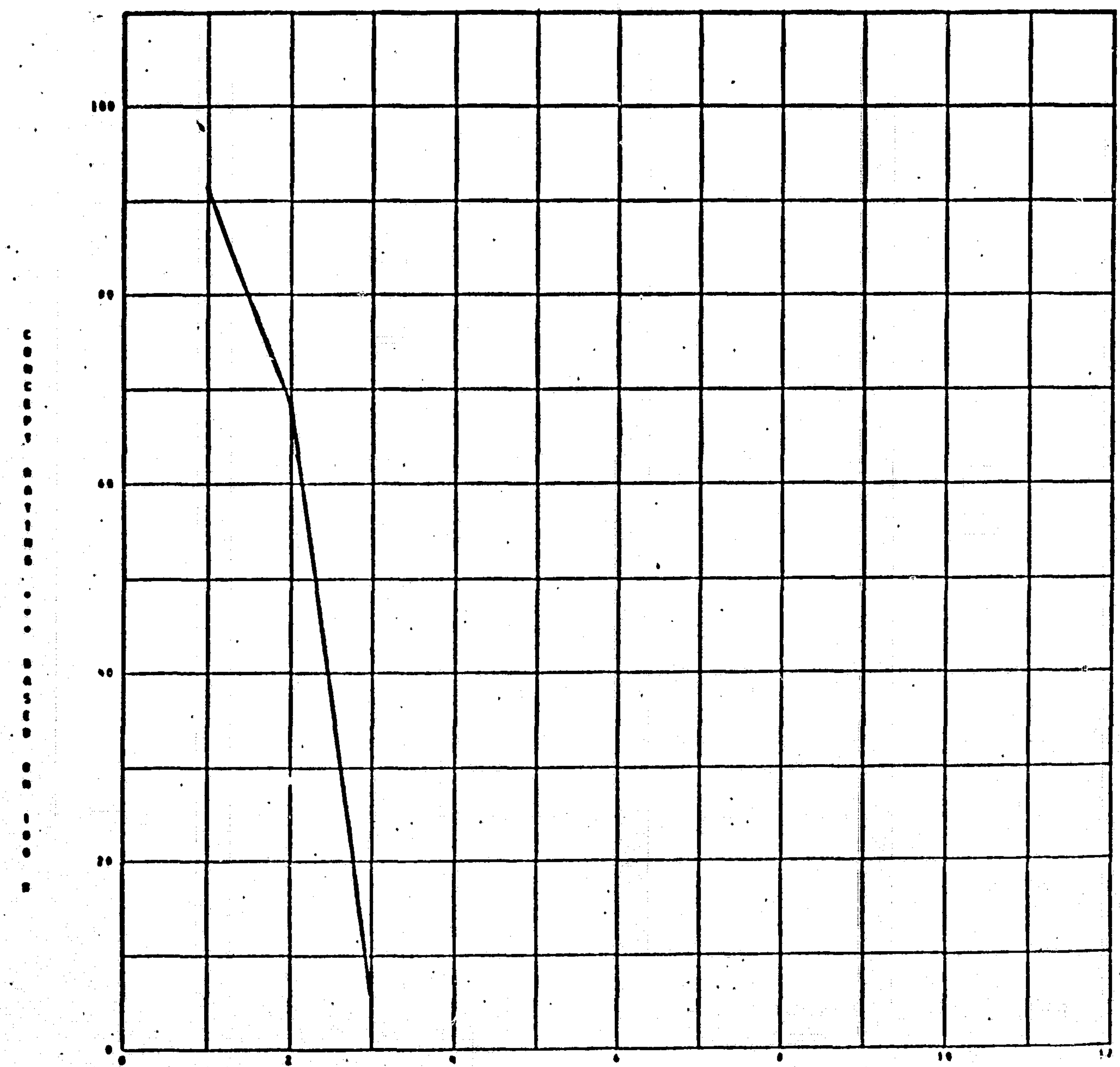
(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	SPACE RADIATOR
2 -	THERMOELECTRIC
3 -	AIR CYCLE-TURBINE/COMPRESSOR



CONCEPT NUMBER

Frozen Food Storage (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 0
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • FROZEN FOOD STORAGE (SHUTTLE)
(12/15/74)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3
WEIGHT	98.700	723.00	15	12.95	10.60	.00
POWER	26.500	8056.0	15	14.95	14.54	.00
VOLUME	7.2500	135.00	10	9.46	8.98	.00
THERMAL	3.7650	488.05	15	14.88	13.53	.00
RELIAB-Y	.98379	.99304	5	2.85	.20	.00
MAINTENC	.99998	.99999	5	2.65	.76	.00
SAFETY	.00000	1.0000	5	5.00	.00	5.00
DEV COST	.00000	70.000	15	15.00	9.64	.00
TOTAL PT	.00000	85.000	85	77.75	58.25	5.00
RATING	.00000	100.00	100	91.48	68.53	5.88

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	91.48	68.53	5.88
WEIGHT	91.06	68.70	5.41
POWER	92.14	70.84	5.41
VOLUME	91.65	69.71	5.56
THERMAL	92.10	70.29	5.41
RELIAB-Y	90.49	66.69	5.71
MAINTENC	90.38	67.00	5.71
SAFETY	91.72	66.57	8.57
DEV COST	92.17	68.19	5.41

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	91.48	68.53	5.88
WEIGHT	[illegible].97	68.32	6.45
POWER	90.68	65.78	6.45
VOLUME	91.28	67.20	6.25
THERMAL	90.73	66.43	6.45
RELIAB-Y	92.52	70.49	6.06
MAINTENC	92.64	70.15	6.06
SAFETY	91.22	70.61	3.03
DEV COST	90.65	68.94	6.45

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.1.3-FREEZERS

APPLIANCE TYPE \ COMPONENT TYPE (NO.)	MOTOR (1)	PUMP (2)	SOLENOID VALVE (3)	HEAT EXCHANGER (16)	CONTROLLER (13)	BLOWER (18)											NUMBER OF SAFETY CRITICAL ITEMS
SPACE RADIATOR	1	1	2	2	1	-											0
THERMOELECTRIC	2	-	-	-	1	2											1
AIR CYCLE TURBINE/COMPRESSOR	2	2	-	1	1	1											0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Frozen Storage

APPLIANCE CONCEPT NO./TITLE 1/Space Radiator

INDEX NO. 1.1.3.1 REF. NO. 184, 255

DESCRIPTION

This concept is simply an insulated food storage box, with coolant from the spacecraft ECS radiators routed through tubing within the freezer walls. This concept was used for the five Skylab food freezers, each of which had the following size:

	WEIGHT		VOLUME	
	kg	lb	m^3	ft^3
Food capacity (packaged and restrained)	24.1	53.2	0.0598	2.11
Total freezer (empty)	45.8	101	0.210	7.41

The Shuttle freezer was sized proportional to the above Skylab data based on the freezer food capacity. The wall insulation was 10.16 cm (4.0 in) thick. It was assumed that the radiator coolant would be of sufficiently low temperature for this concept to be feasible.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Space radiator freezer (Ref. # 184 p 4.1-4.5)

INDEX NUMBER 1.1.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
Controls, valves, illumination, sensors		50					
		50 MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	0	-188	188
Electrical	0	171	171	0
TOTAL	0	(171)	(-17)	(188)
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Space radiator freezer

INDEX NUMBER 1.1.3.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Freezer (total)	98.7	7.25
TOTAL	(98.7) KG (LBS)	(7.25) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)

Σ ③ ______ TOTAL WT/CYCLE (LB)

Σ ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ ① ______

Σ ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

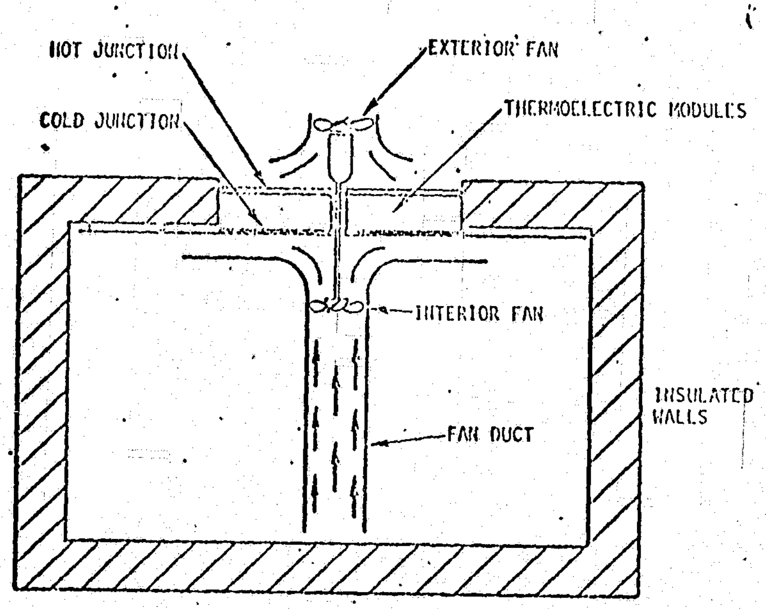
HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Frozen Food Storage

APPLIANCE CONCEPT NO./TITLE 2/Thermoelectric

INDEX NO. 1.1.3.2 REF. NO. 184, 177

DESCRIPTION: In this concept, the freezer has a self-contained cooling unit operating on the thermoelectric principle. Direct electrical current is passed through staged semi-conductor junctions arranged such that heat is removed at one set of junctions (providing the cooling) and rejected at the other. The freezer engineering data used were taken from Reference 184 and 177, which were obtained from catalogue data for commercial units. The reference weight and volume were given separately for the freezer locker and the thermoelectric devices. To keep the concepts on a common basis, the weight and volume of the locker were assumed equal to the locker for the space radiator concept #1.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Thermoelectric freezer (Ref. #184 p 4.6 - 4.12) INDEX NUMBER 1.1.3.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Thermoelectric devices, fans, illumination						570		
			MAXIMUM		TOTAL	570 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	-188	-188	0
Electrical power	0	1783	456	1327
TOTAL	0 WATT (BTU/HR)	(1595) WATT (BTU/HR)	(268) WATT (BTU/HR)	(1327) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Thermoelectric freezer INDEX NUMBER 1.1.3.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Thermoelectric devices	113	6.5
Freezer locker only	98.7	7.25
TOTAL	KG (LBS) (212)	M^3 (FT^3) (13.8)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)

Σ③ ____ TOTAL WT/CYCLE (LB) Σ⑤ ____ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = ____ KG (LB)

TOTAL VOL / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = ____ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ① ____ Σ④ ____

TOTAL WT. / MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

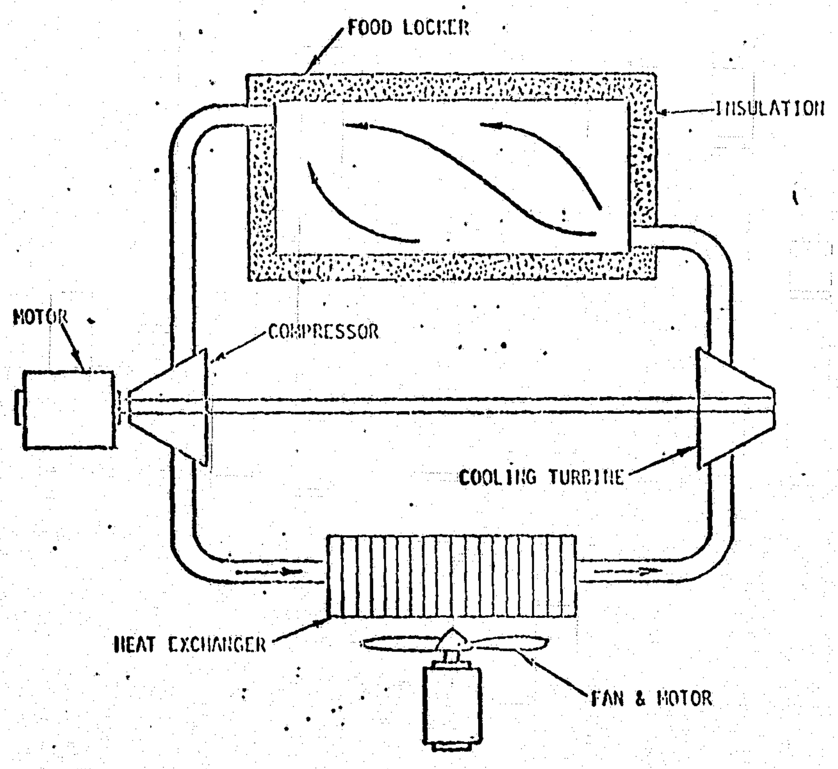
HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Storage

APPLIANCE FUNCTION Frozen Food Storage

APPLIANCE CONCEPT NO./TITLE 3/Air-cycle turbine/compressor

INDEX NO. 1.1.3.3 REF. NO. 184

DESCRIPTION: In this concept, air is alternately compressed and expanded in a closed refrigeration cycle. This concept was included for comparison since it represents a typical commercial aircraft system. In an aircraft, ram air is used to cool the heated working fluid, whereas in the spacecraft system a motor and fan are used.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Air cycle turbine/compressor freezer (Ref. # 184 pp 4.13-4.16, A.34-A.46)

INDEX NUMBER 1.1.3.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Compressor & fan		15,200					
		15,200 MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Box heat leak	0	-188	-188	0
Electrical power	0	13,398	5448	7950
TOTAL	0 WATT (BTU/HR)	(13,210) WATT (BTU/HR)	(5260) WATT (BTU/HR)	(7950) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Air cycle turbine/compressor freezer INDEX NUMBER 1.1.3.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Freezer (total)	723	135
TOTAL	(723) KG (LBS)	(135) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)

Σ③ TOTAL WT/CYCLE (LB)   Σ⑤ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = CYCLES/DAY X DAYS/MISSION X TOT.WT/CYCLE (LB) = KG (LB)

TOTAL VOL/MISSION = CYCLES/DAY X DAYS/MISSION X TOT.VOL/CYCLE (FT^3) = M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ①   Σ④

TOTAL WT./MISSION = CYCLE/DAY X DAYS/MISSION X TOTAL LOST/CYCLE (Σ ④) = (LB) + (Σ ①) = KG (LB)

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.2 Preparation

APPLIANCE FUNCTION 1.2.2 Warming

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

Since current planning in the spacecraft food system area does not include a requirement for cooking, the concepts considered in this section apply to food warming only and not cooking. In Reference 184, it is recommended, for planning purposes, to size ovens based on 80 percent of the maximum allotted frozen food per man-day. Based on the Skylab food mix which was assumed in this study (which contained approximately 100 lbs. of frozen food for 420 planned man-days), this would result in a warming unit sized for 0.24 lbs. per man. This value is obviously low, due to the relatively short supply of frozen food in Skylab. Therefore, the design value of 0.8472 lbs. and 0.1696 cu. ft. of food per man (Reference 184, 276) was assumed throughout this study to size the ovens. For Shuttle, the oven food capacity was therefore 3.4 lbs. and 0.68 cu. ft. Three meal warmings per 24 hours were assumed. To compare the food warming concepts on a common basis, the weight and volume of each food warming concept includes the weight and volume of the trays and tray rack associated with it.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.2.2 .... FOOD WARMING (SHUTTLE)

CONCEPT NO.	USAGE TIME: USES/DAY / HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS: TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS: COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS: PK PWR AC / DC -WATTS-	AVG PWR AC / DC -WATTS-	WT/VOL REQMTS: WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST: AVAIL (**)	INDEX (***)	RESUPPLY: WEIGHT -KG- (LBS)
1	3.000						0.	197.	.0	.0	36.6	.14	1	5	.0
	2.000						(0.)	(672.)	660.0	197.0	(80.6)	(4.80)			(.0)
2	3.000						0.	343.	.0	.0	24.6	.11	2	30	.0
	.500						(0.)	(1170.)	858.0	686.0	(54.3)	(3.90)			(.0)
3	3.000						0.	685.	2745.0	2745.0	37.6	.13	2	30	.0
	.167						(0.)	(2340.)	.0	.0	(82.9)	(4.70)			(.0)

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	HEATING TRAYS (SKYLAB)
2 -	OVEN-HOT AIR CONVECTION (ELECTRICAL HEAT)
3 -	OVEN-MICROWAVE (PLAIN)

(*)

1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

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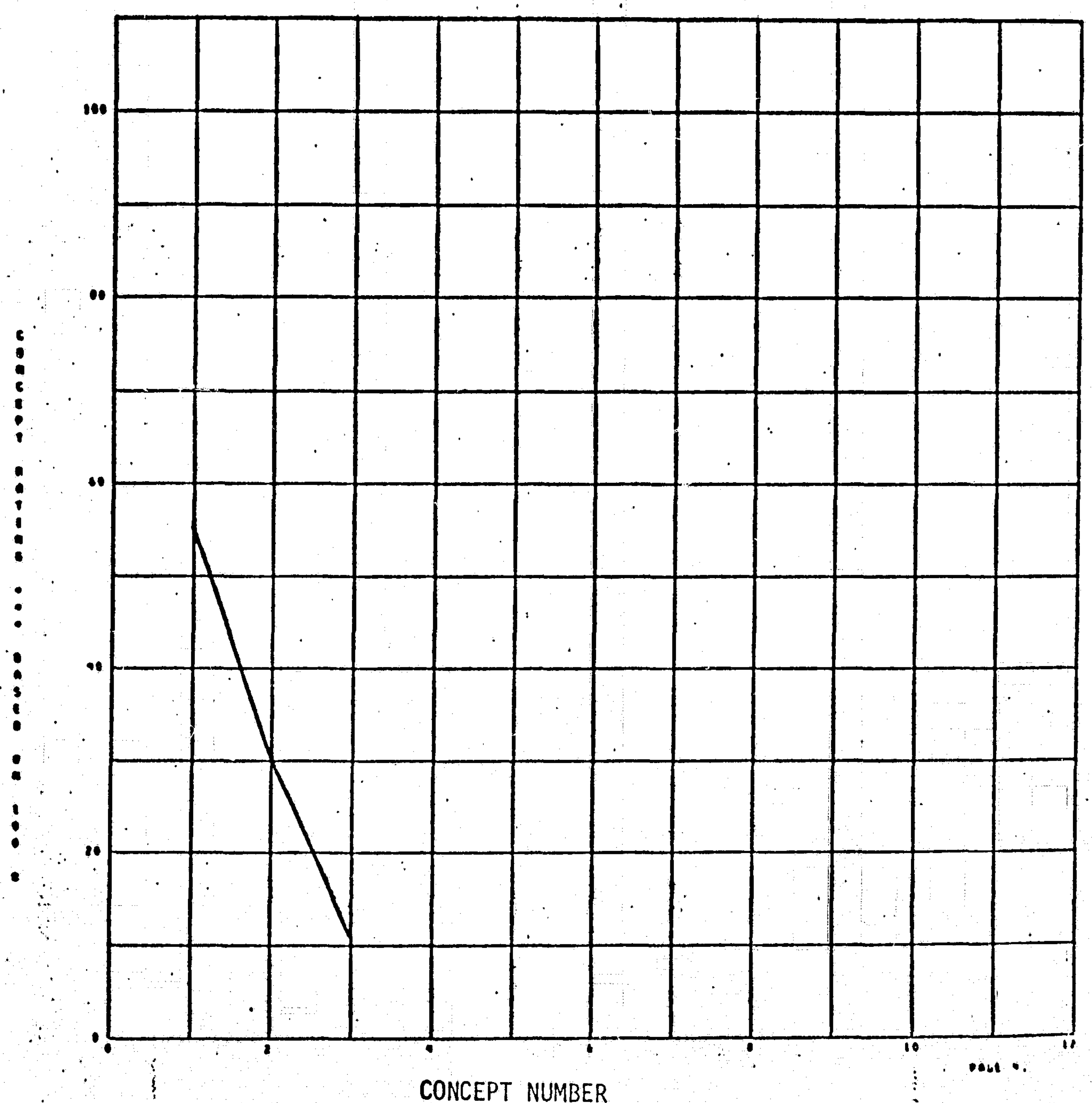
(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	HEATING TRAYS (SKYLAB)
2 -	OVEN-HOT AIR CONVECTION (ELECTRICAL HEAT)
3 -	OVEN-MICROWAVE (PLAIN)



Food Warming (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 0
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • FOOD WARMING (SHUTTLE)
(12/15/74)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3
WEIGHT	54.300	82.90	15	.42	5.17	.00
POWER	283.80	1454.8	15	12.07	11.20	.00
VOLUME	3.9000	4.8000	10	.00	1.88	.21
THERMAL	36.960	128.70	15	10.69	7.50	.00
RELIAB-Y	.99947	.99997	5	2.09	.00	4.76
MAINTENC	.99999	1.00000	5	4.28	.00	4.28
SAFETY	.00000	1.0000	5	5.00	.00	.00
DEV COST	5.0000	30.000	15	12.50	.00	.00
TOTAL PT	.00000	85.000	85	47.05	25.75	9.24
RATING	.00000	100.00	100	55.35	30.29	10.88

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	55.35	30.29	10.88
WEIGHT	51.09	30.63	9.99
POWER	57.39	33.89	9.99
VOLUME	52.28	29.65	10.39
THERMAL	56.65	31.89	9.99
RELIAB-Y	54.97	29.42	13.28
MAINTENC	56.22	29.42	13.01
SAFETY	56.63	29.42	10.56
DEV COST	57.62	27.83	9.99

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	55.35	30.29	10.88
WEIGHT	60.44	29.88	11.93
POWER	52.92	26.00	11.93
VOLUME	58.81	31.01	11.42
THERMAL	53.81	28.38	11.93
RELIAB-Y	55.76	31.21	8.32
MAINTENC	54.44	31.21	8.61
SAFETY	54.00	31.21	11.20
DEV COST	52.65	33.22	11.93

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.2.2-FOOD WARMING

COMPONENT TYPE / APPLIANCE TYPE	MOTOR	BLOWER	HEATER	RF. GEN.	CONTROLLER TIMER												NUMBER OF SAFETY CRITICAL ITEMS
NO.	1	18	17	26	19												
HEATING TRAYS (SKYLAB)	-	-	1(3)*	-	1												0
HOT AIR CONVECTION (ELEC. HEAT) (pg. 5-2)	1	1	1	-	1												1
MICROWAVE (PLAIN)(pg. 5-4)	-	-	-	1	1												1

*Derated to 1 due to low temperature of three ht's.

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Preparation

APPLIANCE FUNCTION Food Warming

APPLIANCE CONCEPT NO./TITLE 1/Heating Trays (Skylab)

INDEX NO. 1.2.2.1 REF. NO. 255, 276

DESCRIPTION : In this concept, an insulated food tray with three heating cavities surrounded by imbedded electrical resistance heating elements is used. This concept was used on Skylab, and the actual Skylab weight/volume/power data were assumed. A heating time of 1½ to 2 hours is required to warm the food. Two hours was used for computing thermal penalties to the cabin cooling circuit.

Each Skylab heating tray weighed 10.9 kg (24 lb). However, of this total weight, 2.7 kg (6 lb) was a stainless steel bracket used for a working surface. To compare with the oven concepts, the weight/volume of this bracket was not included in the heating tray weight/volume. Instead, the data for a tray storage rack was taken from Reference 276 and added to the basic concept weight and volume. No separate dish tray penalty was added for this concept since the tray is already an integral part of the concept.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Heating trays

INDEX NUMBER 1.2.2.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
Heating element (#255)	2				660	197	394
		MAXIMUM		TOTAL	660 MAXIMUM		394 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Heating element (255)	0	672	672	0
TOTAL	0 WATT (BTU/HR)	197 (672) WATT (BTU/HR)	197 (672) WATT (BTU/HR)	0 WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Heating trays INDEX NUMBER 1.2.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Total tray (less bracket)	72	2.3
Rack (#276)	8.6	2.5
TOTAL	KG (LBS) (80.6)	M^3 (FT^3) (4.8)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					
			Σ③ TOTAL WT/CYCLE (LB)		Σ⑤ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = ____ KG (LB)

TOTAL VOL/MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = ____ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				
Σ①			Σ④	

TOTAL WT./MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management **HABITABILITY FUNCTION** Food Preparation

APPLIANCE FUNCTION Food Warming

APPLIANCE CONCEPT NO./TITLE 2/Oven-hot air convection-electric

INDEX NO. 1.2.2.2 **REF. NO.** 276

DESCRIPTION : This concept resembles a conventional electrical oven with resistance heating elements. Oven size is based on the requirement in Section 1.2.2 of 0.0193 cu m (0.68 cu ft) of food per meal. A heating time of 0.5 hours was used, with an additional 0.5 hours allowed for the oven heat to dissipate to the cabin gas. Thus, a total time of 1 hour was assumed for computing the thermal penalty to the cabin cooling circuit.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Oven-hot air convection - electric (Ref. #276)

INDEX NUMBER 1.2.2.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Total electrical	0.5				858	686	343
		MAXIMUM		TOTAL	858 MAXIMUM		343 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Total electrical	0	1170	1170	0
TOTAL	0 WATT (BTU/HR)	343 (1170) WATT (BTU/HR)	343 (1170) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Oven - hot air convection - electric (Ref. #276)

INDEX NUMBER 1.2.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Oven total	28.6	2.1
Tray rack	5.7	1.8
serving trays	20.0	(included in rack)
TOTAL	(54.3) KG (LBS)	(3.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Σ①			Σ④	

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Food Preparation

APPLIANCE FUNCTION Food Warming

APPLIANCE CONCEPT NO./TITLE 3/Oven-Microwave

INDEX NO. 1.2.2.3 REF. NO. 276

DESCRIPTION: This concept resembles a conventional microwave oven. Oven size is based on the requirements described in Section 1.2.2 of 0.0193 cu m (0.68 cu ft) of food per meal. A heating time of 10 minutes was assumed, with an additional 0.5 hours allowed for the oven heat to dissipate to the cabin gas. Thus, a total time of 40 minutes was assumed for computing the thermal penalty to the cabin cooling circuit.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Oven - microwave (Ref. #276)

INDEX NUMBER 1.2.2.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Heater		1/6	2745	2745	458			
			2745 MAXIMUM		458 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Heater	0	2340	2340	0
TOTAL	0 WATT (BTU/HR)	686 (2340) WATT (BTU/HR)	686 (2340) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Oven - microwave INDEX NUMBER 1.2.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Oven total	57.2	2.9
Tray rack	5.7	1.8
Serving trays	20.0	(included in rack)
TOTAL	(82.9) KG (LBS)	(4.7) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①X④ (FT³)
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT³)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT³) = ______ M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Σ①			Σ④	

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.3 Galley Cleanup

APPLIANCE FUNCTION 1.3.1 Dishwasher/Dryer Combination

NUMBER OF CONCEPTS CONSIDERED 10

ASSUMPTIONS

All the automatic dishwashing data found have been for single integrated washer/dryer units. All the dishwasher engineering data used for Space Station were used directly for Shuttle also after adjusting for a crew size of four men (Space Station crew was six men). Therefore, only the total values for each penalty are shown in the following data sheets. Each penalty is 4/6 times the corresponding Space Station penalty. For an itemized breakdown of the various penalties, the Space Station data sheets in Appendix C should be consulted.

Three washings per day were assumed, with 4.53 kg (10 lbs) of water used for washing and 4.53 kg (10 lbs) for rinsing. It is assumed that 0.093 kg (0.20 lb) of residual water remains on the dishes after rinsing to be removed by the dryer.

The amount of dishes required by the crew, assuming an automatic dishwasher/dryer is aboard, was computed and included with the washer/dryer penalty. This was necessary to compare with the disposable dishes case in Section 1.3.2. The packaged weight and volume of the dishes were taken directly from Section 1.3.2 and the results shown in Table B2-3. The total dishes/utensils/cups required with the dishwasher for a four-man crew is 4.10 kg (9.03 lbs) and 0.014 cu m (0.49 cu ft).

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.3.1 •••• DISH WASHER/DRYER COMBINATION (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	3.000	9	9.0720	.00	.0	.0	0.	247.	100.0	.0	321.6	.48	3	65	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(0.)	(845.)	50.0	.0	(709.0)	(16.90)			(.0)
2	3.000	9	9.0720	.00	.0	.0	0.	900.	900.0	.0	319.5	.52	3	60	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(0.)	(3075.)	50.0	.0	(704.3)	(18.20)			(.0)
3	3.000	9	9.0720	.00	.0	.0	164.	247.	111.0	.0	328.0	.48	3	50	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(561.)	(845.)	217.0	.0	(723.0)	(16.90)			(.0)
4	3.000	9	9.0720	.00	.0	.0	65.	246.	116.0	.0	325.5	.52	3	75	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(221.)	(839.)	97.0	.0	(717.7)	(18.50)			(.0)
5	3.000	9	9.0720	.00	.0	.0	262.	170.	124.0	.0	338.4	.51	3	75	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(895.)	(581.)	48.0	.0	(746.0)	(17.90)			(.0)
6	3.000	9	9.0720	.00	.0	.0	0.	412.	167.0	.0	328.5	.50	3	70	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(0.)	(1407.)	49.0	.0	(724.3)	(17.50)			(.0)
7	3.000	9	9.0720	.00	.0	.0	161.	414.	167.0	.0	332.5	.51	3	65	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(551.)	(1414.)	217.0	.0	(733.0)	(17.90)			(.0)
8	3.000	9	9.0720	.00	.0	.0	65.	451.	167.0	.0	331.1	.54	3	75	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(221.)	(1541.)	97.0	.0	(730.0)	(19.20)			(.0)
9	3.000	9	9.0720	.00	.0	.0	263.	170.	167.0	.0	345.2	.52	3	75	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(898.)	(581.)	48.0	.0	(761.0)	(18.50)			(.0)
OK 10	3.000	9	9.0720	.00	.0	.0	40.	234.	14.7	.0	305.9	.30	2	35	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(135.)	(800.)	45.0	.0	(674.3)	(10.70)			(.0)

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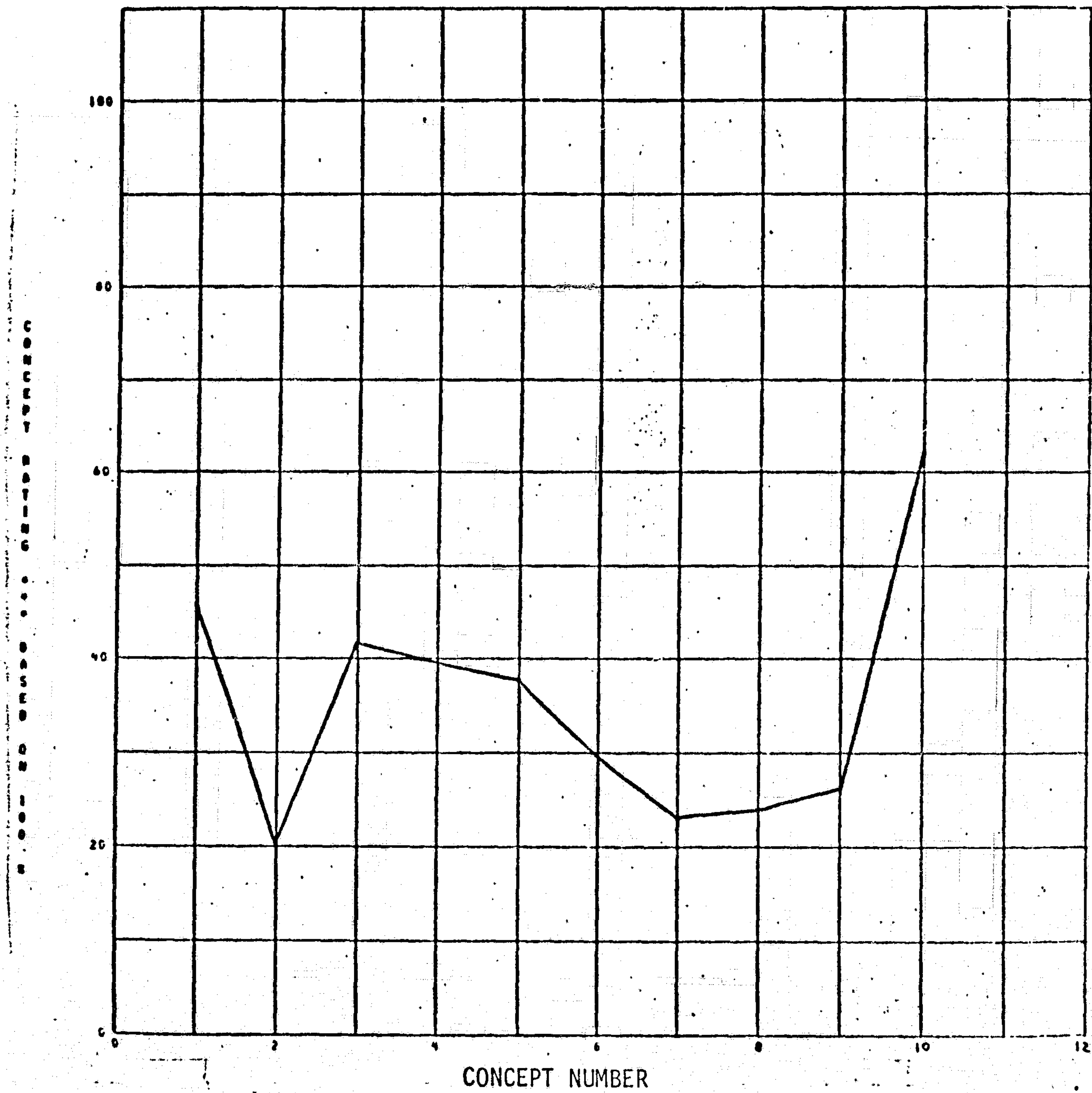
APPLIANCE CONCEPT NO.	CONCEPT NAME
1	HOT WATER SPRAY-CENTRIFUGE DRYING
2	HOT WATER SPRAY-AIR SPRAY DRY
3	HOT WATER SPRAY-FORCED HOT AIR ELECTRIC HEAT DRY
4	HOT WATER SPRAY-DESICCANT ELECTRICALLY DESORBED
5	HOT WATER SPRAY-FORCED HOT AIR DRY-THERMAL STORAGE
6	ULTRASONIC WASH-CENTRIFUGE DRYING
7	ULTRASONIC WASH-FORCRD HOT AIR DRYING
8	ULTRASONIC WASH-FORCED COLD DRY AIR-DESICCANT, ELECTRICALLY DESORBED
9	ULTRASONIC WASH-FORCED HOT AIR DRY-THERMAL STORAGE
10	MANUAL WASH-MANUAL WIPE DRY

(*)

1 - CABIN AIR	(CIRCULATED),	LITERS/SEC	(FT^3/MIN)
2 - CABIN AIR	(LOST)	, KG/HR	(LB/HR)
3 - OXYGEN	(LOST)	, KG/HR	(LB/HR)
4 - COOLING WATER	(CIRCULATED),	KG/HR	(LB/HR)
5 - WATER	(LOST)	, KG/HR	(LB/HR)
6 - NITROGEN	(CIRCULATED),	KG/HR	(LB/HR)
7 - NITROGEN	(USED)	, KG/HR	(LB/HR)
8 - FREON	(CIRCULATED),	KG/HR	(LB/HR)
9 - WATER	(PROCESSED)	, KG/HR	(LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	HOT WATER SPRAY-CENTRIFUGE DRYING
2 -	HOT WATER SPRAY-AIR SPRAY DRY
3 -	HOT WATER SPRAY-FORCED HOT AIR ELECTRIC HEAT DRY
4 -	HOT WATER SPRAY-DESICCANT ELECTRICALLY DESORBED
5 -	HOT WATER SPRAY-FORCED HOT AIR DRY-THERMAL STORAGE
6 -	ULTRASONIC WASH-CENTRIFUGE DRYING
7 -	ULTRASONIC WASH-FORCRD HOT AIR DRYING
8 -	ULTRASONIC WASH-FORCED COLD DRY AIR-DESICCANT, ELECTRICALLY DESORBED
9 -	ULTRASONIC WASH-FORCED HOT AIR DRY-THERMAL STORAGE
10 -	MANUAL WASH-MANUAL WIPE DRY



Dishwasher/Dryer Combination (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 23
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . DISH WASHER/DRYER COMBINATION (SHUTTLE)

(01/25/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5	6	7	8	9	10
WEIGHT	674.30	761.00	15	1.02	1.12	.75	.85	.30	.72	.55	.61	.00	1.71
POWER	27.141	498.50	15	12.76	.00	10.42	11.89	12.40	11.70	9.53	11.08	11.72	14.18
VOLUME	10.700	19.200	10	1.20	.52	1.20	.36	.68	.89	.68	.00	.36	4.43
THERMAL	46.475	169.12	15	10.88	.00	9.63	10.42	10.18	8.14	6.88	6.99	10.17	10.80
RELIAB-Y	.98550	.99862	5	4.13	3.89	3.62	3.58	3.66	.51	.00	.00	.03	4.52
MAINTENC	.99996	.99999	5	3.65	3.67	3.19	3.15	3.21	.46	.00	.00	.02	4.28
SAFETY	.00000	3.0000	5	3.33	5.00	1.67	3.33	1.67	1.67	.00	1.67	.00	5.00
DEV COST	35.000	75.000	15	2.00	3.00	5.00	.00	.00	1.00	2.00	.00	.00	8.00
TOTAL PT	.00000	85.000	85	38.98	17.20	35.49	33.60	32.09	25.08	19.64	20.35	22.30	52.92
RATING	.00000	100.00	100	45.86	20.23	41.75	39.52	37.75	29.51	23.10	23.94	26.24	62.26

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6	7	8	9	10
NORMAL	45.86	20.23	41.75	39.52	37.75	29.51	23.10	23.94	26.24	62.26
WEIGHT	42.70	19.20	38.77	36.78	34.85	27.51	21.53	22.33	24.11	58.14
POWER	49.04	18.59	44.00	42.75	41.39	33.44	26.38	27.99	30.45	64.88
VOLUME	43.98	19.40	40.09	37.53	36.03	28.36	22.20	22.61	24.99	61.26
THERMAL	48.02	18.59	43.57	41.95	40.19	31.51	24.95	25.78	29.61	63.05
RELIAB-Y	46.91	21.88	42.63	40.44	38.76	28.96	22.44	23.26	25.51	63.07
MAINTENC	46.64	21.75	42.38	40.20	38.51	28.93	22.44	23.26	25.50	62.93
SAFETY	46.46	22.51	41.51	40.30	37.62	29.62	22.44	24.21	25.49	63.34
DEV COST	43.22	20.21	41.07	36.32	34.69	27.66	22.31	22.00	24.11	61.54

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6	7	8	9	10
NORMAL	45.86	20.23	41.75	39.52	37.75	29.51	23.10	23.94	26.24	62.26
WEIGHT	49.64	21.47	45.31	42.80	41.21	31.90	24.98	25.87	28.78	67.19
POWER	42.07	22.19	39.06	35.68	33.40	24.81	19.19	19.11	21.22	59.14
VOLUME	47.98	21.17	43.61	41.77	39.69	30.80	24.13	25.44	27.65	63.39
THERMAL	43.28	22.19	39.57	36.63	34.84	27.11	20.90	21.75	22.22	61.32
RELIAB-Y	44.74	18.49	40.82	38.55	36.68	30.10	23.80	24.67	27.02	61.41
MAINTENC	45.04	18.62	41.08	38.81	36.95	30.12	23.80	24.67	27.03	61.55
SAFETY	45.23	17.82	42.00	38.70	37.88	29.39	23.80	23.66	27.04	61.12
DEV COST	49.01	20.26	42.56	43.35	41.40	31.72	24.05	26.26	28.78	63.13

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.3.1-DISHWASHER/DRYER COMBINATION (PAGE 1 OF 2)

COMPONENT TYPE / APPLIANCE TYPE	MOTOR	PUMP	VALVE SOLENOID	ACCUMULATOR	WATER SEPARATOR	TRANSMISSION (GEAR BOX)	FILTER	HEAT EXCHANGER	CONTROLLER TIMER	BLOWER AIR	HEATER DC	DESICCANT CANISTER	THERMAL STORAGE UNIT	ELECTROACOUSTIC TRANSMISSION	HIGH FREQUENCY CONTROLLER		NUMBER OF SAFETY CRITICAL ITEMS
NO.	1	2	3	4	6	7	9	16	19	18	17	21	20	15	14		
HOT WATER SPRAY WASHING, CENTRIFUGE DRYING (pg. 98)	2	1	2	2	1	1	1	-	1	-	-	-	-	-	-		1
HOT WATER SPRAY WASHING, AIR SPRAY DRYING (pg. 100)	1	1	2	2	1	-	1	1	1	1	-	-	-	-	-		0
HOT WATER SPRAY WASHING FORCED HOT AIR ELECTRIC HEAT DRYING (pg. 102)	2	1	2	2	1	1	1	1	1	1	1	-	-	-	-		2
HOT WATER SPRAY WASHING, FORCED COLD AIR-DESICCANT, ELECTRIC DESORBED (pg. 104)	2	1	3	2	1	1	1	1	1	1	1	1	-	-	-		1
HOT WATER SPRAY WASHING, FORCED HOT AIR DRYING USING THERMAL STORAGE (pg. 107)	2	1	2	2	1	1	1	1	1	1	-	-	1	-	-		2
ULTRASONIC WASHING, CENTRIFUGE DRYING (pg. 109)	2	1	2	2	1	1	1	-	1	-	-	-	-	1	1		2
ULTRASONIC WASHING, FORCED HOT AIR ELECTRIC DRYING (pg. 111)	2	1	2	2	1	1	1	1	1	1	1	-	-	1	1		3

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.3.1-DISHWASHER/DRYER COMBINATION (CONCLUDED)(PAGE 2 OF 2)

APPLIANCE TYPE \ COMPONENT TYPE (NO.)	NUMBER OF COMPONENTS																NUMBER OF SAFETY CRITICAL ITEMS
	MOTOR (1)	PUMP (2)	VALVE SOLENOID (3)	ACCUMULATOR (4)	WATER SEPARATOR (6)	TRANSMISSION (GEAR BOX) (7)	FILTER (9)	HEAT EXCHANGER (16)	CONTROLLER TIMER (19)	BLOWER AIR (18)	HEATER DC (17)	DESICCANT CANISTER (21)	THERMAL STORAGE UNIT (20)	ELECTROACOUSTIC TRANSMISSION (15)	HIGH FREQUENCY CONTROLLER (14)	( )	
ULTRASONIC WASHING, FORCED COLD DRY AIR-DESICCANT, ELECTRICALLY DESORBED (pg. 115)	2	1	2	2	1	1	1	1	1	1	1	-	-	1	1		2
ULTRASONIC WASHING, FORCED HOT AIR DRYING USING THERMAL STORAGE (pg. 117)	2	1	2	2	1	1	1	1	1	1	1	-	-	1	1		3
MANUAL WASH-MANUAL WIPE (pg. 119)	1	1	2	1	-	-	-	-	-	-	-	-	-	-	-		0
(2.3.3. SINK)																	

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Cleanup

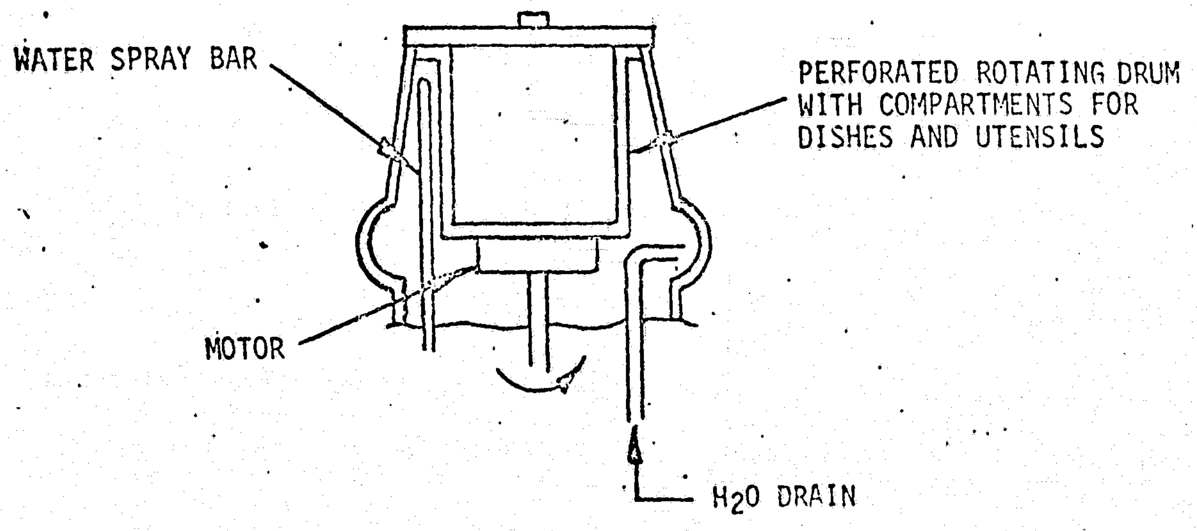
APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 1/Hot Water Spray Wash-Centrifuge Dry

INDEX NO. 1.3.1.1 REF. NO. 90

DESCRIPTION

In this concept, washing is accomplished by spraying hot water (with an 8 psig pump head) over the dishes in a slowly rotating drum. Drying is assumed to be accomplished simply by centrifugal force at high speed rotation. This concept is included in the trades since conceptual data are available; however, the drying method is unproven and doubtful.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray – centrifuge drying

INDEX NUMBER 1.3.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Motor		1						
Valves		0						
Pump		1						
			100 MAXIMUM		TOTAL	50 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
Motor				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	248 (845) WATT (BTU/HR)	248 (845) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray - centrifuge dry INDEX NUMBER 1.3.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Packaging		
Dishes/utensils/cups		
Total		
TOTAL	33.5 (74.0) KG (LBS)	0.477 (16.9) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①x④ (FT³)
Detergent/ germicide	1	.010 (.012)	.012	.00029 .00035	.00035

Σ③ .012 TOTAL WT/CYCLE (LB)

Σ⑤ .00035 TOTAL VOL/CYCLE (FT³)

TOTAL WT./MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x .012 TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL/MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x .00035 TOT.VOL/CYCLE (FT³) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water	10	0	0	10.
Rinse water	10	1.0	10	0

Σ① 20

Σ④ 10.

TOTAL WT./MISSION = 3 CYCLE/DAY x 20.5 DAYS/MISSION x 10. TOTAL LOST/CYCLE (Σ④) = 615 (LB) + 20 (Σ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Cleanup

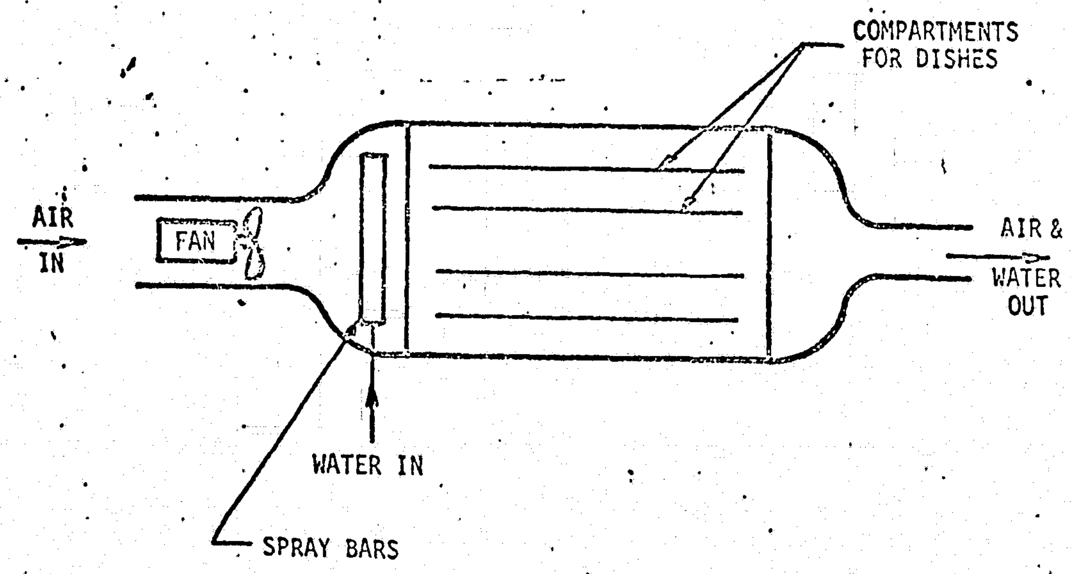
APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 2/Hot Water Spray-Air Spray Dry

INDEX NO. 1.3.1.2 REF. NO. 90

DESCRIPTION

The washing function for this concept is identical to that used in Concept 1. Drying is accomplished by a high-velocity air spray (30 fps) sufficient to drive the water droplets off the dishes. Thus, the drying air is not heated.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray - Air spray dry

INDEX NUMBER 1.3.1.2.

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Valves								
Fan								
Pump								
			900 MAXIMUM		TOTAL	50 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
Fan				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	901 (3075) WATT (BTU/HR)	901 (3075) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray - Air Spray Dry INDEX NUMBER 1.3.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
water separator		
Fan		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	31.5 (69.3) KG (LBS)	0.515 (18.2) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
Detergent/					
germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x ____ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL / MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x ____ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water	10	0		10
Rinse water	10	1		0
Σ①	20		Σ④	10

TOTAL WT. / MISSION = 3 CYCLE/DAY x 20.5 DAYS/MISSION x 10 TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + 20 (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 3/Hot Water Spray Wash-Forced Hot Air Electric Heat Dry

INDEX NO. 1.3.1.3 REF. NO. 90

DESCRIPTION

The washing function for this concept is identical to that used in Concept 1. Washing is accomplished by spraying hot water (with an 8 psig pump head) over the dishes in a slowly rotating drum. Drying is accomplished by a circulating flow of air over the dishes which is heated by an electrical heating element. The heater also heats the dishes by radiation. Heater size is based on a 1 hour drying time.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT *Hot water spray wash - forced hot air electric heat dry*

INDEX NUMBER *1.3.1.3.*

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A C . POWER ② PEAK (WATTS)	A C . POWER ③ AVERAGE (WATTS)	A C . POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	D C POWER ⑤ PEAK (WATTS)	D C POWER ⑥ AVERAGE (WATTS)	D C POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Valving								
Fan								
Motor								
Heater								
Pump								
			111 MAXIMUM		TOTAL	217 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Pump				
Water heat loss (45°F)				
Fan				
Motor				
Heater				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	WATT (BTU/HR)	248 (845) WATT (BTU/HR)	165 (561) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

C-2

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray wash - Forced hot air electric heat dry

INDEX NUMBER 1.3.1.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Fan		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	39.9 (88) KG (LBS)	7.7 (16.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
Detergent/germicide					

Σ③ TOTAL WT/CYCLE (LB)

Σ⑤ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = CYCLES/DAY x DAYS/MISSION x TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL/MISSION = CYCLES/DAY x DAYS/MISSION x TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				

Σ①

Σ④

TOTAL WT./MISSION = CYCLE/DAY x DAYS/MISSION x TOTAL LOST/CYCLE (Σ ④) = (LB) + (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 4/Hot Water Spray Wash-Forced Cold Air Desiccant Dry

INDEX NO. 1.3.1.4 REF. NO. 90

DESCRIPTION

In this concept, washing is accomplished by spraying hot water over the dishes in a slowly rotating drum. A fan is used during washing and rinsing to transport air and excess water out of the washer. The same fan is used to circulate air through the dishes for drying. The air is routed through a desiccant bed upstream of the dryer to dry the air first; thus, no additional heat is assumed necessary. The desiccant is desorbed using an electrical resistance heater sized for a 1 hour desorption time.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray wash - forced cold air desiccant INDEX NUMBER 1.3.1.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Motor								
Fan								
Valves								
Pump								
Heater								
			116 MAXIMUM		TOTAL	97 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
Motor				
Fan				
Heater				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	246 (839) WATT (BTU/HR)	246 (839) WATT (BTU/HR)	65 (221) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray wash- Forced cold air desiccant INDEX NUMBER 1.3.1.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Desiccant bed		
Fan		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	37.5 (82.7) KG (LBS)	.525 (18.5) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①X④ (FT³)
Detergent/					
Germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT³)

TOTAL WT. / MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL / MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT³) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. / MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 5/Hot Water Spray Wash-Forced Hot Air Dry-Thermal Storage

INDEX NO. 1.3.1.5 REF. NO. 90

DESCRIPTION

In this concept, washing is accomplished by spraying hot water (with an 8 psig pump head) over the dishes in a slowly rotating drum. Drying is accomplished by circulating a flow of air over the dishes. Washer water is routed through a thermal storage unit which stores heat to be used during the drying cycle to heat the inlet air.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray wash - Forced hot air dry - thermal storage

INDEX NUMBER 1.3.1.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
Valves								
Motor								
Pump								
Fan								
			124 MAXIMUM		TOTAL	48 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Pump				
Motor				
Fan				
Water / thermal storage				
TOTAL	62 (212) WATT (BTU/HR)	370 (1263) WATT (BTU/HR)	170 (581) WATT (BTU/HR)	262 (895) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray wash - Forced hot air dry - thermal storage INDEX NUMBER 1.3.1.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Fan		
Thermal storage unit		
Packaging		
Dishes/utensils/cups		
Total		
TOTAL	50.3 (111) KG (LBS)	8.2 (17.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
Detergent/ germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL / MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. / MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 6/Ultrasonic Wash-Centrifuge Dry

INDEX NO. 1.3.1.6 REF. NO. 90

DESCRIPTION

This concept is identical to Concept 1 except that ultrasonic cleaning is used to clean the dishes instead of a high velocity water spray. No ultrasonic energy damping is assumed. Drying is assumed to be accomplished by centrifugal force at high speed rotation. The concept is included in the trades since conceptual data are available; however, the drying method is unproven and doubtful.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Ultrasonic wash - centrifuge drying INDEX NUMBER 1.3.1.6

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Valves							
Pump							
Motor							
HF generator							
		167 MAXIMUM		TOTAL	48 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
HF generator				
Motor				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	WATT (BTU/HR)	413 (1407) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Ultrasonic wash - Centrifuge drying INDEX NUMBER 1.3.1.6

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Controller		
Packaging		
Dishes/utensils/cups		
Total		
TOTAL	40.5 (89.3) KG (LBS)	0.50 (17.5) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE. ①X④ (FT^3)
Detergent/ germicide					

Σ③ ____ TOTAL WT/CYCLE (LB) Σ⑤ ____ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				

Σ① ____ Σ④ ____

TOTAL WT. / MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 7/Ultrasonic Wash-Forced Hot Air Electric Dry

INDEX NO. 1.3.1.7 REF. NO. 90

DESCRIPTION

Ultrasonic cleaning is used to clean the dishes, with no ultrasonic energy assumed lost due to damping. Drying is accomplished by a circulating flow of air over the dishes which is heated by an electrical heating element. The heater also heats the dishes by radiation. Heater size is based on 1 hour drying time.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Ultrasonic wash - Forced hot air electric dry INDEX NUMBER 1.3.1.7

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Valves								
Motor								
Heater								
Fan								
HF generator								
Pump								
			167 MAXIMUM		TOTAL	217 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
HF generator				
Motor				
Heater/fan/water				
TOTAL	62 (212) WATT (BTU/HR)	WATT (BTU/HR)	414 (1414) WATT (BTU/HR)	165 (561) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Ultrasonic wash - Forced hot air electric dry INDEX NUMBER 1.3.1.7

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Fan		
Controller		
Packaging		
Dishes/Utensils/cups		
Total		
TOTAL	44.5 (98) KG (LBS)	0.506 (17.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
Detergent/ germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 8/Ultrasonic Wash-Forced Cold Dry Air-Desiccant, Electrically Desorbed

INDEX NO. 1.3.1.8 REF. NO. 90

DESCRIPTION

Ultrasonic cleaning is used to clean the dishes, with no ultrasonic energy assumed lost due to damping. Drying is accomplished by air circulated first through a desiccant bed where it is dried; thus, no additional heat is assumed necessary. The desiccant is desorbed using an electrical heater sized for a 1 hour desorption time.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Ultrasonic wash - Forced cold air dry - desiccant, electrically desorbed

INDEX NUMBER 1.3.1.8

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
Valves								
Motor								
Pump								
Fan								
Heater								
HF generator								
			167 MAXIMUM		TOTAL	97 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
HF generator				
Motor				
Heater/fan/water				
TOTAL	62 (212) WATT (BTU/HR)	WATT (BTU/HR)	451 (1541) WATT (BTU/HR)	65 (221) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Ultrasonic wash- Forced cold dry air - desiccant, electrically desorbed INDEX NUMBER 1.3.1.8

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Desiccant bed		
Fan		
Controller		
Packaging		
Dishes/utinsels/cups		
TOTAL	43 (95) KG (LBS)	8.7 (19.2) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①x④ (FT³)
Detergent/ germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT³)

TOTAL WT. MISSION = ____ CYCLES/DAY x ____ DAYS/MISSION x ____ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL MISSION = ____ CYCLES/DAY x ____ DAYS/MISSION x ____ TOT.VOL/CYCLE (FT³) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 9/Ultrasonic Wash-Forced Hot Air Dry-Thermal Storage

INDEX NO. 1.3.1.9 REF. NO. 90

DESCRIPTION

Ultrasonic cleaning is used to clean the dishes, with no ultrasonic energy assumed lost due to damping. Drying is accomplished by circulating a flow of air over the dishes. Washer water is routed through a thermal storage unit which stores heat to be used during the drying cycle to heat the inlet air.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Ultrasonic wash - Forced hot air dry - thermal storage

INDEX NUMBER 1.3.1.9

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	AC POWER (3) AVERAGE (WATTS)	AC POWER (4) DEMAND (WATT-HR/CYCLE) (1)X(3)	DC POWER (5) PEAK (WATTS)	DC POWER (6) AVERAGE (WATTS)	DC POWER (7) DEMAND (WATT-HR/CYCLE) (1)X(7)
Valves							
Motor							
Pump							
Fan							
HF generator							
		167 MAXIMUM		TOTAL	48 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Pump				
HF generator				
Motor				
Fan				
Water/thermal storage				
TOTAL	62 (212) WATT (BTU/HR)	370 (1263) WATT (BTU/HR)	170 (581) WATT (BTU/HR)	262 (895) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Ultrasonic wash - Forced hot air dry - thermal storage

INDEX NUMBER 1.3.1.9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
Valving		
2 Accumulators		
Water separator		
Fan		
Thermal storage unit		
Controller		
Packaging		
Dishes/utensils/cups		
TOTAL	57.1 (126) KG (LBS)	.76 (18.5) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
Detergent/ germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ④) = ______ (LB) + ______ (Σ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer Combination

APPLIANCE CONCEPT NO./TITLE 10/Manual Wash-Manual Wipe Dry

INDEX NO. 1.3.1.10 REF. NO. 90

DESCRIPTION

In this concept, the dishes are sealed in a Teflon bag equipped with a rubber glove on both sides. The crewman manually scrubs the dishes by fitting his hands into the gloves. When washing is completed, excess water is squeezed out of the bag and the dishes are wiped dry with a towel. It is assumed, according to Reference 90, that 0.136 kg (0.3 lb) of water is wiped by the towel, and that a clothes dryer is available to dry the towel. For this purpose, clothes dryer concept 3.3.2.1 (forced hot air-electric) was assumed. Since the clothes dryer penalties were based on removing 0.454 kg (1.0 lb) of water, the penalties for that concept were multiplied by 0.3 and added to this dishwasher/dryer concept.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Manual wash - Manual wipe dry

INDEX NUMBER 1.3.1.10

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Towel Dryer							
		14.7 MAXIMUM		TOTAL	45 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Towel dryer				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	235 (800) WATT (BTU/HR)	39 (135) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Manual wash - Manual wipe dry INDEX NUMBER 1.3.1.10

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer		
Towel dryer		
Dishes/utinsels/cups		
TOTAL	17.9 (39.3) KG (LBS)	0.31 (10.7) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
Detergent/ germicide					
		Σ③	TOTAL WT/CYCLE (LB)	Σ⑤	TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				
Σ①			Σ④	

TOTAL WT. MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = 288 (635) KG (LB)

HABITABILITY SUBSYSTEM 1.0 Food Management

HABITABILITY FUNCTION 1.3 Cleanup

APPLIANCE FUNCTION 1.3.1 Dishwasher/Dryer with Disposables

NUMBER OF CONCEPTS CONSIDERED 12

ASSUMPTIONS

All the automatic dishwashing data found have been for single integrated washer/dryer units. Three washings per day were assumed, with 4.5 kg (10 lbs) of water used for washing and 4.5 kg (10 lbs) for rinsing. It is assumed that 0.09 kg (0.20 lb) of residual water remains on the dishes after washing to be removed by the dryer. Washing time and drying time are each assumed to be one hour.

The amount of dishes required by the crew, assuming an automatic dishwasher/dryer is aboard, was computed and included with the washer/dryer penalty. This was necessary to compare with the disposable dishes. The packaged weight and volume of the dishes were taken from the disposable dishes study (see results in Table B2-5). The total dishes/utensils/cups required with the dishwasher for a four-man crew is 4.6 kg (10.13 lbs) and 0.023 cu m (0.81 cu ft).

The four highest rated dishwasher/dryer concepts from the trade studies performed for appliance function 1.3.1 were selected to trade with eight of the highest rated disposable dishes cases.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 1.3.2 **** DISH WASHER/DRYER WITH DISPOSABLES - SHUTTLE

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	3.000	9	9.0720	.00	.0	.0	0.	247.	100.0	.0	321.6	.48	3	65	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(0.)	(845.)	50.0	.0	(709.0)	(16.90)			(.0)
2	3.000	9	9.0720	.00	.0	.0	164.	247.	111.0	.0	328.0	.48	3	50	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(561.)	(845.)	217.0	.0	(723.0)	(16.90)			(.0)
3	3.000	9	9.0720	.00	.0	.0	65.	246.	116.0	.0	325.5	.52	3	75	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(221.)	(839.)	108.0	.0	(717.7)	(18.50)			(.0)
4	3.000	9	9.0720	.00	.0	.0	40.	234.	14.7	.0	305.9	.30	2	35	.0
	2.000		(20.0000)	(.00)	(.0)	(.0)	(135.)	(800.)	45.0	.0	(674.3)	(10.70)			(.0)
5	3.000						0.	0.	.0	.0	20.3	.19	1	10	.0
	.333						(0.)	(0.)	.0	.0	(44.7)	(6.70)			(.0)
6	3.000						0.	0.	.0	.0	20.7	.46	1	10	.0
	.333						(0.)	(0.)	.0	.0	(45.7)	(16.40)			(.0)
7	3.000						0.	0.	.0	.0	19.8	.21	1	10	.0
	.333						(0.)	(0.)	.0	.0	(43.6)	(7.30)			(.0)
8	3.000						0.	0.	.0	.0	20.2	.48	1	10	.0
	.333						(0.)	(0.)	.0	.0	(44.6)	(17.10)			(.0)
9	3.000						0.	0.	.0	.0	15.5	.03	1	10	.0
	.333						(0.)	(0.)	.0	.0	(34.2)	(1.20)			(.0)
10	3.000						0.	0.	.0	.0	16.0	.31	1	10	.0
	.333						(0.)	(0.)	.0	.0	(35.2)	(10.90)			(.0)
11	3.000						0.	0.	.0	.0	15.0	.05	1	10	.0
	.333						(0.)	(0.)	.0	.0	(33.1)	(1.80)			(.0)
12	3.000						0.	0.	.0	.0	15.5	.33	1	10	.0
	.333						(0.)	(0.)	.0	.0	(34.1)	(11.60)			(.0)

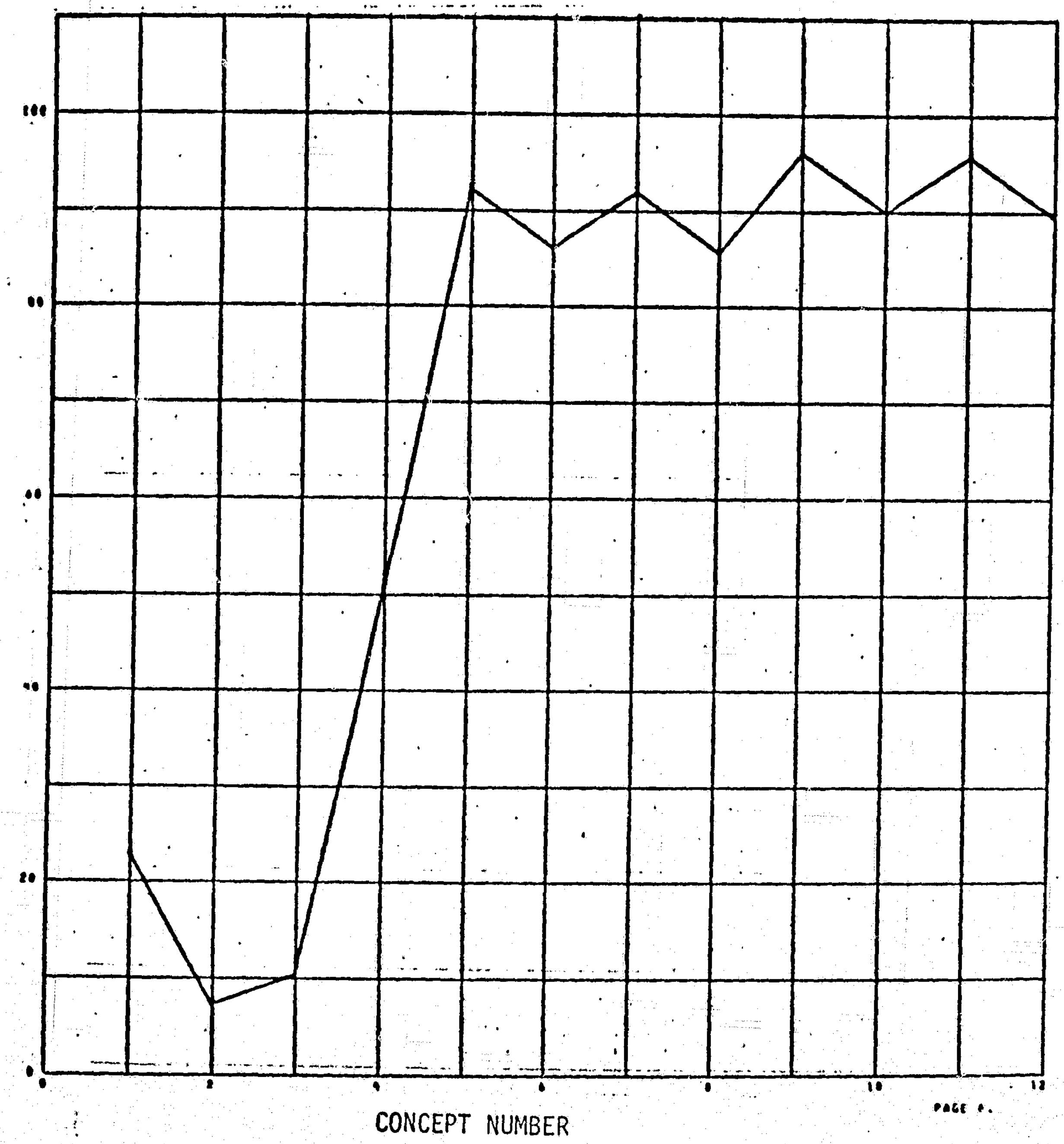
APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	HOT WATER SPRAY-CENTRIFUGE DRYING
2 -	HOT WATER SPRAY-FORCED HOT AIR ELECTRIC HEAT DRYING
3 -	HOT WATER SPRAY-FORCED AIR/DISICCANT/ELECTRICALLY HEATED
4 -	MANUAL WASH-MANUAL WIPE
5 -	DISPOSABLE CUPS-REUSABLE METALLIC UTENSILS AND DISHES
6 -	DISPOSABLE CUPS AND NONMETALLIC DISHES-REUSABLE METALLIC UTENSILS
7 -	DISPOSABLE CUPS AND NONMETALLIC UTENSILS-REUSABLE METALLIC DISHES
8 -	DISPOSABLE CUPS AND NONMETALLIC UTENSILS AND DISHES
9 -	REUSABLE CUPS AND METALLIC UTENSILS AND DISHES
10 -	REUSABLE CUPS AND METALLIC UTENSILS-DISPOSABLE NONMETALLIC DISHES
11 -	REUSABLE CUPS AND METALLIC DISHES--DISPOSABLE NONMETALLIC UTENSILS
12 -	REUSABLE CUPS-DISPOSABLE NONMETALLIC UTENSILS AND DISHES

(*)

1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST), KG/HR (LB/HR)
3 - OXYGEN (LOST), KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST), KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED), KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED), KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	HOT WATER SPRAY-CENTRIFUGE DRYING
2 -	HOT WATER SPRAY-FORCED HOT AIR ELECTRIC HEAT DRYING
3 -	HOT WATER SPRAY-FORCED AIR/DISICCANT/ELECTRICALLY HEATED
4 -	MANUAL WASH-MANUAL WIPE
5 -	DISPOSABLE CUPS-REUSABLE METALLIC UTENSILS AND DISHES
6 -	DISPOSABLE CUPS AND NONMETALLIC DISHES-REUSABLE METALLIC UTENSILS
7 -	DISPOSABLE CUPS AND NONMETALLIC UTENSILS-REUSABLE METALLIC DISHES
8 -	DISPOSABLE CUPS AND NONMETALLIC UTENSILS AND DISHES
9 -	REUSABLE CUPS AND METALLIC UTENSILS AND DISHES
10 -	REUSABLE CUPS AND METALLIC UTENSILS-DISPOSABLE NONMETALLIC DISHES
11 -	REUSABLE CUPS AND METALLIC DISHES--DISPOSABLE NONMETALLIC UTENSILS
12 -	REUSABLE CUPS-DISPOSABLE NONMETALLIC UTENSILS AND DISHES



Dishwasher/Dryer with Dishes (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 24
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • DISH WASHER/DRYER WITH DISPOSABLES - SHUTTLE
(01/30/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5	6	7	8	9	10	11	12
WEIGHT	33.100	723.00	15	.29	.00	.11	1.01	14.07	14.05	14.10	14.07	14.29	14.27	14.31	14.29
POWER	.00000	152.14	15	7.65	.00	4.36	12.32	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
VOLUME	1.2000	18.500	10	.86	.86	.00	4.22	6.38	1.14	6.05	.76	9.35	4.11	9.03	3.73
THERMAL	.00000	60.500	15	3.48	.00	2.19	3.25	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
RELIAB-Y	.99589	1.0000	5	1.95	.14	.00	3.32	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
MAINTENC	.99999	1.0000	5	1.37	.12	.00	3.07	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
SAFETY	.00000	2.0000	5	2.50	.00	2.50	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
DEV COST	10.000	75.000	15	2.00	5.00	.00	8.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
TOTAL PT	.00000	85.000	85	20.10	6.12	9.16	40.19	78.45	73.19	78.15	72.83	81.64	76.38	81.34	76.02
RATING	.00000	100.00	100	23.65	7.21	10.78	47.28	92.30	86.10	91.94	85.68	96.05	89.86	95.69	89.44

D2-119561-2

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT											
	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	23.65	7.21	10.78	47.28	92.30	86.10	91.94	85.68	96.05	89.86	95.69	89.44
WEIGHT	21.89	6.62	9.96	43.99	92.42	86.72	92.11	86.34	95.99	90.28	95.67	89.91
POWER	25.87	6.62	12.26	50.11	92.92	87.23	92.59	86.84	96.37	90.68	96.04	90.29
VOLUME	22.81	7.29	10.18	46.99	90.71	81.95	90.20	81.34	95.91	87.15	95.39	86.54
THERMAL	23.61	6.62	11.09	45.20	92.92	87.23	92.59	86.84	96.37	90.68	96.04	90.29
RELIAB-Y	24.08	7.08	10.47	47.82	92.52	86.50	92.17	86.09	96.16	90.15	95.82	89.74
MAINTENC	23.75	7.07	10.47	47.68	92.52	86.50	92.17	86.09	96.16	90.15	95.82	89.74
SAFETY	24.40	7.00	11.90	48.79	92.52	86.50	92.17	86.09	96.16	90.15	95.82	89.74
DEV COST	22.81	9.32	9.90	47.77	91.84	86.15	91.51	85.76	95.29	89.60	94.96	89.21

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT											
	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	23.65	7.21	10.78	47.28	92.30	86.10	91.94	85.68	96.05	89.86	95.69	89.44
WEIGHT	25.75	7.90	11.75	51.20	92.15	85.37	91.74	84.90	96.12	89.35	95.72	88.87
POWER	21.00	7.90	9.01	43.90	91.55	84.76	91.16	84.30	95.67	88.87	95.28	88.42
VOLUME	24.58	7.12	11.45	47.60	94.08	90.77	93.90	90.57	96.21	92.90	96.03	92.70
THERMAL	23.69	7.90	10.41	49.75	91.55	84.76	91.16	84.30	95.67	88.87	95.28	88.42
RELIAB-Y	23.18	7.34	11.10	46.70	92.06	85.68	91.70	85.25	95.93	89.55	95.56	89.12
MAINTENC	23.54	7.35	11.10	46.85	92.06	85.68	91.70	85.25	95.93	89.55	95.56	89.12
SAFETY	22.85	7.42	9.59	45.68	92.06	85.68	91.70	85.25	95.93	89.55	95.56	89.12
DEV COST	24.64	4.68	11.82	46.69	92.84	86.05	92.45	85.59	96.96	90.16	96.57	89.71

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.3.2-DISHWASHER/DRYER COMBINATIONS WITH DISPOSABLES (PAGE 1 OF 2)

COMPONENT TYPE / APPLIANCE TYPE (NO.)	MOTOR (1)	PUMP (2)	VALVE (3)	ACCUMULATOR (4)	WATER SEPARATOR (6)	TRANSMISSION (GEAR BOX) (7)	FILTER (9)	HEAT EXCHANGER (16)	CONTROLLER TIMER (19)	BLOWER AIR (18)	HEATER DC (17)	DESICCANT CANISTER (21)	( )	( )	( )	( )	NUMBER OF SAFETY CRITICAL ITEMS
HOT WATER SPRAY-CENTRIFUGE DRYING	2	1	2	2	1	1	1	-	1	-	-	-					1
HOT WATER SPRAY WASH-FORCED HOT AIR ELECTRIC HEAT DRYING (pg. 102)	2	1	2	2	1	1	1	1	1	1	1	-					2
HOT WATER SPRAY WASH-FORCED COLD AIR-DESICCANT-ELECTRICALLY HEATED (pg. 104)	2	1	3	2	1	1	1	1	1	1	1	1					1
MANUAL WASH-MANUAL WIPE	1	1	2	1	-	-	-	-	-	-	-	-					0
DISPOSABLE CUPS REUSABLE METALLIC KNIVES, FORKS, SPOONS REUSABLE METALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
DISPOSABLE CUPS REUSABLE METALLIC KNIVES, FORKS, SPOONS DISPOSABLE NONMETALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
DISPOSABLE CUPS DISPOSABLE NONMETALLIC KNIVES, FORKS, SPOONS REUSABLE METALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
DISPOSABLE CUPS DISPOSABLE NONMETALLIC KNIVES, FORKS, SPOONS DISPOSABLE NONMETALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 1.3.2-DISHWASHER/DRYER COMBINATIONS WITH DISPOSABLES (CONCLUDED) (PAGE 2 OF 2)

APPLIANCE TYPE \ COMPONENT TYPE / NO.	MOTOR ①	PUMP ②	VALVE ③	ACCUMULATOR ④	WATER SEPARATOR ⑥	TRANSMISSION (GEAR BOX) ⑦	FILTER ⑨	HEAT EXCHANGER ⑯	CONTROLLER TIMER ⑲	BLOWER AIR ⑱	HEATER DC ⑰	DESICCANT CANISTER ㉑	◯	◯	◯	◯	NUMBER OF SAFETY CRITICAL ITEMS
REUSABLE CUPS REUSABLE METALLIC KNIVES, FORKS, SPOONS REUSABLE METALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
REUSABLE CUPS REUSABLE METALLIC KNIVES, FORKS, SPOONS DISPOSABLE NONMETALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
REUSABLE CUPS DISPOSABLE NONMETALLIC KNIVES, FORKS, SPOONS REUSABLE NONMETALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0
REUSABLE CUPS DISPOSABLE NONMETALLIC KNIVES, FORKS, SPOONS DISPOSABLE NONMETALLIC DISHES	-	-	-	-	-	-	-	-	-	-	-	-					0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer with Dishes

APPLIANCE CONCEPT NO./TITLE 1/Hot Water Spray-Centrifuge Drying

INDEX NO. 1.3.2.1 REF. NO. 90

DESCRIPTION

This is the same concept presented in Section 1.3.1.1. It is included here to compare with the case where no dishwasher/dryer is used and dishes are either disposable or hand-wiped clean.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT *Hot water spray – centrifuge drying* INDEX NUMBER *1.3.2.1*

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
Motor		1						
Valves		0						
Pump		1						
			100 MAXIMUM		TOTAL	50 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
Motor				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	248 (845) WATT (BTU/HR)	248 (845) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT *Hot water spray - centrifuge dry* INDEX NUMBER *1.3.2.1*

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	33.5 (74.0) KG (LBS)	0.477 (16.9) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
Detergent/germicide	1	.010 (.012)	.012	.00029 .00035	.00035

Σ③ .012 TOTAL WT/CYCLE (LB) Σ⑤ .00035 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x .012 TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL/MISSION = 3 CYCLES/DAY x 20.5 DAYS/MISSION x .00035 TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF). (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water	10	0	0	10.
Rinse water	10	1.0	10	0

Σ① 20 Σ④ 10.

TOTAL WT./MISSION = 3 CYCLE/DAY x 20.5 DAYS/MISSION x 10. TOTAL LOST/CYCLE (Σ④) = 615 (LB) + 20 (Σ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer with Dishes

APPLIANCE CONCEPT NO./TITLE 2/Hot Water Spray - Forced Hot Air Electric Heat Drying

INDEX NO. 1.3.2.2 REF. NO. 90

DESCRIPTION: This is the same concept presented in Section 1.3.1.3. It is included here to compare with the case where no dishwasher/dryer is used and dishes are either disposable or hand-wiped clean.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray wash - forced hot air electric heat dry

INDEX NUMBER 1.3.2.2.

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Valving								
Fan								
Motor								
Heater								
Pump								
			111 MAXIMUM		TOTAL	217 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Pump				
Water heat loss (40°F)				
Fan				
Motor				
Heater				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	WATT (BTU/HR)	248 (845) WATT (BTU/HR)	165 (561) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray wash - Forced hot air electric heat dry INDEX NUMBER 1.3.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Fan		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	39.9 (88) KG (LBS)	7.7 (16.9) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①x④ (FT³)
Detergent/germicide					

Σ③ TOTAL WT/CYCLE (LB) Σ⑤ TOTAL VOL/CYCLE (FT³)

TOTAL WT. / MISSION = CYCLES/DAY x DAYS/MISSION x TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL / MISSION = CYCLES/DAY x DAYS/MISSION x TOT.VOL/CYCLE (FT³) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				

Σ① Σ④

TOTAL WT. / MISSION = CYCLE/DAY x DAYS/MISSION x TOTAL LOST/CYCLE (Σ④) = (LB) + (Σ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer with Dishes

APPLIANCE CONCEPT NO./TITLE 3/Hot Water Spray - Forced Air/Desiccant/Desorbed Electrical

INDEX NO. 1.3.2.3 REF. NO. 90

DESCRIPTION: This is the same concept presented in Section 1.3.1.4. It is included here to compare with the case where no dishwasher/dryer is used and dishes are either disposable or hand-wiped clean.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Hot water spray wash - forced cold air desiccant INDEX NUMBER 1.3.2.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Motor								
Fan								
Valves								
Pump								
Heater								
			116 MAXIMUM		TOTAL	97 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Pump				
Motor				
Fan				
Heater				
Water (drying)				
TOTAL	62 (212) WATT (BTU/HR)	246 (839) WATT (BTU/HR)	246 (839) WATT (BTU/HR)	65 (221) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Hot water spray wash- Forced cold air desiccant. INDEX NUMBER 1.3.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
Basic washer/dryer		
Pump		
2 Accumulators		
Valving		
Water separator		
Desiccant bed		
Fan		
Packaging		
Dishes/utinsels/cups		
Total		
TOTAL	37.5 (82.7) KG (LBS)	.525 (18.5) M³ (FT³)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT³)	⑤ VOL/CYCLE ①X④ (FT³)
Detergent/					
Germicide					

Σ③ ______ TOTAL WT/CYCLE (LB)   Σ⑤ ______ TOTAL VOL/CYCLE (FT³)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT³) = 0.00063 (0.02) M³ (FT³)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				

Σ① ______   Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer with Dishes

APPLIANCE CONCEPT NO./TITLE 4/Manual Wash - Manual Wipe Dry

INDEX NO. 1.3.2.4 REF. NO. 90

DESCRIPTION : This is the same concept presented in Section 1.3.1.10. It is a dishwasher concept which is manually operated by a crewman. It is included here to compare with the case where no dishwasher/dryer is used and dishes are either disposable or hand-wiped clean with wet and dry wipes.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Manual wash- Manual wipe dry INDEX NUMBER 1.3.2.4.

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
Towel Dryer							
		14.7 MAXIMUM		TOTAL	45 MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)				
Towel dryer				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	235 (800) WATT (BTU/HR)	39 (135) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Manual wash - Manual wipe dry INDEX NUMBER 1.3.2.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
Basic washer		
Towel dryer		
Dishes/utinsels/cups		
TOTAL	17.9 (39.3) KG (LBS)	0.31 (10.7) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
Detergent/ germicide					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.WT/CYCLE (LB) = 0.3 (0.7) KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.VOL/CYCLE (FT^3) = 0.00063 (0.02) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
Wash water				
Rinse water				

Σ① ______ Σ④ ______

TOTAL WT. MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = 288 (635) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Food Management HABITABILITY FUNCTION Galley Cleanup

APPLIANCE FUNCTION Dishwasher/Dryer with Dishes

APPLIANCE CONCEPT NO./TITLE 5 through 12/Disposable-Reusable Dishes

INDEX NO. 1.3.2.5 through 1.3.2.12 REF. NO. 100, 174, 177, 250, 276

DESCRIPTION

A detailed study was made of the food utensils, trays, and cups to determine the optimum selection from among a wide variety of possible combinations. The possible choices considered in each case are explained in the following paragraphs.

CUPS

Disposable nonmetallic. This is a prefilled collapsible plastic bellows type of cup used on Skylab. The cup is disposed of after use. Data for this case were taken directly from the Skylab cups (Reference 250). The number of cups used was based on the initial Skylab launch value of 1610 cups for 420 planned man-days.

Reusable metallic. This method of drinking resembles drinking from a cup with a straw as on Earth. It was tried on Skylab and was found to be quite satisfactory if the right size of straw is used. Data for this case were taken from Reference 276. It was assumed each man had two cups. One wet and one dry wipe were assumed to be used for each cup use, with the number of cup uses the same as for the disposable nonmetallic case.

UTENSILS - KNIFE/FORK/SPOON

Disposable metallic. This case was included for comparison purposes, although it resulted in a high penalty. Utensil weight and volume for stainless steel utensils, as on Skylab, were taken from Reference 250 and 177. It was assumed one knife/fork/spoon set per man for each meal was used, with no spares.

Reusable metallic. The same utensils as in the above case were assumed, with one wet wipe per man per meal allowed for cleaning as on Skylab. Since Skylab had three extra utensil sets (Reference 250) for a three-man crew, it was assumed one extra set was allowed per man.

Disposable nonmetallic. Data for this case were taken from References 174 and 177, with a 10 percent packaging factor included. One set per man per meal was assumed.

SERVING TRAYS

Two basic types of trays were considered: (1) ordinary dish type and (2) food warming trays. It was assumed the dish type of tray would be used with bulk food packaging, while the warming trays would be used with individual food cans.

APPLIANCE CONCEPT NO./TITLE 5 through 12/Disposable-Reusable Dishes (Continued)

DESCRIPTION

For direct comparison, a food packaging penalty was added to the warming trays to account for the individual food cans. These penalties were taken from Reference 276 for the food mix assumed in this study shown previously for the Food Habitability System 2.0. The resulting penalties are shown in Table B2-3.

Reusable heating type. This concept assumed reusable metallic covers for a heating tray, with two wet wipes and one dry wipe allowed to clean the cover. Data for the covers were from Reference 177, and include a 1 0 percent packaging factor. The food packaging penalty described previously for individual cans was added to the total weight and volume for this case. Based on the Skylab use of five food trays for a three-man crew (Reference 250), it was assumed six heating tray covers allowed for Shuttle.

Reusable metallic dish. Data for the dishes in this case were identical (Reference 177) to the reusable heating tray covers discussed previously, except that bulk food is assumed here with no packaging penalty. Again, two wet wipes and one dry wipe were assumed to clean the dishes per man.

Disposable metallic dish. Weight and volume for this type of dish were assumed the same as for the two previous cases. One dish per man per meal was assumed, with no wipes. Bulk food packaging was assumed; thus, no packaging penalty was added.

Disposable nonmetallic dish. Data for this case are identical to those for the disposable metallic dishes above except for dish weight. Dish weight was estimated using the same ratio used previously for metallic and non-metallic utensils.

The data for all the previous cases are tabulated in Table B2-4 for the Shuttle case. The best eight cases were chosen by inspection, as indicated in the table, and included in the trades. To compare the previous cases with a dishwasher/dryer concept, a set of reusable utensils/dishes/cups to be used with the washer was selected from the previous cases. The number, weight, and volume for these items are shown in Table B2-5. These penalties were added onto the basic washer/dryer penalties given in Section 1.3.1 for direct comparison in the trades. The four best dishwasher/dryer concepts from the trades of Section 1.3.1 were selected in this section to trade with the eight best disposable dishes cases.

TABLE B2-3

PENALTIES ASSOCIATED WITH VARIOUS TYPES OF DISPOSABLE DISHES CONCEPTS FOR SHUTTLE FOUR-MAN CREW

DISPOSABLE DISHES - TYPE		NUMBER	PACKAGED WEIGHT kg (lb)	PACKAGED VOLUME cu m (cu ft)
CUPS	Disposable Nonmetallic	314	(21.5)	(5.95)
	VEHICLE PENALTY		9.8	.169
	Reusable Metallic	8	(2.0)	(.187)
	Wet Wipes	314	(5.84)	(.135)
	Dry Wipes	314	(3.12)	(.125)
	TOTAL		(11.0)	(.45)
	VEHICLE PENALTY		5.0	.00127
KNIVES/ FORKS/ SPOONS	Metallic Disposable Utensils	246	(61.2)	(2.07)
	VEHICLE PENALTY		27.8	.0586
	Metallic Reusable Utensils	6	(1.45)	(.055)
	Wet Wipes	246	(4.58)	(.106)
	TOTAL		(6.03)	(.161)
	VEHICLE PENALTY		2.74	.00456
	Disposable Nonmetallic Utensils	246	(4.87)	(.81)
	VEHICLE PENALTY		2.21	.0229
TRAYS	Reusable Heating-type Tray Covers	6	(5.58)	(.252)
	Wet Wipes	492	(9.15)	(.211)
	Dry Wipes	246	(2.44)	(.098)
	Food Packaging Penalty		(42.6)	(4.01)
	TOTAL		(59.77)	(4.57)
	VEHICLE PENALTY		27.1	.129
	Reusable Metallic Dish-type Tray	6	(5.58)	(.252)
	Wet Wipes	492	(9.15)	(.211)
	Dry Wipes	246	(2.44)	(.098)
	TOTAL		(17.17)	(.561)
	VEHICLE PENALTY		7.79	.0159
	Disposable Metallic Dish-type Tray	246	(230)	(10.3)
	VEHICLE PENALTY		104	.292
	Disposable Nonmetallic Dish-type Tray	246	(18.2)	(10.3)
	VEHICLE PENALTY		8.3	.292

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TABLE B2-4

VEHICLE PENALTIES FOR VARIOUS DISPOSABLE DISHES CONCEPTS ASSUMING NO DISHWASHER AVAILABLE

DISPOSABLE DISHES (TYPE)			SHUTTLE				CONCEPT NUMBER
CUPS	KNIVES, FORKS, SPOONS	TRAYS	WEIGHT		VOLUME		
			LBS	KG	CU FT	CU M	
DISPOSABLE NONMETALLIC	DISPOSABLE METALLIC	REUSABLE HEATING TYPE	142.5	64.6	12.6	.357	*
		REUSABLE METALLIC DISH	99.9	45.3	8.6	.244	*
		DISPOSABLE METALLIC DISH	312.7	141.8	18.3	.518	*
		DISPOSABLE NONMETALLIC DISH	100.9	45.8	18.3	.518	*
	REUSABLE METALLIC	REUSABLE HEATING TYPE	87.3	39.6	10.7	.303	*
		REUSABLE METALLIC DISH	44.7	20.3	6.7	.190	1.3.2.5
		DISPOSABLE METALLIC DISH	257.5	116.8	16.4	.464	*
		DISPOSABLE NONMETALLIC DISH	45.7	20.7	16.4	.464	1.3.2.6
	DISPOSABLE NONMETALLIC	REUSABLE HEATING TYPE	86.2	39.1	11.3	.320	*
		REUSABLE METALLIC DISH	43.6	19.8	7.3	.207	1.3.2.7
		DISPOSABLE METALLIC DISH	256.4	116.3	17.1	.484	*
		DISPOSABLE NONMETALLIC DISH	44.6	20.2	17.1	.484	1.3.2.8
REUSABLE METALLIC	DISPOSABLE METALLIC	REUSABLE HEATING TYPE	132.0	59.9	7.1	.201	*
		REUSABLE METALLIC DISH	89.4	40.6	3.1	.088	*
		DISPOSABLE METALLIC DISH	302.2	137.1	12.8	.362	*
		DISPOSABLE NONMETALLIC DISH	90.4	41.0	12.8	.362	*
	REUSABLE METALLIC	REUSABLE HEATING TYPE	76.8	34.8	5.2	.147	*
		REUSABLE METALLIC DISH	34.2	15.5	1.2	.034	1.3.2.9
		DISPOSABLE METALLIC DISH	247.0	112.0	10.9	.309	*
		DISPOSABLE NONMETALLIC DISH	35.2	16.0	10.9	.309	1.3.2.10
	DISPOSABLE NONMETALLIC	REUSABLE HEATING TYPE	75.7	34.3	5.8	.164	*
		REUSABLE METALLIC DISH	33.1	15.0	1.8	.051	1.3.2.11
		DISPOSABLE METALLIC DISH	245.9	111.5	11.6	.329	*
		DISPOSABLE NONMETALLIC DISH	34.1	15.5	11.6	.329	1.3.2.12

*These concepts were not pursued further due to large penalties.

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TABLE B2-5

WEIGHT AND VOLUME OF DISHES/UTENSILS/CUPS TO BE USED WITH AUTOMATIC DISHWASHER/DRYER FOR SHUTTLE FOUR-MAN CREW

	NUMBER	PACKAGED WEIGHT kg (lb)	PACKAGED VOLUME cu m (cu ft)
DISH/TRAY	6	2.53 (5.58)	0.0071 (0.25)
KNIVES/FORKS/SPOONS	6	0.66 (1.45)	0.00156 (0.055)
CUPS	8	0.9 (2.0)	0.00530 (0.187)
TOTAL VEHICLE PENALTY		4.10 (9.03)	0.014 (0.49)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

APPLIANCE FUNCTIONS CONSIDERED

2.1.1 Fecal Collection/Transfer
2.1.2 Urine Collection/Transfer
2.1.3 Vomitus Collection/Transfer
2.2.1 Whole Body Shower
2.2.2 Partial Body Washing
2.2.3 Partial Body Drying
2.3.1 Shaving
2.3.2 Hair Cutting
2.3.3 Nail Care
2.3.4 Dental

DESCRIPTION

The personal hygiene habitability subsystem provides for waste collection/transfer, body cleansing, and personal grooming. The concepts selected for trade included consideration of the zero-gravity effect on liquid flow and containment, the elimination and/or control of contamination which is easily spread in a zero-gravity environment, and the disposal of waste products within the spacecraft in the absence of the normal terrestrial sewers/septic tanks. These requirements must be satisfied with maximum safety and minimum weight, volume, and use of consumables. Waste collection appliance functions accommodate all of the bodily waste functions. Both partial and whole body washing techniques were considered during the study. The remaining personal hygiene appliance functions presented are for such crewman functions as shaving and hair cutting. The appliance concepts were evaluated to be functionally adequate and acceptable to the crewmembers from both physiological and psychological aspects prior to including them as viable concepts.

The fecal and urine collection/transfer appliance functions were considered separately for the purposes of trade studies. The two functions would most probably be combined for a space vehicle because of the attendant reduction in weight, volume, power, and thermal.

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.1 Waste Collection/Transfer

APPLIANCE FUNCTION 2.1.1 Fecal Collection/Transfer

NUMBER OF CONCEPTS CONSIDERED 9

ASSUMPTIONS

(1) The fecal collection/transfer concepts consider wet, dry, chemical, decomposition, and incineration methods for disposing of fecal waste.

(2) The study assumed one defecation per day per man. The concept use time required per defecation is dependent on the concept type.

(3) Filter weight and volume were included if a high replacement frequency is required. Periodic filter replacement was not included in the study.

(4) Component power requirements were normalized to provide a fair comparison of all concepts. The power requirements were not based on the latest fecal collector designs. This was done because the various manufacturers were in process of a competitive proposal response for the Shuttle waste collection system and could not be contacted for additional information.

(5) Overboard venting was not allowed with the exception of nonfilterable gases. Concepts were modified to satisfy this requirement by adding a vacuum pump to the concept.

(6) Fecal collection concepts requiring a day for decomposition of wastes and cooldown were allocated at one per crewman. The remaining concepts were provisioned at one per vehicle.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.1.1 •••• FECES COLLECTION/TRANSFER (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	4.000	1	.0000	9.44	.0	21.1	0.	200.	675.0	440.0	107.3	.85	2	25	.0
	.150		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(683.)	62.0	52.0	(236.5)	(30.00)			(.0)
		6	.0000	.00	.0	21.1									
			(.0000)	(.00)	(.0)	(70.0)									
2	4.000	1	.0000	9.44	.0	21.1	0.	474.	680.0	440.0	356.8	1.59	2	30	.0
	.225		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(1619.)	420.0	360.0	(786.6)	(56.00)			(.0)
		5	1.4969	88.91	1034.3	32.2									
			(3.3000)	(196.00)	(20.0)	(90.0)									
		6	.0000	.00	1551.4	21.1									
			(.0000)	(.00)	(30.0)	(70.0)									
3	4.000	1	.0000	9.44	.0	21.1	0.	188.	400.0	280.0	148.3	2.02	2	45	.0
	.158		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(642.)	46.0	36.0	(326.9)	(71.50)			(.0)
4	4.000	1	.0000	9.44	.0	21.1	0.	1499.	500.0	360.0	163.5	3.61	3	60	.0
	6.000		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(5120.)	1110.0	1100.0	(340.5)	(127.50)			(.0)
5	4.000	3	.1941	.00	.0	21.1	0.	1196.	500.0	360.0	187.6	3.50	3	65	.0
	6.000		(.4280)	(.00)	(.0)	(70.0)	(0.)	(4085.)	650.0	640.0	(413.6)	(123.50)			(.0)
6	4.000	3	.0572	.00	.0	21.1	0.	1498.	500.0	360.0	176.4	2.59	3	70	.0
	6.000		(.1260)	(.00)	(.0)	(70.0)	(0.)	(5115.)	1150.0	1140.0	(388.8)	(91.50)			(.0)
7	4.000	3	.0767	.00	62058.0	21.1	0.	1050.	600.0	380.0	486.8	4.21	3	75	.0
	3.000		(.1690)	(.00)	(1200.0)	(70.0)	(0.)	(3586.)	640.0	630.0	(1073.3)	(148.50)			(.0)
8	4.000	1	.0000	3.78	.0	21.1	0.	808.	600.0	380.0	46.7	.50	1	10	.0
	.180		(.0000)	(8.00)	(.0)	(70.0)	(0.)	(2760.)	255.0	245.0	(102.9)	(17.80)			(.0)
9	4.000						0.	0.	.0	.0	9.1	.04	1	0	.0
	1.500						(0.)	(0.)	.0	.0	(20.0)	(1.40)			(.0)

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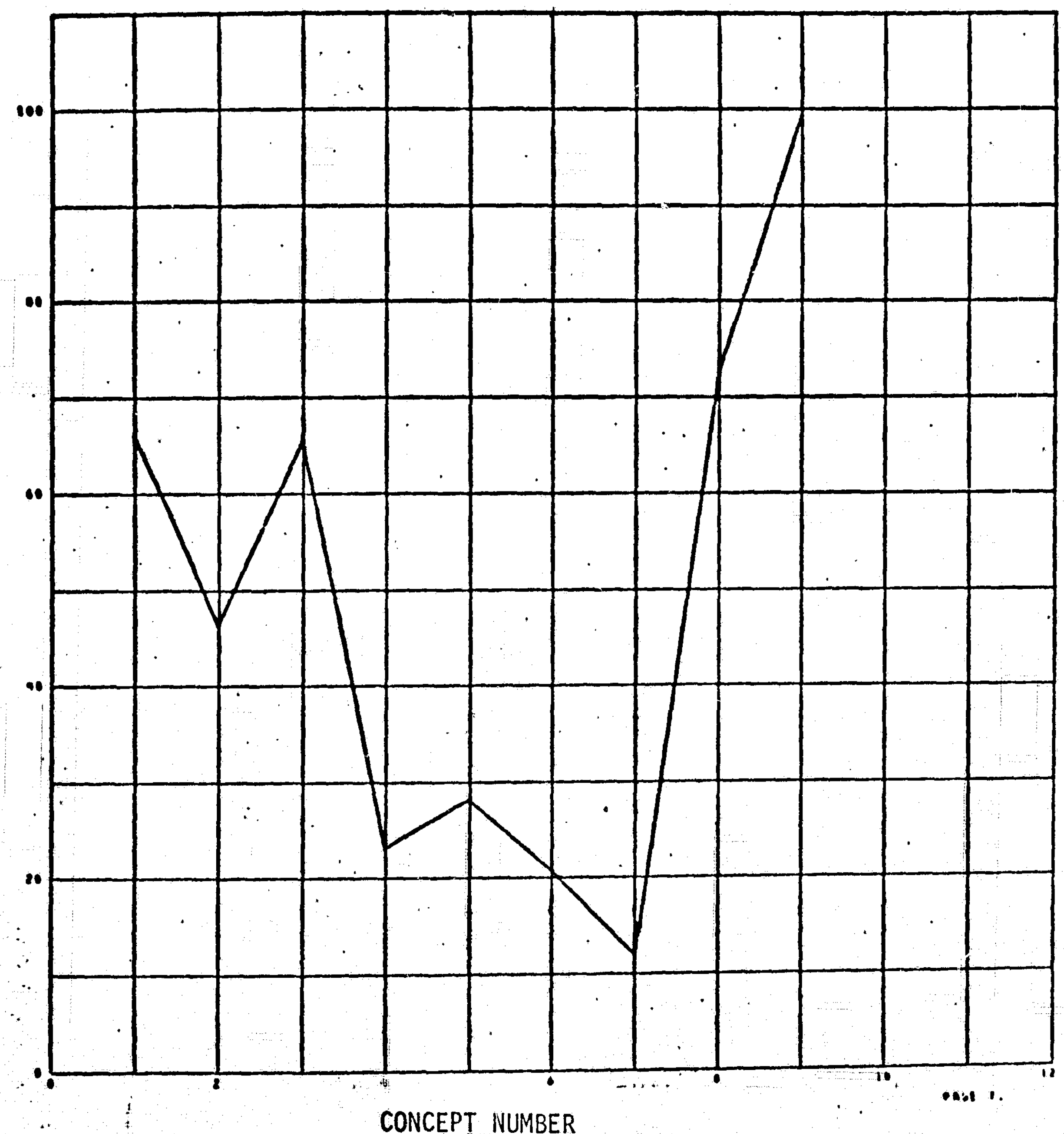
APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	DRY JOHN
2 -	DRY JOHN-ANAL WASH
3 -	GERMICIDE
4 -	INTEGRATED VACUUM DECOMPOSITION
5 -	FLUSH FLOW OXYGEN INCINERATION
6 -	PYROLYSIS/BATCH-INCINERATION
7 -	WET OXIDIZATION
8 -	SEMIAUTOMATIC BAG SYSTEM (SKYLAB)
9 -	DRY BAGS (APOLLO).

(*)

1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.		CONCEPT NAME
1	-	DRY JOHN
2	-	DRY JOHN-ANAL WASH
3	-	GERMICIDE
4	-	INTEGRATED VACUUM DECOMPOSITION
5	-	FLUSH FLOW OXYGEN INCINERATION
6	-	PYROLYSIS/BATCH INCINERATION
7	-	WET OXIDIZATION
8	-	SEMIAUTOMATIC BAG SYSTEM (SKYLAB)
9	-	DRY BAGS (APOLLO)



Fecal Collection/Transfer (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 25
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . FECES COLLECTION/TRANSFER (SHUTTLE)
(01/17/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5	6	7	8	9
WEIGHT	20.000	1073.3	15	11.69	4.01	10.43	9.96	9.22	9.57	.00	13.56	14.72
POWER	.00000	759.50	15	7.41	4.32	10.42	.34	4.25	.00	3.28	6.55	15.00
VOLUME	1.4000	148.50	10	7.98	6.23	5.19	1.41	1.68	3.84	.00	8.80	9.91
THERMAL	.00000	281.60	15	13.00	10.26	13.12	.00	3.03	.01	4.49	6.91	15.00
RELIAB-Y	.97601	1.0000	5	4.91	4.83	4.94	.80	.30	.00	2.35	4.92	5.00
MAINTENC	.99998	1.0000	5	1.10	.45	2.09	1.48	1.06	.89	.00	2.93	5.00
SAFETY	.00000	2.0000	5	.00	.00	2.50	2.50	2.50	2.50	.00	5.00	5.00
DEV COST	.00000	75.000	15	10.00	9.00	6.00	3.00	2.00	1.00	.00	13.00	15.00
TOTAL PT	.00000	85.000	85	56.10	39.09	54.69	19.49	24.03	17.81	10.13	61.68	84.63
RATING	.00000	100.00	100	66.00	45.99	64.34	22.93	28.27	20.95	11.92	72.57	99.56

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6	7	8	9
NORMAL	66.00	45.99	64.34	22.93	28.27	20.95	11.92	72.57	99.56
WEIGHT	66.97	44.43	64.74	26.46	30.96	24.42	10.95	74.01	99.44
POWER	64.65	44.60	64.74	21.26	28.28	19.25	12.73	70.23	99.60
VOLUME	66.76	46.90	63.65	22.44	27.64	21.92	11.26	73.43	99.53
THERMAL	67.67	47.81	66.21	21.07	27.62	19.26	13.38	70.42	99.60
RELIAB-Y	66.92	47.44	65.32	22.73	27.63	20.35	12.92	73.31	99.57
MAINTENC	64.74	44.94	63.70	23.17	28.07	20.86	11.58	72.17	99.57
SAFETY	64.11	44.68	63.93	23.71	28.89	21.78	11.58	73.35	99.57
DEV COST	66.05	47.13	62.37	22.69	27.06	19.79	10.95	73.71	99.60

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6	7	8	9
NORMAL	66.00	45.99	64.34	22.93	28.27	20.95	11.92	72.57	99.56
WEIGHT	64.84	47.86	63.84	18.72	25.06	16.81	13.07	70.84	99.70
POWER	67.60	47.66	63.84	24.93	28.27	22.98	10.95	75.36	99.52
VOLUME	65.13	44.97	65.12	23.48	28.99	19.86	12.66	71.60	99.59
THERMAL	64.00	43.83	62.10	25.15	29.05	22.97	10.17	75.13	99.52
RELIAB-Y	65.02	44.46	63.30	23.14	28.95	21.59	10.85	71.78	99.55
MAINTENC	67.33	47.11	65.02	22.73	28.49	21.05	12.28	72.99	99.55
SAFETY	68.00	47.39	64.77	22.11	27.61	20.07	12.28	71.74	99.55
DEV COST	65.93	44.64	66.69	23.27	29.72	22.33	13.07	71.20	99.52

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.1.1-FECAL COLLECTION/TRANSFER

APPLIANCE TYPE \ COMPONENT TYPE	VALVE SOLENOID	BLOWER	CHECK VALVES	PRESSURE REGULATOR	FILTER	PUMP	CONTROLLER TIMER	MANUAL VALVE	MOTOR	HEATER	ACCUMULATOR						NUMBER OF SAFETY CRITICAL ITEMS
NO.	3	18	22	11	9	2	19	23	1	17	4						
VACUUM DRY o NO ANAL WASH o NONVENTED	4	1	2	1	2	1	1	-	2	-	1						2
VACUUM DRY o ANAL WASH o NONVENTED	6	1	1	3	3	1	1	2	2	1	2						2
GERMICIDE o NO ANAL WASH	2	1	1	-	2	-	1	1	2	-	2						1
INTEGRATED VACUUM DECOMPOSITION o NO ANAL WASH	14	2	2	-	2	-	1	-	-	6	6						1
FLUSH FLOW OXYGEN INCINERATION o NO ANAL WASH	21	2	2	-	2	-	1	-	-	6	6						1
PYROLYSIS/BATCH INCINERATION o NO ANAL WASH	21	2	2	1	2	-	1	-	-	6	7						1
WET OXIDATION o NO ANAL WASH	27	1	-	1	2	1	1	-	1	6	7						2
SEMIAUTOMATIC BAG SYSTEM (SKYLAB) o NO ANAL WASH	-	1	6	-	2	-	1	7	-	3	-						0
DRY BAGS	-	-	-	-	-	-	-	-	-	-	-						0

SPACECRAFT Shuttle

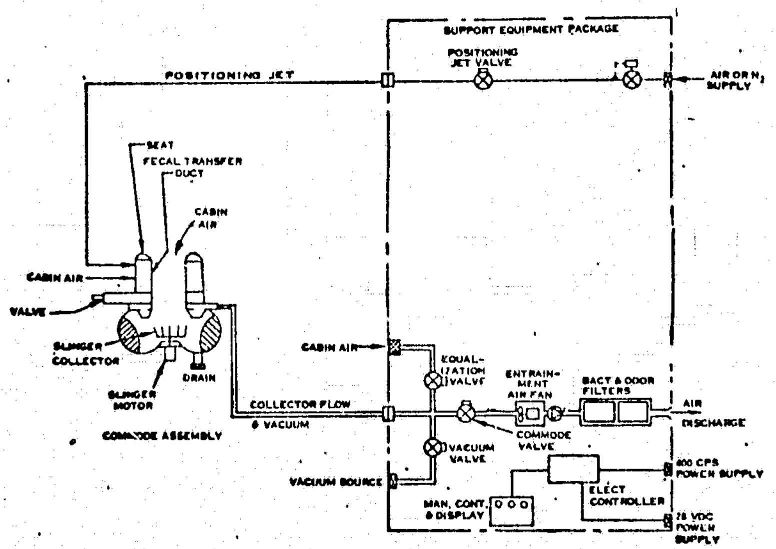
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 1/Dry John

INDEX NO. 2.1.1.1 REF. NO. 207,209,250, & 273

DESCRIPTION The dry john commode assembly serves as a waste collector and feces storage/processing unit. The seat is similar to the terrestrial type with modifications necessary for zero-gravity usage. The feces are transferred to the storage/processing section (collector) via the fecal transfer duct. The fecal transfer duct contains provisions for entrainment airflow for separating and moving the stool from the anus to the collector. Air positioning jets shown on the schematic are used to assist the user in positioning properly on the seat. This portion of the system was not considered part of the appliance, since recent tests have shown the jets are not necessary. The interface between the transfer duct and the feces collector is the collector valve. The valve is manually actuated and seals the collector after use to permit vacuum drying of the feces. A slinger is incorporated to maximize the feces and wipes area exposed to vacuum by depositing the feces and wipes on the wall of the collector. Entrainment air and air removed by the vacuum pump are passed through filters and returned to the cabin. The schematic does not show a vacuum pump; however, the vacuum pump was added to the appliance concept to satisfy the vehicle requirement of no venting external to the spacecraft.



5/5

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT I/DRY JOHN

INDEX NUMBER 2.1.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
~~[illegible]~~ MOTOR (209)	.10	75	60	6	—	—	—
AIR FAN (209)	.10	250	180	18	—	—	—
VACUUM PUMP (209)	.05	350	200	10	—	—	—
SOLENOID VALVES (4) (209)	MOMENTARY	—	—	—	32	32	—
CONTROLLER/TIMER (209)	.15	—	—	—	30	20	3.0
		675 MAXIMUM		34 TOTAL	62 MAXIMUM		3.0 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
~~[illegible]~~ MOTOR	—	103.3	103.3	—
AIR FAN	—	341	341.0	—
VACUUM PUMP	—	238.7	238.7	—
TOTAL	WATT (BTU/HR)	200.3 (683) WATT (BTU/HR)	200.3 (683) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	EXPENDABLE (LB/CYCLE)	THERMAL (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A —					
TOTAL	KG/CYCLE (LB/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/DRY JOHN INDEX NUMBER 2.1.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE/COMPONENTS (209)	87	3.0
PACKAGING	105	26.0
VACUUM PUMP	38	.5
WIPES	6.54	.3
TOTAL	107.3 (236.5) KG (LBS)	.84 (29.8) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184

Σ③ .0798 TOTAL WT/CYCLE (LB)   Σ⑤ .0038 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0798 TOT.WT/CYCLE (LB) = 2.97 (6.54) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0038 TOT.VOL/CYCLE (FT^3) = .009 (.313) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ① ______   Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 2/Dry John with Anal Wash

INDEX NO. 2.1.1.2 REF. NO. 207,209, & 273

DESCRIPTION Same as Concept 1, Dry John, with the incorporation of an anal wash. The anal wash and air dry eliminates the need for expendable wipes. The addition of the anal wash requires the feces collector duct be rinsed with a biocide. The anal wash and commode rinse water are assumed to be recovered within the efficiencies of the vapor compression distillation unit.

2/5

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/DRY JOHN/ANAL WASH — INDEX NUMBER 2.1.1.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
SLINGER MOTOR (209)	.167	80	60	10.02	—	—	—
AIR HEATER (209)	.050	—	—	—	350	300	15.0
SOLENOID VALVES (SY209)	NOMINAL*	—	—	—	40	40	—
AIR FAN (209)	.167	250	180	30.06	—	—	—
CONTROL UNIT/TIMER (209)	.217	—	—	—	30	20	4.3
VACUUM PUMP (209)	.050	350	200	10	—	—	—
		680 MAXIMUM		50.1 TOTAL	420 MAXIMUM		19.3 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
HEATED WATER	—	394	394	—
HEATER AIR	—	238	238	—
SLINGER MOTOR	—	181.4	181.4	—
AIR FAN	—	567.6	567.6	—
VACUUM PUMP	—	238.4	238.4	
TOTAL	WATT (BTU/HR)	474 (1619.4) WATT (BTU/HR)	474 (1619.4) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	EXPENDABLE (LB/CYCLE)	THERMAL (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	KG/CYCLE (LB/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/DRY JOHN/ANAL WASH INDEX NUMBER 2.1.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE COMPONENTS	(207 & 209)	115	4
PACKAGING	(207 & 209)	105	26
PROCESSING COMPONENTS	(207 & 209)	168	15
PACKAGING	(207 & 209)	128	11
TOTAL		234 (516) KG (LBS)	1.59 (56) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
N/A —					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER (ANAL WASH)	1.65 (207)	N/A —	N/A	1.65
WATER (COMMODE RINSE)	1.65 (207)	N/A	N/A	1.65

Σ① 3.30 Σ④ 3.30

TOTAL WT. MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x 3.30 TOTAL LOST/CYCLE (Σ④) = 270.6 (LB) + N/A (Σ①) = 122.7 (270.6) KG (LB)

SPACECRAFT Shuttle

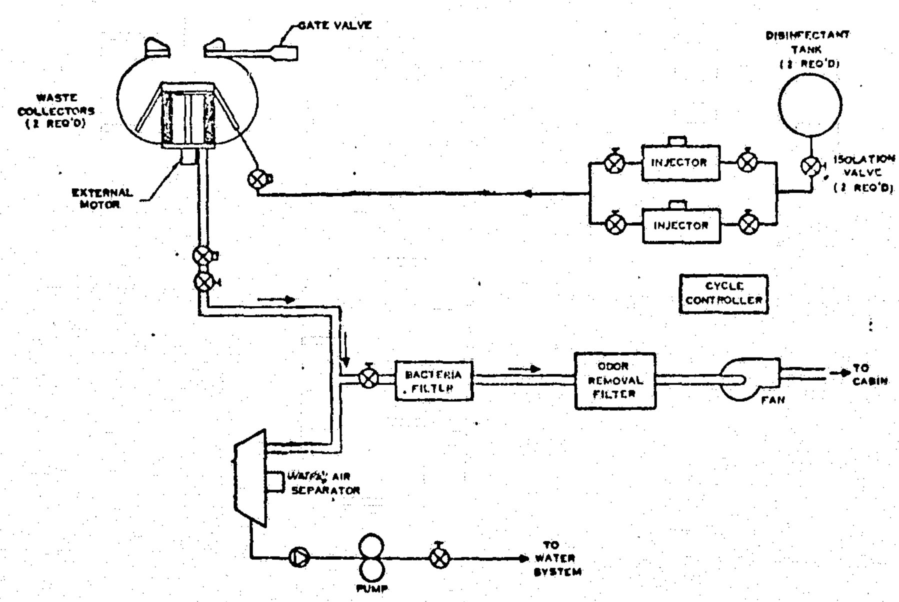
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 3/Liquid Germicide

INDEX NO. 2.1.1.3 REF. NO. 100,207,209,244,250, & 273

DESCRIPTION The liquid germicide commode assembly incorporates a strong biocidal agent throughout the excreta to kill the microorganism population and maintain sterility in storage. The waste collector is provided with a blender and germicidal metering equipment. The blender is used to ensure thorough mixing of the wastes and germicide. The collector gate valve is open only during waste collection. When the container is full, the tank is sealed, removed to storage, and replaced with an empty tank. The waste collectors are sized for replacement every 50 days. Some liquid is recovered, separated, and returned to the water waste management system. Air entrainment of the feces as previously described in Concept 1, is utilized with the air returned through filters to the cabin. The collector when transferred to storage will weigh 332 pounds. Wet and dry wipes are used for this concept and are assumed to be deposited into the collector. The concept was not given credit for liquid recovery, since the majority of the liquid is held in the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/LIQUID GLUTAMICIDE INDEX NUMBER 2.1.1.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
BLENDER MOTOR (100,204)	.05	150	100	5	—	—	—
SOLENOID VALVE (2)	.158	—	—	—	16	16	—
AIR FAN ASSEMBLY	.158	250	180	28.4	—	—	—
CONTROLLER/TIMER	.158	—	—	—	30	20	3.2
		400 MAXIMUM		33.4 TOTAL	46 MAXIMUM		3.2 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
BLENDER MOTOR	N/A	102.3	102.3	N/A
AIR FAN ASSEMBLY (INCLUDES SEPARATOR)	N/A	539.9	539.9	N/A
TOTAL	WATT (BTU/HR)	188.3 (642.2) WATT (BTU/HR)	188.3 (642.2) WATT (BTU/HR)	WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/LIQUID GERMICIDE   INDEX NUMBER 2.1.1.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
LIQ. GERMICIDE SYS. (100, 294)	270	71
WET/DRY WIPES	6.54	.313
TOTAL	125.4 (276.5) KG (LBS)	2.02 (71.3) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184

Σ③ .0798 TOTAL WT/CYCLE (LB)   Σ⑤ .0038 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0798 TOT. WT/CYCLE (LB) = 2.97 (6.54) KG (LB)

TOTAL VOL / MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0038 TOT. VOL/CYCLE (FT^3) = .009 (.313) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
LIQUID GERMICIDE	.615 (100)	N/A	N/A	.615

Σ① .615   Σ④ .615

TOTAL WT. / MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x .615 TOTAL LOST/CYCLE (Σ ④) = 50.43 (LB) + N/A (Σ ①) = 22.9 (50.43) KG (LB)

SPACECRAFT Shuttle

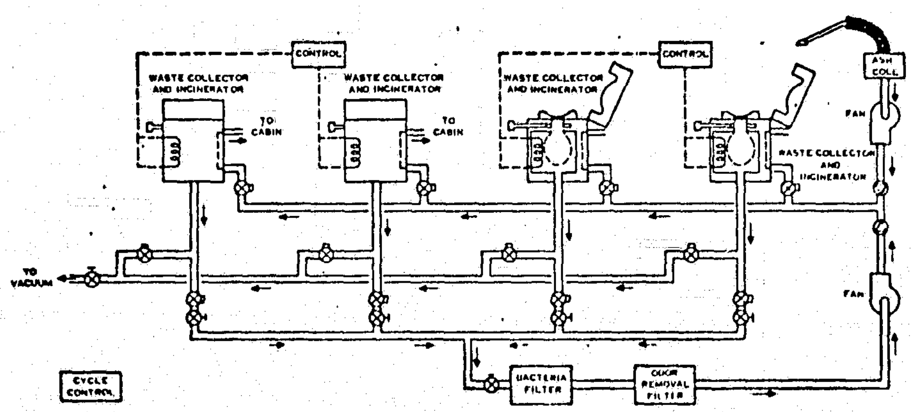
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 4/Integrated Vacuum Decomposition

INDEX NO. 2.1.1.4 REF. NO. 100,250, & Skylab data

DESCRIPTION The integrated vacuum decomposition concept utilizes vacuum and high temperature to decompose the waste materials into gaseous products which can be exhausted to vacuum. The chamber requires cooldown and must be vacuumed at the end of the cooldown period. The process does not require oxygen; however, requires power to sustain the chemical process for 12 hours. Six commodes were assumed to be required due to the 12-hour cooldown time (i.e., one unit can be used once per day). Incinerable collection bags with a hydrophobic patch (Skylab type utilized) were used to eliminate the maintenance and microbiological problems of filter replacement, since clogging is not anticipated with collection bags which are replaced every 24 hours. The residual ash was not considered as a concept penalty. Air entrainment of the feces, as previously described in Concept 1, is utilized with the air returned through filters to the cabin. Wet and dry wipes are used for this concept and are assumed to be deposited into the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 4/INTEGRATED VACUUM DECOMPOSITION

INDEX NUMBER 2.1.1.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	AC POWER (3) AVERAGE (WATTS)	AC POWER (4) DEMAND (WATT-HR/CYCLE) (1)X(3)	DC POWER (5) PEAK (WATTS)	DC POWER (6) AVERAGE (WATTS)	DC POWER (7) DEMAND (WATT-HR/CYCLE) (1)X(7)
AIR FAN ASSY (100)	12	500	360	4320	—	—	—
SOLENOID VALVES (6)	MOMENTARY	—	—	—	40	40	—
VAC. SOLEN. VALVES (6)	MOMENTARY	—	—	—	40	40	
HEATER	12	—	—	—	1000	1000	12000
CONTROLLER/TIMER	24	—	—	—	30	20	480
		500 MAXIMUM		4320 TOTAL	1110 MAXIMUM		12480 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
FAN ASSY	—	1710	1710	—
HEATERS		3410	3410	
TOTAL	WATT (BTU/HR)	1499 (5120) WATT (BTU/HR)	1499 (5120) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/INTEGRATED VACUUM DECOMPOSITION INDEX NUMBER 2.1.1.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE ASSY*	(100)	354	127
WET/DRY WIPES	(250)	6.54	.3
TOTAL		163.5 (360.5) KG (LBS)	3.61 (127.3) M^3 (FT^3)

*INCLUDES INITIAL WEIGHT OF COLLECTOR BAGS

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
COLLECTOR BAGS	1 (100)	.229 (SKYLAB)	.229	.0068 (SKYLAB)	.0068
		Σ③	.309 TOTAL WT/CYCLE (LB)	Σ⑤	.0106 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .309 TOT.WT/CYCLE (LB) = 11.5 (25.3) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0106 TOT.VOL/CYCLE (FT^3) = .024 (.87) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A —				
Σ①			Σ④	

TOTAL WT./MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ④) = ____ (LB) + ____ (Σ①) = ____ KG (LB)

SPACECRAFT Shuttle

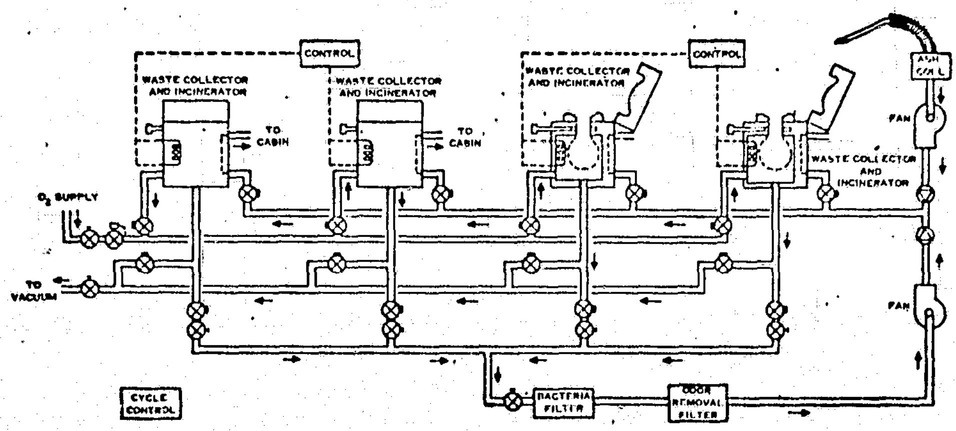
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

• APPLIANCE CONCEPT NO./TITLE 5/Flush Flow Oxygen Incineration

INDEX NO. 2.1.1.5 REF. NO. 100,250, & Skylab data

DESCRIPTION The flush flow oxygen incineration utilizes a continuous oxygen flow to the collection chamber for the 12 hours required for incineration. The wastes are collected by same process of air entrainment used on the previous concepts, sealed in the chamber (no vent to vacuum), heat is applied for a specified time period. The resulting sterilized/vaporized gas and vapors are exhausted to space. The valve is left open and heat is applied to bring the incineration temperature to 1000°F, while a controlled flow of oxygen is continuously supplied to the chamber. The incineration process takes approximately 12 hours with 97 to 99 percent reduction in process waste. Twelve hours are allowed for cooldown which requires one commode per man. The collection bags described in Concept 4 are also used for this concept. Wet and dry wipes are used for this concept and are assumed to be deposited into the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 5/FLUSH FLOW OXYGEN INCINERATION

INDEX NUMBER 2.1.1.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN ASSY. (100)	12	500	360	4320	—	—	—
SOLENOID VALVES (5)	MOMENTARY	—	—	—	40	40	—
VACUUM VALVES (5)	"	—	—	—	40	40	—
O_2 VALVES (5)	"	—	—	—	40	40	—
HEATER	12	—	—	—	500	500	6000
CONTROLLER/TIMER	24	—	—	—	30	20	480
		500 MAXIMUM		4320 TOTAL	650 MAXIMUM		6480 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
AIR FAN MOTOR	N/A	1705	1705	N/A
HEATERS	N/A	2380	2380	N/A
TOTAL	WATT (BTU/HR)	1198 (4085) WATT (BTU/HR)	1198 (4085) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
— N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 5/FLUSH FLOW OXYGEN INCINERATION INDEX NUMBER 2.1.1.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE ASSY.* (100)	372	123
WET/DRY WIPES	6.54	.3
TOTAL	171.7 (378.5) KG (LBS)	3.49 (123.3) M^3 (FT^3)

*INCLUDES WEIGHT OF COLLECTOR BAGS

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
COLLECTOR BAGS	1 (100)	.229 (SKYLAB)	.229	.0068 (SKYLAB)	.0068

Σ③ .309 TOTAL WT/CYCLE (LB)   Σ⑤ .0106 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .309 TOT.WT/CYCLE (LB) = 11.5 (25.3) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0106 TOT.VOL/CYCLE (FT^3) = .024 (.869) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
OXYGEN	.428	N/A	N/A	.428

Σ① .428   Σ④ .428

TOTAL WT./MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x .428 TOTAL LOST/CYCLE (Σ④) = 35.1 (LB) + N/A (Σ①) = 15.9 (35.1) KG (LB)

SPACECRAFT Shuttle

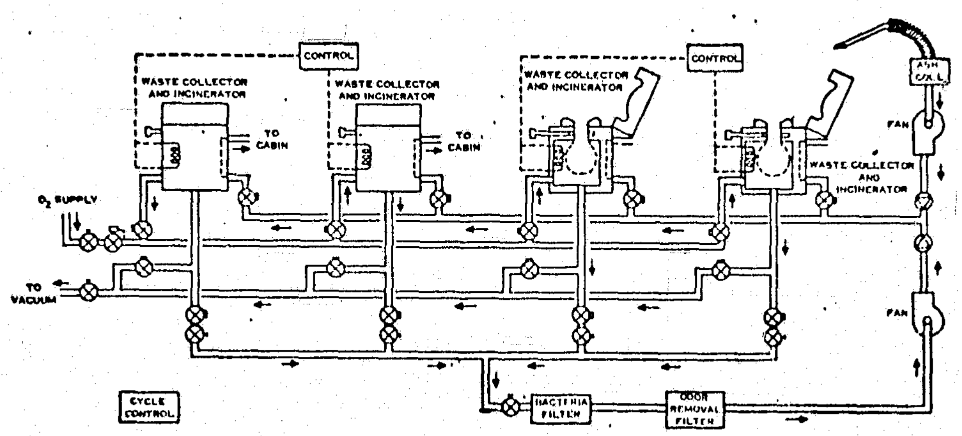
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 6/Pyrolysis/Batch Incineration

INDEX NO. 2.1.1.6 REF. NO. 100,250, & Skylab data

DESCRIPTION The pyrolysis/batch incineration concept utilizes a three-step process to minimize oxygen consumables. The wastes are heated to 250°F and held at this temperature for 30 minutes to ensure sterilization. The vent valve is then opened and the water is flashed to space as a vapor. The chamber is then heated to 1200°F, with the vacuum valve remaining open, and the wastes are pyrolytically decomposed (vacuum decomposition) and the gases are vented to space. At the end of the pyrolysis process, the vent valve is closed, the chamber is charged with oxygen, and several batch incinerations are performed. The batch incineration step reduces the ash residue from 12 to 2 percent of the total wastes processed. After final venting to space, the chamber cooldown takes 12 hours. The pyrolysis/batch incineration process is identical to the schematic shown for Concept 5. The pyrolysis/batch incineration takes 12 hours. The collection bags described in Concept 4 are also used for this concept. Wet and dry wipes are used for this concept and are assumed to be deposited into the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT: 6/PYROLYSIS/BATCH INCINERATION

INDEX NUMBER 2.1.1.6

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN ASSY (100)	12	500	360	4320	—	—	—
SOLENOID VALVES (7)	MOMENTARY	—	—	—	40	40	—
VACUUM VALVES (7)	"	—	—	—	40	40	—
O_2 VALVES (7)	"	—	—	—	40	40	—
HEATER	12	—	—	—	1000	1000	12000
CONTROLLER/TIMER	24	—	—	—	30	20	480
		500 MAXIMUM		4320 TOTAL	1150 MAXIMUM		12480 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
AIR FAN MOTOR	N/A	1705	1705	N/A
HEATER	N/A	3410	3410	N/A
TOTAL	WATT (BTU/HR)	1500 (5115) WATT (BTU/HR)	1500 (5115) WATT (BTU/HR)	- WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 6/PYROLYSIS/BATCH INCINERATION INDEX NUMBER 2.1.1.6

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE ASSY * (100)	372	91
WET/DRY WIPES	6.54	.3
TOTAL	171.7 (378.5) KG (LBS)	2.58 (91.3) M^3 (FT^3)

* INCLUDES INITIAL WEIGHT OF COLLECTOR BAGS

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
COLLECTOR BAGS	1 (100)	.229 (SKYLAB)	.229	.0068 (SKYLAB)	.0068

Σ③ .309 TOTAL WT/CYCLE (LB) Σ⑤ .0106 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .309 TOT.WT/CYCLE (LB) = 11.5 (25.3) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0106 TOT.VOL/CYCLE (FT^3) = .024 (.87) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
OXYGEN	.126	N/A	N/A	.126

Σ① .126 Σ④ .126

TOTAL WT./MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x .126 TOTAL LOST/CYCLE (Σ④) = 10.3 (LB) + N/A (Σ①) = 4.7 (10.3) KG (LB)

SPACECRAFT Shuttle

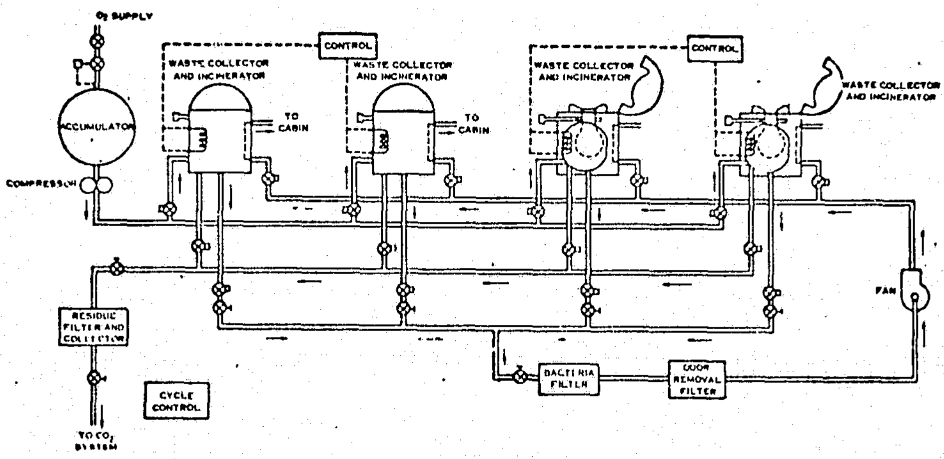
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/Transfer

APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 7/Wet Oxidation

INDEX NO. 2.1.1.7 REF. NO. 100,250, & Skylab data, 247

DESCRIPTION The wet oxidation concept is a moderate temperature, high pressure catalytic process. The system employs an insulated chamber similar to the incineration and decomposition concepts. Waste treatment is accomplished by charging the chamber with 500 psia oxygen at ambient temperature and applying heat to bring the chamber up to oxidation temperature. The final pressure and temperature are approximately 1750 psia and 550^{o}F. The advantage of the wet oxidation process is the production of water which can be processed and reused in the spacecraft. The system requires a high pressure oxygen source, assumed in this study as a compressor. A stirrer would enhance the wet oxidation process, but was not considered in the study due to lack of engineering data. Based on two data sources, the process was assumed to take 12 hours, most of which is cool-down time (10½ to 6 hours). The collection bags described in Concept 4 are also used for this concept. Wet and dry wipes are used for this concept and are assumed to be deposited into the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 7/WET OXIDATION

INDEX NUMBER 2.1.1.7

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN ASSY (100)	6	250	180	1080	—	—	—
SOLENOID VALVES(5)	MOMENTARY	—	—	—	~~40~~	~~40~~	—
RESIDUE COLLECTOR							
SOLENOID VALVES(6)	"	—	—	—	48	48	—
CABIN AIR SOLEN. VALVE(9)	"	—	—	—	72	72	—
HEATER	6	—	—	—	450	450	2700
COMPRESSOR	.5	350	200	100	—	—	—
CONTROLLER/TIMER	12	—	—	—	30	20	240
		600 MAXIMUM		1180 TOTAL	640 MAXIMUM		2940 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
AIR FAN & COMPRESSOR MOTORS	N/A	2050	2050	N/A
HEATER	N/A	1536	1536	N/A
TOTAL	WATT (BTU/HR)	1051.6(3586) WATT (BTU/HR)	1051.6(3586) WATT (BTU/HR)	WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
—N/A—					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 7/WET OXIDATION — INDEX NUMBER 2.1.1.7

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE ASSY * (100)	1053	148
WET/DRY WIPES (250)	6.54	.3
TOTAL	480.6 (1059.5) KG (LBS)	4.2 (148.3) M^3 (FT^3)

*INCLUDES INITIAL WEIGHT OF COLLECTOR BAGS

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
COLLECTION BAGS	1 (100)	.229 (SKYLAB)	.229	.0068 (SKYLAB)	.0068

Σ③ .309 TOTAL WT/CYCLE (LB) — Σ⑤ .0106 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .309 TOT.WT/CYCLE (LB) = 11.5 (25.3) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0106 TOT.VOL/CYCLE (FT^3) = .024 (.87) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
OXYGEN	.169	N/A	N/A	.169

Σ① .169 — Σ④ .169

TOTAL WT./MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x .169 TOTAL LOST/CYCLE (Σ④) = 13.8 (LB) + N/A (Σ①) = 6.3 (13.8) KG (LB)

SPACECRAFT Shuttle

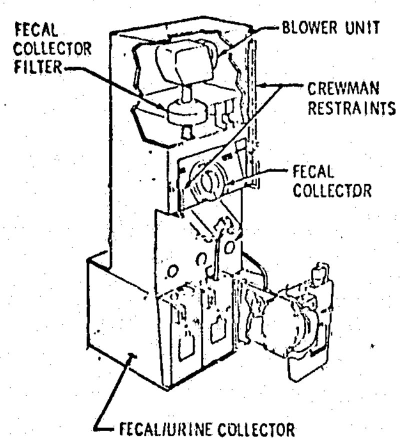
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

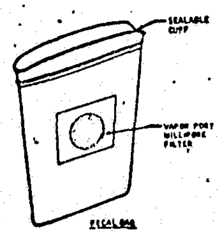
APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 8/Semiautomatic Bag System (Skylab)

INDEX NO. 2.1.1.8 REF. NO. Skylab data,283,250,100

DESCRIPTION The semiautomatic bag concept consists of a wall mounted fecal collector unit using a collection bag, with air entrainment of the feces. The fecal collector consists of a fecal collection receptacle, a mesh liner, and hinged seat. The hinged seat provides access to the mesh liner to permit manual installation of a fecal bag. The seat is contoured and contains airflow holes to allow cabin air to be drawn into the fecal bag as a gravity substitute airflow. The seat upon closure provides an integral seal between the fecal bag and the fecal collection receptacle and between the seat and the user. A blower unit is utilized to provide feces entrainment into the fecal bag. Cabin air is drawn into the fecal bag and is exhausted through the collection bag's vapor port, through the mesh liner and into the fecal collection receptacle. The cabin air is then passed on to the fecal collector filter and blower unit and returned to the cabin. The fecal bag is manually removed from the fecal collector after each defecation and replaced immediately with a new bag. The fecal bag with its contents is then vacuum dried in a waste processor to facilitate on-orbit storage. The waste processor is a separate unit and is included as a part of this concept.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 8/SEMIAUTO BAG SYSTEM (SKYLAB) INDEX NUMBER 2.1.1.8

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN ASSY (SKYLAB)	.2	250	180	36	—	—	—
HEATERS (3) (233)	1	—	—	—	225	225	225
VACUUM PUMP (233)	1	350	200	200			
CONTROLLER/TIMER (233)	1	—	—	—	30	20	20
		600 MAXIMUM		236 TOTAL	255 MAXIMUM		245 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
AIR FAN MOTOR	N/A	800	800	N/A
HEATERS	N/A	768	768	N/A
VACUUM PUMP	N/A	1192	1192	N/A
TOTAL	0 WATT (BTU/HR)	809.4 (2760) WATT (BTU/HR)	809.4 (2760) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
— N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 8/SEMIAUTOMATIC BAG SYSTEM (SKYLAB) INDEX NUMBER 2.1.1.8

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COMMODE/COMPONENTS (SKYLAB)	77.6	17
WET/DRY WIPES (250)	6.54	.3
COLLECTION BAGS	18.8	.6
TOTAL	46.7 (102.9) KG (LBS)	.51 (17.8) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	3 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
COLLECTION BAGS	1 (100)	.229 (SKYLAB)	.229	.0068 (SKYLAB)	.0068
		Σ③	.309 TOTAL WT/CYCLE (LB)	Σ⑤	.0106 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .309 TOT.WT/CYCLE (LB) = 11.5 (25.3) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0106 TOT.VOL/CYCLE (FT^3) = .024 (.87) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
- N/A -				
	Σ①		Σ④	

TOTAL WT./MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

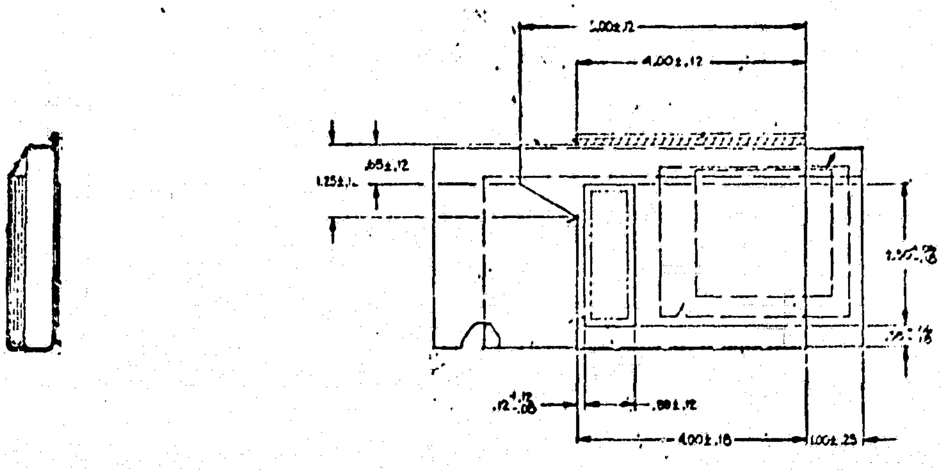
HABITABILITY SUBSYSTEM Personal Hygiene **HABITABILITY FUNCTION** Waste Collection/Transfer

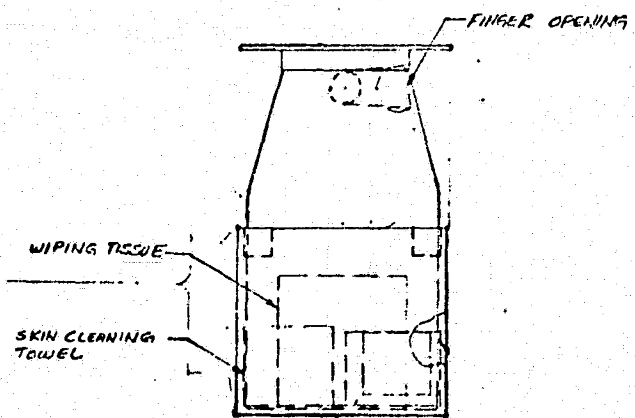
APPLIANCE FUNCTION Fecal Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 9/Dry Bags (Apollo)

INDEX NO. 2.1.1.9 **REF. NO.** Apollo dwgs: V36-601029,V36-601398, V36-601267,V36-601398,V36-787819, and V36-787809

DESCRIPTION The dry bag concept consists of bag which is taped to the buttocks of the crewman. The collection system is manual and requires a large amount of crew time per defecation. The unit is compactly folded for storage and each unit contains biocide and tissues. The bag is unfolded, taped to the buttocks, the botus is separated using the built-in finger, and the tissues are deposited into the bag. The bag is closed, sealed and the biocide is kneeded into the feces for germicide control. The collection bags are deposited into a large bag which has a capacity for 16 feces collection bags. The dry bags were used on Apollo and were provided as a backup for Skylab.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 9/DRY BAGS (APOLLO) INDEX NUMBER 2.1.1.9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
COLLECTION BAGS	16.4	1.4
STOWAGE BAGS	3.6	—
TOTAL	9.1 (20) KG (LBS)	.04 (1.4) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
COLLECTION BAGS	1	.2	.2	.0172*	.0172
STOWAGE BAGS	.055	.8	.044	—	—
		Σ③	.244 TOTAL WT/CYCLE (LB)	Σ⑤	.0172 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .244 TOT. WT/CYCLE (LB) = 9.1 (20) KG (LB)

TOTAL VOL MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0172 TOT. VOL/CYCLE (FT^3) = .04 (1.4) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				
Σ①			Σ④	

TOTAL WT. MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.1 Waste Collection/Transfer

APPLIANCE FUNCTION 2.1.2 Urine Collection/Transfer

NUMBER OF CONCEPTS CONSIDERED 5

ASSUMPTIONS

(1) The urine collection/transfer concepts consider air entrainment and intimate male adapter methods of collecting urine.

(2) The study assumed a total of 42 urinations per day (seven per day per man). The concept use time required per urination is dependent on the concept type.

(3) Filter weight and volume were included if a high replacement frequency is required. Periodic filter replacement was not included in the study.

(4) Component power requirements were normalized to provide a fair comparison of all concepts. The power requirements were not based on the latest urine collector designs. This was done because the various manufacturers were in process of a competitive proposal response for the Shuttle waste collection system and could not be contacted for additional information.

(5) In the case of Space Station, the urine and rinse water was assumed to be collected and processed through a vapor compression distillation unit. Urine recovery was based on 24.8 grams of solids per 1000 grams of urine. The solids were then ratioed by the amount of flush water used. The recovery factor used was 98.15 percent. The Shuttle concepts were considered to be dumped overboard or collected, but no water processing was applied.

(6) The urine collection devices were allocated one per vehicle.

(7) The urine collection devices considered are adaptable to men only; however, when combined with a fecal collector, some of the devices can be adapted to females.

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APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.1.2 •••• URINE COLLECTION/TRANSFER (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	THERMAL REQMTS HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	ELEC PWR REQMTS AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	WT/VOL REQMTS VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	DEVELOPMENT COST INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	28.000	1	.0000	9.44	.0	21.1	0.	248.	226.0	114.0	263.6	.25	2	50	.0
	.018		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(846.)	18.0	18.0	(581.1)	(8.67)			(.0)
		9	.3629	87.09	.0	32.2									
			(.8000)	(192.00)	(.0)	(90.0)									
2	28.000	1	.0000	9.44	.0	21.1	0.	229.	226.0	114.0	128.5	.50	2	25	.0
	.018		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(781.)	18.0	18.0	(283.3)	(17.50)			(.0)
		9	.1497	36.29	.0	32.2									
			(.3300)	(80.00)	(.0)	(90.0)									
3	28.000	1	.0000	9.44	.0	21.1	0.	229.	226.0	114.0	112.5	.05	1	10	.0
	.018		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(781.)	18.0	18.0	(248.0)	(1.79)			(.0)
		9	.1497	36.29	.0	32.2									
			(.3300)	(80.00)	(.0)	(90.0)									
4	28.000	1	.0000	9.44	.0	21.1	0.	229.	215.0	110.0	108.2	.09	2	35	.0
	.018		(.0000)	(20.00)	(.0)	(70.0)	(0.)	(781.)	10.0	10.0	(238.6)	(3.15)			(.0)
		9	.1497	36.29	.0	32.2									
			(.3300)	(80.00)	(.0)	(90.0)									
5	28.000	2	.4296	.35	.0	21.1	0.	0.	.0	.0	251.6	.09	1	10	.0
	.029		(.9470)	(.77)	(.0)	(70.0)	(0.)	(0.)	.0	.0	(554.7)	(3.17)			(.0)

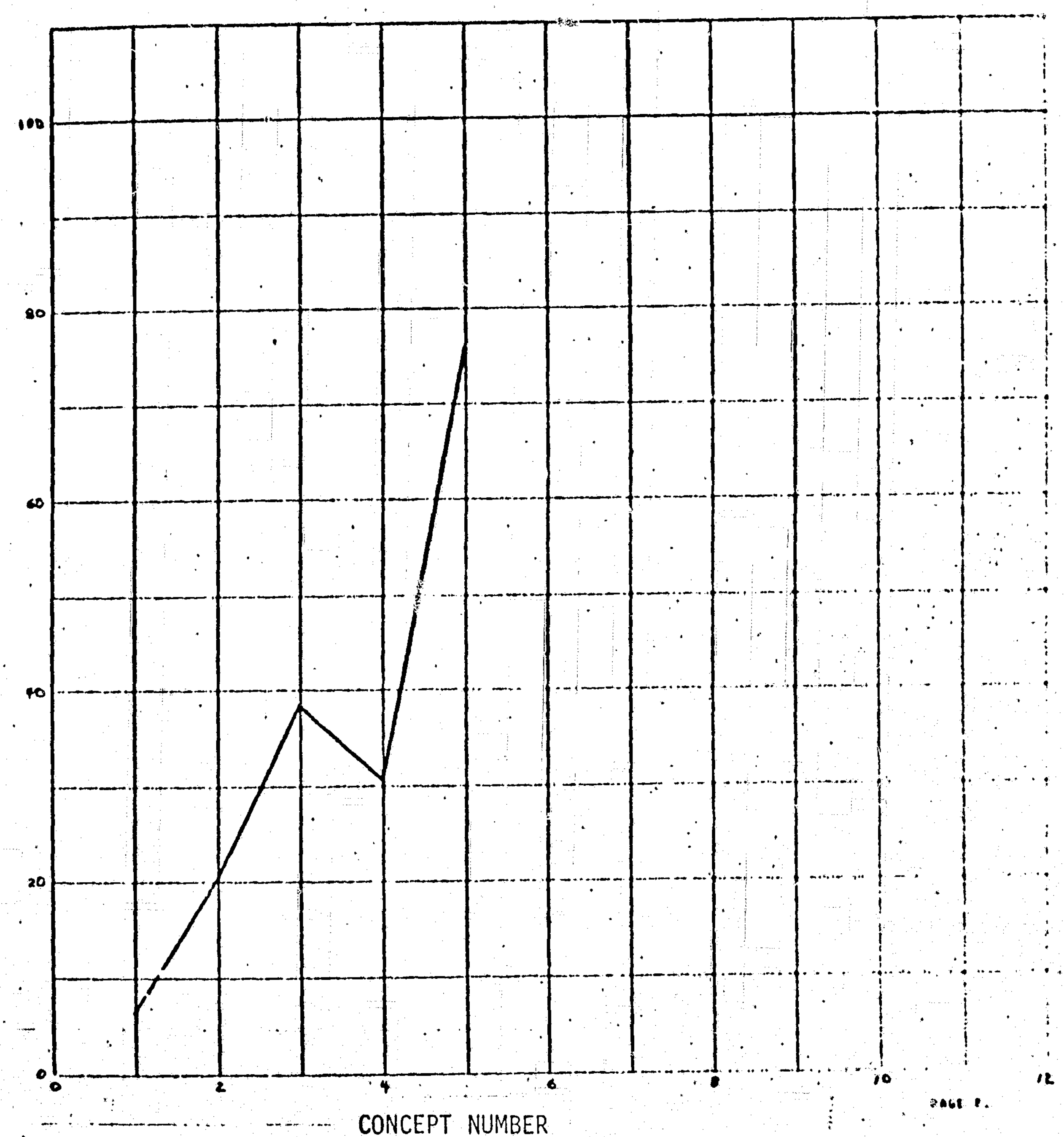
APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	STANDUP URINAL
2 -	COMMODE URINAL
3 -	INTIMATE MALE ADAPTER (SKYLAB)
4 -	APERTURE URINAL
5 -	LIQUID/GAS FLOW CUFF TYPE (APOLLO)

(*)

1 -	CABIN AIR	(CIRCULATED),	LITERS/SEC	(FT^3/MIN)
2 -	CABIN AIR	(LOST)	, KG/HR	(LB/HR)
3 -	OXYGEN	(LOST)	, KG/HR	(LB/HR)
4 -	COOLING WATER	(CIRCULATED),	KG/HR	(LB/HR)
5 -	WATER	(LOST)	, KG/HR	(LB/HR)
6 -	NITROGEN	(CIRCULATED),	KG/HR	(LB/HR)
7 -	NITROGEN	(USED)	, KG/HR	(LB/HR)
8 -	FREON	(CIRCULATED),	KG/HR	(LB/HR)
9 -	WATER	(PROCESSED)	, KG/HR	(LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.		CONCEPT NAME
1	-	STANDUP URINAL
2	-	COMMODE URINAL
3	-	INTIMATE MALE ADAPTER (SKYLAB)
4	-	APERTURE URINAL
5	-	LIQUID/GAS FLOW CUFF TYPE (APOLLO)



Urine Collection/Transfer (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 27
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . URINE COLLECTION/TRANSFER (SHUTTLE)
(01/19/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5
WEIGHT	238.62	581.10	15	.00	7.69	8.60	8.84	.68
POWER	.00000	127.52	15	.00	.00	.00	1.09	15.00
VOLUME	1.7900	17.500	10	5.05	.00	8.98	8.20	8.19
THERMAL	.00000	46.530	15	.00	1.15	1.15	1.15	15.00
RELIAB-Y	.99976	1.00000	5	.03	.00	.00	.44	4.94
MAINTENC	.99999	1.00000	5	.02	.00	.00	.28	4.98
DEV COST	10.000	50.000	15	.00	7.50	12.00	4.50	12.00
TOTAL PT	.00000	80.000	80	5.10	16.34	30.73	24.50	60.79
RATING	.00000	100.00	100	6.38	20.42	38.41	30.63	75.99

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT				
	1	2	3	4	5
NORMAL	6.38	20.42	38.41	30.63	75.99
WEIGHT	5.83	23.07	40.03	33.05	69.87
POWER	5.83	18.67	35.12	28.63	78.05
VOLUME	8.97	19.22	41.43	33.65	76.34
THERMAL	5.83	19.33	35.78	28.66	78.05
RELIAB-Y.	6.20	19.80	37.25	29.97	76.68
MAINTENC	6.20	19.80	37.25	29.87	76.70
DEV COST	5.83	22.96	41.97	30.57	76.33

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT				
	1	2	3	4	5
NORMAL	6.38	20.42	38.41	30.63	75.99
WEIGHT	7.04	17.24	36.45	27.70	83.38
POWER	7.04	22.54	42.38	33.04	73.51
VOLUME	3.44	21.79	34.99	27.20	75.60
THERMAL	7.04	21.74	41.59	33.00	73.51
RELIAB-Y	6.56	21.08	39.65	31.33	75.25
MAINTENC	6.57	21.08	39.65	31.44	75.23
DEV COST	7.04	17.36	34.11	30.69	75.58

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.1.2-URINE COLLECTION/TRANSFER

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS: WATER SEPARATOR	URINE PUMP	SOLENOID VALVES	FILTER	CHECK VALVE	CONTROLLER TIMER	REGULATOR	MOTOR									NUMBER OF SAFETY CRITICAL ITEMS
NO.	6	2	3	9	22	19	11	1									
STANDUP URINAL o NO VENTING	1	1	3	2	2	1	1	2									0
COMMODE URINAL o NO VENTING	1	1	3	3	2	1	1	2									0
INTIMATE MALE ADAPTER URINAL (SKYLAB) o NO VENTING	1	1	3	3	2	1	1	2									0
APERTURE URINAL o NO VENTING	1	1	1	3	-	1	1	2									0
LIQUID/GAS FLOW CUFF TYPE (APOLLO) o VENTED OVERBOARD	-	-	-	1	-	-	-	-									0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

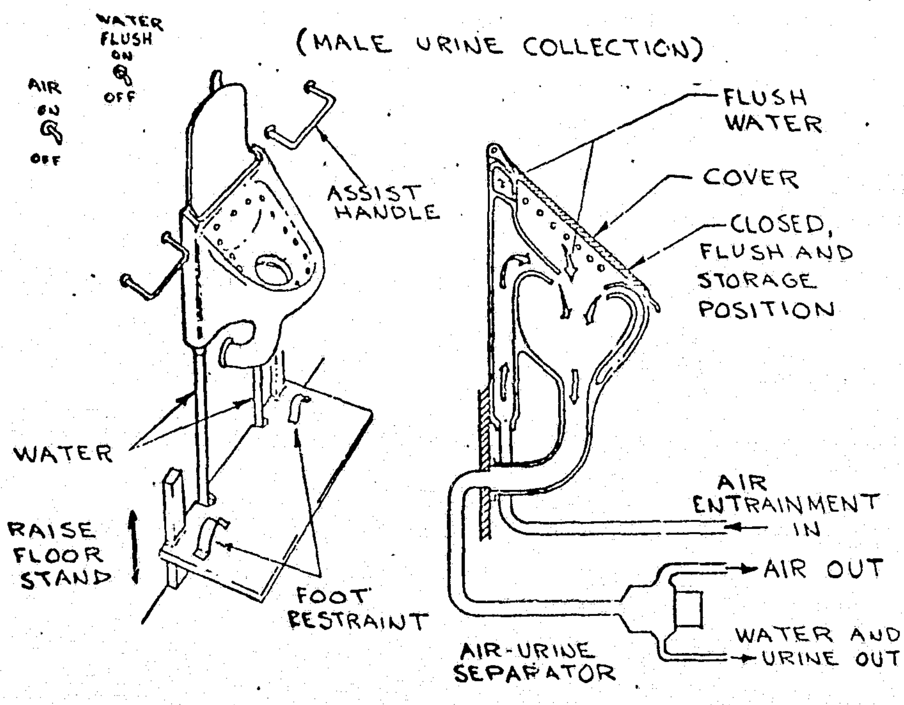
APPLIANCE FUNCTION Urine Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 1/Standup Urinal

INDEX NO. 2.1.2.1 REF. NO. 209, 273, 207

DESCRIPTION

The standup urinal concept consists of a collector utilizing air entrainment for collection and transport of the urine and centrifugal separation of the air/urine. The cabin air used for entrainment is filtered and recirculated back into the cabin. The unit is mounted on the wall of the spacecraft. The unit is activated by opening the cover. After use, the cover is closed;a fixed quantity of flush water is used to flush the urinal. The unit automatically shuts down after the flush is completed. The total operating time was assumed to be one minute using 45 seconds as an average urination time. The flush water assumed used per cycle was 0.8 pound and was heated to 90°F. A pre-treatment chemical was added to the flush water.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/STANDUP URINAL

INDEX NUMBER 2.1.2.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
AIRFAN/SEPARATOR(2Ø)	.0125	200	100	1.25	—	—	—
URINE PUMP	.0125	15	10	.12	—	—	—
SOLENOID VALVES(2)	MOMENTARY	—	—	—	16	16	—
MOTOR VALVE	MOMENTARY	11	4	—	—	—	—
CONTROLLER/TIMER	.017	—	—	—	2	2	.034
		226 MAXIMUM		1.37 TOTAL	18 MAXIMUM		.034 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTORS(FAN&SEPARATOR)	N/A	734	734	N/A
FLUSH WATER COOLDOWN	N/A	112	112	N/A
TOTAL	WATT (BTU/HR)	248 (846) WATT (BTU/HR)	248 (846) WATT (BTU/HR)	WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
- N/A -					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/STANDUP URINAL INDEX NUMBER 2.1.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
URINAL/COMPONENTS (209)	115	8.67
TOTAL	52.2 (115) KG (LBS)	.25 (8.67) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
-N/A-					

Σ③ ____ TOTAL WT/CYCLE (LB) Σ⑤ ____ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = ____ KG (LB)

TOTAL VOL/MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = ____ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
FLUSH WATER	.8 (209)	N/A	N/A	.8
PRETREATMENT CHEMICAL	.012 (209)	N/A	N/A	.012
Σ①	.812		Σ④	.812

TOTAL WT./MISSION = 28 CYCLE/DAY X 20.5 DAYS/MISSION X .812 TOTAL LOST/CYCLE (Σ ④) = 466.1 (LB) + N/A (Σ ①) = 211.4 (466.1) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/Transfer

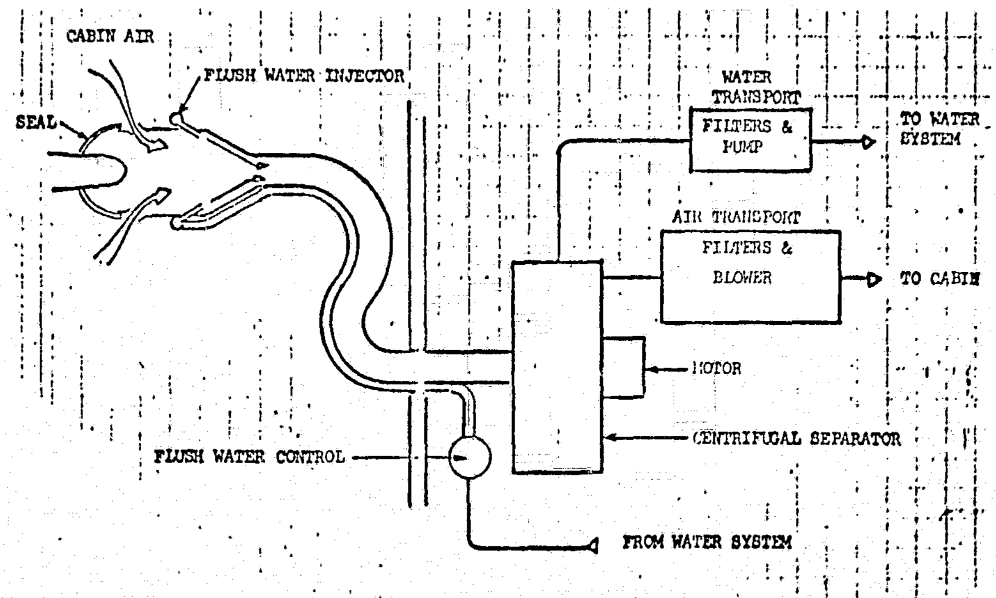
APPLIANCE FUNCTION Urine Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 2/Commode Urinal

INDEX NO. 2.1.2.2 REF. NO. 207, 209, 273

DESCRIPTION

The commode urinal concept consists of a urine collector, centrifugal separator, and flush unit. This unit would be used where combined feces and urine collectors are defined. The unit uses a flush as described in Concept 1; however, 0.33 pound per flush was used because of the smaller surface area requiring biocide treatment. Air entrainment is employed coupled with a properly directed urine stream. The operating time is the same as specified for Concept 1. Cabin air used for urine entrainment is filtered and returned to the cabin.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/COMMODE URINAL

INDEX NUMBER 2.1.2.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN/SEPARATOR (20)	.0125	200	100	1.25	—	—	—
URINE PUMP	.0125	15	10	.12	—	—	—
SOLENOID VALVES (2)	MOMENTARY	—	—	—	16	16	—
MOTOR VALVE	"	11	4	—	—	—	—
CONTROLLER/TIMER	.07	—	—	—	2	2	.034
		226 MAXIMUM		1.37 TOTAL	18 MAXIMUM		.034 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTORS (FAN & SEPARATOR)	N/A	734	734	N/A
FLUSH WATER COOLDOWN	N/A	46.6	46.6	N/A
TOTAL	0 WATT (BTU/HR)	228.9 (780.6) WATT (BTU/HR)	228.9 (780.6) WATT (BTU/HR)	0 WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/COMMODE URINAL

INDEX NUMBER 2.1.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
URINAL/COMPONENTS (207)	87	17.5
TOTAL	39.5 (87) KG (LBS)	.495 (17.5) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB)   Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
FLUSH WATER	.33 (207)	N/A	N/A	.33
PRETREATMENT CHEMICAL	.012 (209)	N/A	N/A	.012
Σ①	.342		Σ④	.342

TOTAL WT. MISSION = 28 CYCLE/DAY x 20.5 DAYS/MISSION x .342 TOTAL LOST/CYCLE (Σ ④) = 196.3 (LB) + N/A (Σ ①) = 89.1 (196.3) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/Transfer

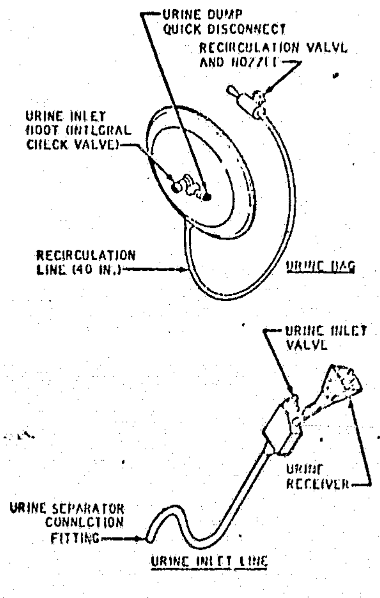
APPLIANCE FUNCTION Urine Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 3/Intimate Male Adapter

INDEX NO. 2.1.2.3 REF. NO. 283, 250

DESCRIPTION

The intimate male adapter concept consists of a wall-mounted unit similar to the unit used for the Skylab fecal/urine collector system. The adapter can be used when seated or in a standing position. Air entrainment is used to provide a substitute for gravity collection. The cabin air used for entrainment is filtered and recirculated back into the cabin. One wipe per cycle was assumed to be used because of splashback during urination. The flushing and operating time are the same as for Concepts 1 and 2. The flush water used was assumed to be 0.33 pound per flush. The second aperture unit pictured below uses an iris-type seal for the penis to prevent cabin contamination. The unit is designed to minimize spashback using a splash retarder. This unit operates the same as the Skylab unit.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/INTIMATE MALE ADAPTER   INDEX NUMBER 2.1.2.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN/SEPARATOR(60)		.0125	200	100	1.25	—	—	—
URINE PUMP		.0125	15	10	.12	—	—	—
SOLENOID VALVES(2)		MOMENTARY	—	—	—	16	16	—
MOTOR VALVE		"	11	4	—	—	—	—
CONTROLLER/TIMER		.07	—	—	—	2	2	.034
			226 MAXIMUM		1.37 TOTAL	18 MAXIMUM		.034 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTORS(FANS&SEPARATOR)	N/A	734	734	N/A
FLUSH WATER COOLDOWN	N/A	46.6	46.6	N/A
TOTAL	0	223.9(780.6)	223.9(780.6)	0
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

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OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
-N/A-					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/INTIMATE MALE ADAPTER INDEX NUMBER 2.1.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
URINAL		2.8	.0058
COMPONENTS		40.0	1.212
DRY WIPES	(250)	8.95	.568
TOTAL		23.5 (51.7) KG (LBS)	.051 (1.79) M^3 (FT^3)

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DRY WIPES	1	2.04/196(250)	.0104	.129/196(250)	.00066
APERTURE SEALS	1	.00026	.00026		NEG
		Σ③	.01066 TOTAL WT/CYCLE (LB)	Σ⑤	.00066 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 42 CYCLES/DAY x 20.5 DAYS/MISSION x .01066 TOT.WT/CYCLE (LB) = 4.2 (9.18) KG (LB)

TOTAL VOL/MISSION = 42 CYCLES/DAY x 20.5 DAYS/MISSION x .00066 TOT.VOL/CYCLE (FT^3) = .016 (.57) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
FLUSH WATER	.33 (207)	N/A	N/A	.33
PRETREATMENT CHEMICAL	.012 (209)	N/A	N/A	.012
Σ①	.342		Σ④	.342

TOTAL WT./MISSION = 28 CYCLE/DAY x 20.5 DAYS/MISSION x .342 TOTAL LOST/CYCLE (Σ④) = 196.3 (LB) + N/A (Σ①) = 89.1 (196.3) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

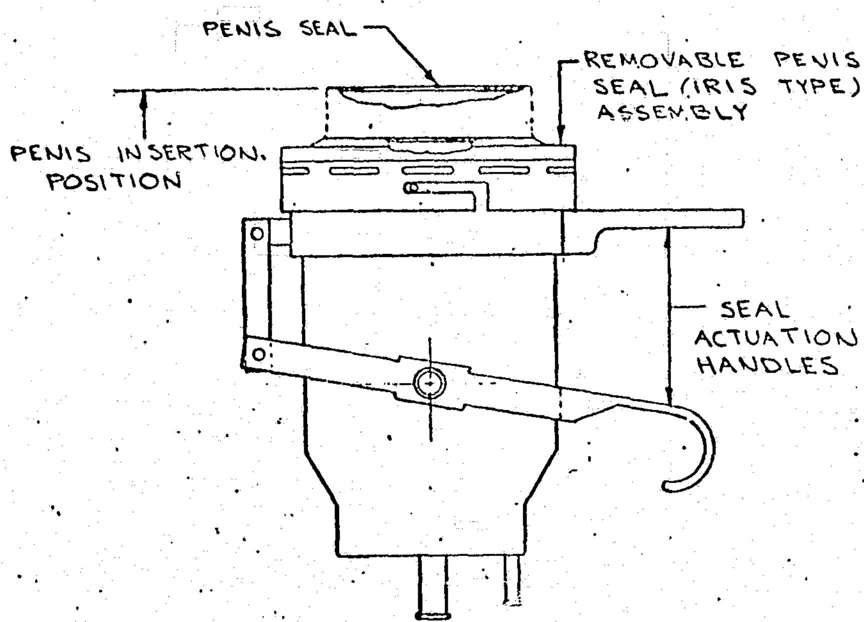
APPLIANCE FUNCTION Urine Collection/Transfer

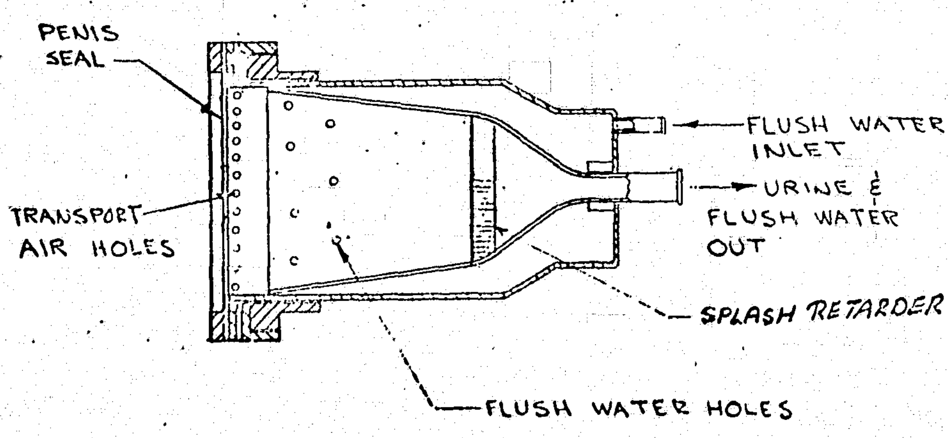
APPLIANCE CONCEPT NO./TITLE 4/Aperture Urinal

INDEX NO. 2.1.2.4 REF. NO. 236, 273, 209, 207

DESCRIPTION

The aperture urinal concept consists of an aperture and centrifugal separator. Urine is collected as described in the previous concepts. The study assumed 0.33 pound of flush water per cycle. The operating time is the same as Concepts 1 through 3.





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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 4/APERTURE URINAL INDEX NUMBER 2.1.2A

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AIR FAN/SEPARATOR(2@)	.0125	200	100	1.25	—	—	—
URINE PUMP	.0125	15	10	.12	—	—	—
SOLENOID VALVE	MOMENTARY	—	—	—	8	8	—
CONTROLLER/TIMER	.017	—	—	—	2	2	.034
		215 MAXIMUM		1.37 TOTAL	10 MAXIMUM		.034 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTORS (FAN & SEPARATOR)	N/A	734	734	N/A
FLUSH WATER	N/A	46.6	46.6	N/A
TOTAL	0 WATT (BTU/HR)	228.9 (780.6) WATT (BTU/HR)	228.9 (780.6) WATT (BTU/HR)	0 WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
-N/A-					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/INTIMATE URINAL

INDEX NUMBER 2.1.2.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
URINAL/COMPONENTS	(236)	42.3	3.15
TOTAL		356.3 (42.3) KG (LBS)	.089 (3.15) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
-N/A-					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
FLUSH WATER	.33 (207)	N/A	N/A	.33
PRETREATMENT CHEMICAL	.012 (209)	N/A	N/A	.012
	Σ① .342			Σ④ .342

TOTAL WT. / MISSION = 28 CYCLE/DAY x 20.5 DAYS/MISSION x .342 TOTAL LOST/CYCLE (Σ ④) = 196.3 (LB) + N/A (Σ ①) = .89 (196.3) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

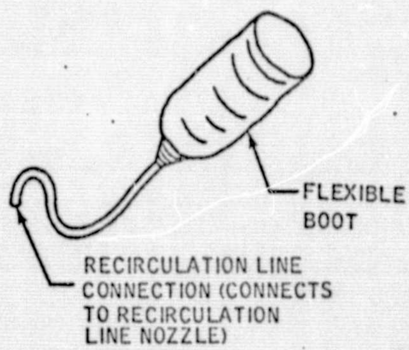
APPLIANCE FUNCTION Urine Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 5/Liquid/Gas Flow Cuff-Type (Apollo)

INDEX NO. 2.1.2.5 REF. NO. Rockwell Dwg. SEB14000010-303

DESCRIPTION

The liquid/gas flow cuff-type concept is the system used on Apollo. A cuff is utilized which fits snuggly to the penis. Urine transfer was accommodated on Apollo using a vacuum; however, a centrifugal separator could also be utilized. The concept presented assumes vacuum transfer since the intimate male adapter (Concept 3) is similar and uses air entrainment. The operating time was assumed to be 1.75 minute using a 45 second urination time. Filter change was considered for this concept due to the frequent changeout required (one per 14.3 man-days).



SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

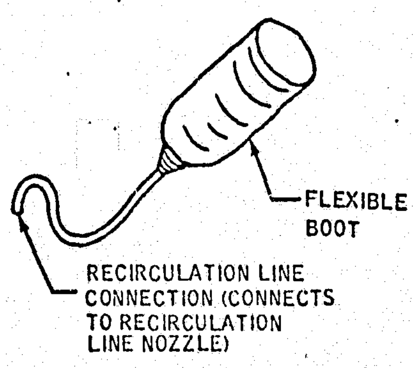
APPLIANCE FUNCTION Urine Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 5/Liquid/Gas Flow Cuff-Type (Apollo)

INDEX NO. 2.1.2.5 REF. NO. Rockwell Dwg. SEB14000010-303

DESCRIPTION

The liquid/gas flow cuff-type concept is the system used on Apollo. A cuff is utilized which fits snuggly to the penis. Urine transfer was accommodated on Apollo using a vacuum; however, a centrifugal separator could also be utilized. The concept presented assumes vacuum transfer since the intimate male adapter (Concept 3) is similar and uses air entrainment. The operating time was assumed to be 1.75 minute using a 45 second urination time. Filter change was considered for this concept due to the frequent changeout required (one per 14.3 man-days).



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 5 / LIQUID / GAS FLOW CUFF TYPE (APOLLO) INDEX NUMBER 2.1.2.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 5/LIQUID/GAS FLOW CUFF TYPE (APOLLO) INDEX NUMBER 2.1.2.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
URINE RECEPTACLE	4.8	1.524
FILTER HOUSING	.6	.254
FILTER	.71	.36
PACKAGING & URINE HOSE	5.0	1.035
TOTAL	5.04 (11.11) KG (LBS)	.09 (3.17) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
FILTERS	.00166	.5	.00083	.25	.00042

Σ③ .00083 TOTAL WT/CYCLE (LB) Σ⑤ .00042 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 42 CYCLES/DAY x 20.5 DAYS/MISSION x .00083 TOT.WT/CYCLE (LB) = .324 (.71) KG (LB)

TOTAL VOL/MISSION = 42 CYCLES/DAY x 20.5 DAYS/MISSION x .00042 TOT.VOL/CYCLE (FT^3) = .01 (.36) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
OXYGEN	.947	N/A	N/A	.947

Σ① .947 Σ④ .947

TOTAL WT./MISSION = 28 CYCLE/DAY x 20.5 DAYS/MISSION x .947 TOTAL LOST/CYCLE (Σ④) = 543.6 (LB) + N/A (Σ①) = 246.6 (543.6) KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.1 Waste Collection/Transfer

APPLIANCE FUNCTION 2.1.3 Vomitus Collection/Transfer

NUMBER OF CONCEPTS CONSIDERED 4

ASSUMPTIONS

(1) The vomitus collection/transfer concept considered portable and fixed methods. The collection devices used in conjunction with the fecal collector or waste disposal unit were considered fixed. The fixed method is not the most ideal since a sick crewman may not always be able to reach the collection device prior to vomiting. Fixed methods, however, were considered for the purpose of comparison.

(2) The study assumed .84 cycles per day for Space Station and .56 cycles per day for Shuttle. The concept use time required per cycle is dependent on the concept type.

(3) Filter weight and volume were included if a high replacement frequency is required. Periodic filter replacement was not included in the study.

(4) Flush water, if required, for a vomitus collection concept was assumed not recoverable since the used flush water would normally be dumped into the fecal collector.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.1.3 **** VOMITUS COLLECTION/TRANSFER (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	.560 .016	1	.0000 (.0000)	9.44 (20.00)	.0 (.0)	21.1 (70.0)	0. (0.)	0. (0.)	.0 .0	.0 .0	.6 (1.3)	.01 (.40)	2	25	.0 (.0)
2	.560 .016	1	.0000 (.0000)	9.44 (20.00)	.0 (.0)	21.1 (70.0)	0. (0.)	0. (0.)	.0 .0	.0 .0	.7 (1.6)	.01 (.33)	2	25	.0 (.0)
3	.560 .016						0. (0.)	0. (0.)	.0 .0	.0 .0	.5 (1.2)	.00 (.01)	1	0	.0 (.0)
4	.560 .016	1	.0000 (.0000)	9.44 (20.00)	.0 (.0)	21.1 (70.0)	0. (0.)	249. (852.)	250.0 .0	180.0 .0	10.0 (22.0)	.03 (.92)	2	30	.0 (.0)
		5	.2268 (.5000)	24.95 (55.00)	1551.4 (30.0)	21.1 (70.0)									

APPLIANCE CONCEPT NO.	CONCEPT NAME
1	INTIMATE PERSONAL ADAPTOR, DISPOSABLE (MATES WITH COMMODE)
2	INTIMATE PERSONAL ADAPTOR, DISPOSABLE (MATES WITH COMMODE)
3	PORTABLE DISPOSABLE COLLECTOR (TYPE USE COMMERCIALLY)
4	REUSABLE PORTABLE COLLECTOR

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

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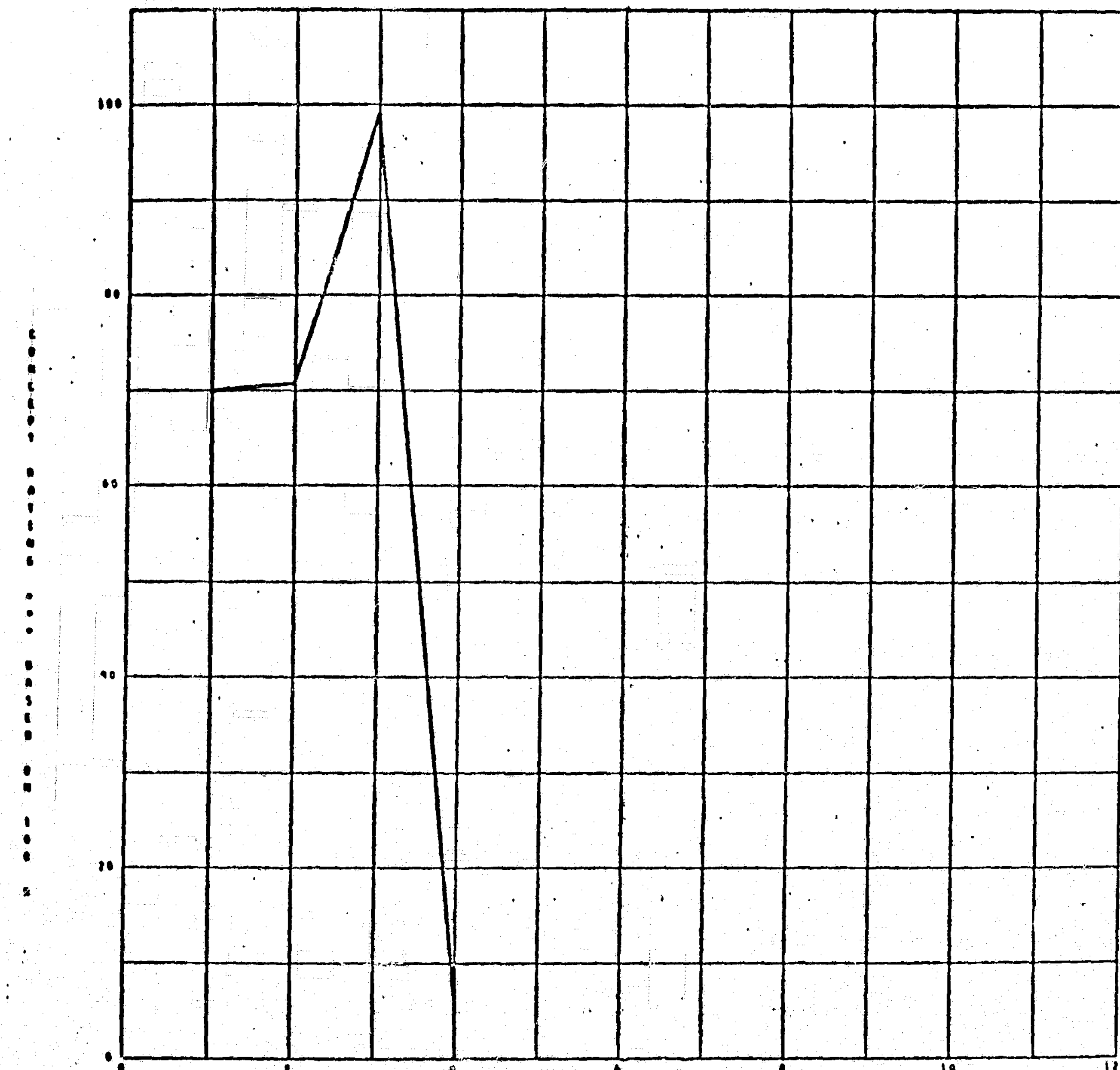
5241

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	INTIMATE PERSONAL ADAPTOR,DISPOSABLE (MATES WITH COMMODE)
2 -	INTIMATE PERSONAL ADAPTOR,DISPOSABLE (MATES WITH COMMODE)
3 -	PORTABLE DISPOSABLE COLLECTOR (TYPE USE COMMERCIALLY)
4 -	REUSABLE PORTABLE COLLECTOR



CONCEPT NUMBER

Vomitus Collection/Transfer (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 26
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300

SELECTION MATRIX • • • • • VOMITUS COLLECTION/TRANSFER (SHUTTLE)
(01/25/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4
WEIGHT	1.1500	22.040	15	14.12	13.92	14.22	.00
POWER	.00000	132.50	15	15.00	15.00	15.00	.00
VOLUME	.10000-01	.92000	10	5.65	6.45	9.89	.00
THERMAL	.00000	46.860	15	15.00	15.00	15.00	.00
SAFETY	.00000	1.0000	5	.00	.00	5.00	5.00
DEV COST	.00000	30.000	15	2.50	2.50	15.00	.00
TOTAL PT	.00000	75.000	75	52.27	52.87	74.11	5.00
RATING	.00000	100.00	100	69.69	70.49	98.81	6.67

D2-118 ICE-2

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4
NORMAL	67.69	70.49	98.81	6.67
WEIGHT	71.91	72.52	98.45	6.06
POWER	72.45	73.18	98.92	6.06
VOLUME	68.87	70.12	98.82	6.25
THERMAL	72.45	73.18	98.92	6.06
SAFETY	67.44	68.22	98.85	9.68
DEV COST	64.87	65.60	98.92	6.06

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4
NORMAL	69.69	70.49	98.81	6.67
WEIGHT	66.98	68.01	99.26	7.41
POWER	66.32	67.22	98.68	7.41
VOLUME	70.63	70.93	98.80	7.14
THERMAL	66.32	67.22	98.68	7.41
SAFETY	72.09	72.92	98.77	3.45
DEV COST	75.58	76.47	98.68	7.41

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.1.3-VOMITUS COLLECTION/TRANSFER

APPLIANCE TYPE \ COMPONENT TYPE	NUMBER OF COMPONENTS: BLOWER (NO. 18)	MANUAL VALVE (NO. 23)	NUMBER OF SAFETY CRITICAL ITEMS
INTIMATE PERSONAL ADAPTER, DISPOSABLE (MATES WITH COMMODE)	-	-	1
INTIMATE PERSONAL ADAPTER, LINED, REUSABLE (MATES WITH COMMODE)	-	-	1
PORTABLE DISPOSABLE COLLECTOR	-	-	0
REUSABLE PORTABLE COLLECTOR	1	1	0

SPACECRAFT Shuttle

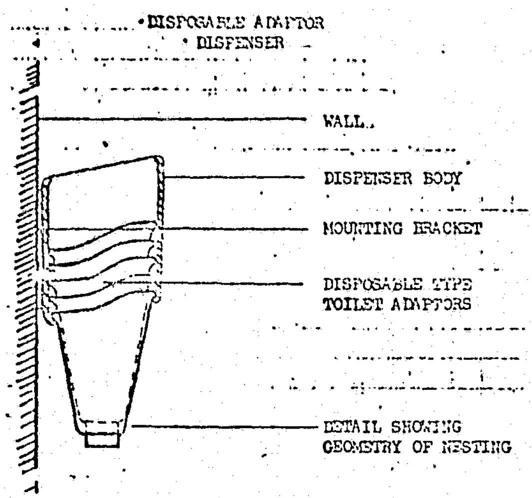
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/Transfer

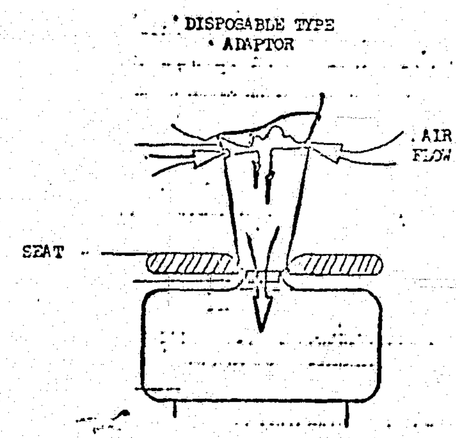
APPLIANCE FUNCTION Vomitus Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 1/Intimate Personal Adapter Disposable (mates with commode)

INDEX NO. 2.1.3.1 REF. NO. 209,186,187,236, & 207

DESCRIPTION The intimate personal disposable adapter concept is made of lightweight plastic or paper and is shaped to interface with the feces collection tube of a commode. The adapter blocks the air transport inlet ports. Holes in the top of the unit provide the air inlet for vomitus entrainment. The top of the unit is formed to a crewman's face affecting a seal over the nose, around the mouth, and under the chin. All vomitus material is expelled directly into the feces collection unit. After use, the adapter is removed and processed in the feces collector. A dispenser for storage of clean vomitus adapters is located near the feces collector.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1 / INTIMATE PERSONAL ADAPTOR, DISPOSABLE

INDEX NUMBER 2.1.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/INTIMATE PERSONAL ADAPTER, DISPOSABLE INDEX NUMBER 2.1.3.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
DISPENSER	(186)	.279	.123
ADAPTERS	(186)	1.15	.28
TOTAL		.602 (1.329) KG (LBS)	.0114 (.403) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
ADAPTERS	1 (186)	.1 (186)	.1	.0244	.0244
		Σ③	.1 TOTAL WT/CYCLE (LB)	Σ⑤	.0244 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .1 TOT.WT/CYCLE (LB) = .521 (1.15) KG (LB)

TOTAL VOL / MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .0244 TOT.VOL/CYCLE (FT^3) = .0079 (.28) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				
Σ①			Σ④	

TOTAL WT. / MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

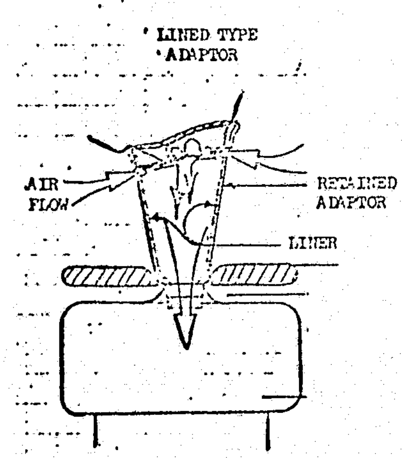
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

APPLIANCE FUNCTION Vomitus Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 2/Intimate Personal Adapter, Lined, Reusable (mates with commode)

INDEX NO. 2.1.3.2 REF. NO. 187,250, & 207

DESCRIPTION The lined intimate personal reusable adapter concept is fabricated of metal with provision for attachment of a plastic or paper liner on the inside surface. The adapter is shaped to interface with the feces collector transfer tube. The liner and adapter are provided with holes to allow cabin air into the adapter for vomitus entrainment. The liner is deposited into the feces collector after usage. The adapter is cleaned to maintain hygienic acceptability and stored near the feces collector. One biocide wipe and one dry wipe were assumed to be adequate to clean the reusable liner. Skylab wipe data were used to determine the wipes penalty. The reusable adapter is identical to the Concept 1 configuration.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/INTIMATE PERSONAL ADAPTOR, LINED, REUSABLE INDEX NUMBER 2.13.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/INTIMATE PERSONAL ADAPTER, LINED, REUSABLE INDEX NUMBER 2.1.3.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
DISPENSER/LINERS	(187)	.312	.2253
LINERS	(187)	.352	.0586
WET/DRY WIPES	(250)	.918	.0434
TOTAL		.718 (1.58) KG (LBS)	.009 (.327) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
LINERS	1 (187)	.0307 (187)	.0307	.0051 (187)	.0051
WET WIPES	1 (250)	3.4/70 (250)	.0486	.129/70 (250)	.00184
DRY WIPES	1 (250)	2.04/196 (250)	.0312	.129/196 (250)	.001975
		Σ③	.111 TOTAL WT/CYCLE (LB)	Σ⑤	.0089 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .111 TOT.WT/CYCLE (LB) = .578 (1.27) KG (LB)

TOTAL VOL/MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .0089 TOT.VOL/CYCLE (FT^3) = .0029 (.102) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				
Σ①			Σ④	

TOTAL WT./MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

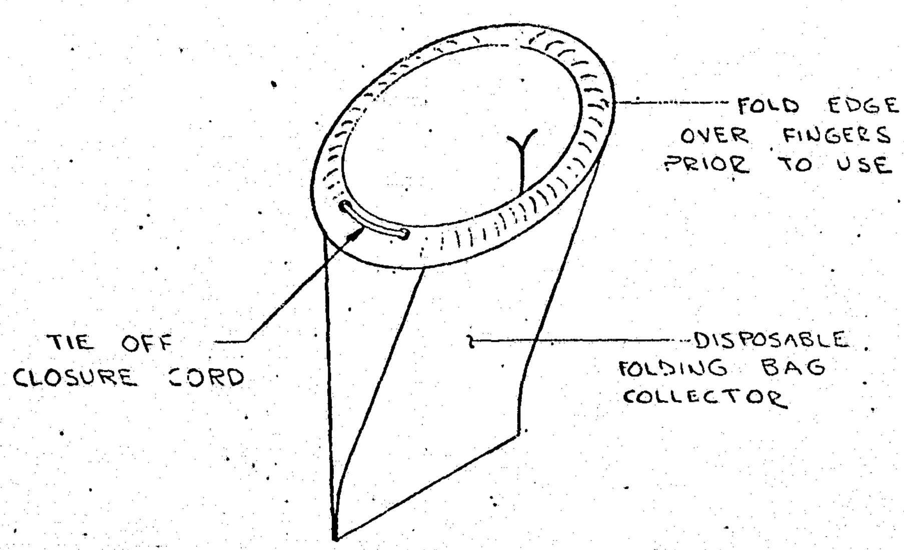
HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

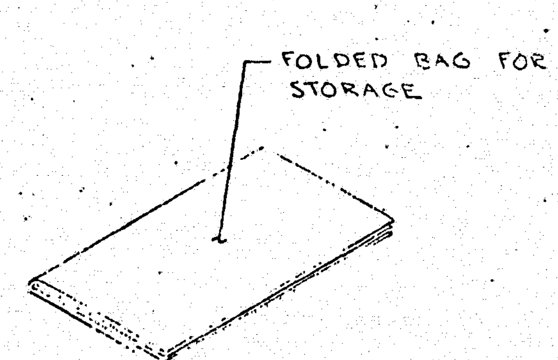
APPLIANCE FUNCTION Vomitus Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 3/Portable Disposable Collector (airline type)

INDEX NO. 2.1.3.3 REF. NO. 187,207,250, & 209

DESCRIPTION The portable disposable collector is a light flexible bag with a drawstring closure device. The bag is used on all airlines and is made of thin gage plastic. The crewman can store the bag in a clothes pocket where it will be ready for use at any time. The bag is unfolded and grasped near the opening by both hands and held against the face enclosing the nose and mouth. Proper placement of the bag against the face provides the seal. The bag is sealed after use by tying a knot in the closure cord and discarding the bag and contents into the feces collector.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/PORTABLE DISPOSABLE COLLECTOR INDEX NUMBER 2.1.3.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/PORTABLE DISPOSABLE COLLECTOR INDEX NUMBER 2.1.3.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
PORTABLE COLLECTORS (209)	1.15	.01
TOTAL	.521 (1.15) KG (LBS)	.00028 (.01) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
PORTABLE COLLECTORS	1	.1 (209)	.1	.000868(209)	.000868

Σ③ ______ TOTAL WT/CYCLE (LB)

Σ⑤ .000868 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .1 TOT.WT/CYCLE (LB) = .521 (1.15) KG (LB)

TOTAL VOL / MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .000868 TOT.VOL/CYCLE (FT^3) = .00028 (.01) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______ Σ④ ______

TOTAL WT. / MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Waste Collection/ Transfer

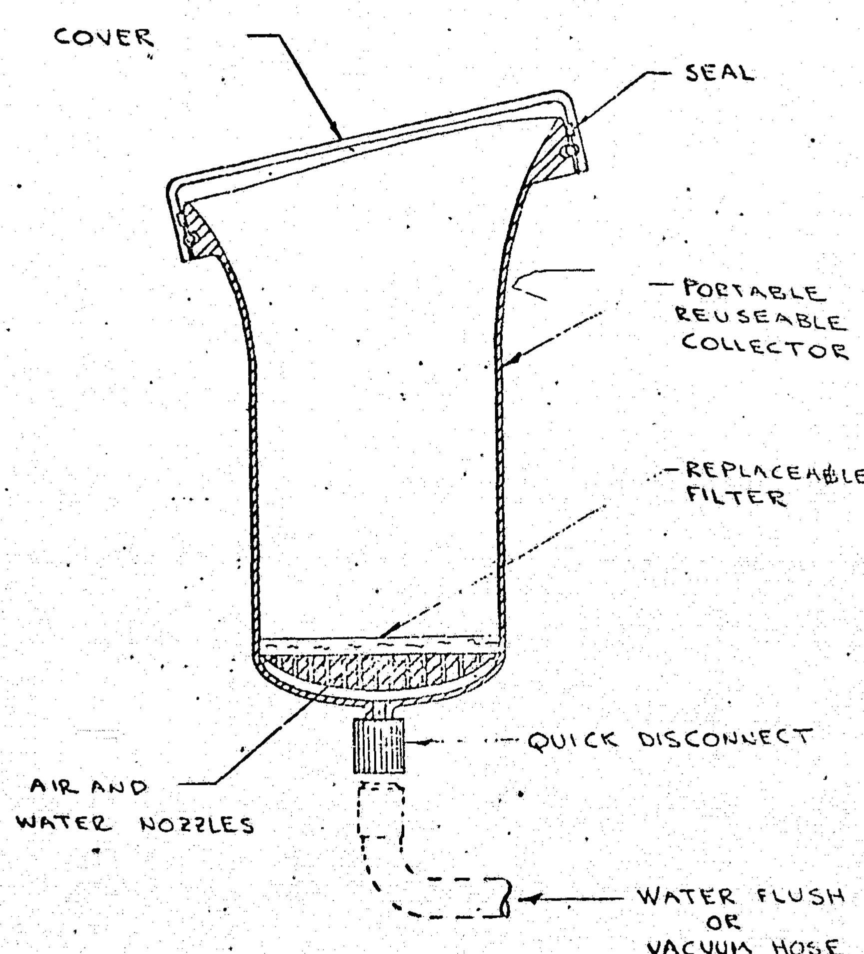
APPLIANCE FUNCTION Vomitus Collection/Transfer

APPLIANCE CONCEPT NO./TITLE 4/Reusable Portable Collector

INDEX NO. 2.1.3.4 REF. NO. 207

DESCRIPTION

The reusable portable collector is constructed of a lightweight metal (aluminum for study) canister type collector with a provision to draw cabin air through it during vomitus expulsion. The resulting entrainment will prevent cabin contamination. The vacuum provision makes sealing at the face less critical than other concepts. A sealing cover prevents spillage. The collector can be used at any vacuum source in the spacecraft. The collector is washed out in a feces collection commode or other suitable debris trap by connecting a flexible flush hose to the collector.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 4/REUSABLE PORTABLE COLLECTOR

INDEX NUMBER 2.1.3.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
FAN ASSY. (207)	.017	250	180	3.06	—	—	—
		250 MAXIMUM		3.06 TOTAL	— MAXIMUM		— TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
FAN ASSY	N/A	852	852	N/A
TOTAL	WATT (BTU/HR)	249.9 (852) WATT (BTU/HR)	249.9 (852) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
-N/A-					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/REUSABLE PORTABLE COLLECTOR INDEX NUMBER 2.1.3.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
COLLECTOR	(207)	2.2	.14
FILTERS	(207)	.12	.0047
VALVE	(209)	4.00	.03
FAN ASSY.	(209)	10.00	.75
TOTAL		7.40 (16.32) KG (LBS)	.026 (.92) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
FILTERS	1 (207)	.01	.01	.00408	.00408
		Σ③	.01 TOTAL WT/CYCLE (LB)	Σ⑤	.00408 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .01 TOT.WT/CYCLE (LB) = 52.1 (.12) KG (LB)

TOTAL VOL MISSION = .56 CYCLES/DAY x 20.5 DAYS/MISSION x .00408 TOT.VOL/CYCLE (FT^3) = .00133 (.0047) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
PRETREATMENT CHEMICAL	.5	N/A	N/A	.5
Σ①	.5		Σ④	.5

TOTAL WT. MISSION = .56 CYCLE/DAY x 20.5 DAYS/MISSION x .5 TOTAL LOST/CYCLE (Σ ④) = 5.74 (LB) + N/A (Σ ①) = 2.6 (5.74) KG (LB)

HABITABILITY SUBSYSTE 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.2 Cleansing

APPLIANCE FUNCTION 2.2.1 Whole Body Shower

NUMBER OF CONCEPTS CONSIDERED 4

ASSUMPTIONS

(1) Whole body shower concepts enclose the entire body to accomplish whole body cleansing. The showers are similar to terrestrial type; however, water usage is much lower.

(2) The shower frequency used is one shower per man per day (Ref. 127 and 273). The use time for one shower is 15 minutes (Ref. 127).

(3) Towels used for drying after showering, if required, are discarded after 60 drying cycles.

(4) Washer/dryer penalty was based on washer Concept 7, Water Spray Agitation, and dryer Concept 1, Forced Hot Air-Electric Dryer.

(5) Water used for Space Station body cleansing was assumed to be recycled minus the water loss associated with suspended solids. Shuttle water used is not recycled.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.2.1 •••• WHOLE BODY SHOWER (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	4.000 .250	1	.0000 (.0000)	21.24 (45.00)	.0 (.0)	21.1 (70.0)	317. (1084.)	292. (997.)	250.0 16.0	250.0 16.0	433.0 (954.6)	2.41 (85.03)	1	25	.0 (.0)
		9	2.2680 (5.0000)	.00 (.00)	1551.4 (30.0)	40.6 (105.0)									
2	4.000 .250	1	.0000 (.0000)	221.81 (470.00)	.0 (.0)	21.1 (70.0)	4665. (15931.)	79. (271.)	5370.0 16.0	5370.0 16.0	359.3 (792.0)	2.20 (77.57)	2	40	.0 (.0)
		9	2.2680 (5.0000)	.00 (.00)	1551.4 (30.0)	40.6 (105.0)									
3	4.000 .250	9	2.2680 (5.0000)	.00 (.00)	1551.4 (30.0)	40.6 (105.0)	124. (424.)	989. (3378.)	337.0 .0	.0 .0	761.6 (1679.0)	2.69 (95.08)	1	15	.0 (.0)
4	4.000 .250	9	2.7216 (6.0000)	.00 (.00)	1292.9 (25.0)	41.1 (106.0)	77. (264.)	292. (997.)	99.0 .0	86.0 .0	394.0 (868.6)	1.73 (61.11)	1	5	.0 (.0)

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	VACUUM PICKUP
2 -	AIR DRAG
3 -	MECHANICAL
4 -	COLLAPSIBLE

ok

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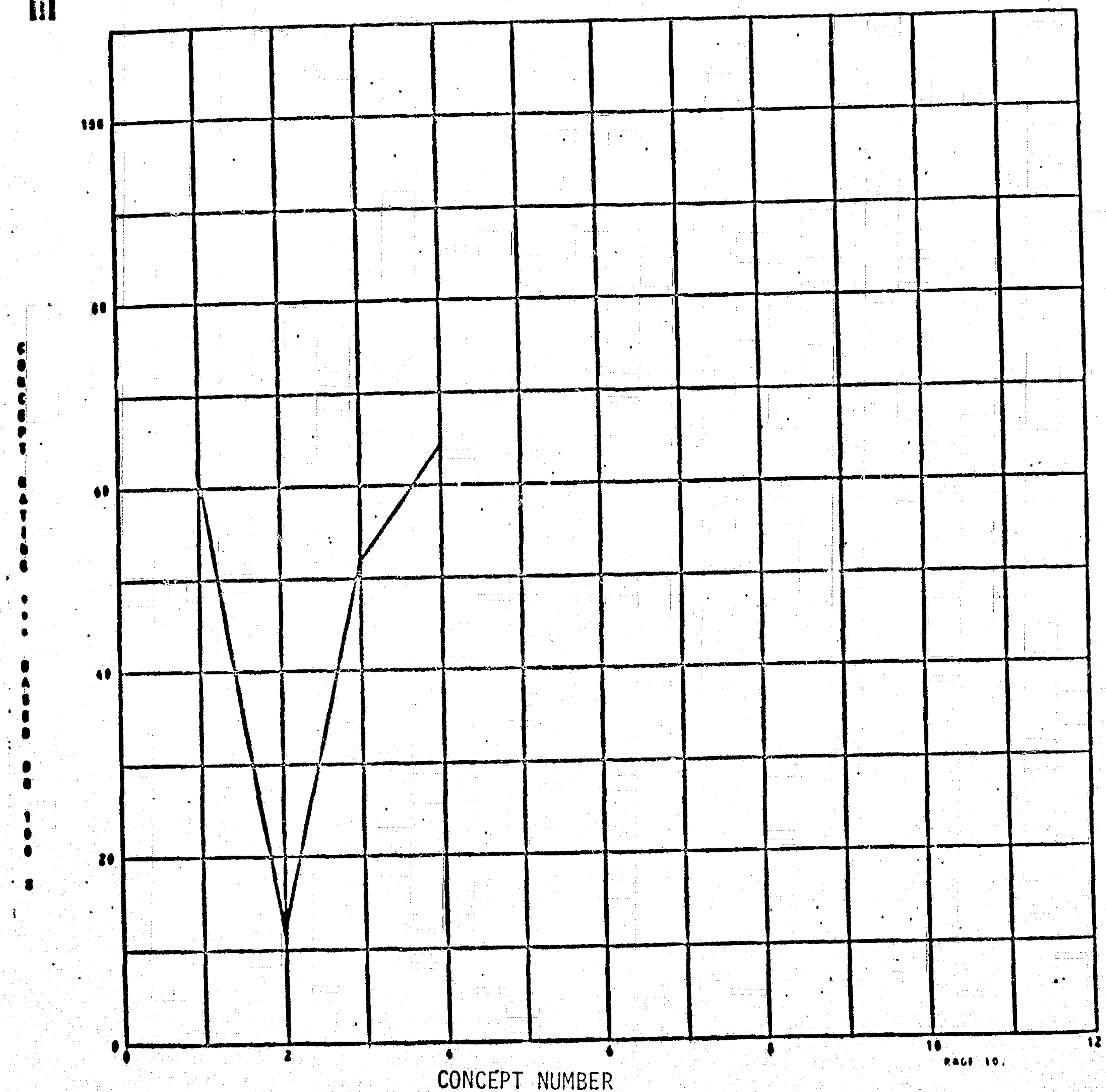
(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO. — CONCEPT NAME

1 = VACUUM PICKUP
2 = AIR DRAG
3 = MECHANICAL
4 = COLLAPSIBLE



Whole Body Shower (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 30
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • WHOLE BODY SHOWER (SHUTTLE)
(02/01/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4
WEIGHT	792.00	1679.0	15	6.47	7.92	.00	7.24
POWER	52.470	2853.0	15	14.27	.00	14.06	14.72
VOLUME	61.107	95.083	10	1.06	1.84	.00	3.57
THERMAL	61.435	413.18	15	12.03	.00	7.87	12.77
RELIAB-Y	.00000	.99998	5	5.00	.00	5.00	.00
MAINTENC	-2554.0	1.00000	5	5.00	.00	5.00	.00
DEV COST	5.0000	40.000	15	5.63	.00	9.38	13.12
TOTAL PT	.00000	80.000	80	49.44	9.77	41.31	51.43
RATING	.00000	100.00	100	61.80	12.21	51.63	64.29

D2-118560-2

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4
NORMAL	61.80	12.21	51.63	64.29
WEIGHT	60.20	15.69	47.21	62.92
POWER	64.66	11.16	55.24	67.19
VOLUME	58.79	12.57	48.60	62.61
THERMAL	63.38	11.16	51.70	66.08
RELIAB-Y	62.96	11.84	53.10	62.34
MAINTENC	62.96	11.84	53.10	62.34
DEV COST	59.72	11.16	52.56	66.28

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4
NORMAL	61.80	12.21	51.63	64.29
WEIGHT	63.73	8.01	56.97	65.95
POWER	58.36	13.47	47.28	60.79
VOLUME	65.22	11.79	55.07	66.19
THERMAL	59.90	13.47	51.55	62.13
RELIAB-Y	60.57	12.60	50.07	66.36
MAINTENC	60.57	12.60	50.07	66.36
DEV COST	64.32	13.47	50.51	61.89

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.2.1-WHOLE BODY SHOWER

COMPONENT TYPE / APPLIANCE TYPE	MOTOR	BLOWER	HEATER	PUMP	CONTROLLER TIMER	HEAT EXCHANGER	WATER SEPARATOR	FILTER	CHECK VALVES	TEMPERATURE CONTROL VALVE	SOLENOID VALVE	MANUAL VALVE	ACCUMULATOR	RELIEF VALVE	REGULATOR VALVE		NUMBER OF SAFETY CRITICAL ITEMS
NO.	1	18	17	2	19	16	6	9	22	24	3	23	4	25	11		
VACUUM PICKUP	2	1	1	1	1	1	1	1	2	1	2	-	-	-	-		0
AIR DRAG	3	1	1	2	1	2	1	1	2	1	2	-	-	-	-		0
MECHANICAL	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-		0
COLLAPSIBLE	2	1	-	1	-	-	1	1	-	-	-	2	1	1	1		0

NUMBER OF COMPONENTS

D2-118561-2

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

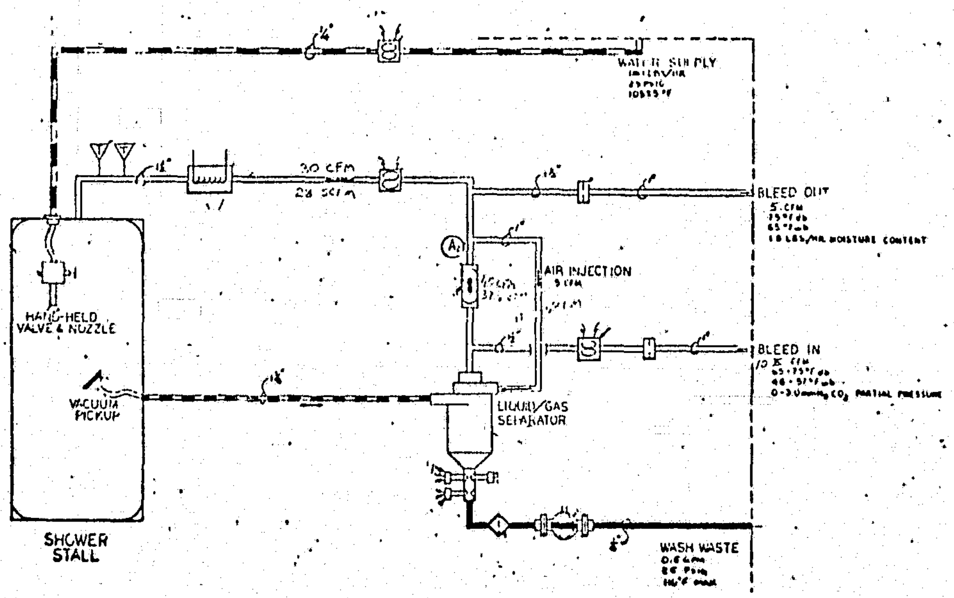
APPLIANCE FUNCTION Whole Body Shower

APPLIANCE CONCEPT NO./TITLE 1/Vacuum Pickup

INDEX NO. 2.2.1.1 REF. NO. 127,278,273,236,209, & 129

DESCRIPTION

The vacuum pickup concept is a shower stall, which includes a transparent door, and is sufficient in size to allow adequate movement of the crewman during showering and stall cleanup. Water is retrieved by a vacuum pickup system and pumped to the water waste management system. The pickup system allows the crewman to collect water from free air and the stall wall, floor, and door. The shower includes a water distribution system which insures proper cleaning with minimum water usage. A fan is used to circulate air to the shower with a cabin air bleed for carbon dioxide control within the stall. The circulated air is heated to provide a comfortable shower environment. The crewman uses terry towels for drying after showering. The terry towels used for the study are 16 x 24 inches and are assumed to contain one pint of water after drying (278). This concept has been brought to the prototype stage and is scheduled to be tested at NASA JSC.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/VACUUM PICKUP

INDEX NUMBER 2.2.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
BLOWER (AIR) (127,270)	.25	88	88	22	—	—	—
AIR HEATER	.25	104	104	26	—	—	—
WATER PUMP	.25	57.5	57.5	14.4	—	—	—
SOLENOID VALVES	MOMENTARY	—	—	—	16	16	
		249.5 MAXIMUM		62.4 TOTAL	16 MAXIMUM		TOTAL

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THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
SHOWER BLEED TO CABIN	820	—	—	820
SHOWER DOOR TO CABIN	—	372	372	—
MOISTURE CARRIED OUT BY CREWMAN	264	—	—	264
TOTAL	336.2 (1084) WATT (BTU/HR)	109.1 (372) WATT (BTU/HR)	109.1 (372) WATT (BTU/HR)	336.2 (1084) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
WASHER	630	—	29.7	25.1	2.245
DRYER	45.5	84.7	37.5	10.0	2.2
TOTAL	198.1 (675.5) WATTS/CYCLE (BTU/HR/CYCLE)	24.8 (84.7) WATTS/CYCLE (BTU/HR/CYCLE)	67.2	15.9 (35.1) KG/MISSION (LB/MISSION)	.126 (4.445) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/VACUUM PICKUP INDEX NUMBER 2.2.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
SHOWER STALL (127)	148	71.1
COMPONENTS MODULE ASSY (127)	173	
TOWELS	.44	.34
TOTAL	145.8 (321.44) KG (LBS)	2.02 (71.44) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
TOWELS	.0166 (236)	.092 (209) .322 (236)	.0054	.125 (209) .250 (209)	.00417

Σ③ .0054 TOTAL WT/CYCLE (LB) Σ⑤ .00417 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0054 TOT.WT/CYCLE (LB) = .20 (.443) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .00417 TOT.VOL/CYCLE (FT^3) = .0097 (.342) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	5.0 (278)	N/A	N/A	5.0
WASHER WATER LOSS PENALTY	2.3	N/A	N/A	2.3
	Σ① 7.3			Σ④ 7.3

TOTAL WT./MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x 7.3 TOTAL LOST/CYCLE (Σ④) = 598.6 (LB) + N/A (Σ①) = 271.5 (598.6) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

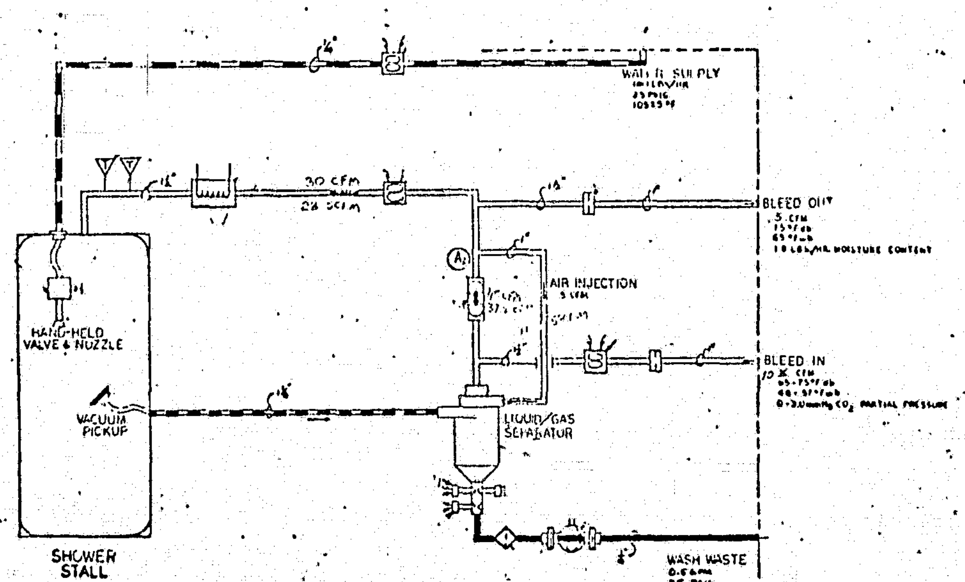
APPLIANCE FUNCTION Whole Body Shower

APPLIANCE CONCEPT NO./TITLE 2/Air Drag

INDEX NO. 2.2.1.2 REF. NO. 278, 127

DESCRIPTION

The air drag concept is the same as Concept 1 with the exception of body drying. Body drying is accomplished by heated air passing over the crewman's body while in the stall. The concept eliminates the requirement for towels and the associated washer/dryer penalties; however, it is a high power consumption unit.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/AIR DRAG

INDEX NUMBER 2.2.1.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A.C. POWER ② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
BLOWER (AIR) (127)	.25	549.9	549.9	137.5			
AIR HEATER (127)	.25	4705.6	4705.6	1176.4			
WATER PUMP (127)	.25	57.5	57.5	14.4			
CONDENSER PUMP (127)	.25	57.5	57.5	14.4			
SOLENOID VALVES (127)	MOMENTARY	—	—	—	16	16	—
		5370.5 MAXIMUM		1342.7 TOTAL	16 MAXIMUM		TOTAL

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THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
SHOWER BLEED TO CABIN (127)	702	—	—	702
SHOWER DOOR TO CABIN	—	271	271	—
MOISTURE CARRIED OUT BY CREWMAN	264	—	—	264
CONDENSER LOAD	14,965	—	—	14,965
TOTAL	4672 (15,931) WATT (BTU/HR)	79.5 (271) WATT (BTU/HR)	79.5 (271) WATT (BTU/HR)	4672 (15,931) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
~N/A-					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/AIR DRAG

INDEX NUMBER 2.2.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
SHOWER STALL (127)	148	71.1
COMPONENTS MODULE ASSY (127)	234	
TOTAL	173.3 (382) KG (LBS)	2.01 (71.1) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	5.0 (278)	N/A	N/A	5.0

Σ① 5.0 Σ④ 5.0

TOTAL WT. MISSION = 4 CYCLE/DAY X 20.5 DAYS/MISSION X 5.0 TOTAL LOST/CYCLE (Σ④) = 410 (LB) + N/A (Σ①) = 185.97 (410) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

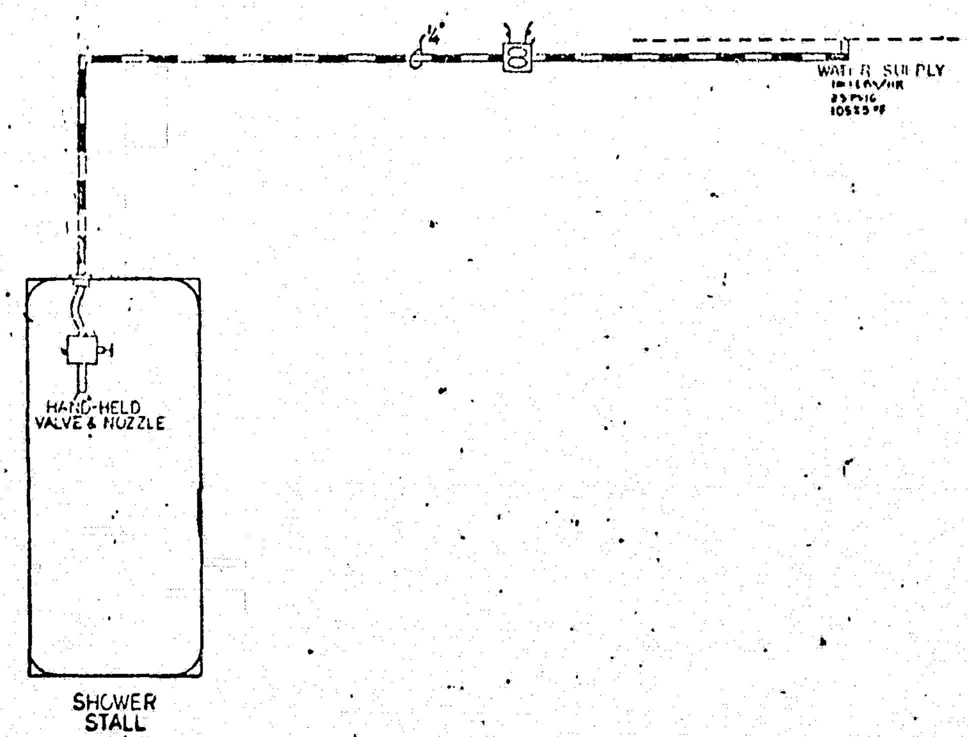
APPLIANCE FUNCTION Whole Body Shower

APPLIANCE CONCEPT NO./TITLE 3/Mechanical

INDEX NO. 2.2.1.3 REF. NO. 278

DESCRIPTION

The mechanical shower concept is whole body showering without air recirculation and vacuum water retrieval systems. The water is picked up manually using towels. The towels are washed and dried after use. Five towels per shower (Ref. 278) are required for crewman drying and water pickup. Each towel is assumed to hold 1.0 pints of water. The stall and water distribution system are identical to Concepts 1 and 2. Water recovery from the towels is accomplished by spin drying in the washing machine. The amount of water left in the towel after spin drying is neglected since it is equivalent to towels being washed and then dried. This is a valid assumption because the towels are washed after each shower.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/MECHANICAL

INDEX NUMBER 2.2.13

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
SHOWER DOOR TO CABIN	—	372	372	—
MOISTURE CARRIED OUT BY CREWMAN/TOWELS	264	—	—	264
TOTAL	77.4 (264) WATT (BTU/HR)	109 (372) WATT (BTU/HR)	109 (372) WATT (BTU/HR)	77.4 (264) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
WASHER	3150	—	148.6	125.4	11.2
DRYER	227.5	424	187.9	50.2	11.2
TOTAL	990.5 (3377.5) WATTS/CYCLE (BTU/HR/CYCLE)	124. (424) WATTS/CYCLE (BTU/HR/CYCLE)	336.5	79.7 (175.6) KG/MISSION (LB/MISSION)	.634 (22.4) M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/MECHANICAL INDEX NUMBER 2.2.1.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT³)
SHOWER STALL	(127)	148	49
TOWELS (5/SHOWER)	(279)	2.2	1.70
TOTAL		68.1 (150.2) KG (LBS)	1.43 (50.7) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
TOWELS	.0833 (278) (236)	.092 (209) .322 (209)	.0268	.125 (209) .250 (209)	.0208
			Σ③ .0268 TOTAL WT/CYCLE (LB)		Σ⑤ .0208 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0268 TOT.WT/CYCLE (LB) = .996 (2.2) KG (LB)

TOTAL VOL MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0208 TOT.VOL/CYCLE (FT^3) = .048 (1.70) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	5.0	N/A	N/A	5.0
WASHER WATER LOSS PENALTY	11.5	N/A	N/A	11.5
	Σ① 16.5			Σ④ 16.5

TOTAL WT. MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x 16.5 TOTAL LOST/CYCLE (Σ ④) = 1353 (LB) + N/A (Σ ①) = 613.7 (1353) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

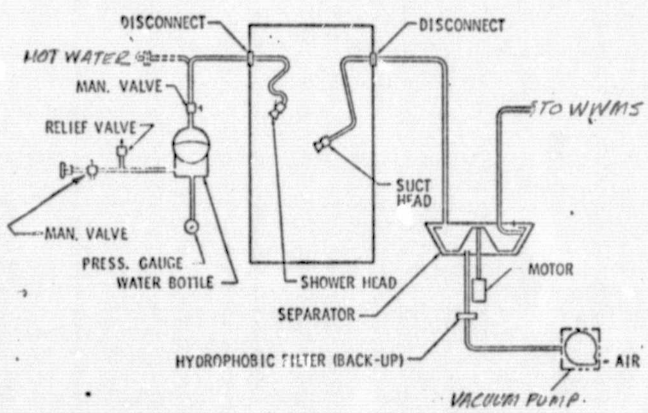
APPLIANCE FUNCTION Whole Body Shower

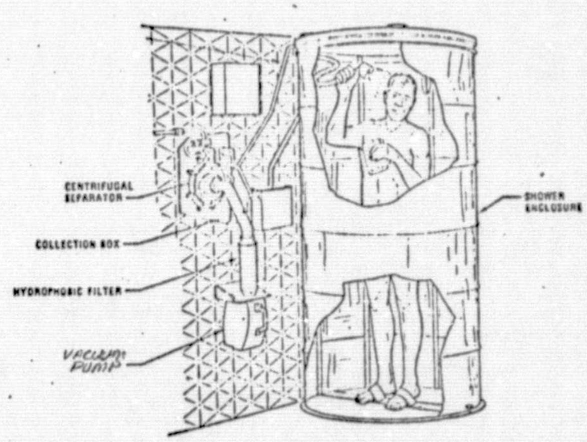
APPLIANCE CONCEPT NO./TITLE 4/Collapsible (Skylab)

INDEX NO. 2.2.1.4 REF. NO. 279,283,297,282,255,209

DESCRIPTION

The collapsible shower concept was used on Skylab. The shower stall is folded down for use to minimize space. The shower enclosure consists of two end ring closures and a translucent Beta cloth skirt with stiffening rings. One end ring attaches to the floor and the other to the ceiling when the shower is in use. Water is delivered through a nozzle with vacuum pickup of water. The waste water is centrifugally separated and routed to the water waste management system. Six pounds of water were used for this concept per shower (Ref. 282). One towel per crewman per shower is used for drying.





SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

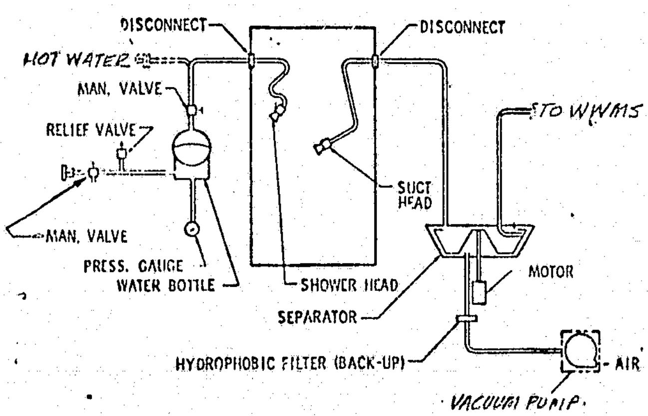
APPLIANCE FUNCTION Whole Body Shower

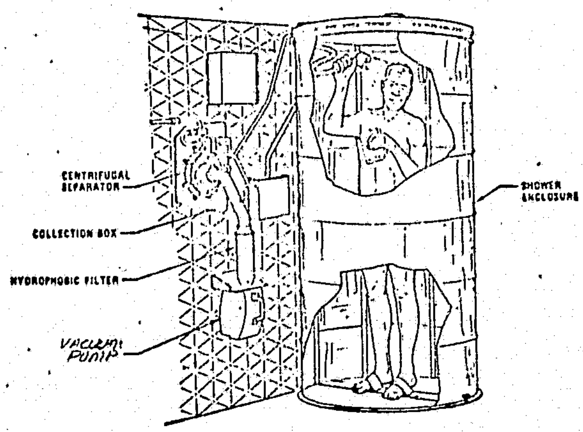
APPLIANCE CONCEPT NO./TITLE 4/Collapsible (Skylab)

INDEX NO. 2.2.1.4 REF. NO. 279,283,297,282,255,209

DESCRIPTION

The collapsible shower concept was used on Skylab. The shower stall is folded down for use to minimize space. The shower enclosure consists of two end ring closures and a translucent Beta cloth skirt with stiffening rings. One end ring attaches to the floor and the other to the ceiling when the shower is in use. Water is delivered through a nozzle with vacuum pickup of water. The waste water is centrifugally separated and routed to the water waste management system. Six pounds of water were used for this concept per shower (Ref. 282). One towel per crewman per shower is used for drying.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 4/COLLAPSIBLE (SKYLAB) INDEX NUMBER 2.2.1.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
WATER SEPARATOR (255)	.25	28	28	7.0	—	—	—
WATER PUMP (255)	.25	57.5	57.8	14.4	—	—	—
		85.5 MAXIMUM		21.4 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
SHOWER INCLOSURE TO CABIN	—	864	864	—
MOISTURE CARRIED OUT BY CREWMAN	264	—	—	264
TOTAL	77.4 (264) WATT (BTU/HR)	253.4 (864) WATT (BTU/HR)	253.4 (864) WATT (BTU/HR)	77.4 (264) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
WASHER	630	—	29.7	25.1	2.245
DRYER	45.5	84.7	37.5	10.0	2.2
TOTAL	198.1 (675.5) WATTS/CYCLE (BTU/HR/CYCLE)	24.8 (84.7) WATTS/CYCLE (BTU/HR/CYCLE)	67.2	15.9 (35.1) KG/MISSION (LB/MISSION)	.126 (4.445) M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/COLLAPSIBLE (SKYLAB) INDEX NUMBER 2.2.1.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
SHOWER STALL/COMPONENTS (MSFC)	152	44.34
TOWELS	0.44	0.34
TOTAL	69.15 (152.44) KG (LBS)	1.26 (44.68) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
TOWELS	.0166 (236)	.092 (209) .322 (236)	.0054	.125 (209) .250 (209)	.00417

Σ③ .0054 TOTAL WT/CYCLE (LB)   Σ⑤ .00417 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .0054 TOT.WT/CYCLE (LB) = .20 (.443) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .00417 TOT.VOL/CYCLE (FT^3) = .0097 (.342) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	6.0 (282)	N/A	N/A	6.0
WASHER WATER LOSS PENALTY	2.3	N/A	N/A	2.3

Σ① 8.3   Σ④ 8.3

TOTAL WT./MISSION = 4 CYCLE/DAY x 20.5 DAYS/MISSION x 8.3 TOTAL LOST/CYCLE (Σ ④) = 680.6 (LB) + N/A (Σ ①) = 308.7 (680.6) KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.2 Body Cleansing

APPLIANCE FUNCTION 2.2.2 Partial Body Washing

NUMBER OF CONCEPTS CONSIDERED 6

ASSUMPTIONS

(1) The partial body washing is the washing of local body areas (i.e., feet, hands, face).

(2) Washer/dryer penalty was based on washer Concept 7, Water Spray Agitation, and dryer Concept 1, Forced Hot Air-Electric Dryer.

(3) Water used for Space Station body cleansing was assumed to be recycled minus the water associated with the suspended solids. Shuttle water used is not recycled.

(4) Partial body washing frequency used for the study is 10 times per day per man with a use time of the wetting unit or equivalent of 2.25 minutes per use.

(5) Washcloths or reusable paper wipes, if required, are discarded after 60 washing cycles.

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APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.2.2 **** PARTIAL BODY WASHING (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	40.000	2	.0003	.00	.0	21.1	105.	278.	500.0	240.0	233.6	.60	2	30	.0
	.037		(.0007)	(.00)	(.0)	(70.0)	(360.)	(948.)	.0	.0	(515.0)	(21.20)			(.0)
		9	.2268	.00	1551.4	.0									
			(.5000)	(.00)	(30.0)	(.0)									
2	40.000	5	.0109	.00	1.0	.0	105.	278.	501.1	240.0	208.1	.10	2	30	.0
	.037		(.0240)	(.00)	(.0)	(.0)	(360.)	(948.)	.0	.0	(458.8)	(3.60)			(.0)
		9	.2268	.01	1551.4	.0									
			(.5000)	(.02)	(30.0)	(.0)									
3	40.000						0.	0.	.0	.0	43.5	.06	1	10	.0
	.037						(0.)	(0.)	.0	.0	(96.0)	(2.20)			(.0)
4	40.000	9	.0227	.00	1551.4	.0	422.	11.	52.0	32.0	28.0	.04	2	50	.0
	.037		(.0500)	(.00)	(30.0)	(.0)	(1440.)	(37.)	.0	.0	(61.7)	(1.51)			(.0)
5	40.000	9	.2268	.00	1551.4	.0	105.	278.	500.0	240.0	546.9	.20	2	30	.0
	.037		(.5000)	(.00)	(30.0)	(.0)	(360.)	(948.)	.0	.0	(1205.6)	(7.20)			(.0)
6	40.000	9	.2268	.00	1810.0	51.7	32.	30.	57.5	.0	213.9	.29	1	5	.0
	.037		(.5000)	(.00)	(35.0)	(125.0)	(110.)	(101.)	140.0	.0	(471.6)	(10.10)			(.0)

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	DISPOSABLE WET WIPES
2 -	REUSABLE WET WIPES
3 -	DISPOSABLE WIPES (PREPACKAGED)
4 -	AUTOMATIC SPONGE
5 -	REUSABLE WASHCLOTHES
6 -	DISPOSABLE WASHCLOTHES (SKYLAB)

(*)

1 - CABIN AIR	(CIRCULATED),	LITERS/SEC	(FT^3/MIN)
2 - CABIN AIR	(LOST)	, KG/HR	(LB/HR)
3 - OXYGEN	(LOST)	, KG/HR	(LB/HR)
4 - COOLING WATER	(CIRCULATED),	KG/HR	(LB/HR)
5 - WATER	(LOST)	, KG/HR	(LB/HR)
6 - NITROGEN	(CIRCULATED),	KG/HR	(LB/HR)
7 - NITROGEN	(USED)	, KG/HR	(LB/HR)
8 - FREON	(CIRCULATED),	KG/HR	(LB/HR)
9 - WATER	(PROCESSED)	, KG/HR	(LB/HR)

(**)AVAILABLE

(1) AVAILABLE

(2) STATE OF THE ART

(3) SOME DEVELOPMENT REQUIRED

(4) EXTENSIVE DEV. REQUIRED

(***)COST INDICATOR
0-25%
25-50%
50-75%
75-100%

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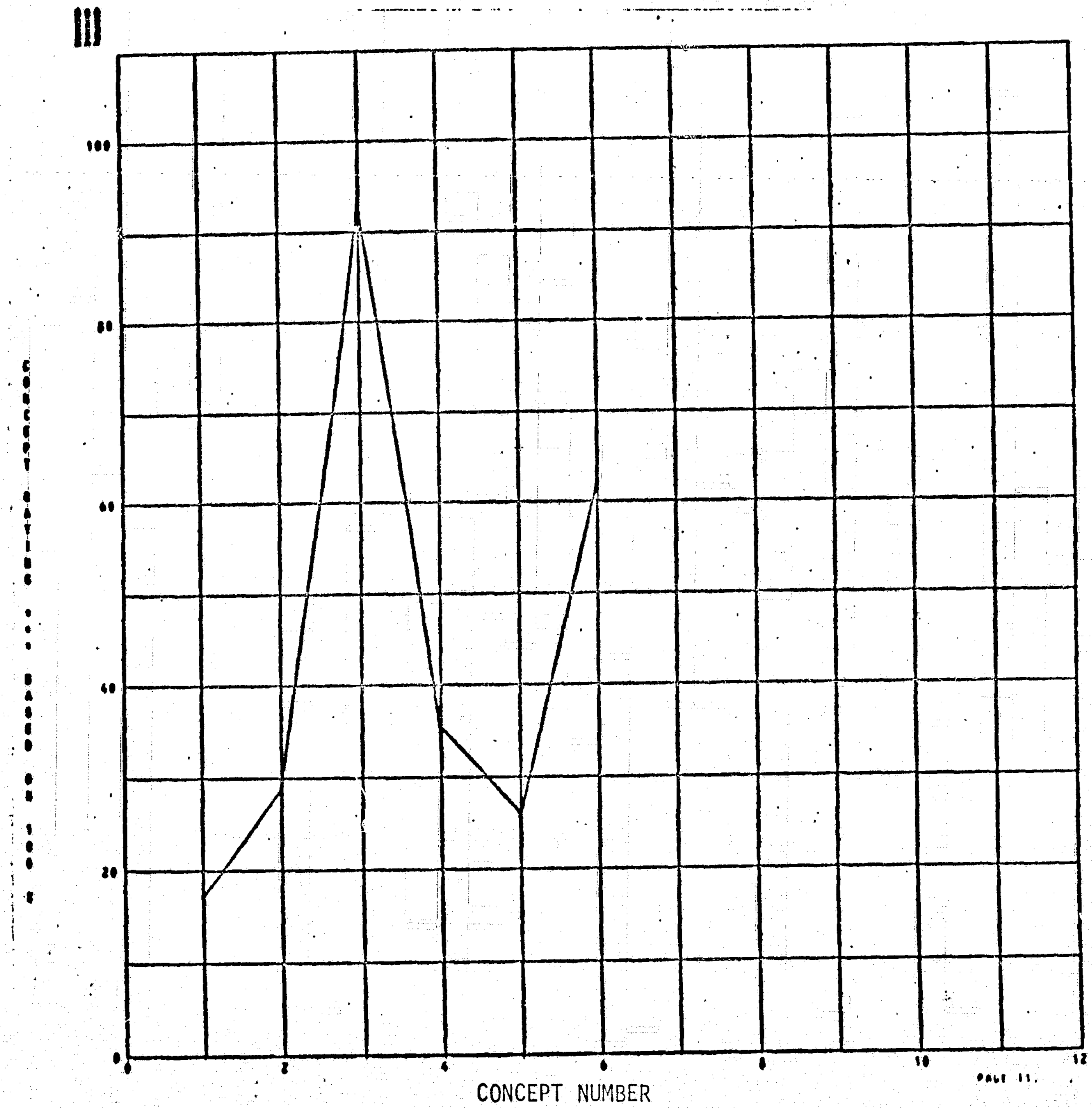
APPLIANCE CONCEPT NO.		CONCEPT NAME
1.	-	DISPOSABLE WET WIPES
2	-	REUSABLE WET WIPES
3	-	DISPOSABLE WIPES (PREPACKAGED)
4	-	AUTOMATIC SPONGE
5	-	REUSABLE WASHCLOTHES
6	-	DISPOSABLE WASHCLOTHES (SKYLAB)



Partial Body Washing (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 28
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . PARTIAL BODY WASHING (SHUTTLE)
(02/04/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5	6
WEIGHT	61.680	1205.6	15	8.59	9.29	13.81	14.23	.00	9.13
POWER	.00000	265.58	15	.03	.00	15.00	13.42	.03	9.88
VOLUME	1.5100	21.200	10	.00	8.30	8.96	9.29	6.60	5.24
THERMAL	.00000	61.140	15	.00	.00	15.00	5.67	.00	12.96
RELIAB-Y	.99940	1.0000	5	.66	.66	5.00	.00	.66	.46
MAINTENC	.99999	1.0000	5	1.56	1.56	5.00	.00	1.56	1.10
DEV COST	5.0000	50.000	15	6.00	6.00	12.00	.00	6.00	13.50
TOTAL PT	.00000	80.000	80	16.85	25.81	74.77	42.61	14.86	52.27
RATING	.00000	100.00	100	21.06	32.27	93.46	53.27	18.57	65.33

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6
NORMAL	21.06	32.27	93.46	53.27	18.57	65.33
WEIGHT	24.16	34.81	93.34	56.83	16.98	64.95
POWER	19.27	29.50	94.02	56.37	17.00	65.38
VOLUME	19.82	35.25	93.23	55.60	21.36	64.57
THERMAL	19.25	29.50	94.02	51.94	16.98	67.14
RELIAB-Y	20.82	31.69	93.66	51.65	18.41	63.63
MAINTENC	21.36	32.23	93.66	51.65	18.95	64.02
DEV COST	22.68	32.93	92.31	48.70	20.41	67.45

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5	6
NORMAL	21.06	32.27	93.46	53.27	18.57	65.33
WEIGHT	17.31	29.20	93.61	48.96	20.49	65.79
POWER	23.21	35.60	92.78	49.52	20.47	65.28
VOLUME	22.46	28.88	93.72	50.62	15.41	66.20
THERMAL	23.24	35.60	92.78	54.86	20.49	63.15
RELIAB-Y	21.31	32.88	93.25	54.98	18.74	67.15
MAINTENC	20.73	32.30	93.25	54.98	18.17	66.73
DEV COST	19.10	31.47	94.85	58.78	16.35	62.78

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.2.2-PARTIAL BODY WASHING

APPLIANCE TYPE \ COMPONENT TYPE (NO.)	WATER SEPARATOR (6)	FILTER (9)	SOLENOID VALVE (3)	HEAT EXCHANGER (16)	ACCUMULATOR (4)	TEMPERATURE CONTROL VALVE (24)	CONTROLLER TIMER (19)	CHECK VALVE (22)	PUMP (2)	MANUAL VALVE (23)	HEATER (17)	RELIEF VALVE (25)	MOTOR (1)	( )	( )	( )	NUMBER OF SAFETY CRITICAL ITEMS
DISPOSABLE WET WIPES	1	2	2	1	1	1	1	1	-	-	-	-	1				0
REUSABLE WET WIPES	1	2	2	1	1	1	1	1	-	-	-	-	1				0
DISPOSABLE WIPES	-	-	-	-	-	-	-	-	-	-	-	-	-				0
AUTOMATIC SPONGE (ASTRO-VAC)	1	2	2	1	-	-	1	1	1	-	-	-	2				0
REUSABLE WASHCLOTHS	1	2	2	1	1	1	1	1	-	-	-	-	1				0
DISPOSABLE WASHCLOTHS (SKYLAB)	-	-	-	-	1	-	1	1	1	5	1	1	1				0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

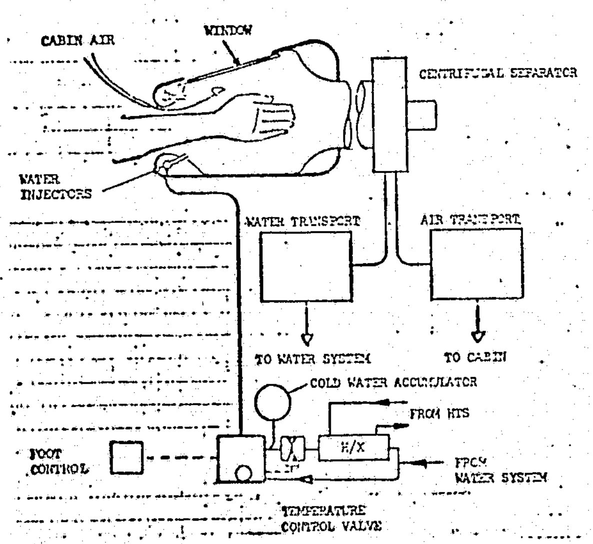
APPLIANCE FUNCTION Partial Body Washing

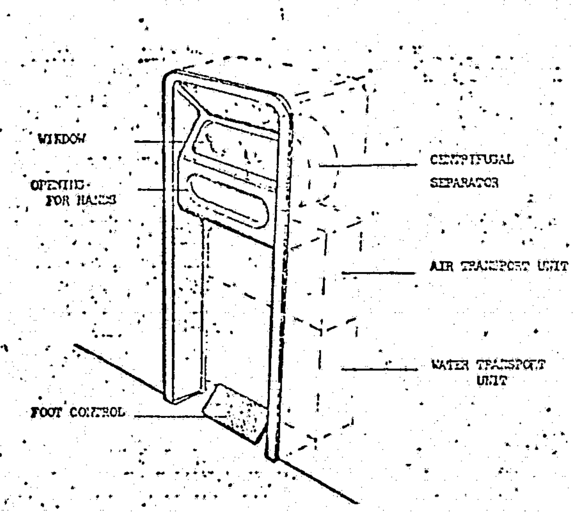
APPLIANCE CONCEPT NO./TITLE 1/Disposable Wet Wipes

INDEX NO. 2.2.2.1 REF. NO. 236, 186

DESCRIPTION

The disposable wet wipes concept is a sponge bath technique used to clean local areas of the body. A wetting and soaping unit, with hand holes is supplied for the function. The unit has a water supply outlet, a storage area for soap and a fan for providing water entrainment during use. A centrifugal separator is provided upstream of the blower to collect used water. Water temperature is controlled by mixing hot with cold water in a temperature controlled mixing valve. The crewman first "soaps up" the wipe in the wetting unit, then uses it to clean the required areas of the body. The wipe is wrung out and rinsed inside the wetting unit. The rinsed damp wipe is used to wipe excess soap from the body. A final rinse and wringing out of the wipe is accomplished and the wipe is disposed of by depositing it into a vacuum drier to remove excess water. The dried wipe is then deposited into the refuse system. The disposable wipes are 12 inch squares of 4 ply wet strength paper, 10 of which are supplied per crewman per day.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/DISPOSABLE WET WIPES INDEX NUMBER 2.2.2.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
WETTING UNIT (236)	.0375	500	240	9	—	—	—
		500 MAXIMUM		9.0 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS	360	—	—	360
MOTORS	—	948	948	—
TOTAL	105.6 (360) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	105.6 (360) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
- N/A -					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/DISPOSABLE WET WIPES

INDEX NUMBER 2.2.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
WETTING UNIT	(236)	55.69	20.1
DISPOSABLE WIPES	(236)	12.3	1.23
TOTAL		30.8 (67.99) KG (LBS)	.604 (21.33) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
WIPES	1 (236)	.015 (236)	.015	.0015	.0015
		Σ③	.015 TOTAL WT/CYCLE (LB)	Σ⑤	.0015 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .015 TOT.WT/CYCLE (LB) = 5.58 (12.3) KG (LB)

TOTAL VOL/MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0015 TOT.VOL/CYCLE (FT^3) = .035 (1.23) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
OXYGEN (WIPE DISPOSAL)	.000719	N/A	N/A	.000719
WATER	.5	N/A	N/A	.5
WATER LOSS (LOSS IN DISPOSED WIPE)	.0444	N/A	N/A	.0444
Σ①	.545		Σ④	.545

TOTAL WT./MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x .545 TOTAL LOST/CYCLE (Σ④) = 446.9 (LB) + N/A (Σ①) = 202.7 (446.9) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

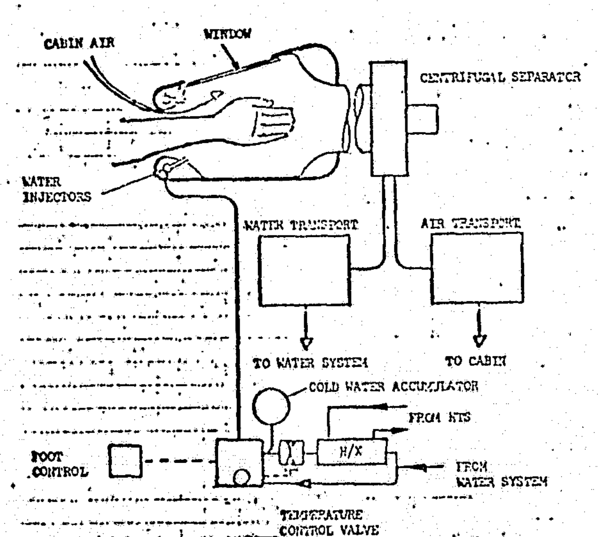
APPLIANCE FUNCTION Partial Body Washing

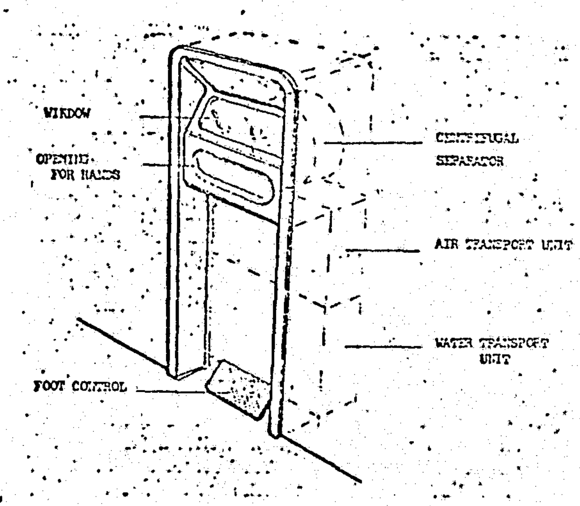
APPLIANCE CONCEPT NO./TITLE 2/Reusable Wet Wipes

INDEX NO. 2.2.2.2 REF. NO. 236, 186

DESCRIPTION

The reusable wet wipe concept is a sponge bath technique used to clean local areas of the body. The wetting unit described in Concept 1 is also required for this concept. The reusable wipes, however, are wrung out in the wetting unit and reused. Reusable wipes are provided on a per man basis. The wipe is washed and dried using a washing machine and dryer. After 60 washings, the wipe is discarded and replaced. The reusable wipes are 10 inches square of 4 ply "wet strength" paper.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/REUSABLE WET WIPES

INDEX NUMBER 2.2.2.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
WETTING UNIT (236)	.0375	500	240.5	9.02	—	—	—
		500 MAXIMUM		9.02 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS	360	—	—	360
MOTORS	—	948	948	—
TOTAL	105.6 (360) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	105.6 (360) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
WASHER	10.95	—	.516	.436	.039
DRYER	.792	1.47	.653	.174	.038
TOTAL	3.44 (11.742) WATTS/CYCLE (BTU/HR/CYCLE)	.43 (1.47) WATTS/CYCLE (BTU/HR/CYCLE)	1.169	.277 (.610) KG/MISSION (LB/MISSION)	.002 (.077) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/REUSABLE WET WIPES INDEX NUMBER E.2.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
WETTING UNIT	(236)	28.49	3.5
REUSABLE WIPES	(236)	.055	.034
TOTAL		12.9 (28.545) KG (LBS)	.10 (3.534) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
WIPES	1 (236)	.0000667 (236)	.0000667	.000042 (236)	.000042
			Σ③ .0000667 TOTAL WT/CYCLE (LB)		Σ⑤ .000042 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0000667 TOT.WT/CYCLE (LB) = .025 (.055) KG (LB)

TOTAL VOL/MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .000042 TOT.VOL/CYCLE (FT^3) = .00097 (.034) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	.5 (236)	N/A	N/A	.5
WASHER WATER LOSS PENALTY	.024	N/A	N/A	.024
	Σ① .524			Σ④ .524

TOTAL WT./MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x .524 TOTAL LOST/CYCLE (Σ ④) = 429.7 (LB) + N/A (Σ ①) = 194.9 (429.7) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

APPLIANCE FUNCTION Partial Body Washing

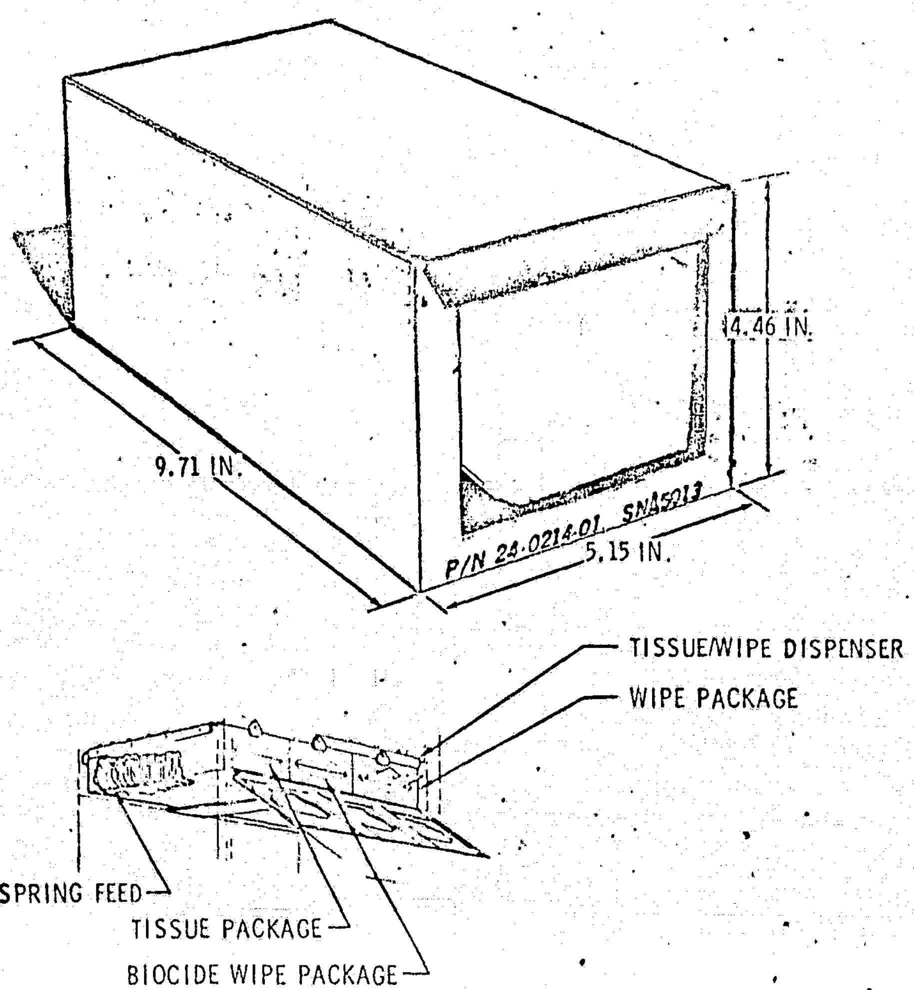
APPLIANCE CONCEPT NO./TITLE 3/Disposable Wipes (Skylab)

INDEX NO. 2.2.2.3 REF. NO. 250, 283

DESCRIPTION

The disposable wipes concept is made up of prepackaged wipes which were used on Skylab. The wipes are contained within a package to eliminate water evaporation during storage. The units are used and discarded. The Skylab size wipe weight and volume were ratioed (6.3) to the 10 inch square wipes used in Concepts 1 and 2 in order to provide an equivalent trade.

Wipe Dispenser



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/DISPOSABLE WIPES (SKYLAB) INDEX NUMBER 2.2.2.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/DISPOSABLE WIPES (SKYLAB) INDEX NUMBER 2.2.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
WIPES/PACKAGING (250)	96.1	2.2
TOTAL	43.6 (96.1) KG (LBS)	.063 (2.20) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
WIPES	1 (236)	5.6/301(63)(mission)	.1172	.129/301(63)(mission)	.0027

Σ③ .1172 TOTAL WT/CYCLE (LB)

Σ⑤ .0027 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .1172 TOT.WT/CYCLE (LB) = 43.6 (96.1) KG (LB)

TOTAL VOL / MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0027 TOT.VOL/CYCLE (FT^3) = .063 (2.2) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)

Σ① ____ Σ④ ____

TOTAL WT. / MISSION = ____ CYCLE/DAY x ____ DAYS/MISSION x TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene **HABITABILITY FUNCTION** Body Cleansing

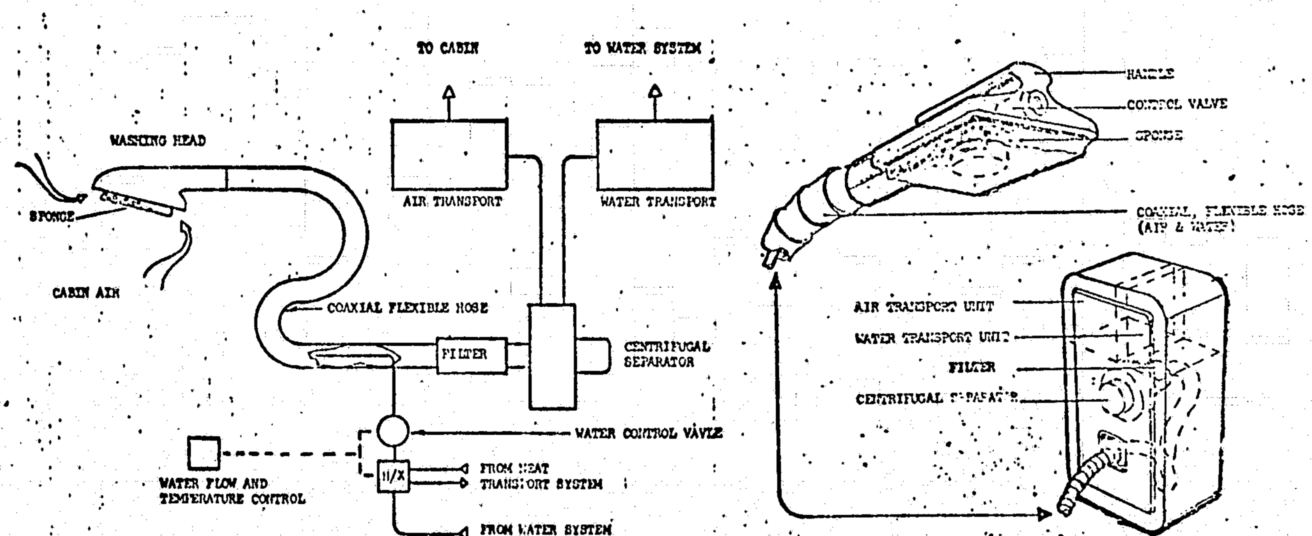
APPLIANCE FUNCTION Partial Body Washing

APPLIANCE CONCEPT NO./TITLE 4/Automatic Sponge

INDEX NO. 2.2.2.4 **REF. NO.** 236, 100

DESCRIPTION

The automatic sponge concept is a hand-held scrubber head connected by coaxial flex tubing to a water supply valve and an air transport system. Water is fed into a sponge in the scrubber head for use in cleaning the body. A water pickup housing connected to the vacuum line surrounds the sponge. A water separator is used to collect water from the cabin air. A pump unit injects the water into the water waste management system. Each crewman has a sponge and is provided with one sponge per month to fit the scrubber head.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 4/AUTOMATIC SPONGE   INDEX NUMBER 2.2.2.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
AUTOMATIC SPONGE UNIT (236)	.0375	52.8	31.7	1.19	—	—	—
		52.8 MAXIMUM		1.19 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS	1440	—	—	1440
MOTORS	—	36.7	36.7	—
TOTAL	422.3 (1440) WATT (BTU/HR)	10.8 (36.7) WATT (BTU/HR)	10.8 (36.7) WATT (BTU/HR)	422.3 (1440) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
— N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/AUTOMATIC SPONGE INDEX NUMBER 2.2.2.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
AUTOMATIC SPONGE UNIT (236)	20.6	1.5
SPONGES	0.081	0.013
TOTAL	9.38 (20.681) KG (LBS)	.043 (1.513) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
SPONGES	.033 (236)	.002989	.0000986	.000481	.0000159

Σ③ .0000986 TOTAL WT/CYCLE (LB) Σ⑤ .0000159 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0000986 TOT.WT/CYCLE (LB) = .037 (.081) KG (LB)

TOTAL VOL/MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0000159 TOT.VOL/CYCLE (FT^3) = .000369 (.013) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	.05 (236)	N/A	N/A	.05

Σ① .05 Σ④ .05

TOTAL WT./MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x .05 TOTAL LOST/CYCLE (Σ④) = 41.0 (LB) + N/A (Σ①) = 18.6 (41.0) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

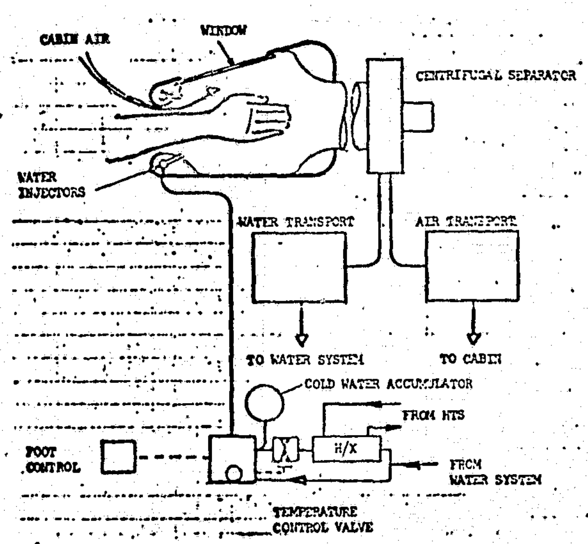
APPLIANCE FUNCTION Partial Body Washing

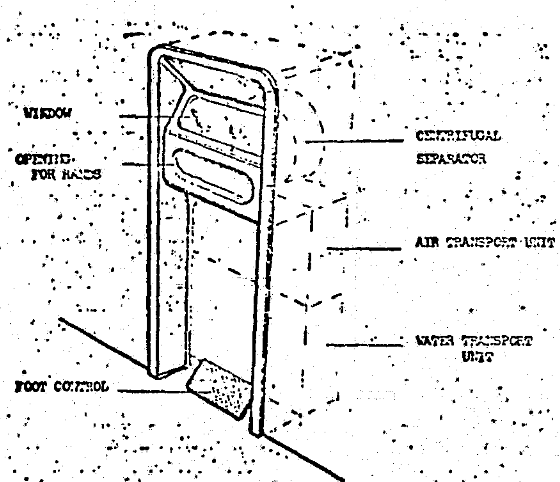
APPLIANCE CONCEPT NO./TITLE 5/Reusable Washcloths

INDEX NO. 2.2.2.5 REF. NO. 236,237,245,209

DESCRIPTION

The reusable washcloths concept is the same as Concept 2; however, terry washcloths are used for cleansing cloths. The terry washcloths are 6 inches square. The washcloth is used for 60 washings then is discarded and replaced. The washcloth is washed and dried daily using a washing machine and dryer.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 5/REUSABLE WASH/CLOTHES

INDEX NUMBER 2.2.2.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
WETTING UNIT (236)	.0375	500	240.5	9.02	—	—	—
		500 MAXIMUM		9.02 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS	360	—	—	360
MOTORS	—	948	948	—
TOTAL	105.6 (360) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	278 (948) WATT (BTU/HR)	105.6 (360) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
WASHER	414	—	19.5	16.5	1.474
DRYER	29.9	56.5	24.6	6.59	1.45
TOTAL	130.2 (443.9) WATTS/CYCLE (BTU/HR/CYCLE)	16.6 (56.5) WATTS/CYCLE (BTU/HR/CYCLE)	44.1	10.47 (23.09) KG/MISSION (LB/MISSION)	.083 (2.924) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 5/REUSABLE WASHCLOTHES INDEX NUMBER 2.2.2.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
WETTING UNIT	(236)	28.49	3.5
WASH CLOTHES		1.07	.746
TOTAL		13.41 (29.56) KG (LBS)	.12 (4.246) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
WASH CLOTHES	.0166 (236)	.077	.0013	.0546 (209)	.00091

Σ③ .0013 TOTAL WT/CYCLE (LB) Σ⑤ .00091 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .0013 TOT.WT/CYCLE (LB) = .483 (1.07) KG (LB)

TOTAL VOL / MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .00091 TOT.VOL/CYCLE (FT^3) = .021 (.746) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	.5 (236)	N/A	N/A	.5
WASHER WATER LOSS PENALTY	.906	N/A	N/A	.906

Σ① 1.406 Σ④ 1.406

TOTAL WT. / MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x 1.406 TOTAL LOST/CYCLE (Σ④) = 1153 (LB) + N/A (Σ①) = .523 (1153) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

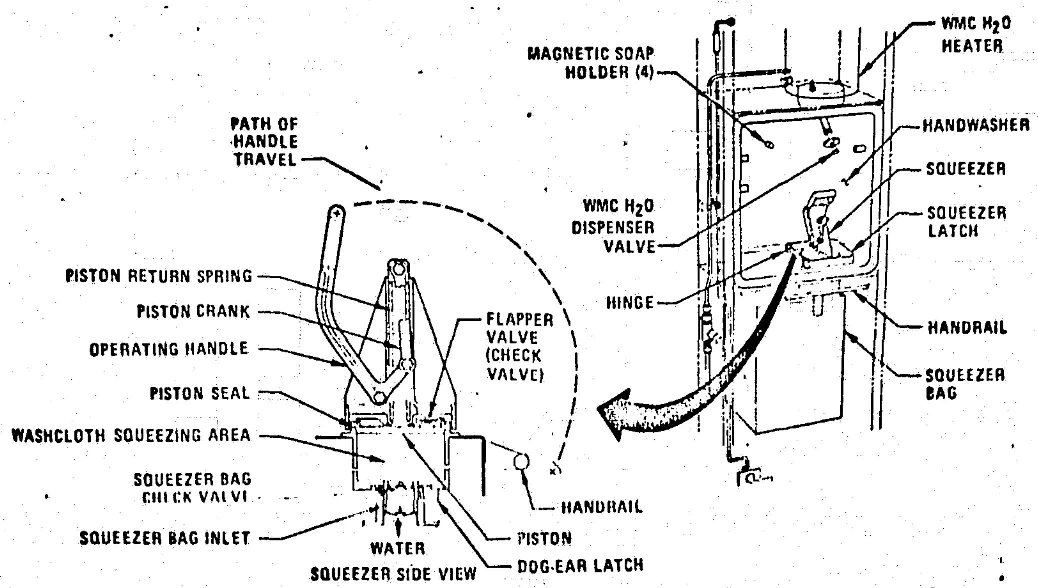
APPLIANCE FUNCTION Partial Body Washing

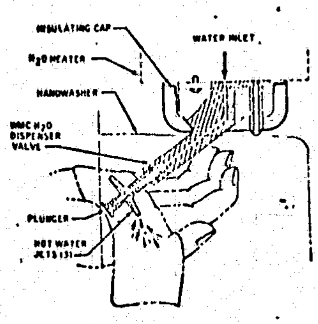
APPLIANCE CONCEPT NO./TITLE 6/Disposable Washcloths (Skylab)

INDEX NO. 2.2.2.6 REF. NO. 236,283

DESCRIPTION

The disposable washcloths concept is the system used on the Skylab vehicle. The terrycloth washcloths are wetted by depressing a water supply valve. The unit will provide warm water from a heated storage tank. After the cloth is used, it is squeezed using a manual squeezer unit. The water squeezed from the washcloth is recovered and routed to the water waste management system. One washcloth is provided per man per day. The washcloths are disposed of by deposit into a vacuum drier to remove excess water. The dried cloth is then deposited into the refuse system.





WMC H_2O DISPENSER VALVE CUTAWAY

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 6/DISPOSABLE WASHCLOTHES INDEX NUMBER 2.2.2.6

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
HEATER (25)	.0375	—	—	—	140	140	5.25
WATER PUMP	.0375	57.5	57.5	2.15	—	—	—
		57.5 MAXIMUM		2.15 TOTAL	140 MAXIMUM		5.25 TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS	110	—	—	110
HEATER	—	71.6	71.6	—
WATER PUMP	—	29.4	29.4	—
TOTAL	32.3 (110) WATT (BTU/HR)	29.6 (101.0) WATT (BTU/HR)	29.6 (101) WATT (BTU/HR)	32.3 (110) WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
— N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 6/DISPOSABLE WASHCLOTHES INDEX NUMBER 2.2.2.6

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
SQUEEZER/WATER DISPENSER (MDAC)	32.4	1.15
WASH CLOTHES	8.84	8.95
TOTAL	18.7 (41.24) KG (LBS)	.286 (10.10) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
WASH CLOTHES	.1 (283)	.1078 (237) .0308 (100)	.01078	.1092 (209) .0546 (100)	.01092

Σ③ .01078 TOTAL WT/CYCLE (LB) Σ⑤ .01092 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .01078 TOT.WT/CYCLE (LB) = 4.0 (8.84) KG (LB)

TOTAL VOL MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .01092 TOT.VOL/CYCLE (FT^3) = .253 (8.95) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	.5 (236)	N/A	N/A	.5
WATER LOSS TO SPACE	.025	N/A	N/A	.025

Σ① .525 Σ④ .525

TOTAL WT. MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x .525 TOTAL LOST/CYCLE (Σ ④) = 430.5 (LB) + N/A (Σ ①) = 195.3 (430.5) KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.2 Body Cleansing

APPLIANCE FUNCTION 2.2.3 Partial Body Drying

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

(1) The wipes and towels considered for partial body drying provide the means for drying local body areas after partial body washing.

(2) Washer/dryer penalty was based on washer Concept 7, Water Spray Agitation, and dryer Concept 1, Forced Hot Air-Electric Dryer.

(3) Vacuum drying, if used, assumes the residual water in the item to be dried is lost to space. Cabin air loss is also computed, since the chamber contains a finite amount of cabin air prior to pump down.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.2.3 **** PARTIAL BODY DRYING (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	90.000	5	3.1298	.00	.0	.0	25.	198.	67.2	.0	2582.8	.14	1	5	.0
	.056		(6.9000)	(.00)	(.0)	(.0)	(85.)	(675.)	.0	.0	(5693.9)	(5.12)			(.0)
2	90.000	5	.0111	.00	.0	.0	0.	0.	.0	.0	19.6	.17	1	5	.0
	.056		(.0245)	(.00)	(.0)	(.0)	(0.)	(0.)	.0	.0	(43.3)	(5.89)			(.0)
3	90.000	1	.0000	70.79	.0	21.1	0.	76.	1725.0	.0	7.3	.02	1	5	.0
	.016		(.0000)	(150.00)	(.0)	(70.0)	(0.)	(261.)	.0	.0	(16.0)	(.53)			(.0)

APPLIANCE CONCEPT NO. — C O N C E P T   N A M E

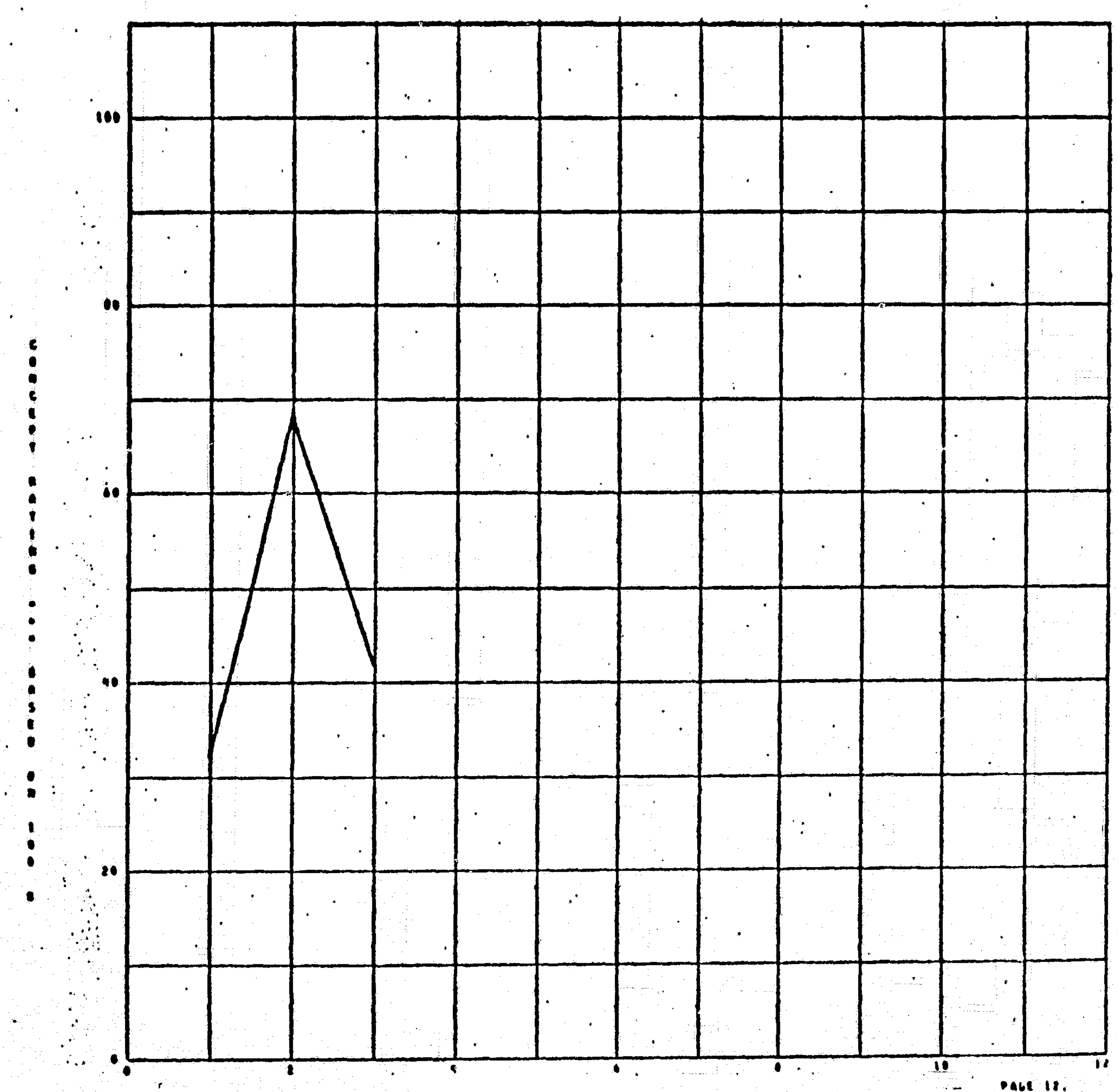
1 - REUSABLE DRY WIPES
2 - DISPOSABLE DRY WIPES
3 - ELECTRIC DRYER

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

ok

APPLIANCE CONCEPT NO.		CONCEPT NAME
1	-	REUSABLE DRY WIPES
2	-	DISPOSABLE DRY WIPES
3	-	ELECTRIC DRYER



Partial Body Drying (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 29
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . PARTIAL BODY DRYING (SHUTTLE)
(02/01/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3
WEIGHT	16.000	5693.9	15	.00	14.89	14.96
POWER	.00000	914.25	15	14.42	15.00	.00
VOLUME	.53000	5.8900	10	1.31	.00	9.10
THERMAL	.00000	39.242	15	.00	15.00	9.51
RELIAB-Y	.99975	1.0000	5	5.00	5.00	.00
MAINTENC	.99999	1.0000	5	5.00	5.00	.00
DEV COST	5.0000	5.0000	15	.00	.00	.00
TOTAL PT	.00000	80.000	80	25.72	54.89	33.57
RATING	.00000	100.00	100	32.15	68.61	41.96

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	32.15	68.61	41.96
WEIGHT	29.40	71.23	46.91
POWER	37.64	71.30	38.37
VOLUME	31.03	64.57	44.85
THERMAL	29.40	71.30	43.80
RELIAB-Y	34.21	69.56	40.69
MAINTENC	34.21	69.56	40.69
DEV COST	29.40	62.73	38.37

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	32.15	68.61	41.96
WEIGHT	35.48	65.44	35.99
POWER	25.54	65.36	46.30
VOLUME	33.43	73.18	38.69
THERMAL	35.48	65.36	39.74
RELIAB-Y	29.97	67.59	43.32
MAINTENC	29.97	67.59	43.32
DEV COST	35.48	75.70	46.30

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.2.3-PARTIAL BODY DRYING

APPLIANCE TYPE \ COMPONENT TYPE (NUMBER OF COMPONENTS)	MOTOR (1)	BLOWER (18)	CONTROLLER TIMER (19)	HEATER (17)	NUMBER OF SAFETY CRITICAL ITEMS
REUSABLE DRY WIPES	-	-	-	-	0
DISPOSABLE DRY WIPES	-	-	-	-	0
ELECTRIC DRIER	1	1	1	1	0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene **HABITABILITY FUNCTION** Body Cleansing

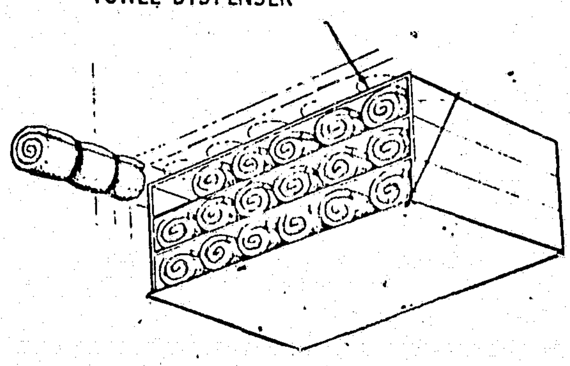
APPLIANCE FUNCTION Partial Body Drying

APPLIANCE CONCEPT NO./TITLE 1/Reusable Dry Wipes

INDEX NO. 2.2.3.1 **REF. NO.** 236,250

DESCRIPTION

The reusable dry wipe concept consists of wipes made of terrycloth. The terrycloth wipes are 15 x 30 inches and are used 10 times per day before washing. The concept includes the weight and volume of the wipe dispenser. The towels are washed and dried after one day of usage and are discarded after 60 washings. The concept is penalized for the washer/dryer function required to recycle the wipes. The terrycloth wipes are smaller and lighter than the terry towels used for whole body drying after showering.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/REUSABLE DRY WIPES

INDEX NUMBER 2.2.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
-N/A-							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
-N/A-				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
WASHER	630	—	29.7	25.1	2.245
DRYER	45.5	84.7	37.5	10.0	2.2
TOTAL	198.1 (675.5) WATTS/CYCLE (BTU/HR/CYCLE)	24.8 (84.7) WATTS/CYCLE (BTU/HR/CYCLE)	67.2	15.9 (35.1) KG/MISSION (LB/MISSION)	.126 (4.445) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/REUSABLE DRY WIPES

INDEX NUMBER 2.2.3.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
DISPENSER	(236)	.716	.632
WIPES (REUSABLE)	(236)	.121	.05
TOTAL		.380 (.837) KG (LBS)	.019 (.682) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
REUSABLE WIPES	.0166 (236)	.0089 (236)	.000148	.00366 (236)	.0000608

Σ③ .000148 TOTAL WT/CYCLE (LB)

Σ⑤ .0000608 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 40 CYCLES/DAY X 20.5 DAYS/MISSION X .000148 TOT.WT/CYCLE (LB) = .055 (.121) KG (LB)

TOTAL VOL / MISSION = 40 CYCLES/DAY X 20.5 DAYS/MISSION X .0000608 TOT.VOL/CYCLE (FT^3) = .0014 (.05) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WASHER WATER LOSS PENALTY	6.9	N/A	N/A	6.9

Σ① 6.9

Σ④ 6.9

TOTAL WT. / MISSION = 40 CYCLE/DAY X 20.5 DAYS/MISSION X 6.9 TOTAL LOST/CYCLE (Σ④) = 5658 (LB) + N/A (Σ①) = 2,566 (5658) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

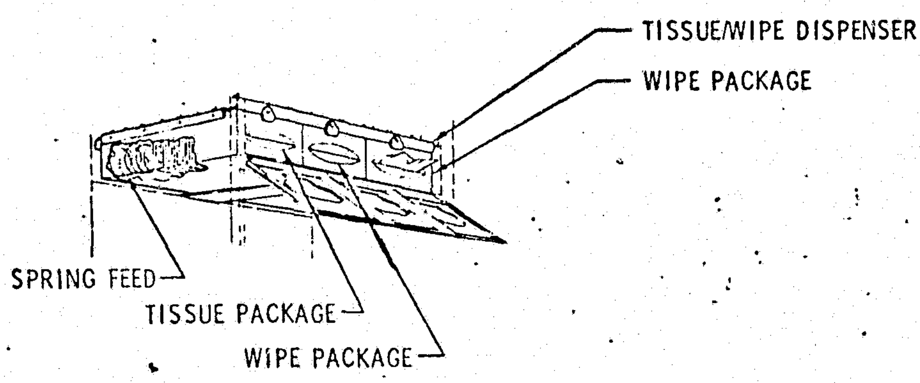
APPLIANCE FUNCTION Partial Body Drying

APPLIANCE CONCEPT NO./TITLE 2/Disposable Dry Wipes

INDEX NO. 2.2.3.2 REF. NO. 236

DESCRIPTION

The disposable dry wipe concept consists of wipes made of 4 ply "wet strength" paper. The paper wipes are 12 x 18 inches and are discarded after two uses. The wipe usage is based on 10 times per day per man. The wipes are disposed of by depositing into a vacuum drier to remove excess water. The dried wipe is then deposited into the refuse system. The concept includes the weight and volume of the wipe dispenser.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/DISPOSABLE DRY WIPES

INDEX NUMBER 2.2.3.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/DISPOSABLE DRY WIPES

INDEX NUMBER 2.2.3.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
DISPENSER	(236)	13.25	4.95
WIPES (DISPOSABLE)	(236)	9.36	.936
TOTAL		10.3 (22.61) KG (LBS)	.167 (5.89) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
DISPOSABLE WIPES	.5 (236)	.02283 (236)	.01142	.002283 (236)	.001142

Σ③ .01142 TOTAL WT/CYCLE (LB)

Σ⑤ .001142 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .01142 TOT.WT/CYCLE (LB) = 4.25 (9.36) KG (LB)

TOTAL VOL MISSION = 40 CYCLES/DAY x 20.5 DAYS/MISSION x .001142 TOT.VOL/CYCLE (FT^3) = .026 (.936) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER LOSS DUE TO VACUUM DRYING	.0245 (236)	N/A	N/A	.0245
CABIN AIR LOSS	.00072 (236)	N/A	N/A	.00072

Σ① .02522

Σ④ .02522

TOTAL WT. MISSION = 40 CYCLE/DAY x 20.5 DAYS/MISSION x .02522 TOTAL LOST/CYCLE (Σ④) = 20.7 (LB) + N/A (Σ①) = 9.4 (20.7) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Body Cleansing

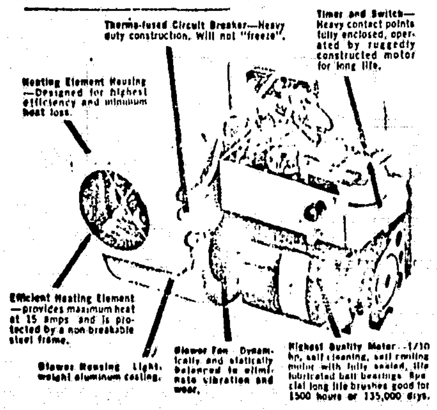
APPLIANCE FUNCTION Partial Body Drying

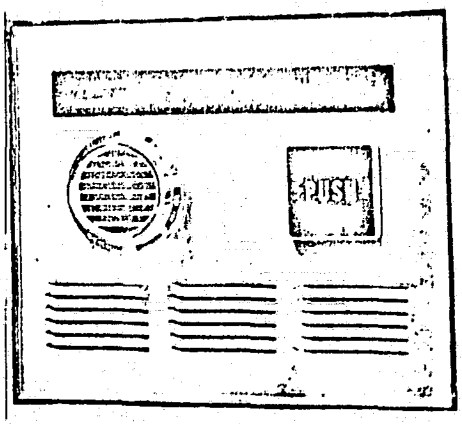
APPLIANCE CONCEPT NO./TITLE 3/Electric Dryer

INDEX NO. 2.2.3.3 REF. NO. Electric-Air Corp.

DESCRIPTION

The electric dryer concept is identical to the terrestrial type used in restrooms. The concept incorporates a fan for blowing warm-dry air on the local body areas requiring drying. A nozzle is provided which can be used to direct the air stream. The concept does not require wipes for drying. A large "button" switch is provided for ease of actuation and the unit uses a timer to automatically turn off the unit after 40 seconds of operation. The automatic shutdown is incorporated to save power.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/ELECTRIC DRYER

INDEX NUMBER 2.2.3.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
HEATER/MOTOR (ELECTRIC AIR CLNG)	.011	1725	1725	18.9	—	—	—
		1725. MAXIMUM		18.9 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
HEATER/MOTORS	—	261	261	—
TOTAL	WATT (BTU/HR)	76.5 (261) WATT (BTU/HR)	76.5 (261) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
-N/A-					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

15

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/ELECTRIC DRYER INDEX NUMBER 2.2.3.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
ELECTRIC DRYER ASSY (ELECTRIC-VAIR CORP)	16	.53
TOTAL	7.26 (16) KG (LBS)	.015 (.53) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
-N/A-					

Σ③ ____ TOTAL WT/CYCLE (LB)   Σ⑤ ____ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = ____ KG (LB)

TOTAL VOL/MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = ____ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				

Σ① ____   Σ④ ____

TOTAL WT./MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.3 Personal Grooming

APPLIANCE FUNCTION 2.3.1 Shaving

NUMBER OF CONCEPTS CONSIDERED 5

ASSUMPTIONS

(1) The shaving concepts are mechanical, electric, and vacuum operated with methods incorporated to retrieve cut hair particles to prevent cabin contamination.

(2) The study assumed one shave per day per man.

(3) Shaving is assumed to take 6 minutes per shave (236).

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.3.1 .... SHAVING (SHUTTLE).

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	4.000						0.	0.	.0	.0	1.0	.00	0	0	.0
	.100						(0.)	(0.)	.0	.0	(2.1)	(.06)			(.0)
2	4.000	1	.0000	4.72	.0	21.1	0.	12.	30.0	30.0	2.2	.01	0	10	.0
	.100		(.0000)	(10.00)	(.0)	(70.0)	(0.)	(41.)	115.0	.0	(4.7)	(.42)			(.0)
3	4.000						0.	0.	.0	.0	.5	.00	0	0	.0
	.100						(0.)	(0.)	.0	.0	(1.0)	(.02)			(.0)
4	4.000	1	.0000	21.71	.0	21.1	0.	0.	.0	.0	.2	.00	0	10	.0
	.100		(.0000)	(46.00)	(.0)	(70.0)	(0.)	(0.)	.0	.0	(.4)	(.30)			(.0)
5	4.000	1	.0000	4.72	.0	21.1	0.	12.	30.0	30.0	1.3	.00	0	15	.0
	.100		(.0000)	(10.00)	(.0)	(70.0)	(0.)	(41.)	115.0	.0	(2.8)	(.10)			(.0)

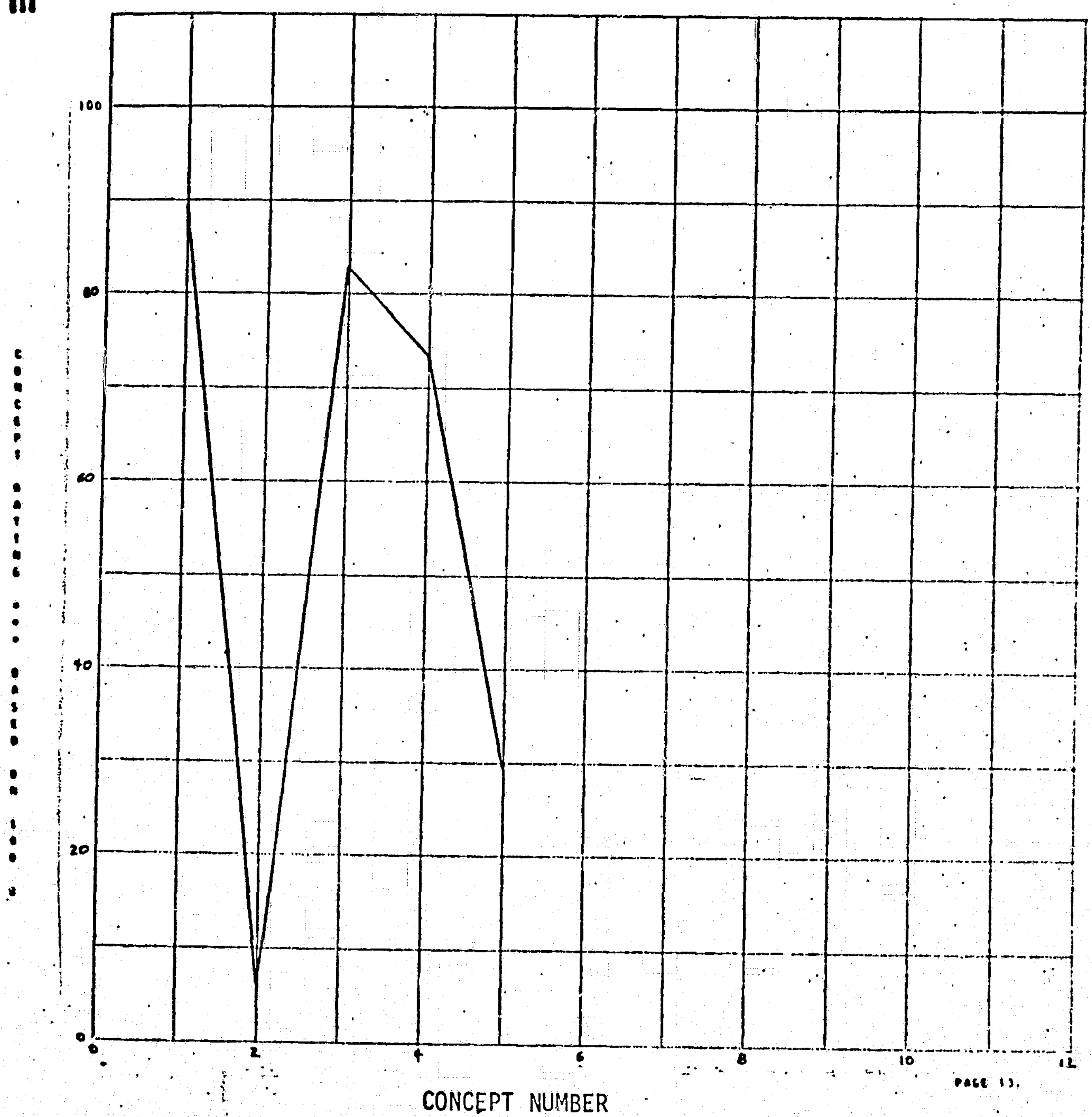
APPLIANCE CONCEPT NO.	CONCEPT NAME
1	WET SHAVE WITH SAFETY RAZOR AND CREAM
2	DRY SHAVE-ELECTRIC RAZOR/VACUUM COLLECTION
3	DRY SHAVE-WINDUP RAZOR
4	DRY SHAVE-VACUUM DRIVEN RAZOR
5	WET SHAVE-SAFETY RAZOR/VACUUM

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST), KG/HR (LB/HR)
3 - OXYGEN (LOST), KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST), KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED), KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED), KG/HR (LB/HR)

(**) AVAILABLE	(***) COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

OK

APPLIANCE CONCEPT NO.		CONCEPT NAME
1	-	WET SHAVE WITH SAFETY RAZOR AND CREAM
2	-	DRY SHAVE-ELECTRIC RAZOR/VACUUM COLLECTION
3	-	DRY SHAVE-WINDUP RAZOR
4	-	DRY SHAVE-VACUUM DRIVEN RAZOR
5	-	WET SHAVE-SAFETY RAZOR/VACUUM



Shaving (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 3
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX . . . . . SHAVING (SHUTTLE)
(01/15/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3	4	5
WEIGHT	.37000	4.7500	15	8.37	.00	11.84	13.83	6.00
POWER	.00000	65.350	15	15.00	.00	15.00	15.00	.00
VOLUME	.45000-02	.42000	10	8.10	.00	9.47	9.89	7.62
THERMAL	.00000	2.2550	15	15.00	.00	15.00	15.00	.00
RELIAB-Y	.99997	1.0000	5	5.00	.00	.00	.00	5.00
MAINTENC	1.00000	1.0000	5	5.00	.00	.00	.00	5.00
DEV COST	.00000	15.000	15	15.00	5.00	15.00	5.00	.00
TOTAL PT	.00000	80.000	80	71.46	5.00	66.31	58.72	23.62
RATING	.00000	100.00	100	89.33	6.25	82.89	73.41	29.52

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5
NORMAL	89.33	6.25	82.89	73.41	29.52
WEIGHT	86.45	5.71	82.55	75.02	30.42
POWER	90.24	5.71	84.35	75.69	26.99
VOLUME	88.84	5.88	83.58	74.91	32.27
THERMAL	90.24	5.71	84.35	75.69	26.99
RELIAB-Y	89.65	6.06	80.37	71.18	31.66
MAINTENC	89.65	6.06	80.37	71.18	31.66
DEV COST	90.24	8.57	84.35	69.97	26.99

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3	4	5
NORMAL	89.33	6.25	82.89	73.41	29.52
WEIGHT	92.80	6.90	83.29	71.46	28.44
POWER	88.23	6.90	81.12	70.65	32.58
VOLUME	89.89	6.67	82.10	71.70	26.41
THERMAL	88.23	6.90	81.12	70.65	32.58
RELIAB-Y	88.99	6.45	85.56	75.77	27.25
MAINTENC	88.99	6.45	85.56	75.77	27.25
DEV COST	88.23	3.45	81.12	77.55	32.58

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.3.1-SHAVING

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS: MOTOR																NUMBER OF SAFETY CRITICAL ITEMS
NO.	1																
WET SHAVE WITH SAFETY RAZOR AND CREAM	-																0
DRY SHAVE-ELECTRIC RAZOR/VACUUM COLLECTION	1																0
DRY SHAVE-WINDUP RAZOR	1																0
DRY SHAVE-VACUUM MOTOR-DRIVEN RAZOR	1																0
WET SHAVE-SAFETY RAZOR/VACUUM	-																0

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

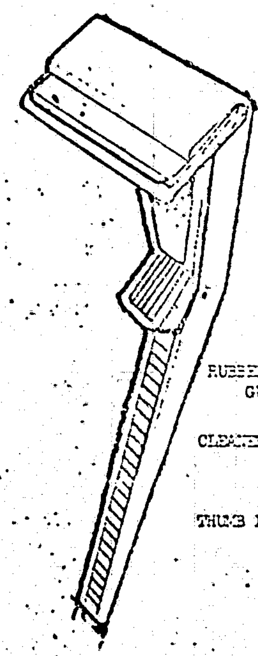
APPLIANCE FUNCTION Shaving

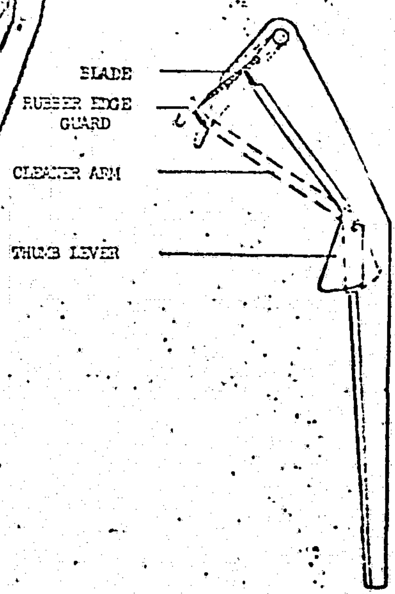
APPLIANCE CONCEPT NO./TITLE 1/Wet Shave-Safety Razor and Cream

INDEX NO. 2.3.1.1 REF. NO. 236,207

DESCRIPTION

The safety razor and cream wet shaving concept consists of a safety razor and cream. The safety razor is an injector type and the shaving cream is contained in aerosol cans. The Skylab crew felt shaving cream should be dispensed using an aerosol can. The safety razor is provided with an arm which is actuated to remove the hair particles and cream prior to wiping the razor. One new blade is provided for every three days of usage. This concept was flown on Apollo.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/WET SHAVE - SAFETY RAZOR & CREAM INDEX NUMBER 2.3.1.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①x③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①x⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/WET SHAVE - SAFETY RAZOR AND CREAM   INDEX NUMBER 2.3.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR/HOLDER	(236)	.446	.04
BLADES		1.60	.043
TOTAL		.928 (2.046) KG (LBS)	.0023 (.083) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
BLADES	.333 (236)	.0587 (236)	.01957	.001587 (236)	.000529

Σ③ .01957 TOTAL WT/CYCLE (LB)   Σ⑤ .000529 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .01957 TOT.WT/CYCLE (LB) = .728 (1.60) KG (LB)

TOTAL VOL / MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .000529 TOT.VOL/CYCLE (FT^3) = .00123 (.043) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______   Σ④ ______

TOTAL WT. / MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

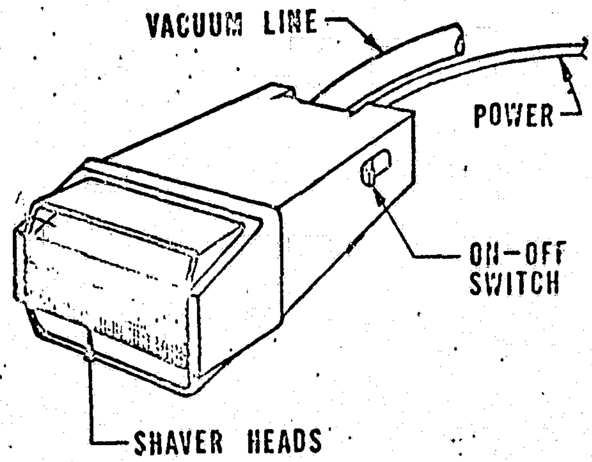
APPLIANCE FUNCTION Shaving

APPLIANCE CONCEPT NO./TITLE 2/Dry Shave-Electric Razor/Vacuum Collection

INDEX NO. 2.3.1.2 REF. NO. 236,207

DESCRIPTION

The electric razor/vacuum collection dry shave concept consists of an electric razor with vacuum collection of the cut hair particles. The electric razor incorporates a hood to aid vacuum collection. The unit requires a vacuum for collection of the hair particles. The concept, therefore, is penalized for a vacuum unit based on operating time. The vacuum unit used is identical to the Skylab power module.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/DRY SHAVE-ELECTRIC RAZOR/VACUUM COLLECTION   INDEX NUMBER 2.3.1.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/CYCLE) (1)x(3)	DC POWER (5) PEAK (WATTS)	(6) AVERAGE (WATTS)	(7) DEMAND (WATT-HR/CYCLE) (1)x(7)
RAZOR MOTOR (236)	.1	30	30	3.0	—	—	—
		30 MAXIMUM		3.0 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
RAZOR MOTOR	—	41	41	—
TOTAL	WATT (BTU/HR)	12 (41) WATT (BTU/HR)	12 (41) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
VACUUM POWER MODULE (SKYLAB)	40	—	115	.75	.02
TOTAL	11.7 (40) WATTS/CYCLE (BTU/HR/CYCLE)	— WATTS/CYCLE (BTU/HR/CYCLE)	115 (DC)	.34 (.75) KG/MISSION (LB/MISSION)	.00057 (.02) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/DRY SHAVE-ELECTRIC RAZOR/VACUUM COLLECTION INDEX NUMBER 2.3.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR/HOLDER	(236)	4.0	.4
	TOTAL	1.8 (4.0) KG (LBS)	.0113 (.4) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB)   Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______   Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

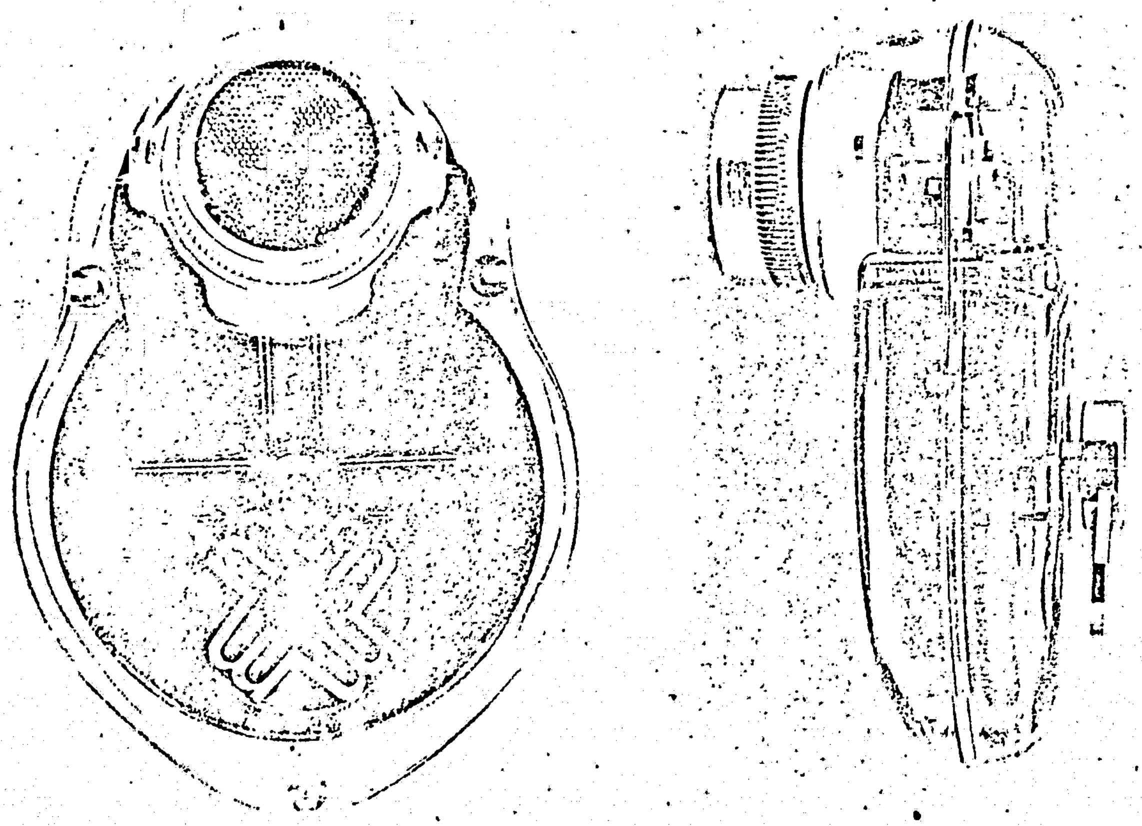
APPLIANCE FUNCTION Shaving

APPLIANCE CONCEPT NO./TITLE 3/Dry Shave-Windup Razor (Skylab)

INDEX NO. 2.3.1.3 REF. NO. NASA JSC, G.E.

DESCRIPTION

The windup razor dry shave concept consists of a mechanical windup motor shaver with a hair particle reservoir. The unit was used on Skylab and the weight and volume figures specified are for the flight weight unit.



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3 / DRY SHAVE - WIND UP RAZOR (SKYLAB) INDEX NUMBER 2.3.1.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/DRY SHAVE - WINDUP RAZOR (SKYLAB) INDEX NUMBER 2.3.1.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR/HOLDER	.977	.0224
TOTAL	.443 (.977) KG (LBS)	.00063 (.0224) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
- N/A -					

Σ③ ____ TOTAL WT/CYCLE (LB) Σ⑤ ____ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.WT/CYCLE (LB) = ____ KG (LB)

TOTAL VOL / MISSION = ____ CYCLES/DAY X ____ DAYS/MISSION X ____ TOT.VOL/CYCLE (FT^3) = ____ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				

Σ① ____ Σ④ ____

TOTAL WT. / MISSION = ____ CYCLE/DAY X ____ DAYS/MISSION X ____ TOTAL LOST/CYCLE (Σ ④) = ____ (LB) + ____ (Σ ①) = ____ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

APPLIANCE FUNCTION Shaving

APPLIANCE CONCEPT NO./TITLE 4/Dry Shave-Vacuum Motor-Driven Razor

INDEX NO. 2.3.1.4 REF. NO. 280

DESCRIPTION

The vacuum motor-driven razor dry shave concept consists of a vacuum driven motor with a hair particle reservoir.

The motor runs on space vacuum which turns the shaver at 2500 RPM.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT A/DRY SHAVE-VACUUM MOTOR-DRIVEN RAZOR INDEX NUMBER 2.3.1.4

ELECTRICAL POWER REQUIREMENTS

			AC POWER			DC POWER		
COMPONENT	(REF)	① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ①X③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

C 4

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 4/DRY SHAVE-VACUUM MOTOR-DRIVEN RAZOR INDEX NUMBER 2.3.1.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR/HOLDER	(200)	.37	.0045
TOTAL		.168 (.37) KG (LBS)	.00013 (.0045) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
-N/A-					

Σ③ ______ TOTAL WT/CYCLE (LB)   Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				

Σ① ______   Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

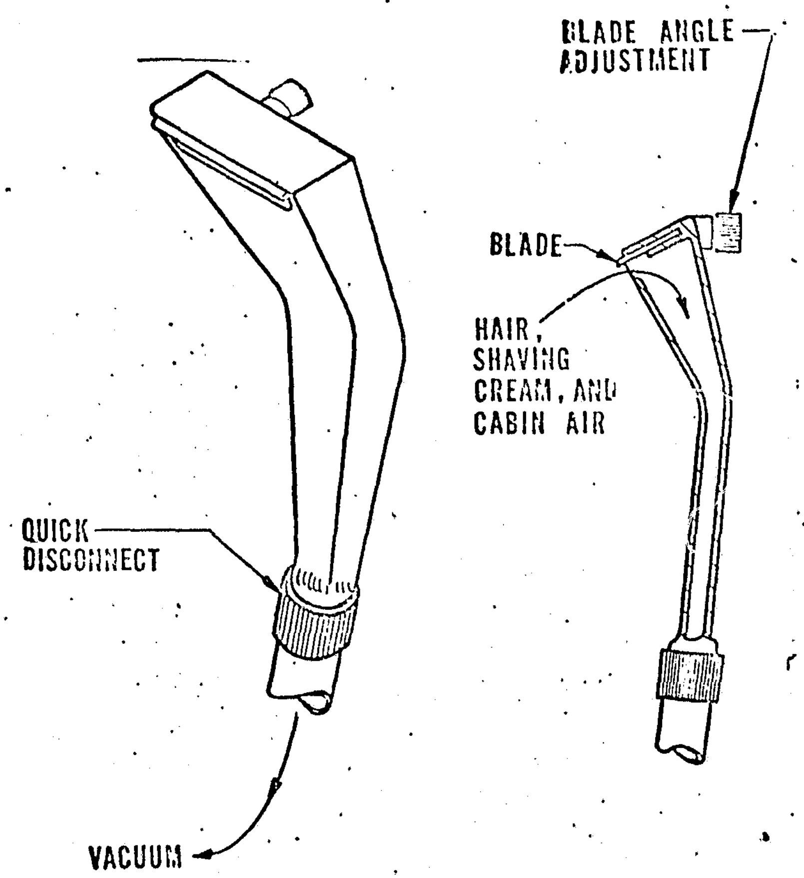
APPLIANCE FUNCTION Shaving

APPLIANCE CONCEPT NO./TITLE 5/Wet Shave-Safety Razor/Vacuum Collection

INDEX NO. 2.3.1.5 REF. NO. 236,206

DESCRIPTION

The wet shave safety razor/vacuum collection concept consists of the same razor described in Concept 1 with the addition of vacuum collection. The vacuum unit used is identical to the Skylab power module. The concept is penalized for a vacuum unit based on operating time.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 5/WET SHAVE-SAFETY RAZOR/VACUUM COLLECTION INDEX NUMBER 2.3.1.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
RAZOR MOTOR (236)	.1	30	30	3.0	—	—	—
		30 MAXIMUM		3.0 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
RAZOR MOTOR	—	41	41	—
TOTAL	WATT (BTU/HR)	12 (41) WATT (BTU/HR)	12 (41) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
VACUUM POWER MODULE (SKYLAB)	40	—	115	.75	.02
TOTAL	11.7 (40) WATTS/CYCLE (BTU/HR/CYCLE)	— WATTS/CYCLE (BTU/HR/CYCLE)	115 (DC)	.34 (.75) KG/MISSION (LB/MISSION)	.00057 (.02) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 5/WET SHAVE-SAFETY RAZOR/VACUUM COLLECTION INDEX NUMBER 2.3.1.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR/HOLDER	(236)	.446	.04
BLADES	(236)	1.60	.043
TOTAL		.928 (2.046) KG (LBS)	.0023 (.083) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
BLADES	.333 (236)	.0587 (236)	.01957	.001587 (236)	.000529

Σ③ .01957 TOTAL WT/CYCLE (LB) Σ⑤ .000529 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .01957 TOT.WT/CYCLE (LB) = .728 (1.60) KG (LB)

TOTAL VOL/MISSION = 4 CYCLES/DAY x 20.5 DAYS/MISSION x .000529 TOT.VOL/CYCLE (FT^3) = .00123 (.043) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
-N/A-				

Σ① ______ Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.3 Personal Grooming

APPLIANCE FUNCTION 2.3.2 Hair Cutting

NUMBER OF CONCEPTS CONSIDERED 2

ASSUMPTIONS

(1) The hair cutting concepts are mechanical and electrically operated with methods incorporated to retrieve cut hair particles to prevent cabin contamination.

(2) The study assumed one haircut every 14 days for Concept 1 and every 7 days for Concept 2.

(3) Hair cutting is assumed to take 15 minutes for Concept 1 and 5 minutes for Concept 2 per haircut.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.3.2 .... HAIR CUTTING (SHUTTLE)

CONCEPT NO.	USAGE TIME USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST AVAIL (**)	INDEX (***)	RESUPPLY WEIGHT -KG- (LBS)
1	.070 .097						0. (0.)	33. (114.)	50.0 115.0	.0 .0	.9 (2.0)	.01 (.25)	0	10	.0 (.0)
2	.140 .203						0. (0.)	3. (11.)	.0 115.0	.0 .0	.7 (1.5)	.01 (.25)	0	10	.0 (.0)

APPLIANCE CONCEPT NO. — C O N C E P T   N A M E

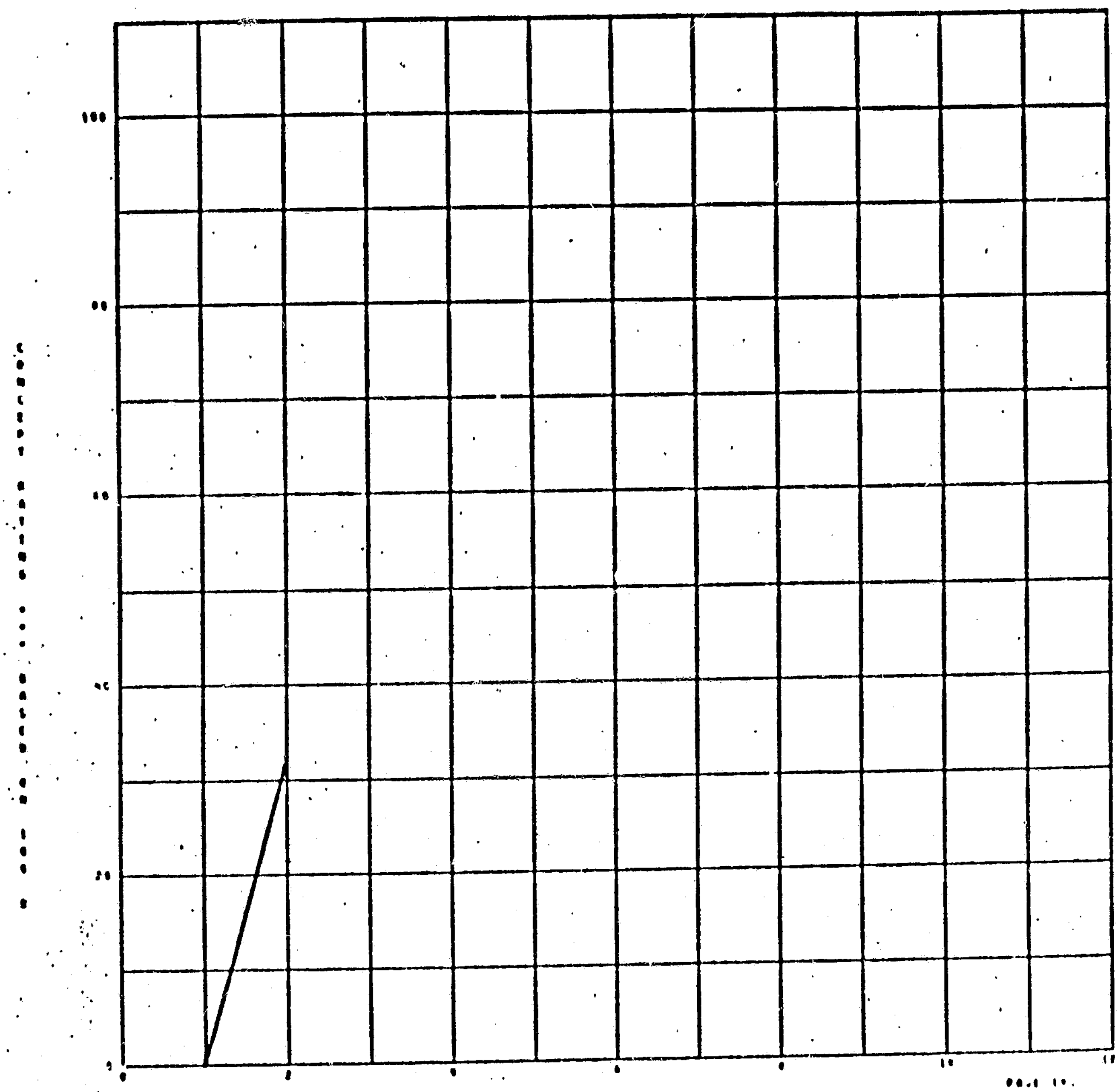
1 - POWER CLIPPER/VACUUM COLLECTION
2 - RAZOR COMB/VACUUM COLLECTION

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST) , KG/HR (LB/HR)
3 - OXYGEN (LOST) , KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST) , KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED) , KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED) , KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE
CONCEPT
NO. CONCEPT NAME

1 =	POWER CLIPPER/VACUUM COLLECTION
2 =	RAZOR COMB/VACUUM COLLECTION



CONCEPT NUMBER

Hair Cutting (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 0
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300
POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX • • • • • HAIR CUTTING (SHUTTLE)
(12/15/74)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	CONCEPT 2
WEIGHT	1.5400	2.0000	15	.00	3.45
POWER	49.450	75.950	15	.00	5.23
VOLUME	.25000	.25000	10	.00	.00
THERMAL	.61270	6.2700	15	.00	13.53
DEV COST	10.000	10.000	15	.00	.00
TOTAL PT	.00000	70.000	70	.00	22.22
RATING	.00000	100.00	100	.00	31.74

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SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	CONCEPT 2
NORMAL	.00	31.74
WEIGHT	.00	30.89
POWER	.00	32.04
VOLUME	.00	29.62
THERMAL	.00	37.40
DEV COST	.00	28.67

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	CONCEPT 2
NORMAL	.00	31.74
WEIGHT	.00	32.79
POWER	.00	31.36
VOLUME	.00	34.18
THERMAL	.00	24.72
DEV COST	.00	35.55

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.3.2-HAIR CUTTING

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS																NUMBER OF SAFETY CRITICAL ITEMS
	MOTOR																
NO.	1																
POWER CLIPPER/VACUUM COLLECTION	1																0
RAZOS COMB/VACUUM COLLECTION	-																0

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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

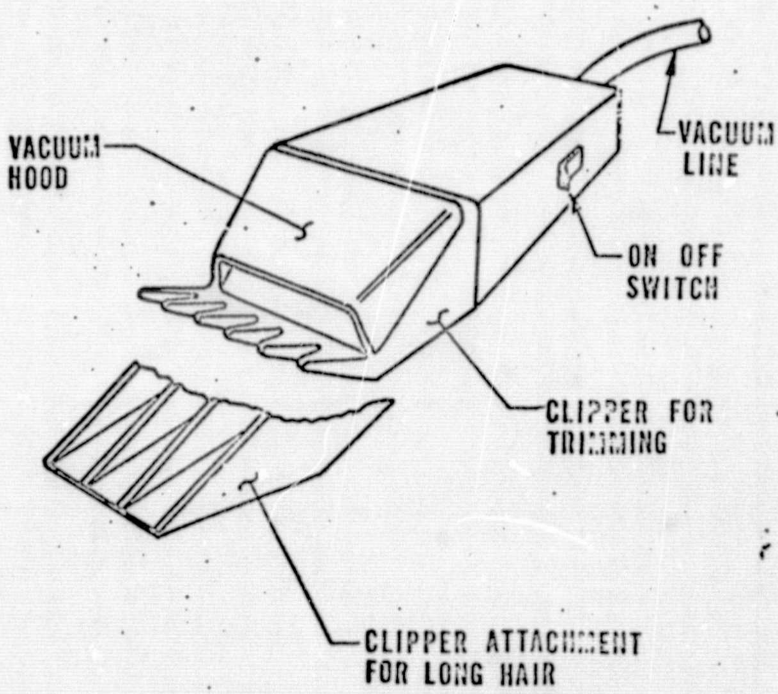
APPLIANCE FUNCTION Hair Cutting

APPLIANCE CONCEPT NO./TITLE 1/Electric Clipper/Vacuum Collection

INDEX NO. 2.3.2.1 REF. NO. 236.207

DESCRIPTION

The electric clipper/vacuum collection concept consists of an electrically driven clipper with vacuum collection of the hair clippings. The clipper is similar to the terrestrial barber type. The unit used for vacuum collection is the power module used on Skylab. A hood is employed over the clipper area to assist in the pickup of the hair clippings.



SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

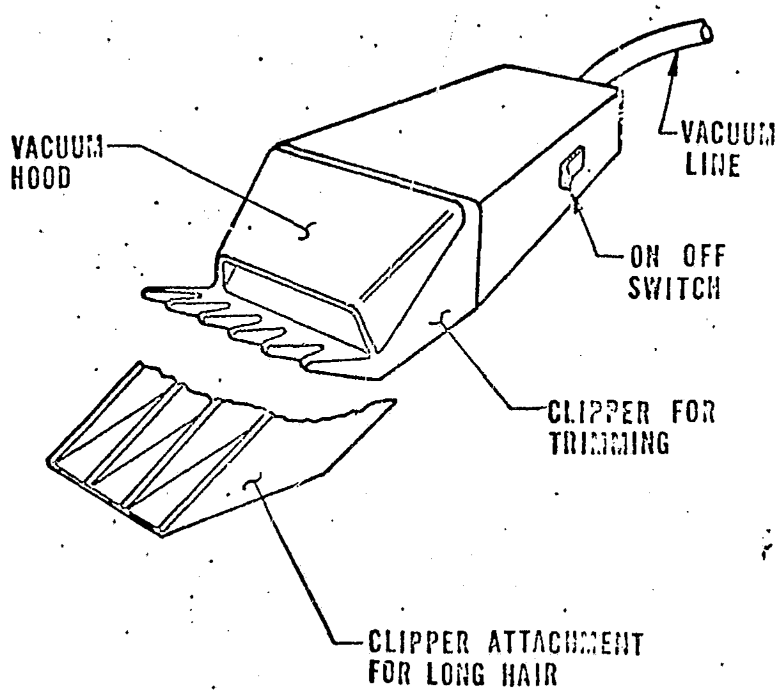
APPLIANCE FUNCTION Hair Cutting

APPLIANCE CONCEPT NO./TITLE 1/Electric Clipper/Vacuum Collection

INDEX NO. 2.3.2.1 REF. NO. 236.207

DESCRIPTION

The electric clipper/vacuum collection concept consists of an electrically driven clipper with vacuum collection of the hair clippings. The clipper is similar to the terrestrial barber type. The unit used for vacuum collection is the power module used on Skylab. A hood is employed over the clipper area to assist in the pickup of the hair clippings.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/ELECTRIC CLIPPER/VACUUM COLLECTION INDEX NUMBER 2.3.2.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
MOTOR	(236)	.14	50	50	7	—	—	—
			50 MAXIMUM		7 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE		LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTOR	(236)	—	114	114	—
	TOTAL	WATT (BTU/HR)	33.4 (114) WATT (BTU/HR)	33.4 (114) WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
VACUUM POWER MODULE (SKYLAB)	2.7	—	115	.04	(neg)
TOTAL	.79 (2.7) WATTS/CYCLE (BTU/HR/CYCLE)	— WATTS/CYCLE (BTU/HR/CYCLE)	115 (ac)	18.1 (.04) KG/MISSION (LB/MISSION)	(neg) M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/ELECTRIC CLIPPER/VACUUM COLLECTION INDEX NUMBER 2.3.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
CLIPPER/HOLDER	(236)	2.0	.25
TOTAL		.907 (2.0) KG (LBS)	(.0071) (.25) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______ Σ④ ______

TOTAL WT. MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene **HABITABILITY FUNCTION** Personal Grooming

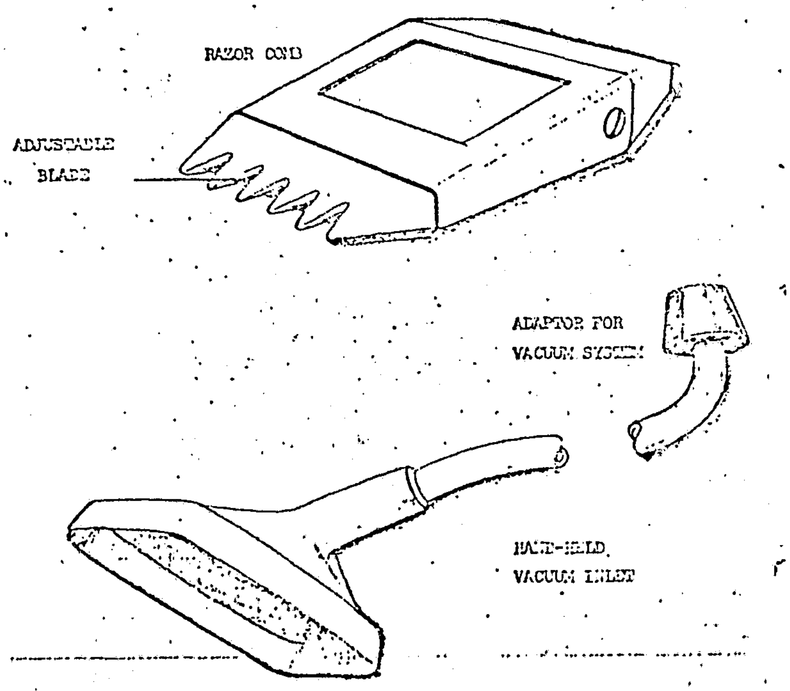
APPLIANCE FUNCTION Hair Cutting

APPLIANCE CONCEPT NO./TITLE 2/Razor-Comb/Vacuum Collection

INDEX NO. 2.3.2.2 **REF. NO.** 236,207

DESCRIPTION

The comb/vacuum collection concept consists of a razor comb with a hand-held vacuum pickup device. The concept requires two men to operate which is a disadvantage from the crew time aspect. The unit used for vacuum collection is the power module used on Skylab.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/RAZOR - COMB/VACUUM COLLECTION INDEX NUMBER 2.3.2.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/RAZOR-COMB/VACUUM COLLECTION INDEX NUMBER 2.3.2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
RAZOR COMB/HOLDER (236)	1.5	.25
TOTAL	.68 (1.5) KG (LBS)	.007 (.25) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL/MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______ Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/RAZOR-COMB/VACUUM COLLECTION INDEX NUMBER 2.3.2.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
-N/A-							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
-N/A-				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
VACUUM POWER MODULE (SKYLAB)	11.14	—	115	.04	neg
TOTAL	3.24 (11.14) WATTS/CYCLE (BTU/HR/CYCLE)	— WATTS/CYCLE (BTU/HR/CYCLE)	115 (DC)	.018 (.04) KG/MISSION (LB/MISSION)	neg M^3/MISSION (FT^3/MISSION)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.3 Personal Grooming

APPLIANCE FUNCTION 2.3.3 Nail Care

NUMBER OF CONCEPTS CONSIDERED 2

ASSUMPTIONS

(1) The nail care concepts considered are manual operations using bag and vacuum collection of nail clippings.

(2) The study assumed nail cutting once every 14 days.

(3) Nail cutting is assumed to take 5 minutes per use.

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2,3,3-NAIL CARE

COMPONENT TYPE / APPLIANCE TYPE	NUMBER OF COMPONENTS																NUMBER OF SAFETY CRITICAL ITEMS
NO.																	
	NO MECHANICAL/ELECTRICAL COMPONENTS																

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

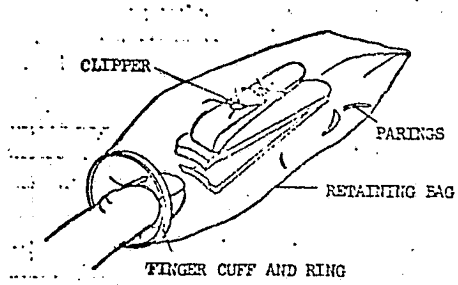
APPLIANCE FUNCTION Nail Care

APPLIANCE CONCEPT NO./TITLE 1/Manual Nail Clipper/Bag Collection

INDEX NO. 2.3.3.1 REF. NO. 236,207

DESCRIPTION

The manual nail clipper/bag collection concept consists of a terrestrial type nail clipper enclosed by a bag to contain nail clippings. The bag incorporates a finger cuff and ring to form a seal around the finger during nail cutting. The collection bag is transparent to observe nail clipping.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/MANUAL NAIL CLIPPER/BAG COLLECTION INDEX NUMBER 2.3.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/MANUAL NAIL CLIPPER/BAG COLLECTION INDEX NUMBER 2.3.3.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
NAIL CLIPPER/BAG	(236)	.32	.0008
TOTAL		.145 (.32) KG (LBS)	.00002 (.0008) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
COLLECTION BAG	.0167 (236)	.1	.00167	.0555	.00093

Σ③ .00167 TOTAL WT/CYCLE (LB) Σ⑤ .00093 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = .286 CYCLES/DAY x 20.5 DAYS/MISSION x .00167 TOT.WT/CYCLE (LB) = .0074 (.009) KG (LB)

TOTAL VOL/MISSION = .286 CYCLES/DAY x 20.5 DAYS/MISSION x .00093 TOT.VOL/CYCLE (FT^3) = .000154 (.005) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______ Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY x ______ DAYS/MISSION x ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

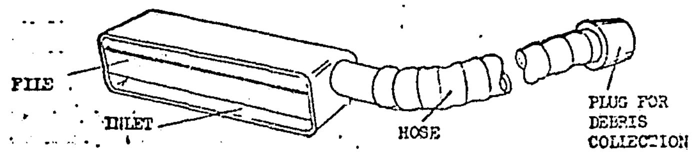
APPLIANCE FUNCTION Nail Care

APPLIANCE CONCEPT NO./TITLE 2/Metal Nail File/Vacuum Collection

INDEX NO. 2.3.3.2 REF. NO. 236.207

DESCRIPTION

The metal nail file/vacuum collection concept consists of a nail file with vacuum collection of nail filings. The file has a hood around the file to improve the vacuum collection efficiency. The concept is penalized for a vacuum unit based on operating time. The vacuum unit used is identical to the Skylab power module.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/METAL NAIL FILE/VACUUM COLLECTION INDEX NUMBER 2.3.3.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	AC POWER (3) AVERAGE (WATTS)	AC POWER (4) DEMAND (WATT-HR/CYCLE) (1)X(3)	DC POWER (5) PEAK (WATTS)	DC POWER (6) AVERAGE (WATTS)	DC POWER (7) DEMAND (WATT-HR/CYCLE) (1)X(7)
N/A							
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
VACUUM POWER MODULE (SKYLAB)	5.6	—	115	.02	neg
TOTAL	1.64 (5.6) WATTS/CYCLE (BTU/HR/CYCLE)	— WATTS/CYCLE (BTU/HR/CYCLE)	115	.009 (.02) KG/MISSION (LB/MISSION)	neg M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/METAL NAIL FILE/VACUUM COLLECTION INDEX NUMBER 2.3.3.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
FILE/HOOD	(236)	1.2	.04
	TOTAL	.544 (1.2) KG (LBS)	.001 (.04) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL MISSION = ______ CYCLES/DAY X ______ DAYS/MISSION X ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______ Σ④ ______

TOTAL WT. MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

HABITABILITY SUBSYSTEM 2.0 Personal Hygiene

HABITABILITY FUNCTION 2.3 Personal Grooming

APPLIANCE FUNCTION 2.3.4 Teethbrushing

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

(1) The dental concepts are manual and electric. Manual brushing and water flushing are the concepts considered by the study.

(2) The study assumed four brushings per day per man.

(3) Teethbrushing is assumed to take 5 minutes per brushing.

(4) Dental floss is provided for each concept for cleaning the crevices of the teeth. Each crewman is supplied a number of 50-foot rolls of dental floss as determined by mission length. The usage is based on approximately one foot per day per crewman.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 2.3.4 .... TEETH BRUSHING (SHUTTLE)

CONCEPT NO.	USAGE TIME: USES/DAY HRS/USE	CONSUMABLES AND FLOW REQUIREMENTS: TYPE (*)	AMT. USED -KG/USE- (LB/USE)	FLOW * (*)	PRESS -MMHG- (PSIG)	TEMP -DEG C- (DEG F)	THERMAL REQMTS: COOLANT -WATTS- (BTU/HR)	HT LEAK -WATTS- (BTU/HR)	ELEC PWR REQMTS: PK PWR AC DC -WATTS-	AVG PWR AC DC -WATTS-	WT/VOL REQMTS: WEIGHT -KG- (LBS)	VOLUME -CU M- (CU FT)	DEVELOPMENT COST: AVAIL (**)	INDEX (***)	RESUPPLY: WEIGHT -KG- (LBS)
1	16.000						0.	0.	.0	.0	6.4	.03	1	0	.0
	.082						(0.)	(0.)	.0	.0	(14.0)	(1.20)			(.0)
2	16.000	5	.0567	.68	1551.4	21.1	0.	8.	24.0	.0	1.2	.00	1	20	.0
	.082		(.125)	(1.50)	(30.0)	(70.0)	(0.)	(27.)	.0	.0	(2.7)	(.09)			(.0)
3	16.000						0.	2.	4.0	.0	5.9	.01	1	10	.0
	.082						(0.)	(7.)	.0	.0	(13.0)	(.37)			(.0)

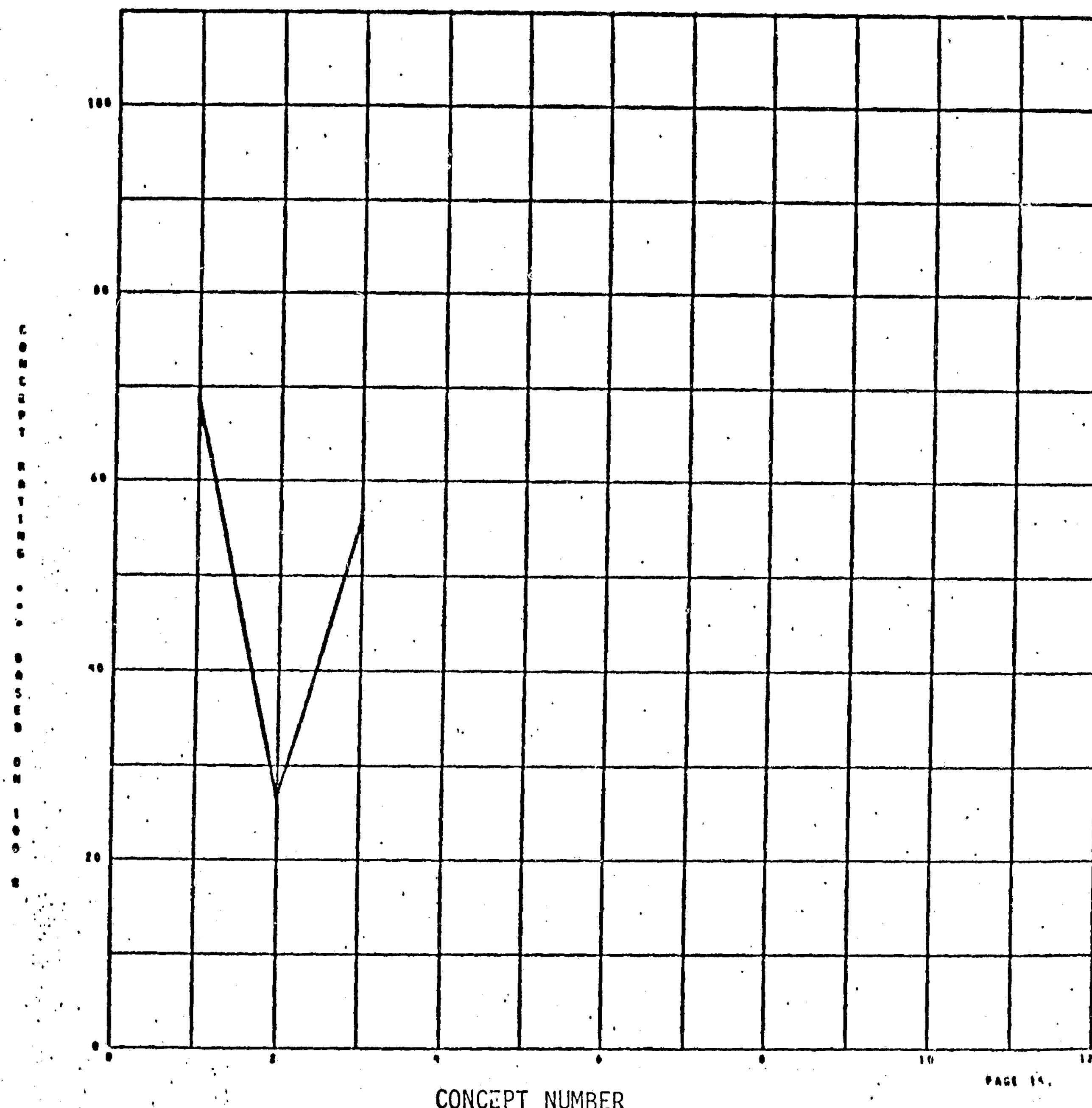
APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	TOOTHPASTE WITH DENTIFRICE
2 -	WATER PIX
3 -	ELECTRIC TOOTHBRUSH

ORIGINAL PAGE IS OF POOR QUALITY

(*)
1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT^3/MIN)
2 - CABIN AIR (LOST), KG/HR (LB/HR)
3 - OXYGEN (LOST), KG/HR (LB/HR)
4 - COOLING WATER (CIRCULATED), KG/HR (LB/HR)
5 - WATER (LOST), KG/HR (LB/HR)
6 - NITROGEN (CIRCULATED), KG/HR (LB/HR)
7 - NITROGEN (USED), KG/HR (LB/HR)
8 - FREON (CIRCULATED), KG/HR (LB/HR)
9 - WATER (PROCESSED), KG/HR (LB/HR)

(**)AVAILABLE	(***)COST INDICATOR
(1) AVAILABLE	0-25%
(2) STATE OF THE ART	25-50%
(3) SOME DEVELOPMENT REQUIRED	50-75%
(4) EXTENSIVE DEV. REQUIRED	75-100%

APPLIANCE CONCEPT NO.	CONCEPT NAME
1 -	TOOTHPASTE WITH DENTIFRICE
2 -	WATER PIX
3 -	ELECTRIC TOOTHBRUSH



Dental (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)
USES MOD SUBROUTINE 31
THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0250
THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .0550
POWER PENALTY (LBS/WATT) TYPE 1 .5300

SELECTION MATRIX . . . . . TEETH BRUSHING (SHUTTLE)
(01/15/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT 1	2	3
WEIGHT	2.7000	14.000	15	.00	12.11	1.07
POWER	.00000	12.720	15	15.00	.00	11.25
VOLUME	.92000-01	1.2000	10	.00	9.23	6.92
THERMAL	.00000	1.4850	15	15.00	.00	11.25
RELIAB-Y	.99967	1.0000	5	5.00	.00	3.45
MAINTENC	.99999	1.0000	5	5.00	.00	2.91
DEV COST	.00000	20.000	15	15.00	.00	7.50
TOTAL PT	.00000	80.000	80	55.00	21.34	44.35
RATING	.00000	100.00	100	68.75	26.68	55.44

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY 50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	68.75	26.68	55.44
WEIGHT	62.86	31.31	51.30
POWER	71.43	24.39	57.12
VOLUME	64.71	30.54	56.25
THERMAL	71.43	24.39	57.12
RELIAB-Y	69.70	25.87	55.85
MAINTENC	69.70	25.87	55.52
DEV COST	71.43	24.39	54.97

SENSITIVITY ANALYSIS

RATING FOR EACH CONCEPT AFTER INCREASING
SINGLE SELECTION PARAMETER WEIGHTING FACTOR BY -50 %
(BASED ON 100 % MAX POINTS)

	CONCEPT 1	2	3
NORMAL	68.75	26.68	55.44
WEIGHT	75.86	21.09	60.44
POWER	65.52	29.44	53.42
VOLUME	73.33	22.30	54.52
THERMAL	65.52	29.44	53.42
RELIAB-Y	67.74	27.54	55.00
MAINTENC	67.74	27.54	55.35
DEV COST	65.52	29.44	56.00

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 2.3.4-TEETH BRUSHING

COMPONENT TYPE / APPLIANCE TYPE (NO.)	MOTOR (1)	PUMP (2)	CONTROLLER TIMER (19)	ELECTROACOUSTIC TRANSMISSION (15)	HIGH FREQUENCY CONTROLLER (14)	○	○	○	○	○	○	○	○	○	○	○	○	NUMBER OF SAFETY CRITICAL ITEMS
TOOTHBRUSH WITH DENTIFICE	-	-	-	-	-													0
WATER PIX	1	1	1	-	-													0
ELECTRIC TOOTHBRUSH WITH DENTIFICE	1	-	-	-	-													0
ULTRASONIC CLEANING DEVICE	-	-	-	1	1													1

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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

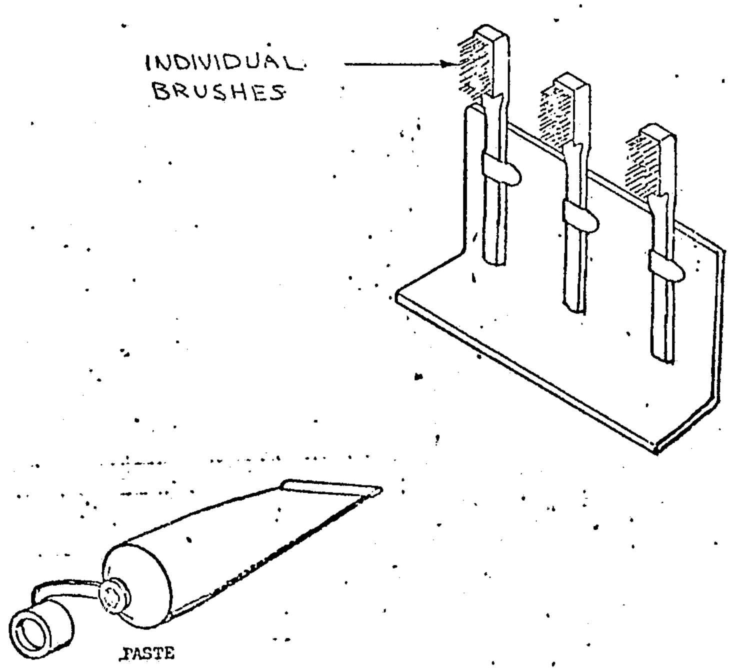
APPLIANCE FUNCTION Teeth Brushing

APPLIANCE CONCEPT NO./TITLE 1/Toothbrush with Dentifrice

INDEX NO. 2.3.4.1 REF. NO. 236

DESCRIPTION

The toothbrush with dentifrice concept consists of a terrestrial type toothbrush with dentifrice. The dentifrice is digestible to be nonhazardous if accidentally swallowed and is dispensed by a roll-up tube. Mouthwash is also provided in a soft plastic "squeeze bottle." One squeeze bottle per each crewman is provided for hygiene reasons. The mouthwash is used to mix with the dentifrice and is expectorated into a sink or fecal collector. This concept has flown on Apollo.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 1/TOOTHBRUSH WITH DENTIFRICE INDEX NUMBER 2.3.4.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
N/A								
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
N/A				
TOTAL	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/TOOTHBRUSH WITH DENTIFRICE INDEX NUMBER 2.3.4.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT^3)
TOOTHBRUSH	(236)	1.85	.9
		12.3	.33
TOTAL		6.42 (14.15) KG (LBS)	.035 (1.23) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
DENTIFRICE/ MOUTHWASH	—	—	.0375 (236)	—	.001 (236)

Σ③ .0375 TOTAL WT/CYCLE (LB)   Σ⑤ .001 TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = 16 CYCLES/DAY X 20.5 DAYS/MISSION X .0375 TOT.WT/CYCLE (LB) = 5.58 (12.3) KG (LB)

TOTAL VOL / MISSION = 16 CYCLES/DAY X 20.5 DAYS/MISSION X .001 TOT.VOL/CYCLE (FT^3) = .0093 (.328) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
N/A				

Σ① ______   Σ④ ______

TOTAL WT. / MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

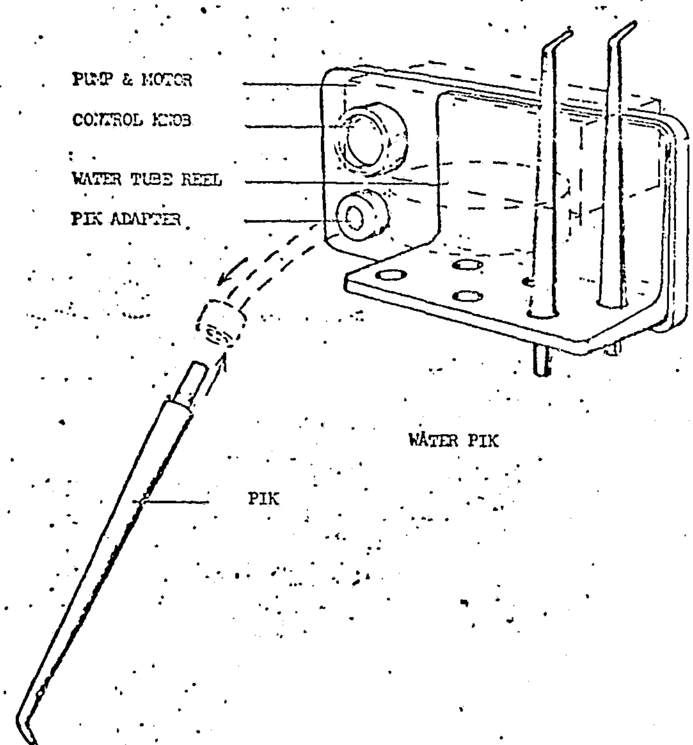
APPLIANCE FUNCTION Teeth Brushing

APPLIANCE CONCEPT NO./TITLE 2/Water Pix

INDEX NO. 2.3.4.2 REF. NO. 236,207

DESCRIPTION

The water pix concept is the same as the terrestrial type. One unit is provided with individual tips for each crewman. The unit is plumbed with water and wired electrically for power. The water pix creates a high velocity spray which is directed at the tooth crevices to loosen debris. The water is collected in the mouth and expectorated into a sink or fecal collector. The water is assumed to be recoverable by the study with the exception of the water loss due to suspended solids.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Z/WATER PIX

INDEX NUMBER 2.3.4.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	(1) USE TIME CYCLE (HR)	AC POWER (2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/CYCLE) (1)X(3)	DC POWER (5) PEAK (WATTS)	(6) AVERAGE (WATTS)	(7) DEMAND (WATT-HR/CYCLE) (1)X(7)
WATER PUMP (216)	.083	24	24	2.0	—	—	—
		24 MAXIMUM		2.0 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTOR	—	27	27	—
TOTAL	— WATT (BTU/HR)	7.9 (27) WATT (BTU/HR)	7.9 (27) WATT (BTU/HR)	— WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT^3/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M^3/MISSION (FT^3/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 2/WATER PIX INDEX NUMBER 2.3.4.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
WATER PIX ASSY. (236)	2.72	.0924
TOTAL	1.23 (2.72) KG (LBS)	.0026 (.0924) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①x④ (FT^3)
N/A					

Σ③ ______ TOTAL WT/CYCLE (LB) Σ⑤ ______ TOTAL VOL/CYCLE (FT^3)

TOTAL WT. / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.WT/CYCLE (LB) = ______ KG (LB)

TOTAL VOL / MISSION = ______ CYCLES/DAY x ______ DAYS/MISSION x ______ TOT.VOL/CYCLE (FT^3) = ______ M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①x② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
WATER	.125 (236)	N/A	N/A	.125

Σ① .125 Σ④ .125

TOTAL WT. / MISSION = 16 CYCLE/DAY x 20.5 DAYS/MISSION x .125 TOTAL LOST/CYCLE (Σ④) = 41 (LB) + N/A (Σ①) = 18.6 (41) KG (LB)

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Personal Hygiene HABITABILITY FUNCTION Personal Grooming

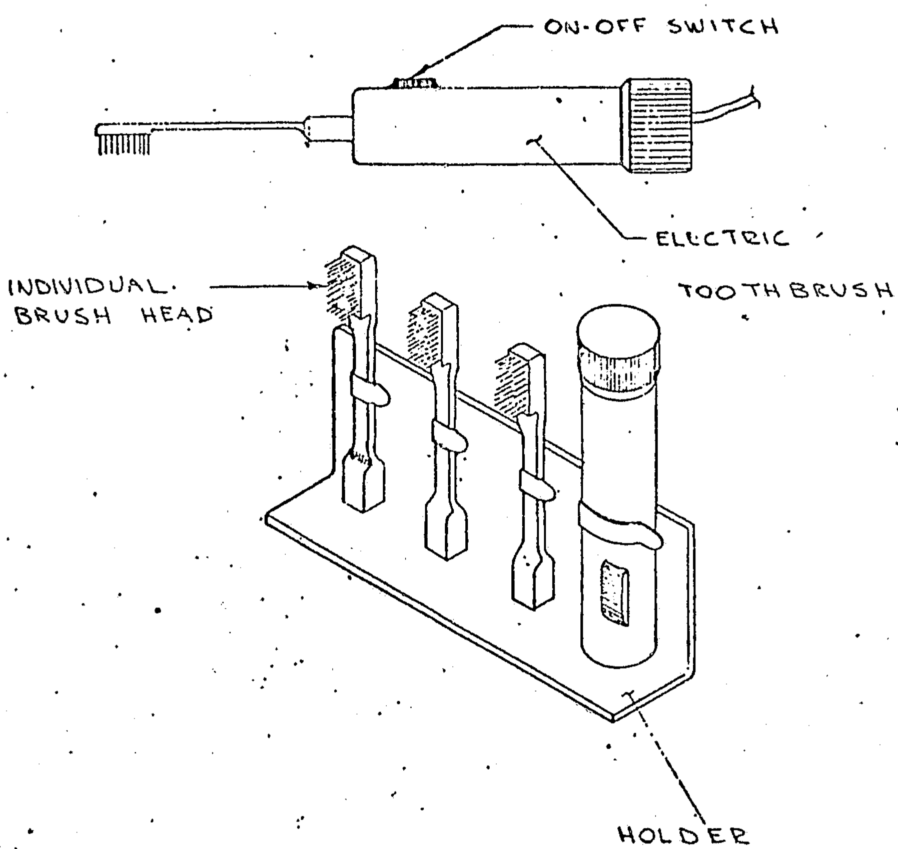
APPLIANCE FUNCTION Teeth Brushing

APPLIANCE CONCEPT NO./TITLE 3/Electric Toothbrush with Dentifrice

INDEX NO. 2.3.4.3 REF. NO. 236,207

DESCRIPTION

The electric toothbrush with dentifrice concept consists of a motor-driven toothbrush with individual brushes for each crewman. The same dentifrice and mouthwash used for Concept 1 are utilized for this concept. The vibratory action of the toothbrush has the advantage of massaging the gums as well as cleaning the tooth. The unit is wired electrically to provide power to the unit.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 3/ELECTRIC TOOTHBRUSH WITH DENTIFRICE

INDEX NUMBER 2.3.4.3

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER ② PEAK (WATTS)	AC POWER ③ AVERAGE (WATTS)	AC POWER ④ DEMAND (WATT-HR/CYCLE) ①X③	DC POWER ⑤ PEAK (WATTS)	DC POWER ⑥ AVERAGE (WATTS)	DC POWER ⑦ DEMAND (WATT-HR/CYCLE) ①X⑦
MOTOR	(236)	.083	6.0	6.0	.5			
			6.0 MAXIMUM		.5 TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
MOTOR	—	6.75	6.75	—
TOTAL	— WATT (BTU/HR)	1.98 (6.75) WATT (BTU/HR)	1.98 (6.75) WATT (BTU/HR)	— WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	THERMAL HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
— N/A —					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 3/ELECTRIC TOOTHBRUSH WITH DENTIFRICE INDEX NUMBER 2.3.4.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT^3)
ELECTRIC TOOTHBRUSH/NY(236)	.7	.0425
DENTIFRICE/MOUTHWASH (236)	12.3	.328
TOTAL	5.9 (13.0) KG (LBS)	.0104 (.3705) M^3 (FT^3)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB).	③ WT/CYCLE ①X② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT^3)	⑤ VOL/CYCLE ①X④ (FT^3)
DENTIFRICE/ MOUTHWASH	—	—	.0375 (236)	—	.001 (236)

Σ③ .0375 TOTAL WT/CYCLE (LB)   Σ⑤ .001 TOTAL VOL/CYCLE (FT^3)

TOTAL WT./MISSION = 16 CYCLES/DAY X 20.5 DAYS/MISSION X .0375 TOT.WT/CYCLE (LB) = 5.58 (12.3) KG (LB)

TOTAL VOL/MISSION = 16 CYCLES/DAY X 20.5 DAYS/MISSION X .001 TOT.VOL/CYCLE (FT^3) = .0093 (.328) M^3 (FT^3)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT.USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT.RECOVERED/CYCLE ①X② (LB)	④ AMT LOST/CYCLE ①-③ (LB)
— N/A —				

Σ① ______   Σ④ ______

TOTAL WT./MISSION = ______ CYCLE/DAY X ______ DAYS/MISSION X ______ TOTAL LOST/CYCLE (Σ ④) = ______ (LB) + ______ (Σ ①) = ______ KG (LB)