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(NASA-CR-144454) CREW APPLIANCE CONCEPTS.

N75-33722

VOLUME 3, APPENDIX B: SHUTTLE ORBITER

APPLIANCES SUPPORTING ENGINEERING DATA

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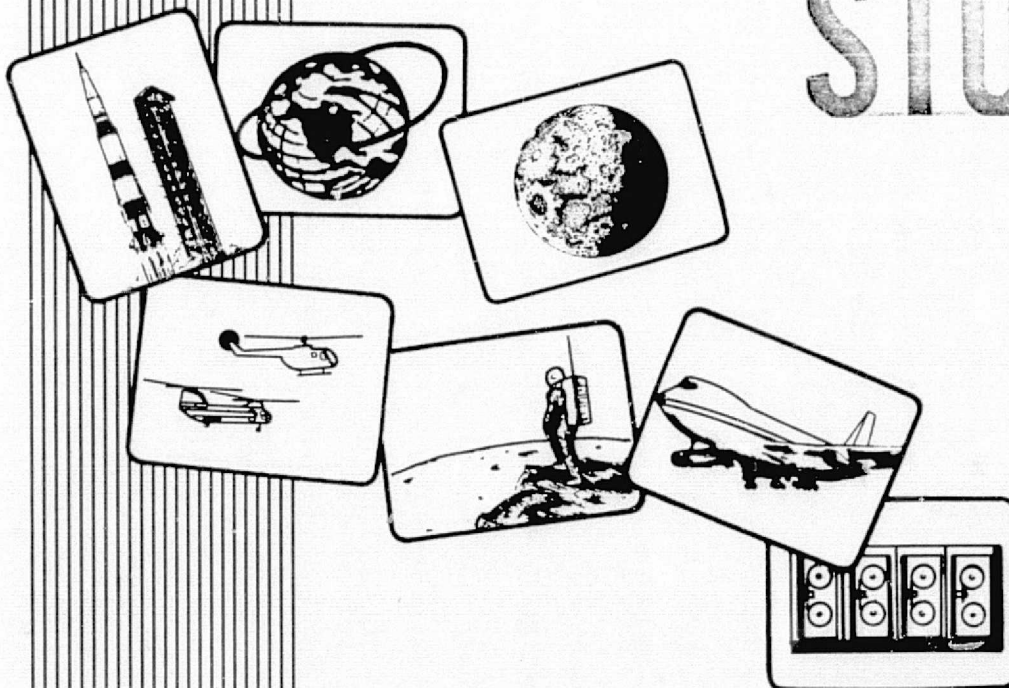
NASA CR-

144454

D2-118561-3

## CREW APPLIANCE CONCEPTS

# CREW APPLIANCE STUDY



THE **BOEING** COMPANY  
HOUSTON, TEXAS

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Prepared by

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CREW APPLIANCE CONCEPTS

APPENDIX B

SHUTTLE ORBITER APPLIANCES  
SUPPORTING ENGINEERING DATA



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SECTION 2  
TECHNICAL DATA (CONTINUED)

## HABITABILITY SUBSYSTEM

## Housekeeping

## APPLIANCE FUNCTIONS CONSIDERED

- 3.1.1 Surface Wiping
- 3.2.1 Manual Collection
- 3.2.2 Vacuum Collection
- 3.2.3 Refuse Transfer
- 3.2.4 Refuse Processing
- 3.2.5 Refuse Disposal
- 3.3.1 Washing
- 3.3.2 Drying
- 3.3.3 Washing/Drying Combination

## DESCRIPTION

The housekeeping habitability subsystem was designed to provide the cleanup, collection, processing, transfer and storage of refuse generated during a mission and crewman garment/linen maintenance. The study assumed refuse transfer would be accomplished manually for the missions under consideration. Longer term missions may eventually require some forms of automatic transfer. The housekeeping routines and equipment interface with all of the crew tasks, including experiments, medical research and care, system operations, dining, recreation, sleep, and personal hygiene.

HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.1 Equipment Cleaning

APPLIANCE FUNCTION 3.1.1 Surface Wiping

NUMBER OF CONCEPTS CONSIDERED 12

#### ASSUMPTIONS

(1) Equipment cleaning includes all methods which use a moist wipe, cloth or sponge and a means of drying the item cleaned.

(2) The equipment cleaning function was assumed to be performed 15 times per day. Three times for meal cleanup, six times for cleanups of the personal hygiene area, three times for cleanup of spills, etc., and two for contingency cleanup.

(3) Usage of a wetting unit, or equivalent, was based on 2.25 minutes per use.

(4) Washer/dryer penalty was based on washer concept 8, Water Spray Agitation and Dryer concept 1, Forced Hot Air - Electric Dryer.

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

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APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 311-1 \*\*\*\*\* SURFACE WIPING (SHUTTLE)

| CONCEPT NO. | USAGE TIME     | CONSUMABLES AND FLOW REQUIREMENTS |                    |                                      |                   | THERMAL REQTS             |                            | ELEC PWR REQTS                 |                                | RT/VOL REQTS       |                     | DEVELOPMENT COST        |                             | RESUPPLY |               |
|-------------|----------------|-----------------------------------|--------------------|--------------------------------------|-------------------|---------------------------|----------------------------|--------------------------------|--------------------------------|--------------------|---------------------|-------------------------|-----------------------------|----------|---------------|
|             |                | USES/DAY<br>HRS/USE               | TYPE<br>(*)        | AHT.<br>USED<br>-KG/USE-<br>(LB/USE) | FLOW<br>*<br>(*)  | PRESS<br>-MMHG-<br>(PSIG) | TEMP<br>-DEG C-<br>(DEG F) | COOLANT<br>-WATTS-<br>(BTU/HR) | HT LEAK<br>-WATTS-<br>(BTU/HR) | PK PWR<br>AC<br>DC | AVG PWR<br>AC<br>DC | WEIGHT<br>-KG-<br>(LBS) | VOLUME<br>-CU M-<br>(CU FT) |          | AVAIL<br>(**) |
| 1           | 15.000<br>.037 | 2                                 | .0003<br>(.0007)   | .00<br>(.00)                         | .0<br>(.0)        | 21.1<br>(70.0)            | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 360.0<br>.0        | 112.5<br>(248.0)    | .65<br>(23.93)          | 2                           | 30       | .0<br>(.0)    |
|             |                | 5                                 | .2268<br>(.5000)   | .00<br>(.00)                         | 1551.4<br>(130.0) | 21.1<br>(70.0)            |                            |                                |                                |                    |                     |                         |                             |          |               |
| 2           | 15.000<br>.037 | 2                                 | .0003<br>(.0007)   | .00<br>(.00)                         | .0<br>(.0)        | .0<br>(.0)                | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 360.0<br>.0        | 103.0<br>(227.0)    | .20<br>(7.10)           | 2                           | 30       | .0<br>(.0)    |
|             |                | 5                                 | .2631<br>(.5600)   | .00<br>(.00)                         | 1551.4<br>(130.0) | 21.1<br>(70.0)            |                            |                                |                                |                    |                     |                         |                             |          |               |
| 3           | 15.000<br>.037 |                                   |                    |                                      |                   |                           | 0.<br>(.0)                 | 0.<br>(.0)                     | .0<br>.0                       | .0<br>.0           | 39.1<br>(86.3)      | .08<br>(2.80)           | 1                           | 10       | .0<br>(.0)    |
| 4           | 15.000<br>.037 | 5                                 | .2268<br>(.5000)   | .00<br>(.00)                         | 1551.4<br>(130.0) | 21.1<br>(70.0)            | 633.<br>(2190.)            | 11.<br>(37.)                   | 52.8<br>.0                     | 31.5<br>.0         | 78.9<br>(173.8)     | .11<br>(3.95)           | 2                           | 50       | .0<br>(.0)    |
| 5           | 15.000<br>.037 | 2                                 | .0003<br>(.0007)   | .00<br>(.00)                         | .0<br>(.0)        | .0<br>(.0)                | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 361.0<br>.0        | 113.6<br>(250.5)    | .25<br>(8.77)           | 2                           | 30       | .0<br>(.0)    |
|             |                | 5                                 | .2835<br>(.6250)   | .00<br>(.00)                         | 1551.4<br>(130.0) | 21.1<br>(70.0)            |                            |                                |                                |                    |                     |                         |                             |          |               |
| 6           | 15.000<br>.037 | 2                                 | .0003<br>(.0007)   | .00<br>(.00)                         | .0<br>(.0)        | .0<br>(.0)                | 32.<br>(110.)              | 30.<br>(101.)                  | 57.5<br>140.0                  | 57.5<br>140.0      | 100.1<br>(220.7)    | .22<br>(7.83)           | 1                           | 5        | .0<br>(.0)    |
|             |                | 5                                 | .2381<br>(.5250)   | .00<br>(.00)                         | 1810.0<br>(135.0) | 51.7<br>(125.0)           |                            |                                |                                |                    |                     |                         |                             |          |               |
| 7           | 15.000<br>.037 | 2                                 | .0003<br>(.0307)   | .00<br>(.00)                         | .0<br>(.0)        | 21.1<br>(70.0)            | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 360.0<br>.0        | 826.7<br>(1822.5)   | 1.46<br>(51.72)         | 2                           | 30       | .0<br>(.0)    |
|             |                | 5                                 | 2.5402<br>(5.6000) | .00<br>(.00)                         | 1551.4<br>(130.0) | 51.7<br>(125.0)           |                            |                                |                                |                    |                     |                         |                             |          |               |
| 8           | 15.000<br>.037 | 5                                 | 2.5764<br>(5.6800) | .00<br>(.00)                         | 1551.4<br>(130.0) | 51.7<br>(125.0)           | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 360.0<br>.0        | 817.3<br>(1801.7)   | .99<br>(34.87)          | 2                           | 30       | .0<br>(.0)    |
| 9           | 15.000<br>.037 | 5                                 | 2.5991<br>(5.7300) | .00<br>(.00)                         | 1551.4<br>(130.0) | 51.7<br>(125.0)           | 105.<br>(360.)             | 278.<br>(948.)                 | 500.0<br>.0                    | 360.0<br>.0        | 828.4<br>(1826.3)   | 1.03<br>(36.54)         | 2                           | 30       | .0<br>(.0)    |
| 10          | 15.000<br>.037 | 5                                 | 2.5402<br>(5.4000) | .00<br>(.00)                         | 1810.0<br>(135.0) | 51.7<br>(125.0)           | 32.<br>(110.)              | 30.<br>(101.)                  | 57.5<br>140.0                  | 57.5<br>140.0      | 814.1<br>(1791.7)   | 1.01<br>(35.52)         | 1                           | 5        | .0<br>(.0)    |

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|    |        |   |        |       |         |         |       |       |       |       |         |        |   |    |     |
|----|--------|---|--------|-------|---------|---------|-------|-------|-------|-------|---------|--------|---|----|-----|
| 11 | 15,000 | 5 | 2268   | 100   | 1551.4  | 51.7    | 105   | 278   | 500.0 | 360.0 | 85.7    | 17     | 2 | 30 | 0   |
|    | 037    |   | (5000) | (100) | (130.0) | (125.0) | (360) | (948) | 0     | 0     | (188.7) | (6.10) |   |    | (0) |
| 12 | 15,000 | 5 | 2268   | 100   | 1551.4  | 51.7    | 32    | 30    | 57.5  | 57.5  | 87.5    | 11     | 1 | 5  | 0   |
|    | 037    |   | (5000) | (100) | (130.0) | (125.0) | (110) | (101) | 140.0 | 140.0 | (172.8) | (3.80) |   |    | (0) |

APPLIANCE  
CONCEPT

NO. CONCEPT NAME

- 1 - DISPOSABLE WET/DRY WIPES
- 2 - REUSABLE WET WIPES-DISPOSABLE DRY WIPES
- 3 - DISPOSABLE WET/DRY WIPES (PREPACKAGED)
- 4 - AUTOMATIC SPONGE MOP
- 5 - REUSABLE-CLEANING-CLOTHS-DISPOSABLE-DRY WIPES
- 6 - DISPOSABLE CLEANING CLOTHS (SKYLAB) DISPOSABLE DRY WIPES
- 7 - DISPOSABLE WET WIPES REUSABLE DRY WIPES
- 8 - REUSABLE WET/DRY WIPES
- 9 - REUSABLE CLEANING CLOTHS/DRY WIPES
- 10 - DISPOSABLE CLEANING CLOTHS REUSABLE DRY WIPES
- 11 - SPONGES/ENCLOSED WETTING UNIT
- 12 - SPONGES/SKYLAB TYPE WETTING UNIT

- (\*)
- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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 0-25%
- (2) STATE OF THE ART 25-50%
- (3) SOME DEVELOPMENT REQUIRED 50-75%
- (4) EXTENSIVE DEV. REQUIRED 75-100%

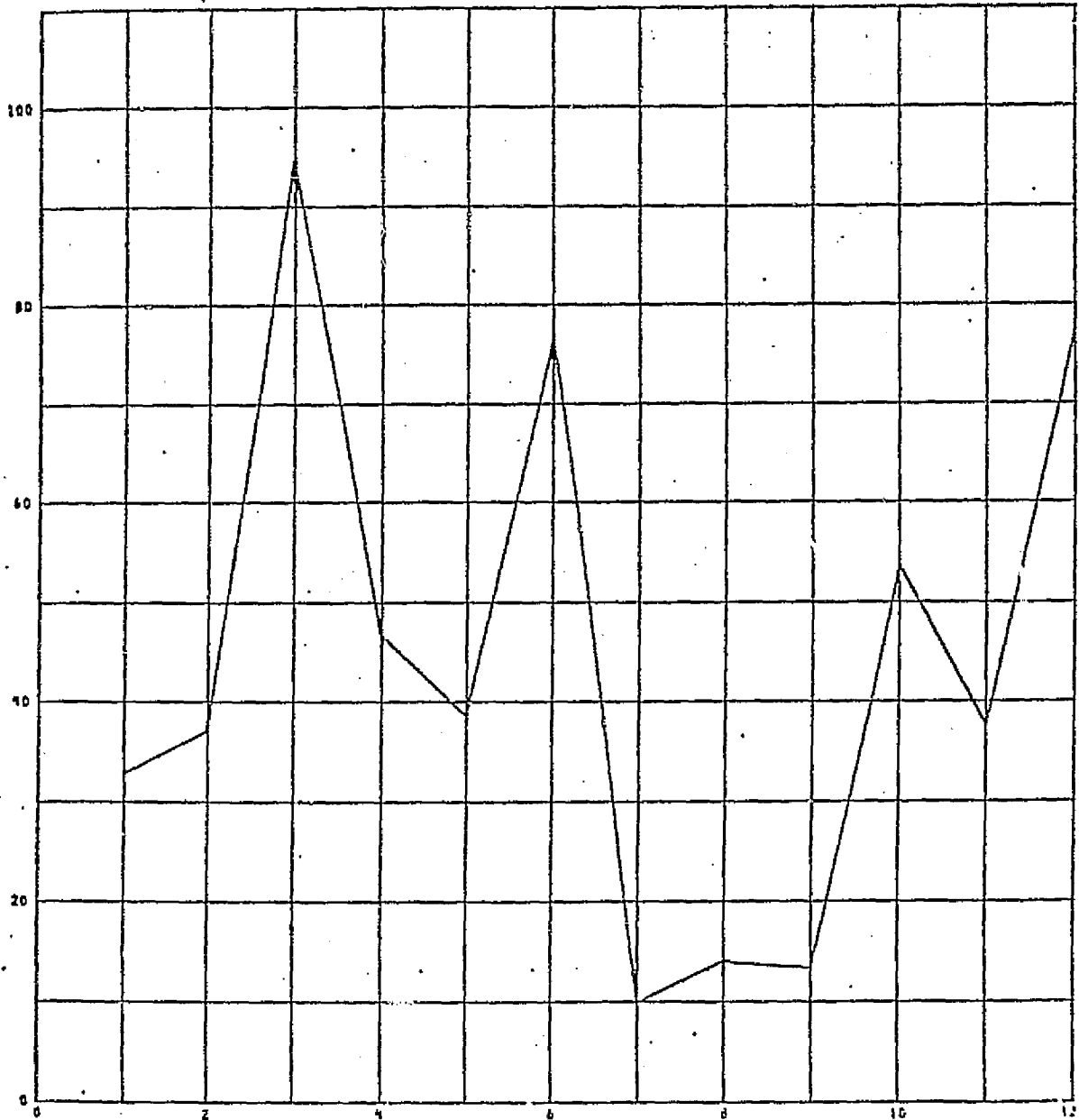
(\*\*\*)COST  
INDICATOR

B2-313

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| APPLIANCE<br>CONCEPT<br>NO. | CONCEPT NAME                                            |
|-----------------------------|---------------------------------------------------------|
| 1                           | DISPOSABLE WET/DRY WIPES                                |
| 2                           | REUSABLE WET WIPES-DISPOSABLE DRY WIPES                 |
| 3                           | DISPOSABLE WET/DRY WIPES (PREPACKAGED)                  |
| 4                           | AUTOMATIC SPONGE MOP                                    |
| 5                           | REUSABLE CLEANING CLOTHS DISPOSABLE DRY WIPES           |
| 6                           | DISPOSABLE CLEANING CLOTHS (SKLAR) DISPOSABLE DRY WIPES |
| 7                           | DISPOSABLE WET WIPES REUSABLE DRY WIPES                 |
| 8                           | REUSABLE WET/DRY WIPES                                  |
| 9                           | REUSABLE CLEANING CLOTHS/DRY WIPES                      |
| 10                          | DISPOSABLE CLEANING CLOTHS REUSABLE DRY WIPES           |

CONCEPT RATING \* \* \* BASED ON DESIGN



CONCEPT NUMBER

Surface Wiping (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 ( .06 YEARS)  
 USES MOD SUBROUTINE 32  
 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 \* \* \* \* \* SURFACE WIPING (SHUTTLE)  
 (09/22/75)

| FACTOR   | MIN VALUE | MAX VALUE | PTS | C O N C E P T |       |       |       |       |       |      |       |       |       |       |       |
|----------|-----------|-----------|-----|---------------|-------|-------|-------|-------|-------|------|-------|-------|-------|-------|-------|
|          |           |           |     | 1             | 2     | 3     | 4     | 5     | 6     | 7    | 8     | 9     | 10    | 11    | 12    |
| WEIGHT   | 86.300    | 1026.3    | 15  | 12.96         | 13.14 | 14.29 | 13.57 | 12.94 | 13.19 | .03  | .20   | .00   | .26   | 13.95 | 13.42 |
| POWER    | .00000    | 265.00    | 15  | .00           | .00   | 15.00 | 13.42 | .00   | 9.87  | .00  | .00   | .00   | 9.87  | .00   | 9.87  |
| VOLUME   | 2.8000    | 51.720    | 10  | 5.37          | 8.63  | 9.46  | 9.23  | 8.30  | 8.49  | .00  | 3.25  | 2.94  | 3.13  | 8.82  | 9.26  |
| THERMAL  | .00000    | 61.140    | 15  | .00           | .00   | 15.00 | 1.26  | .00   | 12.96 | .00  | .00   | .00   | 12.96 | .00   | 12.96 |
| RELIAB-Y | .99971    | 1.0000    | 5   | .51           | .51   | 5.00  | .00   | 1.65  | 1.49  | .51  | .51   | .51   | 1.49  | .51   | 1.49  |
| MAINTENC | .99999    | 1.0000    | 5   | 1.33          | 1.33  | 5.00  | .00   | 2.05  | 1.66  | 1.33 | 1.33  | 1.33  | 1.66  | 1.33  | 1.66  |
| DEV COST | 5.0000    | 50.000    | 15  | 6.00          | 6.00  | 12.00 | .00   | 6.00  | 13.50 | 6.00 | 6.00  | 6.00  | 13.50 | 6.00  | 13.50 |
| TOTAL PT | .00000    | 80.000    | 80  | 26.18         | 29.61 | 75.75 | 37.48 | 30.94 | 61.15 | 7.88 | 11.30 | 10.78 | 42.87 | 30.11 | 62.16 |
| RATING   | .00000    | 100.00    | 100 | 32.73         | 37.01 | 94.67 | 46.85 | 38.68 | 76.44 | 9.85 | 14.13 | 13.48 | 53.58 | 37.64 | 77.70 |

B2-315

D2-18561-3

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 OF POOR QUALITY

~~SENSITIVITY ANALYSIS~~

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| NORMAL   | 32.73         | 37.01 | 94.69 | 46.85 | 38.68 | 76.44 | 9.85  | 14.13 | 13.48 | 53.58 | 37.64 | 77.70 |
| WEIGHT   | 37.33         | 41.34 | 94.74 | 50.59 | 42.76 | 77.42 | 9.02  | 13.03 | 12.32 | 49.14 | 42.10 | 78.70 |
| POWER    | 29.92         | 33.84 | 95.14 | 50.50 | 35.36 | 75.52 | 9.00  | 12.92 | 12.32 | 54.63 | 34.42 | 76.67 |
| VOLUME   | 33.96         | 39.91 | 94.60 | 49.52 | 41.29 | 76.93 | 9.27  | 15.21 | 14.41 | 52.27 | 40.62 | 78.57 |
| THERMAL  | 29.92         | 33.84 | 95.14 | 43.55 | 35.36 | 77.29 | 9.00  | 12.92 | 12.32 | 56.40 | 34.42 | 78.44 |
| RELIAB-Y | 32.05         | 36.20 | 94.85 | 45.43 | 38.50 | 75.02 | 9.86  | 14.01 | 13.38 | 52.86 | 36.81 | 76.24 |
| MAINTENC | 32.54         | 36.70 | 94.85 | 45.43 | 38.75 | 75.13 | 10.36 | 14.51 | 13.88 | 52.97 | 37.31 | 76.35 |
| DEV COST | 33.35         | 37.27 | 93.43 | 42.83 | 38.79 | 77.60 | 12.43 | 16.35 | 15.75 | 56.71 | 37.85 | 78.75 |

~~SENSITIVITY ANALYSIS~~

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| NORMAL   | 32.73         | 37.01 | 94.69 | 46.85 | 38.68 | 76.44 | 9.85  | 14.13 | 13.48 | 53.58 | 37.64 | 77.70 |
| WEIGHT   | 27.17         | 31.78 | 94.63 | 42.33 | 33.75 | 75.25 | 10.84 | 15.45 | 14.87 | 58.95 | 32.26 | 76.48 |
| POWER    | 36.11         | 40.84 | 94.14 | 42.44 | 42.68 | 77.54 | 10.87 | 15.59 | 14.87 | 52.32 | 41.54 | 78.93 |
| VOLUME   | 31.33         | 33.73 | 94.69 | 43.82 | 35.72 | 75.87 | 10.50 | 12.90 | 12.42 | 55.07 | 34.27 | 76.70 |
| THERMAL  | 36.11         | 40.84 | 94.14 | 50.83 | 42.68 | 75.40 | 10.87 | 15.59 | 14.87 | 50.19 | 41.54 | 76.79 |
| RELIAB-Y | 33.45         | 37.87 | 94.52 | 48.36 | 38.86 | 77.94 | 9.83  | 14.25 | 13.58 | 54.35 | 38.53 | 79.24 |
| MAINTENC | 32.92         | 37.35 | 94.52 | 48.36 | 38.60 | 77.83 | 9.31  | 13.72 | 13.05 | 54.24 | 38.00 | 79.13 |
| DEV COST | 31.78         | 36.70 | 96.21 | 51.69 | 38.54 | 75.03 | 6.73  | 11.45 | 10.73 | 49.82 | 37.40 | 76.42 |

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D2-118561-3

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.1.1-EQUIPMENT CLEANING

| COMPONENT TYPE<br>APPLIANCE TYPE                | NUMBER OF COMPONENTS |                 |        |                |                |             |                           |                  |             |      |              |        |              |       | NUMBER OF SAFETY CRITICAL ITEMS |                 |   |
|-------------------------------------------------|----------------------|-----------------|--------|----------------|----------------|-------------|---------------------------|------------------|-------------|------|--------------|--------|--------------|-------|---------------------------------|-----------------|---|
|                                                 | NO.                  | WATER SEPARATOR | FILTER | SOLENOID VALVE | HEAT EXCHANGER | ACCUMULATOR | TEMPERATURE CONTROL VALVE | CONTROLLER TIMER | CHECK VALVE | PUMP | MANUAL VALVE | HEATER | RELIEF VALVE | MOTOR |                                 | ELECTRIC SWITCH |   |
|                                                 | (6)                  | (9)             | (3)    | (16)           | (4)            | (24)        | (19)                      | (22)             | (2)         | (23) | (17)         | (25)   | (1)          | (10)  | ○                               | ○               |   |
| DISPOSABLE WET/DRY WIPES                        | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| REUSABLE WET WIPES/DISPOSABLE WET WIPES         | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| DISPOSABLE WET/DRY WIPES                        | -                    | -               | -      | -              | -              | -           | -                         | -                | -           | -    | -            | -      | -            | -     |                                 |                 | 0 |
| AUTOMATIC SPONGE MOP (ASTRO-VAC)                | 1                    | 2               | 2      | 1              | -              | -           | 1                         | 1                | 1           | -    | -            | -      | 2            | 1     |                                 |                 | 0 |
| REUSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES   | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | -     |                                 |                 | 0 |
| DISPOSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES | -                    | -               | -      | -              | 1              | -           | 1                         | 1                | 1           | 5    | 1            | 1      | 1            | -     |                                 |                 | 0 |
| DISPOSABLE WET WIPES/REUSABLE DRY WIPES         | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| REUSABLE WET WIPES/REUSABLE DRY WIPES           | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| REUSABLE CLEANING CLOTHS/REUSABLE DRY WIPES     | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| DISPOSABLE CLEANING CLOTHS/REUSABLE DRY WIPES   | -                    | -               | -      | -              | 1              | -           | 1                         | 1                | 1           | 5    | 1            | 1      | 1            | -     |                                 |                 | 0 |
| SPONGES/ENCLOSED WETTING UNIT                   | 1                    | 2               | 2      | 1              | 1              | 1           | 1                         | 1                | -           | -    | -            | -      | 1            | 1     |                                 |                 | 0 |
| SPONGES/SKYLAB TYPE WETTING UNIT                | -                    | -               | -      | -              | 1              | -           | 1                         | 1                | 1           | 5    | 1            | 1      | 1            | -     |                                 |                 | 0 |

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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

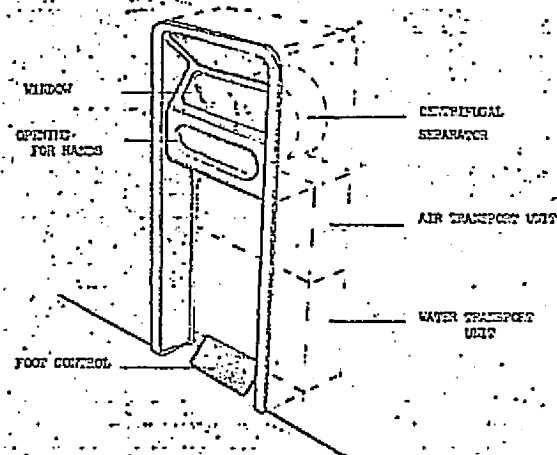
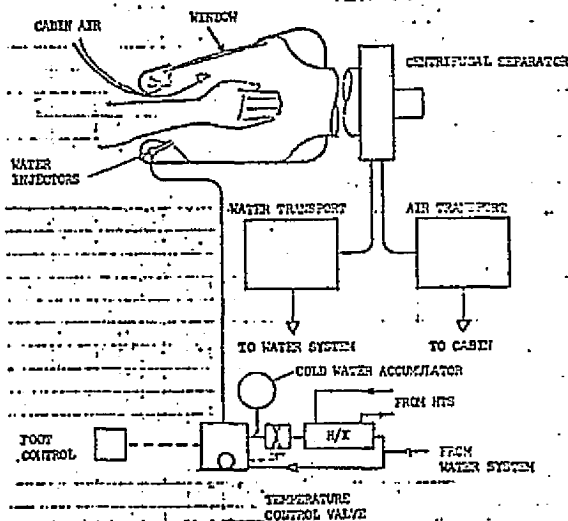
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 1/Disposable Wet/Dry Wipes

INDEX NO. 3.1.1.1

REF. NO. 236,186

DESCRIPTION The disposable wet/dry wipe concept utilizes a wet wipe for clean-up and dry wipe to soak up remaining moisture. A wetting unit with hand holes is supplied for the function. The wetting unit has a water supply outlet 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 wets the wipe, uses it for area cleanup (disinfectant soap is located at the wetting unit) and can be rewetted if necessary for cleanup. The wipe is wrung out in the wetting unit and disposed of by deposit into a vacuum drier to remove excess water. Dry wipe's are provided to dry damp areas left by the wet wipe. The used wipes are deposited into the refuse system. The disposable wipes are 12 inch squares of 4 ply "wet strength" paper. One wet wipe and one dry wipe are provided per cleanup based on a maximum of 15 cleanup functions per day.



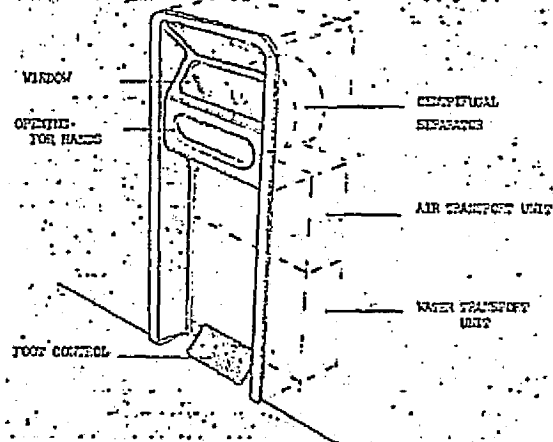
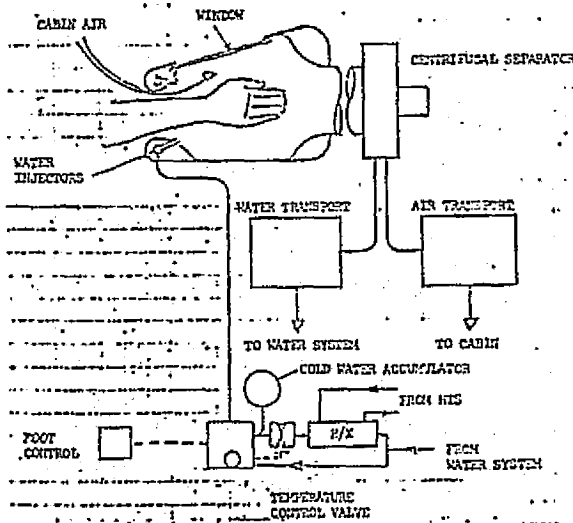






SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning  
 APPLIANCE FUNCTION Surface Wiping  
 APPLIANCE CONCEPT NO./TITLE 2/Reusable Wet/Disposable Dry Wipes  
 INDEX NO. 3.1.1.2 REF. NO. 236,186

DESCRIPTION The reusable wet/disposable dry wipe concept utilizes a wet reusable wipe for cleanup and a disposable dry wipe to soak up remaining moisture. 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. Three reusable wipes are provided for a maximum 15 cleanups per day. The wipe is used a maximum of 5 times before washing. After sixty washings, the wipe is discarded and replaced. The reusable wipes are 10 inches square of 4 ply "wet strength" paper. The disposable dry wipes are 12 inch squares of 4 ply "wet strength" paper. One dry wipe per cleanup are provisioned which are disposed of by deposit into a vacuum drier to remove excess water. The dry wipes are provided to dry damp areas left by the wet wipe.







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SPACECRAFT Shuttle

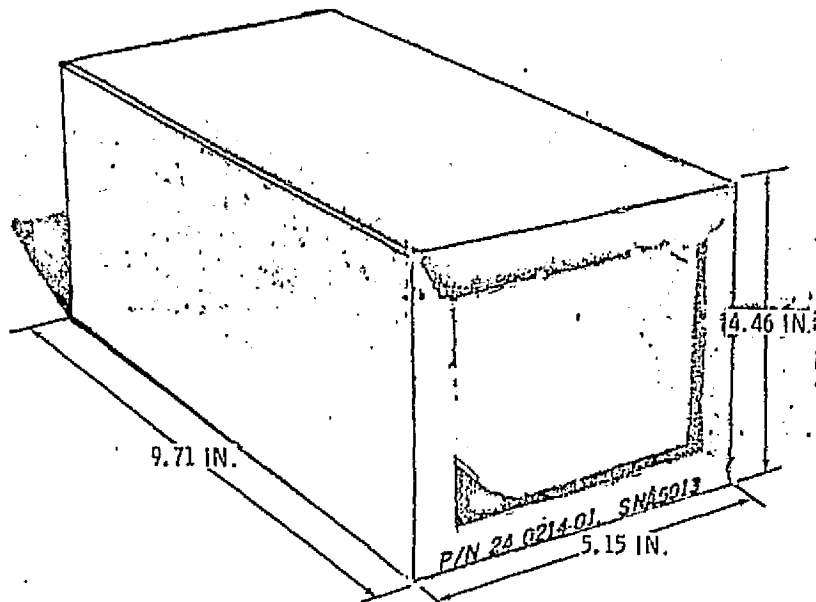
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 3/Disposable Wet/Dry Wipes (Prepackaged)

INDEX NO. 3.1.1.3 REF. NO. 250,283

DESCRIPTION The disposable wet/dry wipes concept consists of prepackaged wet wipes which were used on Skylab. The wet wipes are contained within a package to eliminate water evaporation during storage. The dry wipes are dispensed from a 196 count container. The wet and dry wipes are used for cleanup and discarded. The Skylab size wet wipe weight and volume were ratioed (6.3) to the 10 inch square wipes used in Concepts 1 and 2 in order to provide a equivalent trade.



Wipe Dispenser





SPACECRAFT Shuttle

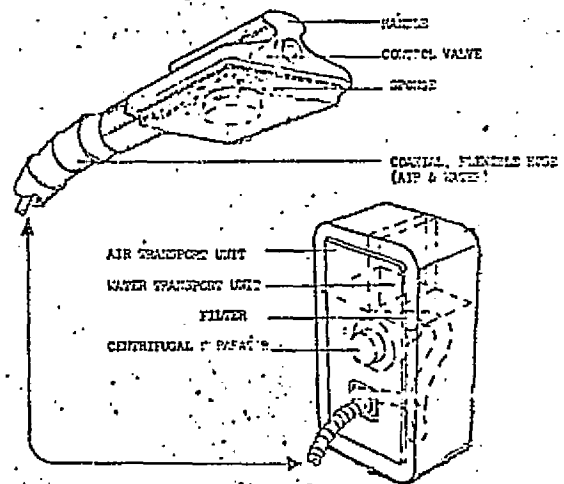
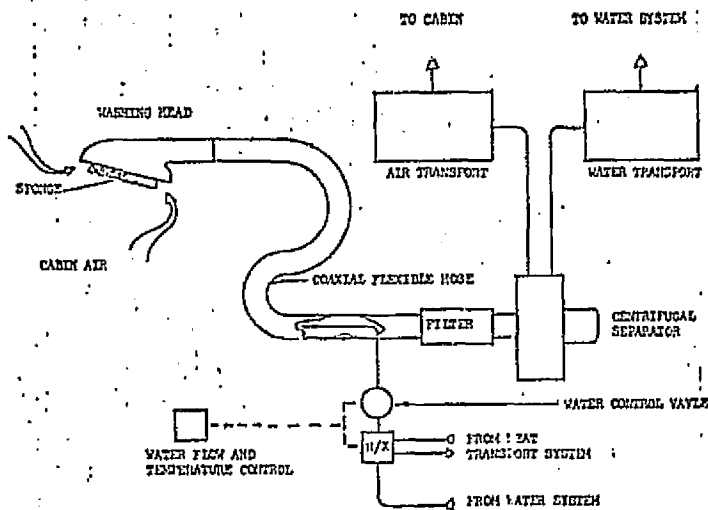
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 4/Automatic Mop

INDEX NO. 3.1.1.4 REF. NO. 236,100

DESCRIPTION The automatic mop 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 equipment. A water pick up 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 water into the water waste management system. One new sponge is provided per week.









SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

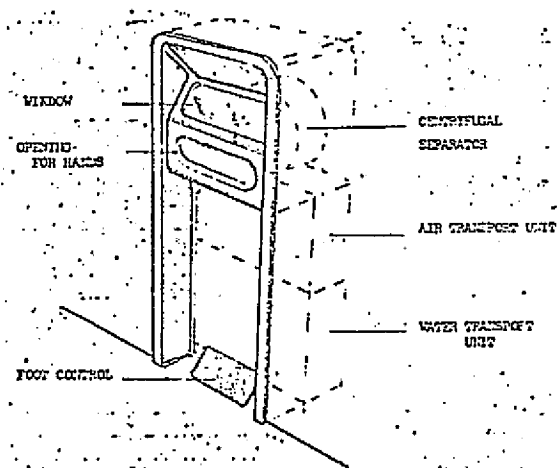
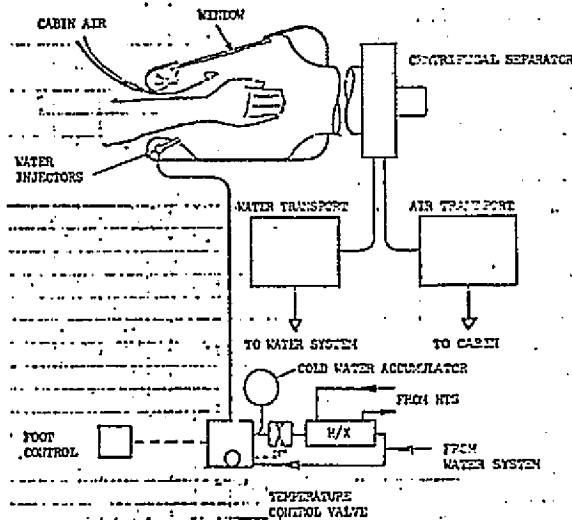
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 5/Reusable Cleaning Cloths/Disposable Dry Wipes

INDEX NO. 3.1.1.5

REF. NO. 236,237,245,209

DESCRIPTION The reusable cleaning cloth/disposable dry wipe concept is the same as Concept 2; however, terry cloth are used for cleansing cloths. The terry wash clothes are 6 inches square. The cleaning cloths are provisioned 3 per day for a maximum of 5 clean up functions. The cleaning cloth is used for sixty washings then is discarded and replaced. The cleaning cloth is washed and dried daily using a washing machine and dryer. The disposable dry wipes are 12 inch squares of 4 ply "wet strength" paper. Once disposable dry wipe is provided per clean up based on a maximum of 15 cleanup functions per day. The wipes are disposed of by deposit in the refuse system. The concept is penalized for the usage of a wash/dryer for recycling the terry cloth cleaning cloths.

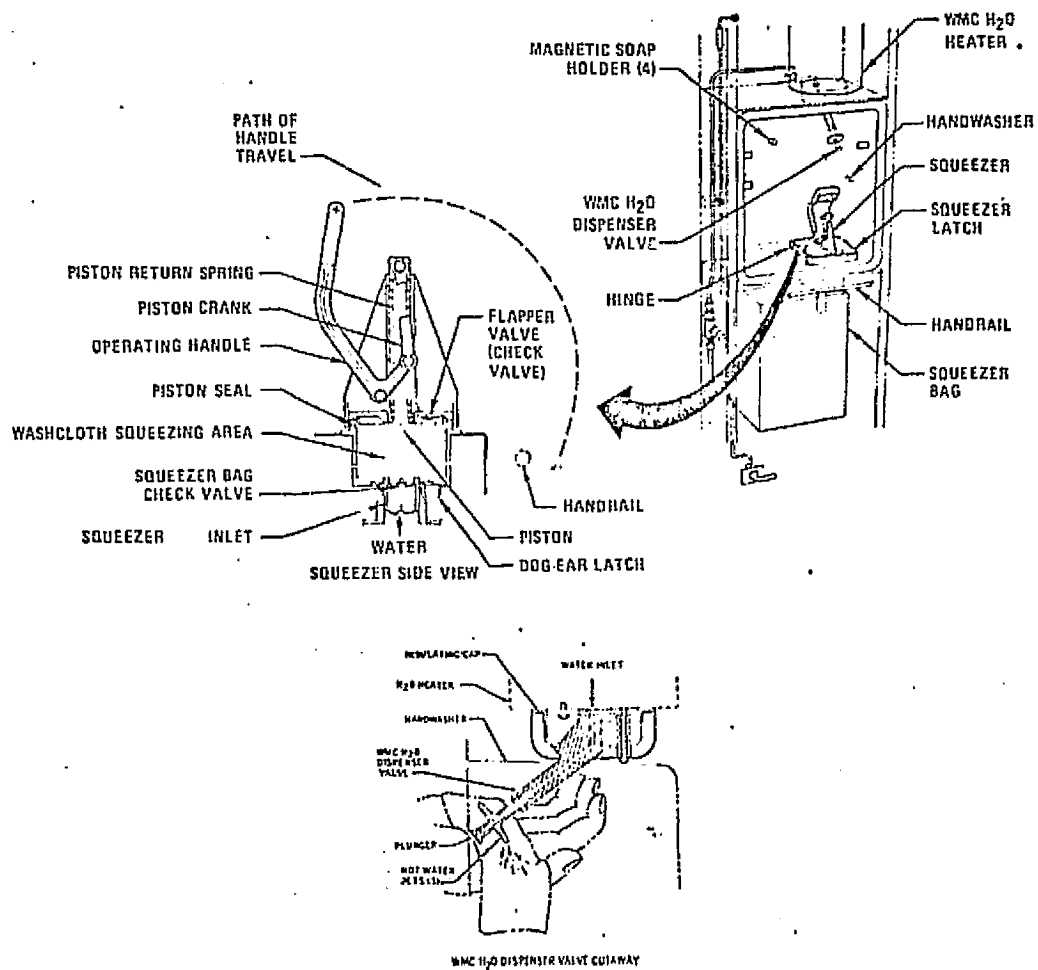






SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning  
 APPLIANCE FUNCTION Surface Wiping  
 APPLIANCE CONCEPT NO./TITLE 6/Disposable Cleaning Cloths/Disposable Dry Wipes  
 INDEX NO. 3.1.1.6 REF. NO. 236,283

DESCRIPTION The disposable cleaning cloths/disposable dry wipes concept is the system used on the Skylab applied to equipment cleaning. The terry cloth cleaning cloths 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 cleaning cloth is assumed to be recovered and routed to the water waste management system. Three cleaning cloths are provided per day for a maximum of 15 cleanup functions. The cleaning cloths are disposed of by deposit into a vacuum dryer to remove excess water. The dried cloth is then deposited into the refuse system. The disposable wipes are 12 inch squares of 4 ply "wet strength" paper. One dry wipe is provided per cleanup based on a maximum of 15 cleanup functions per day. The used dry wipe is deposited into the refuse system.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 6/DISPOSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES INDEX NUMBER 3.1.1.6

**ELECTRICAL POWER REQUIREMENTS**

| COMPONENT         | (REF)        | AC POWER                       |                      |                         | DC POWER                                    |                      |                         |                                             |
|-------------------|--------------|--------------------------------|----------------------|-------------------------|---------------------------------------------|----------------------|-------------------------|---------------------------------------------|
|                   |              | ①<br>USE TIME<br>CYCLE<br>(HR) | ②<br>PEAK<br>(WATTS) | ③<br>AVERAGE<br>(WATTS) | ④<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① x ③ | ⑤<br>PEAK<br>(WATTS) | ⑥<br>AVERAGE<br>(WATTS) | ⑦<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① x ⑤ |
| <u>HEATER</u>     | <u>(2R3)</u> | <u>0.375</u>                   | <u>—</u>             | <u>—</u>                | <u>—</u>                                    | <u>140</u>           | <u>140</u>              | <u>5.25</u>                                 |
| <u>WATER PUMP</u> |              | <u>0.375</u>                   | <u>57.5</u>          | <u>57.5</u>             | <u>2.15</u>                                 | <u>—</u>             | <u>—</u>                | <u>—</u>                                    |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                |                      |                         |                                             |                      |                         |                                             |
|                   |              |                                | <u>57.5</u>          |                         | <u>2.15</u>                                 | <u>140</u>           |                         | <u>5.25</u>                                 |
|                   |              |                                | MAXIMUM              |                         | TOTAL                                       | MAXIMUM              |                         | TOTAL                                       |

**THERMAL REQUIREMENTS**

| SOURCE                 | LATENT<br>(BTU/HR) | SENSIBLE<br>(BTU/HR) | HEAT LEAK<br>(BTU/HR) | TO COOLANT<br>(BTU/HR) |
|------------------------|--------------------|----------------------|-----------------------|------------------------|
| <u>WATER HEAT LOSS</u> | <u>110</u>         | <u>—</u>             | <u>—</u>              | <u>110</u>             |
| <u>HEATER</u>          | <u>—</u>           | <u>71.6</u>          | <u>71.6</u>           | <u>—</u>               |
| <u>WATER PUMP</u>      | <u>—</u>           | <u>29.4</u>          | <u>29.4</u>           | <u>—</u>               |
|                        |                    |                      |                       |                        |
|                        |                    |                      |                       |                        |
|                        |                    |                      |                       |                        |
| TOTAL                  | <u>32.3 (110)</u>  | <u>29.6 (101)</u>    | <u>29.6 (101)</u>     | <u>32.3 (110)</u>      |
|                        | WATT (BTU/HR)      | WATT (BTU/HR)        | WATT (BTU/HR)         | WATT (BTU/HR)          |

**OPERATIONAL PENALTIES**

| SOURCE         | HEAT LEAK<br>(BTU/HR/CYCLE)   | THERMAL<br>TO COOLANT<br>(BTU/HR/CYCLE) | ELECTRICAL<br>(PK WATTS/CYCLE) | WEIGHT<br>(LB/MISSION)     | VOLUME<br>(FT³/MISSION) |
|----------------|-------------------------------|-----------------------------------------|--------------------------------|----------------------------|-------------------------|
| <u>- N/A -</u> |                               |                                         |                                |                            |                         |
|                |                               |                                         |                                |                            |                         |
|                |                               |                                         |                                |                            |                         |
|                |                               |                                         |                                |                            |                         |
|                |                               |                                         |                                |                            |                         |
| TOTAL          |                               |                                         |                                |                            |                         |
|                | WATTS/CYCLE<br>(BTU/HR/CYCLE) | WATTS/CYCLE<br>(BTU/HR/CYCLE)           |                                | KG/MISSION<br>(LB/MISSION) | FT³/MISSION             |

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 6/DISPOSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES

INDEX NUMBER 3.1.1.6

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT (REF)                   | WEIGHT (LBS)       | VOLUME (FT <sup>3</sup> ) |
|-----------------------------------|--------------------|---------------------------|
| SQUEEZER/WATER DISPENSER (McDiac) | 32.9               | 1.15                      |
| DISPOSABLE CLEANING CLOTHS        | 6.76               | 3.36                      |
| DISPOSABLE DRY WIPES              | 4.64               | .45                       |
| TOTAL                             | <b>19.9 (43.8)</b> | <b>.140 (4.96)</b>        |

KG (LBS) M<sup>3</sup> (FT<sup>3</sup>)

SOLID EXPENDABLE WT/VOL REQUIREMENTS

| TYPE                       | ① UNITS/CYCLE(REF)                    | ② WT/UNIT (REF) (PKG. WT/UNIT)(REF) (LB)  | ③ WT/CYCLE ① X ② (LB)                              | ④ VOL/UNIT (REF) (PKG. VOL/UNIT)(REF) (FT <sup>3</sup> ) | ⑤ VOL/CYCLE ① X ④ (FT <sup>3</sup> ) |
|----------------------------|---------------------------------------|-------------------------------------------|----------------------------------------------------|----------------------------------------------------------|--------------------------------------|
| DISPOSABLE CLEANING CLOTHS | .2                                    | .077 (NASA)                               | .022                                               | .1092                                                    | .01092                               |
| DISPOSABLE DRY WIPES       | 1 (236)                               | .015 (100)                                | .015                                               | .0015 (236)                                              | .0015                                |
|                            |                                       |                                           | Σ③ .037                                            |                                                          | Σ⑤ .0124                             |
|                            |                                       |                                           | TOTAL WT/CYCLE (LB)                                |                                                          | TOTAL VOL/CYCLE (FT <sup>3</sup> )   |
| TOTAL WT. MISSION =        | $\frac{15}{\text{CYCLES/DAY}} \times$ | $\frac{20.5}{\text{DAYS/MISSION}} \times$ | $\frac{.037}{\text{TOT. WT/CYCLE (LB)}} \times$    | <b>5.16 (11.4)</b><br>KG (LB)                            |                                      |
| TOTAL VOL. MISSION =       | $\frac{15}{\text{CYCLES/DAY}} \times$ | $\frac{20.5}{\text{DAYS/MISSION}} \times$ | $\frac{.0124}{\text{TOT. VOL/CYCLE (FT3)}} \times$ | <b>.108 (3.81)</b><br>M <sup>3</sup> (FT <sup>3</sup> )  |                                      |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE                    | ① AMT. USED/CYCLE(REF) (LB)          | ② RECOVERY FACTOR                         | ③ AMT. RECOVERED/CYCLE ① X ② (LB)                        | ④ AMT. LOST/CYCLE ① - ③ (LB)                                  |                                |
|-------------------------|--------------------------------------|-------------------------------------------|----------------------------------------------------------|---------------------------------------------------------------|--------------------------------|
| WATER                   | .5 (236)                             | N/A                                       | N/A                                                      | .5                                                            |                                |
| WATER LOSS (WASH CLOTH) | .025                                 | N/A                                       | N/A                                                      | .025                                                          |                                |
| WATER LOSS (DRY WIPES)  | .0490                                | N/A                                       | N/A                                                      | .0490                                                         |                                |
| OXYGEN (WIPE DISPOSAL)  | .000719                              | N/A                                       | N/A                                                      | .000719                                                       |                                |
|                         | Σ① .575                              |                                           | Σ③ .575                                                  |                                                               |                                |
| TOTAL WT. MISSION =     | $\frac{15}{\text{CYCLE/DAY}} \times$ | $\frac{20.5}{\text{DAYS/MISSION}} \times$ | $\frac{.575}{\text{TOTAL LOST/CYCLE (LB) (Σ ④)}} \times$ | $\frac{176.8}{\text{(LB)}} + \frac{N/A}{\text{(Σ ①)}} \times$ | <b>80.2 (176.8)</b><br>KG (LB) |

SPACECRAFT Shuttle

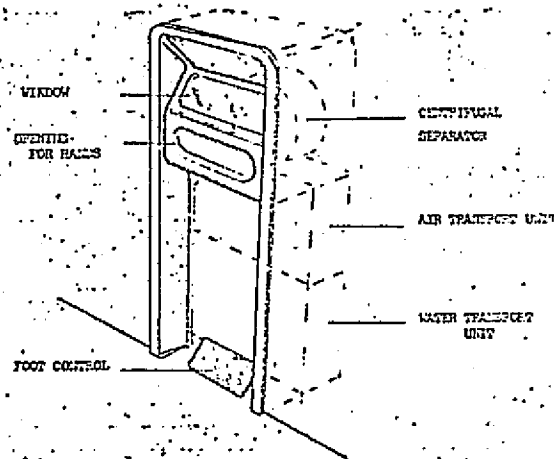
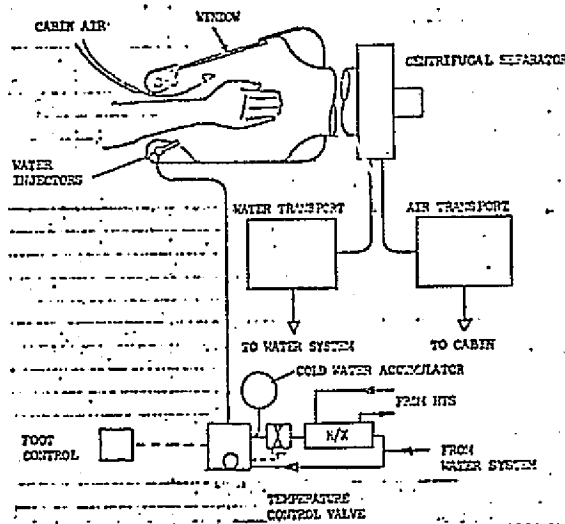
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 7/Disposable Wet Wipes/Reusables Dry Wipes

INDEX NO. 3.1.1.7 REF. NO. 286,186

DESCRIPTION The disposable wet wipes/reusable dry wipes concept is identical to concept 1, however reusable dry wipes are used for equipment drying. The terry cloth reusable dry wipes are 15 inches x 30 inches and are used a maximum of 5 times before washing. 1 wipes are washed and dried after one day of usage and are discarded after 60 was ngs. The dry wipes are provisioned 3 per day for a maximum of 15 cleanup functions. The concept is penalized for the usage of a washer/dryer for recycling the drying cloths.









SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

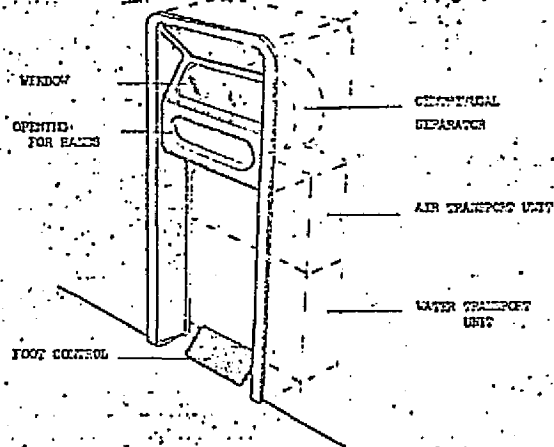
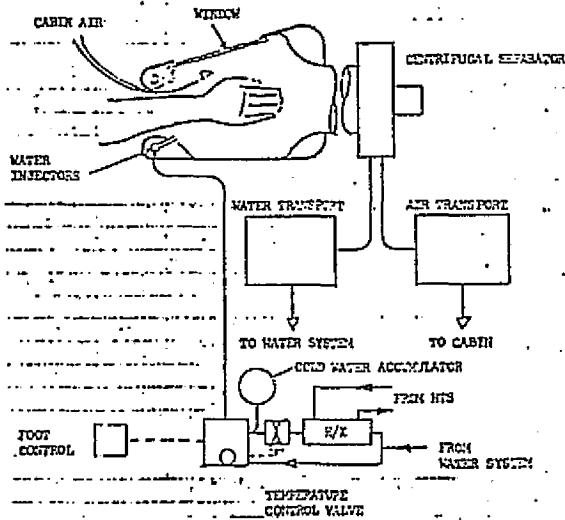
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 8/Reusable Wet/Dry Wipes

INDEX NO. 3.1.1.8

REF. NO. 236,186

DESCRIPTION The reusable wet/dry wipes concept is identical to concept 2; however reusable dry wipes are used for equipment drying. The terry cloth reusable dry wipes are used a maximum of 5 times before washing. The wipes are washed and dried after one day of usage and are discarded after 60 washings. The dry wipes are provisioned 3 per day for a maximum of 15 cleanup functions. The concept is penalized for the usage of a washer/dryer for recycling the cleaning and drying cloths.







SPACECRAFT Shuttle

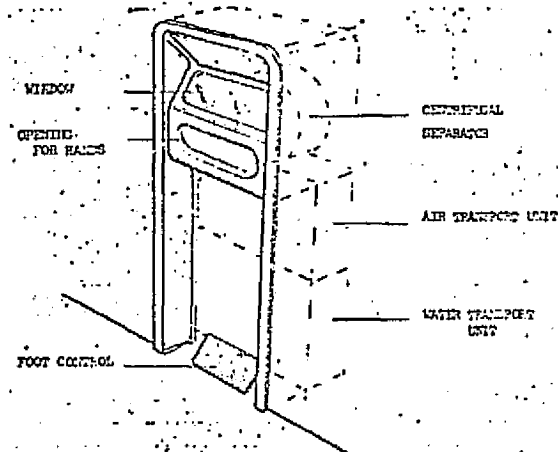
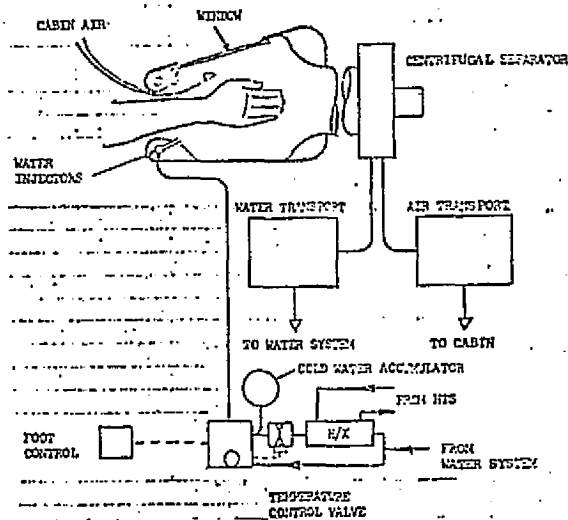
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 9/Reusable Cleaning Cloths/Dry Wipes

INDEX NO. 3.1.1.9 REF. NO. 236,237,245

DESCRIPTION The reusable cleaning cloths/dry wipes concept is identical to concept 5; however, reusable dry wipes are used for equipment drying. The terry cloth reusable dry wipes are used a maximum of 5 times before washing. The wipes are washed and dried after one day of usage and are discarded after 60 washings. The dry wipes are provisioned 3 per day for a maximum of 15 cleanup functions. The concept is penalized for the usage of a washer/dryer for recycling the cleaning and drying cloths.









SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

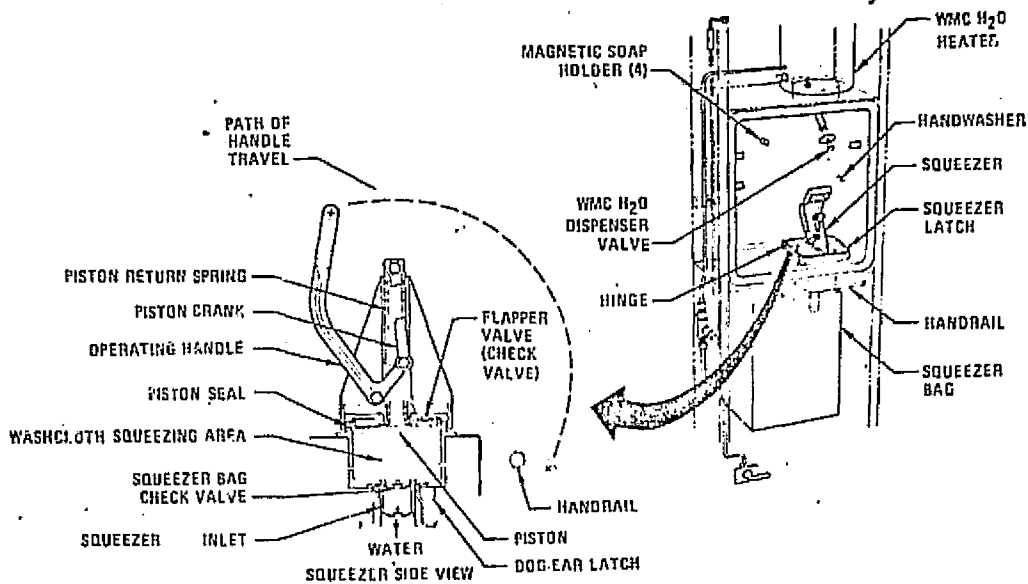
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 10/Disposable Cleaning Cloths/Reusable Dry Wipes

INDEX NO. 3.1.1.10

REF. NO. 236,283

DESCRIPTION The disposable cleaning cloths/reusable dry wipes concept is identical to concept 6; however reusable dry wipes are used for equipment cleaning. The terry cloth reusable dry wipes are used a maximum of 5 times before washing. The wipes are washed and dried after one day of usage and are discarded after 60 washings. The dry wipes are provisioned 3 per day for a maximum of 15 cleanup functions. The concept is penalized for the usage of a washer/dryer for recycling the drying cloths.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 10/DISPOSABLE CLEANING CLOTHS/REUSABLE DRY WIPES INDEX NUMBER 3.1.1.10

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT                        | (REF) | WEIGHT (LBS)        | VOLUME (FT <sup>3</sup> ) |
|----------------------------------|-------|---------------------|---------------------------|
| SQUEEZER/WATER DISPENSER (M/DAC) |       | 32.4                | 1.15                      |
| DISPOSABLE CLEANING CLOTHS       |       | 6.77                | 3.36                      |
| REUSABLE DRY WIPES               |       | .03                 | .02                       |
| TOTAL                            |       | <b>17.78 (39.2)</b> | <b>.128 (4.53)</b>        |

KG (LBS)

M<sup>3</sup> (FT<sup>3</sup>)

SOLID EXPENDABLE W/VOL REQUIREMENTS

| TYPE                       | ① UNITS/CYCLE (REF) | ② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB) | ③ WT/CYCLE (① X ②) (LB)           | ④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> ) | ⑤ VOL/CYCLE (① X ④) (FT <sup>3</sup> ) |
|----------------------------|---------------------|-------------------------------------------|-----------------------------------|-----------------------------------------------------------|----------------------------------------|
| DISPOSABLE CLEANING CLOTHS | .2                  | .077 (NASA)                               | .022                              | .1092                                                     | .01092                                 |
| REUSABLE DRY WIPES         | .0167 (236)         | .1078 (100)                               | .000148                           | .00366 (236)                                              | .000608                                |
|                            |                     |                                           | Σ ③ .022148                       |                                                           | Σ ⑤ .0109808                           |
| TOTAL WT. MISSION =        | 15                  | 20.5                                      | .022148                           |                                                           | 3.09 (6.8)                             |
|                            | CYCLES/DAY          | DAYS/MISSION                              | TOT. WT/CYCLE (LB)                |                                                           | KG (LB)                                |
| TOTAL VOL. MISSION =       | 15                  | 20.5                                      | .0109808                          |                                                           | .096 (3.38)                            |
|                            | CYCLES/DAY          | DAYS/MISSION                              | TOT. VOL/CYCLE (FT <sup>3</sup> ) |                                                           | M <sup>3</sup> (FT <sup>3</sup> )      |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE                        | ① AMT. USED/CYCLE (REF) (LB) | ② RECOVERY FACTOR | ③ AMT. RECOVERED/CYCLE (① X ②) (LB) | ④ AMT. LOST/CYCLE (① - ③) (LB) |                |
|-----------------------------|------------------------------|-------------------|-------------------------------------|--------------------------------|----------------|
| WATER                       | .5                           | N/A               | N/A                                 | .5                             |                |
| WASHER WATER LOSS PENALTY   | 5.1                          | N/A               | N/A                                 | 5.1                            |                |
| WATER LOSS (CLEANING CLOTH) | .025                         | N/A               | N/A                                 | .025                           |                |
|                             | Σ ① 5.625                    |                   | Σ ③                                 | Σ ④ 5.625                      |                |
| TOTAL WT. MISSION =         | 15                           | 20.5              | 5.625                               | 1729.7                         | 784.6 (1729.7) |
|                             | CYCLE/DAY                    | DAYS/MISSION      | TOTAL LOST/CYCLE (④)                | (LB)                           | KG (LB)        |

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HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

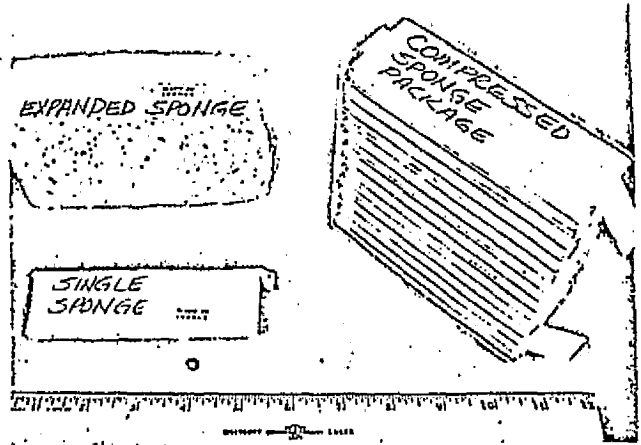
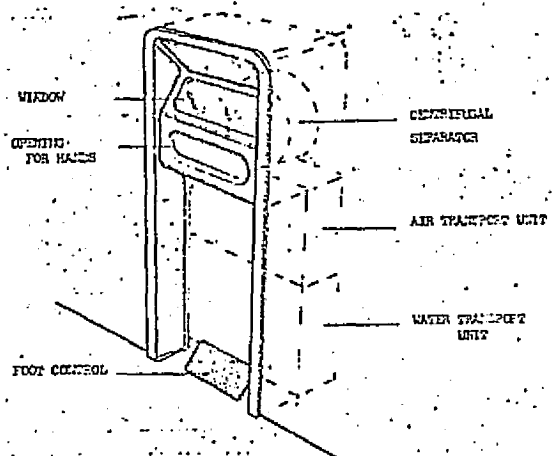
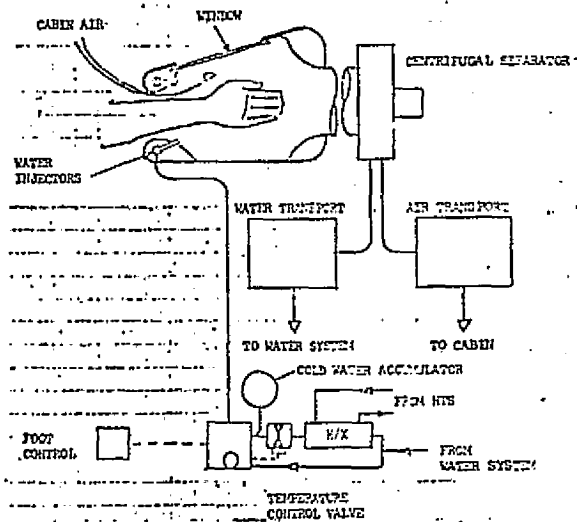
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 11/Sponges/Enclosed Wetting Unit

INDEX NO. 3.1.1.11

REF. NO. 236,170

DESCRIPTION The sponges/enclosed wetting unit concept uses the wetting unit described by concept 1. The sponges are compressed and are used for pickup of spills of any type and general cleanup. The sponges are made of cellulose material which expands to approximately 15 times its compressed volume when soaking up liquid. A single compressed sponge is 5 inches long by 1.6 inches wide by .25 inches depth. The sponge volume is 2.0 cubic inches and weighs 18 grams. The wetting unit is used for wetting/wringing the sponges during cleanup. The sponges are used for cleanup and drying. Five sponges per day are provisioned for a maximum of 15 cleanup and drying functions. Each sponges is used 3 times and discarded into the refuse system.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 11/SPONGES/ENCLOSED WETTING UNIT

INDEX NUMBER 3.1.1.11

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT    | (REF) | WEIGHT (LBS)         | VOLUME (FT <sup>3</sup> )         |
|--------------|-------|----------------------|-----------------------------------|
| WETTING UNIT | (236) | 28.49                | 3.5                               |
| SPONGES      | (170) | 4.06                 | .12                               |
| TOTAL        |       | <b>14.76 (32.55)</b> | <b>.102 (3.62)</b>                |
|              |       | KG (LBS)             | M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE WT/VOL REQUIREMENTS

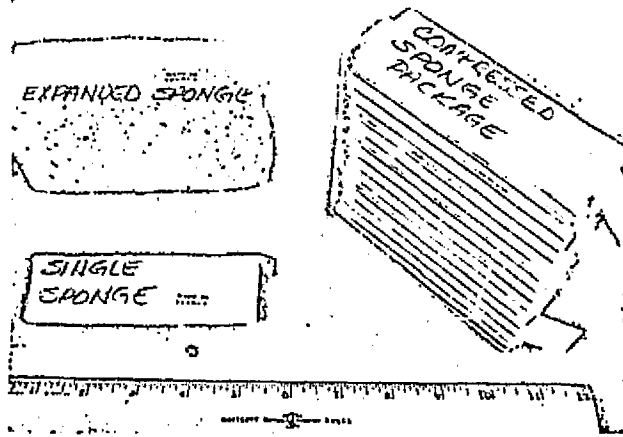
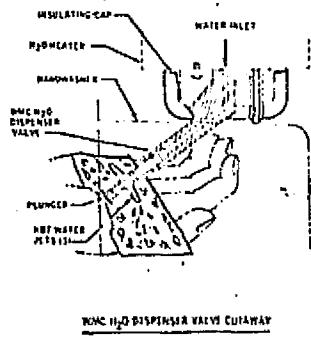
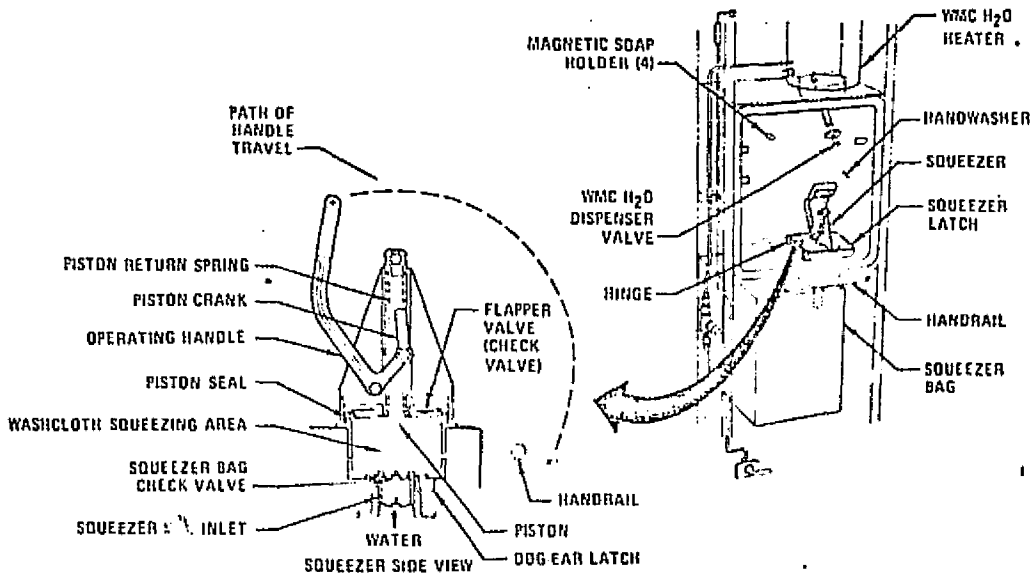
| TYPE               | ① UNITS/CYCLE (REF) | ② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB) | ③ WT/CYCLE ① X ② (LB)             | ④ VOL./UNIT (REF) (PKG.VOL/UNIT)(REF) (FT <sup>3</sup> ) | ⑤ VOL./CYCLE ① X ④ (FT <sup>3</sup> ) |
|--------------------|---------------------|-----------------------------------------|-----------------------------------|----------------------------------------------------------|---------------------------------------|
| SPONGES            | .333                | .0397 (170)                             | .01321                            | .00116 (170)                                             | .000385                               |
|                    |                     |                                         | Σ ③ .01321                        | Σ ⑤ .000385                                              |                                       |
|                    |                     |                                         | TOTAL WT/CYCLE (LB)               | TOTAL VOL/CYCLE (FT <sup>3</sup> )                       |                                       |
| TOTAL WT. MISSION  | 15                  | 20.5                                    | .01321                            | 1.84 (4.06)                                              |                                       |
|                    | CYCLES/DAY          | DAYS/MISSION                            | TOT. WT/CYCLE (LB)                | KG (LB)                                                  |                                       |
| TOTAL VOL. MISSION | 15                  | 20.5                                    | .000385                           | .0033 (.118)                                             |                                       |
|                    | CYCLES/DAY          | DAYS/MISSION                            | TOT. VOL/CYCLE (FT <sup>3</sup> ) | M <sup>3</sup> (FT <sup>3</sup> )                        |                                       |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE                         | ① AMT. USED/CYCLE (REF) (LB) | ② RECOVERY FACTOR | ③ AMT. RECOVERED/CYCLE ① X ② (LB) | ④ AMT. LOST/CYCLE ① - ③ (LB) |              |
|------------------------------|------------------------------|-------------------|-----------------------------------|------------------------------|--------------|
| WATER                        | .5                           | N/A               | N/A                               | .5                           |              |
| WATER LOSS (SPONGE DISPOSAL) | .0083                        | N/A               | N/A                               | .0083                        |              |
| Σ ① .5083                    |                              | Σ ④ .5083         |                                   |                              |              |
| TOTAL WT. MISSION            | 15                           | 20.5              | .5083                             | 156.3 + N/A                  | 70.9 (156.3) |
|                              | CYCLE/DAY                    | DAYS/MISSION      | TOTAL LOST/CYCLE (LB)             | KG (LB)                      |              |

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 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning  
 APPLIANCE FUNCTION Surface Wiping  
 APPLIANCE CONCEPT NO./TITLE 12/Sponges/Skylab Wetting Unit  
 INDEX NO. 3.1.1.12 REF. NO. 236,170

DESCRIPTION The sponges/Skylab wetting unit concept is identical to concept 11; however the Skylab wetting unit is used for sponge wetting/rinsing.









HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.2 Refuse Management

APPLIANCE FUNCTION 3.2.1 Manual Collection

NUMBER OF CONCEPTS CONSIDERED 3

#### ASSUMPTIONS

1. The manual collection of refuse utilizes crewman collection of refuse. The collection devices considered were bags and stationary containers.
2. The refuse mix used for the compressible/noncompressible refuse is summarized on the next page. The refuse mix was based on reference 203.
3. The total compressible and uncompressible refuse volume was divided by the volumetric capacity of the collection devices to obtain the total number of devices required for the missions.
4. The study assumed no compaction for the compressible trash collection devices. Reference material stated that 20 percent compressible was possible by manual compaction by the crewman. However, the conservative approach was taken by assuming no trash compaction because of the variety of collection devices presented the 20 percent might not always apply.
5. The weights and volumes of the refuse from all sources are summarized in Table C2-6.

D2-118561-3

TABLE B2-6

## SPACE STATION/SHUTTLE REFUSE SUMMARY

|                                  | SPACE<br>STATION<br>(LBS)           | SHUTTLE<br>(LBS) | SPACE<br>STATION<br>(FT <sup>3</sup> ) | SHUTTLE<br>(FT <sup>3</sup> ) |        |
|----------------------------------|-------------------------------------|------------------|----------------------------------------|-------------------------------|--------|
| <u>COMPRESSIBLE</u>              |                                     |                  |                                        |                               |        |
| TRASH                            | Health & Safety                     | 11.10            | 1.296                                  | 11.59                         | .372   |
|                                  | Crew Quarters                       | 120.62           | 115.4                                  | 128.7                         | 2.39   |
|                                  | Food/Drink                          | 566.2            | 32.93                                  | 13.08                         | .993   |
|                                  | Crew Hygiene                        | 171.32           | 107.58                                 | 129.36                        | 2.48   |
|                                  | ECS                                 | 0                | 0                                      | 0                             | 0      |
|                                  | RCS                                 | 0                | 0                                      | 0                             | 0      |
|                                  | Power                               | 0                | 0                                      | 0                             | 0      |
|                                  | Structural Maintenance              | 21.15            | .236                                   | .281                          | .030   |
|                                  | Communications                      | 0                | 0                                      | 0                             | 0      |
|                                  | Data Collection                     | .25              | 0                                      | .006                          | 0      |
| <u>COMPRESSIBLE REFUSE TOTAL</u> |                                     |                  |                                        |                               |        |
|                                  | 890.64                              | 257.44           | 283.02                                 | 6.265                         |        |
| <u>NONCOMPRESSIBLE</u>           |                                     |                  |                                        |                               |        |
| BAGS                             | Health & Safety                     | 0                | 0                                      | 0                             | 0      |
|                                  | Crew Quarters                       | 0                | 0                                      | 0                             | 0      |
|                                  | Food/Drink                          | 0                | 0                                      | 0                             | 0      |
|                                  | Crew Hygiene                        | 0                | 0                                      | 0                             | 0      |
|                                  | ECS                                 | 0                | 0                                      | 0                             | 0      |
|                                  | RCS                                 | 0                | 0                                      | 0                             | 0      |
|                                  | Power                               | 0                | 0                                      | 0                             | 0      |
|                                  | Structural Maintenance              | 0                | 0                                      | 0                             | 0      |
|                                  | Communications                      | 0                | 0                                      | 0                             | 0      |
|                                  | <u>NONCOMPRESSIBLE REFUSE TOTAL</u> |                  |                                        |                               |        |
|                                  | 0                                   | 0                | 0                                      | 0                             |        |
| <u>COMPRESSIBLE</u>              |                                     |                  |                                        |                               |        |
| DISPOSAL                         | Health & Safety                     | 144.0            | 10.80                                  | 5.14                          | .386   |
|                                  | Crew Quarters                       | 0                | 0                                      | 0                             | 0      |
|                                  | Food/Drink                          | 3975.56          | 314.12                                 | 158.37                        | 12.237 |
|                                  | Crew Hygiene                        | 61.42            | 2.67                                   | 3.64                          | .095   |
|                                  | ECS                                 | 36.98            | 6.95                                   | .57                           | .43    |
|                                  | RCS                                 | 1.75             | 0                                      | .04                           | 0      |
|                                  | Power                               | 0                | 0                                      | 0                             | 0      |
|                                  | Structural Maintenance              | 0                | 0                                      | 0                             | 0      |
|                                  | Communications                      | 0                | 0                                      | 0                             | 0      |
|                                  | <u>COMPRESSIBLE REFUSE TOTAL</u>    |                  |                                        |                               |        |
|                                  | 4219.71                             | 334.54           | 167.76                                 | 13.15                         |        |
| <u>NONCOMPRESSIBLE</u>           |                                     |                  |                                        |                               |        |
| BAGS                             | Health & Safety                     | 0                | 0                                      | 0                             | 0      |
|                                  | Crew Quarters                       | 0                | 0                                      | 0                             | 0      |
|                                  | Food/Drink                          | 0                | 0                                      | 0                             | 0      |
|                                  | Crew Hygiene                        | 11.38            | .39                                    | .72                           | .002   |
|                                  | ECS                                 | 26.17            | 0                                      | .14                           | 0      |
|                                  | RCS                                 | 207.03           | 0                                      | 13.43                         | 0      |
|                                  | Power                               | 55.16            | 0                                      | .730                          | 0      |
|                                  | Structural Maintenance              | 51.25            | 0                                      | .206                          | 0      |
|                                  | Communications                      | 96.998           | 0                                      | 1.82                          | 0      |
|                                  | Data Collection                     | 8.31             | 0                                      | .078                          | 0      |
| <u>NONCOMPRESSIBLE</u>           |                                     |                  |                                        |                               |        |
|                                  | 456.30                              | .39              | 17.12                                  | .002                          |        |

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.2.1 \*\*\* MANUAL REFUSE COLLECTION (SHUTTLE)

| CONCEPT NO. | USAGE TIME   | CONSUMABLES AND FLOW REQUIREMENTS |             |                                 |           | THERMAL REQHTS          |                          | ELEC PWR REQHTS              |                              | WT/VOL REQHTS      |                     | DEVELOPMENT COST | RESUPPLY WEIGHT |                         |
|-------------|--------------|-----------------------------------|-------------|---------------------------------|-----------|-------------------------|--------------------------|------------------------------|------------------------------|--------------------|---------------------|------------------|-----------------|-------------------------|
|             |              | USES/DAY<br>HRS/USE               | TYPE<br>(*) | AHT. USED<br>KG/USE<br>(LB/USE) | FLOW<br>* | PRESS<br>MMHG<br>(PSIG) | TEMP<br>DEG C<br>(DEG F) | COOLANT<br>WATTS<br>(BTU/HR) | HT LEAK<br>WATTS<br>(BTU/HR) | PK PWR<br>AC<br>DC | AVG PWR<br>AC<br>DC |                  |                 | WEIGHT<br>-KG-<br>(LBS) |
| 1           | .000<br>.000 |                                   |             |                                 |           |                         | 0.<br>( 0.)              | 0.<br>( 0.)                  | 0<br>0                       | 0<br>0             | 6.6<br>( 14.6)      | .09<br>( 3.05)   | 1<br>( 0)       | 0<br>( 0)               |
| 2           | .000<br>.000 |                                   |             |                                 |           |                         | 0.<br>( 0.)              | 0.<br>( 0.)                  | 0<br>0                       | 0<br>0             | 10.3<br>( 22.8)     | .19<br>( 6.83)   | 1<br>( 0)       | 0<br>( 0)               |
| 3           | .000<br>.000 |                                   |             |                                 |           |                         | 0.<br>( 0.)              | 0.<br>( 0.)                  | 0<br>0                       | 0<br>0             | 7.3<br>( 16.1)      | .07<br>( 2.39)   | 1<br>( 0)       | 0<br>( 0)               |

APPLIANCE CONCEPT

| CONCEPT NO. | CONCEPT NAME                 | (*)                                                           |
|-------------|------------------------------|---------------------------------------------------------------|
| 1           | DISPOSABLE TRASH BAG         | 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT <sup>3</sup> /MIN) |
| 2           | REUSABLE WASTE RECEPTICLES   | 2 - CABIN AIR (LOST), KG/HR (LB/HR)                           |
| 3           | DISPOSABLE WASTE RECEPTICLES | 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

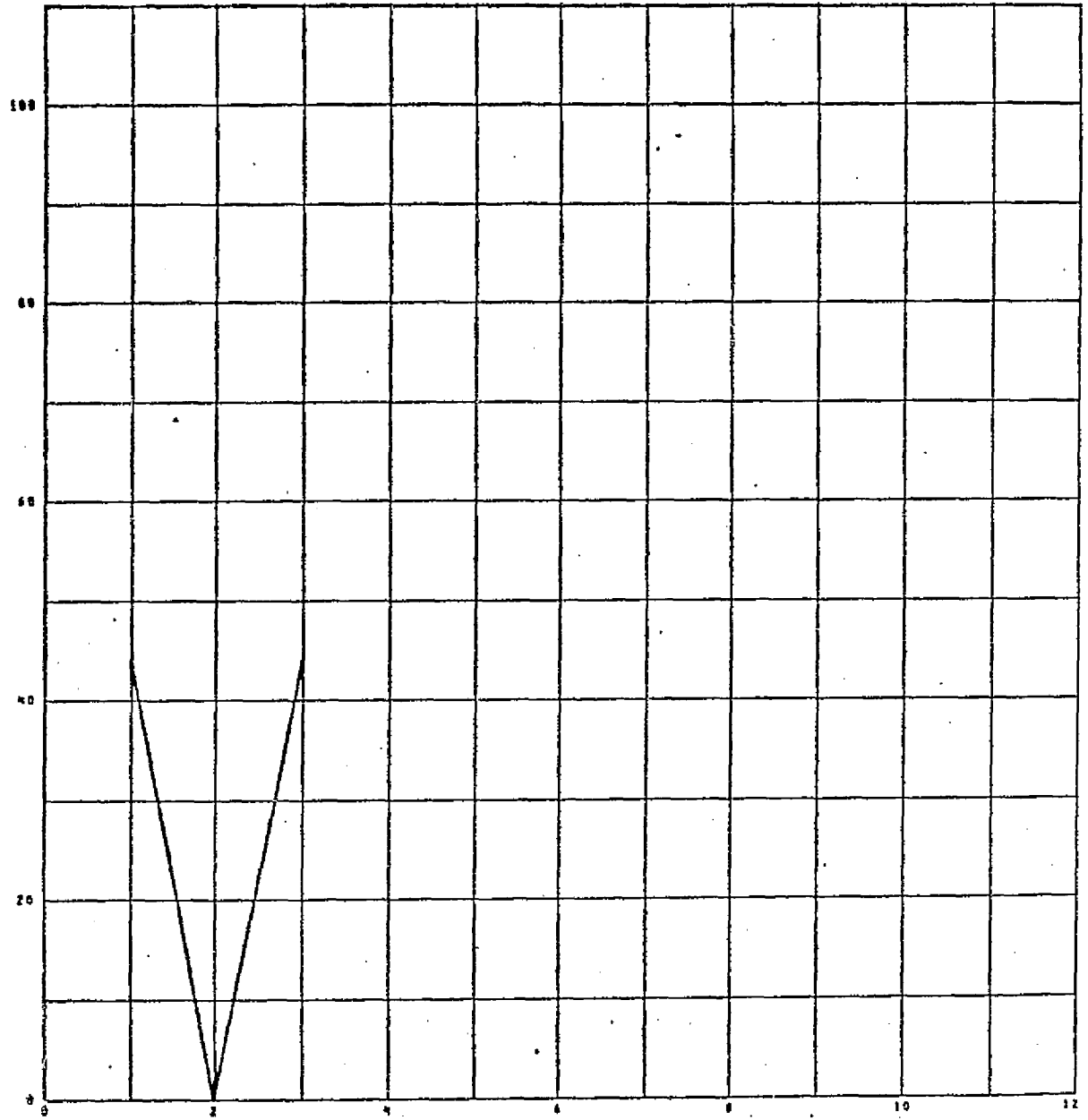
(\*\*\*)COST INDICATOR

- |                               |         |
|-------------------------------|---------|
| (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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OF POOR QUALITY

| APPLIANCE<br>CONCEPT |   | CONCEPT NAME                 |
|----------------------|---|------------------------------|
| NO.                  |   |                              |
| 1                    | = | DISPOSABLE TRASH BAG         |
| 2                    | = | REUSABLE WASTE RECEPTICLES   |
| 3                    | = | DISPOSABLE WASTE RECEPTICLES |

C O N C E P T N A M E  
 B A S E D  
 O N  
 1 9 8 2



CONCEPT NUMBER

Manual Refuse Collection (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 \* \* \* \* \* MANUAL REFUSE COLLECTION (SHUTTLE)  
 (12/15/74)

| FACTOR   | MIN<br>VALUE | MAX<br>VALUE | PTS | C O N C E P T |     |       |
|----------|--------------|--------------|-----|---------------|-----|-------|
|          |              |              |     | 1             | 2   | 3     |
| WEIGHT   | 14.600       | 22.800       | 15  | 5.39          | .00 | 4.39  |
| VOLUME   | 2.3900       | 6.8300       | 10  | 5.53          | .00 | 6.50  |
| TOTAL PT | .00000       | 25.000       | 25  | 10.93         | .00 | 10.90 |
| RATING   | .00000       | 100.00       | 100 | 43.72         | .00 | 43.58 |

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S E N S I T I V I T Y   A N A L Y S I S

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

|        | C O N C E P T |     |       |
|--------|---------------|-----|-------|
|        | 1             | 2   | 3     |
| NORMAL | 43.72         | .00 | 43.58 |
| WEIGHT | 41.93         | .00 | 40.29 |
| VOLUME | 45.65         | .00 | 47.15 |

S E N S I T I V I T Y   A N A L Y S I S

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

|        | C O N C E P T |     |       |
|--------|---------------|-----|-------|
|        | 1             | 2   | 3     |
| NORMAL | 43.72         | .00 | 43.58 |
| WEIGHT | 47.04         | .00 | 47.70 |
| VOLUME | 40.81         | .00 | 38.23 |

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.1-REFUSE/MANUAL COLLECTION

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

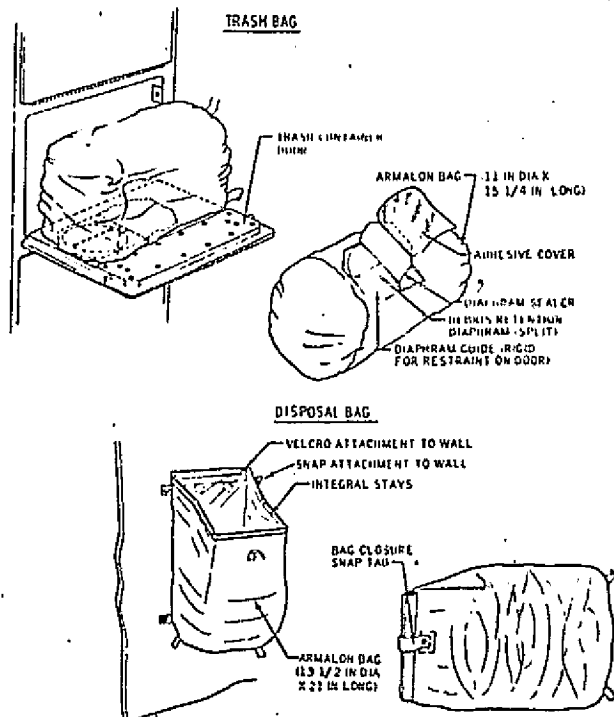
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SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Manual CollectionAPPLIANCE CONCEPT NO./TITLE 1/Waste/Trash BagsINDEX NO. 3.2.1.1REF. NO. 283,203,170,297

DESCRIPTION The waste/trash bags concept employs trash bags and disposable bags for refuse collection. This concept uses the bag concept used on Skylab. The trash containers are mounted on the back side of collector doors. The collector areas are located in the food management, personal hygiene, and other areas where significant amount of bulk refuse is generated. The study assumed 15 collectors for Space Station and 3 collectors for Shuttle. Trash entry into the bag is through the front of the collection door through a slit in the bag. The refuse collection was based on its uncompressed volume. Disposable bags were applied for incompressible trash. The disposable bags are held during use by snaps located at various locations throughout the vehicle. Both types of bags have bag closure devices to seal the bag after filling.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT WASTE/TRASH BAGS

INDEX NUMBER 3.2.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT         | (REF) | WEIGHT (LBS) | VOLUME (FT <sup>3</sup> ) |
|-------------------|-------|--------------|---------------------------|
| COLLECTION DEVICE | (283) | 3.0          | 2.72                      |
| TRASH BAGS        |       | 5.6          | .15                       |
| DISPOSABLE BAGS   |       | 6.1          | .18                       |
| TOTAL             |       | 6.668 (14.7) | .086 (3.05)               |

KG (LBS) M<sup>3</sup> (FT<sup>3</sup>)

SOLID EXPENDABLE W/VOL REQUIREMENTS

| TYPE            | ① UNITS/CYCLE (REF) | ② WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB) | ③ WT/CYCLE DAY (LB) | ④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT <sup>3</sup> ) | ⑤ VOL/CYCLE DAY (FT <sup>3</sup> ) |
|-----------------|---------------------|-----------------------------------------|---------------------|---------------------------------------------------------|------------------------------------|
|                 |                     |                                         |                     |                                                         |                                    |
| TRASH BAGS      | .39                 | .7 (MeDac)                              | .273                | .0185 (MeDac)                                           | .0072                              |
| DISPOSABLE BAGS | .39                 | .75 (MeDac)                             | .293                | .0224 (MeDac)                                           | .0087                              |
| $\Sigma$ ③      |                     |                                         | .566                | $\Sigma$ ⑤                                              |                                    |
|                 |                     |                                         | TOTAL WT/CYCLE (LB) | TOTAL VOL/CYCLE (FT <sup>3</sup> )                      |                                    |

TOTAL WT. MISSION =  $\frac{N/A}{CYCLES/DAY} \times \frac{20.5}{DAYS/MISSION} \times \frac{.566}{TOT. WT/CYCLE (LB)} = 5.26 (11.6)$  KG (LB)

TOTAL VOL. MISSION =  $\frac{N/A}{CYCLES/DAY} \times \frac{20.5}{DAYS/MISSION} \times \frac{.0159}{TOT. VOL/CYCLE (FT^3)} = .0092 (.326)$  M<sup>3</sup> (FT<sup>3</sup>)

GAS/LIQUID EXPENDABLES REQUIREMENTS

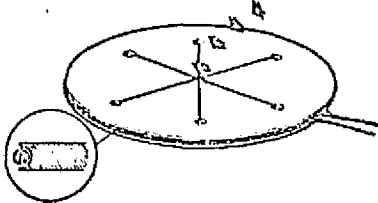
| TYPE       | ① AMT. USED/CYCLE (REF) (LB) | ② RECOVERY FACTOR | ③ AMT. RECOVERED/CYCLE (LB) | ④ AMT. LOST/CYCLE (LB) |
|------------|------------------------------|-------------------|-----------------------------|------------------------|
|            |                              |             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

TOTAL WT. MISSION =  $\frac{CYCLE/DAY}{DAYS/MISSION} \times \frac{TOTAL LOST/CYCLE (LB)}{X ④} + \dots$  KG (LB)

SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Manual CollectionAPPLIANCE CONCEPT NO./TITLE 2/Waste Receptacles/ReusableINDEX NO. 3.2.1.2REF. NO. 170,160

DESCRIPTION The waste receptacles/reusable concept utilizes aluminum rigid trash containers with tops with perforated slits. Replaceable plastic liner bags are used for refuse transport. The containers are held to structure with steel spring-finger retainer strategically placed throughout the vehicle. The number of containers used for space station were 30 and 6 for Shuttle. The number of containers was based on the fact the collectors are at fixed locations within the vehicles. The same container was used for compressible and uncompressible refuse. The number of plastic liners provided for the concept were based on the refuse volume. The plastic liners were assumed to be changed every 5 days based on volume of .68 FT<sup>3</sup>/collector (15 liners/5 days for Space Station, .634 liners/5 days for Shuttle). The liner volume was assumed to be .27 FT<sup>3</sup> less than container volume to allow for positive closure.

COLLECTION/RETENTION DEVICE



- Perforated slit in disc permit center pressure to deflect providing unidirectional waste ingress
- Plastic disk molded or inserted into throes of flexible bag
- Suitable using concept fastens disc to bag
- Suitable for porous, sterile, chemically inert wastes

LOCAL WASTE COLLECTOR



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT 2/WASTE RECEPTACLES/REUSABLE

INDEX NUMBER 3.2.1.2

ELECTRICAL POWER REQUIREMENTS

| COMPONENT  | (REF) | A C P O W E R                    |                        |                           |                                               | D C P O W E R          |                           | (7)<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① x ② |
|------------|-------|----------------------------------|------------------------|---------------------------|-----------------------------------------------|------------------------|---------------------------|-----------------------------------------------|
|            |       | (1)<br>USE TIME<br>CYCLE<br>(HR) | (2)<br>PEAK<br>(WATTS) | (3)<br>AVERAGE<br>(WATTS) | (4)<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① x ③ | (5)<br>PEAK<br>(WATTS) | (6)<br>AVERAGE<br>(WATTS) |                                               |
| <u>N/A</u> |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  |                        |                           |                                               |                        |                           |                                               |
|            |       |                                  | MAXIMUM                |                           | TOTAL                                         | MAXIMUM                |                           | TOTAL                                         |

THERMAL REQUIREMENTS

| SOURCE     | LATENT<br>(BTU/HR) | SENSIBLE<br>(BTU/HR) | HEAT LEAK<br>(BTU/HR) | TO COOLANT<br>(BTU/HR) |
|------------|--------------------|----------------------|-----------------------|------------------------|
| <u>N/A</u> |                    |                      |                       |                        |
|            |                    |                      |                       |                        |
|            |                    |                      |                       |                        |
|            |                    |                      |                       |                        |
| TOTAL      | WATT (BTU/HR)      | WATT (BTU/HR)        | WATT (BTU/HR)         | WATT (BTU/HR)          |

OPERATIONAL PENALTIES

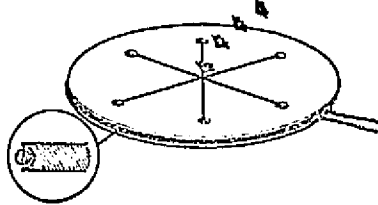
| SOURCE     | THERMAL<br>HEAT LEAK<br>(BTU/HR/CYCLE) | THERMAL<br>TO COOLANT<br>(BTU/HR/CYCLE) | ELECTRICAL<br>(PK WATTS/CYCLE) | WEIGHT<br>(LB/MISSION)     | VOLUME<br>(FT <sup>3</sup> /MISSION)                  |
|------------|----------------------------------------|-----------------------------------------|--------------------------------|----------------------------|-------------------------------------------------------|
| <u>N/A</u> |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
| TOTAL      | WATTS/CYCLE<br>(BTU/HR/CYCLE)          | WATTS/CYCLE<br>(BTU/HR/CYCLE)           |                                | KG/MISSION<br>(LB/MISSION) | M <sup>3</sup> /MISSION<br>(FT <sup>3</sup> /MISSION) |



SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Manual CollectionAPPLIANCE CONCEPT NO./TITLE 3/Waste Receptacles/DisposableINDEX NO. 3.2.1.3REF. NO. 170,160

DESCRIPTION The waste receptacles/disposable concept is identical to concept 2 using disposable plastic containers. Plastic liners were not used since the disposable container provides the means of refuse transport. The disposable plastic collectors are held to the structure with plastic spring-finger retainers. The spring retainers are strategically located throughout the vehicles (30 for Space Station; 6 for Shuttle). The number of plastic collectors were based on the trash volume (2.16 per day for Space Station; .83 per day for Shuttle) based on .95 FT<sup>3</sup>/collector. The storage volume of the containers was based on a stacked configuration, i.e. like paper cup storage.

COLLECTION/RETENTION DEVICE



- Perforated slots in disc permit easier passage to debris-providing multidirectional waste ingress
- Plastic disk molded or inserted into throat of flexible bag
- Collapsible tying concept fastens disc to bag
- Suitable for antibiotic, sterile, chemically inert wastes

LOCAL WASTE COLLECTOR









HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.2 Refuse Management

APPLIANCE FUNCTION 3.2.2 Vacuum Collection

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

1. The vacuum collection of refuse utilizes various types of vacuum cleaners to assist in cleaning of the vehicles. A central vacuum system was not considered because sizing of the unit is dependent on the detailed vehicle configuration. The configuration was not defined well enough to size a representative system for trade purposes, therefore only hand held units were considered for the study.
2. The vacuum usage was based on 24.5 minutes per day. This was based on the following rationale.

(1 use/day) 8.5 minutes/day (1 hr/week)-general cleanup

(3 uses/day) 6.0 minutes/day (2 min/meal)-meal cleanup

(1 use/day) 10.0 minutes/day - emergency cleanup

24.5 minutes per day (.408 hrs/day)

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.2.2 \*\*\* VACUUM REFUSE COLLECTION (SHUTTLE)

| CONCEPT NO. | USAGE TIME    | CONSUMABLES AND FLOW REQUIREMENTS |            |           |         | THERMAL REQHTS |          | ELEC PWR REQHTS |       | WT/VOL REQHTS |         | DEVELOPMENT COST | RE SUPPLY |
|-------------|---------------|-----------------------------------|------------|-----------|---------|----------------|----------|-----------------|-------|---------------|---------|------------------|-----------|
|             |               | AMT. USED                         | FLOW       | PRESS     | TEMP    | COOLANT        | HT LEAK  | AC              | AC    | WEIGHT        | VOLUME  |                  |           |
|             |               | (*) KG/USE                        | (*)        | (PSIG)    | (DEG F) | (BTU/HR)       | (BTU/HR) | DC              | DC    | (KG)          | (CU FT) | (**)             | (***)     |
|             |               | (LB/USE)                          | (*)        |           |         |                |          | WATTS           | WATTS | (LBS)         |         |                  | (LBS)     |
| 1           | 5.000<br>.082 |                                   |            |           |         | 0              | 77       | 0               | 0     | 13.8          | .02     | 1                | 5         |
|             |               |                                   |            |           |         | ( 0 )          | ( 262 )  | 115.0           | 0     | ( 30.4 )      | ( .79 ) |                  | ( .01 )   |
| 2           | 5.000<br>.082 |                                   |            |           |         | 0              | 160      | 240.0           | 0     | 4.6           | .01     | 1                | 20        |
|             |               |                                   |            |           |         | ( 0 )          | ( 546 )  | 0               | 0     | ( 10.0 )      | ( .30 ) |                  | ( .10 )   |
| 3           | 5.000<br>.082 | 3                                 | .6214      | 4.54      | 0       | 21.1           | 0        | 0               | 0     | 66.9          | .01     | 1                | 25        |
|             |               |                                   | ( 1.3700 ) | ( 10.00 ) | ( .0 )  | ( 70.0 )       | ( 0 )    | ( 0 )           | 0     | ( 147.5 )     | ( .19 ) |                  | ( .0 )    |

APPLIANCE CONCEPT

| NO. | CONCEPT NAME                   |
|-----|--------------------------------|
| 1   | VACUUM CLEANER (SKYLAB)        |
| 2   | VACUUM CLEANER (COMMERCIAL)    |
| 3   | VACUUM CLEANER-VENTED TO SPACE |

(\*)

|   |               |               |                                   |
|---|---------------|---------------|-----------------------------------|
| 1 | CABIN AIR     | (CIRCULATED), | LITERS/SEC (FT <sup>3</sup> /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)                   |

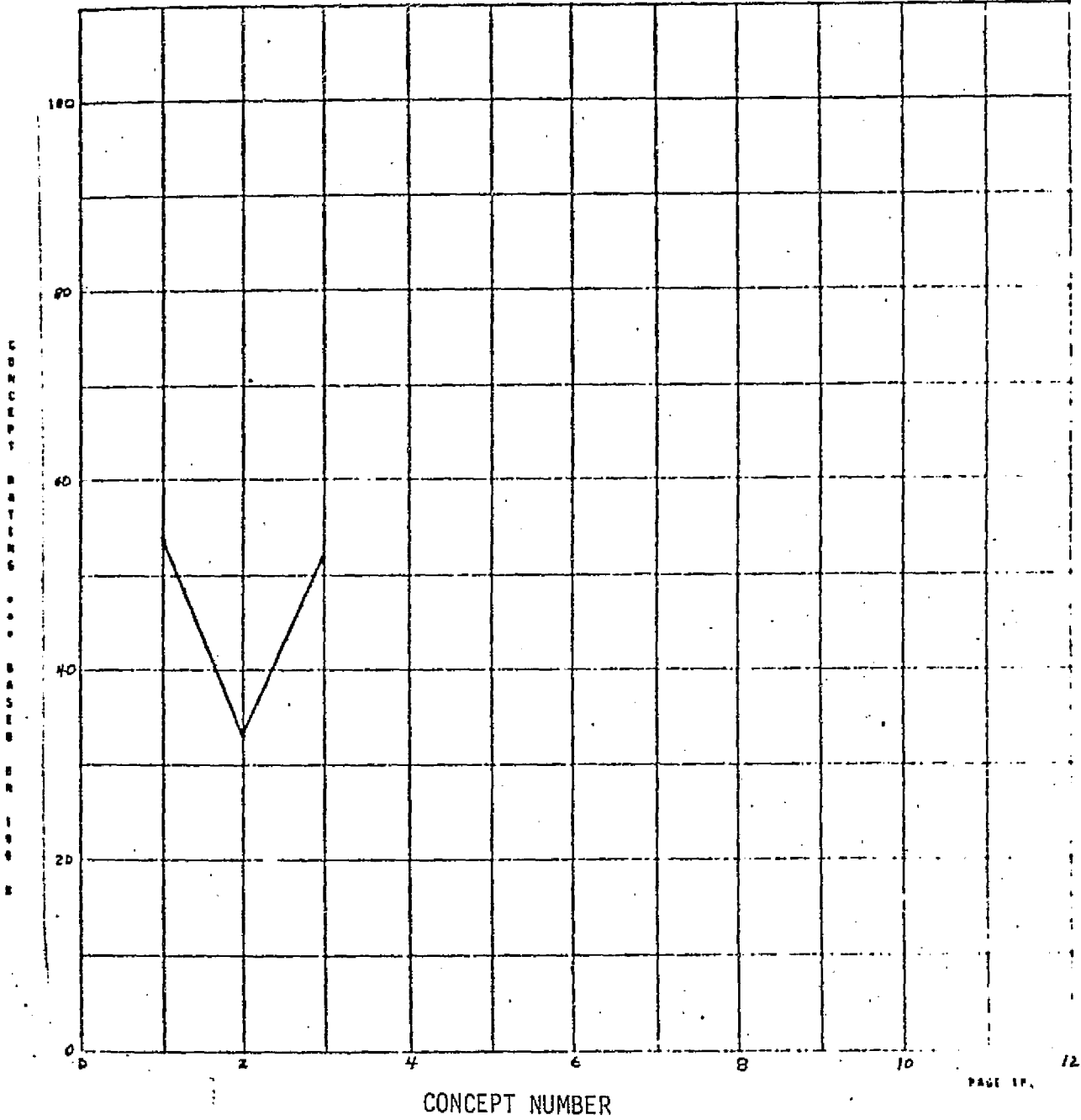
| (**) | AVAILABLE                 | (***) | COST INDICATOR |
|------|---------------------------|-------|----------------|
| (1)  | AVAILABLE                 |       | 0-25%          |
| (2)  | STATE OF THE ART          |       | 25-50%         |
| (3)  | SOME DEVELOPMENT REQUIRED |       | 50-75% 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

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| APPLIANCE<br>CONCEPT<br>NO. | CONCEPT NAME                   |
|-----------------------------|--------------------------------|
| 1                           | VACUUM CLEANER (SKYLAB)        |
| 2                           | VACUUM CLEANER (COMMERCIAL)    |
| 3                           | VACUUM CLEANER-VENTED TO SPACE |



CONCEPT NUMBER

Vacuum Refuse Collection (Shuttle)  
Concept Trade

NUMBER OF DAYS = 20.5 ( .06 YEARS)  
 USES MOD SUBROUTINE 33  
 THERMAL PENALTY = DIRECT TO COOLANT (LB/BTUH) .0250  
 THERMAL PENALTY = CABIN HEAT LEAK (LB/BTUH) .0550  
 POWER PENALTY (LB5/WATT) TYPE 1 .5300  
 POWER PENALTY (LB5/WATT) TYPE 2 .4300

SELECTION MATRIX \* \* \* \* \* VACUUM REFUSE COLLECTION (SHUTTLE)  
 (01/19/75)

| FACTOR   | MIN. VALUE | MAX. VALUE | PTS | C O N C E P T |       |       |
|----------|------------|------------|-----|---------------|-------|-------|
|          |            |            |     | 1             | 2     | 3     |
| WEIGHT   | 10.040     | 147.54     | 15  | 11.91         | 13.98 | .00   |
| POWER    | .00000     | 127.20     | 15  | 9.17          | .00   | 15.00 |
| VOLUME   | .19000     | .79000     | 10  | .00           | 6.20  | 7.59  |
| THERMAL  | .00000     | 30.030     | 15  | 7.80          | .00   | 15.00 |
| RELIAB-Y | .99986     | .99994     | 5   | .00           | .00   | 2.98  |
| MAINTENC | .99999     | 1.00000    | 5   | .00           | .00   | 3.65  |
| SAFETY   | .00000     | 1.00000    | 5   | 5.00          | 5.00  | .00   |
| DEV COST | 5.00000    | 25.000     | 15  | 12.00         | 3.00  | .00   |
| TOTAL PT | .00000     | 85.000     | 85  | 45.88         | 28.18 | 44.23 |
| RATING   | .00000     | 100.00     | 100 | 53.98         | 33.16 | 52.03 |

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SENSITIVITY ANALYSIS

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

|          | C O N C E P T |       |       |
|----------|---------------|-------|-------|
|          | 1             | 2     | 3     |
| NORMAL   | 53.98         | 33.16 | 52.03 |
| WEIGHT   | 56.04         | 38.02 | 47.81 |
| POWER    | 54.56         | 30.47 | 55.92 |
| VOLUME   | 50.98         | 34.76 | 53.56 |
| THERMAL  | 53.82         | 30.47 | 55.92 |
| RELIAB-Y | 52.43         | 32.21 | 52.25 |
| MAINTENC | 52.43         | 32.21 | 52.63 |
| SAFETY   | 55.29         | 35.06 | 50.54 |
| DEV COST | 56.09         | 32.09 | 47.81 |

SENSITIVITY ANALYSIS

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

|          | C O N C E P T |       |       |
|----------|---------------|-------|-------|
|          | 1             | 2     | 3     |
| NORMAL   | 53.98         | 33.16 | 52.03 |
| WEIGHT   | 51.52         | 27.34 | 57.07 |
| POWER    | 53.28         | 36.36 | 47.39 |
| VOLUME   | 57.35         | 31.35 | 50.54 |
| THERMAL  | 54.17         | 36.36 | 47.39 |
| RELIAB-Y | 55.61         | 34.16 | 51.80 |
| MAINTENC | 55.61         | 34.16 | 51.40 |
| SAFETY   | 52.58         | 31.13 | 53.61 |
| DEV COST | 51.46         | 34.43 | 57.07 |

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.2-REFUSE/VACUUM COLLECTION

| COMPONENT TYPE<br>APPLIANCE TYPE     | NUMBER OF COMPONENTS |         |                   |          |               |                   |               |                   |                  |   |   |   |   |   |   |   | NUMBER OF SAFETY CRITICAL ITEMS |
|--------------------------------------|----------------------|---------|-------------------|----------|---------------|-------------------|---------------|-------------------|------------------|---|---|---|---|---|---|---|---------------------------------|
|                                      | NO.                  | ① MOTOR | ② BLOWER (VACUUM) | ③ FILTER | ④ ACCUMULATOR | ⑤ WATER SEPARATOR | ⑥ CHECK VALVE | ⑦ ELECTRIC SWITCH | ⑧ SOLENOID VALVE | ○ | ○ | ○ | ○ | ○ | ○ | ○ |                                 |
| PORTABLE VACUUM CLEANER (SKYLAB)     |                      | 1       | 1                 | 1        | 1             | 1                 | 1             | 1                 | -                |   |   |   |   |   |   |   | 0                               |
| PORTABLE VACUUM CLEANER (COMMERCIAL) |                      | 1       | 1                 | 1        | 1             | 1                 | 1             | 1                 | -                |   |   |   |   |   |   |   | 0                               |
| VACUUM CLEANER VENTING TO SPACE      |                      | -       | -                 | 1        | 1             | -                 | 1             | 1                 | 1                |   |   |   |   |   |   |   | 1                               |

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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

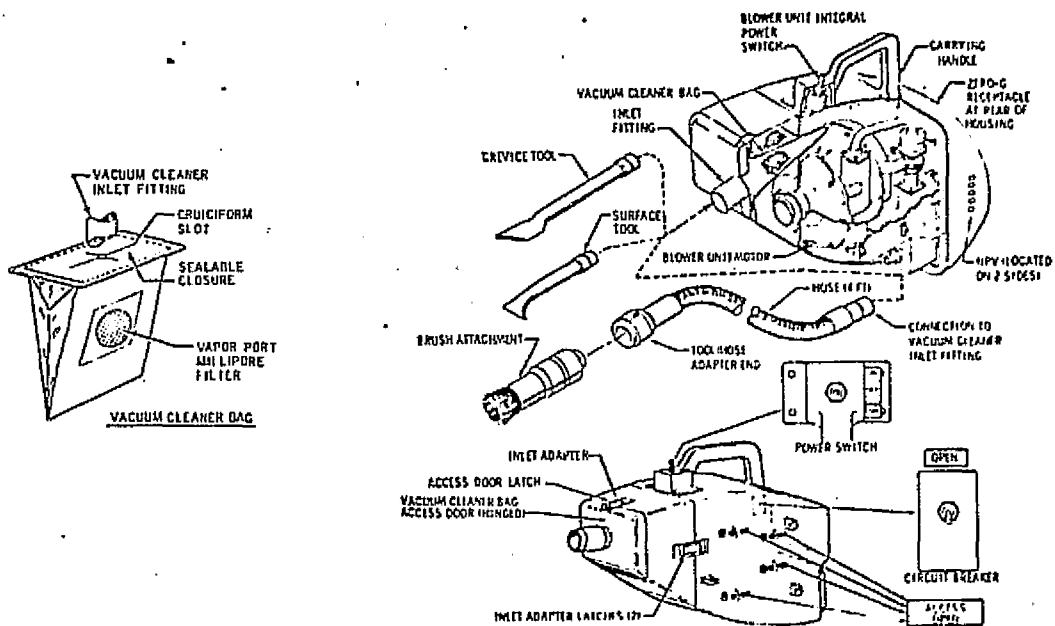
APPLIANCE FUNCTION Vacuum Collection

APPLIANCE CONCEPT NO./TITLE 1/Portable Vacuum/Electric (Skylab)

INDEX NO. 3.2.2.1

REF. NO. McDac, 297,283

DESCRIPTION The portable vacuum/electric is identical to the vacuum used on Skylab. The vacuum has a hose and pickup attachments to assist in vacuum pickup. The unit has a strap and handle for carrying/using the unit. Vacuum cleaner bags were assumed to require changing once per week (.142 cycles per day).



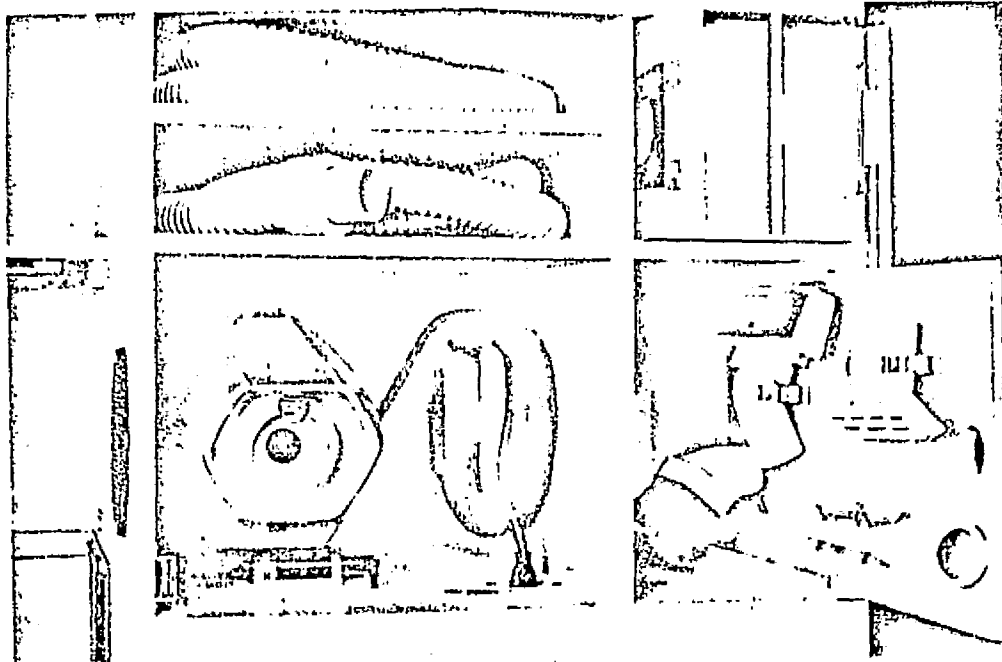






SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Vacuum CollectionAPPLIANCE CONCEPT NO./TITLE 2/Portable Vacuum/Electric (Commercial)INDEX NO. 3.2.2.2REF. NO. 170

DESCRIPTION The portable vacuum/electric (commercial) concept is the same as concept 1 except the unit is made of plastic and is a commercial unit operating on AC power. The unit is lighter than the concept 1 version, therefore was presented for the purposes of trade. The unit would require considerable development and was penalized for its development cost. The vacuum cleaner bags are identical to concept 1 and are replaced at the same frequency.







SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management  
APPLIANCE FUNCTION Vacuum Collection  
APPLIANCE CONCEPT NO./TITLE 3/Portable Vacuum/Space Venting  
INDEX NO. 3.2.2.3 REF. NO. 1022

DESCRIPTION The portable vacuum/space venting concept uses a vacuum unit vented to space. A maximum 14.7 psi delta pressure is available, however the filter required will reduce the possible suction at the pickup nozzle. The concept was tried on Apollo, but did not provide enough suction. Proper design of the hose and penetration in the vehicle shell can make this unit operational. The collection bag used in concepts 1 and 2 serves as the filter and refuse trap. The flow used was based on the concept 1; 10 CFM. Venting overboard is allowed, since the vented gas is filtered and clean.



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)  
 CONCEPT 3/PORTABLE VACUUM/SPACE VENTING

INDEX NUMBER 3.2.2.3

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT (REF)                                       | WEIGHT (LBS)                    | VOLUME (FT <sup>3</sup> )                               |
|-------------------------------------------------------|---------------------------------|---------------------------------------------------------|
| VACUUM UNIT (170)<br>(INCLUDES HOSES AND ATTACHMENTS) | 7.0                             | .175                                                    |
| VACUUM CLEANER BAGS                                   | .099                            | .009                                                    |
| TOTAL                                                 | <b>3.197 (7.05)</b><br>KG (LBS) | <b>.075 (1.84)</b><br>M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE WT/VOL REQUIREMENTS

| TYPE                | ① UNITS/CYCLE (REF) | ② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB) | ③ WT/CYCLE ① x ② (LB)                          | ④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> ) | ⑤ VOL/CYCLE ① x ④ (FT <sup>3</sup> ) |
|---------------------|---------------------|-------------------------------------------|------------------------------------------------|-----------------------------------------------------------|--------------------------------------|
| VACUUM CLEANER BAGS | 1                   | .017 (170)                                | .017                                           | .003067 (170)                                             | .003067                              |
| Σ ③                 |                     |                                           | .017<br>TOTAL WT/CYCLE (LB)                    | Σ ⑤<br>.003067<br>TOTAL VOL/CYCLE (FT <sup>3</sup> )      |                                      |
| TOTAL WT. MISSION   | .142<br>CYCLES/DAY  | x 20.5<br>DAYS/MISSION                    | x .017<br>TOT. WT/CYCLE (LB)                   | .022 (0.99)<br>KG (LB)                                    |                                      |
| TOTAL VOL. MISSION  | .142<br>CYCLES/DAY  | x 20.5<br>DAYS/MISSION                    | x .003067<br>TOT. VOL/CYCLE (FT <sup>3</sup> ) | .00025 (0.009)<br>M <sup>3</sup> (FT <sup>3</sup> )       |                                      |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE              | ① AMT. USED/CYCLE (REF) (LB) | ② RECOVERY FACTOR      | ③ AMT. RECOVERED/CYCLE ① x ② (LB)     | ④ AMT. LOST/CYCLE ① - ③ (LB) |                         |
|-------------------|------------------------------|------------------------|---------------------------------------|------------------------------|-------------------------|
| OXYGEN            | 1.37                         | N/A                    | N/A                                   | 1.37                         |                         |
| Σ ①               |                              |                        |                                       | Σ ④ 1.37                     |                         |
| TOTAL WT. MISSION | 5<br>CYCLE/DAY               | x 20.5<br>DAYS/MISSION | x 1.37<br>TOTAL LOST/CYCLE (LB) (Σ ④) | .140.5 + N/A (LB) (Σ ①)      | 63.7 (140.5)<br>KG (LB) |



HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.2 Refuse Management

APPLIANCE FUNCTION 3.2.4 Refuse Processing

NUMBER OF CONCEPTS CONSIDERED 12

#### ASSUMPTIONS

1. The refuse processing of refuse utilizes, compaction, shredding, incineration, and decomposition methods for processing. The shredders were combined with other processing concepts, such as compactors to increase the efficiency of refuse volume reduction. Shredders were not considered as a separate method for trash processing since it actually increases the refuse volume and requires the aid of a compactor or incinerator for reducing refuse volume.
2. The refuse mix used for the compressible refuse volume is summarized on the next page.
3. The incineration and decomposition concepts 9 through 12 were considered only with shredders. Reference data indicates shredders are necessary to achieve efficient performance of these units.

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## TABLE

## SHUTTLE REFUSE SUMMARY

|          |                        | SPACE<br>STATION<br>(LBS)           | SHUTTLE<br>(LBS) | SPACE<br>STATION<br>(FT <sup>3</sup> ) | SHUTTLE<br>(FT <sup>3</sup> ) |              |
|----------|------------------------|-------------------------------------|------------------|----------------------------------------|-------------------------------|--------------|
|          | <u>COMPRESSIBLE</u>    |                                     |                  |                                        |                               |              |
| TRASH    | Health & Safety        | 11.10                               | 1.296            | 11.59                                  | .372                          |              |
|          | Crew Quarters          | 120.62                              | 115.4            | 128.7                                  | 2.39                          |              |
|          | Food/Drink             | 566.2                               | 32.93            | 13.08                                  | .993                          |              |
|          | Crew Hygiene           | 171.32                              | 107.58           | 129.36                                 | 2.48                          |              |
|          | ECS                    | 0                                   | 0                | 0                                      | 0                             |              |
|          | RCS                    | 0                                   | 0                | 0                                      | 0                             |              |
|          | Power                  | 0                                   | 0                | 0                                      | 0                             |              |
|          | Structural Maintenance | 21.15                               | .236             | .281                                   | .030                          |              |
|          | Communications         | 0                                   | 0                | 0                                      | 0                             |              |
|          | Data Collection        | .25                                 | 0                | .006                                   | 0                             |              |
|          |                        | <b>COMPRESSIBLE REFUSE TOTAL</b>    | <b>890.64</b>    | <b>257.44</b>                          | <b>283.02</b>                 | <b>6.265</b> |
|          | <u>NONCOMPRESSIBLE</u> |                                     |                  |                                        |                               |              |
| BAGS     | Health & Safety        | 0                                   | 0                | 0                                      | 0                             |              |
|          | Crew Quarters          | 0                                   | 0                | 0                                      | 0                             |              |
|          | Food/Drink             | 0                                   | 0                | 0                                      | 0                             |              |
|          | Crew Hygiene           | 0                                   | 0                | 0                                      | 0                             |              |
|          | ECS                    | 0                                   | 0                | 0                                      | 0                             |              |
|          | RCS                    | 0                                   | 0                | 0                                      | 0                             |              |
|          | Power                  | 0                                   | 0                | 0                                      | 0                             |              |
|          | Structural Maintenance | 0                                   | 0                | 0                                      | 0                             |              |
|          | Communications         | 0                                   | 0                | 0                                      | 0                             |              |
|          |                        | <b>NONCOMPRESSIBLE REFUSE TOTAL</b> | <b>0</b>         | <b>0</b>                               | <b>0</b>                      | <b>0</b>     |
|          | <u>COMPRESSIBLE</u>    |                                     |                  |                                        |                               |              |
| DISPOSAL | Health & Safety        | 144.0                               | 10.80            | 5.14                                   | .386                          |              |
|          | Crew Quarters          | 0                                   | 0                | 0                                      | 0                             |              |
|          | Food/Drink             | 3975.56                             | 314.12           | 158.37                                 | 12.237                        |              |
|          | Crew Hygiene           | 61.42                               | 2.67             | 3.64                                   | .095                          |              |
|          | ECS                    | 36.98                               | 6.95             | .57                                    | .43                           |              |
|          | RCS                    | 1.75                                | 0                | .04                                    | 0                             |              |
|          | Power                  | 0                                   | 0                | 0                                      | 0                             |              |
|          | Structural Maintenance | 0                                   | 0                | 0                                      | 0                             |              |
|          | Communications         | 0                                   | 0                | 0                                      | 0                             |              |
|          |                        | <b>COMPRESSIBLE REFUSE TOTAL</b>    | <b>4219.71</b>   | <b>334.54</b>                          | <b>167.76</b>                 | <b>13.15</b> |
|          |                        | <u>NONCOMPRESSIBLE</u>              |                  |                                        |                               |              |
| BAGS     | Health & Safety        | 0                                   | 0                | 0                                      | 0                             |              |
|          | Crew Quarters          | 0                                   | 0                | 0                                      | 0                             |              |
|          | Food/Drink             | 0                                   | 0                | 0                                      | 0                             |              |
|          | Crew Hygiene           | 11.38                               | .39              | .72                                    | .002                          |              |
|          | ECS                    | 26.17                               | 0                | .14                                    | 0                             |              |
|          | RCS                    | 207.03                              | 0                | 13.43                                  | 0                             |              |
|          | Power                  | 55.16                               | 0                | .730                                   | 0                             |              |
|          | Structural Maintenance | 51.25                               | 0                | .206                                   | 0                             |              |
|          | Communications         | 96.998                              | 0                | 1.82                                   | 0                             |              |
|          | Data Collection        | 8.31                                | 0                | .078                                   | 0                             |              |
|          | <b>NONCOMPRESSIBLE</b> | <b>456.30</b>                       | <b>.39</b>       | <b>17.12</b>                           | <b>.002</b>                   |              |

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3-2-4 \*\*\* REFUSE PROCESSING (SHUTTLE)

| CONCEPT NO. | USAGE TIME      | CONSUMABLES AND FLOW REQUIREMENTS |                   |                                   |                     | THERMAL REQHTS  |                 | ELEC PWR REQHTS     |                     | WT/VOL REQHTS      |                     | DEVELOPMENT COST |                   | RESUPPLY WEIGHT (LBS) |               |
|-------------|-----------------|-----------------------------------|-------------------|-----------------------------------|---------------------|-----------------|-----------------|---------------------|---------------------|--------------------|---------------------|------------------|-------------------|-----------------------|---------------|
|             |                 | USAGES/DAY<br>HRS/USE             | TYPE              | AMT. USED<br>(KG/USE)<br>(LB/USE) | FLOW                | PRESS<br>(PSIG) | TEMP<br>(DEG F) | COOLANT<br>(BTU/HR) | HT LEAK<br>(BTU/HR) | PK PWR<br>AC<br>DC | AVG PWR<br>AC<br>DC | WEIGHT<br>(LBS)  | VOLUME<br>(CU FT) |                       | AVAIL<br>(**) |
| 1           | 2-010<br>.017   | 1                                 | .0000<br>(.0000)  | .00                               | 1810.0<br>(35.0)    | 21.1<br>(70.0)  | 0.              | 0.                  | .0                  | .0                 | 35.0<br>(77.2)      | .08<br>(.300)    | 2                 | 30                    | .0<br>(.0)    |
| 2           | 2-010<br>.017   | 2                                 | .0163<br>(.0360)  | .00                               | .0<br>(.0)          | .0<br>(.0)      | 0.              | 0.                  | .0                  | .0                 | 36.4<br>(80.3)      | .09<br>(.320)    | 2                 | 30                    | .0<br>(.0)    |
| 3           | 2-010<br>.017   |                                   |                   |                                   |                     |                 | 0.              | 50.                 | 745.0               | 745.0              | 37.3<br>(82.2)      | .08<br>(.300)    | 2                 | 30                    | .0<br>(.0)    |
| 4           | 9-180<br>.017   |                                   |                   |                                   |                     |                 | 0.              | 0.                  | .0                  | .0                 | 12.9<br>(28.5)      | .91<br>(14.40)   | 2                 | 50                    | .0<br>(.0)    |
| 5           | 2-010<br>.017   | 1                                 | .0000<br>(.0000)  | .00                               | 1810.0<br>(35.0)    | 21.1<br>(70.0)  | 0.              | 149.                | 745.0               | 745.0              | 69.1<br>(152.2)     | .13<br>(.460)    | 2                 | 40                    | .0<br>(.0)    |
| 6           | 2-010<br>.017   | 2                                 | .0163<br>(.0360)  | .00                               | .0<br>(.0)          | .0<br>(.0)      | 0.              | 149.                | 745.0               | 745.0              | 69.7<br>(153.7)     | .13<br>(.460)    | 2                 | 40                    | .0<br>(.0)    |
| 7           | 2-010<br>.017   |                                   |                   |                                   |                     |                 | 0.              | 199.                | 745.0               | 745.0              | 71.3<br>(157.2)     | .13<br>(.460)    | 2                 | 40                    | .0<br>(.0)    |
| 8           | 9-180<br>.017   |                                   |                   |                                   |                     |                 | 0.              | 149.                | 745.0               | 745.0              | 46.9<br>(103.4)     | .45<br>(16.00)   | 2                 | 40                    | .0<br>(.0)    |
| 9           | 2-000<br>12-000 | 1                                 | .0000<br>(.0000)  | 9.44<br>(20.00)                   | .0<br>(.0)          | .0<br>(.0)      | 0.              | 1394.<br>(4760.)    | 1400.0              | .0                 | 65.0<br>(187.5)     | 1.83<br>(.6450)  | 3                 | 40                    | .0<br>(.0)    |
| 10          | 2-000<br>12-000 | 3                                 | .5820<br>(1.2830) | .00                               | .0<br>(.0)          | 21.1<br>(70.0)  | 0.              | 999.<br>(3410.)     | 1000.0              | .0                 | 113.0<br>(249.1)    | 1.77<br>(.6260)  | 3                 | 45                    | .0<br>(.0)    |
| 11          | 2-000<br>12-000 | 3                                 | .1706<br>(.3760)  | .00                               | .0<br>(.0)          | 21.1<br>(70.0)  | 0.              | 1394.<br>(4760.)    | 1400.0              | .0                 | 96.1<br>(211.9)     | 1.31<br>(.4630)  | 3                 | 70                    | .0<br>(.0)    |
| 12          | 2-000<br>12-000 | 3                                 | .2291<br>(.5050)  | .00                               | 62858.0<br>(1200.0) | 21.1<br>(70.0)  | 0.              | 899.<br>(3070.)     | 900.0               | .0                 | 253.0<br>(557.7)    | 2.13<br>(.7530)  | 3                 | 75                    | .0<br>(.0)    |

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ORIGINAL PAGE IS  
OF GOOD QUALITY

APPLIANCE  
CONCEPT

NO. CONCEPT NAME

- 1 - COMPACTOR-AIR PRESSURE
- 2 - COMPACTOR-VACUUM
- 3 - COMPACTOR-MOTOR
- 4 - COMPACTOR-MANUAL
- 5 - COMPACTOR-AIR PRESSURE W/SHREDDER
- 6 - COMPACTOR-VACUUM W/SHREDDER
- 7 - COMPACTOR-MOTOR W/SHREDDER
- 8 - COMPACTOR-MANUAL W/SHREDDER
- 9 - INTEGRATED VACUUM DECOMPOSITION/SHREDDER
- 10 - FLUSH FLOW OXYGEN INCINERATION/SHREDDER
- 11 - PYROLYSIS/BATCH INCINERATION/SHREDDER
- 12 - WET OXIDIZATION/ SHREDDER

(\*)

- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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%

FINAL PAGE  
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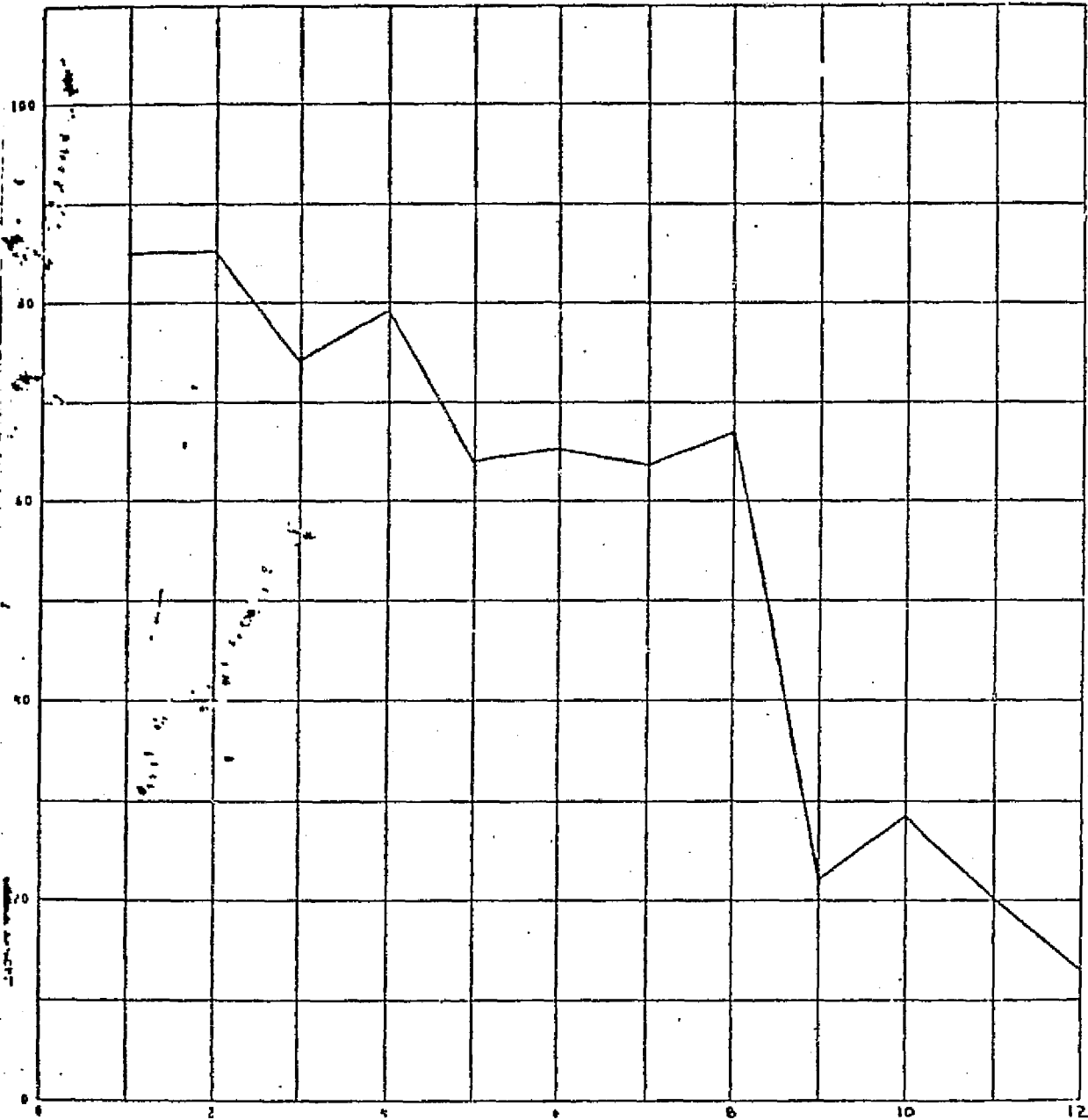
D2-118561-3

APPLIANCE  
CONCEPT

| NO. | CONCEPT NAME                             |
|-----|------------------------------------------|
| 1   | COMPACTOR-AIR PRESSURE                   |
| 2   | COMPACTOR-VACUUM                         |
| 3   | COMPACTOR-MOTOR                          |
| 4   | COMPACTOR-MANUAL                         |
| 5   | COMPACTOR-AIR PRESSURE W/SHREDDER        |
| 6   | COMPACTOR-VACUUM W/SHREDDER              |
| 7   | COMPACTOR-MOTOR W/SHREDDER               |
| 8   | COMPACTOR-MANUAL W/SHREDDER              |
| 9   | INTEGRATED VACUUM DECOMPOSITION/SHREDDER |
| 10  | FLUSH FLOW OXYGEN INCINERATION/SHREDDER  |
| 11  | PYROLYSIS/BATCH INCINERATION/SHREDDER    |
| 12  | WET OXIDIZATION/ SHREDDER                |



CONCEPT RANKING



CONCEPT NUMBER

PAGE 14

Refuse Processing (Shuttle) Concept Trade

NUMBER OF DAY<sup>S</sup> \* 20.5 (.06 YEAR<sup>S</sup>)

USES MOD SUBROUTINE 34

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 \* \* \* \* REFUSE PROCESSING (SHUTTLE)  
(01/25/75)

| FACTOR              | MIN VALUE | MAX VALUE | PTS | CONCEPT |       |       |       |       |       |       |       |       |       |       |       |
|---------------------|-----------|-----------|-----|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                     |           |           |     | 1       | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| WEIGHT              | 28.450    | 557.70    | 15  | 12.92   | 12.84 | 12.79 | 14.23 | 10.91 | 10.87 | 10.77 | 12.22 | 9.96  | 8.30  | 9.30  | .00   |
| POWER VOLUME        | .00000    | 742.00    | 15  | 14.91   | 14.91 | 7.02  | 15.00 | 6.93  | 6.93  | 7.02  | 7.02  | .00   | 4.29  | .00   | 5.36  |
|                     | 3.0000    | 75.300    | 10  | 9.60    | 9.58  | 9.60  | 8.09  | 9.39  | 9.39  | 9.39  | 7.88  | 1.43  | 1.69  | 3.85  | .00   |
| THERMAL RELIABILITY | .00000    | 261.80    | 15  | 15.00   | 15.00 | 14.47 | 15.00 | 13.40 | 13.40 | 12.86 | 13.40 | .00   | 4.25  | .00   | 5.33  |
|                     | .98038    | 1.00000   | 5   | 5.00    | 5.00  | 5.00  | 5.00  | 5.00  | 5.00  | 5.00  | 5.00  | .72   | .36   | .00   | .30   |
| MAINTENANCE SAFETY  | .99999    | 1.00000   | 5   | 3.27    | 3.51  | 2.63  | 4.97  | 1.67  | 2.89  | 2.00  | 4.35  | 1.15  | .83   | .61   | .00   |
|                     | 1.0000    | 2.0000    | 5   | 2.50    | 2.50  | 2.50  | .00   | .00   | .00   | .00   | .00   | 2.50  | 2.50  | 2.50  | .00   |
| DEV COST            | 30.000    | 75.000    | 15  | 9.00    | 9.00  | 9.00  | 5.00  | 7.00  | 7.00  | 7.00  | 7.00  | 3.00  | 2.00  | 1.00  | .00   |
| TOTAL PT            | .00000    | 85.000    | 85  | 72.20   | 72.34 | 63.00 | 67.30 | 54.29 | 55.47 | 54.03 | 56.86 | 18.75 | 24.22 | 17.27 | 10.98 |
| RATING              | .00000    | 100.00    | 100 | 84.94   | 85.11 | 74.11 | 79.17 | 63.87 | 65.25 | 63.57 | 66.88 | 22.06 | 28.50 | 20.31 | 12.92 |

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SENSITIVITY ANALYSIS

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| NORMAL   | 84.94         | 85.11 | 74.11 | 79.17 | 63.87 | 65.25 | 63.57 | 66.88 | 22.06 | 28.50 | 20.31 | 12.92 |
| WEIGHT   | 85.04         | 85.15 | 75.02 | 80.45 | 64.59 | 65.84 | 64.24 | 68.06 | 25.66 | 30.67 | 23.69 | 11.87 |
| POWER    | 86.12         | 86.27 | 71.90 | 80.86 | 62.44 | 63.71 | 62.21 | 65.25 | 20.28 | 28.50 | 18.67 | 14.77 |
| VOLUME   | 85.56         | 85.70 | 75.33 | 79.27 | 65.54 | 66.85 | 65.25 | 67.54 | 21.64 | 27.85 | 21.32 | 12.20 |
| THERMAL  | 86.16         | 86.32 | 75.92 | 80.86 | 65.93 | 67.20 | 65.37 | 68.70 | 20.28 | 28.48 | 18.67 | 14.75 |
| RELIAB-Y | 85.37         | 85.53 | 74.85 | 79.77 | 64.90 | 66.25 | 64.61 | 67.82 | 21.84 | 27.89 | 19.73 | 12.72 |
| MAINTENC | 84.38         | 84.68 | 73.50 | 79.75 | 63.00 | 65.04 | 62.90 | 67.45 | 22.09 | 28.16 | 20.08 | 12.55 |
| SAFETY   | 83.94         | 84.10 | 73.42 | 76.91 | 62.04 | 63.39 | 61.75 | 64.97 | 22.86 | 29.11 | 21.16 | 12.55 |
| DEV COST | 82.92         | 83.07 | 72.97 | 75.46 | 62.47 | 63.75 | 62.20 | 65.24 | 21.90 | 27.27 | 19.21 | 11.87 |

SENSITIVITY ANALYSIS

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    | 12    |
| NORMAL   | 84.94         | 85.11 | 74.11 | 79.17 | 63.87 | 65.25 | 63.57 | 66.88 | 22.06 | 28.50 | 20.31 | 12.92 |
| WEIGHT   | 84.83         | 84.06 | 73.03 | 77.65 | 63.01 | 64.56 | 62.77 | 65.47 | 17.78 | 25.90 | 16.28 | 14.17 |
| POWER    | 83.54         | 83.72 | 76.76 | 77.16 | 65.58 | 67.10 | 65.19 | 68.83 | 24.10 | 28.49 | 22.28 | 10.71 |
| VOLUME   | 84.25         | 84.44 | 72.74 | 79.07 | 61.99 | 63.46 | 61.68 | 66.14 | 22.55 | 29.22 | 19.18 | 13.73 |
| THERMAL  | 83.49         | 83.67 | 71.95 | 77.16 | 61.41 | 62.93 | 61.42 | 64.71 | 24.20 | 28.51 | 22.28 | 10.73 |
| RELIAB-Y | 84.49         | 84.66 | 73.33 | 78.54 | 62.78 | 64.20 | 62.47 | 65.88 | 22.30 | 29.14 | 20.93 | 13.13 |
| MAINTENC | 85.54         | 85.56 | 74.77 | 78.56 | 64.79 | 65.48 | 64.28 | 66.27 | 22.04 | 28.85 | 20.56 | 13.31 |
| SAFETY   | 86.00         | 86.17 | 79.84 | 81.57 | 65.80 | 67.23 | 65.50 | 68.91 | 21.22 | 27.84 | 19.41 | 13.31 |
| DEV COST | 87.36         | 87.54 | 75.48 | 83.61 | 65.53 | 67.05 | 65.21 | 68.84 | 22.26 | 29.96 | 21.63 | 14.17 |

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FORMS

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.4 REFUSE PROCESSING

| COMPONENT TYPE                           |     | NUMBER OF COMPONENTS |             |        |                    |                  |              |          |                 |       |                 |        |              |        |      |   | NUMBER OF SAFETY CRITICAL ITEMS |   |
|------------------------------------------|-----|----------------------|-------------|--------|--------------------|------------------|--------------|----------|-----------------|-------|-----------------|--------|--------------|--------|------|---|---------------------------------|---|
|                                          |     | SOLENOID VALVE       | ACCUMULATOR | FILTER | PRESSURE REGULATOR | CONTROLLER TIMER | RELIEF VALVE | ACTUATOR | PRESSURE SWITCH | MOTOR | ELECTRIC SWITCH | BLOWER | CHECK VALVES | HEATER | PUMP |   |                                 |   |
| APPLIANCE TYPE                           | NO. | ③                    | ④           | ⑨      | ①                  | ⑱                | ⑲            | ⑲        | ⑲               | ①     | ⑩               | ⑱      | ⑲            | ⑲      | ⑲    | ⑲ |                                 |   |
| COMPACTOR/AIR PRESSURE                   |     | 1                    | 1           | 1      | 1                  | 1                | 1            | 1        | -               | 1     | -               | -      | -            | -      | -    | - | -                               | 1 |
| COMPACTOR/VACUUM PRESSURE                |     | 1                    | 1           | 1      | -                  | 1                | -            | 1        | 1               | -     | 1               | -      | -            | -      | -    | - | -                               | 1 |
| COMPACTOR/MOTOR                          |     | -                    | 1           | 1      | -                  | 1                | -            | 1        | 1               | 1     | 1               | -      | -            | -      | -    | - | -                               | 1 |
| COMPACTOR/MANUAL                         |     | -                    | 1           | 1      | -                  | -                | -            | 1        | -               | -     | -               | -      | -            | -      | -    | - | -                               | 2 |
| COMPACTOR/AIR PRESSURE & SHREDDER        |     | 1                    | 1           | 1      | 1                  | 1                | 1            | 1        | 1               | 1     | 2               | -      | -            | -      | -    | - | -                               | 2 |
| COMPACTOR/VACUUM PRESSURE AND SHREDDER   |     | 1                    | 1           | 1      | -                  | 1                | -            | 1        | 1               | -     | 2               | -      | -            | -      | -    | - | -                               | 2 |
| COMPACTOR/MOTOR & SHREDDER               |     | -                    | 1           | 1      | -                  | 1                | -            | 1        | 1               | 1     | 2               | -      | -            | -      | -    | - | -                               | 2 |
| COMPACTOR/MANUAL & SHREDDER              |     | -                    | 1           | 1      | -                  | -                | -            | 1        | -               | -     | 1               | -      | -            | -      | -    | - | -                               | 2 |
| INTEGRATED VACUUM DECOMPOSITION/SHREDDER |     | 10                   | 2           | 2      | -                  | 1                | -            | -        | -               | -     | -               | 2      | 2            | 2      | -    | - | -                               | 1 |
| FLUSH FLOW OXYGEN INCINERATION/SHREDDER  |     | 14                   | 2           | 2      | -                  | 1                | -            | -        | -               | -     | -               | 2      | 2            | 2      | -    | - | -                               | 1 |
| PYROLYSIS/BATCH INCINERATION/SHREDDER    |     | 14                   | 3           | 2      | 1                  | 1                | -            | -        | -               | -     | -               | 2      | 2            | 2      | -    | - | -                               | 1 |
| WET OXIDATION/SHREDDER                   |     | 13                   | 3           | 2      | 1                  | 1                | -            | -        | -               | 1     | -               | 1      | -            | 2      | 1    | - | -                               | 2 |

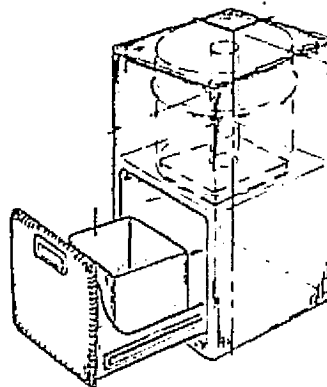
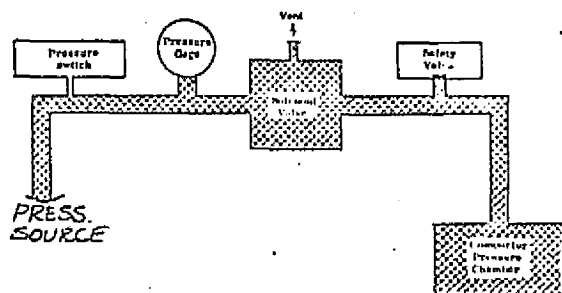
B2-392

D2-118561-3



SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 1/Compactor-Air PressureINDEX NO. 3.2.4.1 REF. NO. 203,123,170,270

DESCRIPTION The compactor-air pressure concept uses air pressure against a piston for refuse compaction. The compactor is used for dry and moist compactible refuse. The unit provides a sterilant to the waste to prevent bacterial growth. The refuse is placed into a waste storage bag in the compactor. The compactor is actuated and compression of the refuse is accomplished using cabin air pressure of 40 psi. The piston used for the study was 9 inches square which results in 4000# of compaction pressure. The curve (see next page) from reference 123 shows 30 psi is more than adequate to attain a 0.2 compression ratio. The uncompressed refuse volume per day 2.45 FT<sup>3</sup>/day for Space Station and .947 FT<sup>3</sup>/day for Shuttle was divided by the compactor volume of .47FT<sup>3</sup> to determine the uses per day. Prior to tying the waste storage bag liner a sterilant capsule is placed into the bag. After tying, the capsule is broken releasing the sterilant gas.



B2-394

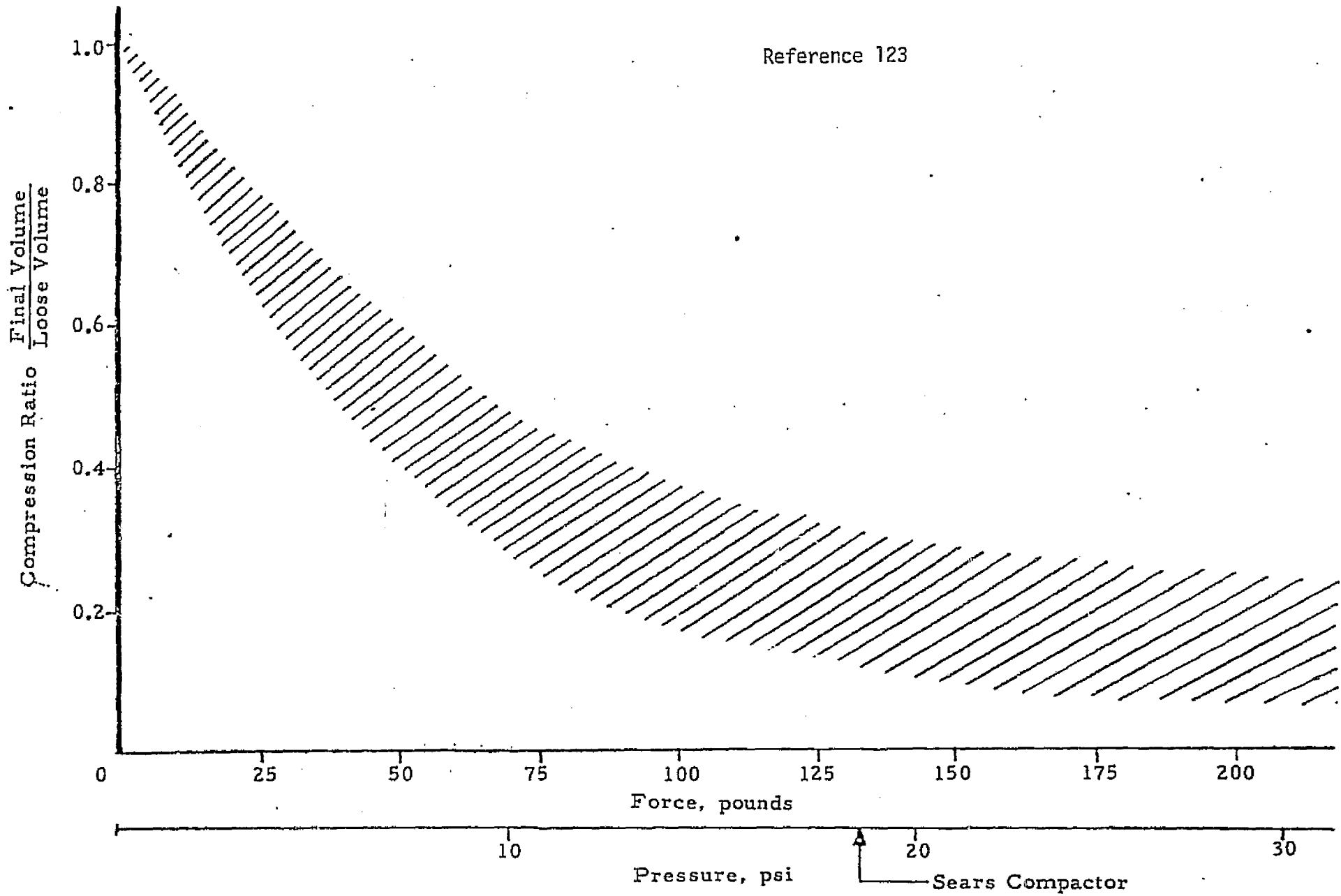


Figure B2-1. COMPOSITE COMPACTION DATA FOR TRASH MIXURES





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SPACECRAFT Shuttle

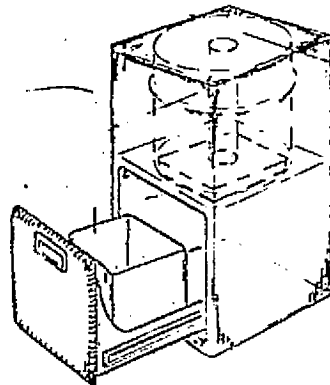
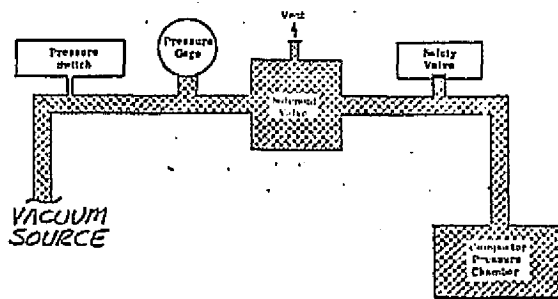
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 2/Compactor-Vacuum

INDEX NO. 3.2.4.2 REF. NO. 203,123,170,270

DESCRIPTION The compactor-vacuum concept is identical to concept 1 with the exception that a vacuum is used to apply the compaction pressure. The maximum pressure available is 14.7 psi, therefore, using the same size compactor, the compression ratio will be 0.35. The uses per day is the same as concept 1, however more bags will be used per mission due to the lower compression ratio. Cabin air is lost each time the unit is vented to vacuum. Venting overboard was allowed, since the cabin air is not contaminated.

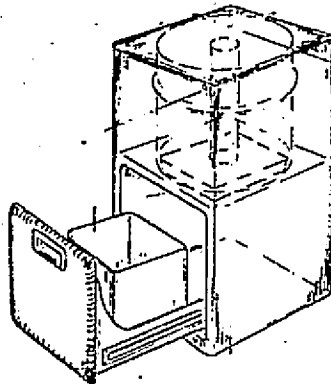






SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 3/Compactor-MotorINDEX NO. 3.2.4.3REF. NO. 203,123,170,270,202

DESCRIPTION The compactor-motor concept is identical to concept 1 with the exception that a motor is used to apply the compaction pressure. The motor is a linear actuator. The compactor actuation and loading was assumed to be identical to concept 1.









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SPACECRAFT Shuttle

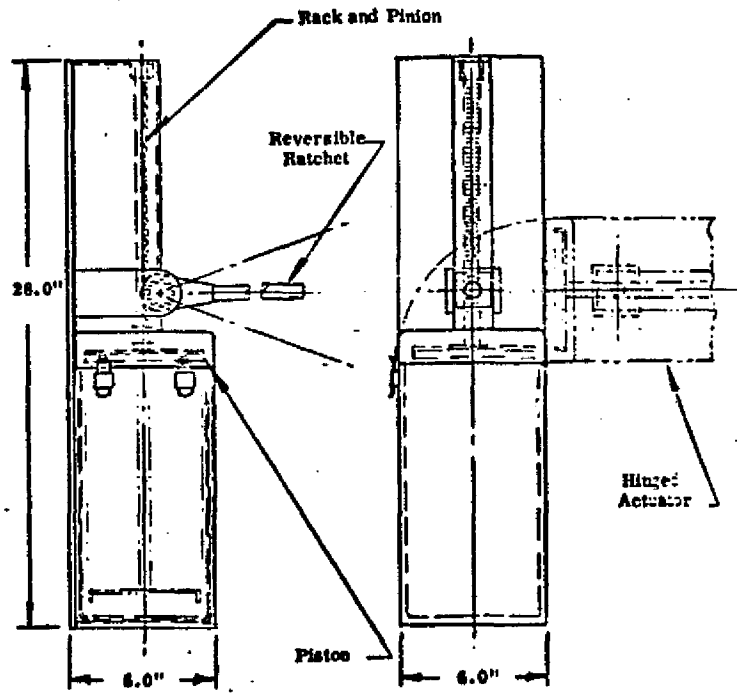
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 4/Compactor-Manual

INDEX NO. 3.2.4.4 REF. NO. 160

DESCRIPTION: The compactor-manual concept is a manually actuated piston refuse compactor. The manual compactor cannot be the same size as concepts 1 through 3 because of the crewman physical limitations. The concept requires a large amount of crew time because of its smaller size increases its uses per day. The design utilizes a piston actuated by a lever which contains a double acting ratchet mechanism and a pinion gear which drives a gear rack shaft. By an up and down pumping action, the piston compacts the refuse. The same waste bag weight and volume is assumed for this unit since it processed the same volume of refuse as concepts 1 through 3.







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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE: 5/Compactor-Air Pressure w/Shredder

INDEX NO. 3.2.4.5 REF. NO. 203, 123, 170, 270, 202

DESCRIPTION: The compactor-air pressure with shredder is identical to concept 1 with the addition of a shredder. Reference 202 stated that dry waste can be compacted more efficiently if previously shredded. Reference 123, see curve at front of appliance function section, test data does not indicate shredding will accommodate any change in compression ratio since the curve becomes asymptotic to the force line for this compactor. However, the shredder was added to the air pressure compactor for the purpose of comparison. The shredder is a commercial type used to shred paper and could with modification handle moist shreddable waste. The units were based on one use for each of 3 meals, 2 scheduled cleanups, 3 spills (unscheduled), and 3 miscellaneous for paper, books, etc. The time per use was assumed to be 3 minutes. Shredding of solid wastes was not considered by this concept.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 5/COMPACTOR-AIR PRESSURE W/SHREDDER

INDEX NUMBER 3.2.4.5

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT (REF)                              | WEIGHT (LBS)                      | VOLUME (FT <sup>3</sup> )                               |
|----------------------------------------------|-----------------------------------|---------------------------------------------------------|
| COMPACTOR (INCLUDES (170) LUBRICANT AMPULS.) | 75                                | 2.8                                                     |
| SHREDDER                                     | 75                                | 1.6                                                     |
| WASTE STORAGE BAGS                           | 2.25                              | .215                                                    |
| TOTAL                                        | <b>69.06 (152.25)</b><br>KG (LBS) | <b>.131 (4.62)</b><br>M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE W/VOL REQUIREMENTS

| TYPE               | ①<br>UNITS/CYCLE (REF) | ②<br>WT/UNIT (REF)<br>(PKG. WT/UNIT) (REF)<br>(LB) | ③<br>WT/CYCLE<br>① x ②<br>(LB)          | ④<br>VOL/UNIT (REF)<br>(PKG. VOL/UNIT) (REF)<br>(FT <sup>3</sup> ) | ⑤<br>VOL/CYCLE<br>① x ④<br>(FT <sup>3</sup> )     |
|--------------------|------------------------|----------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------|---------------------------------------------------|
| WASTE STORAGE BAGS | 218 (170)              | .25 (170)                                          | .0545                                   | .024 (170)                                                         | .0052                                             |
|                    |                        |                                                    | Σ ③                                     |                                                                    | Σ ⑤                                               |
|                    |                        |                                                    | TOTAL WT/CYCLE (LB)                     |                                                                    | TOTAL VOL/CYCLE (FT <sup>3</sup> )                |
| TOTAL WT. MISSION  | 2.01<br>CYCLES/DAY     | 20.5<br>DAYS/MISSION                               | .0545<br>TOT. WT/CYCLE (LB)             |                                                                    | 1.019 (2.25)<br>KG (LB)                           |
| TOTAL VOL. MISSION | 2.01<br>CYCLES/DAY     | 20.5<br>DAYS/MISSION                               | .0<br>TOT. VOL/CYCLE (FT <sup>3</sup> ) |                                                                    | .0061 (2.15)<br>M <sup>3</sup> (FT <sup>3</sup> ) |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE              | ①<br>AMT. USED/CYCLE (REF)<br>(LB) | ②<br>RECOVERY FACTOR | ③<br>AMT. RECOVERED/CYCLE<br>① x ②<br>(LB) | ④<br>AMT. LOST/CYCLE<br>① - ③<br>(LB) |
|-------------------|------------------------------------|----------------------|--------------------------------------------|---------------------------------------|
| N/A               |                                    |                      |                                            |                                       |
|                   |                                    |                      |                                            |                                       |
|                   |                                    |                      |                                            |                                       |
|                   |                                    |                      |                                            |                                       |
|                   |                                    |                      |                                            |                                       |
|                   | Σ ①                                |                      | Σ ④                                        |                                       |
| TOTAL WT. MISSION |                                    |                      |                                            |                                       |
|                   | CYCLE/DAY                          | DAYS/MISSION         | TOTAL LOST/CYCLE (LB)                      | KG (LB)                               |



D2-118561-3

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 6/Compactor-Vacuum w/Shredder

INDEX NO. 3.2.4.6 REF. NO. 203,123,170, 270, 202

DESCRIPTION : The compactor-vacuum with shredder concept is identical to concept 2 with the addition of the shredder described in concept 5. The compression ratio was changed from 0.35 to 0.2 based on the increase of compacting efficiency using a shredder.





SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 7/Compactor-Motor w/Shredder

INDEX NO. 3.2.4.7 REF. NO. 203, 123, 170, 270, 202

DESCRIPTION : The compactor-motor w/shredder concept is identical to concept 3 with the addition of the shredder described in concept 5.





SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 8/Compactor-Manual w/ShredderINDEX NO. 3.2.4.8 REF. NO. 160, 202

DESCRIPTION: The compactor-manual with shredder is identical to concept 4 with the addition of the shredder described in concept 5.







SPACECRAFT Shuttle

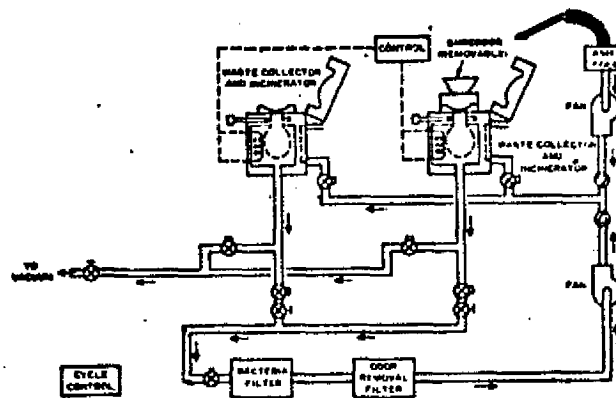
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 9/Integrated Vacuum Decomposition/Shredder

INDEX NO. 3.2.4.9 REF. NO. 100, 250

DESCRIPTION: The integrated vacuum decomposition/shredder concept utilizes vacuum and high temperature to decompose the refuse materials into gaseous products which can be exhausted to vacuum. The shredder is required to expose more refuse area to increase the decomposition efficiency. The chamber requires cool-down period. The process does not require oxygen; however, requires power to sustain the chemical process for 21 hours. Two units were assumed based on the refuse volume and the 12-hour cooldown time required by the unit (one unit can be used once per day). Incinerable collection bags with a hydrophobic patch 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.

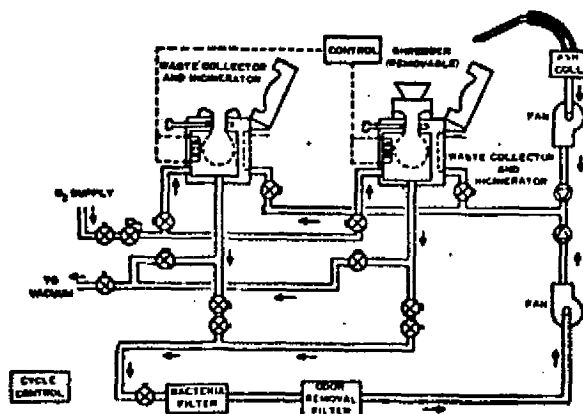






SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 10/Flush Flow Oxygen Incineration/ShredderINDEX NO. 3.2.4.10REF. NO. 100, 250

DESCRIPTION: The flush flow oxygen incineration/shredder concept utilizes a continuous oxygen flow to the collection chamber for the 12 hours required for incineration. The refuse is collected/shredded and inserted into the chamber, sealed in the chamber (no vent to vacuum), heat is applied for a specified time period. The resulting sterilized/vaporized gas and vapors are exhaust 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 refuse volume. Twelve hours are allowed for cooldown requiring two units per vehicle. The collection bags described in concept 9 are also used for this concept.

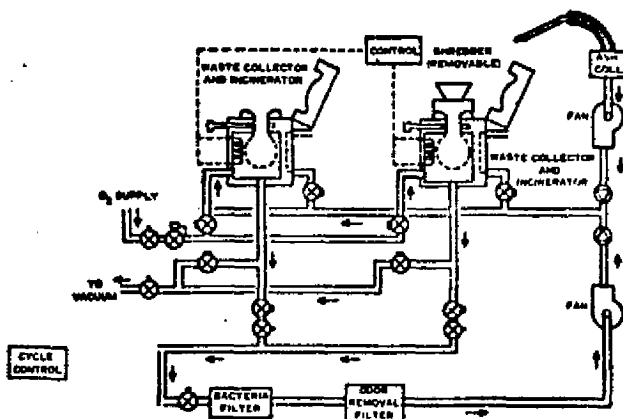






SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 11/Pyrolysis/Batch Incineration/ShredderINDEX NO. 3.2.4.11REF. NO. 100, 250

DESCRIPTION: The pyrolysis/batch incineration/shredder concept utilizes a three-step process to minimize oxygen consumables. The shredded refuse is 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 also 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 10. The pyrolysis/batch incineration takes 12 hours. The collection bags described in concept 9 are also used for this concept.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
CONCEPT LI/PYROLYSIS/BATCH INCINERATION/SHREDDER

INDEX NUMBER 3.2.4.11

ELECTRICAL POWER REQUIREMENTS

| COMPONENT                    | (REF)     | AC POWER                       |                      |                         | DC POWER                                    |                      |                         |
|------------------------------|-----------|--------------------------------|----------------------|-------------------------|---------------------------------------------|----------------------|-------------------------|
|                              |           | ①<br>USE TIME<br>CYCLE<br>(HR) | ②<br>PEAK<br>(WATTS) | ③<br>AVERAGE<br>(WATTS) | ④<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① X ③ | ⑤<br>PEAK<br>(WATTS) | ⑥<br>AVERAGE<br>(WATTS) |
| <u>COLLECTION UNIT (100)</u> | <u>12</u> |                                | <u>1400</u>          |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                |                      |                         |                                             |                      |                         |
|                              |           |                                | MAXIMUM              | TOTAL                   | MAXIMUM                                     |                      | TOTAL                   |

THERMAL REQUIREMENTS

| SOURCE                       | LATENT<br>(BTU/HR) | SENSIBLE<br>(BTU/HR) | HEAT LEAK<br>(BTU/HR) | TO COOLANT<br>(BTU/HR) |
|------------------------------|--------------------|----------------------|-----------------------|------------------------|
| <u>COLLECTION UNIT (100)</u> | <u>—</u>           | <u>4760</u>          | <u>4760</u>           | <u>—</u>               |
|                              |                    |                      |                       |                        |
|                              |                    |                      |                       |                        |
|                              |                    |                      |                       |                        |
|                              |                    |                      |                       |                        |
| TOTAL                        | <u>—</u>           | <u>1396 (4760)</u>   | <u>1396 (4760)</u>    | <u>—</u>               |
|                              | WATT (BTU/HR)      | WATT (BTU/HR)        | WATT (BTU/HR)         | WATT (BTU/HR)          |

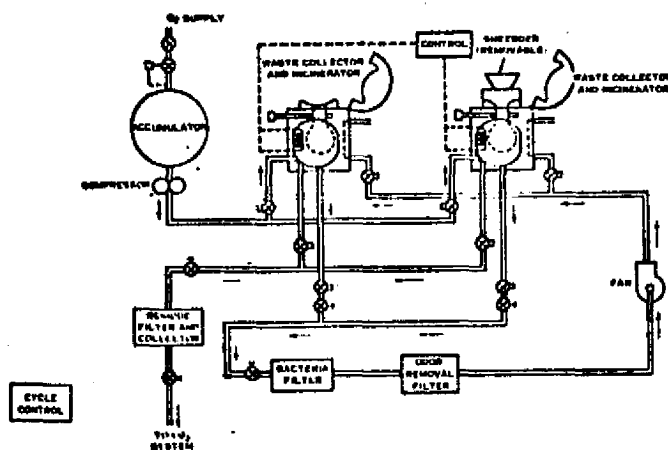
OPERATIONAL PENALTIES

| SOURCE     | HEAT LEAK<br>(BTU/HR/CYCLE)   | THERMAL<br>TO COOLANT<br>(BTU/HR/CYCLE) | ELECTRICAL<br>(PK WATTS/CYCLE) | WEIGHT<br>(LB/MISSION)     | VOLUME<br>(FT <sup>3</sup> /MISSION)                  |
|------------|-------------------------------|-----------------------------------------|--------------------------------|----------------------------|-------------------------------------------------------|
| <u>N/A</u> |                               |                                         |                                |                            |                                                       |
|            |                               |                                         |                                |                            |                                                       |
|            |                               |                                         |                                |                            |                                                       |
|            |                               |                                         |                                |                            |                                                       |
|            |                               |                                         |                                |                            |                                                       |
| TOTAL      | WATTS/CYCLE<br>(BTU/HR/CYCLE) | WATTS/CYCLE<br>(BTU/HR/CYCLE)           |                                | KG/MISSION<br>(LB/MISSION) | M <sup>3</sup> /MISSION<br>(FT <sup>3</sup> /MISSION) |



SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 12/Wet Oxidization/ShredderINDEX NO. 3.2.4.12REF. NO. 100, 250

DESCRIPTION: The wet oxidization/shredder concept is a moderate temperature, high pressure catalytic process. The system employs an insulated chamber similar to the incineration and decomposition concepts. Shredded refuse 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 500°F. The advantage of the wet oxidization 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 oxidization process, but was not considered in this study due to lack of engineering data. Based on two data sources, the process was assumed to take 21 hours, most of which is cooldown time (10½ to 6 hours). The collection bags described in concept 9 are also used for this concept.







HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.2 Refuse Management

APPLIANCE FUNCTION 3.2.5 Refuse Disposal

NUMBER OF CONCEPTS CONSIDERED 3

**ASSUMPTIONS**

(1) Refuse disposal includes concepts most likely to be used on near term spacecraft. The concepts consider vacuum storage, static onboard storage, and jettison to earth for aerodynamic incineration. Disposal of refuse using rockets to the sun was not used, since radioactive wastes were not considered by the study.

(2) The refuse volume and weight is based on those tabulated in Table B2-6.

(3) The uncompressed volume of trash was used to size all of the concepts.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3-2-5 \*\*\* REFUSE DISPOSAL (SHUTTLE)

| CONCEPT NO. | USAGE TIME | CONSUMABLES AND FLOW REQUIREMENTS |      |           |        | THERMAL REQNTS |          | ELEC PWR REQNTS |         | HT/VOL REQNTS |          | DEVELOPMENT COST |        | RESUPPLY WEIGHT |       |
|-------------|------------|-----------------------------------|------|-----------|--------|----------------|----------|-----------------|---------|---------------|----------|------------------|--------|-----------------|-------|
|             |            | USES/DAY                          | TYPE | AMT. USED | FLOW   | PRESS          | TEMP     | COOLANT         | HT LEAK | PK PWR        | AVG PWR  | WEIGHT           | VOLUME |                 | AVAIL |
|             |            | (#)                               |      | (#)       | (PSIG) | (DEG F)        | (BTU/HR) | (BTU/HR)        | AC      | DC            | (KG)     | (CU FT)          | (#)    | (#)             | (KG)  |
| 1           | .783       | 2                                 |      | .1450     | .00    | .00            | .00      | .00             | .00     | .00           | .790     | .23              | 1      | 10              | .00   |
|             | .691       |                                   |      | .321011   | .007   | (.00)          | (.00)    | (.00)           | (.00)   | (.00)         | (.17409) | (.8020)          |        |                 | (.00) |
| 2           | .787       |                                   |      |           |        |                | .00      | .00             | .00     | .00           | .807     | .34              | 1      | 10              | .00   |
|             | .641       |                                   |      |           |        |                | (.00)    | (.00)           | (.00)   | (.00)         | (.1902)  | (.13028)         |        |                 | (.00) |
| 3           | .098       |                                   |      |           |        |                | .00      | .00             | .00     | .00           | .750     | .52              | 2      | 35              | .00   |
|             | .328       |                                   |      |           |        |                | (.00)    | (.00)           | 10.00   | (.00)         | (.10001) | (.18091)         |        |                 | (.00) |

APPLIANCE CONCEPT

| CONCEPT NO. | CONCEPT NAME                   |
|-------------|--------------------------------|
| 1           | VACUUM STORAGE                 |
| 2           | STORAGE BIN/CONTAINER          |
| 3           | SOLID PROPELLANT REFUSE ROCKET |

- (\*)
- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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%

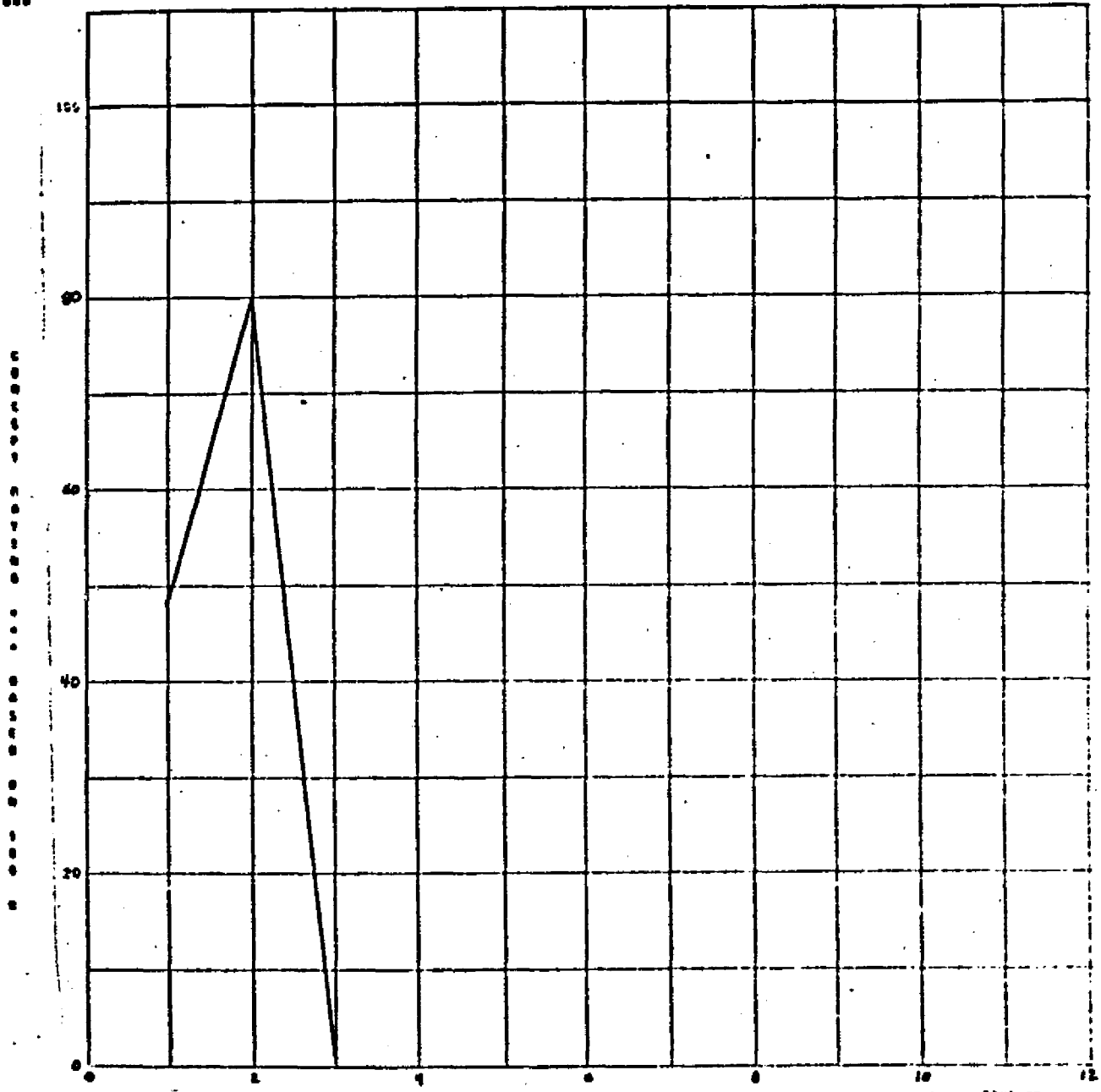
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B2-431

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| APPLIANCE<br>CONCEPT |                                |
|----------------------|--------------------------------|
| NO.                  | CONCEPT NAME                   |
| 1                    | VACUUM STORAGE                 |
| 2                    | STORAGE BIN/CONTAINER          |
| 3                    | SOLID PROPELLANT REFUSE ROCKET |



PAGE 70.

CONCEPT NUMBER

Refuse Disposal (Shuttle) Concept Trade



NUMBER OF DAYS = 20.5 ( .06 YEARS)

USES MOD. SUBROUTINE 35

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 . . . . . REFUSE DISPOSAL (SHUTTLE)  
(01/15/75)

| FACTOR   | MIN<br>VALUE | MAX<br>VALUE | PTS | C O N C E P T |       |      |
|----------|--------------|--------------|-----|---------------|-------|------|
|          |              |              |     | 1             | 2     | 3    |
| WEIGHT   | 19.180       | 174.35       | 15  | .60           | 13.35 | .71  |
| POWER    | .00000       | 4.3000       | 15  | 15.00         | 15.00 | .00  |
| VOLUME   | 0.2000       | 16.410       | 10  | 5.55          | 2.79  | .00  |
| RELIAB-Y | 1.00000      | 1.0000       | 5   | .60           | 5.00  | .00  |
| MAINTENC | 1.00000      | 1.0000       | 5   | .30           | 5.00  | .00  |
| DEV COST | 10.000       | 35.000       | 15  | 10.71         | 10.71 | .00  |
| TOTAL PT | .00000       | 65.000       | 65  | 31.26         | 51.85 | .71  |
| RATING   | .00000       | 100.00       | 100 | 48.09         | 79.77 | 1.09 |

B2-433

D2-118561-3

**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |      |
|----------|---------------|-------|------|
|          | 1             | 2     | 3    |
| NORMAL   | 48.09         | 79.77 | 1.09 |
| WEIGHT   | 43.12         | 80.72 | 1.47 |
| POWER    | 53.46         | 81.86 | 0.98 |
| VOLUME   | 48.02         | 76.66 | 1.01 |
| RELIAB-Y | 46.31         | 80.52 | 1.05 |
| MAINTENC | 46.31         | 80.52 | 1.05 |
| DEV COST | 50.51         | 78.91 | 0.98 |

**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |      |
|----------|---------------|-------|------|
|          | 1             | 2     | 3    |
| NORMAL   | 48.09         | 79.77 | 1.09 |
| WEIGHT   | 54.37         | 78.57 | 0.62 |
| POWER    | 41.32         | 77.13 | 1.23 |
| VOLUME   | 47.48         | 84.10 | 1.18 |
| RELIAB-Y | 50.02         | 78.96 | 1.14 |
| MAINTENC | 50.02         | 78.96 | 1.14 |
| DEV COST | 45.05         | 80.86 | 1.23 |

D2-118561-3

B2-434

07107

**APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX**

**APPLIANCE FUNCTION: 3.2.5-REFUSE DISPOSAL**

| COMPONENT TYPE<br><br>APPLIANCE TYPE                      | NUMBER OF COMPONENTS |            |                |                |                 |   |   |   |   |   |   |   |   |   | NUMBER OF SAFETY CRITICAL ITEMS |   |
|-----------------------------------------------------------|----------------------|------------|----------------|----------------|-----------------|---|---|---|---|---|---|---|---|---|---------------------------------|---|
|                                                           | NO.                  | ① ACTUATOR | ② MANUAL VALVE | * ROCKET MOTOR | * MOTOR IGNITER | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |                                 | ○ |
| VACUUM STORAGE/RESTORAGE/<br>BIOLOGICAL STABILIZED        |                      | 1          | 1              | -              | -               |   |   |   |   |   |   |   |   |   |                                 | 0 |
| STORAGE BIN/CONTAINER/RESTORAGE/<br>BIOLOGICAL STABILIZED |                      | -          | -              | -              | -               |   |   |   |   |   |   |   |   |   |                                 | 0 |
| SOLID PROPELLANT REFUSE ROCKET                            |                      | 1          | 1              | UNK            | UNK             |   |   |   |   |   |   |   |   |   |                                 | 0 |
| *TBD                                                      |                      |            |                |                |                 |   |   |   |   |   |   |   |   |   |                                 |   |

B2-435

D2-118561-3

SPACECRAFT Shuttle

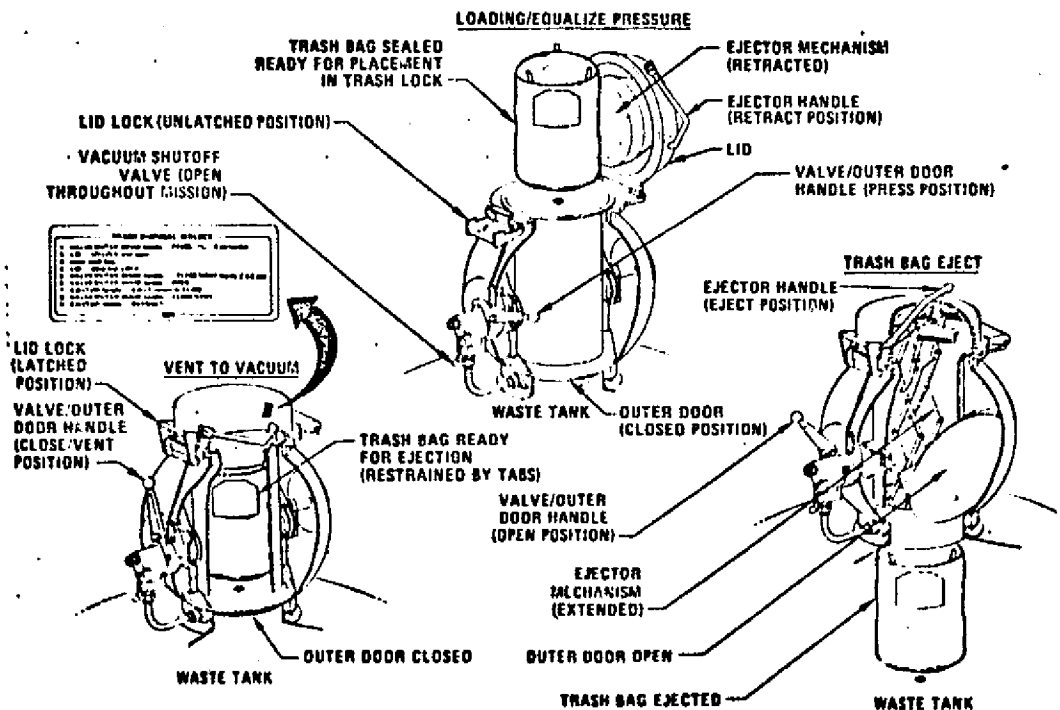
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Disposal

APPLIANCE CONCEPT NO./TITLE 1/Vacuum Storage

INDEX NO. 3.2.5.1 REF. NO. MacDac, 283, 297

DESCRIPTION: The vacuum storage concept considered was the same as used for Skylab. The Skylab airlock was used as the means to deposit refuse into the vacuum storage tank. The vacuum environment stops bacterial growth in the refuse. The internal volume of the airlock is 4.3 ft<sup>3</sup> and was used to calculate the cabin air lost during each airlock refuse disposal cycle. The vacuum container was assumed to be a 10.4 foot diameter spherical tank fabricated of 6061 aluminum. The 10.4 foot diameter tank can be accommodated in both the Space Station and the Shuttle payload bay. Aluminum, 6061, was chosen as a material for the following reasons: (1) inexpensive, (2) easy to work, and (3) good weldability. The tank was assumed to be a pressure vessel with a maximum working pressure of 14.7 psi. The number of uses per mission was based on the size of Skylab disposal and trash bags. The trash bags are fabricated of a material which will retain water, but will also allow the bag to breath to allow pumpdown of the refuse to the vacuum pressure of the tank. Operation of the airlock was assumed to be 2 minutes per cycle.







SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse DisposalAPPLIANCE CONCEPT NO./TITLE 2/Storage Bin/ContainerINDEX NO. 3.2.5.2REF. NO. 170

DESCRIPTION: The storage bin/container concept employs a locker to store the refuse. Sterilant capsules were assumed for retarding the bacterial growth. The refuse was assumed to be collected by bags (Skylab, or equivalent, and transferred to the storage locker. A concept provides a sterilant capsule for each bag of refuse stored in the locker. The capsules used for the study were 2.25 grams each with a volume of .33 cubic inches. The walls of the storage locker were assumed to be aluminum. Sizing of the locker was based on the refuse volume including the storage bags.



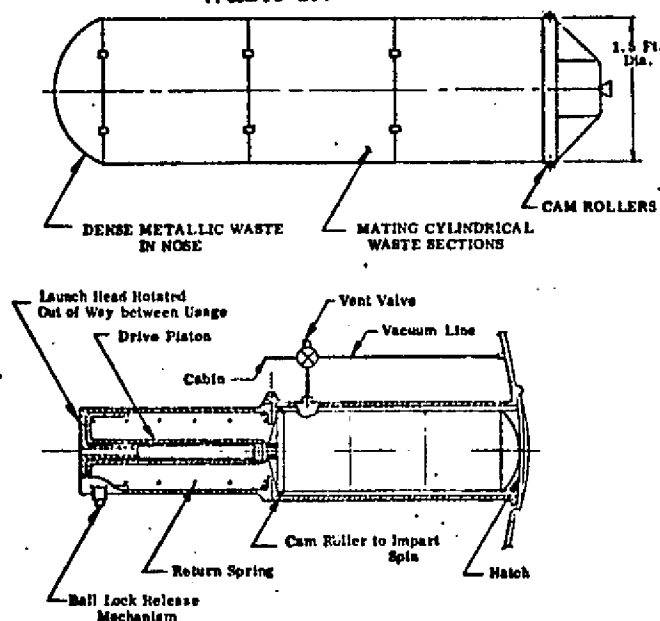




SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 3/Solid Propellant Refuse RocketINDEX NO. 3.2.5.3REF. NO. 202

DESCRIPTION: The solid propellant refuse rocket concept utilizes a rocket to jettison refuse to earth for aerodynamic incineration. The study assumes the refuse is jettisoned from a 300 nautical mile orbit using an incremental velocity ( $\Delta V$ ) of 434 feet/second to alter the rockets velocity to cause it to reenter the earth atmosphere. Atmosphere drag at the 300,000 foot re-entry altitude chosen for the calculations (reference 202) is of such magnitude as to cause the trajectory to degenerate rapidly. The equation for a minimum energy Hohmann transfer ellipse were used for determining the required velocity increment for reentry. A solid rocket was chosen because a solid rocket is easy to use and transport, and may be fired with simple electrical circuits. The ability of solid propellants to withstand long storage periods at extremes in temperature and pressure without attention is also a benefit for this type of application. The solid rocket in this application is superior to a liquid rocket in total impulse to total weight ratio primarily because of the greater energy per unit volume. Therefore, less dead weight structure is required to carry the propellant. The size of the rocket was based on the total refuse volume compressed by a compactor to minimize the rocket volume. The concept was penalized for a compactor with a compression ratio of 0.2. (Air Pressure Type).

## Waste Rocket



## Operation:

Rotate launch handle to "eject" position (not shown). The following events occur automatically:

1. Launch tube is vented to space and then hatch opens.
2. Launch piston is released and rocket is spin ejected. Cabin pressure provides launch force. Helical groove in launch tube imparts spin.
3. Hatch closes.
4. Launch tube is vented to cabin and spring retracts launch piston.

Launch Tube for Spin Ejecting Waste Rocket





HABITABILITY SUBSYSTEM 3.0 HousekeepingHABITABILITY FUNCTION 3.3 Garment/Linen MaintenanceAPPLIANCE FUNCTION 3.3.1 Garment/Linen WashingNUMBER OF CONCEPTS CONSIDERED 10

## ASSUMPTIONS

A number of references were found which present data for various clothes washer and dryer concepts (Reference 70, 90, 91, 100, 127, 161, 171, 185, 202, 237 and 245). These references were reviewed in detail, and the engineering data from each examined. It was soon found that much of the data did not agree. The primary reason for discrepancies was that the data were mostly very sketchy, without detailed breakdowns to define the data. For example, the clothes washer weight in one reference would include the agitator tub only, while another would include peripheral equipment such as water accumulators, processing equipment or other miscellaneous items. One reference was found (#90) which contained all the concepts found throughout the other reports and presented the data for each in a consistent manner for direct comparison. Therefore, it was decided to collect all the clothes washer and dryer data for this study from Reference 90.

All the clothes washer and dryer engineering data used for Space Station were used directly for Shuttle also after adjusting for the crew size of 4 men (Space Station crewman-6 men). With this ground rule, the following assumptions were made:

1. Two clothes washings per day
2. Maximum washer clothes load 1.21 kg (2.67 lb.)
3. Water usage for the automatic concepts was 16.63 kg (36.67 lb.) for washing and 16.63 kg (36.67 lb.) for rinse
4. Rinse water is temporarily stored and reused as wash water
5. No water recovery system is available
6. Concepts are penalized for the weight of wash water, 16.63 kg (36.67 lb.) used each washing
7. Wash/rinse time is one hour

Only the total weight/volume, power, etc. penalties for each concept are included in the data worksheets. As explained above, these are taken from the Space Station washer concept data and multiplied by 4/6. For a detailed breakdown of the penalties, the Space Station worksheets should be consulted.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.3.1 \*\*\*\* GARMENT/LINEN WASHING (SHUTTLE)

| CONCEPT NO. | USAGE TIME | CONSUMABLES AND FLOW REQUIREMENTS |           |                                   |             | THERMAL REQHTS  |                            | ELEC PWR REQHTS     |                     | WT/VOL REQHTS      |                     | DEVELOPMENT COST       |                             | SUPPLY WEIGHT (KG) |                              |
|-------------|------------|-----------------------------------|-----------|-----------------------------------|-------------|-----------------|----------------------------|---------------------|---------------------|--------------------|---------------------|------------------------|-----------------------------|--------------------|------------------------------|
|             |            | USES/DAY<br>HRS/USE               | TYPE (*)  | AMT. USED<br>(KG/USE)<br>(LB/USE) | FLOW<br>(*) | PRESS<br>(PSIG) | TEMP<br>(DEG C)<br>(DEG F) | COOLANT<br>(BTU/HR) | HT LEAK<br>(BTU/HR) | PK PWR<br>AC<br>DC | AVG PWR<br>AC<br>DC | WEIGHT<br>(KG)<br>(LB) | VOLUME<br>(CU M)<br>(CU FT) |                    | AVAIL INDEX<br>(**)<br>(***) |
| 1           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 0.                         | 972.                | 150.0               | .0                 | 776.2               | .33                    | 3                           | 70                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (0.)                       | (3320.)             | .0                  | .0                 | (1711.1)            | (11.40)                |                             |                    | (.0)                         |
| 2           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 0.                         | 980.                | 158.0               | .0                 | 774.3               | .35                    | 3                           | 40                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (0.)                       | (3347.)             | .0                  | .0                 | (1707.1)            | (12.30)                |                             |                    | (.0)                         |
| 3           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 395.                       | 923.                | 144.0               | .0                 | 843.7               | 1.34                   | 4                           | 90                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (1350.)                    | (3152.)             | 454.0               | .0                 | (1860.1)            | (47.40)                |                             |                    | (.0)                         |
| 4           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 395.                       | 902.                | 144.0               | .0                 | 846.5               | 1.34                   | 4                           | 90                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (1350.)                    | (3079.)             | 454.0               | .0                 | (1866.1)            | (47.40)                |                             |                    | (.0)                         |
| 5           | 2.000      | 7                                 | .0907     | .00                               | .0          | .0              | 0.                         | 872.                | 50.0                | .0                 | 746.3               | .28                    | 4                           | 95                 | .0                           |
|             | 1.000      |                                   | (.2000)   | (.00)                             | (.0)        | (.0)            | (0.)                       | (2979.)             | .0                  | .0                 | (1689.3)            | (10.00)                |                             |                    | (.0)                         |
| 6           | 2.000      | 7                                 | .1341     | .00                               | .0          | .0              | 0.                         | 872.                | 50.0                | .0                 | 743.5               | .27                    | 4                           | 95                 | .0                           |
|             | 1.000      |                                   | (.3000)   | (.00)                             | (.0)        | (.0)            | (0.)                       | (2979.)             | .0                  | .0                 | (1683.1)            | (9.70)                 |                             |                    | (.0)                         |
| 7           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 0.                         | 980.                | 158.0               | .0                 | 776.2               | .34                    | 2                           | 90                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (0.)                       | (3347.)             | .0                  | .0                 | (1711.1)            | (11.90)                |                             |                    | (.0)                         |
| 8           | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 0.                         | 1847.               | 1023.0              | .0                 | 780.7               | .37                    | 3                           | 60                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (0.)                       | (6307.)             | .0                  | .0                 | (1721.1)            | (12.90)                |                             |                    | (.0)                         |
| 9           | 2.000      | 9                                 | 6.0782    | .00                               | .0          | .0              | 244.                       | 170.                | 96.0                | .0                 | 194.6               | .80                    | 3                           | 50                 | .0                           |
|             | 1.000      |                                   | (13.4000) | (.00)                             | (.0)        | (.0)            | (900.)                     | (579.)              | 303.0               | .0                 | (429.1)             | (28.30)                |                             |                    | (.0)                         |
| 10          | 2.000      | 9                                 | 33.2942   | .00                               | .0          | .0              | 0.                         | 980.                | 158.0               | .0                 | 776.2               | .34                    | 3                           | 50                 | .0                           |
|             | 1.000      |                                   | (73.4000) | (.00)                             | (.0)        | (.0)            | (0.)                       | (3347.)             | .0                  | .0                 | (1711.1)            | (11.90)                |                             |                    | (.0)                         |

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CONCEPT

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B2-446

APPLIANCE  
CONCEPT

NO. C O N C E P T N A M E

- 1 - MECHANICAL OSCILLATION
- 2 - FLUIDIC AGITATION
- 3 - PISTON AGITATION
- 4 - CYCLIC VALVE AND PUMP AGITATION
- 5 - DIAPHRAM ACTUATED-ONE DIRECTIONAL SQUEEZE
- 6 - DIAPHRAM ACTUATED-TWO DIRECTIONAL SQUEEZE
- 7 - WATER SPRAY AGITATED
- 8 - ULTRASONIC
- 9 - MANUAL DASHBOARD
- 10 - PLAIN RECIRCULATION

(\*)

- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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

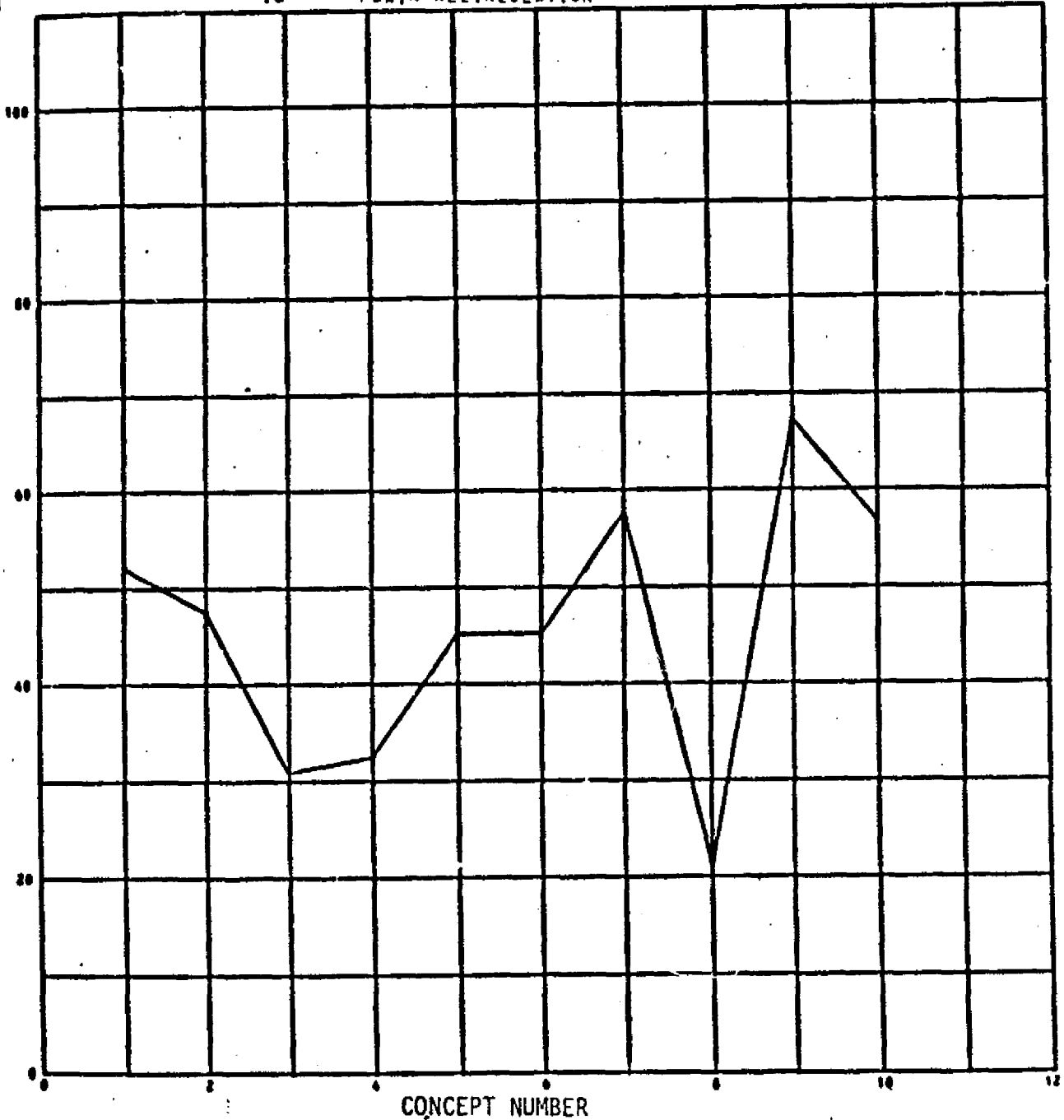
- (1) AVAILABLE
- (2) STATE OF THE ART
- (3) SOME DEVELOPMENT REQUIRED
- (4) EXTENSIVE DEV. REQUIRED

(\*\*\*)COST  
INDICATOR

- 0-25%
- 25-50%
- 50-75%
- 75-100%

D2-118561-3

| APPLIANCE<br>CONCEPT<br>NO. | CONCEPT NAME                              |
|-----------------------------|-------------------------------------------|
| 1                           | MECHANICAL OSCILLATION                    |
| 2                           | FLUIDIC AGITATION                         |
| 3                           | PISTON AGITATION                          |
| 4                           | CYCLIC VALVE AND PUMP AGITATION           |
| 5                           | DIAPHRAM ACTUATED-ONE DIRECTIONAL SQUEEZE |
| 6                           | DIAPHRAM ACTUATED-TWO DIRECTIONAL SQUEEZE |
| 7                           | WATER SPRAY AGITATED                      |
| 8                           | ULTRASONIC                                |
| 9                           | MANUAL WASHBOARD                          |
| 10                          | PLAIN RECIRCULATION                       |



Garment/Linen Washing (Shuttle) Concept Trade



NUMBER OF DAYS = 20.5 (.06 YEARS)  
 USES MOD SUBROUTINE 21  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/STUH) .0250  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/STUH) .0550  
 POWER PENALTY (LBS/WATT) TYPE 1 .5300  
 POWER PENALTY (LBS/WATT) TYPE 2 .4300

SELECTION MATRIX \* \* \* \* \* GARMENT/LINEN WASHING (SHUTTLE)  
 (02/01/75)

| FACTOR   | MIN<br>VALUE | MAX<br>VALUE | PTS | C O N C E P T |       |       |       |       |       |       |       |       |       |
|----------|--------------|--------------|-----|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          |              |              |     | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| WEIGHT   | 429.10       | 1866.1       | 15  | 1.25          | 1.28  | .05   | .00   | 1.42  | 1.47  | 1.25  | 1.17  | 11.55 | 1.25  |
| POWER    | 26.500       | 542.19       | 15  | 12.80         | 12.68 | 7.49  | 7.49  | 14.27 | 14.27 | 12.68 | .00   | 9.99  | 12.38 |
| VOLUME   | 9.7000       | 47.400       | 10  | 7.55          | 7.41  | .00   | .00   | 7.89  | 7.95  | 7.49  | 7.28  | 4.03  | 7.49  |
| THERMAL  | 54.345       | 346.88       | 15  | 7.10          | 7.04  | 6.04  | 6.22  | 7.92  | 7.92  | 7.04  | .00   | 12.65 | 7.04  |
| RELIAB-Y | .99487       | .99894       | 5   | 3.37          | 1.41  | 3.43  | 3.97  | 3.35  | 3.35  | 3.43  | .00   | 3.43  | 3.81  |
| MAINTENC | .99995       | .99999       | 5   | 3.30          | .00   | 3.39  | 4.11  | 3.43  | 3.43  | 3.39  | .78   | 3.40  | 3.84  |
| SAFETY   | .00000       | 3.0000       | 5   | 5.00          | 5.00  | 5.00  | 5.00  | .00   | .00   | 5.00  | 3.33  | 5.00  | 5.00  |
| DEV COST | 40.000       | 95.000       | 15  | 3.95          | 5.53  | .79   | .79   | .00   | .00   | 8.68  | 5.53  | 7.11  | 7.11  |
| TOTAL PT | .00000       | 85.000       | 85  | 44.32         | 40.34 | 26.19 | 27.57 | 38.28 | 38.39 | 48.96 | 18.09 | 57.16 | 48.21 |
| RATING   | .00000       | 100.00       | 100 | 52.14         | 47.46 | 30.81 | 32.44 | 45.03 | 45.17 | 57.60 | 21.28 | 67.24 | 56.72 |

B2-449

D2185613

**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| NORMAL   | 52.14         | 47.46 | 30.81 | 32.44 | 45.03 | 45.17 | 57.60 | 21.28 | 67.24 | 56.72 |
| WEIGHT   | 48.59         | 44.30 | 28.34 | 29.81 | 42.15 | 42.30 | 53.61 | 20.18 | 68.03 | 52.79 |
| POWER    | 54.83         | 50.46 | 32.36 | 33.85 | 49.09 | 49.22 | 59.79 | 19.55 | 67.19 | 58.97 |
| VOLUME   | 53.44         | 48.93 | 29.10 | 30.64 | 46.91 | 47.07 | 58.56 | 24.14 | 65.75 | 57.73 |
| THERMAL  | 51.75         | 47.41 | 31.58 | 33.17 | 45.66 | 45.78 | 56.74 | 19.55 | 68.63 | 55.92 |
| RELIAB-Y | 52.58         | 46.90 | 31.87 | 33.78 | 45.66 | 45.79 | 57.92 | 20.67 | 67.28 | 57.27 |
| MAINTENC | 52.54         | 46.10 | 31.87 | 33.86 | 45.71 | 45.84 | 57.90 | 21.12 | 67.24 | 57.29 |
| SAFETY   | 53.51         | 48.96 | 32.79 | 34.37 | 43.75 | 43.87 | 58.82 | 22.58 | 68.18 | 57.95 |
| DEV COST | 50.05         | 46.60 | 28.74 | 30.23 | 41.38 | 41.50 | 57.63 | 22.54 | 65.63 | 55.96 |

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**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    |
| NORMAL   | 52.14         | 47.46 | 30.81 | 32.44 | 45.03 | 45.17 | 57.60 | 21.28 | 67.24 | 56.72 |
| WEIGHT   | 56.38         | 51.22 | 33.76 | 35.58 | 48.47 | 48.59 | 62.38 | 22.59 | 66.30 | 61.40 |
| POWER    | 48.93         | 43.87 | 28.96 | 30.75 | 40.19 | 40.33 | 55.00 | 23.34 | 67.31 | 54.02 |
| VOLUME   | 50.68         | 45.79 | 32.74 | 34.46 | 42.92 | 43.02 | 56.52 | 18.06 | 68.93 | 55.58 |
| THERMAL  | 52.60         | 47.51 | 29.89 | 31.57 | 44.28 | 44.43 | 58.64 | 23.34 | 65.59 | 57.64 |
| RELIAB-Y | 51.68         | 48.04 | 29.67 | 31.02 | 44.37 | 44.50 | 57.27 | 21.92 | 67.20 | 56.13 |
| MAINTENC | 51.72         | 48.89 | 29.69 | 30.93 | 44.32 | 44.45 | 57.29 | 21.45 | 67.22 | 56.11 |
| SAFETY   | 50.69         | 45.86 | 28.72 | 30.39 | 46.40 | 46.53 | 56.32 | 19.90 | 66.25 | 55.40 |
| DEV COST | 54.64         | 48.48 | 33.28 | 35.07 | 49.39 | 49.54 | 57.58 | 19.77 | 69.17 | 57.62 |

D2-118561-3

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.3.1-GARMENT/LINEN/WASHING

| COMPONENT TYPE<br>APPLIANCE TYPE                     | NUMBER OF COMPONENTS |       |      |                |             |                     |                 |              |                |        |                 |                    |                   |            |                           | NUMBER OF SAFETY CRITICAL ITEMS |                            |
|------------------------------------------------------|----------------------|-------|------|----------------|-------------|---------------------|-----------------|--------------|----------------|--------|-----------------|--------------------|-------------------|------------|---------------------------|---------------------------------|----------------------------|
|                                                      | NO.                  | MOTOR | PUMP | SOLENOID VALVE | ACCUMULATOR | ACCUMULATOR BLADDER | WATER SEPARATOR | TRANSMISSION | FLUIDIC SWITCH | FILTER | ELECTRIC SWITCH | PRESSURE REGULATOR | VALVE (PNEUMATIC) | CONTROLLER | HIGH FREQUENCY CONTROLLER |                                 | ELECTROACOUSTIC TRANSDUCER |
|                                                      | ①                    | ②     | ③    | ④              | ⑤           | ⑥                   | ⑦               | ⑧            | ⑨              | ⑩      | ⑪               | ⑫                  | ⑬                 | ⑭          | ⑮                         | ○                               |                            |
| NONDISPOSABLE CLOTHES                                | -                    | -     | -    | -              | -           | -                   | -               | -            | -              | -      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| MECHANICAL OSCILLATION (pg. 21)                      | 2                    | 1     | 2    | 2              | -           | 1                   | 1               | -            | 1              | 4      | -               | -                  | -                 | -          | -                         | -                               | 1                          |
| FLUIDIC AGITATION (pg. 24)                           | 5                    | 2     | 2    | 2              | -           | 1                   | -               | 10           | 1              | 7      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| PISTON AGITATION (pg. 27)                            | 2                    | 1     | 2    | 2              | -           | 1                   | -               | -            | 1              | 4      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| CYCLIC VALVE AND PUMP (pg. 29)                       | -                    | 1     | 2    | 2              | -           | 1                   | -               | -            | -              | 3      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| DIAPHRAGM ACTIVATED-ONE DIRECTIONAL SQUEEZE (pg. 31) | -                    | 1     | 2    | -              | 2           | 1                   | -               | -            | -              | 4      | 1               | 1                  | 1                 | -          | -                         | -                               | 3                          |
| DIAPHRAGM ACTIVATED-TWO DIRECTIONAL SQUEEZE (pg. 24) | -                    | 1     | 2    | -              | 2           | 1                   | -               | -            | -              | 4      | 1               | 1                  | 1                 | -          | -                         | -                               | 3                          |
| WATER SPRAY AGITATED (pg. 36)                        | 2                    | 1     | 2    | 2              | -           | 1                   | -               | -            | 1              | 4      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| ULTRASONIC WASHER (pg. 38)                           | 2                    | 1     | 2    | 2              | -           | 1                   | -               | -            | -              | 4      | -               | -                  | -                 | 1          | 1                         | -                               | 1                          |
| MANUAL WASHBOARD (pg. 41)                            | 2                    | 1     | 2    | 2              | -           | 1                   | -               | -            | -              | 4      | -               | -                  | -                 | -          | -                         | -                               | 0                          |
| PLAIN RECIRCULATION (pg. 45)                         | 1                    | 1     | 2    | 2              | -           | 1                   | -               | -            | 1              | 3      | -               | -                  | -                 | -          | -                         | -                               | 0                          |

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D2-118561-3

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Garment/Line Maintenance

APPLIANCE FUNCTION Garment/Linen Washing

APPLIANCE CONCEPT NO./TITLE 1/Mechanical Oscillation

INDEX NO. 3.3.1.1

REF. NO. 90

DESCRIPTION

This concept is similar to a conventional washer. A central agitator provides the washing either by rotational or translational oscillation. A high-speed rotation extracts wash and rinse water and is used to spin dry the clothes before final drying.





D2-118561-3

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 2/Fluidic Agitation  
INDEX NO. 3.3.1.2 REF. NO. 90

DESCRIPTION

In this concept, water is sprayed through a central column of stacked fluidic switches which direct water in alternating directions through jets. A high-speed rotation extracts wash and rinse water, and is used to spin-dry the clothes before final drying.







SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washing  
 APPLIANCE CONCEPT NO./TITLE 3/Piston Agitation  
 INDEX NO. 3.3.1.3 REF. NO. 90

## DESCRIPTION

In this concept, two pistons are actuated alternately to pump water back and forth within the drum. Screens are added to increase turbulence and to contain the clothing within the drum.

Since there is no spin-dry capability, it was assumed, as recommended in Reference 90, that 0.91 kg (2.0 lbs) of water are left in the clothes over and above the water left by the other concepts after spin-dry. Therefore, a dryer penalty was assumed to handle this added water. For this purpose, the dryer concept 3.3.2.1 was assumed (forced hot air electric) since it had already been selected in the past (Reference 237) to build a prototype clothes dryer. Since the dryer penalties were based on removing .302 kg (.667 lb) of water, and this washer concept has 0.91 kg (2.0 lb) extra water to be dried, all the penalties for dryer concept 3.3.2.1 were multiplied by 3 and added to the penalties for this clothes wash concept. The peak electrical power and thermal requirements were the maximum for the washer and assumed dryer rather than the sum of the two.





D2-118561-3

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 4/Cyclic Valve and Pump  
INDEX NO. 3.3.1.4 REF. NO. 90

DESCRIPTION

This concept is identical in operation to #3 (Piston Agitation), except that the water pumping is accomplished by a pump and cyclic valve rather than opposing pistons. Screens are included to contain the clothing within the drum as well as to increase turbulence.

No spin-dry capability was assumed, just as in concept #3, and again 0.91 kg (2.0 lb) additional water was assumed to require drying. This was handled in the same manner as was explained in concept #3; thus, all the penalties for dryer concept #3.3.2.1 were multiplied by 3 and added to the penalties for this clothes washer concept.





SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 5/Diaphragm Actuated - One Directional Squeeze  
INDEX NO. 3.3.1.5 REF. NO. 90

## DESCRIPTION

This concept utilizes compressible diaphragms, operated by pressurized nitrogen, to alternately squeeze and soak the clothes. Wash and rinse water are removed at the end of each cycle by simultaneously pressurizing both diaphragms. This concept has been shown to be feasible, but its cleaning effectiveness remains to be proven by further testing.





# D2-118561-3

## APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Diaphragm actuated - one directional squeeze

INDEX NUMBER 2.3.1.5

### FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT          | (REF) | WEIGHT (LBS)      | VOLUME (FT <sup>3</sup> )         |
|--------------------|-------|-------------------|-----------------------------------|
| Basic washer       |       |                   |                                   |
| Pump               |       |                   |                                   |
| 2 Accumulators     |       |                   |                                   |
| Valves             |       |                   |                                   |
| Water separator    |       |                   |                                   |
| Control lines      |       |                   |                                   |
| Pressure regulator |       |                   |                                   |
| Cyclic valve       |       |                   |                                   |
| Packaging          |       |                   |                                   |
| Miscellaneous      |       |                   |                                   |
| <b>TOTAL</b>       |       | <b>46.7 (103)</b> | <b>.283 (10.0)</b>                |
|                    |       | KG (LBS)          | M <sup>3</sup> (FT <sup>3</sup> ) |

### SOLID EXPENDABLE WT/VOL REQUIREMENTS

| TYPE                | ①<br>UNITS/CYCLE(REF) | ②<br>WT/UNIT (REF)<br>(PKG.WT/UNIT)(REF)<br>(LB) | ③<br>WT/CYCLE<br>① x ②<br>(LB) | ④<br>VOL/UNIT (REF)<br>(PKG.VOL/UNIT)(REF)<br>(FT <sup>3</sup> ) | ⑤<br>VOL/CYCLE<br>① x ④<br>(FT <sup>3</sup> )  |
|---------------------|-----------------------|--------------------------------------------------|--------------------------------|------------------------------------------------------------------|------------------------------------------------|
| Detergent/germicide |                       |                                                  |                                |                                                                  |                                                |
|                     |                       |                                                  |                                |                                                                  |                                                |
|                     |                       |                                                  |                                |                                                                  |                                                |
|                     |                       |                                                  |                                |                                                                  |                                                |
|                     |                       |                                                  |                                |                                                                  |                                                |
|                     |                       | Σ ③                                              | .044<br>TOTAL WT/CYCLE<br>(LB) | Σ ⑤                                                              | .0013<br>TOTAL VOL/CYCLE<br>(FT <sup>3</sup> ) |

TOTAL WT. MISSION =  $\frac{\text{CYCLES/DAY}}{\text{CYCLES/DAY}} \times \frac{\text{DAYS/MISSION}}{\text{DAYS/MISSION}} \times \frac{\text{TOT. WT./CYCLE (LB)}}{\text{TOT. WT./CYCLE (LB)}} = \frac{0.82}{\text{KG (LB)}} \text{ (1.8)}$

TOTAL VOL. MISSION =  $\frac{\text{CYCLES/DAY}}{\text{CYCLES/DAY}} \times \frac{\text{DAYS/MISSION}}{\text{DAYS/MISSION}} \times \frac{\text{TOT. VOL./CYCLE (FT}^3\text{)}}{\text{TOT. VOL./CYCLE (FT}^3\text{)}} = \frac{0.0015}{\text{M}^3 \text{ (FT}^3\text{)}} \text{ (.053)}$

### GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE                      | ①<br>AMT. USED/CYCLE(REF)<br>(LB) | ②<br>RECOVERY<br>FACTOR | ③<br>AMT. RECOVERED/CYCLE<br>① x ②<br>(LB) | ④<br>AMT LOST/CYCLE<br>① - ③<br>(LB) |
|---------------------------|-----------------------------------|-------------------------|--------------------------------------------|--------------------------------------|
| Wash water                | 36.7                              | 0                       | 0                                          | 36.7                                 |
| Rinse water               | 36.7                              | 1                       | 36.7                                       | 0                                    |
| N <sub>2</sub> pressurant | 0.2                               | 0                       | 0                                          | 0.2                                  |
|                           |                                   |                         |                                            |                                      |
|                           |                                   |                         |                                            |                                      |
|                           | Σ ①                               |                         | Σ ④                                        | 36.9                                 |

TOTAL WT. MISSION =  $\frac{2}{\text{CYCLE/DAY}} \times \frac{20.5}{\text{DAYS/MISSION}} \times \frac{36.9}{\text{TOTAL TOST/CYCLE (LB)}} \cdot 1513 + \frac{73.5}{\text{KG (LB)}} = \frac{720}{\text{KG (LB)}} \text{ (1586)}$

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 6/Diaphragm Actuated - Two Directional Squeeze  
INDEX NO. 3.3.1.6 REF. NO. 90

## DESCRIPTION

This concept is similar to concept #5 except that the clothes are stored in two tanks. Pressurized diaphragms are again used to alternately squeeze and soak the clothes. As in concept #5, cleaning effectiveness remains to be proven by further testing.





D2-118561-3

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION

Garment/Linen  
Maintenance

APPLIANCE FUNCTION Garment/Linen Washing

APPLIANCE CONCEPT NO./TITLE 7/Water Spray Agitation

INDEX NO. 3.3.1.7

REF. NO. 90

DESCRIPTION

In this concept, a high velocity jet of water is sprayed into a wire mesh drum from the outer circumference. The drum is slowly rotated to allow continuous removal of the water. A high speed spin cycle is used to remove the excess water after washing and rinsing.







D2-118561-3

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 8/Ultrasonic  
INDEX NO. 3.3.1.8 REF. NO. 90

DESCRIPTION

In this concept, ultrasonic energy is used to wash the clothes. A damping factor of 2 was assumed, which probably results in a gross underestimate of the actual electrical power required. The amount of water required was assumed to be the same as for the other washing concepts.





SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washing  
 APPLIANCE CONCEPT NO./TITLE 9/Manual Washboard  
 INDEX NO. 3.3.1.9 REF. NO. 90

## DESCRIPTION

Due to the large amount of crew time required to manually wash clothes, this concept was not felt to be practical. However, it was included for comparison purposes with the automatic concepts. A zippered, Teflon bag is used to contain the clothes and water. The crewman manipulates the bag to achieve washing, and squeezes it to rinse and remove excess water. It was assumed that only 3.02 kg (6.67 lb) of wash and 3.02 kg (6.67 lb) of rinse water are required. It was estimated 0.60 kg (1.33 lb) of water will be left in the clothes after final rinsing, over and above the amount left by the other concepts. This water is treated in the same manner as for concept #4; that is, the penalties for clothes dryer concept #1 were multiplied by 2 and added to the penalties for this clothes washing concept.





D2-118561-3

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Washing  
APPLIANCE CONCEPT NO./TITLE 10/Plain Recirculation  
INDEX NO. 3.3.1.10 REF. NO. 90

DESCRIPTION

In this concept, water is simply recirculated through the clothes washing tub, with no means to vigorously agitate the water. Cleaning effectiveness is, therefore, relatively poor, and its adequacy would have to be proven by further testing. A spin dry cycle is used to remove the excess water after washing and rinsing.







HABITABILITY SUBSYSTEM 3.0 HousekeepingHABITABILITY FUNCTION 3.3 Garment/Linen MaintenanceAPPLIANCE FUNCTION 3.3.2 Garment/Linen DryingNUMBER OF CONCEPTS CONSIDERED 9

## ASSUMPTIONS

A number of references were found which present data for various clothes washer and dryer concepts (References 70, 90, 91, 100, 127, 161, 171, 185, 202, 237 and 245). These references were reviewed in detail, and the engineering data from each examined. It was soon found that much of the data did not agree. The primary reason for discrepancies was that the data were mostly very sketchy, without detailed breakdowns to define the data. For example, the clothes dryer weight in one reference would include the tub only, while another would include peripheral equipment such as heat exchanger, water separator, or other miscellaneous items. One reference was found (Ref. 90) which contained all the concepts found throughout the other reports and presented the data for each in a consistent manner for direct comparison. Therefore, it was decided to collect all the clothes washer and dryer data for this study from Reference 90.

All the clothes dryer engineering data used for Space Station were used directly for Shuttle also after adjusting for a crew size of 4 men (Space Station crew was 6 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.

Two clothes washings/dryings per day were assumed. For most concepts, the drying time can be varied by sizing the hardware; e.g., one could choose a large heater for fast drying, or a smaller heater for slower drying. Based on the recommendation of Reference 237, a drying time of 4 hours was assumed for these cases. The dryer was assumed to remove 0.302 kg (0.67 lb) of residual water from the clothes according to Reference 90. More testing is required to refine this assumption; however, data from Reference 202 indicate this amount of water may be too high. Where applicable, ambient conditions are assumed to be 760 mm Hg (14.7 psia), 21.1°C (70°F) and 50 percent relative humidity. Wherever a component is connected directly to the cabin cooling circuit, it is assumed 85 percent of the energy transferred goes to the cooling circuit and 15 percent is heat leak to the cabin atmosphere.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.3.2 \*\*\* GARMENT/LINEN DRYING (SHUTTLE)

| CONCEPT NO. | USAGE TIME | CONSUMABLES AND FLOW REQUIREMENTS |          |        |         |          | THERMAL REQTS |         | ELEC PWR REQTS |          | WT/VOL REQMS |       | DEVELOPMENT COST |        | RESUPPLY |
|-------------|------------|-----------------------------------|----------|--------|---------|----------|---------------|---------|----------------|----------|--------------|-------|------------------|--------|----------|
|             |            | AMT                               | FLOW     | PRESS  | TEMP    | COOLANT  | HT LEAK       | AC DC   | AC DC          | WEIGHT   | VOLUME       | AVAIL | INDX             | WEIGHT |          |
| USES/DAY    | TYPE       | USED                              |          |        |         |          |               |         |                |          |              |       |                  |        |          |
| MRS/USE     | (#)        | (KG/USE)                          | (#)      | (PSIG) | (DEG F) | (BTU/HR) | (BTU/HR)      | DC      | DC             | KG       | CU FT        | (#)   | (#)              | (LBS)  |          |
| (LB/USE)    |            |                                   |          |        |         |          |               | -WATTS- | -WATTS-        | (LBS)    | (CU FT)      |       |                  | (LBS)  |          |
| 1           | 2.000      |                                   |          |        |         | 132.     | 71.           | 48.0    | .0             | 24.0     | .33          | 2     | 30               | .0     |          |
|             | 4.000      |                                   |          |        |         | ( 450.)  | ( 242.)       | 151.0   | .0             | ( 53.0)  | ( 11.70)     |       |                  | ( .0)  |          |
| 2           | 2.000      |                                   |          |        |         | 219.     | 100.          | 62.0    | .0             | 54.4     | .43          | 3     | 65               | .0     |          |
|             | 4.000      |                                   |          |        |         | ( 747.)  | ( 343.)       | .0      | .0             | ( 120.0) | ( 15.10)     |       |                  | ( .0)  |          |
| 3           | 2.000      | 2                                 | .0014    | .00    | .0      | .0       | 44.           | 91.3    | .0             | 35.2     | .39          | 3     | 60               | .0     |          |
|             | 4.000      |                                   | ( .0031) | ( .00) | ( .0)   | ( .0)    | ( 217.)       | .0      | .0             | ( 77.6)  | ( 13.60)     |       |                  | ( .0)  |          |
|             |            | 5                                 | .2404    | .00    | .0      |          |               |         |                |          |              |       |                  |        |          |
|             |            |                                   | ( .5300) | ( .00) | ( .0)   | ( .0)    |               |         |                |          |              |       |                  |        |          |
| 4           | 2.000      |                                   |          |        |         | 59.      | 64.           | 91.3    | .0             | 23.1     | .34          | 3     | 60               | .0     |          |
|             | 4.000      |                                   |          |        |         | ( 200.)  | ( 217.)       | 67.3    | .0             | ( 51.0)  | ( 11.90)     |       |                  | ( .0)  |          |
| 5           | 2.000      | 2                                 | .0231    | .00    | .0      | .0       | .0            | 36.7    | .0             | 24.8     | .15          | 2     | 30               | .0     |          |
|             | 3.175      |                                   | ( .0510) | ( .00) | ( .0)   | ( .0)    | ( .0)         | .0      | .0             | ( 59.0)  | ( 5.40)      |       |                  | ( .0)  |          |
|             |            | 5                                 | .2404    | .00    | .0      |          |               |         |                |          |              |       |                  |        |          |
|             |            |                                   | ( .5300) | ( .00) | ( .0)   | ( .0)    |               |         |                |          |              |       |                  |        |          |
| 6           | 2.000      | 2                                 | .0231    | .00    | .0      | .0       | 9.            | 36.7    | .0             | 31.3     | .17          | 2     | 35               | .0     |          |
|             | 4.000      |                                   | ( .0510) | ( .00) | ( .0)   | ( .0)    | ( 30.)        | 60.0    | .0             | ( 69.0)  | ( 6.00)      |       |                  | ( .0)  |          |
|             |            | 5                                 | .2404    | .00    | .0      |          |               |         |                |          |              |       |                  |        |          |
|             |            |                                   | ( .5300) | ( .00) | ( .0)   | ( .0)    |               |         |                |          |              |       |                  |        |          |
| 7           | 2.000      | 2                                 | .0231    | .00    | .0      | .0       | 9.            | 36.7    | .0             | 35.8     | .20          | 3     | 70               | .0     |          |
|             | 4.000      |                                   | ( .0510) | ( .00) | ( .0)   | ( .0)    | ( 30.)        | .0      | .0             | ( 79.0)  | ( 7.00)      |       |                  | ( .0)  |          |
|             |            | 5                                 | .2404    | .00    | .0      |          |               |         |                |          |              |       |                  |        |          |
|             |            |                                   | ( .5300) | ( .00) | ( .0)   | ( .0)    |               |         |                |          |              |       |                  |        |          |
| 8           | 2.000      |                                   |          |        |         | .0       | 31.           | 4.7     | .0             | 15.1     | 2.48         | 1     | 5                | .0     |          |
|             | 8.000      |                                   |          |        |         | ( .0)    | ( 105.)       | .0      | .0             | ( 33.3)  | ( 87.70)     |       |                  | ( .0)  |          |
| 9           | 2.000      |                                   |          |        |         | .0       | 172.          | 2.0     | .0             | 12.1     | 2.64         | 1     | 10               | .0     |          |
|             | 4.000      |                                   |          |        |         | ( .0)    | ( 589.)       | 171.0   | .0             | ( 26.7)  | ( 93.30)     |       |                  | ( .0)  |          |

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APPLIANCE  
CONCEPT

NO. CONCEPT NAME

- 1 - FORCED HOT AIR-ELECTRIC
- 2 - FORCED HOT AIR-HEAT FROM THERMAL STORAGE UNIT
- 3 - FORCED COLD DRY AIR-DISICCANT(VACUUM REGENERABLE)
- 4 - FORCED COLD DRY AIR-DISICCANT(ELECTRIC HEAT REGENERABLE)
- 5 - VACUUM DRY
- 6 - THERMAL VACUUM DRY-ELECTRIC HEAT
- 7 - THERMAL VACUUM DRY-THERMAL STORAGE/RADIANT HEAT
- 8 - CLOTHES LINE-FORCED CONVECTION
- 9 - CLOTHES LINE-FORCED CONVECTION-ELECTRIC HEAT

(\*)

- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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

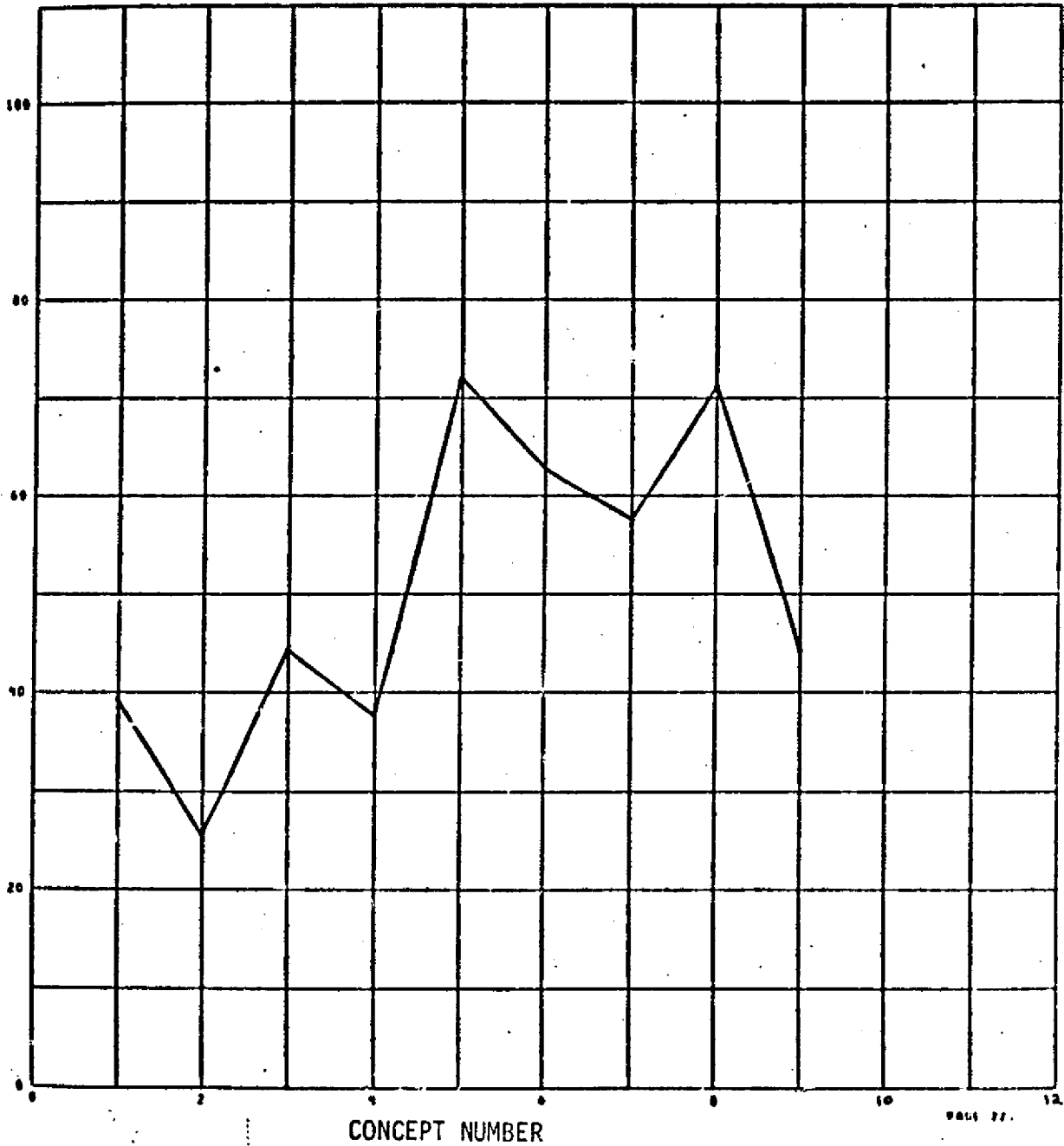
- (1) AVAILABLE
- (2) STATE OF THE ART
- (3) SOME DEVELOPMENT REQUIRED
- (4) EXTENSIVE DEV. REQUIRED

(\*\*\*)COST  
INDICATOR

- 0-25%
- 25-50%
- 50-75%
- 75-100%

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| APPLIANCE<br>CONCEPT<br>NO. | CONCEPT NAME                                              |
|-----------------------------|-----------------------------------------------------------|
| 1                           | FORCED HOT AIR-ELECTRIC                                   |
| 2                           | FORCED HOT AIR-HEAT FROM THERMAL STORAGE UNIT             |
| 3                           | FORCED COLD DRY AIR-DESICCANT (VACUUM REGENERABLE)        |
| 4                           | FORCED COLD DRY AIR-DESICCANT (ELECTRIC HEAT REGENERABLE) |
| 5                           | VACUUM DRY                                                |
| 6                           | THERMAL VACUUM DRY-ELECTRIC HEAT                          |
| 7                           | THERMAL VACUUM DRY-THERMAL STORAGE/RADIANT HEAT           |
| 8                           | CLOTHES LINE-FORCED CONVECTION                            |
| 9                           | CLOTHES LINE-FORCED CONVECTION-ELECTRIC HEAT              |



Garment/Linen Drying (Shuttle) Concept Trade

NUMBER OF DAYS = 20.5 (.06 YEARS)  
 USES MOD SUBROUTINE 22  
 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 . . . . . GARMENT/LINEN DRYING (SHUTTLE)  
 (01/25/75)

| FACTOR   | MIN<br>VALUE | MAX<br>VALUE | PTS | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|--------------|--------------|-----|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          |              |              |     | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| WEIGHT   | 26.700       | 120.00       | 15  | 8.37          | .00   | 5.31  | 8.52  | 7.62  | 6.37  | 5.12  | 10.84 | 11.66 |
| POWER    | 2.4910       | 90.370       | 15  | .00           | 9.55  | 6.97  | 2.16  | 11.77 | 7.49  | 11.77 | 14.59 | 2.62  |
| VOLUME   | 5.4000       | 93.300       | 10  | 8.75          | 8.38  | 8.54  | 8.72  | 9.42  | 9.36  | 9.25  | .60   | .00   |
| THERMAL  | .00000       | 37.540       | 15  | 5.19          | .00   | 10.23 | 8.23  | 15.00 | 14.34 | 14.34 | 12.69 | 2.04  |
| RELIAB-Y | .99597       | .99958       | 5   | .68           | .83   | .84   | .49   | 4.48  | 4.14  | 4.30  | .00   | 2.29  |
| MAINTENC | .99999       | 1.00000      | 5   | .20           | .27   | .39   | .00   | 4.33  | 4.17  | 4.25  | 2.87  | 2.71  |
| SAFETY   | .00000       | 3.0000       | 5   | 1.67          | 1.67  | 3.33  | 1.67  | .00   | .00   | .00   | 5.00  | 3.33  |
| DEV COST | 5.0000       | 70.000       | 15  | 8.57          | 1.07  | 2.14  | 2.14  | 8.57  | 7.50  | .00   | 13.93 | 12.86 |
| TOTAL PT | .00000       | 85.000       | 85  | 33.42         | 21.77 | 37.75 | 32.05 | 61.20 | 53.37 | 49.03 | 60.52 | 37.53 |
| RATING   | .00000       | 100.00       | 100 | 39.32         | 25.62 | 44.42 | 37.70 | 72.00 | 62.79 | 57.68 | 71.20 | 44.16 |

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**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| NORMAL   | 39.32         | 25.62 | 44.42 | 37.70 | 72.00 | 62.79 | 57.68 | 71.20 | 44.16 |
| WEIGHT   | 40.66         | 23.54 | 43.68 | 39.31 | 70.28 | 61.14 | 55.77 | 71.28 | 46.88 |
| POWER    | 36.13         | 28.70 | 44.58 | 35.82 | 72.52 | 61.75 | 59.37 | 73.31 | 41.99 |
| VOLUME   | 41.99         | 28.85 | 46.70 | 40.46 | 73.23 | 64.50 | 59.61 | 67.58 | 41.70 |
| THERMAL  | 38.94         | 23.54 | 46.35 | 39.10 | 74.27 | 65.45 | 60.75 | 72.29 | 41.69 |
| RELIAB-Y | 38.58         | 25.36 | 43.63 | 36.91 | 72.50 | 63.36 | 58.49 | 69.16 | 44.21 |
| MAINTENC | 38.31         | 25.04 | 43.37 | 36.63 | 72.42 | 63.38 | 58.46 | 70.81 | 44.44 |
| SAFETY   | 39.15         | 25.84 | 45.05 | 37.58 | 69.94 | 60.99 | 56.03 | 72.02 | 44.80 |
| DEV COST | 40.76         | 24.12 | 41.97 | 35.80 | 70.79 | 61.75 | 53.00 | 72.95 | 47.53 |

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**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| NORMAL   | 39.32         | 25.62 | 44.42 | 37.70 | 72.00 | 62.79 | 57.68 | 71.20 | 44.16 |
| WEIGHT   | 37.72         | 28.09 | 45.29 | 35.79 | 74.05 | 64.75 | 59.96 | 71.10 | 40.90 |
| POWER    | 43.12         | 21.94 | 44.22 | 39.95 | 71.37 | 64.03 | 55.67 | 68.68 | 46.74 |
| VOLUME   | 36.31         | 21.98 | 41.85 | 34.61 | 70.61 | 60.86 | 55.50 | 75.27 | 46.92 |
| THERMAL  | 39.78         | 28.09 | 42.11 | 36.04 | 69.29 | 59.61 | 54.01 | 69.90 | 47.10 |
| RELIAB-Y | 40.10         | 25.89 | 45.26 | 38.55 | 71.47 | 62.18 | 56.82 | 73.36 | 44.10 |
| MAINTENC | 40.39         | 26.23 | 45.52 | 38.85 | 71.55 | 62.16 | 56.85 | 71.61 | 43.85 |
| SAFETY   | 39.50         | 25.38 | 43.74 | 37.84 | 74.18 | 64.69 | 59.43 | 70.33 | 43.47 |
| DEV COST | 37.59         | 27.40 | 47.33 | 39.97 | 73.44 | 64.03 | 63.26 | 69.10 | 40.13 |

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.3.2-GARMENT/LINEN DRYING

| COMPONENT TYPE                                                    |     | NUMBER OF COMPONENTS |             |                 |                |           |            |        |                         |                  |                      |       |                    |   |   |   | NUMBER OF SAFETY CRITICAL ITEMS |   |
|-------------------------------------------------------------------|-----|----------------------|-------------|-----------------|----------------|-----------|------------|--------|-------------------------|------------------|----------------------|-------|--------------------|---|---|---|---------------------------------|---|
|                                                                   |     | MOTOR                | ACCUMULATOR | WATER SEPARATOR | HEAT EXCHANGER | HEATER DC | BLOWER AIR | FILTER | TRANSMISSION (GEAR BOX) | CONTROLLER TIMER | THERMAL STORAGE UNIT | VALVE | DESICCANT CANISTER |   |   |   |                                 |   |
| APPLIANCE TYPE                                                    | NO. | ①                    | ④           | ⑥               | ⑬              | ⑰         | ⑱          | ⑨      | ⑦                       | ⑲                | ⑳                    | ③     | ⑵                  | ○ | ○ | ○ | ○                               |   |
| FORCED HOT AIR-ELECTRIC (pg. 51)                                  | 1   | 1                    | 1           | 1               | 1              | 1         | 1          | 1      | 1                       | 1                | -                    | -     | -                  |   |   |   |                                 | 2 |
| FORCED HOT AIR-HEAT FROM THERMAL STORAGE UNIT (pg. 55)            | 1   | 1                    | 1           | 1               | -              | 1         | 1          | 1      | 1                       | 1                | 1                    | -     | -                  |   |   |   |                                 | 2 |
| FORCED COLD DRY AIR-DESICCANT-VACUUM REGENERABLE (pg. 58)         | 1   | 1                    | -           | -               | -              | 1         | 1          | 1      | 1                       | 1                | -                    | 2     | 1                  |   |   |   |                                 | 1 |
| FORCED COLD DRY AIR-DESICCANT ELECTRIC HEAT REGENERATION (pg. 61) | 1   | 1                    | 1           | 1               | 1              | 1         | 1          | 1      | 1                       | 1                | -                    | 1     | 1                  |   |   |   |                                 | 2 |
| VACUUM DRY (pg. 64)                                               | -   | 1                    | -           | -               | -              | -         | -          | -      | -                       | 1                | -                    | 1     | -                  |   |   |   |                                 | 3 |
| THERMAL VACUUM DRY-ELECTRIC HEAT (pg. 65)                         | -   | 1                    | -           | -               | 1              | -         | -          | -      | -                       | 1                | -                    | 1     | -                  |   |   |   |                                 | 3 |
| THERMAL/VACUUM DRY-THERMAL STORAGE/RADIANT HEAT (pg. 68)          | -   | 1                    | -           | -               | -              | -         | -          | -      | -                       | 1                | 1                    | 1     | -                  |   |   |   |                                 | 3 |
| CLOTHES LINE-FORCED CONVECTION (pg. 72)                           | -   | -                    | 1           | 1               | -              | 1         | -          | -      | -                       | -                | -                    | -     | -                  |   |   |   |                                 | 0 |
| CLOTHES LINE-FORCED CONVECTION + ELECTRIC HEAT (pg. 74)           | -   | -                    | 1           | 1               | 1              | 1         | -          | -      | -                       | -                | -                    | -     | -                  |   |   |   |                                 | 1 |

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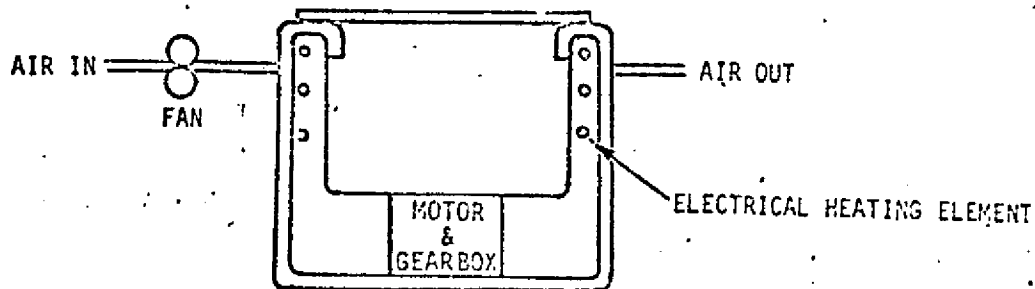
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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Drying  
APPLIANCE CONCEPT NO./TITLE 1/Forced Hot Air - Electric  
INDEX NO. 3.3.2.1 REF. NO. 90

## DESCRIPTION

In this concept, a jet of air spray at 60°C (140°F) is directed into the clothes from outside the drum. The clothes are contained in a wire mesh drum which is rotated slowly in a direction counter to the air inlet. A prototype clothes dryer using this concept is described in Reference 237.



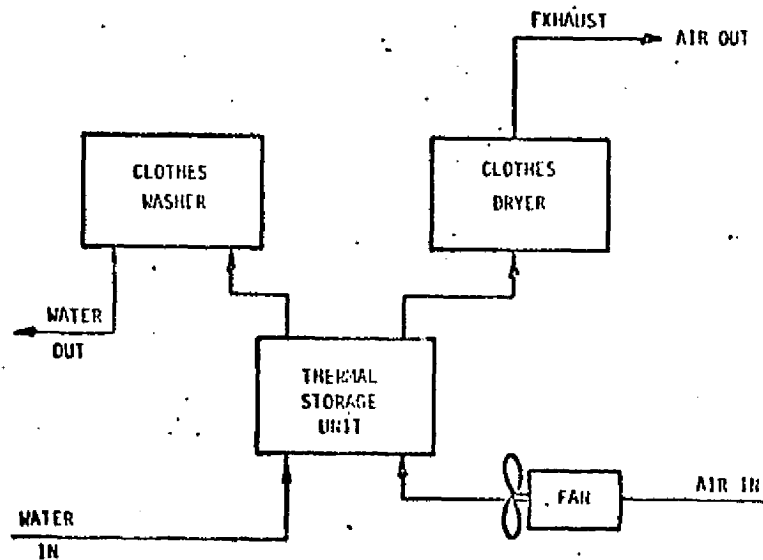




SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen MaintenanceAPPLIANCE FUNCTION Garment/Linen DryingAPPLIANCE CONCEPT NO./TITLE 2/Forced Hot Air - Thermal StorageINDEX NO. 3.3.2.2REF. NO. 90

## DESCRIPTION

This dryer concept is the same as Concept 1 except the electrical heater is replaced by a thermal storage unit which utilizes waste heat from the wash/rinse cycle. This concept should receive a credit for cooling the clothes washer water; however, this has been neglected. Clothes are dried by air at  $49^{\circ}\text{C}$  ( $120^{\circ}\text{F}$ ) from the thermal storage unit directed into the slowly revolving wire mesh drum.



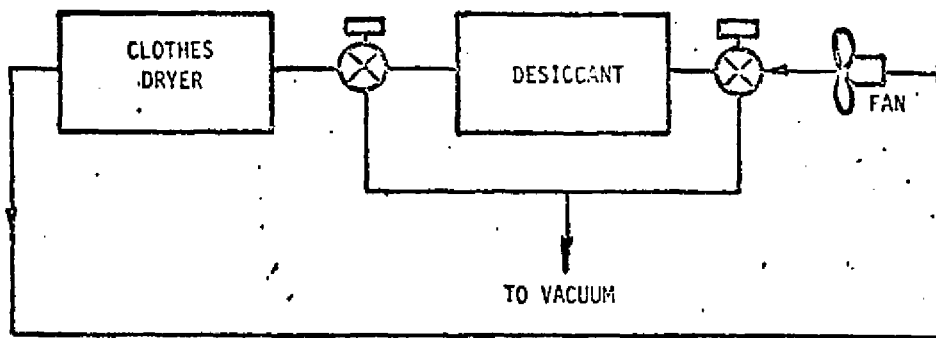




SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION: Garment/Linen Drying  
APPLIANCE CONCEPT NO./TITLE 3/Forced Cold Dry Air-Desiccant-Vacuum Regenerable  
INDEX NO. 3.3.2.3 REF. NO. 90

DESCRIPTION

In this concept, a closed loop of air circulates through a silica gel desiccant bed, where it is dried, and then through the clothes dryer tub where it dries the clothes. After the clothes are dried, space vacuum is used to dry the desiccant. The fan size is selected based on a 4-hour clothes drying time, and 4 hours are assumed for desiccant vacuum regeneration.









SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

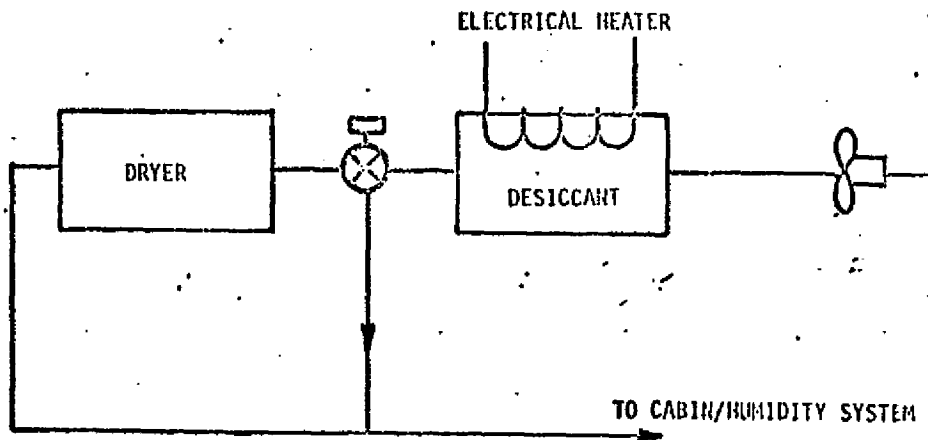
APPLIANCE FUNCTION Garment/Linen Drying

APPLIANCE CONCEPT NO./TITLE 4/Forced Cold Air-Desiccant-Heat Regenerable

INDEX NO. 3.3.2.4 REF. NO. 90

DESCRIPTION

This concept is identical to Concept 3 except that the desiccant is regenerated by an electrical heater instead of vacuum.



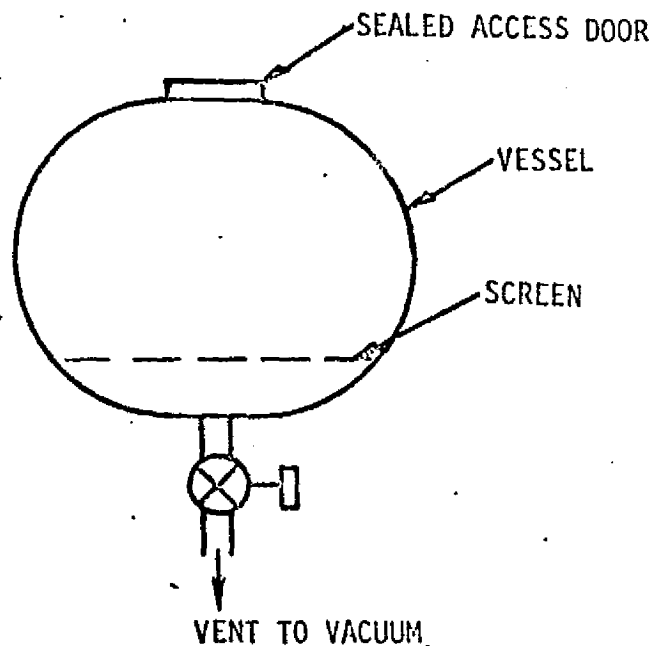




SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Drying  
APPLIANCE CONCEPT NO./TITLE 5/Vacuum Dry  
INDEX NO. 3.3.2.5 REF. NO. 90

## DESCRIPTION

In this concept, clothes are simply sealed in a tub which is vented to space vacuum. The water will first freeze due to rapid evaporation, after which the ice will gradually sublime from the heat of conduction and radiation through the structural walls. Drying time is assumed, according to Reference 90, to be 6.35 hours.



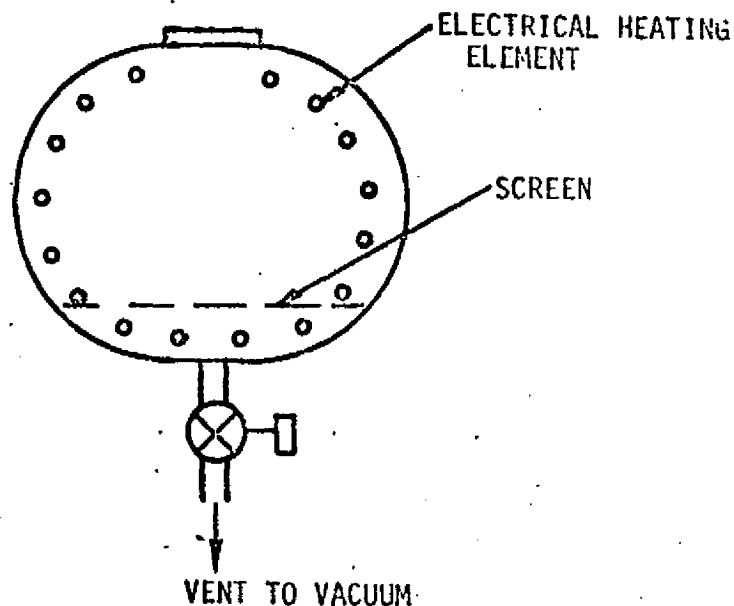




SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen Drying  
APPLIANCE CONCEPT NO./TITLE 6-Thermal Vacuum Dry - Electric Heat  
INDEX NO. 3.3.2.6 REF. NO. 90

## DESCRIPTION

This concept is identical to Concept 5 except that an electrical heater has been added to provide additional heat to aid the sublimation process. Heater size was based on a drying time of 4 hours to be consistent with the other concepts.





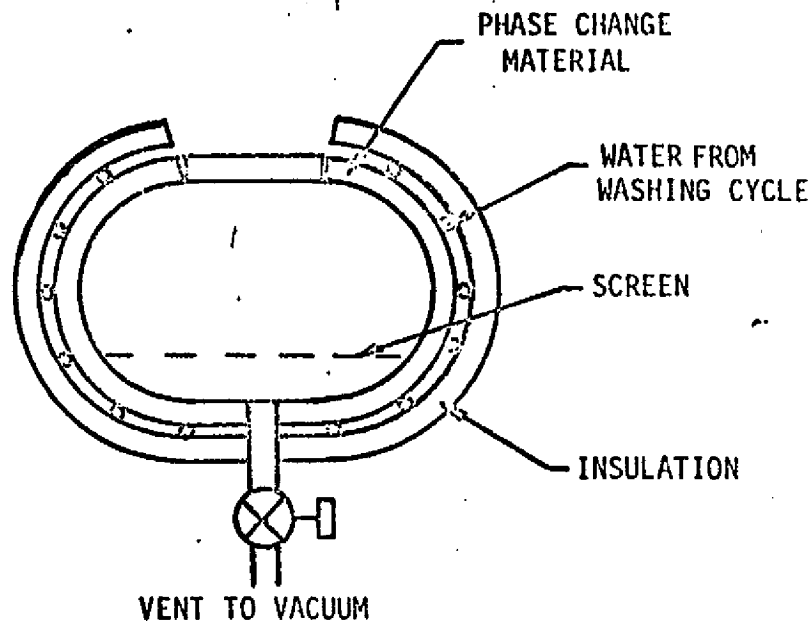




SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Drying  
 APPLIANCE CONCEPT NO./TITLE 7/Thermal Vacuum Dry-Thermal Storage-Radiant Heat  
 INDEX NO. 3.3.2.7 REF. NO. 90

## DESCRIPTION

This concept is identical to Concept 6 except that the electrical heater is replaced by a thermal storage unit which stores the heat from the wash and rinse water. Clothes are sealed in a tub which is vented to space vacuum, and the energy required for sublimation provided by the thermal storage unit. A drying time of 4 hours was assumed.



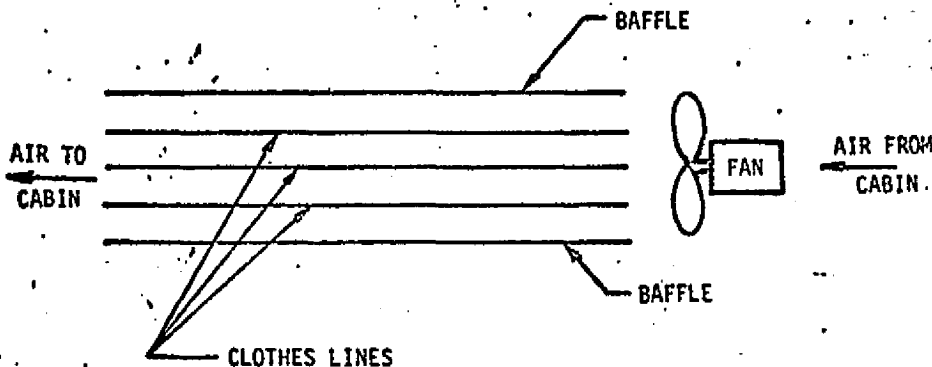




SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Drying  
 APPLIANCE CONCEPT NO./TITLE 8/Clothesline-Forced Convection  
 INDEX NO. 3.3.2.8 REF. NO. 90

DESCRIPTION

In this concept, clothes are attached (with pins, snaps, velcro, etc.) to wide mesh screen panels which are stacked in parallel racks. A fan is used to force air between the panels to dry the clothes. Crew time would be relatively high compared with the other concepts. Drying time was assumed to be 8 hours.









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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

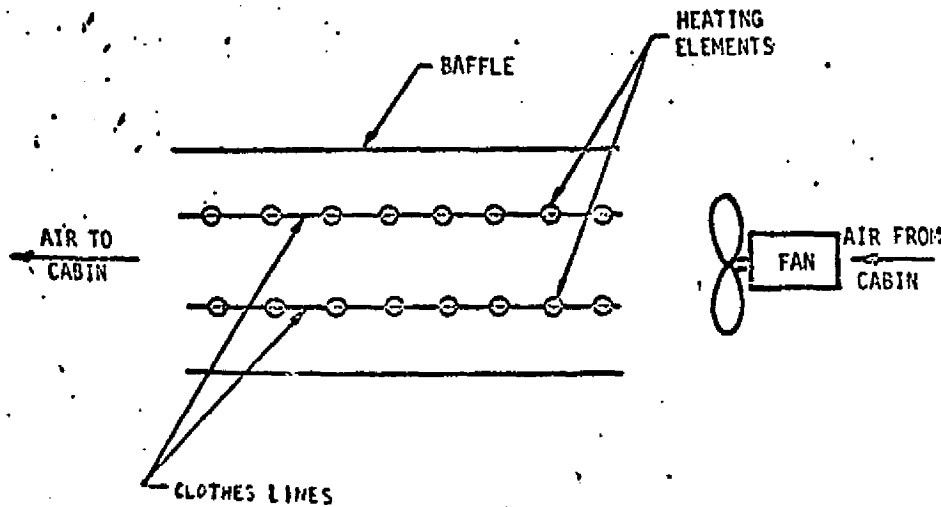
APPLIANCE FUNCTION Garment/Linen Drying

APPLIANCE CONCEPT NO./TITLE 9/Clothesline-Forced Convection plus Electric Heat

INDEX NO. 3.3.2.9 REF. NO. 90

DESCRIPTION

This concept is identical to Concept 8 except that an electrical heating element has been added within the clothes panels to expedite the drying process. Heater size is based on a drying time of 4 hours.







HABITABILITY SUBSYSTEM 3.0 HousekeepingHABITABILITY FUNCTION 3.3 Garment/Linen MaintenanceAPPLIANCE FUNCTION 3.3.3 Garment/Linen Washer/Dryer-Disposable ClothesNUMBER OF CONCEPTS CONSIDERED 9

## ASSUMPTIONS

For this appliance function, the most promising individual clothes washer concepts (Section 3.3.1) were combined with the most promising clothes dryers (Section 3.3.2) to form integrated clothes washer/dryer units. The data for each case were taken directly from the data sheets for Section 3.3.1 and 3.3.2. Washer and dryer data were combined, and the redundant components eliminated. Peak power and thermal requirements were taken to be the maximum for the individual washer and dryer, rather than the sum of the two, since each is operated at separate times.

The washer/dryer combinations were compared with disposable clothes. Clothes wear rates and weights assumed with a washer/dryer were taken from References 237 and 245 and are shown in Table B2-7. A clothes weight packaging factor of 1.31, and clothes packaged density, were taken from Reference 100. This resulted in a total clothes/linens size of 40.8 kg (90 lbs) and 0.483 cu m (17.07 cu ft) required for a 4-man crew with an automatic clothes washer/dryer.

The clothes required for the disposable case were computed from a wear rate of 0.481 kg (1.061 lb) per man per day, with the volume again taken from Reference 100.

TABLE B2-7 CLOTHES/LINENS USAGE RATES ASSUMED PER  
MAN WITH A CLOTHES WASHER/DRYER AVAILABLE

| ITEM                  | WEAR<br>INTERVAL | NUMBER | ARTICLE WEIGHT |             | TOTAL WEIGHT |            |
|-----------------------|------------------|--------|----------------|-------------|--------------|------------|
|                       |                  |        | kg             | lb          | kg           | lb         |
| Short sleeve shirt    | 3 days           | 4      | 0.20           | 0.45        | 0.82         | 1.80       |
| Trousers              | 7 days           | 3      | .54            | 1.20        | 1.63         | 3.60       |
| Jacket                | 7 days           | 3      | .50            | 1.10        | 1.50         | 3.30       |
| Undershorts/sox/shirt | 2 days           | 6      | .26            | .57         | 1.55         | 3.42       |
| Shoes (pr.)           |                  | 3      | .31            | .69         | .94          | 2.07       |
| Gloves                | 21 days          | 3      | .08            | .17         | .23          | .51        |
| Towels                | 1 day            | 7      | .10            | .23         | .73          | 1.61       |
| Washcloth             | .5 day           | 12     | <u>.035</u>    | <u>.077</u> | <u>.42</u>   | <u>.92</u> |
| <b>Total</b>          |                  |        | 2.035          | 4.50        | 7.82         | 17.23      |

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APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.3.3. \*\*\*\* GARMENT/LINEN WASHER/DRYER-DISPOSABLE CLOTHES (SHUTTLE)

| CONCEPT NO. | USAGE TIME | CONSUMABLES AND FLOW REQUIREMENTS |                                  |       |                 | THERMAL REQNTS  |                     | ELEC PWR REQNTS     |                               | WT/VOL REQNTS                  |                 | DEVELOPMENT COST  |               | RESUPPLY WEIGHT |                |
|-------------|------------|-----------------------------------|----------------------------------|-------|-----------------|-----------------|---------------------|---------------------|-------------------------------|--------------------------------|-----------------|-------------------|---------------|-----------------|----------------|
|             |            | TYPE                              | AMT-USED<br>(KG/USE)<br>(LB/USE) | FLOW  | PRESS<br>(PSIG) | TEMP<br>(DEG F) | COOLANT<br>(BTU/HR) | HT LEAK<br>(BTU/HR) | PK PWR<br>AC<br>DC<br>-WATTS- | AVG PWR<br>AC<br>DC<br>-WATTS- | WEIGHT<br>(LBS) | VOLUME<br>(CU FT) | AVAIL<br>(**) |                 | INDEX<br>(***) |
| 1           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 132.                | 980.                | 158.0                         | .0                             | 111.6           | .43               | 3             | 60              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (450.)              | (3347.)             | (151.0)                       | (.0)                           | (296.0)         | (15.10)           |               |                 | (.00)          |
| 2           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 219.                | 980.                | 158.0                         | .0                             | 120.2           | 1.07              | 3             | 65              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (747.)              | (3347.)             | (.0)                          | (.0)                           | (265.0)         | (37.60)           |               |                 | (.00)          |
| 3           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 0.                  | 980.                | 158.0                         | .0                             | 91.2            | 2.91              | 3             | 60              | .00            |
|             | 9.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (0.)                | (3347.)             | (.0)                          | (.0)                           | (201.0)         | (102.70)          |               |                 | (.00)          |
| 4           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 0.                  | 980.                | 158.0                         | .0                             | 87.5            | 3.10              | 3             | 60              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (0.)                | (3347.)             | (171.0)                       | (.0)                           | (193.0)         | (109.40)          |               |                 | (.00)          |
| 5           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 132.                | 980.                | 158.0                         | .0                             | 90.3            | .94               | 2             | 40              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (450.)              | (3347.)             | (151.0)                       | (.0)                           | (199.0)         | (15.40)           |               |                 | (.00)          |
| 6           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 219.                | 980.                | 158.0                         | .0                             | 122.0           | .67               | 3             | 65              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (747.)              | (3347.)             | (.0)                          | (.0)                           | (269.0)         | (23.80)           |               |                 | (.00)          |
| 7           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 0.                  | 980.                | 158.0                         | .0                             | 93.0            | 2.90              | 2             | 40              | .00            |
|             | 9.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (0.)                | (3347.)             | (.0)                          | (.0)                           | (205.0)         | (102.50)          |               |                 | (.00)          |
| 8           | 2.000      | 9                                 | 33.2942                          | .00   | .0              | .0              | 0.                  | 980.                | 158.0                         | .0                             | 90.3            | 3.09              | 2             | 40              | .00            |
|             | 5.000      |                                   | (73.4000)                        | (.00) | (.0)            | (.0)            | (0.)                | (3347.)             | (171.0)                       | (.0)                           | (199.0)         | (109.00)          |               |                 | (.00)          |
| 9           | .000       | 9                                 | .0000                            | .00   | .0              | .0              | 0.                  | 0.                  | 158.0                         | .0                             | 51.7            | .61               | 1             | 0               | .00            |
|             | .000       |                                   | (.0000)                          | (.00) | (.0)            | (.0)            | (0.)                | (0.)                | (.0)                          | (.0)                           | (114.0)         | (21.50)           |               |                 | (.00)          |

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APPLIANCE  
CONCEPT  
NO.

C O N C E P T N A M E

- 1 - FLUIDIC AGITATION/FORCED HOT AIR-ELECTRIC HEATER
- 2 - FLUIDIC AGITATION/FORCED HOT AIR-THERMAL STORAGE HEATER
- 3 - FLUIDIC AGITATION/FORCED AIR DRYING-CLOTHES LINE
- 4 - FLUIDIC AGITATION/FORCED AIR DRYING-CLOTHES LINE
- 5 - WATER SPRAY AGITATION/FORCED HOT AIR-ELECTRIC HEATER
- 6 - WATER SPRAY AGITATION/FORCED HOT AIR-THERMAL STORAGE HEATER
- 7 - WATER SPRAY AGITATION/FORCED AIR DRYING-CLOTHES LINE
- 8 - WATER SPRAY AGITATION/ELECTRICALLY HEATED-CLOTHES LINE
- 9 - DISPOSABLE CLOTHES

(\*)

- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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

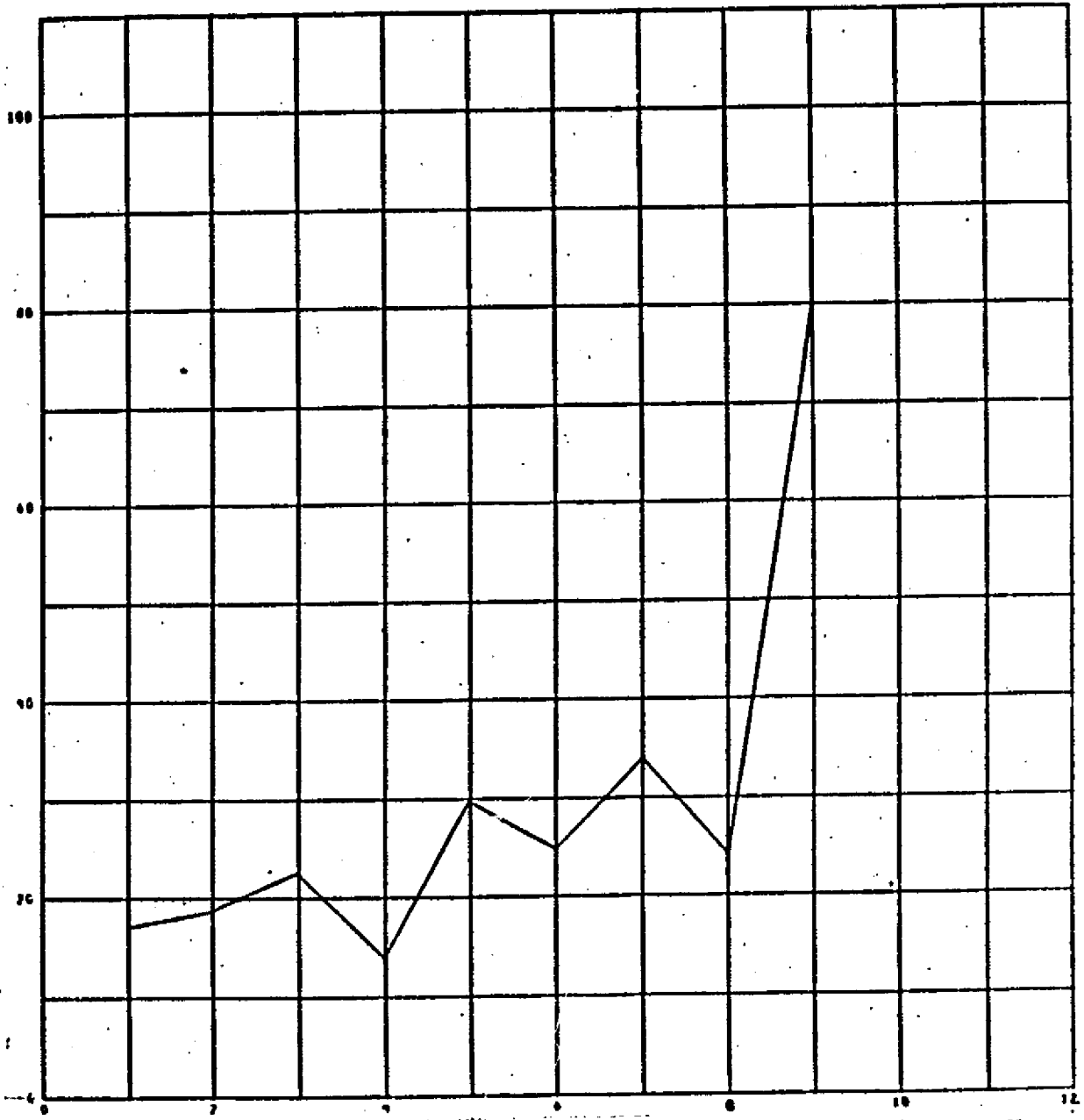
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- 50-75%
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OF POOR QUALITY

APPLIANCE  
CONCEPT

| NO. | CONCEPT NAME                                                |
|-----|-------------------------------------------------------------|
| 1   | FLUIDIC AGITATION/FORCED HOT AIR-ELECTRIC HEATER            |
| 2   | FLUIDIC AGITATION/FORCED HOT AIR-THERMAL STORAGE HEATER     |
| 3   | FLUIDIC AGITATION/FORCED AIR DRYING-CLOTHES LINE            |
| 4   | FLUIDIC AGITATION/FORCED AIR DRYING-CLOTHES LINE            |
| 5   | WATER SPRAY AGITATION/FORCED HOT AIR-ELECTRIC HEATER        |
| 6   | WATER SPRAY AGITATION/FORCED HOT AIR-THERMAL STORAGE HEATER |
| 7   | WATER SPRAY AGITATION/FORCED AIR DRYING-CLOTHES LINE        |
| 8   | WATER SPRAY AGITATION/ELECTRICALLY HEATED-CLOTHES LINE      |
| 9   | DISPOSABLE CLOTHES                                          |

CONCEPT RANKING



CONCEPT NUMBER

PAGE 22.

Garment/Linen Washer/Dryer-Disposable Clothes (Shuttle)  
Concept Trade



NUMBER OF DAYS \* 20.5 (.06 YEARS)  
 USES MOD SUBROUTINE 37  
 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 ••••• GARMENT/LINEN WASHER/DRYER-DISPOSABLE CLOTHES (SHUTTLE)  
 (04/18/75)

| FACTOR   | MIN VALUE | MAX VALUE | PTS | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|-----------|-----------|-----|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          |           |           |     | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| WEIGHT   | 114.00    | 269.00    | 15  | 1.28          | .22   | 3.79  | 4.24  | 3.90  | .00   | 3.57  | 3.90  | 8.64  |
| POWER    | 83.740    | 157.27    | 15  | .82           | 7.01  | 7.01  | .00   | .82   | 7.01  | 7.01  | .00   | 7.01  |
| VOLUME   | 15.100    | 109.40    | 10  | 8.82          | 6.54  | .61   | .00   | 8.59  | 7.82  | .63   | .04   | 8.03  |
| THERMAL  | .00000    | 202.76    | 15  | .55           | .00   | 1.38  | 1.38  | .55   | .00   | 1.38  | 1.38  | 15.00 |
| RELIABTY | .96199    | 1.0000    | 5   | 2.07          | 2.09  | .00   | 2.27  | 3.21  | 3.41  | 2.39  | 3.62  | 5.00  |
| MAINTENC | .99999    | .99999    | 5   | .00           | .03   | .19   | .39   | 2.45  | 2.91  | 3.10  | 3.30  | 4.54  |
| SAFETY   | .00000    | 2.0000    | 5   | .00           | .00   | 5.00  | 2.50  | .00   | .00   | 5.00  | 2.50  | 5.00  |
| DEV COST | .00000    | 85.000    | 15  | 1.15          | .00   | 1.15  | 1.15  | 5.77  | .00   | 5.77  | 5.77  | 15.00 |
| TOTAL PT | .00000    | 85.000    | 85  | 14.49         | 15.90 | 19.14 | 11.94 | 25.29 | 21.15 | 28.85 | 20.51 | 68.23 |
| RATING   | .00000    | 100.00    | 100 | 17.05         | 18.71 | 22.52 | 14.05 | 29.75 | 24.89 | 33.94 | 24.13 | 80.27 |

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**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| NORMAL   | 17.05         | 18.71 | 22.52 | 14.05 | 29.75 | 24.89 | 33.94 | 24.13 | 80.27 |
| WEIGHT   | 16.36         | 17.31 | 22.75 | 15.20 | 29.45 | 22.87 | 33.12 | 24.28 | 78.43 |
| POWER    | 16.11         | 20.98 | 24.49 | 12.91 | 27.78 | 26.66 | 34.98 | 22.17 | 77.55 |
| VOLUME   | 20.89         | 21.30 | 21.61 | 13.27 | 32.87 | 27.85 | 32.41 | 22.81 | 80.28 |
| THERMAL  | 15.96         | 17.19 | 21.44 | 13.66 | 27.64 | 22.87 | 31.94 | 22.92 | 81.87 |
| RELIABTY | 17.74         | 19.37 | 21.88 | 14.94 | 30.73 | 26.13 | 34.34 | 25.51 | 80.83 |
| MAINTENC | 16.56         | 18.19 | 21.99 | 13.87 | 30.30 | 25.84 | 34.74 | 25.33 | 80.57 |
| SAFETY   | 16.56         | 18.17 | 24.74 | 15.07 | 28.90 | 24.18 | 35.83 | 24.87 | 80.83 |
| DEV COST | 16.29         | 17.19 | 21.32 | 13.53 | 30.46 | 22.87 | 34.31 | 25.29 | 81.87 |

**SENSITIVITY ANALYSIS**

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

|          | C O N C E P T |       |       |       |       |       |       |       |       |
|----------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
|          | 1             | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
| NORMAL   | 17.05         | 18.71 | 22.52 | 14.05 | 29.75 | 24.89 | 33.94 | 24.13 | 80.27 |
| WEIGHT   | 17.87         | 20.37 | 22.25 | 12.67 | 30.11 | 27.30 | 34.92 | 23.95 | 82.46 |
| POWER    | 18.17         | 15.99 | 20.18 | 15.41 | 32.10 | 22.77 | 32.70 | 26.47 | 83.51 |
| VOLUME   | 12.73         | 15.78 | 23.55 | 14.93 | 26.24 | 21.55 | 35.67 | 25.62 | 80.27 |
| THERMAL  | 18.35         | 20.52 | 23.81 | 14.52 | 32.28 | 27.30 | 36.34 | 25.57 | 78.36 |
| RELIABTY | 16.31         | 18.00 | 23.20 | 13.10 | 28.71 | 23.58 | 33.52 | 22.67 | 79.67 |
| MAINTENC | 17.57         | 19.24 | 23.09 | 14.23 | 29.17 | 23.88 | 33.09 | 22.86 | 79.95 |
| SAFETY   | 17.57         | 19.27 | 20.17 | 12.96 | 30.65 | 25.64 | 31.94 | 23.35 | 79.67 |
| DEV COST | 17.96         | 20.52 | 23.96 | 14.66 | 28.91 | 27.30 | 33.51 | 22.74 | 78.36 |

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.3.3-GARMENT/LINEN/WASHING/DRYING COMBINATIONS

| COMPONENT TYPE<br>APPLIANCE TYPE                            | NUMBER OF COMPONENTS |       |      |                |             |                 |        |                 |            |                |                |           |            |              |                      |                    | NUMBER OF SAFETY CRITICAL ITEMS |
|-------------------------------------------------------------|----------------------|-------|------|----------------|-------------|-----------------|--------|-----------------|------------|----------------|----------------|-----------|------------|--------------|----------------------|--------------------|---------------------------------|
|                                                             | NO.                  | MOTOR | PUMP | SOLENOID VALVE | ACCUMULATOR | WATER SEPARATOR | FILTER | ELECTRIC SWITCH | CONTROLLER | FLUIDIC SWITCH | HEAT EXCHANGER | HEATER DC | BLOWER AIR | TRANSMISSION | THERMAL STORAGE UNIT | DESICCANT CANISTER |                                 |
|                                                             | ①                    | ②     | ③    | ④              | ⑤           | ⑥               | ⑦      | ⑧               | ⑨          | ⑩              | ⑪              | ⑫         | ⑬          | ⑭            | ⑮                    | ⑯                  | ⑰                               |
| FLUIDIC AGITATION/FORCED HOT AIR-ELECTRIC HEATER.           | 6                    | 2     | 2    | 2              | 1           | 1               | 7      | 1               | 10         | 1              | 1              | 1         | 1          | -            | -                    |                    | 2                               |
| FLUIDIC AGITATION/FORCED HOT AIR-THERMAL HEATER             | 6                    | 2     | 2    | 2              | 1           | 1               | 7      | 1               | 10         | -              | -              | 1         | 1          | 1            | -                    | -                  | 2                               |
| FLUIDIC AGITATION/FORCED AIR DRYING RACK                    | 5                    | 2     | 2    | 2              | 1           | 1               | 7      | -               | 10         | 1              | -              | 1         | -          | -            | -                    | -                  | 0                               |
| FLUIDIC AGITATION/ELECTRICALLY HEATED DRYING RACK           | 5                    | 2     | 2    | 2              | 1           | 1               | 7      | -               | 10         | 1              | 1              | 1         | -          | -            | -                    | -                  | 1                               |
| WATER SPRAY AGITATION/FORCED HOT AIR-ELECTRIC HEATER        | 3                    | 1     | 2    | 2              | 1           | 1               | 4      | 1               | -          | 1              | 1              | 1         | 1          | -            | -                    | -                  | 2                               |
| WATER SPRAY AGITATION/FORCED HOT AIR-THERMAL STORAGE HEATER | 3                    | 1     | 2    | 2              | 1           | 1               | 4      | 1               | -          | 1              | 1              | 1         | 1          | -            | -                    | -                  | 2                               |
| WATER SPRAY AGITATION/FORCED AIR DRYING RACK                | 2                    | 1     | 2    | 2              | 1           | 1               | 4      | -               | -          | 1              | -              | 1         | -          | -            | -                    | -                  | 0                               |
| WATER SPRAY AGITATION/ELECTRICALLY HEATED DRYING RACK       | 2                    | 1     | 2    | 2              | 1           | 1               | 4      | -               | -          | 1              | 1              | 1         | -          | -            | -                    | -                  | 1                               |

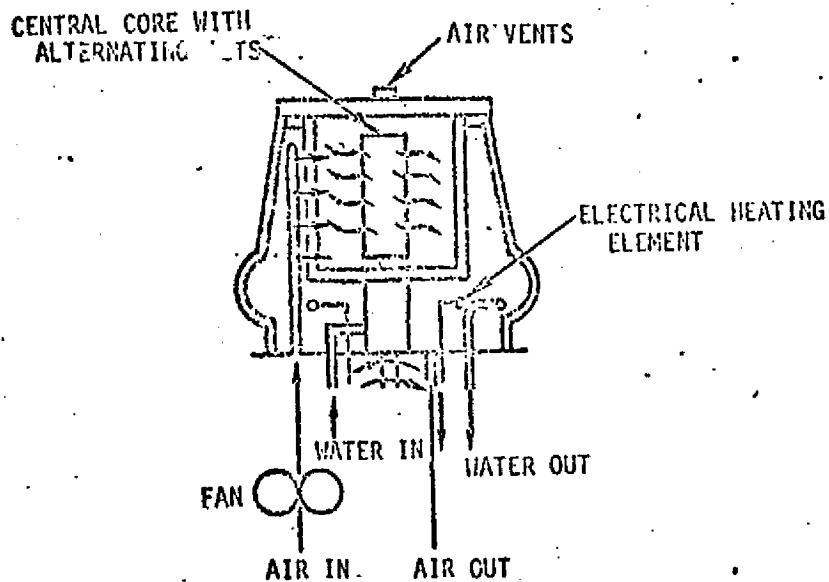
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SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washer/Dryer-Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE 1/Fluidic Agitation/Forced Hot Air-Electric Heat  
 INDEX NO. 3.3.3.1 REF. NO. 90

## DESCRIPTION

This concept is a combination of clothes washer Concept 2 and clothes dryer Concept 1, as described previously in Section 3.3.1 and 3.3.2.



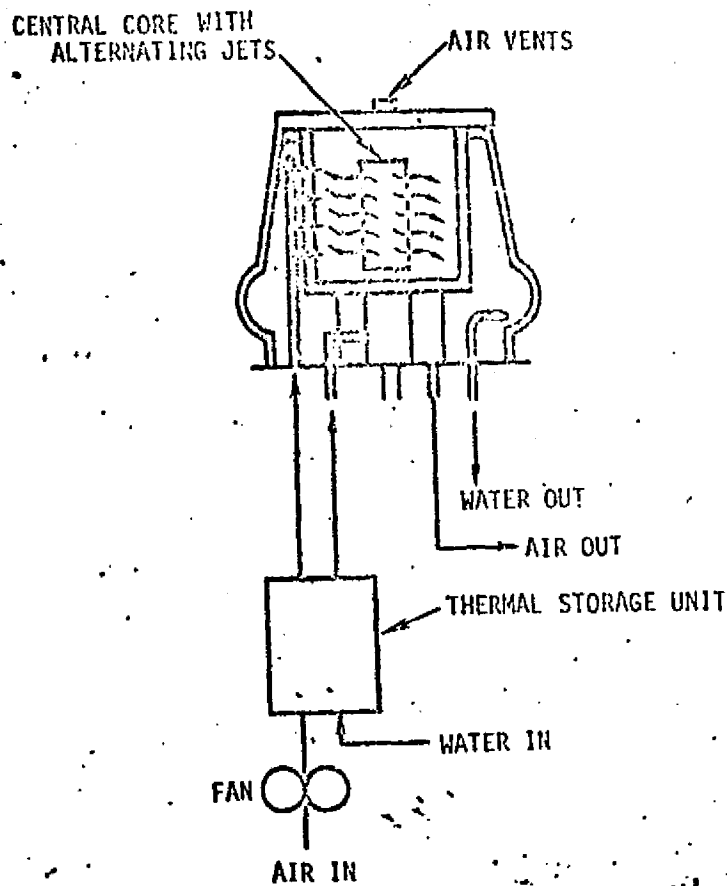




SPACECRAFT ShuttleHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen MaintenanceAPPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable ClothesAPPLIANCE CONCEPT NO./TITLE 2/Fluidic Agitation/Forced Hot Air-Thermal StorageINDEX NO. 3.3.3.2 REF. NO. 90

## DESCRIPTION

This concept is a combination of clothes washer Concept 2 and clothes dryer Concept 2 as described previously in Section 3.3.1 and 3.3.2.







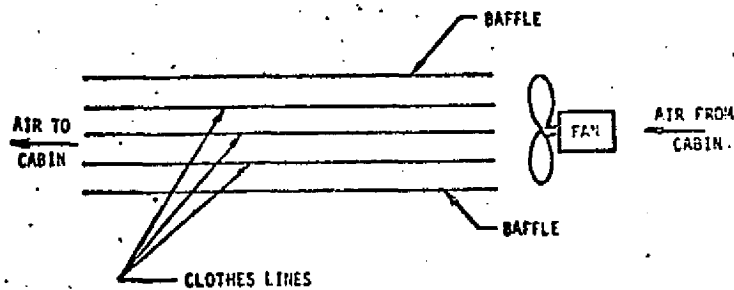
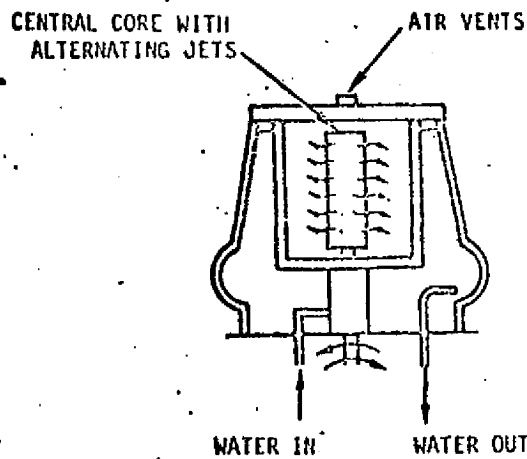


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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
APPLIANCE CONCEPT NO./TITLE 3/Fluidic Agitation/Clothesline-Forced Convection  
INDEX NO. 3:3.3.3 REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 1 and clothes dryer Concept 8 as described previously in Section 3.3.1 and 3.3.2.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)  
 CONCEPT FLUID MIXTURE/CLOTHES LINE - FORCED CONVECTION INDEX NUMBER 3.3.3.3  
 (REF 10 70, 24, 25, 72, 73)

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT | (REF) | WEIGHT (LBS) | VOLUME (FT <sup>3</sup> )         |
|-----------|-------|--------------|-----------------------------------|
| WASHER    |       | 129          | 12.2                              |
| DRYER     |       | 39           | 8.7                               |
| CLOTHES   |       | 39           | 3.8                               |
| TOTAL     |       | 91.2 (201)   | 2.41 (102.7)                      |
|           |       | KG (LBS)     | M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE WT/VOL REQUIREMENTS

| TYPE                | ① UNITS/CYCLE (REF) | ② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB) | ③ WT/CYCLE (① X ②) (LB)           | ④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> ) | ⑤ VOL/CYCLE (① X ④) (FT <sup>3</sup> ) |
|---------------------|---------------------|-------------------------------------------|-----------------------------------|-----------------------------------------------------------|----------------------------------------|
| Detergent/germicide |                     |                                           |                                   |                                                           |                                        |
| Σ ③                 |                     |                                           | TOTAL WT/CYCLE (LB)               | Σ ⑤                                                       |                                        |
| TOTAL WT. MISSION   | CYCLES/DAY          | DAYS/MISSION                              | TOT. WT/CYCLE (LB)                | 0.80 (1.76) KG (LB)                                       |                                        |
| TOTAL VOL. MISSION  | CYCLES/DAY          | DAYS/MISSION                              | TOT. VOL/CYCLE (FT <sup>3</sup> ) | 0.0014 (.05) M <sup>3</sup> (FT <sup>3</sup> )            |                                        |

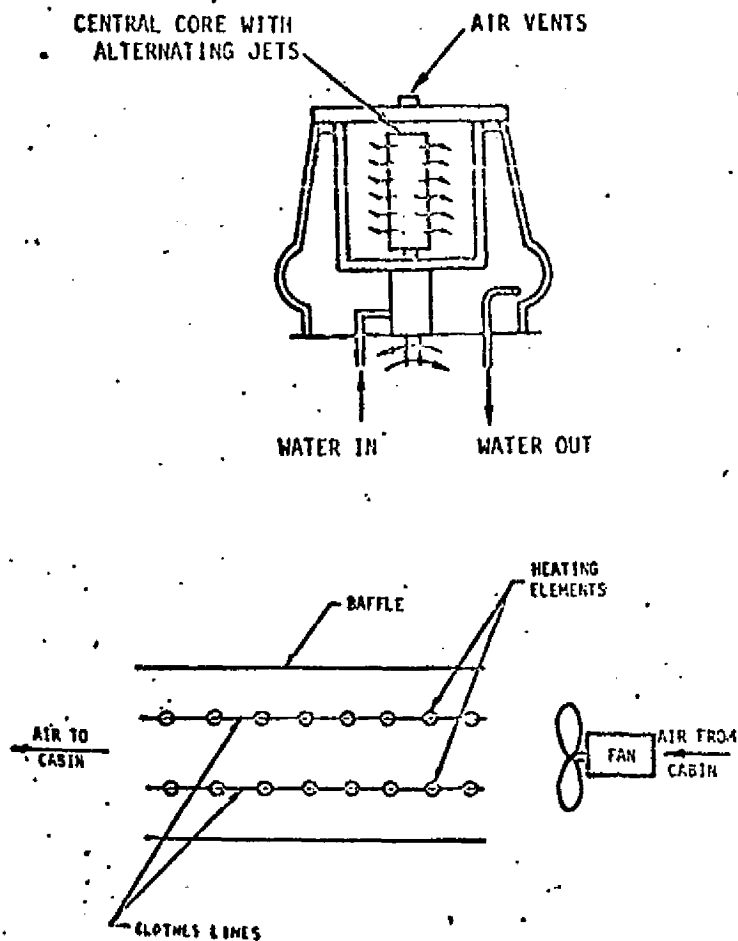
GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE              | ① AMT. USED/CYCLE (REF) (LB) | ② RECOVERY FACTOR | ③ AMT. RECOVERED/CYCLE (① X ②) (LB) | ④ AMT. LOST/CYCLE (① - ③) (LB) |
|-------------------|------------------------------|-------------------|-------------------------------------|--------------------------------|
| Wash water        |                              |                   |                                     |                                |
| Rinse water       |                              |                   |                                     |                                |
| Σ ①               |                              |                   | Σ ④                                 |                                |
| TOTAL WT. MISSION | CYCLE/DAY                    | DAYS/MISSION      | TOTAL LOST/CYCLE (LB)               | 716 (1578) KG (LB)             |

SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE 4/Fluidic Agitation/Clothesline-Forced Convection with Electric Heat  
 INDEX NO. 3.3.3.4 REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 1 and clothes dryer Concept 9 as described previously in Section 3.3.1 and 3.3.2.



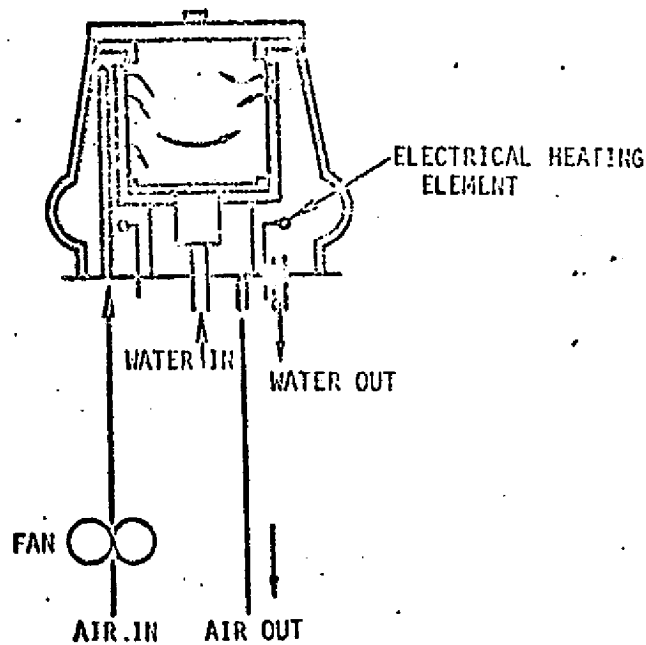




SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE 5/Water Spray Agitation/Force Hot Air-Electric Heat  
 INDEX NO. 3.3.3.5 REF. NO. 90

## DESCRIPTION

This concept is a combination of clothes washer Concept 7 and clothes dryer Concept 1, as described previously in Section 3.3.1 and 3.3.2.









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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Garment/Linen Maintenance

APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes

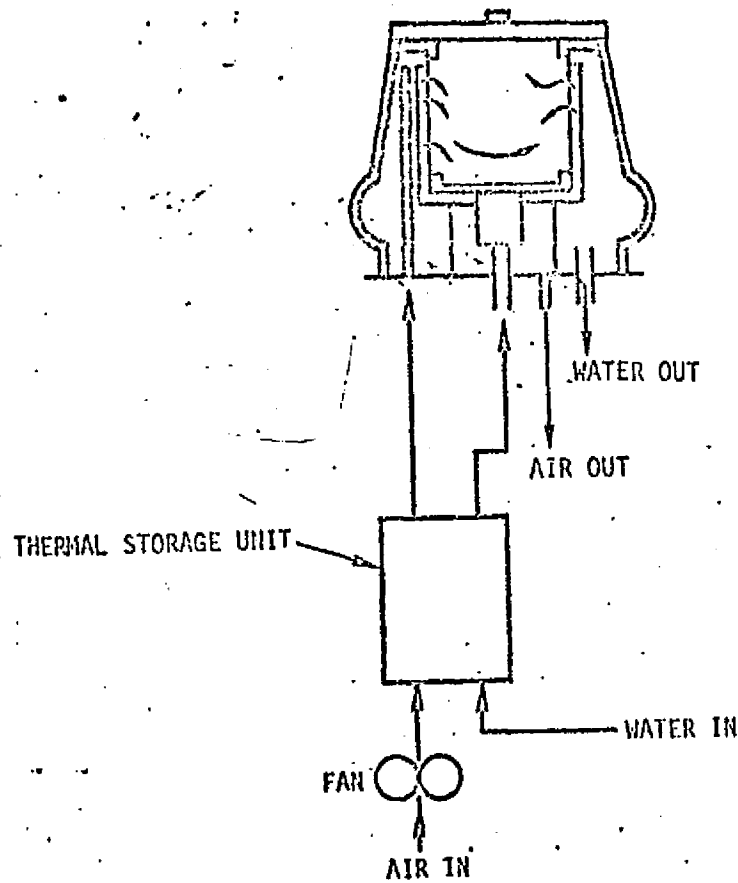
APPLIANCE CONCEPT NO./TITLE 6/Water Spray Agitation/Forced Hot Air-Thermal Storage

INDEX NO. 3.3.3.6

REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 7 and clothes dryer Concept 2 as described previously in Section 3.3.1 and 3.3.2.







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SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

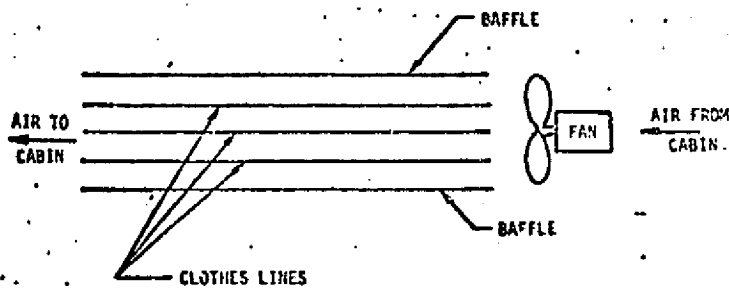
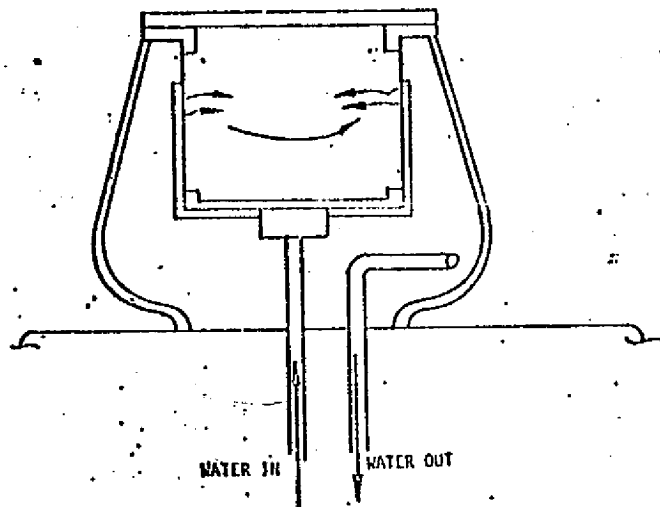
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes

APPLIANCE CONCEPT NO./TITLE 7/Water Spray Agitation/Clothesline-Forced Convection

INDEX NO. 3.3.3.7 REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 7 and clothes dryer Concept 8 as described previously in Section 3.3.1 and 3.3.2.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT WATER SPRAY AGITATION/CLOTHES LINE-FORCED CONVECTION INDEX NUMBER 3.3.3.7  
 (REF #90, P #6, 37, 72, 73)

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT | (REF) | WEIGHT (LBS)           | VOLUME (FT <sup>3</sup> )                         |
|-----------|-------|------------------------|---------------------------------------------------|
| WASHER    |       | 133                    | 11.9                                              |
| DRYER     |       | 33                     | 8.7                                               |
| CLOTHES   |       | 39                     | 3.8                                               |
| TOTAL     |       | 93.0 (205)<br>KG (LBS) | 2.90 (102.4)<br>M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE WT/VOL REQUIREMENTS

| TYPE                    | ①<br>UNITS/CYCLE(REF) | ②<br>WT/UNIT (REF)<br>(PKG. WT/UNIT)(REF)<br>(LB) | ③<br>WT/CYCLE<br>① X ②<br>(LB)    | ④<br>VOL/UNIT (REF)<br>(PKG. VOL/UNIT)(REF)<br>(FT <sup>3</sup> ) | ⑤<br>VOL/CYCLE<br>① X ④<br>(FT <sup>3</sup> ) |
|-------------------------|-----------------------|---------------------------------------------------|-----------------------------------|-------------------------------------------------------------------|-----------------------------------------------|
| Detergent/<br>germicide |                       |                                                   |                                   |                                                                   |                                               |
| Σ ③                     |                       |                                                   | TOTAL WT/CYCLE (LB)               | Σ ⑤                                                               |                                               |
| TOTAL WT. MISSION       | CYCLES/DAY            | DAYS/MISSION                                      | TOT. WT/CYCLE (LB)                | 0.80 (1.76)<br>KG (LB)                                            |                                               |
| TOTAL VOL. MISSION      | CYCLES/DAY            | DAYS/MISSION                                      | TOT. VOL/CYCLE (FT <sup>3</sup> ) | 0.0014 (.05)<br>M <sup>3</sup> (FT <sup>3</sup> )                 |                                               |

GAS/LIQUID EXPENDABLES REQUIREMENTS

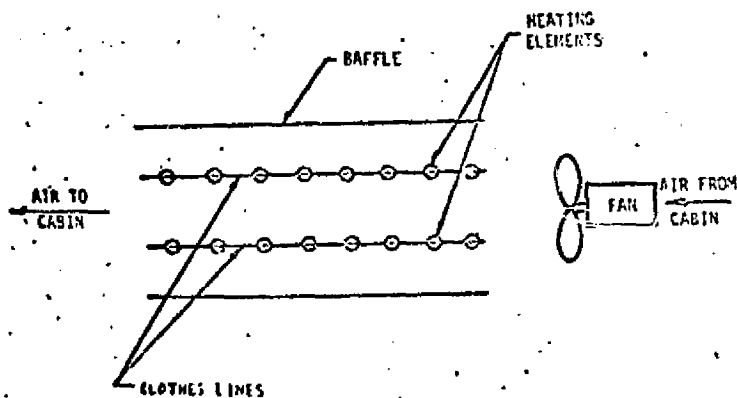
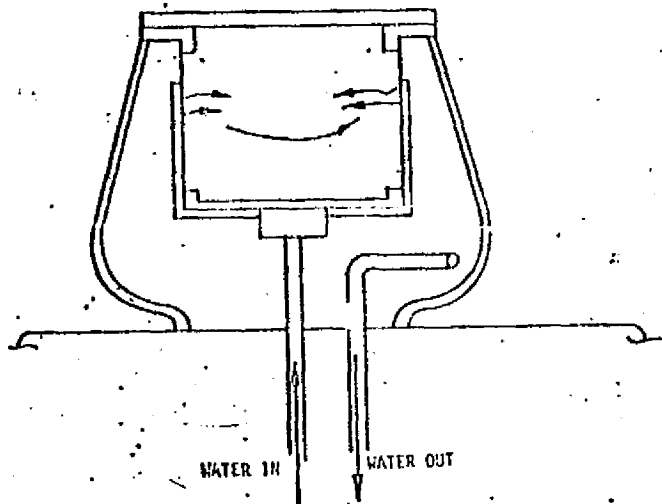
| TYPE              | ①<br>AMT. USED/CYCLE(REF)<br>(LB) | ②<br>RECOVERY FACTOR | ③<br>AMT. RECOVERED/CYCLE<br>① X ②<br>(LB) | ④<br>AMT LOST/CYCLE<br>① - ③<br>(LB) |
|-------------------|-----------------------------------|----------------------|--------------------------------------------|--------------------------------------|
| Wash water        |                                   |                      |                                            |                                      |
| Rinse water       |                                   |                      |                                            |                                      |
| Σ ①               |                                   |                      | Σ ④                                        |                                      |
| TOTAL WT. MISSION | CYCLE/DAY                         | DAYS/MISSION         | TOTAL LOST/CYCLE (LB)                      | 716 (1578)<br>KG (LB)                |



SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE: 8/Water Spray Agitation/Clothesline-Forced Convection with Electric Heat  
 INDEX NO. 3.3.3.8 REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 7 and clothes dryer Concept 9 as described previously in Section 3.3.1 and 3.3.2.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT WATER SPRAY AGITATION/CLOTHES LINE FORCED CONVECTION WITH ELECTRIC HEAT INDEX NUMBER 3.3.3.8

**ELECTRICAL POWER REQUIREMENTS**

| COMPONENT | (REF) | AC POWER                       |                       |                         |                                             | DC POWER              |                         |
|-----------|-------|--------------------------------|-----------------------|-------------------------|---------------------------------------------|-----------------------|-------------------------|
|           |       | ①<br>USE TIME<br>CYCLE<br>(HR) | ②<br>PEAK<br>(WATTS)  | ③<br>AVERAGE<br>(WATTS) | ④<br>DEMAND<br>(WATT-HR/<br>CYCLE)<br>① x ③ | ⑤<br>PEAK<br>(WATTS)  | ⑥<br>AVERAGE<br>(WATTS) |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                |                       |                         |                                             |                       |                         |
|           |       |                                | <u>158</u><br>MAXIMUM |                         | <u>105</u><br>TOTAL                         | <u>171</u><br>MAXIMUM | TOTAL                   |

**THERMAL REQUIREMENTS**

| SOURCE | LATENT<br>(BTU/HR)                 | SENSIBLE<br>(BTU/HR)               | HEAT LEAK<br>(BTU/HR)              | TO COOLANT<br>(BTU/HR)    |
|--------|------------------------------------|------------------------------------|------------------------------------|---------------------------|
|        |                                    |                                    |                                    |                           |
|        |                                    |                                    |                                    |                           |
|        |                                    |                                    |                                    |                           |
|        |                                    |                                    |                                    |                           |
| TOTAL  | <u>51.9 (177)</u><br>WATT (BTU/HR) | <u>901 (3347)</u><br>WATT (BTU/HR) | <u>981 (3547)</u><br>WATT (BTU/HR) | <u>0</u><br>WATT (BTU/HR) |

**OPERATIONAL PENALTIES**

| SOURCE     | THERMAL<br>HEAT LEAK<br>(BTU/HR/CYCLE) | THERMAL<br>TO COOLANT<br>(BTU/HR/CYCLE) | ELECTRICAL<br>(PK WATTS/CYCLE) | WEIGHT<br>(LB/MISSION)     | VOLUME<br>(FT <sup>3</sup> /MISSION)                  |
|------------|----------------------------------------|-----------------------------------------|--------------------------------|----------------------------|-------------------------------------------------------|
| <u>N/A</u> |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
|            |                                        |                                         |                                |                            |                                                       |
| TOTAL      | WATTS/CYCLE<br>(BTU/HR/CYCLE)          | WATTS/CYCLE<br>(BTU/HR/CYCLE)           |                                | KG/MISSION<br>(LB/MISSION) | M <sup>3</sup> /MISSION<br>(FT <sup>3</sup> /MISSION) |



SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/ Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washer/Dryer - Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE 9/Disposable Clothes  
 INDEX NO. 3.3.3.9 REF. NO. \_\_\_\_\_

DESCRIPTION : This concept assumes no clothes washer/dryer will be used, and soiled clothing will simply be disposed of and replaced by new ones. An average wear rate of .484 kg (1.066 lb) clothing/towels/washcloths per man per day was assumed from Reference 245. A packaging weight factor of 1.3 was used from Reference 100. Bulk density of the clothes, including packaging, was assumed to be 0.0119 cu m/kg (0.190 cu ft/lb) as recommended in Reference 100.





HABITABILITY SUBSYSTEM Off-Duty Activity

## APPLIANCE FUNCTIONS CONSIDERED

- 4.1.1 Music
- 4.1.2 Library
- 4.1.3 Television
- 4.1.4 Games
- 4.2.1 Exercisers

## DESCRIPTION

The off-duty activity habitability subsystem was designed to provide the crew entertainment and physical exercise in their off-duty hours. The subsystem considered by the study is primarily based on the off-duty equipment provided for Skylab and Apollo crews. A television receiver was the only addition to the subsystem. The Shuttle Orbiter would not utilize most of the equipment presented in this subsystem due to the present mission duration. The equipment was, however, considered for Shuttle Orbiter for the benefit of future missions as they are extended with the addition of payloads such as Spacelab.

HABITABILITY SUBSYSTEM 4.0 Off-Duty Activity

HABITABILITY FUNCTION 4.1 Entertainment

APPLIANCE FUNCTION 4.1.1 Music

NUMBER OF CONCEPTS CONSIDERED 1

#### ASSUMPTIONS

- (1) The music appliance function provides the crewmen with music and a means of recording. A system to play the recorder through speakers mounted in the spacecraft is provided for better fidelity of sound.
- (2) The actual Skylab equipment was used for the appliance function. This was the only concept used because of the simplicity of the appliance function.
- (3) The Skylab equipment quantities were ratioed by crew size; i.e., six men divided by three men for Space Station and four men divided by three men for Shuttle. The weight and volumes were then multiplied by these ratios.



APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 4.0-OFF-DUTY ACTIVITIES

| COMPONENT TYPE<br><br>APPLIANCE TYPE                                                                                                          | NUMBER OF COMPONENTS |   |   |   |   |   |   |   |   |   |   |   |   |   | NUMBER OF SAFETY CRITICAL ITEMS |
|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---------------------------------|
|                                                                                                                                               | NO.                  |   |   |   |   |   |   |   |   |   |   |   |   |   |                                 |
|                                                                                                                                               | ○                    | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |                                 |
| NO MECHANICAL/ELECTRICAL COMPONENTS<br>RECORDED FOR THE 4.0 APPLIANCE<br>FUNCTIONS, SINCE NO TRADES WERE<br>MADE FOR THE APPLIANCE FUNCTIONS. |                      |   |   |   |   |   |   |   |   |   |   |   |   |   |                                 |

B2-552

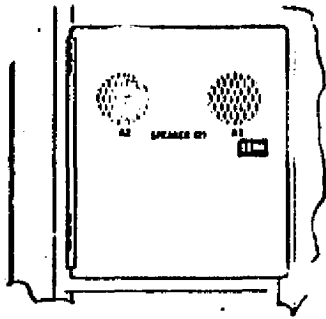
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SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
 APPLIANCE FUNCTION Music  
 APPLIANCE CONCEPT NO./TITLE 1/Cassette Player/Recorder  
 INDEX NO. 4.1.1.1 REF. NO. 293, 96

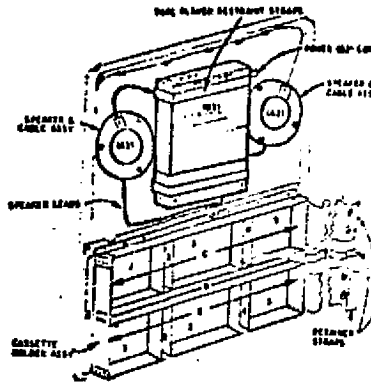
## DESCRIPTION

The cassette player/recorder concept includes the following equipment: (1) tape player/recorder, (2) headsets, (3) microphone kit, (4) power cord/converter, (5) batteries, (6) cassette kit, and (7) wardroom speakers. The tape player can be used on conventional batteries or via a converter from 28 VDC to 6 VDC on spacecraft power. The tape recorder plays cassettes and is provided with a speaker and an adaption to headsets for private use. The number of units provided for each of the above units is summarized below:

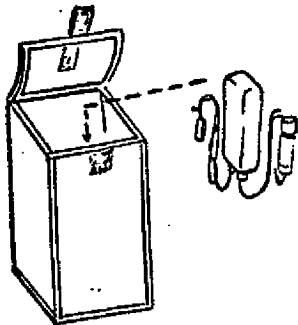
|                      | <u>Shuttle</u>                | <u>Space Station</u> |
|----------------------|-------------------------------|----------------------|
| Tape recorder        | 5                             | 7                    |
| Headsets             | 3                             | 4                    |
| Microphones          | 3                             | 4                    |
| Power cord/converter | 1                             | 2                    |
| Batteries            | adequate for mission duration |                      |
| Cassettes            | 80                            | 120                  |
| Speaker              | 1                             | 1                    |



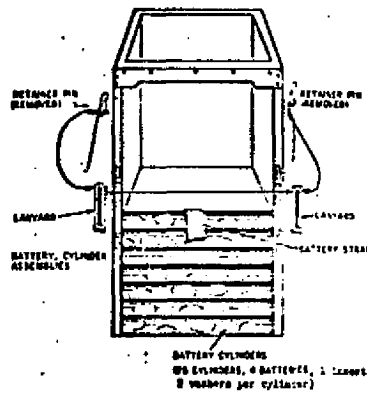
SPEAKER DOOR (FRONT VIEW)



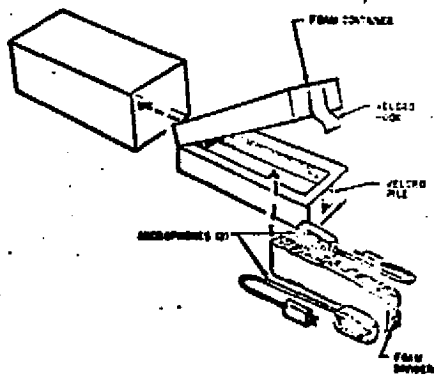
SPEAKER DOOR (REAR VIEW)



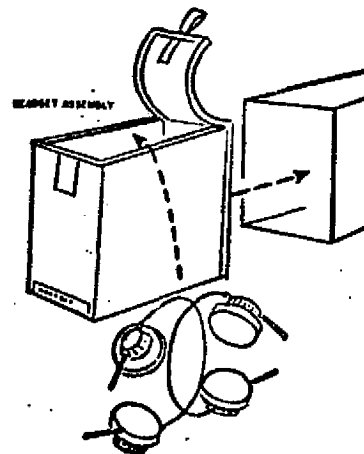
POWER CORD/CONVERTER



BATTERY DISPENSER



MICROPHONE



HEADSETS

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 4.1.1 0000 MUSIC (SHUTTLE)

| CONCEPT NO. | USAGE TIME     | CONSUMABLES AND FLOW REQUIREMENTS |          |                             |          | THERMAL REQTS |                      | ELEC PWR REQTS   |                  | WT/VOL REQTS |               | DEVELOPMENT COST |                | RESUPPLY WEIGHT |           |
|-------------|----------------|-----------------------------------|----------|-----------------------------|----------|---------------|----------------------|------------------|------------------|--------------|---------------|------------------|----------------|-----------------|-----------|
|             |                | USES/DAY HRS/USE                  | TYPE (°) | AMT. USED (KG/USE) (LB/USE) | FLOW (°) | PRESS (PSIG)  | TEMP (DEG C) (DEG F) | COOLANT (BTU/HR) | HT LEAK (BTU/HR) | PK PWR AC DC | AVG PWR AC DC | WEIGHT (LBS)     | VOLUME (CU FT) |                 | AVAIL (°) |
| 1           | 2.000<br>2.000 |                                   |          |                             |          |               | 0.<br>0.             | 0.<br>0.         | 0.<br>0.         | 0.<br>0.     | 29.2<br>64.3  | .04<br>1.99      | 1              | 5               | 0.<br>0.  |

APPLIANCE CONCEPT NO. 1 - CASSETTE PLAYER/RECORDER

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HABITABILITY SUBSYSTEM 4.0 Off-Duty Activity

HABITABILITY FUNCTION 4.1 Entertainment

APPLIANCE FUNCTION 4.1.2 Library

NUMBER OF CONCEPTS CONSIDERED 1

ASSUMPTIONS

- (1) The library appliance function provides the crewmen with reading material for off-duty time. Provisions are added to make the paper books non-flammable by adding covers while the books are in use.
- (2) The actual Skylab equipment was used for the library appliance function. This was the only concept used because of the short mission duration.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO: 9.1.2 000 LIBRARY (SHUTTLE)

| CONCEPT NO. | USAGE TIME     | CONSUMABLES AND FLOW REQUIREMENTS |             |                                      |             |                 | THERMAL REQTS              |                                | ELEC PWR REQTS                 |                    | WT/VOL REQTS        |                         | DEVELOPMENT COST            |               | RESUPPLY WEIGHT |
|-------------|----------------|-----------------------------------|-------------|--------------------------------------|-------------|-----------------|----------------------------|--------------------------------|--------------------------------|--------------------|---------------------|-------------------------|-----------------------------|---------------|-----------------|
|             |                | USES/DAY<br>MRS/USE               | TYPE<br>(*) | AMT.<br>USED<br>(KG/USE)<br>(LB/USE) | FLOW<br>(*) | PRESS<br>(PSIG) | TEMP<br>(DEG C)<br>(DEG F) | COOLANT<br>-WATTS-<br>(BTU/HR) | HT LEAK<br>-WATTS-<br>(BTU/HR) | PK PWR<br>AC<br>DC | AVG PWR<br>AC<br>DC | WEIGHT<br>-KG-<br>(LBS) | VOLUME<br>-CU M-<br>(CU FT) | AVAIL<br>(**) |                 |
| 1           | 2.000<br>2.000 |                                   |             |                                      |             |                 | 0.<br>0.2                  | 0.<br>0.2                      | .0<br>.0                       | .0<br>.0           | .5<br>1.0           | .01<br>.33              | 1                           | 5             | .0<br>.01       |

APPLIANCE CONCEPT

NO. CONCEPT NAME  
1 - BOOKS

D2-118561-3

B2-559



SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Library  
APPLIANCE CONCEPT NO./TITLE 1/Books  
INDEX NO. 4.1.2.1 REF. NO. 293, 96

DESCRIPTION

The book concept consists of individually selected off-the-shelf paperback books taken on the mission. The books are stored and when in use are provided with a cover for nonflammability. The covers are fabricated from Beta cloth.



FIRE RESISTANT  
BOOK COVERS  
STOWED IN W714G ONLY

LIBRARY BOOKS  
INDIVIDUALLY SELECTED



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1/BOOKS

INDEX NUMBER 9.1.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

| COMPONENT    | (REF) | WEIGHT (LBS)                   | VOLUME (FT <sup>3</sup> )                              |
|--------------|-------|--------------------------------|--------------------------------------------------------|
| <u>BOOKS</u> |       | <u>1.05</u>                    | <u>.33</u>                                             |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
|              |       |                                |                                                        |
| TOTAL        |       | <u>.476 (1.05)</u><br>KG (LBS) | <u>.009 (.33)</u><br>M <sup>3</sup> (FT <sup>3</sup> ) |

SOLID EXPENDABLE W/VOL REQUIREMENTS

| TYPE                 | ①<br>UNITS/CYCLE (REF) | ②<br>WT/UNIT (REF)<br>(PKG.WT/UNIT)(REF)<br>(LB) | ③<br>WT/CYCLE<br>① X ②<br>(LB)    | ④<br>VOL/UNIT (REF)<br>(PKG.VOL/UNIT)(REF)<br>(FT <sup>3</sup> ) | ⑤<br>VOL/CYCLE<br>① X ④<br>(FT <sup>3</sup> ) |
|----------------------|------------------------|--------------------------------------------------|-----------------------------------|------------------------------------------------------------------|-----------------------------------------------|
|                      |                        |                                                  |                                   |                                                                  |                                               |
| <u>N/A</u>           |                        |                                                  |                                   |                                                                  |                                               |
|                      |                        |                                                  |                                   |                                                                  |                                               |
|                      |                        |                                                  |                                   |                                                                  |                                               |
|                      |                        |                                                  |                                   |                                                                  |                                               |
|                      |                        |                                                  |                                   |                                                                  |                                               |
| TOTAL WT. MISSION =  | _____ X _____ X        | _____ X _____ X                                  | TOT. WT/CYCLE (LB)                |                                                                  | _____ KG (LB)                                 |
| TOTAL VOL. MISSION = | _____ X _____ X        | _____ X _____ X                                  | TOT. VOL/CYCLE (FT <sup>3</sup> ) |                                                                  | _____ M <sup>3</sup> (FT <sup>3</sup> )       |

GAS/LIQUID EXPENDABLES REQUIREMENTS

| TYPE                | ①<br>AMT. USED/CYCLE (REF)<br>(LB) | ②<br>RECOVERY FACTOR | ③<br>AMT. RECOVERED/CYCLE<br>① X ②<br>(LB) | ④<br>AMT. LOST/CYCLE<br>① - ③<br>(LB) |
|---------------------|------------------------------------|----------------------|--------------------------------------------|---------------------------------------|
|                     |                                    |                      |                                            |                                       |
| <u>N/A</u>          |                                    |                      |                                            |                                       |
|                     |                                    |                      |                                            |                                       |
|                     |                                    |                      |                                            |                                       |
|                     |                                    |                      |                                            |                                       |
|                     |                                    |                      |                                            |                                       |
| TOTAL WT. MISSION = | _____ X _____ X                    | _____ X _____ X      | TOTAL LOST/CYCLE (LB)                      | _____ KG (LB)                         |

HABITABILITY SUBSYSTEM 4.0 Off-Duty Activity

HABITABILITY FUNCTION 4.1 Entertainment

APPLIANCE FUNCTION 4.1.3 Visual Recreation

NUMBER OF CONCEPTS CONSIDERED 1

**ASSUMPTIONS**

- (1) The visual appliance function provides the means for programed television to be displayed on board the spacecraft.
- (2) The Panasonic and Sony television sets were the basis for the engineering numbers.
- (3) One unit was assumed to be provided for each vehicle.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 4.1.3 0000 VISUAL RECREATION (SHUTTLES)

254

| CONCEPT NO. | USAGE TIME     | CONSUMABLES AND FLOW REQUIREMENTS |          |                             |                 | THERMAL REQTS |                      | ELEC PWR REQTS   |                  | WT/VOL REQTS |                 | DEVELOPMENT COST  |                       | RESUPPLY WEIGHT (LBS) |                  |
|-------------|----------------|-----------------------------------|----------|-----------------------------|-----------------|---------------|----------------------|------------------|------------------|--------------|-----------------|-------------------|-----------------------|-----------------------|------------------|
|             |                | USES/DAY HRS/USE                  | TYPE (#) | AMT. USED (KG/USE) (LB/USE) | FLOW (#) (PSIG) | PRESS (PSIG)  | TEMP (DEG C) (DEG F) | COOLANT (BTU/HR) | HT LEAK (BTU/HR) | PK PWR AC DC | AVG PWR AC DC   | WEIGHT (KG) (LBS) | VOLUME (CU M) (CU FT) |                       | AVAIL INDEX (**) |
| 1           | 2.000<br>2.000 |                                   |          |                             |                 |               | 0.<br>( 0.1          | 120.<br>( 409.4) | 120.0<br>.0      | .0<br>.0     | 22.7<br>( 50.0) | .12<br>( 4.27)    | 3                     | 75                    | .0<br>.01        |

APPLIANCE CONCEPT

NO. CONCEPT NAME  
1 - TELEVISION

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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Visual Recreation  
APPLIANCE CONCEPT NO./TITLE 1/Television  
INDEX NO. 5.1.3.1 REF. NO. 1

## DESCRIPTION

The television concept provides programmed television programs to the crewmen. The data presented were based on 15-inch Panasonic. The Sony is also very similar to this model. The unit does not provide the means for use of video tape.







HABITABILITY SUBSYSTEM 4.0 Off-Duty Activity

HABITABILITY FUNCTION 4.1 Entertainment

APPLIANCE FUNCTION 4.1.4 Games

NUMBER OF CONCEPTS CONSIDERED 5

ASSUMPTIONS

- (1) The games appliance function provides games to occupy crewman time during off-duty activity. The devices used are varied to prevent boredom.
- (2) The actual Skylab equipment was used for the appliance function.
- (3) The Skylab equipment quantities were ratioed by crew size; i.e., six men divided by three men for Shuttle. The weight and volumes were then multiplied by the ratios.
- (4) The concepts presented are not presented for trade purposes. Each of these concepts are candidates for off-duty activity equipment.

**APPLIANCE CONCEPT FUNCTION MATRIX**

INDEX NO: 9-1-4      0000 GAMES (SHUTTLE)

| CONCEPT NO. | USAGE TIME    | CONSUMABLES AND FLOW REQUIREMENTS |          |           |        |         | THERMAL REQTS |           | ELEC PWR REQTS |            | WT/VOL REQTS |            | DEVELOPMENT COST | RESUPPLY WEIGHT |            |
|-------------|---------------|-----------------------------------|----------|-----------|--------|---------|---------------|-----------|----------------|------------|--------------|------------|------------------|-----------------|------------|
|             |               | USES/DAY                          | TYPE     | AMT. USED | FLOW   | PRESS   | TEMP          | COOLANT   | HT LEAK        | PK PWR     | AVG PWR      | WEIGHT     |                  |                 | VOLUME     |
|             | MRS/USE       | (*)                               | -KG/USE- | (*)       | -MMHG- | +DEG C- | -WATTS-       | -WATTS-   | DC             | DC         | -KG-         | -CU M-     | (**)             | (***)           | -KG-       |
|             |               |                                   | (LB/USE) | (*)       | (PSIG) | (DEG F) | (BTU/HR)      | (BTU/HR)  | -WATTS-        | -WATTS-    | (LBS)        | (CU FT)    |                  |                 | (LBS)      |
| 1           | .500<br>2.000 |                                   |          |           |        |         | 0.<br>0.1     | 0.<br>0.1 | 0.0<br>0.0     | 0.0<br>0.0 | 0.4<br>0.8   | 100<br>200 | 1                | 5               | 0.0<br>0.0 |

APPLIANCE CONCEPT NO.      CONCEPT NAME

1      HANDBALL

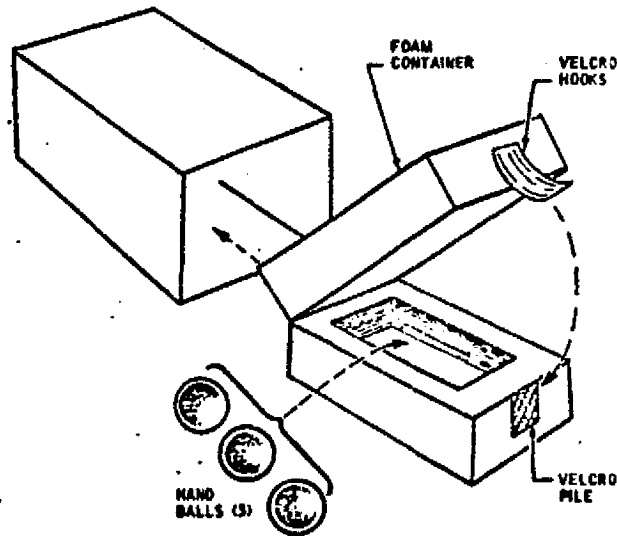
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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Games  
APPLIANCE CONCEPT NO./TITLE 1/Handball  
INDEX NO. 4.1.4.1 REF. NO. 293, 96

DESCRIPTION

The handball concept provides three hand balls, one pyrell, one sponge, and one rubber hand ball. The balls are covered with a nonflammable Fluorel covering. One commercial ball is coated with Fluorel. The pyrell NERF ball was dipped in ammonium-dehydrogen phosphate and coated with Fluorel. The third ball is a toy ball coated with Fluorel. The balls are packaged in a sponge rubber container.



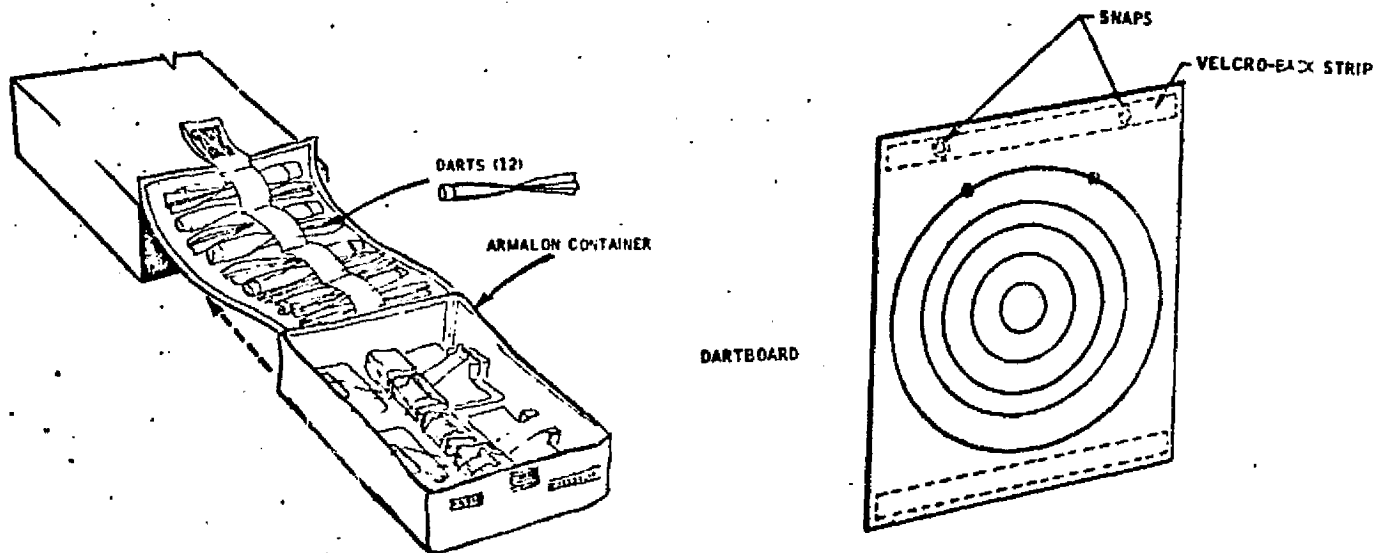




SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
 APPLIANCE FUNCTION Games  
 APPLIANCE CONCEPT NO./TITLE 2/Dart Board/Darts  
 INDEX NO. 4.1.4.2 REF. NO. 293, 96

DESCRIPTION

The dart board concept utilizes darts and board with velcro for a zero-g dart game. Twelve darts were provided with the heads covered with velcro hooks and attach to the board by means of velcro pile/hook attachment system. A dart holder container was provided as part of the concept. The system did not work well on Skylab (darts were not stable), so redesign of this system would be required prior to flight.





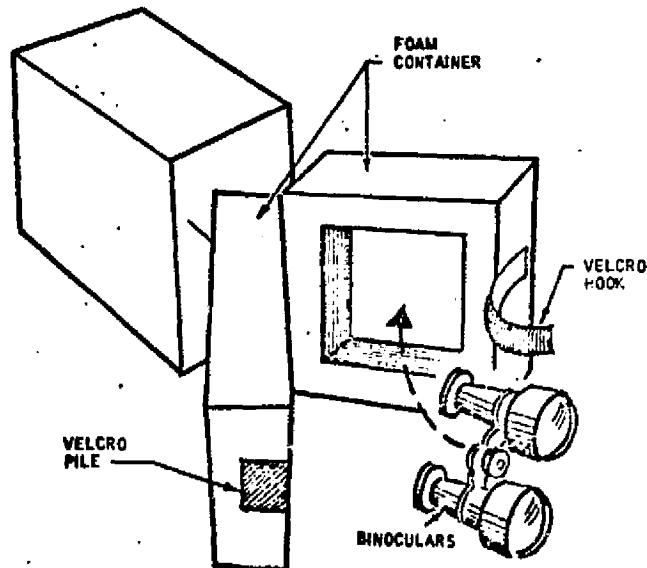




SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Games  
APPLIANCE CONCEPT NO./TITLE 3/Binocular Kit  
INDEX NO. 4.1.4.3 REF. NO. 293, 96

## DESCRIPTION

The binocular kit concept provides binoculars for viewing distant objects such as earth and satellites. The binoculars are "trinovid" 10 x 40, manufactured by E. Leitz, Inc. Velcro attachment strips are provided for attachment when used in specified areas.





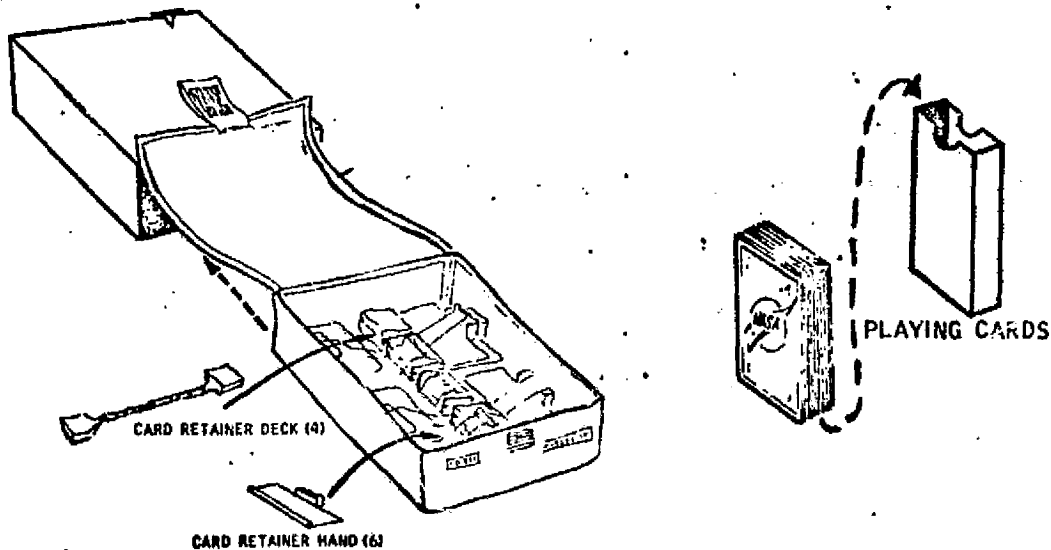


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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Games  
APPLIANCE CONCEPT NO./TITLE 4/Cards  
INDEX NO. 4.1.4.4 REF. NO. 293, 96

DESCRIPTION

The cards concept provides card decks and card deck retainers for card playing in zero-g. The card retainer is constructed using a flexible strap with a magnet at each end. The assembly is covered with Beta cloth. The cards are standard cards manufactured using a lamination of three layers of Scheufelin paper E-20. Each deck is stored in an aluminum container for nonflammability. Eight decks of cards were assumed for Space Station and four for Shuttle.



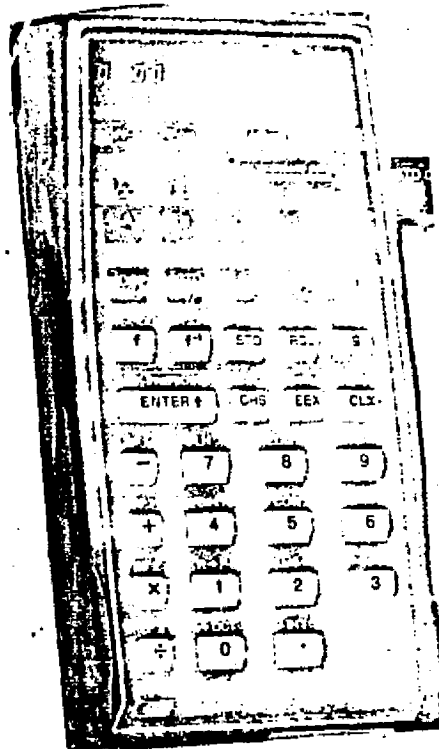




SPACECRAFT Shuttle  
Off-Duty  
HABITABILITY SUBSYSTEM Activity HABITABILITY FUNCTION Entertainment  
APPLIANCE FUNCTION Games  
APPLIANCE CONCEPT NO./TITLE 5/Calculator  
INDEX NO. 4.1.4.5 REF. NO. \_\_\_\_\_

DESCRIPTION

The calculator concept provides a Hewlett-Packard HP-65 programable pocket calculator. The calculator is an electronic slide rule with programable tapes for special programs. The study assumed four units were supplied for Shuttle and six for Space Station.









HABITABILITY SUBSYSTEM 4.0 Off-Duty Activity

HABITABILITY FUNCTION 4.2 Physical Conditioning

APPLIANCE FUNCTION 4.2.1 Exercisers

NUMBER OF CONCEPTS CONSIDERED 2

#### ASSUMPTIONS

- (1) The exercisers appliance function provides for maintenance of crewman physical condition under the influence of zero-gravity.
- (2) The actual Skylab equipment was used for the appliance function.
- (3) The Skylab equipment quantities were ratioed by crew size; i.e., six men divided by three men for Space Station and four men divided by three men for Shuttle. The weights and volumes were then multiplied by the ratios.
- (4) The concepts presented are not presented for trade purposes. Each of these concepts are candidates for off-duty activity equipment.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 4.2.1 \*\*\*\*\* EXERCISERS (SMUTTLED)

| CONCEPT NO. | USAGE TIME     | CONSUMABLES AND FLOW REQUIREMENTS |          |          |             | THERMAL REQNTS       |                  | ELEC PWR REQNTS  |              | WT/VOL REQNTS |                   | DEVELOPMENT COST      |           | RESUPPLY WEIGHT (LBS) |
|-------------|----------------|-----------------------------------|----------|----------|-------------|----------------------|------------------|------------------|--------------|---------------|-------------------|-----------------------|-----------|-----------------------|
|             |                | AMT. USED (KG/USE) (LB/USE)       | TYPE (1) | FLOW (1) | PNSS (PSIG) | TEMP (DEG C) (DEG F) | COOLANT (BTU/HR) | HT LEAK (BTU/HR) | PK PWR AC DC | AVG PWR AC DC | WEIGHT (KG) (LBS) | VOLUME (CU M) (CU FT) | AVAIL (1) |                       |
| 1           | 4.000<br>1.000 |                                   |          |          |             | 0.<br>( 0.)          | 0.<br>( 0.)      | 0.<br>0          | 0.<br>0      | 0.<br>( 0.)   | 01<br>( 29)       | 1                     | 5         | 0<br>( 0)             |
| 2           | 4.000<br>.000  |                                   |          |          |             | 0.<br>( 0.)          | 0.<br>( 0.)      | 0.<br>0          | 0.<br>0      | 1<br>( 3)     | 00<br>( 03)       | 1                     | 5         | 0<br>( 0)             |

- APPLIANCE CONCEPT NO.      CONCEPT NAME
- 1 - EXER-GYM
  - 2 - HAND EXERCISER

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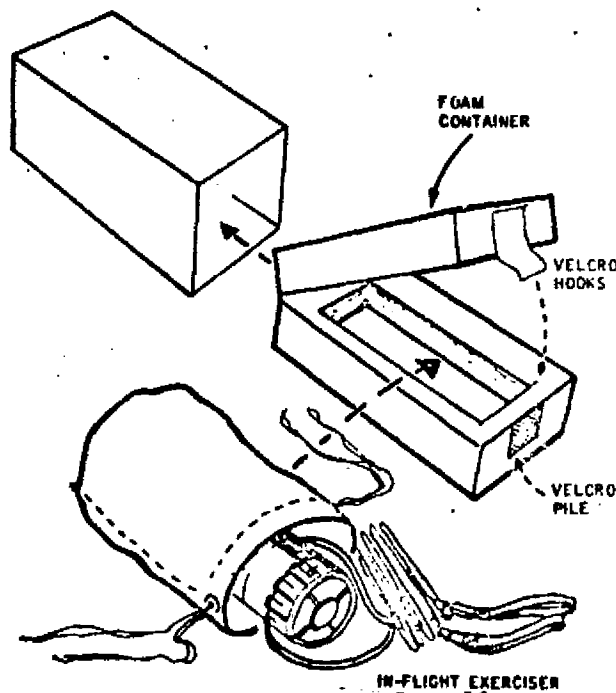
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SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Physical Conditioning  
 APPLIANCE FUNCTION Exercisers  
 APPLIANCE CONCEPT NO./TITLE 1/Exer-Gym  
 INDEX NO. 4.2.1.1 REF. NO. 293, 96

## DESCRIPTION

The exer-gym concept is a commercial grade of exer-gyms manufactured by Exer-Genie. The unit provides exercise by means of varying rope tension to produce the desired push/pull restraint forces. Exer-gym works by putting each foot in the strap loops and pulling rope with one or two hands. A storage container is provided for the exer-gym. The study assumed four exer-gyms were provided for Shuttle and six for Space Station.



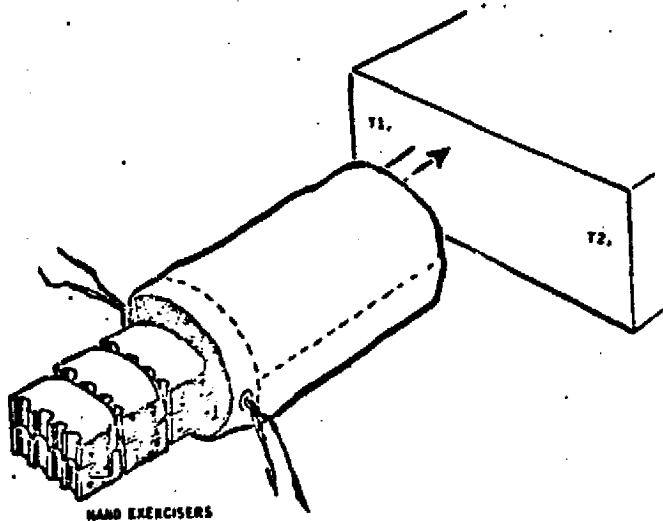




SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Physical Conditioning  
 APPLIANCE FUNCTION Exercisers  
 APPLIANCE CONCEPT NO./TITLE 2/Hand Exerciser  
 INDEX NO. 4.2.1.2 REF. NO. 293, 96

DESCRIPTION

The hand exerciser concept is provided to keep hand and arm muscle condition. The hand exercisers are shaped to fit the hand and are used as a "squeeze" type exerciser for maintaining grip strength. The units are coated with Fluorel for nonflammability. The study assumed four hand exercisers were provided for Shuttle and six for Space Station.









## HABITABILITY SUBSYSTEM

Medical

## APPLIANCE FUNCTIONS CONSIDERED

- 5.1.1 Autoclaves
- 5.2.1 Ergometers

## DESCRIPTION

The medical appliance subsystem considered by the study were those items judged to have a direct interface with the ECLSS. The Space Station will probably include more appliances than were considered in this section; however, the autoclave and ergometer appliances were the only appliance functions defined for a near term Space Station. The Shuttle Orbiter, because of its short-term mission, would not require these appliances. These appliance functions were, however, compiled for possible application to future Shuttle missions.

HABITABILITY SUBSYSTEM 5.0 Medical

HABITABILITY FUNCTION 5.1 Sterilization

APPLIANCE FUNCTION 5.1.1 Autoclaves

NUMBER OF CONCEPTS CONSIDERED 3

ASSUMPTIONS

- (1) Venting of the autoclave chamber to vacuum was allowed since the contamination level was considered low.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 5.1.1 \*\*\* AUTOCLAVES (SHUTTLE)

| CONCEPT NO. | USAGE TIME | CONSUMABLES AND FLOW REQUIREMENTS |       |                             |        |              | THERMAL REQMTS       |                  | ELEC PWR REQMTS  |                   | WT/VOL REQMTS      |              | DEVELOPMENT COST |             | RESUPPLY WEIGHT (LBS) |
|-------------|------------|-----------------------------------|-------|-----------------------------|--------|--------------|----------------------|------------------|------------------|-------------------|--------------------|--------------|------------------|-------------|-----------------------|
|             |            | USGS/DAY                          | TYPE  | AMT. USED (KG/USE) (LB/USE) | FLOW   | PRESS (PSIG) | TEMP (DEG C) (DEG F) | COOLANT (BTU/HR) | HT LEAK (BTU/HR) | PK PWR AC (WATTS) | AVG PWR DC (WATTS) | WEIGHT (LBS) | VOLUME (CU FT)   | AVAIL (1-3) |                       |
| 1           | 1.000      | 2                                 | .0603 | .00                         | .0     | .0           | 0.                   | 308.             | 1520.0           | 845.0             | 14.9               | .16          | 1                | 25          | .0                    |
|             | .500       |                                   | .1330 | .00                         | .0     | .0           | 0.                   | (1053.)          | .0               | .0                | ( 32.0)            | ( 5.59)      |                  |             | ( .0)                 |
|             |            | 9                                 | .0717 | 4.54                        | 1551.4 | 21.1         |                      |                  |                  |                   |                    |              |                  |             |                       |
|             |            |                                   | .1500 | (10.00)                     | (30.0) | ( 70.0)      |                      |                  |                  |                   |                    |              |                  |             |                       |
| 2           | 1.000      |                                   |       |                             |        |              | 0.                   | 421.             | 800.0            | 259.0             | 10.9               | .14          | 1                | 25          | .0                    |
|             | 2.330      |                                   |       |                             |        |              | ( 0.)                | (1438.)          | .0               | .0                | ( 24.0)            | ( 9.78)      |                  |             | ( .0)                 |
| 3           | 1.000      | 2                                 | .0603 | .00                         | .0     | .0           | 0.                   | 112.             | 230.0            | 171.0             | 39.0               | .17          | 2                | 45          | .0                    |
|             | 20.700     |                                   | .1330 | .00                         | .0     | .0           | ( 0.)                | ( 381.)          | .0               | .0                | ( 86.0)            | ( 6.09)      |                  |             | ( .0)                 |
|             |            | 5                                 | .0014 | .00                         | .0     | .0           |                      |                  |                  |                   |                    |              |                  |             |                       |
|             |            |                                   | .0030 | .00                         | .0     | .0           |                      |                  |                  |                   |                    |              |                  |             |                       |

APPLIANCE CONCEPT

- 1 - MOIST HEAT
- 2 - DRY HEAT
- 3 - ETHYLENE OXIDE

- (\*)
- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/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%             |

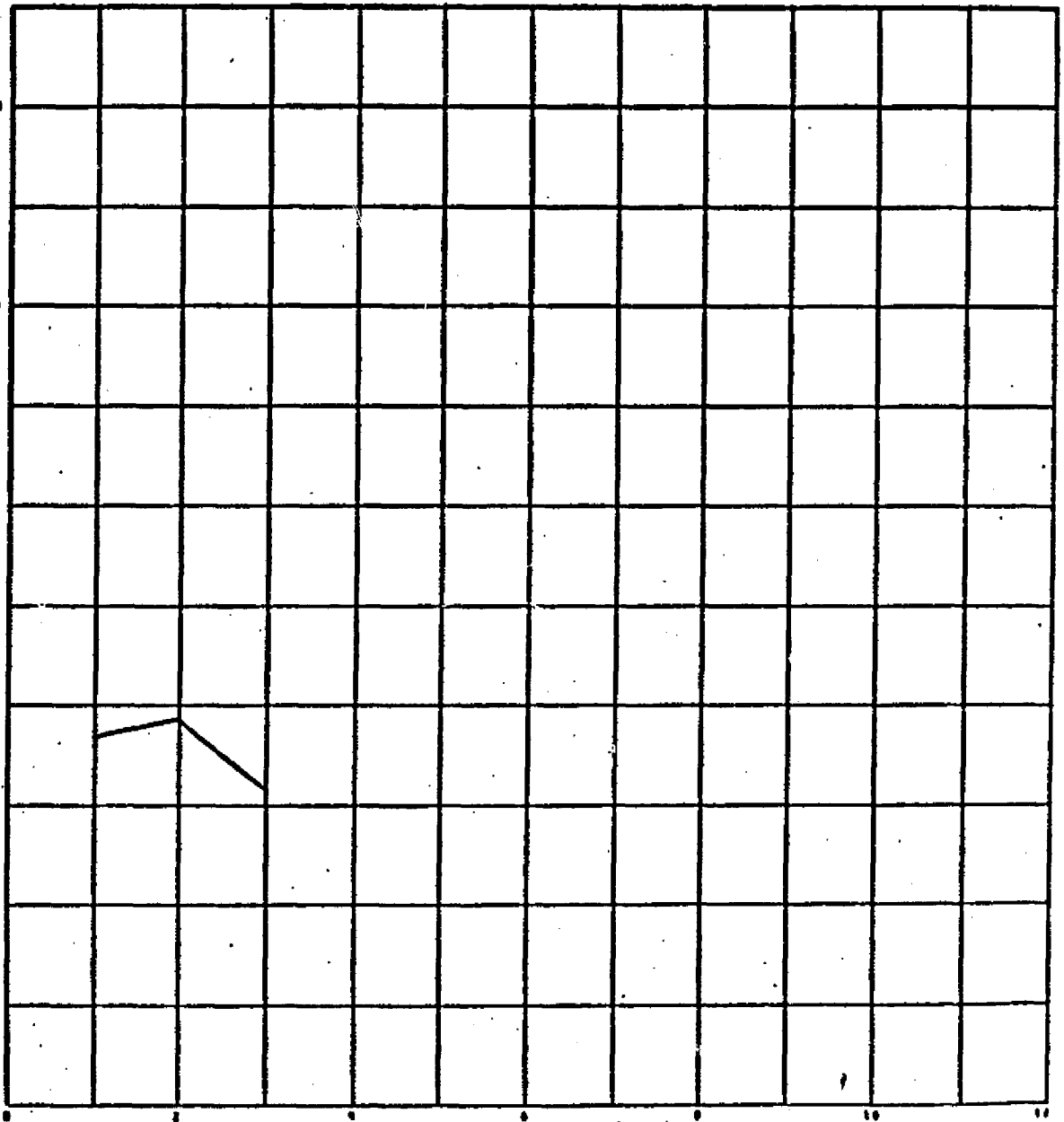
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APPLIANCE  
CONCEPT

| NO. | CONCEPT NAME   |
|-----|----------------|
| 1   | MOIST HEAT     |
| 2   | DRY HEAT       |
| 3   | ETHYLENE OXIDE |



CONCEPT NUMBER

Autoclaves (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 • • • • • AUTOCLAVES (SHUTTLE)

(04/10/75)

| FACTOR   | MIN<br>VALUE | MAX<br>VALUE | PTS | C O N C E P T |       |       |
|----------|--------------|--------------|-----|---------------|-------|-------|
|          |              |              |     | 1             | 2     | 3     |
| WEIGHT   | 24.000       | 86.000       | 15  | 9.28          | 10.61 | .00   |
| POWER    | 121.90       | 805.60       | 15  | .00           | 7.11  | 12.73 |
| VOLUME   | 4.7800       | 6.0900       | 10  | .82           | 2.15  | .00   |
| THERMAL  | 20.955       | 79.090       | 15  | 4.02          | .00   | 11.03 |
| RELIABTY | .99619       | .99990       | 5   | 4.67          | 3.80  | .00   |
| MAINTENC | .99999       | 1.00000      | 5   | 3.16          | .00   | 3.17  |
| SAFETY   | 1.0000       | 2.0000       | 5   | 2.50          | 2.50  | .00   |
| DEV COST | 25.000       | 45.000       | 15  | 6.67          | 6.67  | .00   |
| TOTAL PT | .00000       | 85.000       | 85  | 31.32         | 33.04 | 26.93 |
| RATING   | .00000       | 100.00       | 100 | 36.84         | 38.87 | 31.68 |

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**SENSITIVITY ANALYSIS**

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

**C O N C E P T**

|                 | 1     | 2     | 3     |
|-----------------|-------|-------|-------|
| <b>NORMAL</b>   | 36.84 | 38.87 | 31.68 |
| <b>WEIGHT</b>   | 38.87 | 41.56 | 29.11 |
| <b>POWER</b>    | 33.86 | 39.56 | 35.99 |
| <b>VOLUME</b>   | 35.25 | 37.91 | 29.92 |
| <b>THERMAL</b>  | 36.03 | 35.72 | 35.07 |
| <b>RELIAB-Y</b> | 38.58 | 39.93 | 30.77 |
| <b>MAINTENC</b> | 37.60 | 37.76 | 32.58 |
| <b>SAFETY</b>   | 37.22 | 39.19 | 30.77 |
| <b>DEV COST</b> | 37.46 | 39.32 | 29.11 |

**SENSITIVITY ANALYSIS**

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

**C O N C E P T**

|                 | 1     | 2     | 3     |
|-----------------|-------|-------|-------|
| <b>NORMAL</b>   | 36.84 | 38.87 | 31.68 |
| <b>WEIGHT</b>   | 34.42 | 35.66 | 34.74 |
| <b>POWER</b>    | 40.41 | 38.05 | 26.53 |
| <b>VOLUME</b>   | 38.63 | 39.96 | 33.66 |
| <b>THERMAL</b>  | 37.82 | 42.63 | 27.63 |
| <b>RELIAB-Y</b> | 35.00 | 37.74 | 32.64 |
| <b>MAINTENC</b> | 36.04 | 40.05 | 30.72 |
| <b>SAFETY</b>   | 36.44 | 38.53 | 32.64 |
| <b>DEV COST</b> | 36.11 | 38.33 | 34.74 |

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 5.1.1-AUTOCLAVES

| COMPONENT TYPE            |     | NUMBER OF COMPONENTS |              |                |                    |              |             |        |                  |        |       |        |   |   |   | NUMBER OF SAFETY CRITICAL ITEMS |   |   |
|---------------------------|-----|----------------------|--------------|----------------|--------------------|--------------|-------------|--------|------------------|--------|-------|--------|---|---|---|---------------------------------|---|---|
|                           |     | ACCUMULATOR          | RELIEF VALVE | SOLENOID VALVE | PRESSURE REGULATOR | MANUAL VALVE | CHECK VALVE | HEATER | CONTROLLER TIMER | FILTER | MOTOR | BLOWER |   |   |   |                                 |   |   |
| APPLIANCE TYPE            | NO. | ④                    | ②⑤           | ③              | ⑪                  | ②③           | ②②          | ①⑦     | ①⑨               | ⑨      | ①     | ①⑧     | ○ | ○ | ○ | ○                               | ○ |   |
| AUTOCLAVE, MOIST HEAT     | 3   | 1                    | 2            | 1              | 1                  | 1            | 1           | 1      | -                | -      | -     | -      |   |   |   |                                 |   | 1 |
| AUTOCLAVE, DRY HEAT       | 1   | -                    | 1            | -              | -                  | -            | 1           | 1      | 1                | 1      | 1     | 1      |   |   |   |                                 |   | 1 |
| AUTOCLAVE, ETHYLENE OXIDE | 3   | 2                    | 3            | 1              | -                  | -            | 1           | 1      | -                | -      | -     | -      |   |   |   |                                 |   | 2 |

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SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION Sterilization  
APPLIANCE FUNCTION Autoclaves  
APPLIANCE CONCEPT NO./TITLE 1/Moist Heat Sterilizer  
INDEX NO. 5.1.1.1 REF. NO. 202

## DESCRIPTION

The moist heat sterilization concept utilizes high temperature saturated steam as the agent for sterilization. The advantages of this system are its rapid heating, penetration, and moisture which facilitate the coagulation of proteins. This is the mechanism by which the organisms are destroyed. The units sterilization operating temperature range is 121°C to 132°C (250°F - 270°F). The period of time used for this method of sterilization was assumed to be 15 minutes at 1551 mmHg (30 psia). The air within the autoclave was assumed to be exhausted overboard prior to each sterilization cycle to assure efficient sterilization. The volume of the chamber used for computing the vented gas was .0504 m<sup>3</sup> (1.78 ft<sup>3</sup>). The water used per cycle was 0.072 kgms/use (0.158 lb/use) which is recondensed and recovered.





D2-118561-3

SPACECRAFT Shuttle  
HABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION Sterilization  
APPLIANCE FUNCTION Autoclaves  
APPLIANCE CONCEPT NO./TITLE 2/Dry Heat Sterilization  
INDEX NO. 5.1.1.2 REF. NO. 202

DESCRIPTION

The dry heat sterilization concept uses dry heat as the sterilization agent. This concept requires much higher temperatures and longer exposure times than Concept 1. The study assumed a 2 hour sterilization time period at 320°F. The dry heat destroys organisms by means of oxidation of their intercellular constituents. The unit will sterilize everything but aqueous materials because of its low vapor pressure. The dry heat chamber (1.78 ft<sup>3</sup>) was assumed to be insulated with a .038 meter (1.5 inch) thick polystyrene foam.

The heat leak calculated was based on this insulation system. In addition to the 2 hour sterilization period, a 20 minute warmup time was assumed.





D2-118561-3

SPACECRAFT Shuttle

HABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION Sterilization

APPLIANCE FUNCTION Autoclaves

APPLIANCE CONCEPT NO./TITLE 3/Ethylene Oxide Sterilizer

INDEX NO. 5.1.1.3 REF. NO. 202, 292

DESCRIPTION

The ethylene oxide sterilizer concept uses a mixture of Freon 12 and ethylene oxide as a sterilant agent. The sterilizer was assumed to operate at 54 °C (130°F) temperature, 1337 mmHg (22 psia) pressure, and at a relative humidity of 40%. The water used to raise the humidity and the air required evacuated prior to usage were assumed lost after each cycle. Since ethylene oxide is extremely flammable in air, mixtures of 88% Freon 12 and 12% ethylene oxide or 90% carbon dioxide and 10% ethylene oxide to circumvent this problem. The ethylene oxide sterilant mixtures are toxic and corrosive. A design using this concept would require careful interlocking of the chamber door to prevent accidental injury. The internal volume of the chamber was assumed to be .05 m<sup>3</sup> (1.78 ft<sup>3</sup>) with approximately .003 pounds of water per charge for maintenance of relative humidity. The sterilant mixture is exhausted after the sterilization cycle is complete. The study assumed 20 hours were required for sterilization with a 5 minute warmup period. The cylinders used for the sterilant mixture were assumed to be aluminum.







HABITABILITY SUBSYSTEM 5.0 Medical

HABITABILITY FUNCTION 5.2 Physical Monitoring

APPLIANCE FUNCTION 5.2.1 Ergometers

NUMBER OF CONCEPTS CONSIDERED 1

ASSUMPTIONS

None

SPACECRAFT Shuttle  
 HABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION Physical Monitoring  
 APPLIANCE FUNCTION Ergometer  
 APPLIANCE CONCEPT NO./TITLE Ergometer  
 INDEX NO. 5.2.1 REF. NO. 94, Skylab unit

## DESCRIPTION

The ergometer is a bicycle-type, floor-mounted exercise machine with handlebars, bicycle seat, bicycle pedals, and a chest board. The ergometer is designed to allow the crew to exercise in a zero-g environment, using either his hands or his feet to drive the ergometer. The ergometer is capable of automatically programming heart rate (100 to 200 beats per minute) which is accomplished by a feedback loop control in which the workload varies automatically to produce desired heart rates. The exercise is accomplished by manually pedaling which drives a DC torque motor. The work is released to the environment as heat. The rate of power application in the automatic mode shall be adjustable from 25 to 100 watts per minute. The manual mode workload range is 25 to 300 watts.

