

(NASA-CR-144456) CREW APPLIANCE CONCEPTS.  
VOLUME 5, APPENDIX C: MODULAR SPACE STATION  
APPLIANCES SUPPORTING ENGINEERING DATA  
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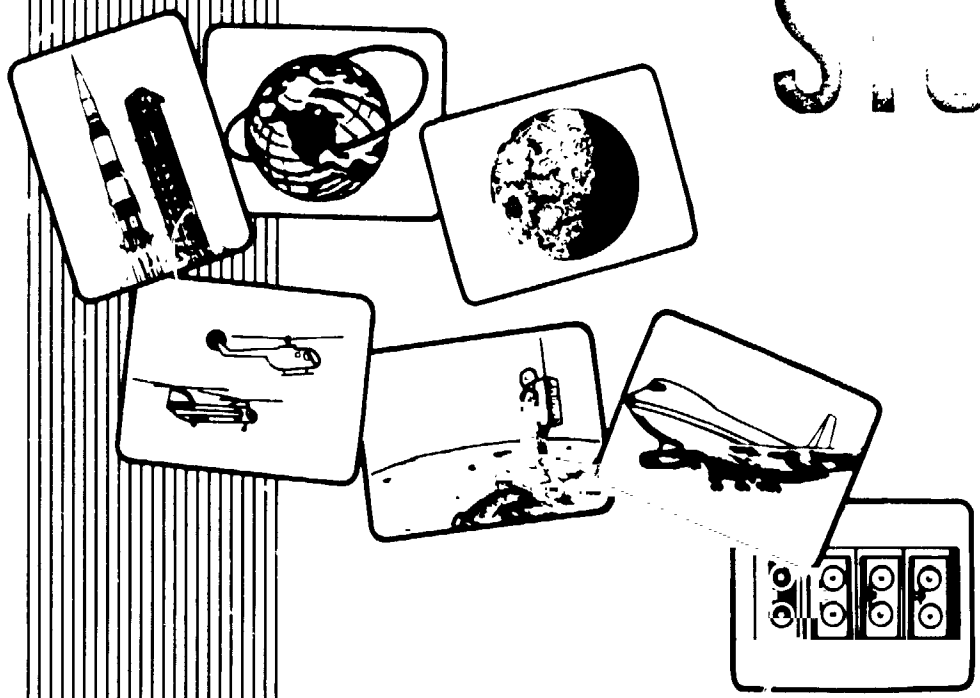
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### CREW APPLIANCE CONCEPTS

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THE **BOEING** COMPANY  
HOUSTON, TEXAS

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CREW APPLIANCE CONCEPTS  
APPENDIX C  
MODULAR SPACE STATION APPLIANCES  
SUPPORTING ENGINEERING DATA

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SECTION 2  
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**HABITABILITY SUBSYSTEM Housekeeping**

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**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. 3.1.1 \*\*\* SURFACE WIPING (SPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS				THERMAL REQTS				ELEC PWR REQTS				WT/VOL REQTS				DEVELOPMENT REQS			
		AMT	UNIT	TYPE	REQ	TEMP	LEAK	WATTS	BTU/HR	PK PWR	AC	DC	AVG PWR	AC	DC	WGT	VOL	REQTS	DEVELOPMENT	REQS	
1	15.000	2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	.2248	.00	1551.4	21.1															
			(.5000)	(.00)	(130.0)	(70.0)															
2	15.000	2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	.2412	.00	1551.4	21.1															
			(.6200)	(.00)	(130.0)	(70.0)															
3	15.000	2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	.2248	.00	1551.4	21.1															
			(.5000)	(.00)	(130.0)	(70.0)															
4	15.000	5	.2248	.00	1551.4	21.1															
	.037		(.5000)	(.00)	(130.0)	(70.0)															
		2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	.2435	.00	1551.4	21.1															
			(.6250)	(.00)	(130.0)	(70.0)															
6	15.000	2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	.2381	.00	1810.0	51.7															
			(.5250)	(.00)	(135.0)	(125.0)															
7	15.000	2	.0003	.00	21.1	0	278.	105.	278.	500.0	360.0	360.0	192.0	5.97	2	30	156.3				
	.037		(.007)	(.00)	(70.0)	(360.1)	(948.1)						(423.3)	(193.30)			(344.6)				
		5	2.5402	.00	1551.4	51.7															
			(5.6000)	(.00)	(130.0)	(125.0)															
8	15.000	5	2.5402	.00	1551.4	51.7															
	.037		(5.7200)	(.00)	(130.0)	(125.0)															
		5	2.6002	.00	1551.4	51.7															
	.037		(5.7500)	(.00)	(130.0)	(125.0)															
10	15.000	5	2.5402	.00	1810.0	51.7															
	.037		(5.6000)	(.00)	(135.0)	(125.0)															

11	15-000	5	.2268	.00	1551.4	51.7	105.	278.	500.0	360.0	90.4	.13	2	30	27.5
	.037		(.50001)	(.00)	(125.0)	(360.)	(940.)		.0	.0	(89.1)	(9.00)			(60.6)
12	15-000	6	.2268	.00	1551.4	51.7	32.	30.	57.5	140.0	91.0	.06	1	5	27.5
	.037		(.50001)	(.00)	(125.0)	(110.)	(101.)		140.0	140.0	(92.1)	(2.20)			(60.6)

APPLIANCE CONCEPT NO.	C O N C E P T	N A M E	(CIRCULATED) (LOST)	LITERS/SEC (LB/HR)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)	(CIRCULATED) (LOST)
1	DISPOSABLE NET/DRY WIPES	DISPOSABLE NET/DRY WIPES	1	CABIN AIR	1	1	1	1	1	1	1	1	1	1	1
2	REUSABLE NET/DRY WIPES	REUSABLE NET/DRY WIPES	2	CABIN AIR	2	2	2	2	2	2	2	2	2	2	2
3	DISPOSABLE NET/DRY WIPES (PREPACKAGED)	DISPOSABLE NET/DRY WIPES (PREPACKAGED)	3	OXYGEN	3	3	3	3	3	3	3	3	3	3	3
4	AUTOMATIC SPONGE MOP	AUTOMATIC SPONGE MOP	4	COOLING WATER	4	4	4	4	4	4	4	4	4	4	4
5	REUSABLE CLEANING CLOTHS	REUSABLE CLEANING CLOTHS	5	WATER	5	5	5	5	5	5	5	5	5	5	5
6	DISPOSABLE CLEANING CLOTHS (SKLAB)	DISPOSABLE CLEANING CLOTHS (SKLAB)	6	NITROGEN	6	6	6	6	6	6	6	6	6	6	6
7	DISPOSABLE NET/DRY WIPES	DISPOSABLE NET/DRY WIPES	7	NITROGEN	7	7	7	7	7	7	7	7	7	7	7
8	REUSABLE NET/DRY WIPES	REUSABLE NET/DRY WIPES	8	FREON	8	8	8	8	8	8	8	8	8	8	8
9	REUSABLE CLEANING CLOTHS/DRY WIPES	REUSABLE CLEANING CLOTHS/DRY WIPES	9	WATER	9	9	9	9	9	9	9	9	9	9	9
10	DISPOSABLE CLEANING CLOTHS	DISPOSABLE CLEANING CLOTHS	10		10	10	10	10	10	10	10	10	10	10	10
11	SPONGES/ENCLOSED WETTING UNIT	SPONGES/ENCLOSED WETTING UNIT	11		11	11	11	11	11	11	11	11	11	11	11
12	SPONGES/SKLAB TYPE WETTING UNIT	SPONGES/SKLAB TYPE WETTING UNIT	12		12	12	12	12	12	12	12	12	12	12	12

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

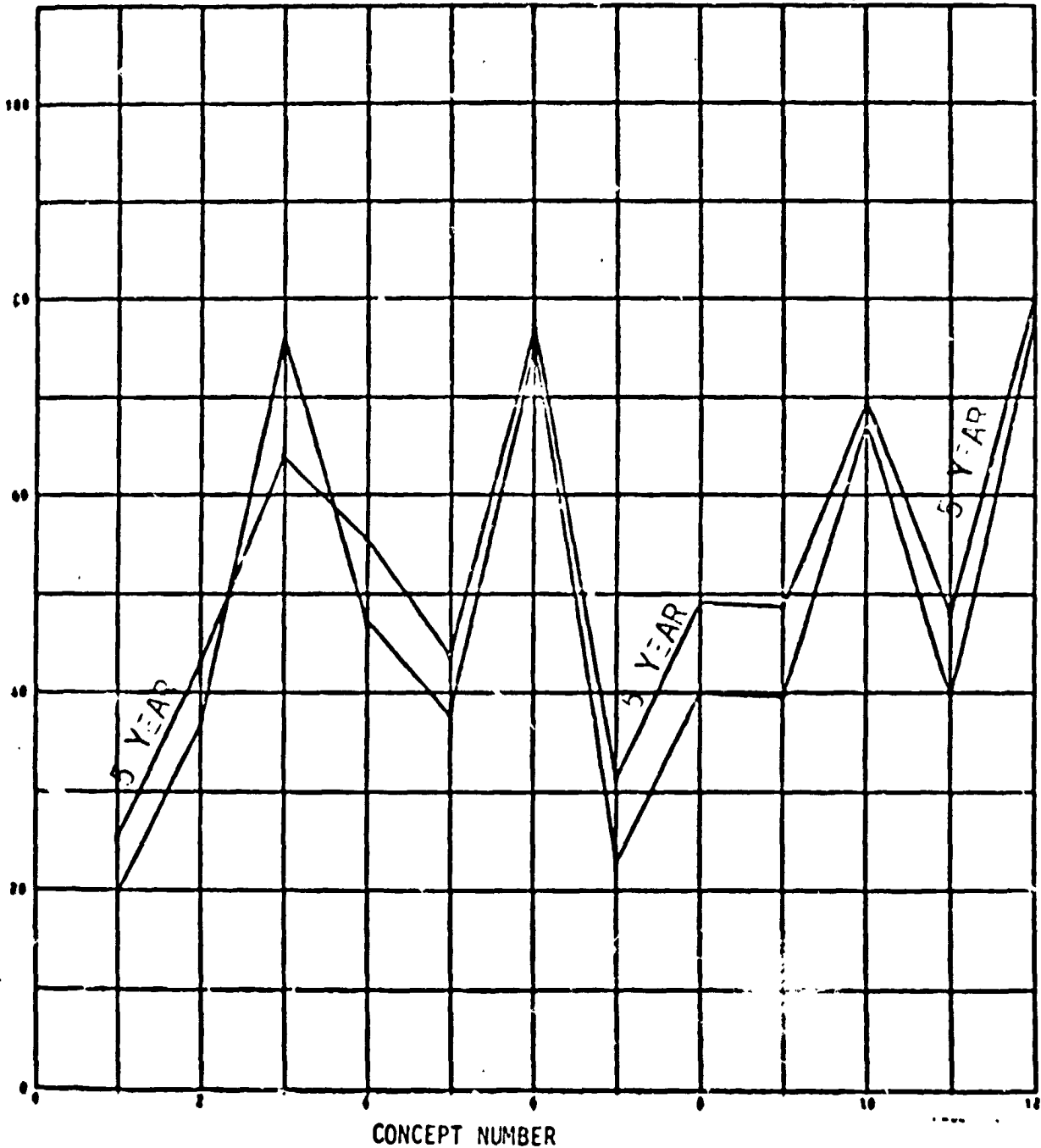
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APPEARANCE  
CONCEPT  
NO.

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



CONCEPT NUMBER

Surfacing Wiping (Space Station) Concept Trade

NUMBER OF DAYS = 180.0 ( .49 YEARS)  
 USES MOD SUBROUTINE 12  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX \* \* \* \* \* SURFACE WIPING (SPACE STATION)  
 (02/01/75)

FACTOR	MIN VALUE		PTS	C O N C E P T											
	1	2		3	4	5	6	7	8	9	10	11	12		
WEIGHT	23.042	774.10	15	6.80	10.86	.00	14.55	10.70	12.33	9.47	13.58	13.41	11.08	13.27	13.21
POWER	.00000	355.00	15	.00	.00	15.00	13.42	.00	9.78	.00	.00	.00	9.78	.00	9.78
VOLUME	1.7000	193.30	10	.00	9.57	8.69	9.91	8.85	8.17	.05	9.60	9.45	8.20	9.76	9.89
THERMAL	.00000	150.50	15	.97	.97	15.00	.00	.97	13.12	.97	.97	.97	8.05	.97	13.12
RELIAB-Y	.99745	1.0000	5	.51	.51	5.00	.00	1.65	1.48	.51	.51	.51	1.48	.51	1.48
MAINTENC	.99959	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	15.61	29.25	60.67	37.88	30.22	60.04	18.33	31.99	31.67	53.75	31.85	62.64
RATING	.00000	100.00	100	19.52	36.56	75.86	47.35	37.77	75.05	22.91	39.99	39.58	67.19	39.81	78.30

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SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	19.52	36.56	75.86	47.35	37.77	75.05	22.91	39.99	39.58	67.19	39.81	78.30
WEIGHT	21.73	39.63	69.36	51.61	40.65	75.66	26.35	41.32	43.85	67.76	43.98	79.14
POWER	17.84	33.43	77.93	50.96	34.53	74.21	20.94	36.56	36.19	67.02	36.40	77.18
VOLUME	18.37	40.04	76.50	50.40	40.76	75.44	21.59	43.28	42.81	68.06	43.21	79.51
THERMAL	18.40	33.98	77.93	43.29	35.09	76.12	21.50	37.11	36.75	66.03	36.95	79.09
RELIAB-Y	19.24	35.76	76.59	45.92	37.62	73.68	22.53	39.09	38.70	66.05	38.92	76.83
MAINTENC	19.73	36.26	76.59	45.92	37.87	73.78	23.02	39.58	39.19	66.16	39.41	76.94
DEV COST	21.27	36.85	76.21	43.29	37.96	76.33	24.37	39.99	39.62	69.14	39.83	79.31

SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	19.52	36.56	75.86	47.35	37.77	75.05	22.91	39.99	39.58	67.19	39.81	78.30
WEIGHT	16.85	32.85	83.70	42.21	34.30	74.31	18.75	34.76	34.43	66.50	34.78	77.29
POWER	21.53	40.34	73.36	43.00	41.68	76.07	25.28	44.13	43.68	67.39	43.93	79.66
VOLUME	20.82	32.62	75.12	43.90	34.39	74.61	24.40	36.25	35.93	66.20	35.96	76.93
THERMAL	20.87	39.67	73.36	52.25	41.01	73.77	24.61	43.46	43.01	68.59	43.26	77.36
RELIAB-Y	19.81	37.41	75.08	48.88	37.93	76.52	23.32	40.95	40.53	68.40	40.76	79.87
MAINTENC	19.29	34.88	75.08	48.88	37.67	76.40	22.79	40.42	40.00	68.28	40.24	79.76
DEV COST	17.40	36.20	75.43	52.25	37.54	73.51	21.14	39.99	39.54	64.83	39.79	77.09

NUMBER OF DAYS = 1826.0 (15.00 YEARS)  
 USES MOD SUBROUTINE 12  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX (02/01/75) SURFACE WIPING (SPACE STATION)

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	23.042	774.10	15	6.80	10.86	.00	14.55	10.70	12.33	9.47	13.58	13.41	11.08	13.27	13.21
POWER	.00000	355.00	15	.00	.00	15.00	13.42	.00	9.78	.00	.00	.00	.00	9.78	.00
VOLUME	1.7000	193.30	10	.00	9.57	8.69	9.91	8.85	8.17	.05	9.60	9.45	8.20	9.76	9.89
THERMAL	.00000	150.50	15	.97	.97	15.00	.00	.97	13.12	.97	.97	.97	8.05	.97	13.12
RELIAB-Y	.97442	1.0000	5	.51	.51	5.00	.00	1.63	1.47	.51	.51	.51	1.47	.51	1.47
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
REC COST	2.4420	774.20	15	8.32	11.55	.00	14.95	11.48	13.00	11.49	14.72	14.65	12.21	13.82	13.82
TOTAL PT	.00000	95.000	95	23.93	40.79	60.69	52.83	41.68	73.03	29.81	46.70	46.31	65.95	45.67	76.46
RATING	.00000	100.00	100	25.19	42.94	63.88	55.61	43.88	76.87	31.38	49.16	48.75	69.42	48.07	80.48

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SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	25.19	42.94	63.88	55.61	43.88	76.87	31.38	49.16	48.75	69.42	48.07	80.48
WEIGHT	26.66	45.09	59.21	58.64	45.89	77.26	33.70	52.19	51.72	69.74	51.03	81.04
POWER	23.35	39.79	66.52	58.09	40.67	76.02	29.09	45.56	45.18	69.11	44.55	79.36
VOLUME	23.93	45.57	65.03	57.79	46.11	77.11	29.84	51.50	51.03	70.05	50.55	81.40
THERMAL	23.82	40.27	66.52	51.25	41.14	77.65	29.56	46.04	45.05	68.26	45.03	80.99
RELIAB-Y	24.80	42.10	64.81	54.19	43.59	75.65	30.84	48.16	47.76	68.39	47.10	79.17
MAINTENC	25.23	42.52	64.81	54.19	43.80	75.75	31.26	48.58	48.18	68.49	47.52	79.27
DEV COST	26.27	42.72	65.06	51.55	43.59	77.83	32.01	48.49	48.11	70.92	47.48	81.18
REC COST	27.41	45.43	59.21	58.84	46.26	77.59	34.69	52.74	52.32	70.29	51.30	81.34

SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	25.19	42.94	63.88	55.61	43.88	76.87	31.38	49.16	48.75	69.42	48.07	80.48
WEIGHT	23.46	40.41	69.36	52.07	41.52	76.41	28.66	45.62	45.26	69.04	44.61	79.83
POWER	27.35	46.62	60.78	52.72	47.64	77.87	34.07	53.38	52.92	69.78	52.19	81.79
VOLUME	26.59	40.00	62.60	53.20	41.40	76.60	33.10	46.56	46.21	68.72	45.32	79.46
THERMAL	26.80	46.06	60.78	60.38	47.08	75.96	33.52	52.82	52.37	70.77	51.64	79.88
RELIAB-Y	25.60	43.82	62.90	57.12	44.18	78.15	31.96	50.22	49.79	70.50	49.10	81.86
MAINTENC	25.15	43.38	62.90	57.12	43.95	78.05	31.51	49.77	49.34	70.40	48.65	81.76
DEV COST	23.92	43.19	62.50	60.38	44.21	75.75	30.64	49.95	49.50	67.65	48.76	79.66
REC COST	22.59	40.02	69.36	51.84	41.08	76.03	27.51	44.97	44.55	68.39	44.29	79.48

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.1.1-EQUIPMENT CLEANING

COMPONENT TYPE APPLIANCE TYPE	NUMBER OF COMPONENTS													NUMBER OF SAFETY CRITICAL ITEMS		
	WATER SEPARATOR	FILTER	SOLENOID VALVE	HEAT EXCHANGER	ACCUMULATOR	TEMPERATURE CONTROL VALVE	CONTROLLER	TIMER	CHECK VALVE	PUMP	MANUAL VALVE	HEATER	RELIEF VALVE		MOTOR	ELECTRIC SWITCH
DISPOSABLE WET/DRY WIPES	1	2	2	1	1	1	1	1	1	-	-	-	-	1	1	0
REUSABLE WET WIPES/DISPOSABLE WET WIPES	1	2	2	1	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	1	1	1	-	-	-	2	1	0
REUSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES	1	2	2	1	1	1	1	1	1	-	-	-	-	1	-	0
DISPOSABLE CLEANING CLOTHS/DISPOSABLE DRY WIPES	-	-	-	-	1	1	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	1	0
REUSABLE WET WIPES/REUSABLE DRY WIPES	1	2	2	1	1	1	1	1	1	-	-	-	-	1	1	0
REUSABLE CLEANING CLOTHS/REUSABLE DRY WIPES	1	2	2	1	1	1	1	1	1	-	-	-	-	1	1	0
DISPOSABLE CLEANING CLOTHS/REUSABLE DRY WIPES	-	-	-	-	1	1	1	1	1	1	5	1	1	1	-	0
SPONGES/ENCLOSED WETTING UNIT	1	2	2	1	1	1	1	1	1	-	-	-	-	1	1	0
SPONGES/SKYLAB TYPE WETTING UNIT	-	-	-	-	1	1	1	1	1	1	5	1	1	1	-	0

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

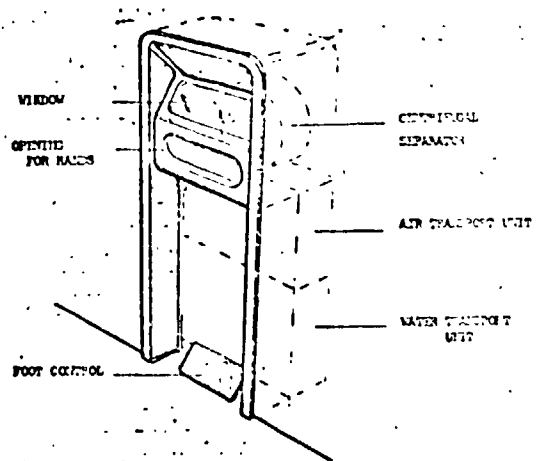
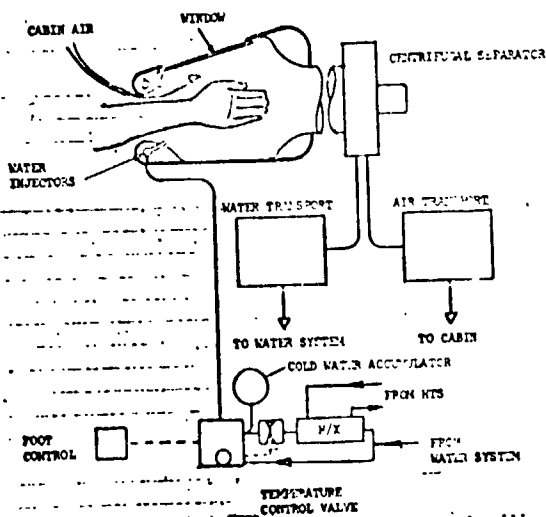
APPLIANCE FUNCTION Surface Wiping

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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT DISPOSABLE WET/DRY WIPES

INDEX NUMBER 3.1.6.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER			DC POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)
<u>WETTING UNIT (236)</u>		<u>.0375</u>	<u>500</u>	<u>360</u>	<u>13.5</u>	<u>-</u>	<u>-</u>
_____							
_____							
_____							
_____							
_____							
			<u>500</u>		<u>13.5</u>		
			MAXIMUM		TOTAL	MAXIMUM	TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS</u>	<u>360</u>	<u>-</u>	<u>-</u>	<u>360</u>
<u>MOTORS</u>	<u>-</u>	<u>948</u>	<u>948</u>	<u>-</u>
_____				
_____				
TOTAL	<u>105.6 (360)</u>	<u>278 (948)</u>	<u>278 (948)</u>	<u>105.6 (360)</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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





SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Equipment Cleaning

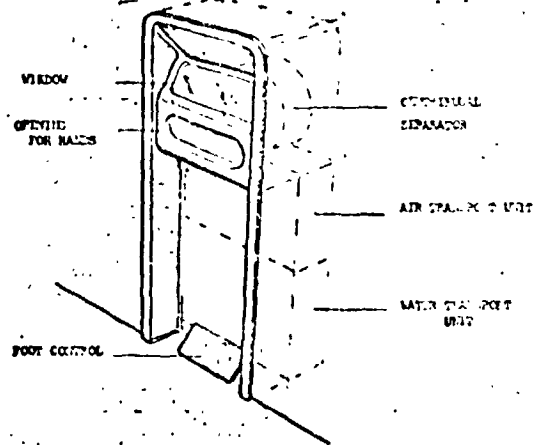
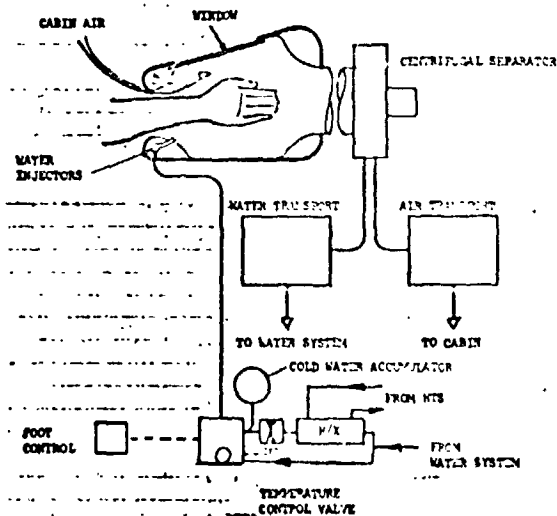
APPLIANCE FUNCTION Surface Wiping

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.

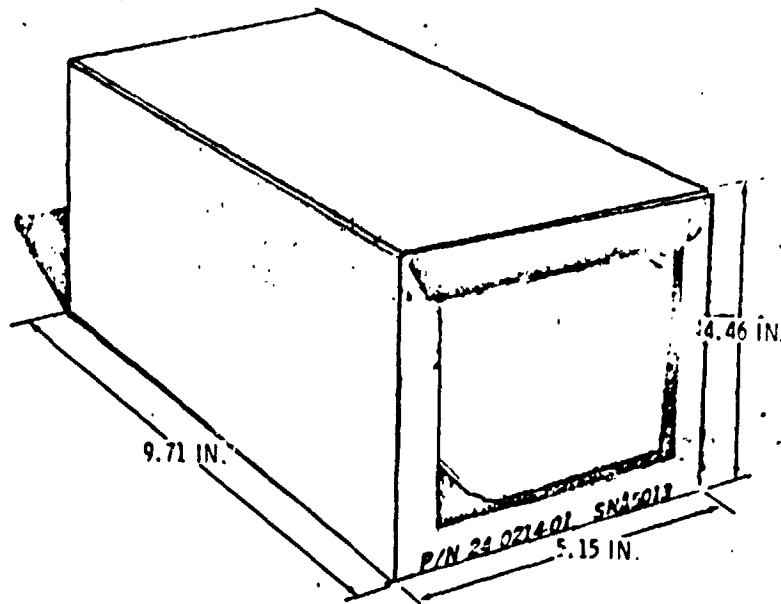






SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment CleaningAPPLIANCE FUNCTION Surface WipingAPPLIANCE CONCEPT NO./TITLE 3/Disposable Wet/Dry Wipes (Prepackaged)INDEX NO. 3.1.1.3REF. NO. 250,283

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 Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

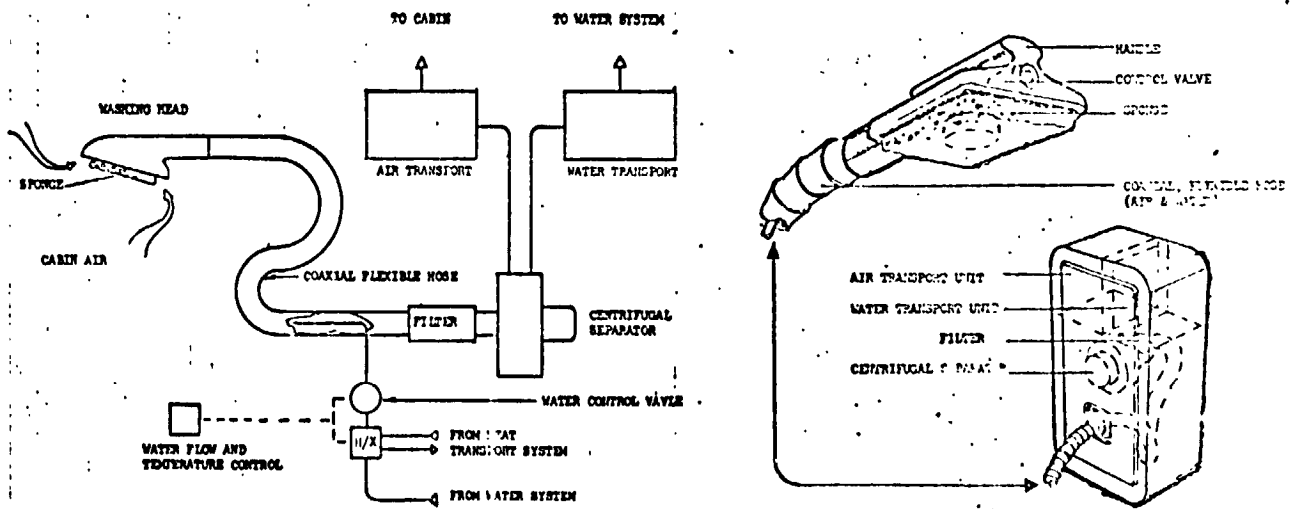
APPLIANCE FUNCTION Surface Wiping

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 Space Station

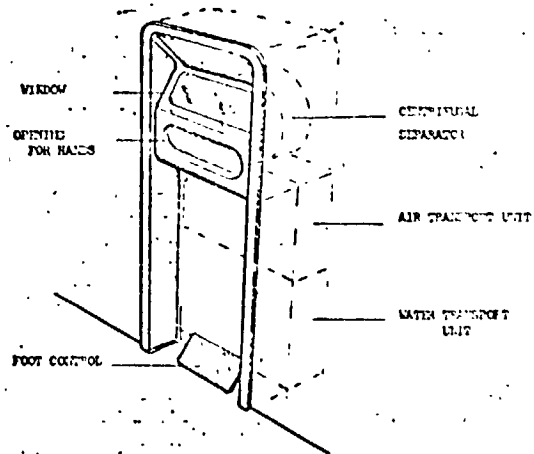
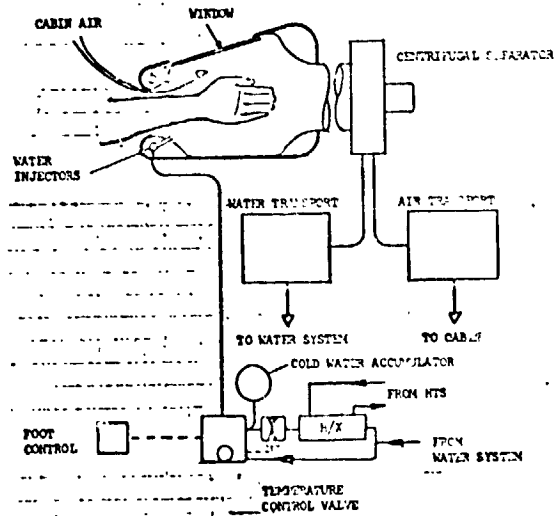
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

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 Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

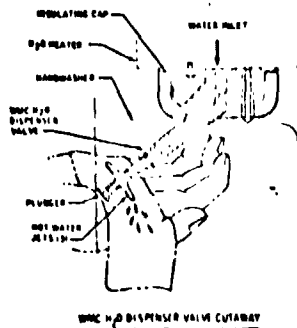
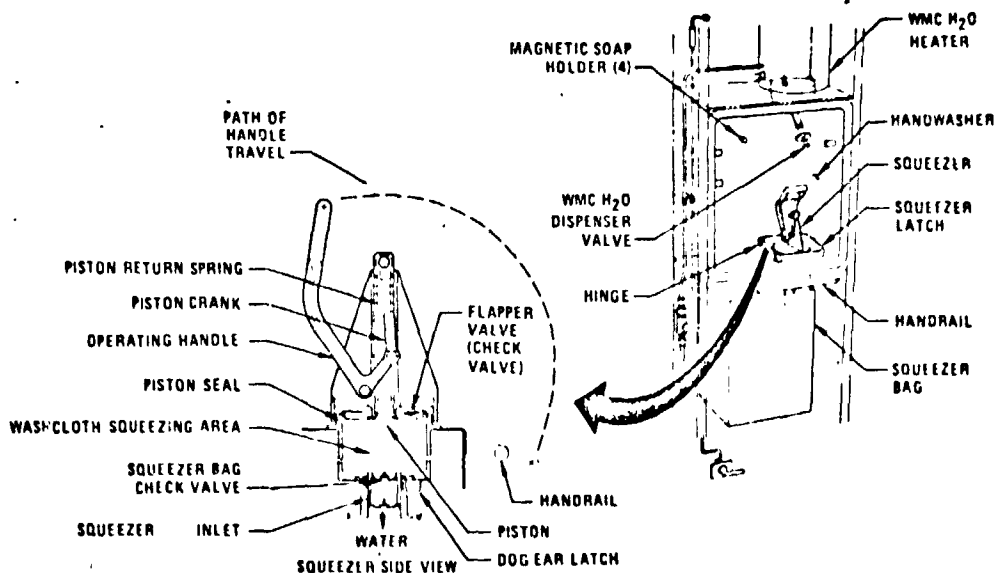
APPLIANCE FUNCTION Surface Wiping

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.









SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Equipment Cleaning

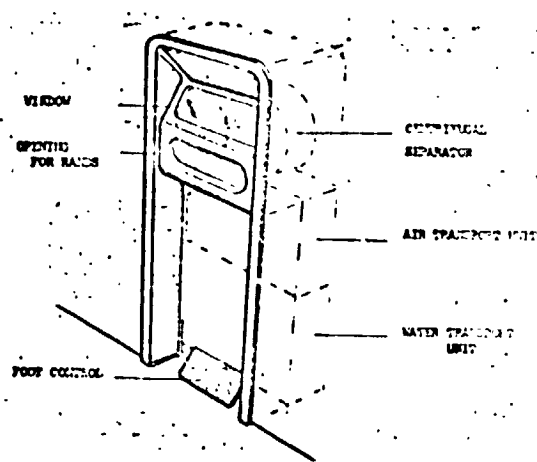
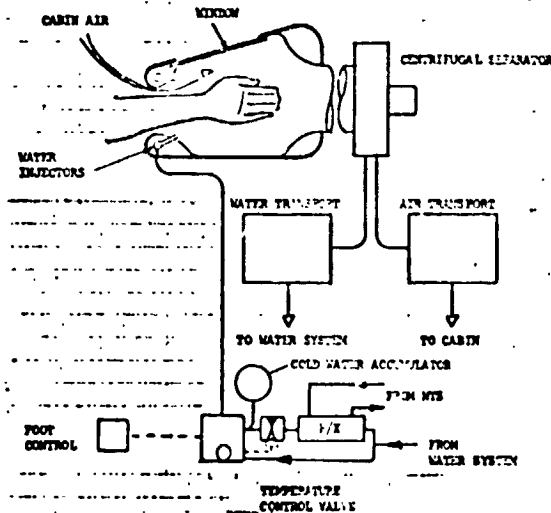
APPLIANCE FUNCTION Surface Wiping

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. 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.



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 7/DISPOSABLE WLT WIPOS/REUSABLE DRY WIPOS

INDEX NUMBER 3.1.1.7

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A C P O W E R			D C P O W E R		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① x ⑥
<u>MELTING UNIT (33)</u>	<u>0.375</u>	<u>500</u>	<u>360</u>	<u>13.5</u>			
		<u>500</u>		<u>13.5</u>			
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS</u>	<u>360</u>	<u>-</u>	<u>-</u>	<u>360</u>
<u>MOTORS</u>	<u>-</u>	<u>948</u>	<u>948</u>	<u>-</u>
TOTAL	<u>105.6(360)</u>	<u>278 (948)</u>	<u>278 (948)</u>	<u>105.6(360)</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>WASHER</u>	<u>165</u>	<u>-</u>	<u>22</u>	<u>18.5</u>	<u>1.66</u>
<u>DRYER</u>	<u>33.6</u>	<u>62.5</u>	<u>27.7</u>	<u>7.4</u>	<u>1.63</u>
TOTAL	<u>142.2</u>	<u>18.3</u>	<u>49.7</u>	<u>11.7</u>	<u>.093</u>
	<u>(498.6)</u>	<u>(62.5)</u>		<u>(25.9)</u>	<u>(3.29)</u>
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)	KG/MISSION (LB/MISSION)	M <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 7/DISPOSABLE WET WIPES/REUSABLE DRY WIPES

INDEX NUMBER 3.1.1.7

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
WETTING UNIT	(236)	76.69	185.0
DISPOSABLE WET WIPES		41.40	4.14
REUSABLE DRY WIPES		.403	.17
TOTAL		<b>53.75 (118.493)</b>	<b>5.35 (89.31)</b>
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	②	③	④	⑤
		WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	WT/CYCLE ① x ② (LB)	VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	VOL./CYCLE ① x ④ (FT <sup>3</sup> )
WET WIPES	1 (236)	.015 (236)	.015	.0015	.0015
REUSABLE DRY WIPES	.0166	.0058 (236)	.000199	.00366 (236)	.0000608
		Σ ③	.015148 TOTAL WT/CYCLE (LB)	Σ ⑤	.0015608 TOTAL VOL./CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .015148 TOT. WT/CYCLE (LB)	x	18.96 (41.81) KG (LB)
TOTAL VOL. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .0015608 TOT. VOL./CYCLE (FT <sup>3</sup> )	x	1.22 (4.31) M <sup>3</sup> (FT <sup>3</sup> )

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	①	②	③	④	
	AMT. USED/CYCLE (REF) (LB)	RECOVERY FACTOR	AMT. RECOVERED/CYCLE ① x ② (LB)	AMT. LOST/CYCLE ① - ③ (LB)	
WATER	.5	1-.0009	.4995	.0005	
WATER LOSS (WET WIPES)	.0954	N/A	N/A	.0954	
OXYGEN WIPER DISK (WIPER)	.000719	N/A	N/A	.000719	
WASHER WATER LOSS PENALTY	5.1	1-.0009	5.0954	.00459	
Σ ④			5.65	Σ ④	.05121
TOTAL WT. MISSION	15 CYCLE/DAY	184 DAYS/MISSION	x .05121 TOTAL LOST/CYCLE (LB)	x	141.34 (66.67) (146.99) KG (LB)

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HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

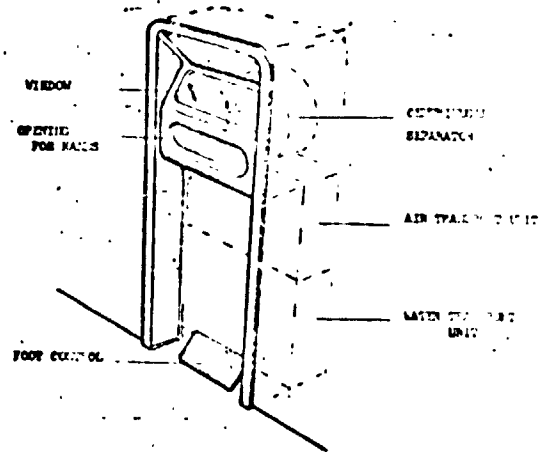
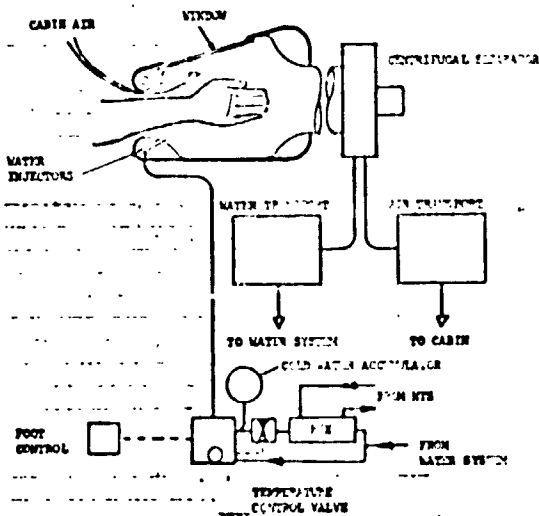
APPLIANCE FUNCTION Surface Wiping

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.





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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT B/REUSABLE WLT/DRY WIPES

INDEX NUMBER 3.1.1.8

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
WETTING UNIT	(236)	28.49	3.5
REUSABLE WGT WIPES		.18	.12
REUSABLE DRY WIPES		.16	.16
TOTAL		13.1 (28.83)	.107 (3.78)
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	①	②	③	④	⑤
	UNITS/CYCLE (REF)	WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	WT/CYCLE ① x ② (LB)	VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	VOL/CYCLE ① x ④ (FT <sup>3</sup> )
WET WIPES	.0167 (236)	.009 (236)	.000663	.00252 (236)	.000421
DRY WIPES	.0167 (236)	.0058 (236)	.000948	.00366 (236)	.000608
			Σ ③ .000214		Σ ⑤ .0001029
			TOTAL WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION =	15	184	.000124	.155	.34
	CYCLES/DAY	DAYS/MISSION	TOT. WT/CYCLE (LB)	KG (LB)	
TOTAL VOL. MISSION =	15	184	.0001029	.008	.28
	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	②	③	④	
	AMT. USED/CYCLE (REF) (LB)	RECOVERY FACTOR	AMT. RECOVERED/CYCLE ① x ② (LB)	AMT. LOST/CYCLE ① - ③ (LB)	
WATER	.5	1-.0009	.4995	.0005	
WASHER WATER LOSS PENALTY	5.22	1-.0009	5.2153	.0047	
			Σ ③ .0052	Σ ④ .0052	
			TOTAL LOST/CYCLE (LB)		
TOTAL WT. MISSION =	15	184	.0052	9.1	20.07
	CYCLE/DAY	DAYS/MISSION	(LB)	KG (LB)	

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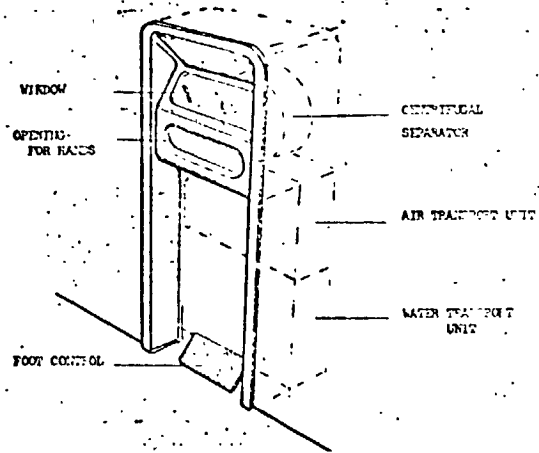
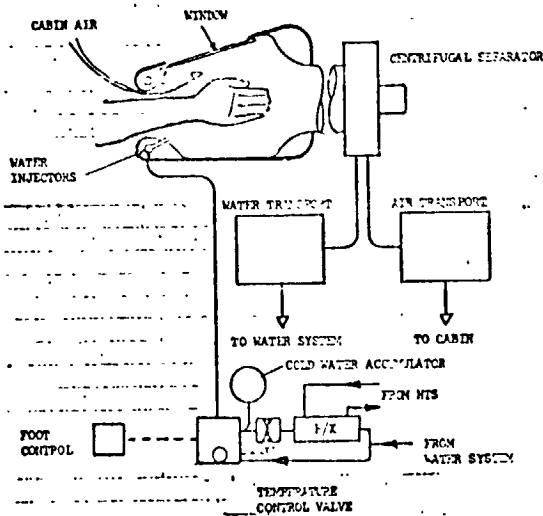
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 2/REUSABLE CLEANNING CLOTHS/ DRY WIPES

INDEX NUMBER 3.1.1.9

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A.C. POWER			D.C. POWER		⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑦
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	
<u>WETTING UNIT (23%)</u>		<u>0.375</u>	<u>500</u>	<u>360</u>	<u>13.5</u>	<u>-</u>	<u>-</u>	<u>-</u>
			<u>500</u>		<u>13.5</u>			
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS</u>	<u>360</u>	<u>-</u>	<u>-</u>	<u>360</u>
<u>MOTORS</u>	<u>-</u>	<u>948</u>	<u>948</u>	<u>-</u>
TOTAL	<u>105.6 (360)</u>	<u>278 (948)</u>	<u>278 (948)</u>	<u>105.6 (360)</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>WASHER</u>	<u>636</u>	<u>-</u>	<u>30</u>	<u>25.3</u>	<u>2.27</u>
<u>DRYER</u>	<u>45.9</u>	<u>85.4</u>	<u>37.7</u>	<u>10.1</u>	<u>2.23</u>
TOTAL	<u>181.5</u> <u>(681.9)</u>	<u>25.0</u> <u>(85.4)</u>	<u>67.7</u>	<u>16.06</u> <u>(35.4)</u>	<u>.127</u> <u>(4.50)</u>
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 9/REUSABLE CLEANING CLOTHS/ DRY WIPES

INDEX NUMBER 3.1.1.9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
WETTING UNIT	(236)	28.49	3.5
CLEANING CLOTHS		3.59	2.54
REUSABLE DRY WIPES		.41	.17
TOTAL		<b>14.74 (32.49)</b>	<b>.175 (6.18)</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> )
CLEANING CLOTHS	.0166 (236)	.077	.0013	.0546 (209)	.00091
REUSABLE DRY WIPES	.0167 (234)	.0095	.000193	.00366 (22)	.000608
			Σ ③ .001448		Σ ⑤ .0009708
TOTAL WT. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .001448 TOT. WT/CYCLE (LB)		1.813 (4.0) KG (LB)
TOTAL VOL. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .0009708 TOT. VOL/CYCLE (FT <sup>3</sup> )		.076 (2.68) 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	1-.0009	.4995	.0005
WASHER WATER LOSS PENALTY	5.25	1-.0009	5.2453	.0047
	Σ ① 5.75		Σ ③ .0052	
TOTAL WT. MISSION	15 CYCLE/DAY	184 DAYS/MISSION	x .0052 TOTAL LOST/CYCLE x ③ (LB)	14.35 + 5.72 = 9.1 (20.07) KG (LB)

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HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

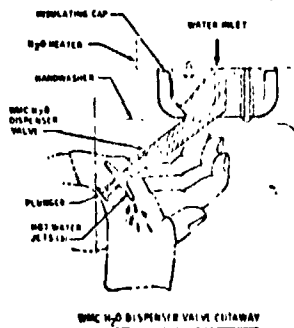
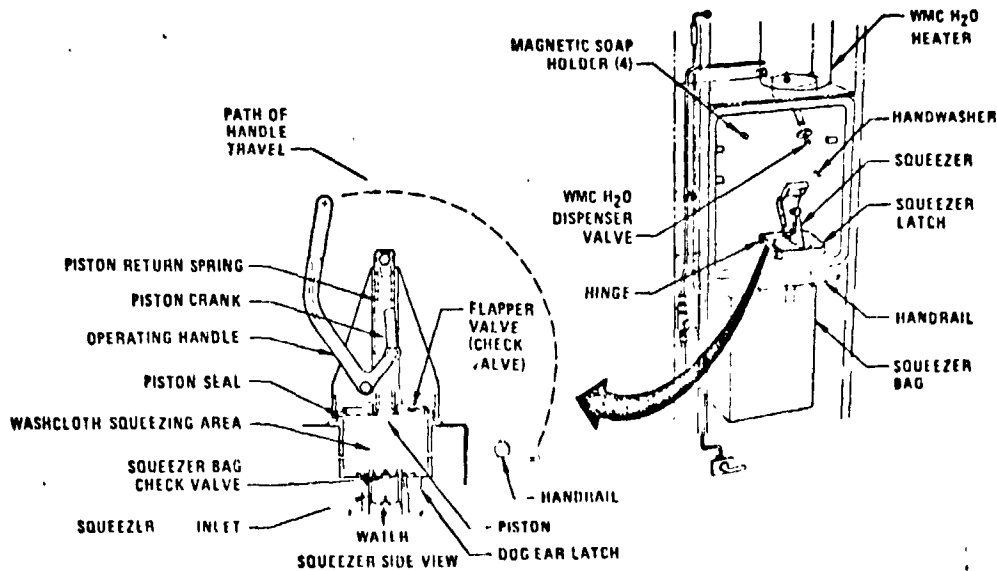
APPLIANCE FUNCTION Surface Wiping

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.



CONCEPT 10/DISPOSABLE CLEANING CLOTHS/REUSABLE DRY WIPES APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.1.1.10

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A C POWER			D C POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HP/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HP/ CYCLE) ① X ⑥
<u>HEATER</u>	<u>(293)</u>	<u>.0375</u>	<u>-</u>	<u>-</u>	<u>-</u>	<u>190</u>	<u>190</u>	<u>5.25</u>
<u>WATER PUMP</u>		<u>.0375</u>	<u>57.5</u>	<u>57.5</u>	<u>2.15</u>			
			<u>57.5</u>		<u>2.15</u>	<u>190</u>		<u>5.25</u>
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (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 (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>WASHER</u>	<u>465</u>	<u>-</u>	<u>22</u>	<u>18.50</u>	<u>1.66</u>
<u>DRYER</u>	<u>33.6</u>	<u>62.5</u>	<u>27.7</u>	<u>7.90</u>	<u>1.63</u>
TOTAL	<u>142.2</u> <u>(498.6)</u>	<u>18.3</u> <u>(62.5)</u>	<u>49.7</u>	<u>11.7</u> <u>(25.9)</u>	<u>.093</u> <u>(3.29)</u>
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE	KG/MISSION (LB/MISSION)	M <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)

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		60.72	30.14
REUSABLE DRY WIPES		.41	.17
TOTAL		<b>42.93 (43.53)</b>	<b>.89 (31.46)</b>
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE W/VCL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	②	③	④	⑤
		WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	WT/CYCLE ① X ② (LB)	VL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	VOL/CYCLE ① X ④ (FT <sup>3</sup> )
DISPOSABLE CLEANING CLOTHS	.2	.077 (N/A)	.022	.1092	.01092
REUSABLE DRY WIPES	.0167 (236)	.0075 (100)	.000148	.00366 (236)	.0000608
			Σ ③ .022148 TOTAL WT/CYCLE (LB)		Σ ⑤ .0109808 TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .022148 TOT. WT/CYCLE (LB)	= 27.73 (61.13) KG (LB)	
TOTAL VOL. MISSION	15 CYCLES/DAY	184 DAYS/MISSION	x .0109808 TOT. VOL/CYCLE (FT <sup>3</sup> )	= .858 (30.31) M <sup>3</sup> (FT <sup>3</sup> )	

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③	④
			AMT. RECOVERED/CYCLE ① X ② (LB)	AMT. LOST/CYCLE ① - ③ (LB)
WATER	.5	1-.0009	.4995	.0005
WASHER WATER LOSS PENALTY	5.1	1-.0009	5.0954	.0046
WATER LOSS (CLEANING CLOTH)	.025	N/A	N/A	.025
			Σ ③ 5.625	Σ ④ .0301
TOTAL WT. MISSION	15 CYCLE/DAY	184 DAYS/MISSION	x .0301 TOTAL LOST/CYCLE (LB)	= 83.03 (LB)
			x ⑤ 5.6	= 40.2 (88.7) KG (LB)

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HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Equipment Cleaning

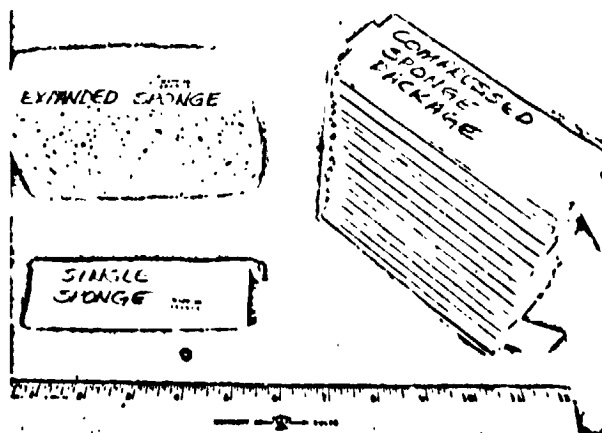
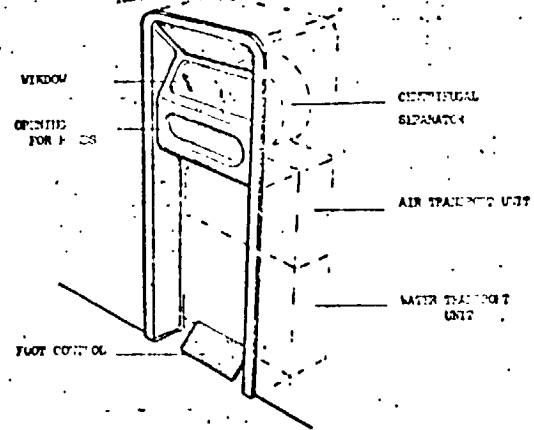
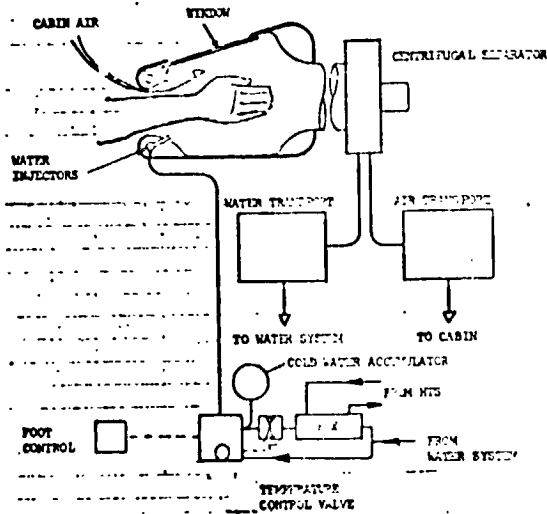
APPLIANCE FUNCTION Surface Wiping

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 deep. 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  
 CONCEPT 11/SPONGES/ENCLOSED WETTING UNIT

INDEX NUMBER 3.1.1.11

**ELECTRICAL POWER REQUIREMENTS**

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A C P O W E R			D C P O W E R		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① X ②
<u>WETTING UNIT (2X)</u>		<u>.0375</u>	<u>500</u>	<u>360</u>	<u>13.5</u>	-	-	-
			<u>500</u>		<u>13.5</u>			
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

**THERMAL REQUIREMENTS**

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS</u>	<u>360</u>	-	-	<u>360</u>
<u>MOTORS</u>	-	<u>948</u>	<u>948</u>	-
<b>TOTAL</b>	<u>105.6 (360)</u>	<u>278 (948)</u>	<u>278 (948)</u>	<u>105.6 (360)</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

**OPERATIONAL PENALTIES**

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

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)	28.99	3.5
SPONGES	(170)	36.46	1.06
TOTAL		<b>29.46 (64.95)</b> KG (LBS)	<b>.129 (4.56)</b> 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) (LB)	③ WT/CYCLE (① x ②) (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (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 TOTAL WT/CYCLE (LB)	Σ ⑤ .000385 TOTAL VOL/CYCLE (FT <sup>3</sup> )	
TOTAL WT MISSION	15 CYCLES/DAY	184 DAYS/MISSION	.01321 TOT. WT/CYCLE (LB)	<b>16.54 (36.46)</b> KG (LB)	
TOTAL VOL MISSION	15 CYCLES/DAY	184 DAYS/MISSION	.000385 TOT. VOL/CYCLE (FT <sup>3</sup> )	<b>.030 (1.06)</b> 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	1-.0009	.4995	.0005
WATER LOSS (SPONGE DISPOSAL)	.0083	N/A	N/A	.0083
Σ ④ .5083				Σ ④ .0088
TOTAL WT MISSION	15 CYCLE/DAY	184 DAYS/MISSION	.0088 TOTAL POST/CYCLE (LB)	<b>24.29 (11.25)</b> KG (LB)

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HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Equipment Cleaning

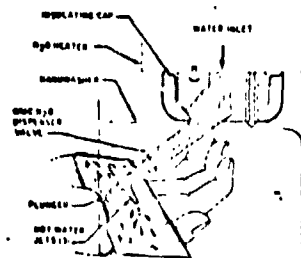
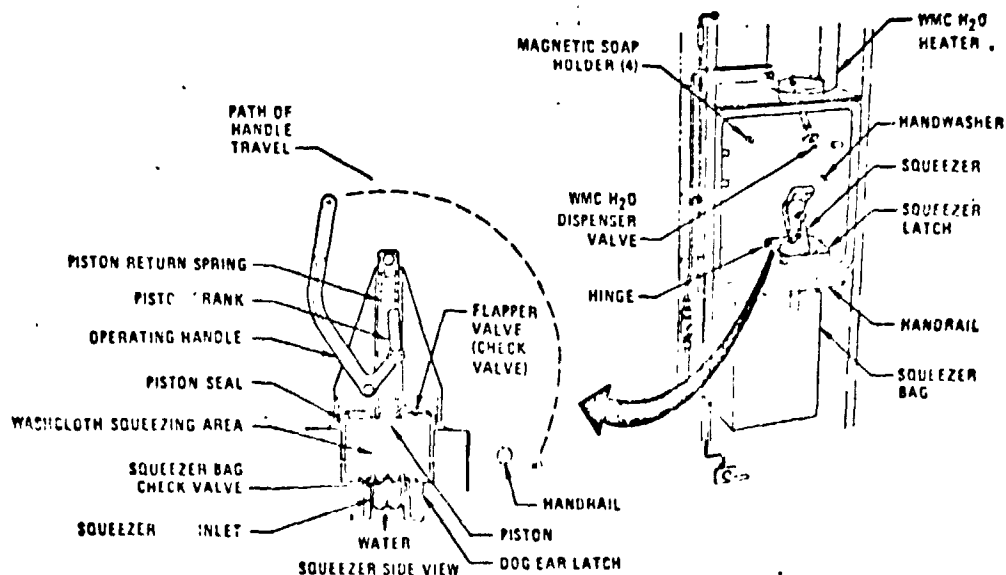
APPLIANCE FUNCTION Surface Wiping

APPLIANCE CONCEPT NO./TITLE 12/Sponges/Skylab Wetting Unit

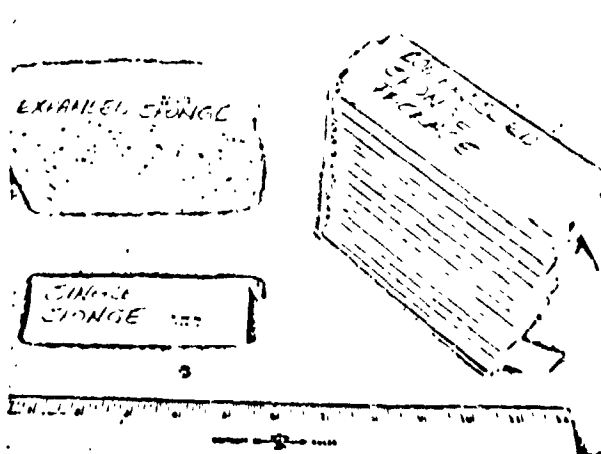
INDEX NO. 3.1.1.12

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.



WMC H<sub>2</sub>O DISPENSER VALVE ASSEMBLY







APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 12/SPONGES/SKYLAB WETTING UNIT

INDEX NUMBER 3.1.1.12

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
SQUEEZER/WATER DISPENSER (MADAC)		32.4	1.15
SPONGES	(170)	36.46	1.06
TOTAL		31.23 (68.86)	.063 (221)
		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	184	.01321	16.54 (36.46)	
	CYCLES/DAY	DAYS/MISSION	TOT. WT/CYCLE (LB)	KG (LB)	
TOTAL VOL. MISSION	15	184	.000385	.030 (1.06)	
	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. RECOVERY/CYCLE (① x ②) (LB)	④ AMT. LOST/CYCLE (① - ③) (LB)
WATER	.5	1-0009	.4995	.0005
WATER LOSS (SPONGE DISPOSAL)	.0083	N/A	N/A	.0083
Σ ① .5083				Σ ④ .0088
TOTAL WT. MISSION	15	184	.0083	24.29
	CYCLE/DAY	DAYS/MISSION	TOTAL LOST/CYCLE (LB)	5083
				11.25 (24.8)
				KG (LB)

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.

SPACE STATION/SHUTTLE REFUSE SUMMARY

		SPACE STATION (LBS)	SHUTTLE (LBS)	SPACE STATION (FT <sup>3</sup> )	SHUTTLE (FT <sup>3</sup> )	
TRASH	<u>COMPRESSIBLE</u>					
	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>
	BAGS	<u>NONCOMPRESSIBLE</u>				
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>	
DISPOSAL	<u>COMPRESSIBLE</u>					
	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>
	BAGS	<u>NONCOMPRESSIBLE</u>				
		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. 3-2.1 \*\*\*\*\* MANUAL REFUSE COLLECTION ISPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS		THERMAL REQMTS		ELEC PWR REQMTS		WT/VOL REQMTS		DEVELOPMENT COST		RESUPPLY
		MRS/USE	AMT. USED	TEMP	COOLANT	AC	DC	AC	DC	WT	VOLUME	
1	.000											
2	.000											
3	.000											

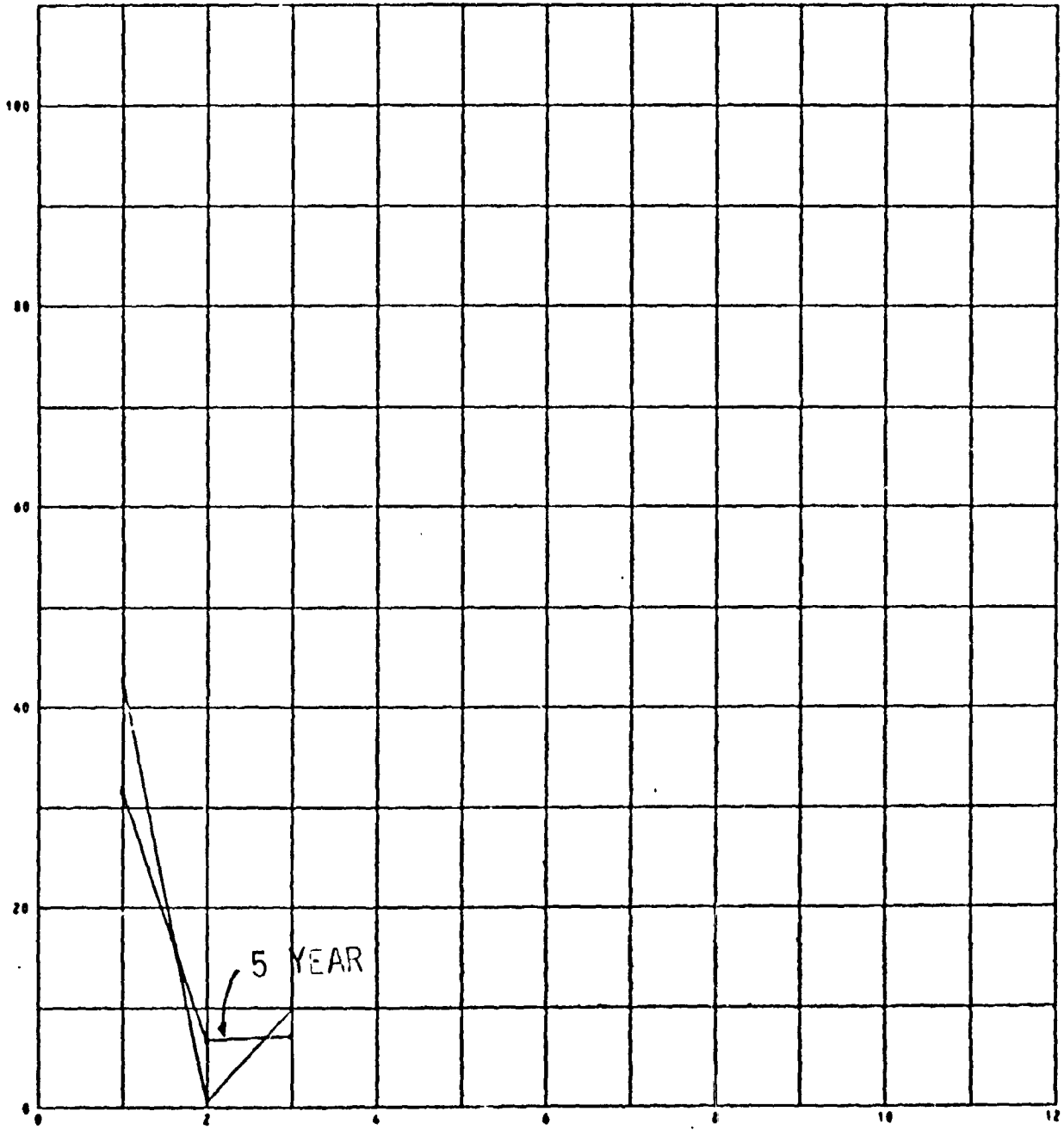
- (\*) CONCEPT NAME
- 1 - DISPOSABLE TRASH BAG
  - 2 - REUSABLE WASTE RECEPTILES
  - 3 - DISPOSABLE WASTE RECEPTILES
- (\*\*) AVAILABLE INDICATOR
- 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/MIN)
  - 2 - CABIN AIR (LOST), KG/HR (LB/HR)
  - 3 - OXYGEN (LOST), KG/HR (LB/HR)
  - 4 - COOLING 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 - FRESH (CIRCULATED), KG/HR (LB/HR)
  - 9 - WATER (PROCESSED), KG/HR (LB/HR)

- (\*\*\*) 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	DISPOSABLE TRASH BAG
2	REUSABLE WASTE RECEPTICLES
3	DISPOSABLE WASTE RECEPTICLES

CONCEPT RATING  
BASED ON



CONCEPT NUMBER

NUMBER OF DAYS = 180.0 ( .49 YEARS)  
 USES MOD SU4ROUTINE 0  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100

SELECTION MATRIX \* \* \* \* \* MANUAL REFUSE COLLECTION (SPACE STATION)  
 (12/09/74)

FACTOR	MIN		MAX		PTS	C O N C E P T		
	VALUE	VALUE	VALUE	VALUE		1	2	3
WEIGHT	334.00	337.60	15	.00	.16	.07		
VOLUME	22.510	55.140	10	5.92	.00	3.84		
DEV COST	5.0000	20.000	15	11.25	.00	.00		
TOTAL PT	.00000	40.000	40	17.17	.16	3.91		
RATING	.00000	100.00	100	42.92	.40	9.76		

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	42.92	40	9.76
WEIGHT	36.14	.51	8.29
VOLUME	44.73	.36	12.95
DEV COST	47.98	.34	8.22

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	42.92	40	9.76
WEIGHT	52.62	.25	11.92
VOLUME	40.60	.46	5.68
DEV COST	35.52	.49	12.02



NUMBER OF DAYS = 1826.0 (5.00 YEARS)  
 USES MOD SUBROUTINE 0  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100

SELECTION MATRIX • • • • • MANUAL REFUSE COLLECTION (SPACE STATION)  
 (12/09/74)

FACTOR	MIN		MAX	VALUE	PTS	CONCEPT		
	VALUE					1	2	3
WEIGHT	334.00		337.60		15	.00	.16	.07
VOLUME	22.510		55.140		10	5.92	.00	3.64
DEV COST	5.0000		20.000		15	11.25	.00	.00
REC COST	243.00		318.00		15	.19	3.54	.00
TOTAL PT	.00000		55.000		55	17.36	3.70	3.91
RATING	.00000		100.00		100	31.56	6.72	7.10

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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	31.56	6.72	7.10
WEIGHT	27.77	6.04	6.30
VOLUME	33.86	6.16	9.71
DEV COST	36.77	5.92	6.25
REC COST	27.92	8.75	6.25

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	31.56	6.72	7.10
WEIGHT	36.54	7.62	8.15
VOLUME	28.80	7.40	3.97
DEV COST	24.70	7.78	8.22
REC COST	36.34	4.06	8.22

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.1-REFUSE/MANUAL COLLECTION

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

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Refuse Management

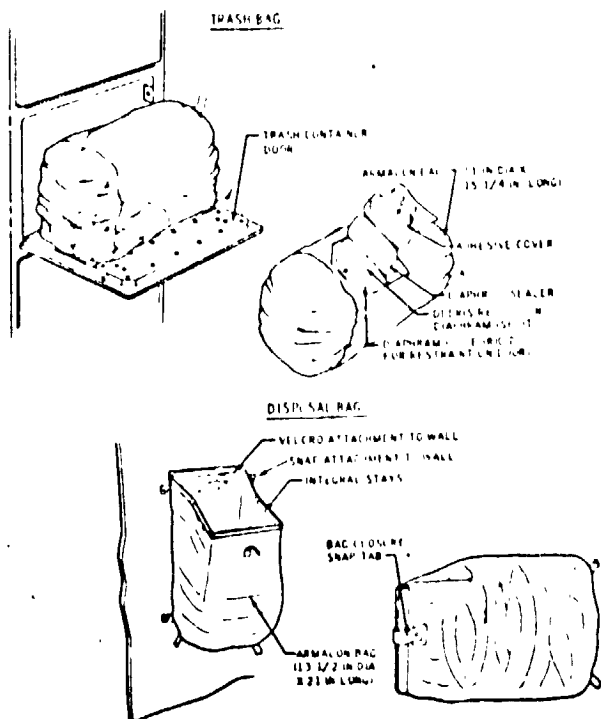
APPLIANCE FUNCTION Manual Collection

APPLIANCE CONCEPT NO./TITLE 1/Waste/Trash Bags

INDEX NO. 3.2.1.1

REF. 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.



CONCEPT WASIC/TASK BASIS

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.2.1.1

ELECTRICAL POWER REQUIREMENTS

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

THERMAL REQUIREMENTS

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

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1 WALK TRASH BAGS

INDEX NUMBER 3.2.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COLLECTION DEVICE	(283)	15.0	13.6
TRASH BAGS		290.8	6.37
DISPOSABLE BAGS		81.7	2.93
TOTAL		153.1 (337.5)	.634 (22.4)
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	②	③	④	⑤
		WT/UNIT (PEF) (PKG. WT/UNIT) (PEF) (LB)	WT/CYCLE DAY ① x ② (LB)	VOL/UNIT (PEF) (PKG. VOL/UNIT) (PEF) (FT <sup>3</sup> )	VOL/CYCLE DAY ① x ④ (FT <sup>3</sup> )
TRASH BAGS	1.87	.7 (McDac)	1.309	.0185 (McDac)	.0346
DISPOSABLE BAGS	.59	.75 (McDac)	.444	.0224 (McDac)	.0132
			Σ ③		Σ ⑤
			TOTAL WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT MISSION	<u>N/A</u>	<u>184</u> DAYS/MISSION	<u>1.753</u>	<u>146.3</u>	<u>(322.5)</u>
	CYCLES/DAY		TOT. WT/CYCLE (LB)	KG (LB)	
TOTAL VOL MISSION	<u>N/A</u>	<u>184</u> DAYS/MISSION	<u>.0478</u>	<u>.249</u>	<u>(8.79)</u>
	CYCLES/DAY		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)
<u>- N/A -</u>				
	Σ ①		Σ ④	
TOTAL WT MISSION			TOTAL LOST/CYCLE	
CYCLE/DAY	DAYS/MISSION		α ③ (LB)	α ④ (LB)

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Manual Collection

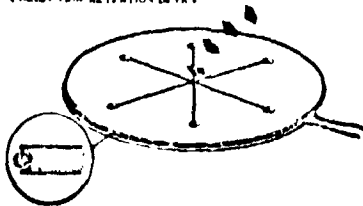
APPLIANCE CONCEPT NO./TITLE 2/Waste Receptacles/Reusable

INDEX NO. 3.2.1.2

REF. 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 LEVEL



- Perforated slit to allow waste to enter plastic liner bag
- Plastic liner bag to contain waste
- Spring-finger retainer to hold liner bag in place
- Multiple spring-finger retainers to hold liner bag in place
- Multiple spring-finger retainers to hold liner bag in place
- Multiple spring-finger retainers to hold liner bag in place

LOCAL WASTE COLLECTION





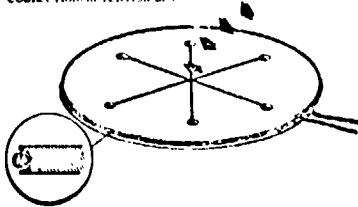




SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Manual CollectionAPPLIANCE CONCEPT NO./TITLE 3/Waste Receptacles/DisposableINDEX NO. 3.2.1.3REF. NO. 170,160

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 DISC



- Perforated slots in disc permit center portion to deflect providing unidirectional waste ingress
- Plastic disk molded or machined into sheet of flexible bag
- Suitable ring concept fastens disc to bag
- Suitable for non-toxic, inert, chemically inert wastes

LOCAL WASTE COLLECTOR



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 3/WASTE RECEPTACLES/DISPOSABLES

INDEX NUMBER 3.2.1.3

ELECTRICAL POWER REQUIREMENTS

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

THERMAL REQUIREMENTS

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

OPERATIONAL PENALTIES

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



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 (SPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS	THERMAL REQTS	ELEC. PWR REQTS	WT/VOL REQTS	DEVELOPMENT COST	RESULT
		AMT. USED	COOLANT HT LEAK	AC	WEIGHT VOLUME	AVAIL INDEX	WEIGHT
		(KG/USE)	(BTU/HR)	(WATTS)	(LBS) (CU FT)	(%)	(KG)
1	5.000 .082	0.0	0.0	115.0	13.8	0.02	1
2	5.000 .082	0.0	160.0	240.0	4.7	0.01	20
3	5.000 .082	6214 (1.3700)	21.1 (70.0)	0.0	574.9 (1267.4)	0.01	25 (1233.0)

APPLIANCE CONCEPT

CONCEPT NO.	CONCEPT NAME	(*)	(**)AVAILABLE	(***)COST INDICATOR
1	VACUUM CLEANER (SKYLAB)	1 - CABIN AIR (CIRCULATED), LITERS/SEC (LB/HR)	AVAILABLE	0-25%
2	VACUUM CLEANER (COMMERCIAL)	2 - OXYGEN (LOST)	STATE OF THE ART	25-50%
3	VACUUM CLEANER-OVENTED TO SPACE	3 - COOLING WATER (CIRCULATED), KG/HR	SOME DEVELOPMENT REQUIRED	50-75%
		4 - WATER (LOST)	EXTENSIVE DEV. REQUIRED	75-100%
		5 - NITROGEN (CIRCULATED), KG/HR		
		6 - NITROGEN (USED), KG/HR		
		7 - FREON (CIRCULATED), KG/HR		
		8 - WATER (PROCESSED), KG/HR		
		9 - WATER (PROCESSED), KG/HR		

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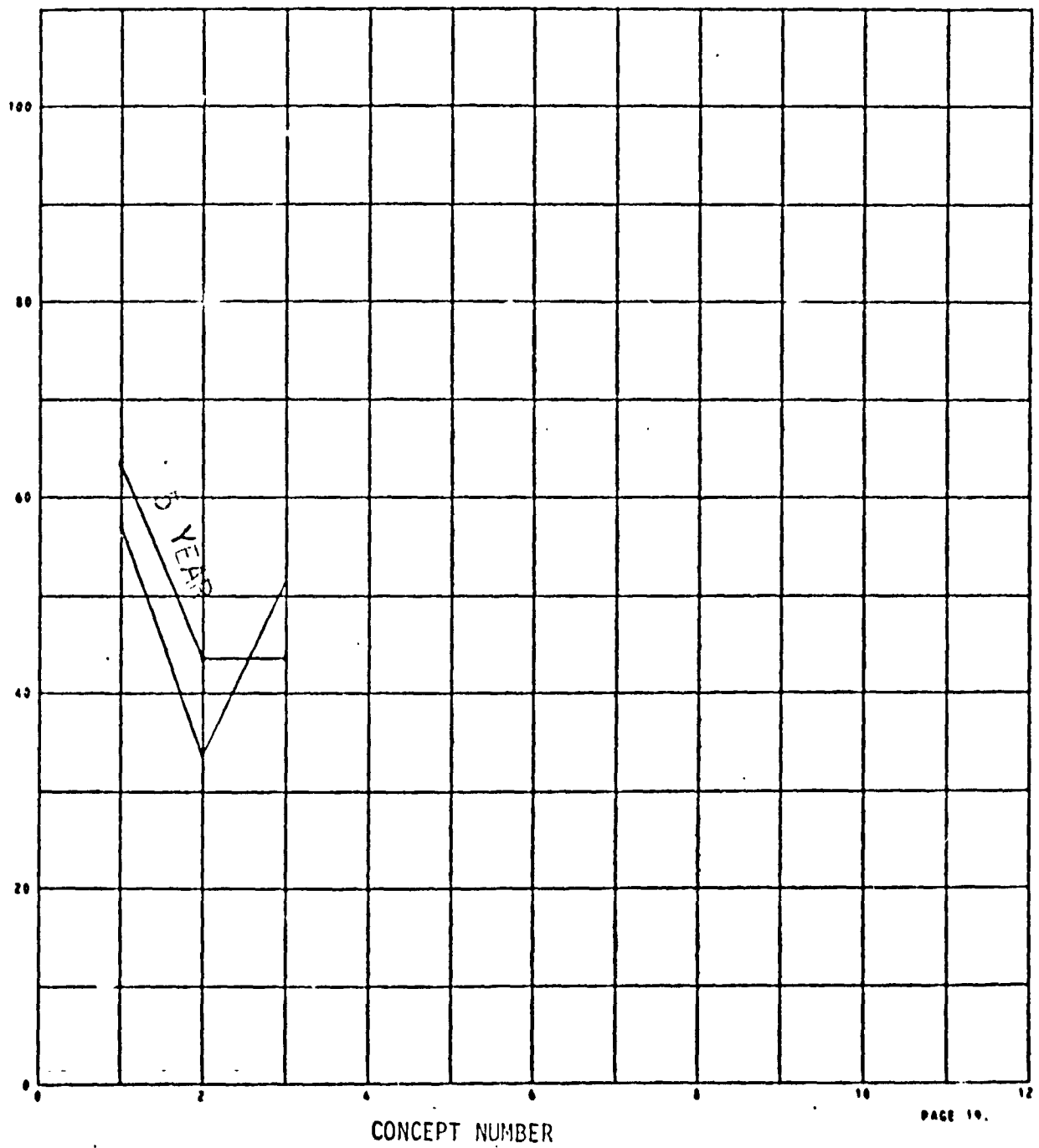
APPLIANCE  
CONCEPT  
NO.

CONCEPT NAME

- 1 - VACUUM CLEANER (SKYLAR)
- 2 - VACUUM CLEANER (COMMERCIAL)
- 3 - VACUUM CLEANER-VENTED TO SPACE



CONCEPT RATING BASED ON 1000



CONCEPT NUMBER

Vacuum Refuse Collection (Space Station)  
Concept Trade  
C2-417

NUMBER OF DAYS = 180.0 ( .49 YEARS)  
 USES MOD SUBROUTINE 13  
 THERMAL PENALTY = DIRECT TO COOLANT (LB/BIUH) .0540  
 THERMAL PENALTY = CABIN HEAT LEAK (LB/BIUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

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

C-O-N-C-E-P-T

FACTOR	MIN VALUE	MAX VALUE	PTS	1	2	3
WEIGHT	10.440	1267.4	15	14.64	14.88	.00
POWER	.00000	170.40	15	9.02	.00	15.00
VOLUME	.26000	.86000	10	.00	5.70	6.98
THERMAL	.00000	69.888	15	7.80	.00	15.00
RELIAB-Y	.99874	.99949	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	5.0000	25.000	15	12.00	3.00	.00
TOTAL PT	.00000	85.000	85	48.46	28.57	43.61
RATING	.00000	100.00	100	57.01	33.62	51.30



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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	57.01	33.62	51.30
WEIGHT	60.30	38.93	47.14
POWER	57.26	30.89	55.25
VOLUME	53.84	34.91	52.33
THERMAL	56.61	30.89	55.25
RELIAB-ty	55.38	32.66	51.92
MAINTENC	55.24	35.51	49.84
SAFETY	58.87	32.51	47.14
DEV COST			

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	57.01	33.62	51.30
WEIGHT	53.08	27.27	56.27
POWER	56.71	36.87	46.59
VOLUME	60.57	32.14	50.15
THERMAL	57.49	36.87	46.59
RELIAB-ty	58.74	34.64	51.05
MAINTENC	58.74	34.64	50.65
SAFETY	55.71	31.60	52.84
DEV COST	54.79	34.93	56.27

NUMBER OF DAYS = 1826.0 (5.00 YEARS)

USES MOD SUBROUTINE 13

THERMAL PENALTY = DIRECT TO COOLANT (LB/BTUH) .0540

THERMAL PENALTY = CABIN HEAT LEAK (LB/BTUH) .1280

POWER PENALTY (LBS/WATT) TYPE 1 .7100

POWER PENALTY (LBS/WATT) TYPE 2 .5910

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

C O N C E P T

FACTOR	MIN		PTS	MAX		
	VALUE	VALUE		1	2	3
WEIGHT	10.440	1267.4	15	14.64	14.88	.00
POWER	.00000	170.40	15	9.02	.00	15.00
VOLUME	.26000	.86000	10	.00	5.70	6.98
THERMAL	.00000	69.888	15	7.80	.00	15.00
RELIAB-Y	.99725	.99484	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	25.0000	15	12.00	3.00	.00
REC COST	.43000	1233.0	15	14.99	14.99	.00
TOTAL PT	.00000	100.00	100	63.45	43.57	43.60
RATING	.00000	100.00	100	63.45	43.57	43.60

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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	63.45	43.57	43.60
WEIGHT	65.84	47.45	40.56
POWER	63.22	40.53	47.54
VOLUME	60.43	44.21	44.85
THERMAL	62.66	40.53	47.54
RELIAB-ty	61.91	42.51	43.99
MAINTENC	61.91	42.51	44.32
SAFETY	64.35	44.95	42.54
DEV COST	64.61	41.92	40.56
REC COST	66.00	47.50	40.56

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	63.45	43.57	43.60
WEIGHT	60.69	39.06	47.14
POWER	63.72	47.10	39.03
VOLUME	46.79	42.86	42.22
THERMAL	64.38	47.10	39.03
RELIAB-ty	65.08	44.69	43.19
MAINTENC	65.08	44.69	42.85
SAFETY	62.52	42.12	44.72
DEV COST	62.11	45.48	47.14
REC COST	60.49	39.00	47.14

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.2-REFUSE/VACUUM COLLECTION

COMPONENT TYPE	NUMBER OF COMPONENTS												NUMBER OF SAFETY CRITICAL ITEMS	
	(1) MOTOR	(2) BLOWER (VACUUM)	(3) FILTER	(4) ACCUMULATOR	(5) WATER SEPARATOR	(6) CHECK VALVE	(7) ELECTRIC SWITCH	(8) SOLENOID VALVE	(9)	(10)	(11)	(12)		
APPLIANCE TYPE	1	1	1	1	1	1	1	1	1	1	1	1	1	0
PORTABLE VACUUM CLEANER (SKYLAB)	1	1	1	1	1	1	1	1	1	1	1	1	1	0
PORTABLE VACUUM CLEANER (COMMERCIAL)	1	1	1	1	1	1	1	1	1	1	1	1	1	0
VACUUM CLEANER VENTING TO SPACE	-	-	1	1	-	1	1	1	-	1	1	1	1	1

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Refuse Management

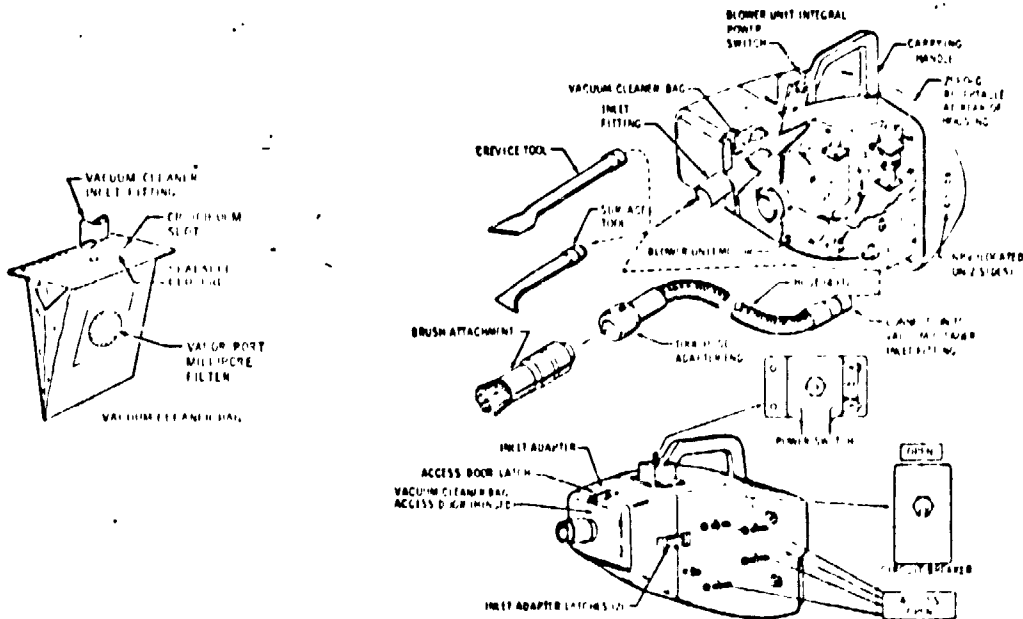
APPLIANCE FUNCTION Vacuum Collection

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).



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 1/P. CABLE VACUUM/LECTRIC (SAFETY)

INDEX NUMBER 3221

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A.C. POWER			D.C. POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑤
<i>MOTOR</i>	<i>(P. 1/2)</i>	<i>.102</i>	—	—	—	<i>115</i>	<i>115</i>	<i>11.73</i>
						<i>115</i>		<i>11.73</i>
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<i>MOTOR</i>	—	<i>262</i>	<i>262</i>	—
TOTAL		<i>76.8(262)</i>	<i>76.8(262)</i>	
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

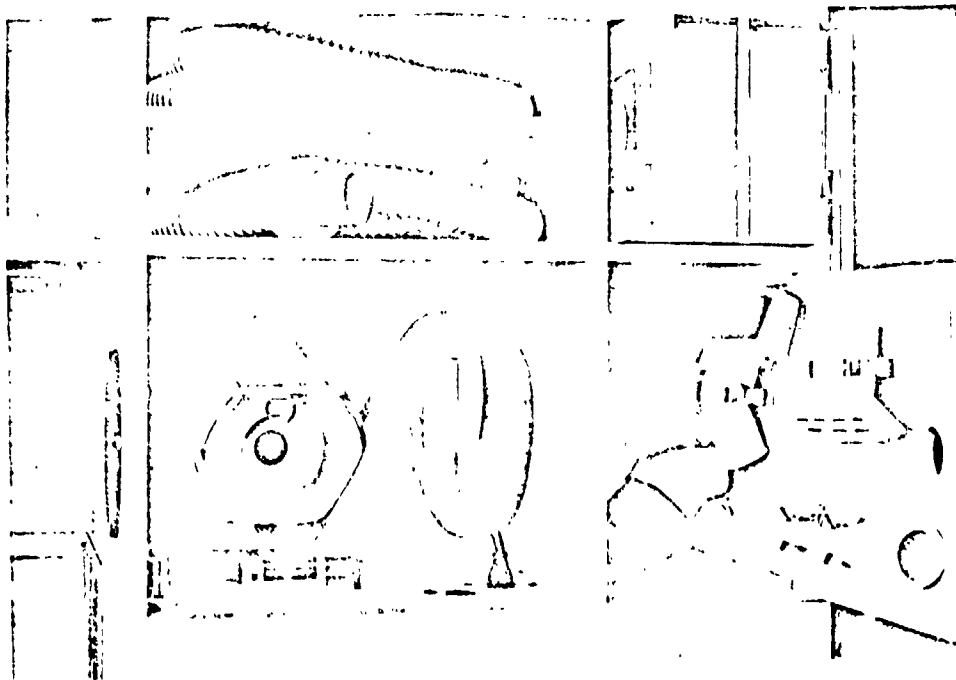
OPERATIONAL PENALTIES

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



SPACECRAFT Space StationHABITABILITY 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.





ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A C P O W E R			D C P O W E R		⑦ DEMAND (WATT-HR/ CYCLE) ① X ②
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	
<u>MOTOR</u>	<u>(170)</u>	<u>102</u>	<u>290</u>	<u>290</u>	<u>29.5</u>	<u>---</u>	<u>---</u>	<u>---</u>
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---	---	---	<u>290</u> MAXIMUM	---	<u>29.5</u> TOTAL	---	---	TOTAL:

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>MOTOR</u>	<u>---</u>	<u>596</u>	<u>596</u>	<u>---</u>
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
---	---	---	---	---
TOTAL	---	<u>160 (596)</u>	<u>160 (596)</u>	---
---	---	---	---	---

OPERATIONAL PENALTIES

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



SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Vacuum CollectionAPPLIANCE CONCEPT NO./TITLE 3/Portable Vacuum/Space VentingINDEX NO. 3.2.2.3REF. 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.

ELECTRICAL POWER REQUIREMENTS

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

THERMAL REQUIREMENTS

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

OPERATIONAL PENALTIES

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

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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 (FT³)
<u>VACUUM UNIT</u>	<u>(1.10)</u>	<u>7.0</u>	<u>.175</u>
<u>(INCLUDES HOSES AND ATTACHMENTS)</u>			
<u>VACUUM CLEANER BAGS</u>		<u>.444</u>	<u>.020</u>
TOTAL		<u>3.37 (7.44)</u> KG (LBS)	<u>.077 (.255)</u> M³ (FT³)

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) (FT³)	⑤ VOL/CYCLE ① x ④ (FT³)
<u>VACUUM CLEANER BAGS</u>	<u>1</u>	<u>.017 (.175)</u>	<u>.017</u>	<u>.003067 (.11)</u>	<u>.003067</u>
			$\Sigma$ ③ <u>.017</u> TOTAL WT/CYCLE (LB)	$\Sigma$ ⑤ <u>.003067</u> TOTAL VOL/CYCLE (FT³)	
TOTAL WT. MISSION	<u>.142</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	<u>.017</u> TOT. WT/CYCLE (LB)	<u>.201 (7.44)</u> KG (LBS)	
TOTAL VOL. MISSION	<u>.142</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	<u>.003067</u> TOT. V. L/CYCLE (FT³)	<u>.00227 (.050)</u> M³ (FT³)	

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)
<u>OXYGEN</u>	<u>1.37</u>	<u>N/A</u>	<u>N/A</u>	<u>1.37</u>
Σ ① <u>1.37</u>			Σ ④ <u>1.37</u>	
TOTAL WT. MISSION	<u>5</u> CYCLE/DAY	<u>184</u> DAYS/MISSION	<u>1.37</u> TOTAL LOST/CYCLE ② ③ (LB)	<u>1260</u> KG (LBS)
			<u>N/A</u> ② ①	<u>571.2 (1260)</u> KG (LBS)

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 in Table C2-6.
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.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3-2-9 0000 REFUSE PROCESSING (SPACE STATION)

CONCEPT USAGE CONSUMABLES AND FLOW REQUIREMENTS THERMAL RIGHTS ELEC PAR RIGHTS WT/VOL RIGHTS DEVELOPMENT RESUPPLY

CONCEPT NO.	USAGE TIME	AMT.	TYPE	USED	FLOOR	PRESS	TEMP	COOLANT	HT LEAK	AC	DC	AVG PAR	WT	VOLUME	AVAIL	INDEX	WEIGHT
				(KG/USE)	(PSIG)	(DEG F)	(BTU/MR)	(BTU/MR)	(BTU/MR)	(CU FT)	(CU FT)	(CU FT)	(KG)	(CU M)	(KG)	(KG)	(LBS)
1	5-200	017	1	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	55.9	21.2	30	21.5	47.3
				(000001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(123.2)	(7.4)			
2	5-200	017	2	0163	00	0.	0.	0.	0.	0.	10.0	10.0	87.8	31.2	30	52.4	116.1
				(03601)	(00)	(0.)	(0.)	(0.)	(0.)	(0.)	(0.)	(0.)	(193.5)	(10.95)			
3	5-200	017	0	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	58.2	21.2	30	21.5	47.3
				(00001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(128.2)	(7.4)			
4	24-300	017	0	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	33.7	53.2	50	21.5	47.3
				(00001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(71.4)	(18.81)			
5	5-200	017	1	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	89.9	25.2	40	21.5	47.3
				(00001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(198.2)	(9.00)			
6	5-200	017	2	0163	00	0.	0.	0.	0.	0.	10.0	10.0	105.5	25.2	40	36.7	80.9
				(03601)	(00)	(0.)	(0.)	(0.)	(0.)	(0.)	(0.)	(0.)	(232.5)	(9.00)			
7	5-200	017	0	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	92.2	25.2	40	21.5	47.3
				(00001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(203.2)	(9.00)			
8	24-300	017	0	0000	00	1810.0	21.1	0.	0.	0.	10.0	10.0	67.8	58.2	40	21.5	47.3
				(00001)	(00)	(135.0)	(70.0)	(0.)	(0.)	(0.)	(0.)	(0.)	(149.4)	(20.50)			
9	2-000	12-000	1	0000	9.44	0.	0.	0.	0.	0.	1400.0	1400.0	122.8	2.14	3	41.8	91.7
				(00001)	(20.00)	(0.)	(0.)	(0.)	(0.)	(0.)	(4760.)	(0.)	(270.7)	(75.40)			
10	2-000	12-000	3	0820	00	0.	21.1	0.	0.	0.	1000.0	1000.0	341.4	2.05	3	251.5	556.1
				(12830)	(00)	(0.)	(70.0)	(0.)	(0.)	(0.)	(3410.)	(0.)	(752.7)	(72.50)			
11	2-000	12-000	3	01704	00	0.	21.1	0.	0.	0.	1400.0	1400.0	189.8	1.62	3	103.1	227.4
				(3760)	(00)	(0.)	(70.0)	(0.)	(0.)	(0.)	(4760.)	(0.)	(418.1)	(57.20)			
12	2-000	12-000	3	02291	00	6205.0	21.1	0.	0.	0.	900.0	900.0	346.0	2.44	3	124.4	274.2
				(5050)	(00)	(1800.0)	(70.0)	(0.)	(0.)	(0.)	(3070.)	(0.)	(800.8)	(86.20)			

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APPLIANCE  
CONCEPT  
NO.

APPLIANCE CONCEPT NO.	CONCEPT NAME
1	COMPACTOR-AIR PRESSURE
2	COMPACTOR-VACUUM
3	COMPACTOR-MOTOR
4	COMPACTOR-MANUAL
5	COMPACTOR-AID PRESSURE W/SHREDDER
6	COMPACTOR-VACUUM W/SHREDDER
7	COMPACTOR-MOTOR W/SHREDDER
8	INTEGRATED-MANUAL W/SHREDDER
9	INTEGRATED VACUUM W/SHREDDER
10	FLUSH FLOOR OXYGEN DECOMPOSITION/SHREDDER
11	PARALYSIS/BATCH INCINERATION/SHREDDER
12	NET OXIDIZATION/ SHREDDER

(\*)

1 - CABIN AIR	(CIRCULATED), LITERS/SEC (FT <sup>3</sup> /MIN)
2 - CRYOGEN	(LOST) * KG/HR
3 - COOLING WATER	(CIRCULATED) * KG/HR
4 - WATER	(LOST)
5 - NITROGEN	(CIRCULATED) * KG/HR
6 - FRESH AIR	(CIRCULATED) * KG/HR
7 - FRESH AIR	(CIRCULATED) * KG/HR
8 - WATER	(CIRCULATED) * KG/HR
9 - WATER	(REFRESHED) * KG/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%

C2-434

1001

102-11-1010



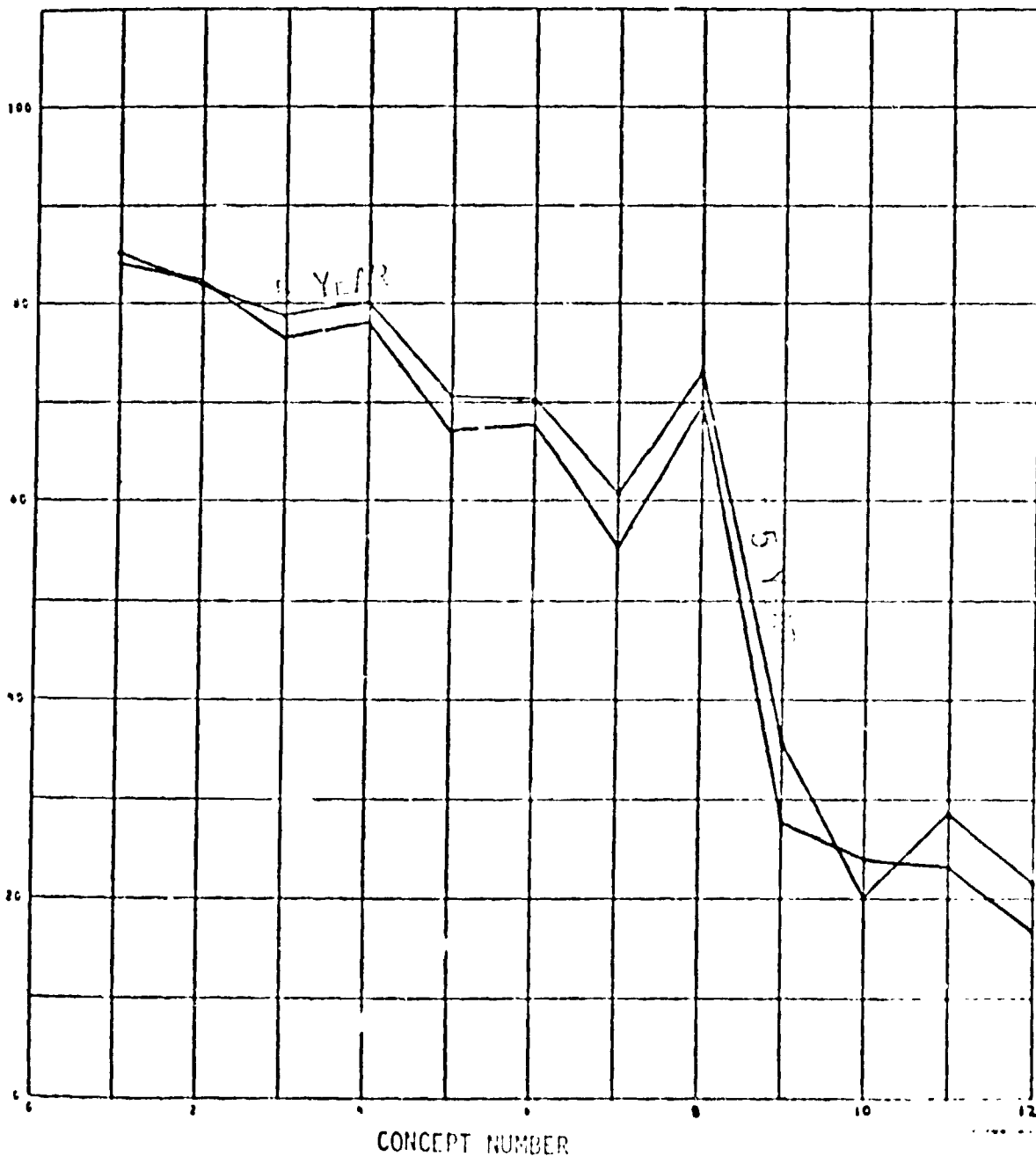
APPLIANCE  
CONCEPT

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 DAYTIME INCINERATION/SHREDDER
- 11 - PYROLYSIS/NIGHT INCINERATION/SHREDDER
- 12 - NET OXIDIZATION/SHREDDER

CONCEPT RATINGS BASED ON



Refuse Processing (Space Station) Concept Trade

NUMBER OF DAYS = 1026.0 (5.00 YEARS)

USES MOD SUBROUTINE 14

THERMAL PENALTY = DIRECT TO COOLANT (LB/BTUH) .0540

THERMAL PENALTY = CABIN HEAT LEAK (LB/BTUH) .1280

POWER PENALTY (LBS/WATT) TYPE 1 .7100

POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX \* \* \* \* \* REFUSE PROCESSING (SPACE STATION)  
(01/25/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	1	2	3	4	5	6	7	8	9	10	11	12
WEIGHT	74.400	806.80	15	12.71	11.40	12.62	13.62	11.32	10.68	11.22	12.22	9.97	1.01	7.22	.00
POWER	.00000	1.9848	15	14.94	14.34	9.71	15.00	9.65	9.65	.00	9.71	5.05	7.89	5.05	8.60
VOLUME	7.9000	86.200	10	9.14	9.73	9.14	7.82	8.96	8.96	8.96	7.53	1.25	1.59	3.36	.00
THERMAL	.00000	609.28	15	15.00	15.00	14.47	15.00	13.40	13.40	12.86	13.40	.00	4.25	.00	5.03
RELIAB-V	.17119	.99986	5	4.98	4.99	4.99	5.00	4.98	4.98	4.98	4.97	.00	.14	.00	.12
MAINTENC	.99999	1.00000	5	3.27	3.51	2.63	4.97	1.67	2.89	2.00	4.35	1.15	.83	.81	.00
SAFETY	1.0000	2.0000	5	2.50	2.50	2.50	.00	.00	.00	.00	.00	2.50	2.50	2.50	.00
LEV 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
FEC COST	47.300	554.42	15	13.72	11.66	13.72	13.72	13.72	12.91	13.72	13.72	12.52	.00	8.85	7.59
TOTAL PT	.00000	100.00	100	85.26	81.94	78.76	80.13	70.68	70.36	60.74	73.00	35.74	20.22	28.60	21.63
RATING	.00000	100.00	100	85.26	81.94	78.76	80.13	70.68	70.36	60.74	73.00	35.74	20.22	28.60	21.63

SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	85.26	81.94	78.76	80.13	70.68	70.36	60.74	73.00	35.74	20.22	28.60	21.63
WEIGHT	85.23	81.52	79.13	80.87	71.01	70.42	61.72	73.59	37.88	19.27	29.96	20.12
POWER	86.26	83.17	77.78	81.51	70.24	69.94	56.50	72.42	35.59	22.48	28.95	24.12
VOLUME	85.55	82.19	79.36	80.64	71.58	71.27	62.11	73.16	34.63	20.01	28.84	20.80
THERMAL	86.29	83.20	79.95	81.51	71.98	71.68	62.48	74.14	33.24	20.79	26.60	22.60
RELIABILITY	85.61	82.37	79.27	80.61	71.39	71.07	61.69	73.65	35.01	19.79	27.90	21.16
MAINTENANCE	84.78	81.65	78.12	80.60	69.77	70.05	60.23	73.34	35.42	20.13	28.20	21.10
SAFETY	84.40	81.16	78.06	78.17	68.76	68.64	59.26	71.22	36.09	20.94	29.12	21.10
DEV COST	83.50	80.41	77.45	76.86	69.01	68.71	59.76	71.16	34.64	19.74	27.07	20.12
REC COST	85.70	81.74	79.65	80.92	72.13	71.41	62.68	74.29	39.67	18.81	30.72	23.64

SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9	10	11	12
NORMAL	85.26	81.94	78.76	80.13	70.68	70.36	60.74	73.00	35.74	20.22	28.60	21.63
WEIGHT	85.31	82.42	78.33	79.26	70.30	70.27	59.60	72.31	33.25	21.31	27.02	23.38
POWER	84.10	80.50	79.93	78.52	71.20	70.85	65.66	73.67	35.90	17.59	28.19	18.73
VOLUME	84.94	81.65	78.09	80.73	71.69	69.35	59.22	72.62	36.96	20.45	28.33	22.77
THERMAL	84.07	80.47	77.33	78.77	71.7	68.82	58.71	71.66	38.64	19.58	30.92	20.50
RELIABILITY	84.89	81.46	78.22	79.74	71.54	69.61	59.74	72.32	36.50	20.66	29.33	22.12
MAINTENANCE	85.77	82.23	79.73	79.93	71.64	70.68	61.27	72.64	36.07	20.21	29.02	22.18
SAFETY	84.17	82.75	79.12	82.18	74.49	72.16	62.30	74.87	35.37	19.45	28.05	22.16
DEV COST	87.31	83.71	80.73	83.92	72.63	72.28	61.68	75.13	37.01	20.78	30.38	23.38
REC COST	84.76	82.17	77.53	77.21	69.00	69.14	59.25	71.50	31.87	21.86	26.14	19.28

NUMBER OF DAYS = 100.0 ( .99 YEARS)

USES MOD SUBROUTINE 14

THERMAL PENALTY - DIRECT TO COOLANT (L3/BTUH) .0540

THERMAL PENALTY - CARIN HEAT LEAK (LB/BTUH) .1280

POWER PENALTY (LBS/WATT) TYPE 1 .7100

POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX . . . . REFUSE PROCESSING (SPACE STATION)

(01/25/75)

FACTOR	MIN VALUE	MAX VALUE	PTS	1	2	3	4	5	6	7	8	9	10	11	12
WEIGHT	74.400	806.80	15	12.71	11.40	12.62	13.62	11.32	10.68	11.22	12.22	9.97	1.01	7.22	.00
PCARR	.00000	1498.8	15	14.94	14.94	9.71	15.00	9.65	9.65	.00	9.71	5.05	7.89	5.05	0.00
VOLUME	7.4000	46.200	10	9.14	8.73	9.14	7.82	8.96	8.96	8.96	7.63	1.25	1.59	3.36	.00
THERMAL	.00000	609.28	15	15.00	15.00	14.47	15.00	13.40	13.40	12.86	13.40	.00	4.35	.00	5.33
RELIABTY	.82031	.99999	5	4.99	4.99	4.99	5.00	4.99	4.99	4.99	4.99	.67	.34	.00	.00
MAINTENC	.99999	1.00000	5	3.27	3.51	2.63	4.97	1.67	2.69	2.00	4.35	1.15	.83	.61	.00
SAFETY	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	25	71.55	70.08	65.05	66.41	56.97	57.56	47.03	59.29	23.59	20.41	19.75	14.21
RATING	.00000	100.00	100	64.18	62.45	74.53	76.13	67.03	67.71	55.33	69.76	27.75	24.01	23.24	16.72

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SENSITIVITY ANALYSIS

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

	1	2	3	C O N C E P T											
				4	5	6	7	8	9	10	11	12			
NORMAL	84.18	82.45	76.53	78.13	67.03	67.71	55.33	69.76	27.75	24.01	23.24	16.72			
WEIGHT	84.22	81.93	77.14	79.15	67.71	67.99	56.91	70.71	30.89	22.61	25.26	15.36			
POWER	85.43	83.84	75.57	79.90	66.81	67.44	50.84	69.35	28.23	26.33	24.08	20.01			
VOLUME	84.58	82.72	77.35	78.13	62.28	60.53	57.21	70.12	26.91	21.56	23.82	15.70			
THERMAL	85.46	83.67	78.14	79.90	60.83	69.56	57.79	71.34	25.50	24.37	21.35	18.24			
RELIAB-Y	84.62	82.95	77.19	78.75	67.96	68.63	56.60	70.61	27.34	21.52	22.57	16.70			
MAINTENC	83.84	82.10	75.84	78.74	66.07	67.43	54.89	70.25	27.61	3.80	22.93	16.24			
SAFETY	83.20	81.52	75.77	75.89	65.11	65.78	53.75	77.76	28.39	17.76	24.00	16.24			
DEV COST	82.22	80.63	75.19	74.50	65.38	66.01	54.63	67.68	27.12	23.15	21.69	15.36			

SENSITIVITY ANALYSIS

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

	1	2	3	C O N C E P T											
				4	5	6	7	8	9	10	11	12			
NORMAL	84.18	82.45	76.53	78.13	67.03	67.71	55.33	69.76	27.75	24.01	23.24	16.72			
WEIGHT	84.12	83.07	75.79	76.90	66.21	67.38	53.44	68.62	24.01	23.69	20.83	18.33			
POWER	82.68	80.79	77.67	76.01	67.29	68.04	60.68	70.24	27.18	21.25	22.23	12.78			
VOLUME	83.72	82.15	75.60	78.12	65.62	66.35	53.19	69.34	28.70	24.52	23.59	17.76			
THERMAL	82.64	80.75	74.60	76.01	64.7	65.62	32.36	67.66	30.44	23.59	25.49	14.90			
RELIAB-Y	83.70	81.92	75.82	77.46	66.04	66.74	53.98	68.65	28.19	24.54	23.94	17.05			
MAINTENC	84.75	82.82	77.25	77.48	68.05	68.01	55.79	69.23	27.90	24.24	23.57	17.22			
SAFETY	85.21	83.13	77.33	80.49	67.06	69.76	57.00	71.57	27.06	23.23	22.43	17.22			
DEV COST	86.52	84.62	78.13	82.46	69.03	69.75	56.17	71.99	26.50	23.05	24.64	18.33			

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

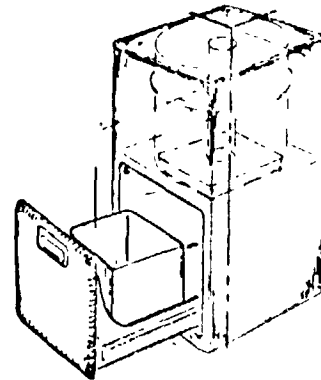
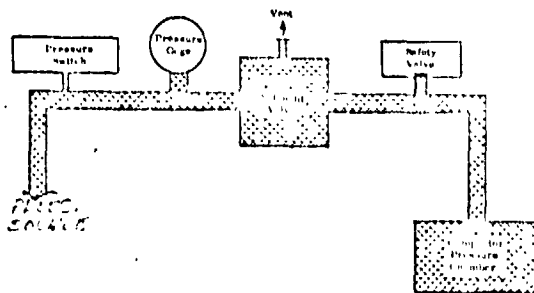
APPLIANCE FUNCTION: 3.2.4-REFUSE PROCESSING

COMPONENT TYPE	NUMBER OF COMPONENTS													NUMBER OF SAFETY CRITICAL ITEMS	
	SOLENOID VALVE (3)	ACCUMULATOR (4)	FILTER (9)	PRESSURE REGULATOR (17)	CONTROLLER TIMER (19)	RELIEF VALVE (25)	ACTUATOR (27)	PRESSURE SWITCH (28)	MOTOR (1)	ELECTRIC SWITCH (10)	BLOWER (8)	CHECK VALVES (22)	HEATER (17)		PUMP (2)
APPLIANCE TYPE	NO.														
COMPACTOR/AIR PRESSURE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COMPACTOR/VACUUM PRESSURE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COMPACTOR/MOTOR	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COMPACTOR/MANUAL	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1
COMPACTOR/AIR PRESSURE & SHREDDER	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2
COMPACTOR/VACUUM PRESSURE AND SHREDDER	1	1	1	1	1	1	1	1	1	2	1	1	1	1	2
COMPACTOR/MOTOR & SHREDDER	-	1	1	1	1	1	1	1	1	2	1	1	1	1	2
COMPACTOR/MANUAL & SHREDDER	-	1	1	1	1	1	1	1	1	1	1	1	1	1	2
INTEGRATED VACUUM DECOMPOSITION/SHREDDER	10	2	2	1	1	1	1	1	1	1	2	2	2	1	1
FLUSH FLOW OXYGEN INCINERATION/SHREDDER	14	2	2	1	1	1	1	1	1	1	2	2	2	1	1
PYROLYSIS/BATCH INCINERATION/SHREDDER	14	3	2	1	1	1	1	1	1	1	2	2	2	1	1
WET OXIDATION/SHREDDER	13	3	2	1	1	1	1	1	1	1	1	1	2	1	2

C.2

SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 1/Compactor-Air PressureINDEX NO. 3.2.4.1REF. 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 Fig. C2-1) 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.



Reference 123

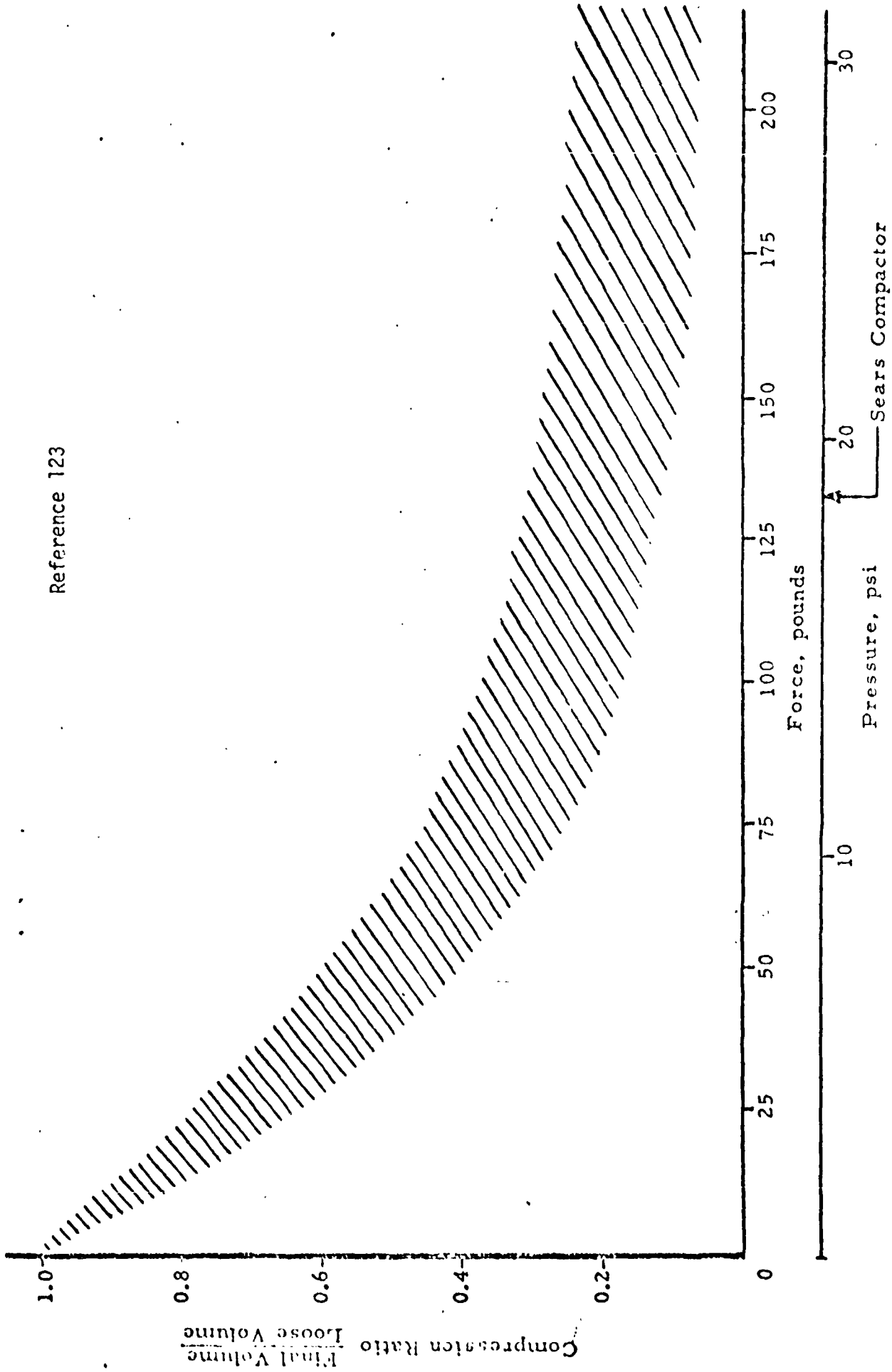


Figure C2-1. COMPOSITE COMPACTION DATA FOR TRASH MIXTURES



CONCEPT 1/COMBINATION AIR PROCESSOR

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.2.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A.C. POWER			D.C. POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① X ⑥
<u>VALVE</u>	<u>.0167</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>8</u>	<u>8</u>	<u>.134</u>
<u>CONTROLLER</u>	<u>.0167</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>2</u>	<u>2</u>	<u>.033</u>
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____
		MAXIMUM		TOTAL	MAXIMUM		TOTAL
					<u>10</u>		<u>.167</u>

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>VALVE/CONTROLLER</u>	<u>—</u>	<u>NEG.</u>	<u>NEG.</u>	<u>—</u>
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
TOTAL	_____	<u>NEG.</u>	<u>NEG.</u>	_____
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND FINALITIES CALCULATIONS (CONTINUED)

CONCEPT 1/2 WASTE RECYCLING

INDEX NUMBER 3.2.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LB)	VOLUME (FT <sup>3</sup> )
<i>COMPONENT (1/2) (176)</i>		<i>75</i>	<i>2.8</i>
<i>WASTE BAG</i>		<i>48.2</i>	<i>4.6</i>
<b>TOTAL</b>		<b><i>55.88 (123.2)</i></b>	<b><i>.207 (7.4)</i></b>

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> )
<i>WASTE BAG</i>	<i>.201 (170)</i>	<i>.25 (110)</i>	<i>.0504</i>	<i>.024 (170)</i>	<i>.00482</i>
			<b>Σ ③</b>		<b>Σ ⑤</b>
			<i>.0504</i>		<i>.00482</i>
<b>TOTAL WT. MISSION</b>	<i>5.2</i> CYCLES/DAY	<i>1.84</i> DAYS/MISSION	<i>.0504</i> TOT. WT./CYCLE (LB)		<i>27.57 (97.2)</i> KG (LB)
<b>TOTAL VOL MISSION</b>	<i>5.2</i> CYCLES/DAY	<i>1.84</i> DAYS/MISSION	<i>.00482</i> TOT. VOL./CYCLE (FT <sup>3</sup> )		<i>.131 (4.6)</i> M <sup>3</sup> (FT <sup>3</sup> )

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECYCLED/CYCLE ① X ② (LB)	④ AMT. LOST/CYCLE ① - ③ (LB)
<i>N/A</i>				
			<b>Σ ③</b>	<b>Σ ④</b>
<b>TOTAL WT. MISSION</b>				
	CYCLE/DAY	DAYS/MISSION	TOTAL TOST/CYCLE Σ ③ (LB)	Σ ④ (LB)

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

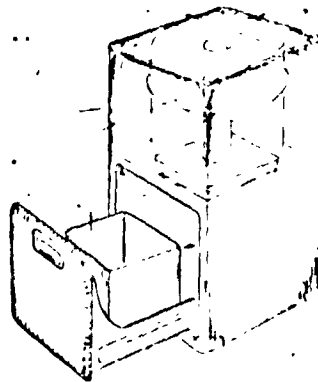
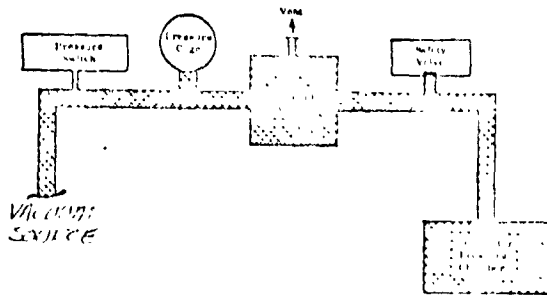
APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 2/Compactor-Vacuum

INDEX NO. 2.2.4.2

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.





### DEFINITION

CONCEPT RECONSTRUCTION

INDEX NUMBER 02-447

### FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>CONSTRUCTION WASTE</u>	<u>1110</u>	<u>75</u>	<u>2.0</u>
<u>WASTE ENGINE OIL</u>	<u>1110</u>	<u>84.2</u>	<u>8.09</u>
<b>TOTAL</b>		<b>72.21 (157.2)</b>	<b>.309 (10.1)</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) (PRG WT/UNIT) (LB)	③ WT/CYCLE (LB)	④ VOL/UNIT (REF) (PRG VOL/UNIT) (FT <sup>3</sup> )	⑤ VOL/CYCLE (FT <sup>3</sup> )
<u>WASTE ENGINE OIL</u>	<u>352</u>	<u>.25 (170)</u>	<u>.088</u>	<u>.027 (170)</u>	<u>.00945</u>
<u>BAGS</u>					
			<b>Σ ③</b>		<b>Σ ⑤</b>
			<u>.088</u>		<u>.00945</u>
TOTAL WT. MISSION	<u>5.2</u>	<u>184</u>	<u>.088</u>		
CYCLES/DAY		DAYS/MISSION	TOT. WT./CYCLE (LB)		
				<b>Σ ③</b>	<b>Σ ⑤</b>
				<u>32.19</u>	<u>(81.2)</u>
				KG (LL)	
TOTAL VOL. MISSION	<u>5.2</u>	<u>184</u>	<u>.00945</u>		
CYCLES/DAY		DAYS/MISSION	TOT. VOL./CYCLE (FT <sup>3</sup> )		
				<b>Σ ④</b>	<b>Σ ⑤</b>
				<u>.229</u>	<u>(6.0)</u>
				M <sup>3</sup> (FT <sup>3</sup> )	

### GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. REQUIRED/CYCLE (LB)	④ AMT. LOST/CYCLE (LB)
<u>CABIN AIR</u>	<u>.036</u>	<u>N/A</u>	<u>N/A</u>	<u>.036</u>
	<b>Σ ①</b>		<b>Σ ③</b>	<b>Σ ④</b>
	<u>.036</u>			<u>.036</u>
TOTAL WT. MISSION	<u>5.2</u>	<u>184</u>	<u>.036</u>	<u>34.4</u>
CYCLES/DAY		DAYS/MISSION	TOTAL WT./CYCLE (LB)	(LB)
				<u>N/A</u>
				<b>Σ ④</b>
				<u>15.6</u>
				<u>(34.1)</u>
				KG (LL)

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HABITABILITY SUBSYSTEM Housekeeping

HABITABILITY FUNCTION Refuse Management

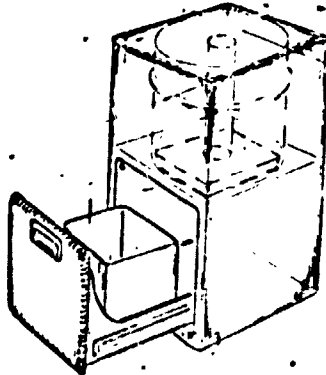
APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 3/Compactor-Motor

INDEX NO. 3.2.4.3

REF. 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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTY CALCULATIONS (CONCLUDED)

CONCEPT 3/COMPACTOR MOTOR

INDEX NUMBER 3.2.9.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>COMPACTOR (INCLUDES (112) SKIDALL OPINUS)</u>		<u>80</u>	<u>2.8</u>
<u>WASTE STORAGE BAGS</u>		<u>48.2</u>	<u>4.6</u>
<b>TOTAL</b>		<b>58.15 (128.2)</b>	<b>.209 (7.4)</b>

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> )	
<u>WASTE STORAGE BAGS</u>	<u>.201 (170)</u>	<u>.25 (170)</u>	<u>.0504</u>	<u>.024 (170)</u>	<u>.00482</u>	
			Σ ③		Σ ⑤	
			<u>.0504</u> TOTAL WT/CYCLE (LB)		<u>.00482</u> TOTAL VOL/CYCLE (FT <sup>3</sup> )	
<b>TOTAL WT. MISSION</b>	<u>5.2</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	X	<u>.0504</u> TOT. WT/CYCLE (LB)	X	<b>21.87 (18.2)</b> KG (LB)
<b>TOTAL VOL. MISSION</b>	<u>5.2</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	X	<u>.00482</u> TOT. VOL/CYCLE (FT <sup>3</sup> )	X	<b>.131 (4.6)</b> M <sup>3</sup> (FT <sup>3</sup> )

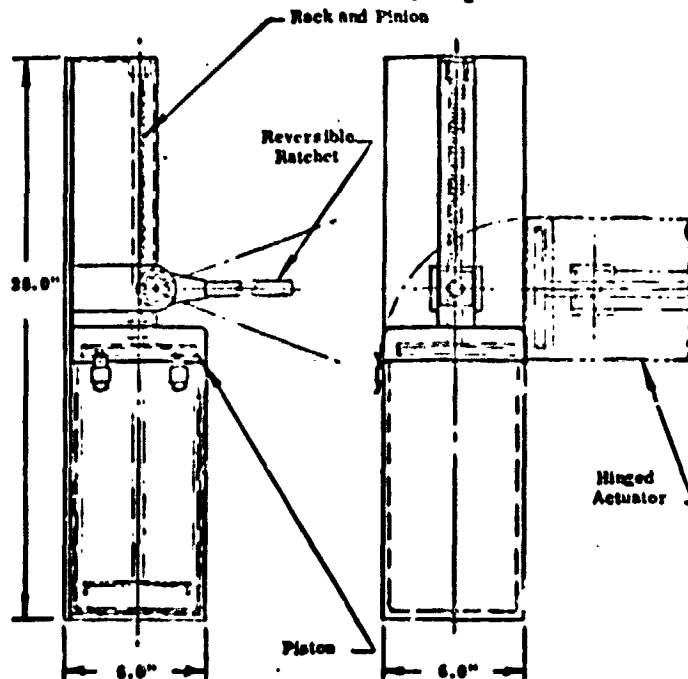
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
<u>- N/A -</u>				
			Σ ③	Σ ④
<b>TOTAL WT. MISSION</b>			<b>TOTAL LOST/CYCLE</b> 	
	<u> </u> CYCLE/DAY	<u> </u> DAYS/MISSION	<u> </u> 	<u> </u> 
			(LB)	(LB)



SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 4/Compactor-ManualINDEX NO. 3.2.4.4REF. 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 Space Station

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.

CONCEPT S/COMPACTOR - AIR PRESSURE W/SHREDDER

INDEX NUMBER 3.2.4.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	AC POWER				DC POWER		
	① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① x ⑤
VALVE	.0167	—	—	—	8	8	.134
CONTROLLER	.0167	—	—	—	2	2	.033
SHREDDER MOTOR	.05	745	745	37.25	—	—	—
		745		37.25	10		.167
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
VALVE/CONTROLLER	—	NEG.	NEG.	—
SHREDDER MOTOR	—	509	509	—
TOTAL		149.3(509)	149.3(509)	
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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



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SPACECRAFT Space Station

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.

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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 6/COMPACTOR-VACUUM W/SHREDDER

INDEX NUMBER 3.2.4.6

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ①x③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ①x⑦
VALVE		.0167	—	—	—	8	8	.134
CONTROLLER		.0167	—	—	—	2	2	.033
SHREDDER MOTOR		.05	745	745	37.25	—	—	—
			745		37.25	10		.167
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
VALVE/CONTROLLER	—	NEG.	NEG.	—
SHREDDER MOTOR	—	509	509	—
TOTAL	—	149.3(509)	149.3(509)	—
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 6/COMPACTOR-VACUUM W/SHREDDER

INDEX NUMBER 3.2.4.6

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COMPACTOR (INCLUDES (170) STERILANT AMPULS.)	75	2.8
SHIELDPLK	75	1.6
WASTIC STORAGE BAGS	48.2	4.6
TOTAL	89.9 (198.2)	.255 (9.0)
	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> )
WASTIC STORAGE BAGS	201 (170)	.25 (170)	.0504	.029 (170)	.00982
			Σ ③ .0504 TOTAL WT/CYCLE (LB)		Σ ⑤ .00982 TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	5.2 CYCLES/DAY	184 DAYS/MISSION	.0504 TOT. WT/CYCLE (LB)		21.87 (48.2) KG (LB)
TOTAL VOL. MISSION	5.2 CYCLES/DAY	184 DAYS/MISSION	.00982 TOT. VOL/CYCLE (FT <sup>3</sup> )		.131 (4.6) 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)
N/A				
	Σ ①		Σ ④	
TOTAL WT. MISSION	CYCLE/DAY	DAYS/MISSION	TOTAL LOST/CYCLE Σ ④ (LB)	KG (LB)

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SPACECRAFT Space Station

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.

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 7/COMPACTOR-MOTOR W/SHREDDER

INDEX NUMBER 3.2.4.7

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER				DC POWER		
		(1) USE TIME CYCLE (HR)	(2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/CYCLE) (1 x 3)	(5) PEAK (WATTS)	(6) AVERAGE (WATTS)	(7) DEMAND (WATT-HR/CYCLE) (1 x 1)
<u>MOTOR</u>		<u>.0167</u>	<u>745</u>	<u>745</u>	<u>12.4</u>			
<u>SHREDDER MOTOR</u>		<u>.05</u>	<u>745</u>	<u>745</u>	<u>37.25</u>			
			<u>1490</u> MAXIMUM		<u>49.65</u> TOTAL			<u></u> TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>MOTOR</u>	<u>-</u>	<u>169.5</u>	<u>169.5</u>	<u>-</u>
<u>SHREDDER MOTOR</u>	<u>-</u>	<u>509</u>	<u>509.0</u>	<u>-</u>
<b>TOTAL</b>	<u>-</u> WATT (BTU/HR)	<u>1990</u> WATT (BTU/HR)	<u>1990</u> WATT (BTU/HR)	<u>-</u> WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCENT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 7/COMPACTOR-MOTOR W/SHREDDER

INDEX NUMBER 3.2.4.7

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COMPACTOR (INCLUDES SIMILANT NUMPLS)	(170)	80	2.8
SHREDDER		75	1.6
WASTE STORAGE BAGS		48.2	4.6
TOTAL		92.17 (203.2)	.255 (9.0)
		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) (P.F) (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> )
WASTE STORAGE BAGS	.201 (170)	.25 (170)	.0504	.024 (170)	.00482
			Σ ③ .0504	Σ ⑤ .00482	
TOTAL WT. MISSION	5.2	184	.0504	21.87 (48.2)	
	CYCLES/DAY	DAYS/MISSION	TOT. WT/CYCLE (LB)	KG (LB)	
TOTAL VOL. MISSION	5.2	184	.00482	.131 (4.6)	
	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)
N/A				
			Σ ③	Σ ④
TOTAL WT. MISSION				
	CYCLE/DAY	DAYS/MISSION	TOTAL LOST/CYCLE (LB)	KG (LB)

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SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Processing

APPLIANCE CONCEPT NO./TITLE 8/Compactor-Manual w/Shredder

INDEX 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.



APPLIANCE CONCEPT REQUIREMENTS AND DETAILS CALCULATIONS (CONCLUDED)

CONCEPT 8/COMPACTOR-MANUAL W/SHREDDER

INDEX NUMBER 3.2.4.8

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COMPACTOR (INCLUDES STERILANT AMPULES)	(160)	26.2	14.2
SHREDDER		7.5	1.6
WASTE STORAGE BAGS		3.8	4.6
TOTAL		67.77 (149.4)	.578 (20.4)

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> )
WASTE STORAGE BAGS	.144	.0747	.0108	.00714	.00103
Σ ③			.0108	Σ ⑤	.00103
TOTAL WT. MISSION	24.3 CYCLES/DAY	184 DAYS/MISSION	.0108 TOT WT/CYCLE (LB)	21.87 (48.2) KG (LB)	
TOTAL VOL MISSION	24.3 CYCLES/DAY	184 DAYS/MISSION	.00103 TOT VOL/CYCLE (FT <sup>3</sup> )	.131 (4.6) 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)
N/A				
Σ ①			Σ ③	
TOTAL WT. MISSION	CYCLE/DAY	DAYS/MISSION	TOTAL LOST/CYCLE x ④ (LB)	kg (lb)

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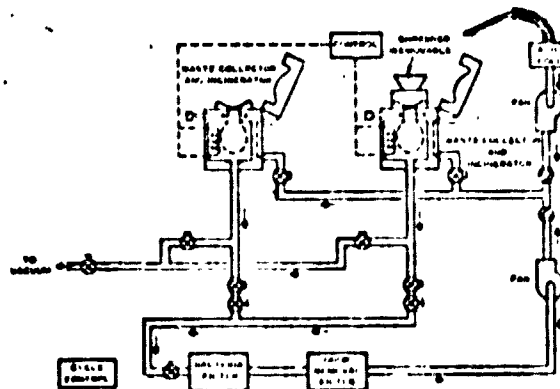
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 9/UNIC GRADE VACUUM DECOMPOSITION/SHELDOR INDEX NUMBER 3.49

ELECTRICAL POWER REQUIREMENTS

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

THERMAL REQUIREMENTS

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

APPLIANCE CONCEPT REQUIREMENTS AND FINALITY CALCULATIONS (CONCLUDED)  
 CONCEPT 9/INTEGRATED VACUUM DECOMPOSITION/SHREDDER INDEX NUMBER 3.2.4.9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COLLECTION UNIT	(100)	177	63.5
COLLECTION BAGS		93.7	11.9
TOTAL		<b>122.8 (270.7)</b>	<b>2.13 (75.4)</b>
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

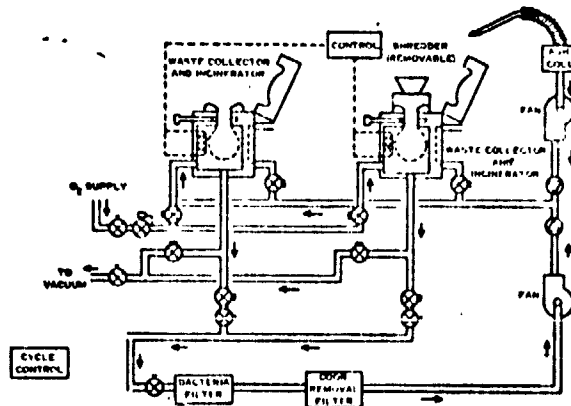
TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	③ WT/CYCLE (1) X (2) (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	⑤ VOL/CYCLE (1) X (4) (FT <sup>3</sup> )
COLLECTION BAGS	1 (100)	.255 (100)	.255	.0323 (100)	.0323
Σ ③			TOTAL WT/CYCLE (LB) .255	Σ ⑤	
TOTAL WT. MISSION =			2 CYCLES/DAY X 184 DAYS/MISSION X .255	<b>42.5 (93.7)</b>	
TOTAL VOL. MISSION =			2 CYCLES/DAY X 184 DAYS/MISSION X .0323	<b>.337 (11.9)</b>	
			TOT. WT/CYCLE (LB)	KG (LB)	
			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)
- N/A -				
Σ ①			Σ ④	
TOTAL WT. MISSION =			<b>KG (LB)</b>	
CYCLE/DAY X DAYS/MISSION X			TOTAL TOST/CYCLE (2) (3) (LB)	

SPACECRAFT Space StationHABITABILITY 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT 10/FLOW FLOW OXYGEN INCINERATION/SHREDDER INDEX NUMBER 3.2.4.10

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A.C. POWER			D.C. POWER		⑦ DEMAND (WATT-HR/ CYCLE) ① x ③
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	
<u>COLLECTOR UNIT (100)</u>		<u>12</u>	<u>1000</u>					
			<u>1000</u>					
			MAXIMUM		TOTAL		MAXIMUM	TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>COLLECTOR UNIT (100)</u>	<u>—</u>	<u>3410</u>	<u>3410</u>	<u>—</u>
TOTAL	<u>—</u>	<u>1000 (3410)</u>	<u>1000 (3410)</u>	<u>—</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 10/FRESH FLOW OXYGEN INCLINATION/SHIELDER INDEX NUMBER 3.2.4.10

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
COLLECTION UNIT	(100)	186	61.6
COLLECTION BAGS		93.7	11.9
TOTAL		<b>126.9 (279.7)</b>	<b>2.05 (72.5)</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> )
COLLECTION BAGS	1 (100)	.255 (100)	.255	.0323 (100)	.0323
			Σ ③	Σ ④	
			TOTAL WT/CYCLE (LB)	TOTAL VOL/CYCLE (FT <sup>3</sup> )	

TOTAL WT. MISSION =  $2 \text{ CYCLES/DAY} \times 184 \text{ DAYS/MISSION} \times .255 \text{ TOT. WT/CYCLE (LB)} = 42.5 \text{ KG (LB)} \text{ (93.7)}$

TOTAL VOL MISSION =  $2 \text{ CYCLES/DAY} \times 184 \text{ DAYS/MISSION} \times .0323 \text{ TOT. VOL/CYCLE (FT}^3\text{)} = .337 \text{ M}^3 \text{ (FT}^3\text{)} \text{ (11.9)}$

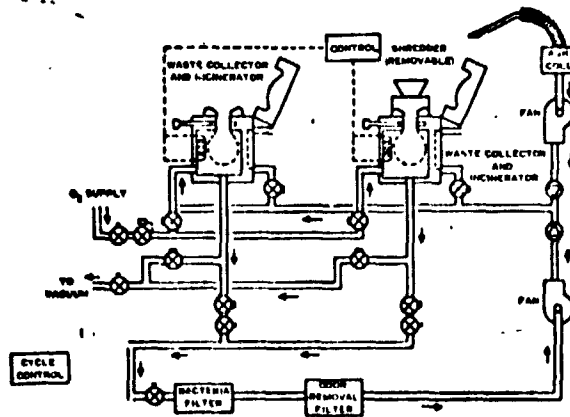
GAS/LIQUID EXPENDABLES REQUIREMENTS

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	1.283	N/A	N/A	1.283
				Σ ④
				TOTAL LOST/CYCLE (LB)

TOTAL WT. MISSION =  $2 \text{ CYCLES/DAY} \times 184 \text{ DAYS/MISSION} \times 1.283 \text{ TOTAL LOST/CYCLE (LB)} = 472 \text{ (LB)} \times 1.28 = 214.7 \text{ KG (LB)} \text{ (473.3)}$

SPACECRAFT Space StationHABITABILITY 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.



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
CONCEPT LL/PYROLYSIS/BATCH INCINERATION/SMRCDDER

INDEX NUMBER 3.2.4.11

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A C POWER			D C POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① X ⑦
<u>COLLECTION UNIT (100)</u>	<u>12</u>	<u>1400</u>					
		<u>MAXIMUM</u>		<u>TOTAL</u>	<u>MAXIMUM</u>		<u>TOTAL</u>

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>COLLECTION UNIT (100)</u>	<u>-</u>	<u>4760</u>	<u>4760</u>	<u>-</u>
<b>TOTAL</b>	<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 (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOL. E (FT <sup>3</sup> /MISSION)
<u>N/A</u>					
<b>TOTAL</b>	<u>WATTS/CYCLE (BTU/HR/CYCLE)</u>	<u>WATTS/CYCLE (BTU/HR/CYCLE)</u>		<u>KG/MISSION (LB/MISSION)</u>	<u>M<sup>3</sup>/MISSION (FT<sup>3</sup>/MISSION)</u>

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT II/PYROLYSIS/BATCH INCINERATION/SHREDDER INDEX NUMBER 3.2.4.11

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT³)
COLLECTION UNIT	100	186	45.3
COLLECTION BAGS		93.7	11.9
TOTAL		126.9 (279.7)	1.62 (57.2)
		KG (LBS)	M³ (FT³)

SOLID EXPENDABLE M/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) (FT³)	⑤ VOL/CYCLE ① X ④ (FT³)
COLLECTION BAGS	1 (100)	.255 (100)	.255	.0323 (100)	.0323
Σ ③			TOTAL WT/CYCLE (LB)	Σ ⑤ TOTAL VOL/CYCLE (FT³)	
TOTAL WT. MISSION	2 CYCLES/DAY	184 DAYS/MISSION	.255	42.5 (93.7) KG (LB)	
TOTAL VOL. MISSION	2 CYCLES/DAY	184 DAYS/MISSION	.0323	.337 (11.9) M³ (FT³)	

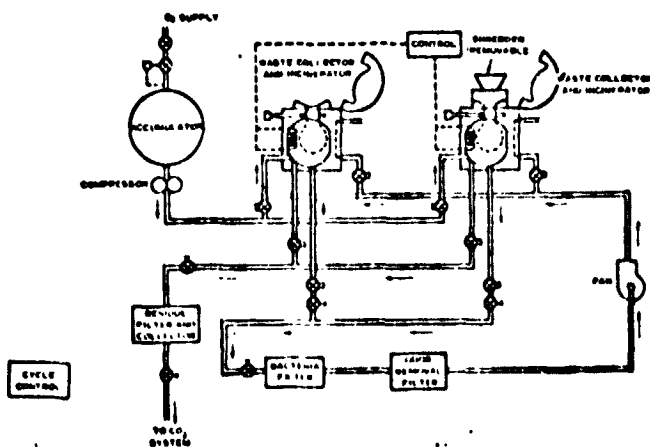
GAS/LIQUID EXPENDABLES REQUIREMENTS

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	.376	N/A	N/A	.376
Σ ①			Σ ④	
TOTAL WT. MISSION	2 CYCLE/DAY	184 DAYS/MISSION	.376	138.3 (62.9) (138.7) KG (LB)
			⑥ ④ (LB)	⑦ ④



SPACECRAFT Space StationHABITABILITY 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 psfa 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 oxidation process is the production of water which can be processed and reused in the spacecraft. The system requires a high pressure oxygen source, assumed in this study as a compressor. A stirrer would enhance the wet oxidation process, but was not considered in 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 the tabulation on Table C2-6.

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

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX No. 3028 000 REUSE DISPOSAL SPACE STATION

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS	TEMPERATURE REQUIREMENTS	ELC. PER REQTS	WT/VOL REQTS	DEVELOPMENT COST	RESUPPLY
		AMT.		PE PER AVE PER	WEIGHT VOLUME	AVAIL INDEX	WEIGHT
		USEC	TEMP	AC	-EG- -CU M-	(100) (1000)	-EG-
		WRS/USE	PSI	DC	(LBS) (CU FT)		(LBS)
1	1.000 .032	2 0.000	0.00 0.00	0.0 0.0	235.9 (120.0)	16.62 (107.00)	10 (120.3)
2	1.000 .032	2 0.000	0.00 0.00	0.0 0.0	94.3 (47.6)	14.37 (1505.00)	10 (1.0)
3	1.000 .001	2 0.000	0.00 0.00	0.0 10.0	290.6 (1500.0)	.73 (29.00)	2 35 (191.1) (421.4)

APPLIANCE CONCEPT

- CONCEPT NAME
- 1 - VACUUM STORAGE
  - 2 - STORAGE TANK/CONTAINER
  - 3 - SOLID PROPPELLANT-REFUSE-SOCKET

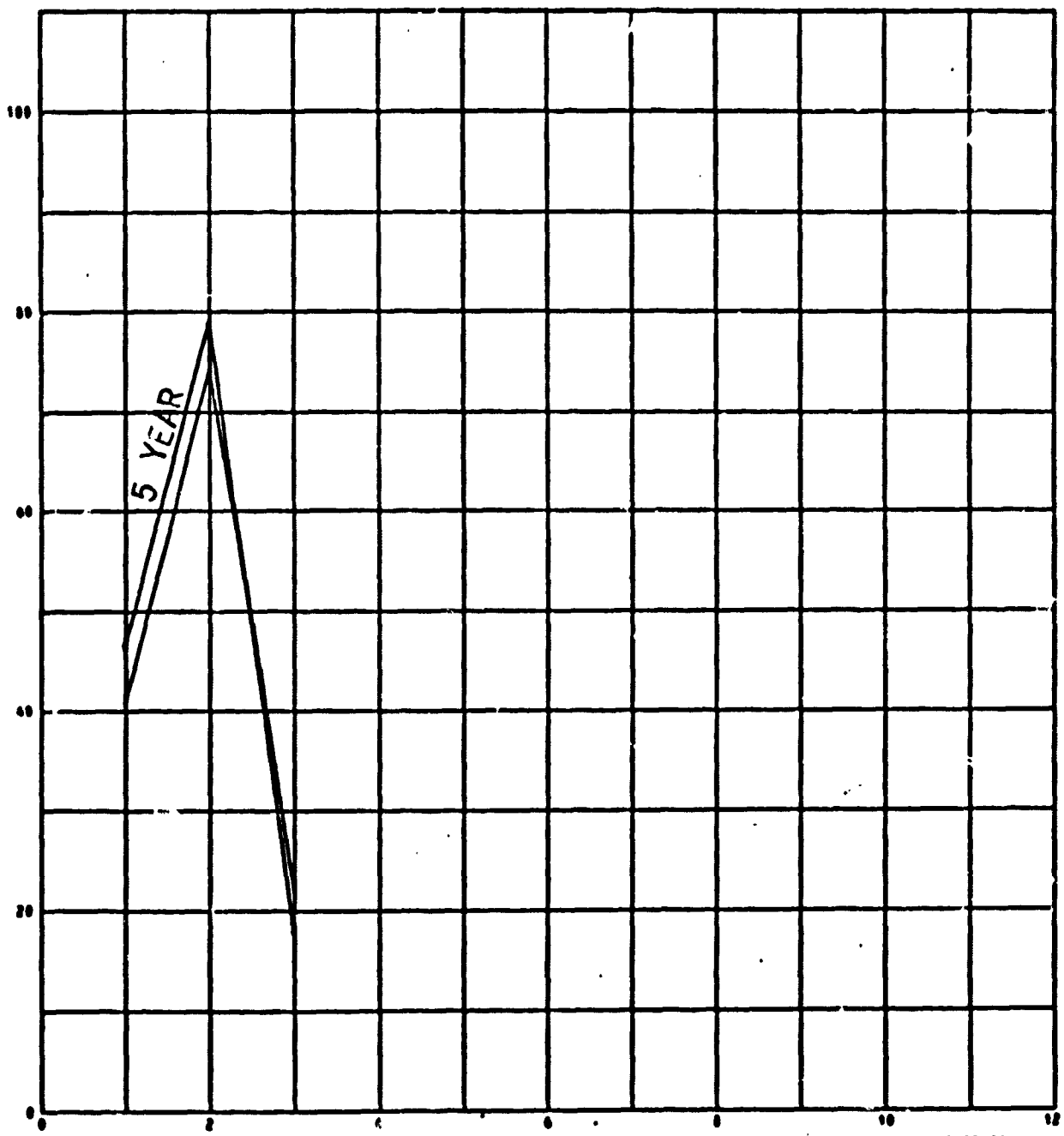
- (\*)
- 1 - CABIN AIR (CIRCULATED). LITERS/SEC (FT<sup>3</sup>/MIN)
  - 2 - CABIN AIR (LOST) . KG/HR (LB/HR)
  - 3 - OXYGEN (LOST) . KG/HR (LB/HR)
  - 4 - COOLING WATER (CIRCULATED). HR (LB/HR)
  - 5 - WATER (LOST) . KG/HR (LB/HR)
  - 6 - NITROGEN (CIRCULATED). KG/HR (LB/HR)
  - 7 - NITROGEN (USED)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

- (\*\*)AVAILABLE 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.                    C O N C E P T   N A M E

- 1 - VACUUM STORAGE
- 2 - STORAGE BIN/CONTAINER
- 3 - SOLID PROPELLANT REFUSE ROCKET



CONCEPT NUMBER

Refuse Disposal (Space Station) Concept Trade

NUMBER OF DAYS = 180.0 ( .99 YEARS)  
 USES MOD SUBROUTINE IS  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) = .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) = .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 = .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 = .5910

SELECTION MATRIX (12/09/74) REFUSE DISPOSAL (SPACE STATION)

FACTOR	MIN VALUE		PTS	CONCEPT		
	1	2		3	2	3
WEIGHT	97.600	549.00	15	.77	12.33	.00
POWER	.00000	5.9100	15	15.00	15.00	.00
VOLUME	25.900	587.00	10	.00	.03	9.56
RELIAB-Y	.99997	1.0000	5	.00	5.00	4.81
MAINTENC	1.00000	1.0000	5	.00	5.00	.00
DEV COST	10.000	35.000	15	10.71	10.71	.00
TOTAL PT	.00000	65.000	65	26.48	48.08	14.37
RATING	.00000	100.00	100	40.74	73.94	22.11

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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	40.74	73.96	22.11
WEIGHT	37.05	74.82	19.82
POWER	46.87	76.66	19.82
VOLUME	37.83	68.71	27.36
RELIAB-Y	39.23	74.93	24.86
MAINTENC	39.23	74.93	21.29
DEV COST	43.91	73.70	19.82

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	40.74	73.96	22.11
WEIGHT	45.39	72.89	24.99
POWER	33.01	70.57	24.99
VOLUME	44.13	80.10	15.99
RELIAB-Y	42.37	72.92	19.14
MAINTENC	42.37	72.92	22.99
DEV COST	36.74	74.30	24.99



NUMBER OF DAYS = 1826.0 (5.00 YEARS)  
 USES MOD SURROUTINE 15  
 THERMAL PENALTY - DIRECT TO COOLANT (LR/BTUH) .0540  
 THERMAL PENALTY - CARIN HEAT LEAK (LR/BTUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7109  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX \* \* \* \* \* REFUSE DISPOSAL (SPACE STATION)  
 (12/09/74)

FACTOR	MIN VALUE		MAX VALUE		PTS	CONCEPT		
	1	2	1	2		1	2	3
WEIGHT	97.600		548.00		15	.77	12.33	.00
POWER	.00000		5.9100		15	15.00	15.00	.00
VOLUME	25.900		587.00		10	.00	.03	9.56
RELIAB-Y	.99973		1.0000		5	.00	5.00	4.81
MAINTENC	1.00000		1.0000		5	.00	5.00	.00
DEV COST	10.000		35.000		15	10.71	10.71	.00
REC COST	1.8600		421.40		15	10.72	14.93	.00
TOTAL PT	.00000		80.000		80	37.20	63.01	14.37
RATING	.00000		100.00		100	46.50	78.76	17.97

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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	46.50	78.76	17.97
WEIGHT	42.95	79.06	16.43
POWER	51.08	80.58	16.43
VOLUME	43.76	74.15	22.53
RELIAB-Y	45.09	79.41	20.34
MAINTENC	45.09	79.41	17.42
DEV COST	48.63	78.13	16.43
REC COST	48.64	80.55	16.43

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	46.50	78.76	17.97
WEIGHT	50.78	78.41	19.83
POWER	40.96	76.57	19.83
VOLUME	49.60	83.99	12.79
RELIAB-Y	48.00	78.08	15.44
MAINTENC	48.00	78.08	18.55
DEV COST	43.92	79.52	19.83
REC COST	43.92	76.61	19.83

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 3.2.5-REFUSE DISPOSAL

COMPONENT TYPE	NUMBER OF COMPONENTS													NUMBER OF SAFETY CRITICAL ITEMS			
	APPLIANCE TYPE	NO.	ACTUATOR	MANUAL VALVE	ROCKET MOTOR	MOTOR IGNITER											
VACUUM STORAGE/RESTORAGE/ BIOLOGICAL STABILIZED STORAGE BIN/CONTAINER/RESTORAGE/ BIOLOGICAL STABILIZED SOLID PROPELLANT REFUSE ROCKET		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
																	0
																	0

\*TBD

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

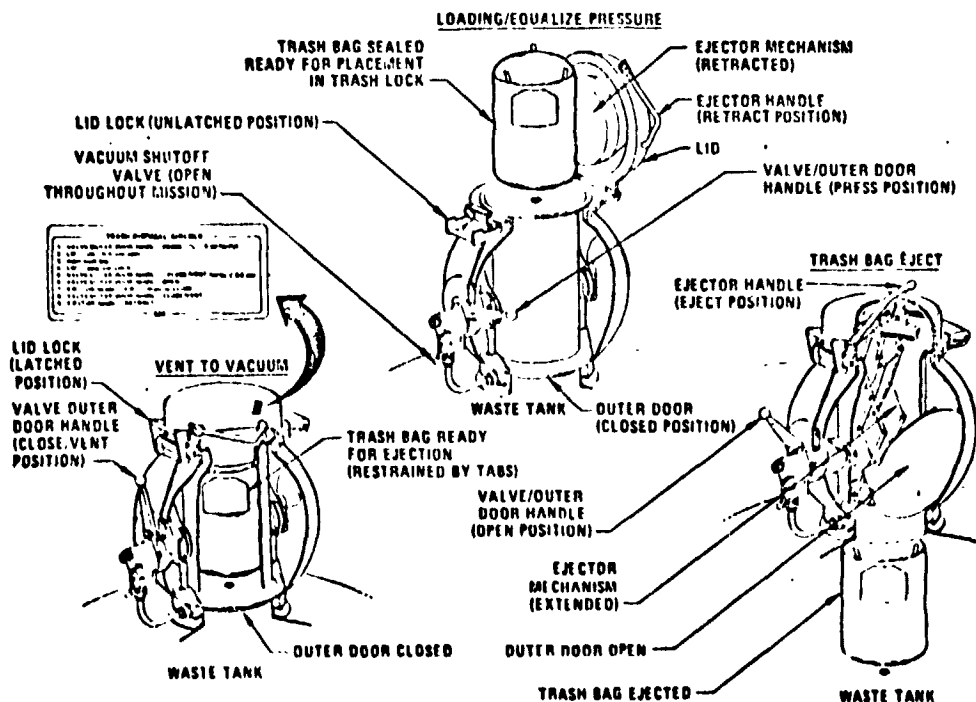
APPLIANCE FUNCTION Refuse Disposal

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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT VACUUM STORAGE

INDEX NUMBER 3.2.5.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>STORAGE TANK (ALUMINUM)</u>		<u>239</u>	<u>585</u>
<u>REFUSE AIRLOCK (283)</u>		<u>153</u>	<u>2</u>
TOTAL		<b>180.1 (397)</b> KG (LBS)	<b>16.6 (587)</b> 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 ①x② (LB)	④ VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT <sup>3</sup> )	⑤ VOL/CYCLE ①x④ (FT <sup>3</sup> )			
<u>N/A</u>								
Σ ③			TOTAL WT/CYCLE (LB)	Σ ⑤				
TOTAL WT. MISSION =		<u>        </u> CYCLES/DAY	x	<u>        </u> DAYS/MISSION	x	<u>        </u> TOT.WT/CYCLE (LB)	=	<u>        </u> KG (LB)
TOTAL VOL. MISSION =		<u>        </u> CYCLES/DAY	x	<u>        </u> DAYS/MISSION	x	<u>        </u> TOT.VOL/CYCLE (FT <sup>3</sup> )	=	<u>        </u> 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 ①x② (LB)	④ AMT. LOST/CYCLE ①-③ (LB)				
<u>CABIN AIR</u>	<u>.321</u>	<u>N/A</u>	<u>N/A</u>	<u>.321</u>				
Σ ①			Σ ④					
TOTAL WT. MISSION =		<u>2.08</u> CYCLE/DAY	x	<u>184</u> DAYS/MISSION	x	<u>.321</u> TOTAL LOST/CYCLE ② x ④ (LB)	=	<u>122.8</u> (LB)
TOTAL WT. MISSION =		<u>2.08</u> CYCLE/DAY	x	<u>184</u> DAYS/MISSION	x	<u>.321</u> TOTAL LOST/CYCLE ② x ④ (LB)	=	<u>55.79 (123)</u> KG (LB)

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse Management

APPLIANCE FUNCTION Refuse Disposal

APPLIANCE CONCEPT NO./TITLE 2/Storage Bin/Container

INDEX NO. 3.2.5.2 REF. 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.



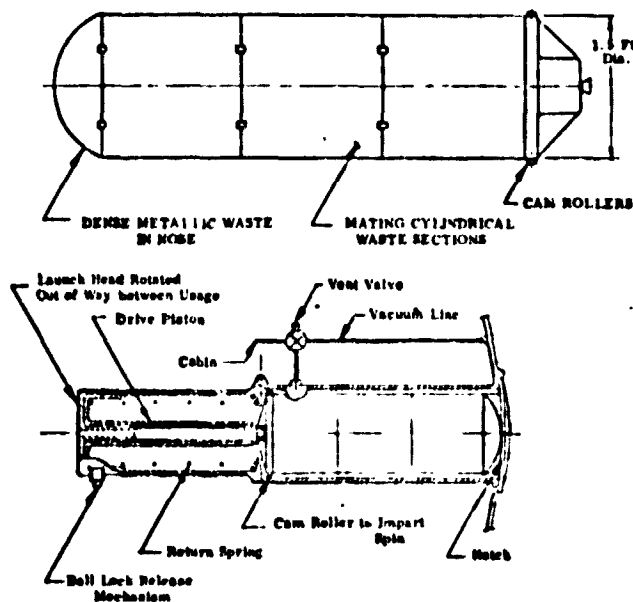




SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Refuse ManagementAPPLIANCE FUNCTION Refuse ProcessingAPPLIANCE CONCEPT NO./TITLE 3/Solid Propellant Refuse RocketINDEX NO. 3.2.5.3REF. NO. 202

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 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

CONCEPT 3/SOLID PROPELLANT REFUSE ROCKET APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.2.5.3

ELECTRICAL POWER REQUIREMENTS

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

THERMAL REQUIREMENTS

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

OPERATIONAL PENALTIES

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>COMPACTOR (AIR PRESSURE)</u>	<u>-</u>	<u>-</u>	<u>10</u>	<u>75</u>	<u>2.8</u>
<u>WASTE COLLECTION BAGS</u>	<u>-</u>	<u>-</u>	<u>--</u>	<u>98.2</u>	<u>9.61</u>
TOTAL	<u>-</u>	<u>-</u>	<u>10</u>	<u>55.9 (1232)</u> LB/MISSION	<u>.21 (7.41)</u> FT <sup>3</sup> /MISSION

CONCEPT 3/SOLID PROPELLANT REFUSE ROCKET

INDEX NUMBER 3,2,5,3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
ROCKET MOTOR	(202)	349	3.51
EJECTION MECHANISM		50	15.00
TOTAL		<b>181 (399)</b>	<b>.524 (18.51)</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) (LBS)	③ WT/CYCLE (① x ②) (LBS)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (FT <sup>3</sup> )	⑤ VOL/CYCLE (① x ④) (FT <sup>3</sup> )
ROCKET MOTORS	1 (202)	19.40 (202)	19.40	.195 (202)	.195
			Σ ③	Σ ⑤	
			TOTAL WT/CYCLE (LBS)	TOTAL VOL/CYCLE (FT <sup>3</sup> )	
TOTAL WT MISSION	.0978 CYCLES/DAY	184 DAYS/MISSION	19.40	<b>158.4 (349)</b>	
			TOT. WT/CYCLE (LBS)	KG (LBS)	
TOTAL VOL MISSION	.0978 CYCLES/DAY	184 DAYS/MISSION	.195	<b>.0993 (3.51)</b>	
			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) (LBS)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE (① x ②) (LBS)	④ AMT. LOST/CYCLE (① - ③) (LBS)
N/A				
			Σ ③	Σ ④
			TOTAL LOS/CYCLE (LBS)	KG (LBS)
TOTAL WT MISSION	CYCLE/DAY	DAYS/MISSION	TOTAL LOS/CYCLE (LBS)	

HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.3 Garment/Linen Maintenance

APPLIANCE FUNCTION 3.3.1 Garment/Linen Washing

NUMBER 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.

A ground rule of 2-clothes washings per day was assumed from Reference 273. For this condition, and assuming a 6-man space station crew, a detailed study of Space Station clothing usage (Reference 245) has shown a maximum laundry load of 1.66 kg (3.68 lbs). Since the clothes washer load assumed in Reference 90 is only slightly larger than this, or 1.81 kg (4.0 lbs), the data from that reference were used directly without adjusting

The water usage for the automatic concept was assumed 24.9 kg (55 lbs) for washing and 24.9 kg (55 lbs) for rinse as recommended in Reference 273. Rinse water was assumed to be temporarily stored to be reused as wash water. Wash/rinse time was taken to be one hour.

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.3.1 GARMET/LINEN WASHING (SPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS	THERMAL REQTS	ELEC PWR REQTS	HT/VOL REQTS	DEVELOPMENT COST	RESUPPLY
		AMT. USED -KG/USE- (LR/USE)	TEMP -DEG C- (DEG F)	HT LEAK -WATTS- (BTU/MR)	AVG PWR AC DC -WATTS- (CU FT)	AVAIL INDEX (%)	WEIGHT -KG- (LBS)
1	2-000 1-000	49.8960 110.0000	.00 (.00)	0. (1980.)	225.0 .0	51 (18.10)	18.9 (41.6)
2	2-000 1-000	49.8960 110.0000	.00 (.00)	0. (5020.)	237.0 .0	54 (19.10)	18.9 (41.6)
3	2-000 1-000	49.8960 110.0000	.00 (.00)	593. (2025.)	216.0 681.0	2.04 (71.90)	18.9 (41.6)
4	2-000 1-000	49.8960 110.0000	.00 (.00)	593. (2025.)	216.0 681.0	2.04 (71.90)	18.9 (41.6)
5	2-000 1-000	1361 .3000	.00 (.00)	0. (4468.)	75.0 .0	.44 (15.70)	67.7 (149.2)
6	2-000 1-000	1769 .3900	.00 (.00)	0. (4468.)	75.0 .0	.43 (15.20)	82.3 (181.5)
7	2-000 1-000	49.8960 110.0000	.00 (.00)	0. (5020.)	237.0 .0	53 (18.10)	18.9 (41.6)
8	2-000 1-000	49.8960 110.0000	.00 (.00)	0. (4468.)	1537.0 .0	57 (20.10)	18.9 (41.6)
9	2-000 1-000	49.8960 110.0000	.00 (.00)	395. (1350.)	144.0 454.0	1.22 (43.10)	16.8 (37.0)
10	2-000 1-000	49.8960 110.0000	.00 (.00)	0. (5020.)	237.0 .0	53 (18.10)	18.9 (41.6)

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- (\*) 1 - CABIN AIR (CIRCULATED), LITERS/SEC (FT<sup>3</sup>/MIN) (LB/HR)
- 2 - CABIN AIR (LOST), KG/HR (LB/HR)
- 3 - OXYGEN (CIRCULATED), 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 - FRESH (CIRCULATED), KG/HR (LB/HR)
- 9 - WATER (PROCESSED), KG/HR (LB/HR)

(\*\*)-AVAILABLE  
(\*\*\*)COST INDICATOR

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

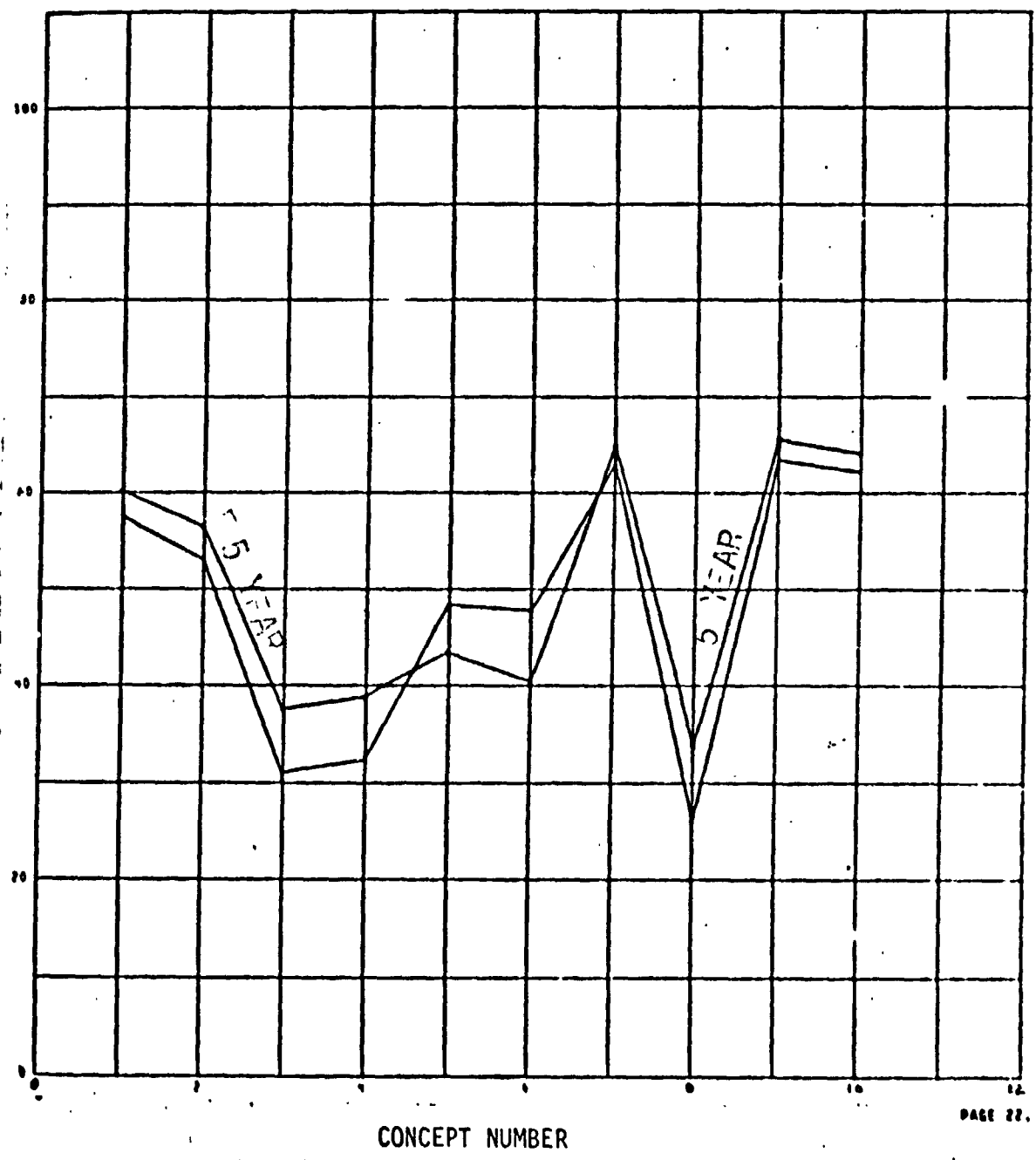
APPLIANCE CONCEPT NO.	CONCEPT NAME
1	MECHANICAL OSCILLATION
2	FLUIDIC AGITATION
3	PISTON AGITATION
4	CYCLIC VALVE AND PUMP AGITATION
5	DIAPHRAM ACTJATED-ONE DIRECTIONAL SQUEEZE
6	DIAPHRAM ACTJATED-TWO DIRECTIONAL SQUEEZE
7	WATER SPRAY AGITATED
8	ULTRASONIC
9	MANUAL WASHBOARD
10	PLAIN RECIRCULATION

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APPLIANCE  
CONCEPT

NO.	CONCEPT NAME
1	MECHANICAL OSCILLATION
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7	WATER SPRAY AGITATED
8	ULTRASONIC
9	MANUAL WASHBOARD
10	PLAIN RECIRCULATION

C O N C E P T T R A D E S T A N D A R D S



Garment/Linen Washing (Space Station) Concept Trade



NUMBER OF DAYS = 180.0 ( .49 YEARS)  
 USES MOD SJROUTINE 1  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1280  
 POWER PENALTY (LBS/WATT)-TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX (04/18/75) GARMENT/LINEN WASHING (SPACE STATION)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT									
				1	2	3	4	5	6	7	8	9	10
WEIGHT	259.60	584.50	15	5.95	6.13	.23	.00	4.31	3.85	5.95	5.57	8.34	5.95
POWER	53.250	1071.3	15	12.80	12.69	7.36	7.36	14.27	14.27	12.69	.00	9.91	12.69
VOLUME	15.200	71.900	10	7.48	7.34	.00	.00	7.82	7.89	7.41	7.20	4.01	7.41
THERMAL	184.00	1210.9	15	7.10	7.04	6.15	6.32	7.92	7.92	7.04	.00	12.72	7.04
RELIABILITY	.95585	.97073	5	3.35	1.39	3.41	3.95	3.33	3.33	3.41	.00	3.41	3.79
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	48.94	45.112	26.33	27.53	41.07	40.68	53.58	22.42	53.89	52.83
RATING	100.000	100.000	100	57.58	53.08	30.97	32.39	48.32	47.86	63.03	26.37	63.40	62.15

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	57.58	53.08	30.97	32.39	48.32	47.86	63.03	26.37	63.40	62.15
WEIGHT	56.13	52.07	28.59	29.77	46.73	46.06	61.14	27.24	62.76	60.33
POWER	59.83	55.63	32.44	33.74	52.12	51.69	64.78	24.23	63.61	63.97
VOLUME	58.53	54.21	29.25	30.59	49.98	49.58	63.65	28.91	62.10	62.81
THERMAL	56.75	52.58	31.79	33.18	48.68	48.26	61.73	24.23	65.13	60.91
RELIAB-Y	57.84	52.35	32.04	33.72	48.84	48.39	63.18	25.62	63.53	62.54
MAINTENC	57.82	51.56	32.03	33.82	48.90	48.45	63.17	26.07	63.53	62.57
SAFETY	58.79	54.42	32.95	34.32	46.94	46.49	64.09	27.52	64.44	63.23
DEV COST	55.04	51.76	28.89	30.19	44.40	43.98	62.62	27.22	62.10	60.95

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	57.58	53.08	30.97	32.39	48.32	47.86	63.03	26.37	63.40	62.15
WEIGHT	59.31	54.26	33.82	35.53	50.22	50.01	65.29	25.33	64.15	64.32
POWER	54.89	50.03	29.22	30.78	43.79	43.29	60.95	28.92	63.14	59.98
VOLUME	56.50	51.81	32.91	34.42	46.46	45.92	62.34	23.52	64.85	61.40
THERMAL	58.56	53.67	30.01	31.45	47.69	47.38	64.59	28.92	61.32	63.62
RELIAB-Y	57.29	53.85	29.85	30.98	47.77	47.29	62.88	27.17	63.25	61.73
MAINTENC	57.32	54.69	29.86	30.88	47.70	47.23	62.89	26.70	63.26	61.71
SAFETY	56.28	51.66	28.88	30.34	49.79	49.31	61.91	25.15	62.29	61.00
DEV COST	60.60	54.65	33.46	35.02	53.00	52.49	63.53	25.36	64.95	63.58

NUMBER OF DAYS = 1826.0 (15.00 YEARS)  
 USES MOD SUBROUTINE I  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION-MATRIX (04/18/75) GARMENT/LINEN WASHING (SPACE STATION)

FACTOR	MIN VALUE		PTS	CONCEPT									
	VALUE			1	2	3	4	5	6	7	8	9	10
WEIGHT	259.60	584.50	15	5.95	6.13	.23	.00	4.31	3.65	5.95	5.57	8.34	5.95
POWER	53.250	1091.3	15	12.80	12.69	7.36	7.36	14.27	14.27	12.69	.00	9.91	12.69
VOLUME	15.200	71.900	10	7.48	7.34	.00	.00	7.82	7.89	7.41	7.20	4.01	7.41
THERMAL	184.00	1210.9	15	7.10	7.04	6.15	6.32	7.92	7.92	7.04	.00	12.72	7.04
RELIAB-T	.63253	.90982	5	3.11	1.18	3.18	3.77	3.10	3.10	3.18	.00	3.18	3.60
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
REC COST	37.000	181.47	15	11.56	11.56	11.56	11.56	2.67	.00	11.56	11.56	11.94	11.56
TOTAL PT	.00000	100.00	100	60.27	56.48	37.66	38.92	43.51	40.45	64.91	33.98	65.60	64.19
RATING	.00000	100.00	100	60.27	56.48	37.66	38.92	43.51	40.45	64.91	33.98	65.60	64.19

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SENSITIVITY ANALYSIS

WEIGHTING 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	60.27	56.48	37.66	38.92	43.51	40.45	64.91	33.98	65.60	64.19
WEIGHT	58.83	55.39	35.14	36.20	42.48	39.42	63.15	34.20	64.90	62.49
POWER	62.02	58.44	38.46	39.63	47.11	44.26	66.28	31.61	65.63	65.62
VOLUME	60.96	57.29	35.87	37.07	45.16	42.28	65.35	35.79	64.38	64.67
THERMAL	59.37	55.81	37.90	39.14	44.15	41.31	63.66	31.61	66.94	62.99
RELIAB-Y	60.32	55.68	38.29	39.81	43.96	40.97	64.88	33.15	65.55	64.38
MAINTENC	60.41	55.10	38.40	39.98	44.12	41.14	64.98	33.53	65.66	64.50
SAFETY	61.24	57.54	39.18	40.41	42.45	39.46	65.77	34.78	66.44	65.07
DEV COST	57.90	55.11	35.40	36.57	40.47	37.63	64.42	34.18	64.33	63.02
REC COST	61.44	57.92	40.41	41.58	41.71	37.63	65.76	36.99	66.58	65.09

SENSITIVITY ANALYSIS

WEIGHTING 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	60.27	56.48	37.66	38.92	43.51	40.45	64.91	33.98	65.60	64.19
WEIGHT	61.94	57.74	40.59	42.07	44.71	41.65	66.96	33.72	66.41	66.18
POWER	58.24	54.20	36.74	38.10	39.32	38.01	63.32	36.73	65.56	62.54
VOLUME	59.50	55.59	39.45	40.97	41.68	38.43	64.43	31.98	66.94	63.67
THERMAL	61.32	57.25	37.39	38.66	42.76	39.45	66.37	36.73	64.04	65.59
RELIAB-Y	60.22	57.32	37.00	37.98	43.04	39.90	64.95	34.85	65.65	64.00
MAINTENC	60.12	57.93	36.89	37.81	42.86	39.72	64.84	34.45	65.54	63.87
SAFETY	59.25	55.36	36.06	37.35	44.62	41.48	64.01	33.14	64.72	63.28
DEV COST	63.02	58.07	40.29	41.65	47.04	43.73	65.48	33.75	67.08	65.56
REC COST	58.91	54.81	34.47	35.82	45.59	43.73	63.93	30.48	64.46	63.15

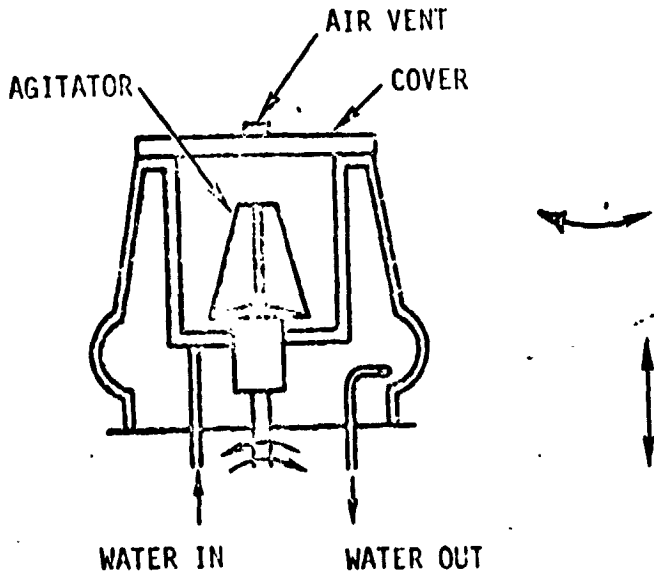
APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX  
 APPLIANCE FUNCTION: 3.3.1-GARMENT/LINEN/WASHING

COMPONENT TYPE	NUMBER OF COMPONENTS														NUMBER OF SAFETY CRITICAL ITEMS					
	APPLIANCE TYPE	NO.	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15		
			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		
NONDISPOSABLE CLOTHES			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
MECHANICAL OSCILLATION (pg. 21)			2	1	2	2	2	-	1	1	-	1	4	-	-	-	-	-	-	1
FLUIDIC AGITATION (pg. 24)			5	2	2	2	2	-	1	-	10	1	7	-	-	-	-	-	-	0
PISTON AGITATION (pg. 27)			2	1	2	2	2	-	1	-	-	1	4	-	-	-	-	-	-	0
CYCLIC VALVE AND PUMP (pg. 29)			-	1	2	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	2	-	1	-	-	1	4	-	-	-	-	-	-	0
ULTRASONIC WASHER (pg. 38)			2	1	2	2	2	-	1	-	-	-	4	-	-	-	1	1	-	1
MANUAL WASHBOARD (pg. 41)			2	1	2	2	2	-	1	-	-	-	4	-	-	-	-	-	-	0
PLAIN RECIRCULATION (pg. 45)			1	1	2	2	2	-	1	-	-	1	3	-	-	-	-	-	-	0

SPACECRAFT Space Station  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen 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.



CONCEPT Mechanical ventilation  
 (Ref. # 92 p. 120)

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.2.1.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑥
<u>Valving</u>		<u>0</u>	<u>55</u>	<u>0</u>	<u>0</u>			
<u>Pump</u>		<u>1</u>	<u>20</u>	<u>20</u>				
<u>Agitation motor</u>		<u>1</u>	<u>150</u>	<u>150</u>				
			<u>225</u>			<u>0</u>		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Water heat loss (40°F)</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	<u>0</u>
<u>Pump</u>	<u>0</u>	<u>68</u>	<u>19</u>	<u>0</u>
<u>Agitation motor</u>	<u>0</u>	<u>512</u>	<u>512</u>	<u>0</u>
<b>TOTAL</b>	<u>0</u>	<u>1459 (40°F)</u>	<u>1459 (40°F)</u>	<u>0</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT 1. Local Station

INDEX NUMBER 3.3.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>Basic cabinet</u>		<u>85</u>	<u>10</u>
<u>Accessories</u>		<u>40</u>	<u>3.6</u>
<u>Power cord</u>		<u>4</u>	
<u>Valves</u>		<u>6</u>	
<u>Video printer</u>		<u>3</u>	
<u>Yoke</u>		<u>67</u>	
<u>Miscellaneous</u>			<u>2.8</u>
TOTAL		<u>90.7 (41.5)</u> KG (LBS)	<u>0.493 (17.4)</u> M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	②	③	④	⑤
		WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	WT/CYCLE ① X ② (LB)	VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	VOL/CYCLE ① X ④ (FT <sup>3</sup> )
<u>Integrity/Germicide</u>	<u>1</u>	<u>.055 (.055)</u>	<u>.055</u>	<u>.019 (.019)</u>	<u>.019</u>
			Σ ③	Σ ④	
			TOTAL WT/CYCLE (LB)	TOTAL VOL/CYCLE (FT <sup>3</sup> )	
TOTAL WT. MISSION	<u>2</u> CYCLES/DAY	<u>104</u> DAYS/MISSION	<u>.066</u> TOT. WT/CYCLE (LB)	<u>11.0</u> KG (LB)	<u>(24.3)</u>
TOTAL VOL. MISSION	<u>2</u> CYCLES/DAY	<u>104</u> DAYS/MISSION	<u>.019</u> TOT. VOL/CYCLE (FT <sup>3</sup> )	<u>6.03</u> M <sup>3</sup> (FT <sup>3</sup> )	<u>(0.7)</u>

GAS/LIQUID EXPENDABLES REQUIREMENTS

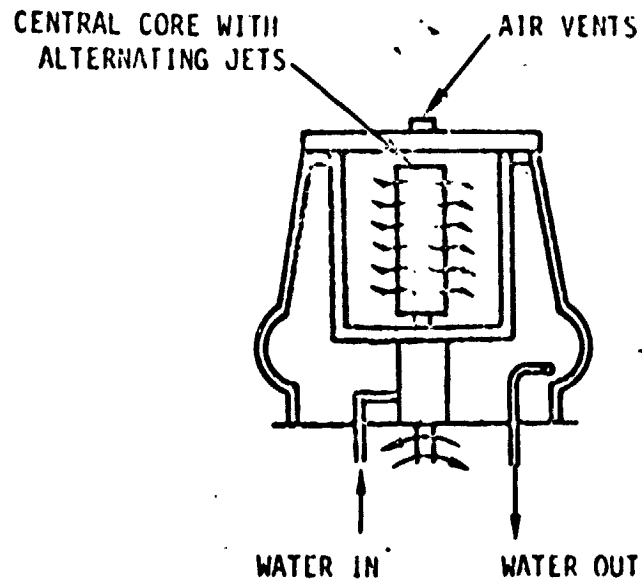
TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③	④
			AMT. RECOVERED/CYCLE ① X ② (LB)	AMT. LOST/CYCLE ① - ③ (LB)
<u>Wash water</u>	<u>55</u>	<u>.9991</u>		<u>.0405</u>
<u>Rinse water</u>	<u>55</u>	<u>1000</u>		<u>0</u>
			Σ ③	Σ ④
			TOTAL	
TOTAL WT. MISSION	<u>2</u> CYCLES/DAY	<u>104</u> DAYS/MISSION	<u>.0495</u> TOTAL (LB)	<u>58.2</u> KG (LB)



SPACECRAFT Space Station  
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.



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Electric Appliance  
(Ref. # 90, 26.1)

INDEX NUMBER 21112

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	A C P O W E R			D C P O W E R		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑦
<u>Vehicle</u>		0	55	0				
<u>Pump</u>		1	20	30				
<u>Ignition motor</u>		1	150	150				
			<u>277</u>			<u>0</u>		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Water, head loss (4400)</u>	0	4400	4400	0
<u>Pump</u>	0	100	100	0
<u>Ignition motor</u>	0	500	500	0
TOTAL	0	<u>1471 (500)</u>	<u>1471 (500)</u>	0
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

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OPERATIONAL PENALTIES

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

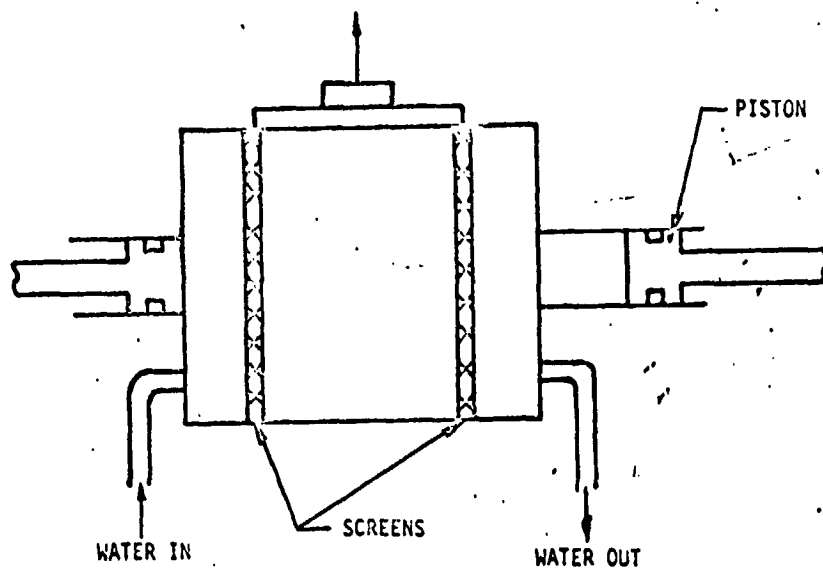


SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washing  
 APPLIANCE CONCEPT NO./TITLE 3/Piston Agitation  
 INDEX NO. 3.3.1.3 REF. NO. 90

## 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 1.36 kg (3.0 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 0.456 kg (1.0 lb) of water, and this washer concept has 1.36 kg (3.0 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 washer concept.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT W. Wash Cycle  
(Ref #90 p 27,28)

INDEX NUMBER 2.2.1.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Electric motor		70	10
2 Actuators		40	2.6
Valves		6	
Water separator		2	
Pump		4	
Packaging		60	
Miscellaneous			4.7
TOTAL		83.0 (40.3)	0.52 (10.4)
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

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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> )
Detergent / Germicide	1	.055 (.0663)	.066	.0016 (.0019)	.0019
Σ ③			.066 TOTAL WT/CYCLE (LB)	Σ ⑤	
TOTAL WT. MISSION =		2	184	0.066	11.0 (24.3)
		CYCLES/DAY	DAYS/MISSION	TOT. WT/CYCLE (LB)	KG (LB)
TOTAL VOL. MISSION =		2	184	0.0019	0.020 (0.7)
		CYCLES/DAY	DAYS/MISSION	TOT. VOL/CYCLE (FT <sup>3</sup> )	M <sup>3</sup> (FT <sup>3</sup> )

GAS/LIQUID EXPENDABLES REQUIREMENTS

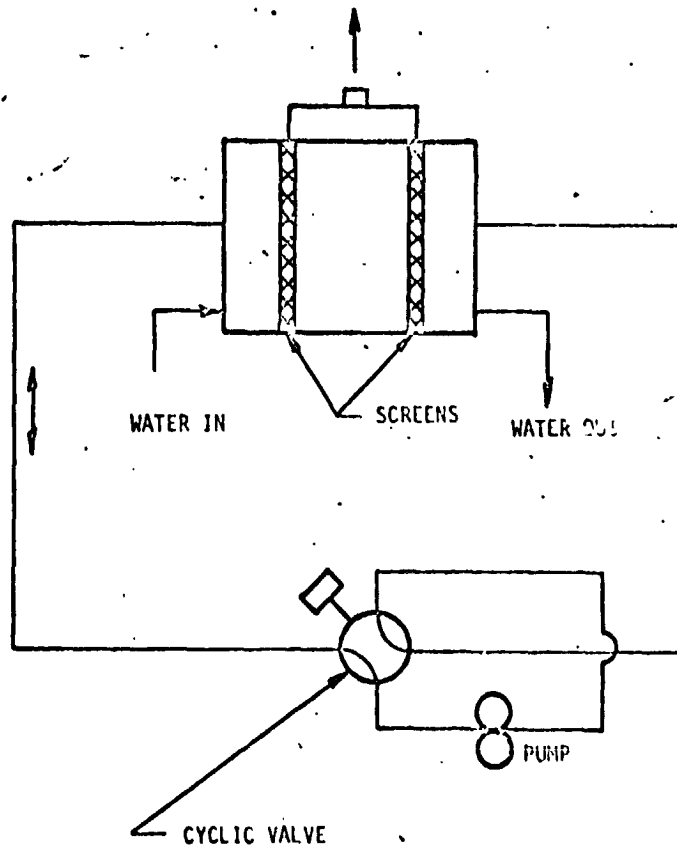
TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE (① x ②) (LB)	④ AMT. LOST/CYCLE (① - ③) (LB)	
Wash water	55	.9991		.0495	
Rinse water	55	.0009		0	
Σ ④				.0495	
TOTAL WT. MISSION =		2	184	0.0495	58.2 (127.0)
		CYCLE/DAY	DAYS/MISSION	TOTAL LOST/CYCLE (LB)	KG (LB)

SPACECRAFT Space Station  
 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 #4 (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 #4, and again 1.36 kg (3.0 lb) additional water was assumed to require drying. This was handled in the same manner as was explained in concept #4; 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.







APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT C. H. ...

INDEX NUMBER 3.3.1.4

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>...</u>		<u>7.2</u>	<u>1.0</u>
<u>...</u>		<u>4.0</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>4.0</u>
<u>...</u>		<u>...</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>...</u>
<u>...</u>		<u>...</u>	<u>...</u>
<b>TOTAL</b>		<b>87.1 (14.2)</b>	<b>0.52 (1.5)</b>
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (LB)	③ WT/CYCLE (① x ②) (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (FT <sup>3</sup> )	⑤ VOL/CYCLE (① x ④) (FT <sup>3</sup> )
<u>Detergent / Germicide</u>	<u>1</u>	<u>.055</u>	<u>.055</u>	<u>.0016</u>	<u>.0016</u>
<u>...</u>					
<u>...</u>					
<u>...</u>					
<u>...</u>					
<u>...</u>					
<b>TOTAL MISSION</b>	<u>2</u>	<u>1.1</u>	<u>.11</u>	<u>0.0032</u>	<u>.0032</u>
<b>TOTAL MISSION</b>	<u>2</u>	<u>1.1</u>	<u>.11</u>	<u>0.0032</u>	<u>.0032</u>

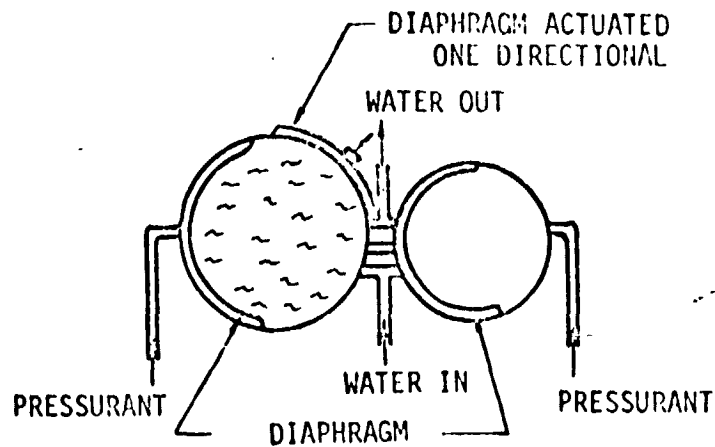
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
<u>...</u>	<u>55</u>	<u>.9991</u>	<u>54.86</u>	<u>.14</u>
<u>...</u>	<u>55</u>	<u>1.000</u>	<u>55.00</u>	<u>0</u>
<u>...</u>				
<u>...</u>				
<u>...</u>				
<b>TOTAL MISSION</b>	<u>110</u>	<u>.9991</u>	<u>109.9</u>	<u>.1</u>
<b>TOTAL MISSION</b>	<u>110</u>	<u>.9991</u>	<u>109.9</u>	<u>.1</u>

SPACECRAFT Space Station  
 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.



CONCEPT Diaphragm actuated - on demand system (see #90, 121-122) APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS INDEX NUMBER 27-1-1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① X ⑦
<u>Valve</u>		<u>0</u>	<u>55</u>					
<u>Pump</u>		<u>1</u>	<u>20</u>					
			<u>75</u>			<u>0</u>		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Water heat loss (WHL)</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	<u>0</u>
<u>Pump</u>	<u>0</u>	<u>65</u>	<u>65</u>	<u>0</u>
TOTAL	<u>0</u>	<u>1309 (4400)</u>	<u>1309 (4400)</u>	<u>0</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Drydown - one day

INDEX NUMBER 2-1-5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
TOTAL		<b>47.2 (15.0)</b> KG (LBS)	<b>0.42 (11.0)</b> M <sup>3</sup> (FT <sup>3</sup> )

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	③ WT/CYCLE 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> )	
Detonated/	1	0.55	0.55	0.019	0.019	
Germinants						
Σ ③			0.55	Σ ⑤		0.019
TOTAL WT MISSION			2	TOTAL VOL MISSION		2
CYCLES/DAY		180	DAYS/MISSION	TOT. WT/CYCLE (LB)		TOT. VOL/CYCLE (FT <sup>3</sup> )
x		x	x	11.0 (2.72)		0.038 (1.0)

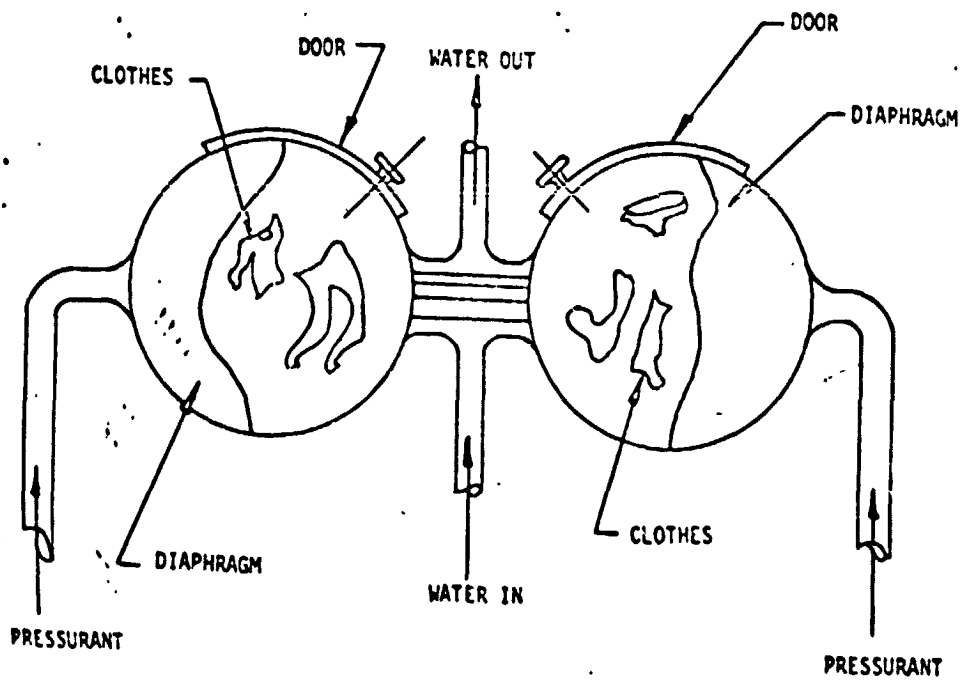
GAS/LIQUID EXPENDABLES REQUIREMENTS

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	55	0.29	15.75	39.25	
Pine	55	1.00	55	0	
Ammonia	6.3	0	0	6.3	
Σ ①		111.3	Σ ④		39.25
TOTAL WT MISSION		2	TOTAL WT MISSION		2
CYCLE/DAY		180	DAYS/MISSION		129
x		x	110.0		109 (240)

SPACECRAFT Space Station  
 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEP: *Proposed pump structure for two directional control valves*  
 (Ref. # 9: p. 2/3, 3)  
 INDEX NUMBER: *2, 2, 1, 6.*

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① X ⑤
<i>Valves</i>		<i>0</i>	<i>55</i>					
<i>Pump</i>		<i>1</i>	<i>20</i>					
			<i>75</i>			<i>0</i>		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<i>Water heat pump (4400)</i>	<i>0</i>	<i>4400</i>	<i>4400</i>	<i>0</i>
<i>Pump</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
TOTAL	<i>0</i>	<i>1309 (4400)</i>	<i>1309 (4400)</i>	<i>0</i>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT *Dehydration - low directional*

INDEX NUMBER *2, 4, 1, 6*

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<i>Basic number</i>	<i>2</i>	<i>2.0</i>
<i>1</i>	<i>7</i>	
<i>2</i>	<i>40</i>	
<i>Volume</i>	<i>1</i>	
<i>1</i>	<i>2</i>	
<i>4</i>	<i>4</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<i>2</i>	<i>2</i>	
<b>TOTAL</b>	<b>63.1 (12.1)</b>	<b>0.40 (14.5)</b>
	KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	②	③	④	⑤
		WT/UNIT (REF) (PKG.WT/UNIT)(REF) (LB)	WT/CYCLE ① X ② (LB)	VOL/UNIT (REF) (PKG.VOL/UNIT)(REF) (FT <sup>3</sup> )	VOL/CYCLE ① X ④ (FT <sup>3</sup> )
<i>Decontam/Germicide</i>	<i>1</i>	<i>0.55 (2.2)</i>	<i>0.66</i>	<i>0.016 (0.062)</i>	<i>0.019</i>
			<b>Σ ③</b>		<b>Σ ⑤</b>
			<i>0.66</i> TOTAL WT/CYCLE (LB)		<i>0.019</i> TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	<i>2</i> CYCLES/DAY	<i>104</i> DAYS/MISSION	<i>0.66</i> TOT. WT/CYCLE (LB)		<i>11.0</i> KG (LB) <i>(2.2)</i>
TOTAL VOL. MISSION	<i>2</i> CYCLES/DAY	<i>104</i> DAYS/MISSION	<i>0.019</i> TOT. VOL/CYCLE (FT <sup>3</sup> )		<i>0.020</i> M <sup>3</sup> (FT <sup>3</sup> ) <i>(0.7)</i>

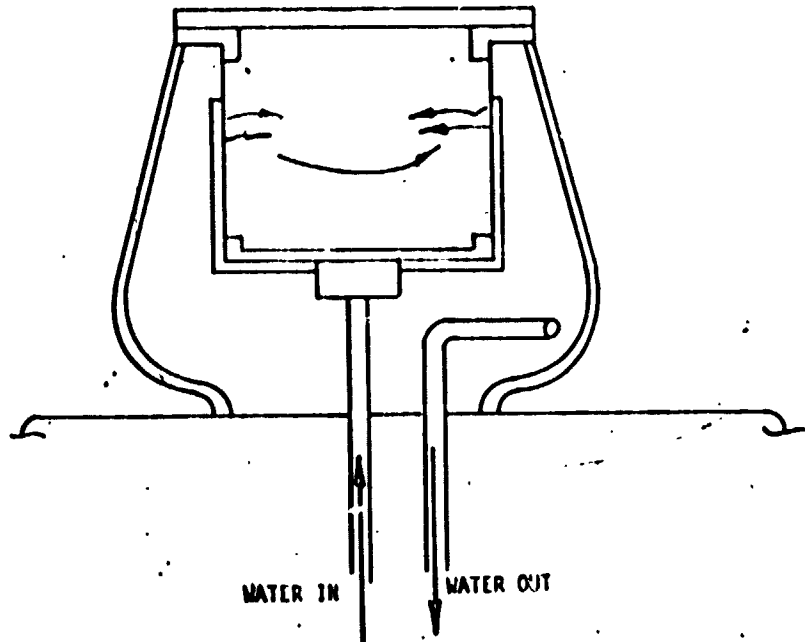
GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③	④
			AMT. RECOVERED/CYCLE ① X ② (LB)	AMT. LOST/CYCLE ① - ③ (LB)
<i>Water</i>	<i>55</i>	<i>99.9</i>		<i>0.05</i>
<i>1</i>	<i>55</i>	<i>1.0</i>		<i>0</i>
<i>1/2</i>	<i>0.39</i>	<i>0</i>		<i>0.39</i>
			<b>Σ ③</b>	<b>Σ ④</b>
			<i>110.75</i>	<i>43.95</i>
TOTAL WT. MISSION	<i>2</i> CYCLE/DAY	<i>104</i> DAYS/MISSION	<i>43.95</i> TOTAL WT/CYCLE (LB) <b>Σ ③</b>	<i>162</i> (LB)
			<i>110.75</i> <b>Σ ①</b>	<i>124</i> KG (LB) <i>(2.7)</i>

SPACECRAFT Space Station  
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.







APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Water spray agitator

INDEX NUMBER 3.3.1.7

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT³)
<u>Plastic water</u>	<u>80</u>	<u>10.5</u>
<u>Pump</u>	<u>1</u>	<u></u>
<u>2 feet of pipe</u>	<u>1</u>	<u>2.6</u>
<u>Valve</u>	<u>1</u>	<u></u>
<u>Water agitator</u>	<u>1</u>	<u></u>
<u>Particulate</u>	<u>1.1</u>	<u></u>
<u>Aluminum</u>	<u></u>	<u>3.3</u>
<b>TOTAL</b>	<b>90.7 (4.1)</b>	<b>0.507 (0.01)</b>
	KG (LBS)	M³ (FT³)

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	③ WT/CYCLE ① x ② (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT³)	⑤ VOL/CYCLE ① x ④ (FT³)
<u>Tetrasol / Germicide</u>	<u>1</u>	<u>0.55 (0.01)</u>	<u>0.66</u>	<u>0.016 (0.001)</u>	<u>0.019</u>
<b>Σ ③</b>			<b>0.66</b>	<b>Σ ⑤</b>	
			TOTAL WT/CYCLE (LB)	TOTAL VOL/CYCLE (FT³)	
TOTAL WT. MISSION	<u>2</u> CYCLES/DAY	<u>104</u> DAYS/MISSION	<u>0.66</u> TOT. WT/CYCLE (LB)	<b>11.0 (24.3)</b> KG (LB)	
TOTAL VOL. MISSION	<u>2</u> CYCLES/DAY	<u>104</u> DAYS/MISSION	<u>0.019</u> TOT. VOL/CYCLE (FT³)	<b>0.020 (0.7)</b> M³ (FT³)	

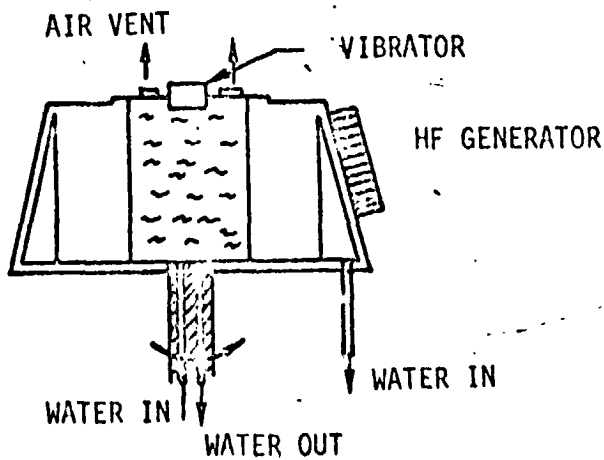
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
<u>Wash water</u>	<u>55</u>	<u>99%</u>		<u>0.495</u>
<u>River water</u>	<u>55</u>	<u>2.00</u>		<u>0</u>
<b>Σ ①</b>				<b>0.495</b>
				TOTAL LOST/CYCLE (LB)
TOTAL WT. MISSION	<u>2</u> CYCLE/DAY	<u>104</u> DAYS/MISSION	<u>0.495</u> TOTAL LOST/CYCLE (LB)	<b>58.2 (5.4)</b> KG (LB)

SPACECRAFT Space Station  
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 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT D/H/1110  
 (Ref #90425-40)

INDEX NUMBER 3.3.15

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑤
Pump		1	222					
Amplifier		1	1350					
RF generator		1	1200					
Voltage		0	15					
			1537			0		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Water heat loss (40°F)	0	4400	4400	0
Pump	0	100	100	0
Metro	0	512	512	0
RF generator	0	1110	1110	0
TOTAL	0	2172 (911.5)	2772 (911.5)	0
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

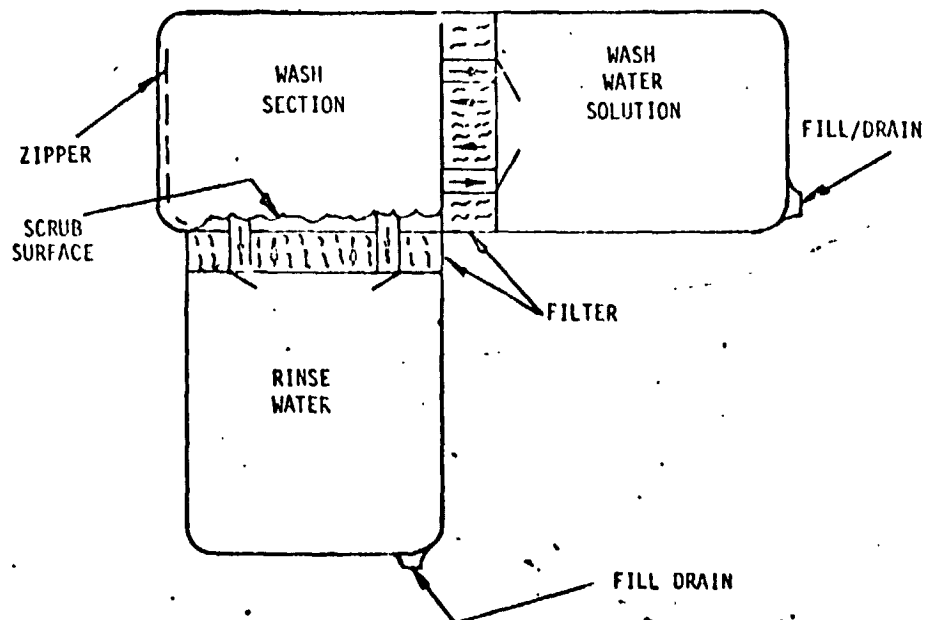
SOURCE	HEAT LEAK (BTU/HR)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL					
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)



SPACECRAFT Space Station  
 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 4.54 kg (10 lb) of wash and 4.54 kg (10 lb) of rinse water are required. It was estimated that 0.907 kg (2 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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Manual Washdown

INDEX NUMBER 3,2,1,9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Washer	10	2.0
Pump	4	0.5
Water Supply	4.5	
Valves	2	
Pipes	1.5	
Alloys		1.5
TOTAL	<b>23.6 (1.1)</b>	<b>0.204</b>

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SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE(REF)	② WT/UNIT (REF)	③ WT/CYCLE	④ VOL/UNIT (REF)	⑤ VOL/CYCLE
		(PKG. WT/UNIT)(REF) (LB)	① X ② (LB)	(PKG. VOL/UNIT)(REF) (FT <sup>3</sup> )	① X ⑤ (FT <sup>3</sup> )
Detergent/Germicide	1	0.55 (6.6)	0.66	0.016 (0.16)	0.019
		Σ ③	TOTAL WT/CYCLE (LB)	Σ ⑤	TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	2	1.14	2.32	11.0	0.038
TOTAL VOL. MISSION	2	1.14	2.32	0.076	0.076

GAS/LIQUID EXPENDABLES REQUIREMENTS

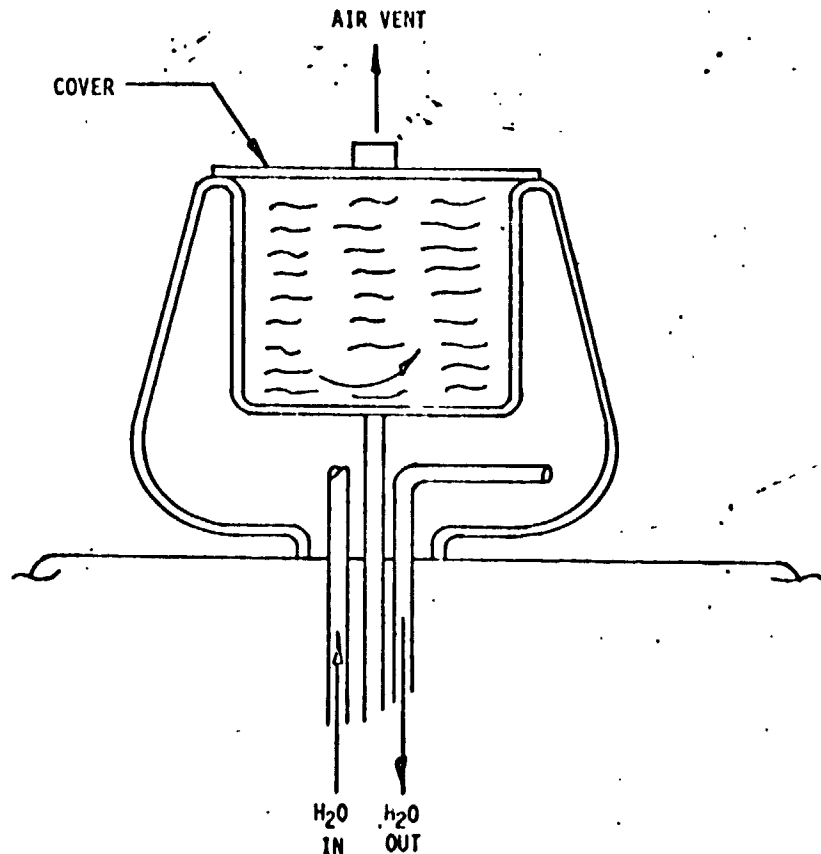
TYPE	① AMT. USED/CYCLE(REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE	④ AMT. LOST/CYCLE
			① X ② (LB)	① - ③ (LB)
Wash water	10	0.99	9.9	0.1
Rinse water	10	1.00	10.0	0
		Σ ④	Σ ④	Σ ④
TOTAL WT. MISSION	2	1.94	3.88	10.6



SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Washing  
 APPLIANCE CONCEPT NO./TITLE 10/Plan 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Plain reconstruction

INDEX NUMBER 2-1-1

(i.e. # 90 y 5/2)

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑤
<u>16 hrs</u>		<u>0</u>						
<u>Pump</u>		<u>1</u>						
<u>Motor</u>		<u>1</u>						
			<u>207</u>			<u>0</u>		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Building heat loss (16 hrs)</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	<u>0</u>
<u>Pump</u>	<u>0</u>	<u>109</u>	<u>109</u>	<u>0</u>
<u>Motor</u>	<u>0</u>	<u>11</u>	<u>11</u>	<u>0</u>
TOTAL	<u>0</u>	<u>1471 (500)</u>	<u>1471 (500)</u>	<u>0</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL - PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Phosphine

INDEX NUMBER 3.1.1.10

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>Phosphine</u>		<u>80</u>	<u>11.0</u>
<u>Booster</u>		<u>4</u>	<u>2.5</u>
<u>Canister</u>		<u>60</u>	
<u>Valve</u>		<u>1</u>	
<u>Wiring</u>		<u>1</u>	
<u>Probe</u>		<u>17</u>	
<u>Aluminum</u>		<u>1</u>	<u>2.5</u>
<u> </u>		<u> </u>	<u> </u>
<u> </u>		<u> </u>	<u> </u>
TOTAL		<u>190.7</u> (400) KG (LBS)	<u>0.51</u> (100) 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> )
<u>Detonator/Germicide</u>	<u>1</u>	<u>0.55 (1.00)</u>	<u>0.55</u>	<u>0.019 (0.017)</u>	<u>0.019</u>
<u> </u>					
<u> </u>					
<u> </u>					
		Σ ③	<u>0.55</u> TOTAL WT/CYCLE (LB)	Σ ⑤	<u>0.019</u> TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT MISSION	<u>2</u> CYCLES/DAY	<u>1.1</u> DAYS/MISSION	<u>0.55</u> TOT. WT/CYCLE (LB)	<u>11.0</u> KG (LB)	<u>0.038</u> M <sup>3</sup> (FT <sup>3</sup> )
TOTAL VOL MISSION	<u>2</u> CYCLES/DAY	<u>1.1</u> DAYS/MISSION	<u>0.019</u> TOT. VOL/CYCLE (FT <sup>3</sup> )	<u>0.020</u> M <sup>3</sup> (FT <sup>3</sup> )	<u>0.020</u> 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)
<u>Phosphine</u>	<u>110</u>	<u>0.8</u>	<u>88</u>	<u>22</u>
<u> </u>				
<u> </u>				
<u> </u>				
	Σ ①		Σ ③	<u>22</u>
TOTAL WT MISSION	<u>2</u> CYCLE/DAY	<u>1.1</u> DAYS/MISSION	<u>190.7</u> TOTAL WT/CYCLE (LB)	<u>44</u> KG (LB)

HABITABILITY SUBSYSTEM 3.0 Housekeeping

HABITABILITY FUNCTION 3.3 Garment/Linen Maintenance

APPLIANCE FUNCTION 3.3.2 Garment/Linen Drying

NUMBER 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.

A ground rule of two clothes washings/dryings per day was assumed from Reference 273. For this condition, and assuming a six-man Space Station crew, a detailed study of Space Station clothing usage (Reference 245) has shown a maximum laundry load of 1.66 kg (3.68 lbs). Since the clothes dryer load assumed in Reference 90 is only slightly larger than this, or 1.81 kg (4.0 lbs), the data from that reference were used directly without adjusting.

The dryers were assumed to remove 0.454 kg (1.0 lb) of residual water from the clothes, as specified in Reference 90. More testing is required to refine this assumption; however, data from Reference 202 indicate this amount of water may be too high. 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 and the Space Station system requirement in Reference 273, a drying time of 4 hours was assumed for these cases. 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 0000 GARMENT/LINEN DRYING (SPACE STATION)

CONCEPT USAGE CONSUMABLES AND FLOW REQUIREMENTS THERMAL REQTS ELEC PER REQTS WT/VOL REQTS DEVELOPMENT RESUPPLY  
NO. TIME

CONCEPT NO.	USAGE TIME	ARTS	TYPE	USED	FLOOR	PRESS	TEMP	COOLANT	MT LEAK	AC	PK PER	AVG PER	AC	DC	WT/VOL	REQTS	DEVELOPMENT	RESUPPLY	COST
1	2.000							199.	104.	72.0	0.0	0.0	0.0	0.0	36.3	0.50	2	30	0.0
	0.000							(.75)	(.363)	227.0	0.0	0.0	0.0	0.0	(.80)	(.17)			(.0)
2	2.000							328.	151.	93.0	0.0	0.0	0.0	0.0	81.6	0.64	3	65	0.0
	0.000							(.112)	(.515)	0.0	0.0	0.0	0.0	0.0	(.18)	(.227)			(.0)
3	2.000							0.	95.	137.0	0.0	0.0	0.0	0.0	214.0	0.95	3	60	131.2
	0.000							(.0)	(.325)	0.0	0.0	0.0	0.0	(.471)	(.337)			(.289)	
4	2.000							86.	95.	137.0	0.0	0.0	0.0	0.0	34.9	0.51	3	60	0.0
	0.000							(.300)	(.325)	101.0	0.0	0.0	0.0	0.0	(.77)	(.17)			(.0)
5	2.000							0.	0.	55.0	0.0	0.0	0.0	212.7	0.61	2	30	152.9	
	3.175							(.0)	(.0)	0.0	0.0	0.0	0.0	(.46)	(.315)			(.315)	
6	2.000							0.	13.	55.0	0.0	0.0	0.0	219.5	0.64	2	35	142.9	
	0.000							(.0)	(.45)	90.0	0.0	0.0	0.0	(.84)	(.225)			(.315)	
7	2.000							0.	13.	55.0	0.0	0.0	0.0	226.2	0.68	3	70	142.9	
	0.000							(.0)	(.157)	0.0	0.0	0.0	0.0	(.50)	(.130)			(.0)	
8	2.000							0.	25.	3.0	0.0	0.0	0.0	18.1	3.96	1	10	0.0	
	0.000							(.0)	(.83)	256.0	0.0	0.0	0.0	(.40)	(.150)			(.0)	

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- (\*) 1 - CABIN AIR (CIRCULATED) • LITERS/SEC (FT<sup>3</sup>/MIN)
- 2 - CABIN AIR (LOST) • LB/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 - FRESH (CIRCULATED) • KG/HR (LB/HR)
- 9 - WATER (PROCESSED) • KG/HR (LB/HR)

(\*\*\*) COST INDICATOR

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

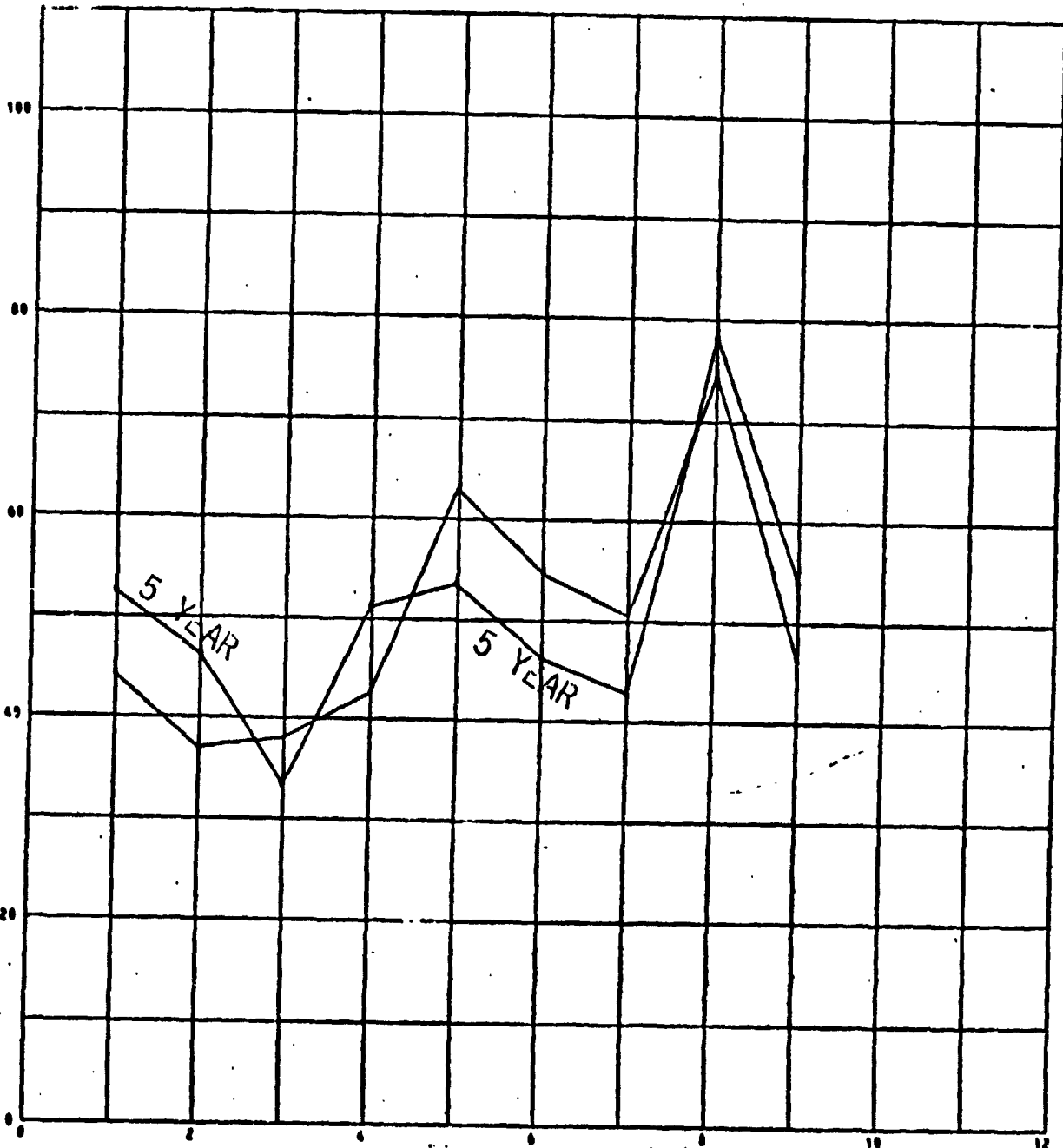
APPLIANCE CONCEPT NO.	CONCEPT NAME
1	FORCED HOT AIR-ELECTRIC
2	FORCED HOT AIR-HEAT FROM THERMAL STORAGE UNIT
3	FORCED COLD DRY AIR-DESICCANT/VACUUM REGENERABLE
4	FORCED COLD DRY AIR-DESICCANT/ELECTRIC HEAT REGENERABLE
5	VACUUM DRY
6	THERMAL VACUUM DRY-ELECTRIC HEAT
7	THERMAL VACUUM DRY-THERMAL STORAGE/RADIANT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

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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



RADIANT HEAT

CONCEPT NUMBER

L-3

NUMBER OF DAYS = 180.0 ( .99 YEARS)  
 USES MOD SUBROUTINE 2  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUH) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUH) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX (GARMEN/TINEN DRYING TSPACE STATION)  
 104/13/751

FACTOR	MIN VALUE	MAX VALUE	PTS	C O N C E P T									
				1	2	3	4	5	6	7	8	9	
WEIGHT	40.000	999.00	15	12.60	9.59	.82	12.69	.90	.45	.00	13.50	13.80	
POWER	4.9700	185.28	15	.00	9.65	7.13	2.29	11.84	7.53	11.84	14.60	2.58	
VOLUME	17.600	140.00	10	8.74	8.38	7.59	8.72	8.46	8.39	8.28	.71	.00	
THERMAL	.00000	126.70	15	5.16	.00	10.06	8.14	15.00	14.32	14.32	12.62	1.59	
RELIAB-Y	.96514	.99631	5	.67	.82	.83	.48	4.47	4.13	4.29	.00	2.28	
MAINTENC	.99999	1.00000	5	.20	.27	.39	.00	4.33	4.17	4.25	2.87	2.71	
SAFETY	.00000	2.0000	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	37.60	31.46	32.30	36.13	53.58	46.49	42.97	63.23	39.14	
RATING	100.000	100.00	100	44.24	37.01	38.00	42.51	63.04	54.70	50.56	74.38	46.05	

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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	44.24	37.01	38.00	42.51	63.04	54.70	50.56	74.38	46.05
WEIGHT	47.46	39.19	35.36	45.92	58.41	50.50	46.46	75.65	49.77
POWER	40.65	39.23	38.77	40.30	44.32	44.33	52.86	76.24	43.71
VOLUME	46.64	39.61	40.10	44.99	64.24	56.32	52.35	70.65	43.49
THERMAL	43.44	34.01	40.36	43.46	66.03	58.00	54.20	75.17	43.17
RELIAB-Y	43.36	36.42	37.38	41.57	63.79	55.49	51.56	72.26	46.03
MAINTENC	43.09	36.11	37.14	41.29	63.71	55.52	51.54	73.90	46.28
SAFETY	43.93	36.90	38.82	42.25	61.24	53.13	49.11	75.11	46.63
DEV COST	45.29	34.59	36.07	40.22	62.56	54.32	46.46	75.68	49.26

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	44.24	37.01	38.00	42.51	63.04	54.70	50.56	74.38	46.05
WEIGHT	40.39	34.40	41.14	38.44	68.55	59.70	55.45	72.87	41.60
POWER	48.52	34.36	37.08	45.14	61.50	55.13	47.81	72.16	48.84
VOLUME	41.54	34.08	35.63	39.72	61.69	52.87	48.54	78.59	48.92
THERMAL	45.19	40.59	35.18	41.37	59.46	50.75	46.21	73.44	49.48
RELIAB-Y	45.17	37.63	38.65	43.50	62.24	53.85	49.49	76.64	46.06
MAINTENC	45.46	37.96	38.91	43.80	62.32	53.83	49.52	74.90	45.80
SAFETY	44.57	37.12	37.13	42.79	64.95	56.35	52.09	73.61	45.42
DEV COST	42.99	39.90	40.29	45.24	63.61	55.15	55.45	72.60	42.21

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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	52.51	46.35	33.41	51.06	53.50	46.37	42.87	78.23	53.94
WEIGHT	54.71	47.58	31.47	53.40	50.19	43.35	39.88	79.05	56.59
POWER	48.85	47.61	34.40	48.57	55.28	46.64	45.39	79.56	51.38
VOLUME	54.18	48.13	35.44	52.79	54.98	48.16	44.77	74.84	51.37
THERMAL	51.25	43.12	35.76	51.29	56.75	49.80	46.54	78.64	50.91
RELIAB-Y	51.51	45.57	32.95	50.02	54.34	47.20	43.87	76.32	53.64
MAINTENC	51.33	45.35	32.79	49.82	54.31	47.28	43.90	77.72	53.95
SAFETY	52.05	46.03	34.23	50.63	52.20	45.24	41.83	78.76	54.25
DEV COST	52.84	43.61	32.08	48.50	53.76	46.62	39.88	79.25	56.16
REC COST	55.93	50.09	31.65	54.98	49.77	43.14	39.88	79.74	57.15

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	52.51	46.35	33.41	51.06	53.50	46.37	42.87	78.23	53.94
WEIGHT	49.96	44.92	35.68	48.35	57.35	49.89	46.35	77.27	50.85
POWER	56.77	44.89	32.27	53.97	51.44	46.06	39.95	76.68	56.92
VOLUME	50.68	44.38	31.18	49.16	51.86	44.40	40.77	81.97	56.78
THERMAL	53.98	50.11	30.68	50.80	49.73	42.39	38.61	77.75	57.45
RELIAB-Y	53.56	47.17	33.90	52.16	52.62	45.50	41.82	80.23	54.26
MAINTENC	53.76	47.40	34.07	52.37	52.65	45.42	41.79	78.76	53.93
SAFETY	53.00	46.68	32.56	51.52	54.87	47.56	43.97	77.67	53.61
DEV COST	52.14	49.53	34.97	54.05	53.21	46.08	46.35	77.04	51.36
REC COST	48.66	42.00	35.46	47.10	57.84	50.13	46.35	76.46	50.20

NUMBER OF DAYS = 1826.0 (5.00 YEARS)  
 USES MOD SUBROUTINE 2  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0590  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX (04/16/75)  
 GARMENY/LINEN DRYING (SPACE STATION)

FACTOR	MIN VALUE	MAX VALUE	PTS	C O N C E P T								
				1	2	3	4	5	6	7	8	9
WEIGHT	90.000	999.00	15	12.60	9.59	.82	12.69	.90	.45	.00	13.50	13.80
POWER	4.9700	185.28	15	.00	9.65	7.13	2.29	11.84	7.53	11.84	14.60	2.58
VOLUME	17.600	140.00	10	8.74	8.38	7.59	8.72	8.46	8.39	8.28	.71	.00
THERMAL	.00000	126.40	15	5.14	.00	10.06	8.14	15.00	14.32	14.32	12.62	1.59
RELIAB-Y	.69772	.96324	5	.58	.72	.72	.42	4.39	4.01	4.18	.00	2.08
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	.00000	70.000	15	8.57	1.07	2.14	2.14	8.57	7.50	.00	13.93	12.86
REC COST	.00000	315.00	15	15.00	15.00	1.23	15.00	.00	.00	.00	15.00	15.00
TOTAL PT	.00000	100.00	100	52.51	46.35	33.41	51.06	53.50	46.37	42.87	78.23	53.94
RATING	.00000	100.00	100	52.51	46.35	33.41	51.06	53.50	46.37	42.87	78.23	53.94

D2-118561-5

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

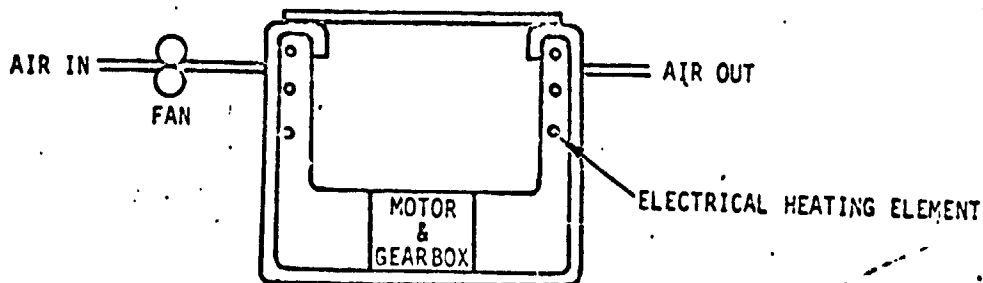
APPLIANCE FUNCTION: 3.3.2-GARMENT/LINEN DRYING

COMPONENT TYPE	NUMBER OF COMPONENTS													NUMBER OF SAFETY CRITICAL ITEMS		
	MOTOR	ACCUMULATOR	WATER SEPARATOR	HEAT EXCHANGER	DC HEATER	BLOWER AIR	FILTER	TRANSMISSION (GEAR BOX)	CONTROLLER TIMER	THERMAL STORAGE UNIT	VALVE	DESICCANT CANISTER				
APPLIANCE TYPE	NO.	④	⑥	⑫	⑬	⑱	⑨	⑦	⑲	⑳	③	⑫	○	○	○	○
FORCED HOT AIR-ELECTRIC (pg. 51)	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	-	-	-	-	-	2
FORCED COLD DRY AIR-DESICCANT-VACUUM REGENERABLE (pg. 58)	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	-	-	-	2
VACUUM DRY (pg. 64)	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-	3
THERMAL VACUUM DRY-ELECTRIC HEAT (pg. 66)	-	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	-	-	-	-	-	-	-	-	-	0
CLOTHES LINE-FORCED CONVECTION + ELECTRIC HEAT (pg. 74)	-	-	1	1	1	1	-	-	-	-	-	-	-	-	-	1

SPACECRAFT Space StationHABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen MaintenanceAPPLIANCE FUNCTION Garment/Linen DryingAPPLIANCE CONCEPT NO./TITLE 1/Forced Hot Air - ElectricINDEX 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT Low cost hot air electric INDEX NUMBER 3.3.2.1  
 (Ref # 90 p. 51-54)

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	A.C. POWER			D.C. POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)
Motor		4	62				
Fan		4	10				
Heater		4				227	
			72			227	
			MAXIMUM		TOTAL	MAXIMUM	TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
Motor	0	217	217	0
Fan	0	26	26	0
Heater/Heater	265	527	117	175
TOTAL	77.6 (265)	226 (775)	106 (265)	198 (675)
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

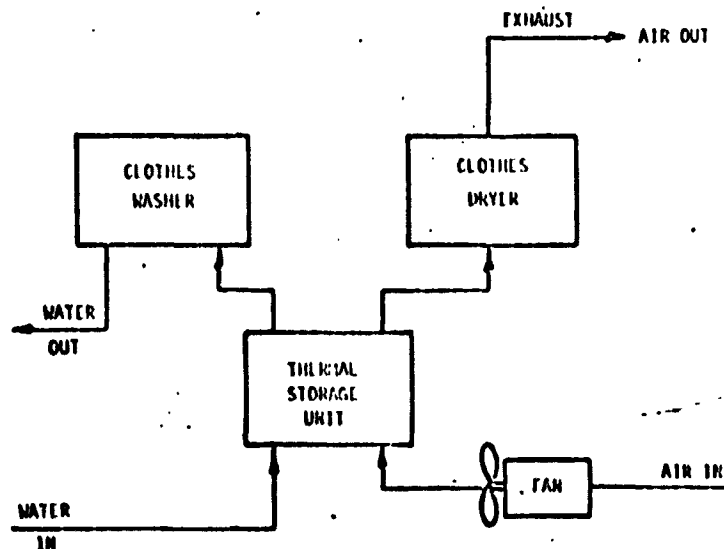
SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT³/MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M³/MISSION (FT³/MISSION)



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





D2-118561-5

CONCEPT Fixed Hot Air Thermal Storage APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

INDEX NUMBER 3.3.2.2

(Ref. #901 15-37)

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER			DC POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)
<u>Motors</u>		<u>4</u>	<u>60</u>				
<u>Fans</u>		<u>4</u>	<u>31</u>				
			<u>92</u>		<u>0</u>		
			MAXIMUM	TOTAL	MAXIMUM	TOTAL	

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Motors</u>	<u>0</u>	<u>212</u>	<u>212</u>	<u>0</u>
<u>Fans</u>	<u>0</u>	<u>105</u>	<u>105</u>	<u>0</u>
<u>Wiring / Thermal storage</u>	<u>265</u>	<u>1053</u>	<u>198</u>	<u>11</u>
<b>TOTAL</b>	<b><u>27.6</u></b>	<b><u>401</u></b>	<b><u>151</u></b>	<b><u>328</u></b>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Fixed Heat ex - thermal storage  
(see # 118561-4)

INDEX NUMBER 7.7 2.2

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
TOTAL		81.6 (144) KG (LBS)	0.64 (20.7) 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> )
N/A					
		Σ ②	Σ ③ TOTAL WT/CYCLE (LB)		Σ ⑤ TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION					
CYCLES/DAY	X	DAYS/MISSION	X	TOT. WT/CYCLE (LB)	
					KG (LB)
TOTAL VOL MISSION					
CYCLES/DAY	X	DAYS/MISSION	X	TOT. VOL/CYCLE (FT <sup>3</sup> )	
					M <sup>3</sup> (FT <sup>3</sup> )

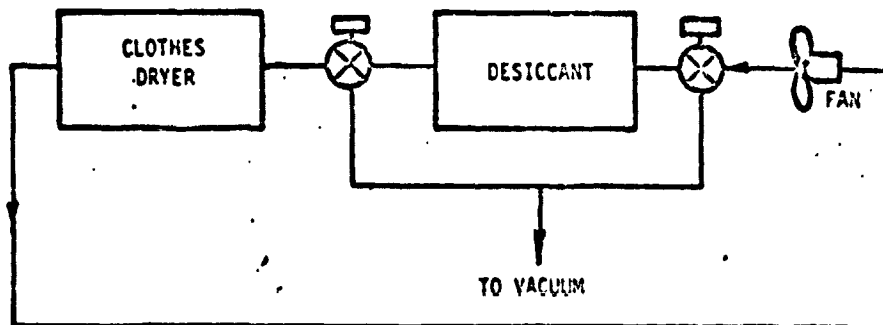
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
N/A				
	Σ ①		Σ ③	Σ ④
TOTAL WT. MISSION				
CYCLE/DAY	X	DAYS/MISSION	X	TOTAL LOST/CYCLE (LB)
				KG (LB)

SPACECRAFT Space Station  
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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Fixed cold dry air - dehumid - vacuum recoverable  
(Ref. #90 p 25-60)

INDEX NUMBER 3, 3, 2, 3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT³)
Dryer		40	
Dehumidifier		30	
Seal		40	
Valves		2	
TOTAL		32.7	0.55

ORIGINAL PAGE OF POOR QUALITY

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) (FT³)	⑤ VOL/CYCLE (① x ④) (FT³)
N/A					
			Σ ③		Σ ⑤

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

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

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LB)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE (① x ②) (LB)	④ AMT. LOST/CYCLE (① - ③) (LB)
Air lost to space	0.0046			
Water lost to space	0.80			
			Σ ③	Σ ④

TOTAL WT. MISSION =  $\frac{2}{\text{CYCLE/DAY}} \times \frac{184}{\text{DAYS/MISSION}} \times \frac{134}{\text{TOTAL LOST/CYCLE (LB)}} = 134 (296) \text{ KG (LB)}$

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

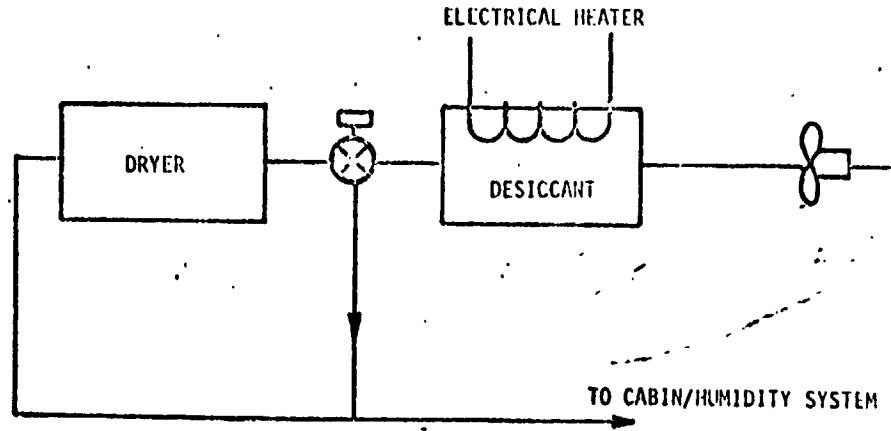
APPLIANCE FUNCTION Garment/Linen Drying

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.



CONCEPT Finned coil dry air - desiccant - heat regenerative (Ref. #90 p. 61-64) APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS INDEX NUMBER 7.2.2.4

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑤
<u>Valves</u>		<u>0</u>	<u>55</u>					
<u>Motor</u>		<u>4</u>	<u>62</u>					
<u>Fan</u>		<u>8</u>	<u>20</u>					
<u>Heater</u>		<u>4</u>				<u>101</u>		
			<u>137</u>			<u>101</u>		
			MAXIMUM	TOTAL		MAXIMUM	TOTAL	

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>Motor</u>	<u>0</u>	<u>212</u>	<u>212</u>	<u>0</u>
<u>Fan</u>	<u>0</u>	<u>68</u>	<u>68</u>	<u>0</u>
<u>Heater</u>	<u>0</u>	<u>80</u>	<u>45</u>	<u>0</u>
<b>TOTAL</b>	<u>77.6 (265)</u>	<u>105 (300)</u>	<u>95 (115)</u>	<u>88 (300)</u>
		WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Fixed bed (dry air - dehumid - heat regenerable)  
(Ref. # 90 p 61-62)

INDEX NUMBER 3,3,2,4

**FIXED WEIGHT/VOLUME REQUIREMENTS**

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Drum		40	
Beams	bed	20	
		10	
		5	
TOTAL		<b>34.9 (17.9)</b> KG (LBS)	<b>0.51 (17.9)</b> 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> )
N/A					
			Σ ③		Σ ⑤

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

TOTAL VOL. MISSION =                      CYCLES/DAY x                      DAYS/MISSION x                      TOT. VOL./CYCLE (FT<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)
N/A				
			Σ ③	Σ ④

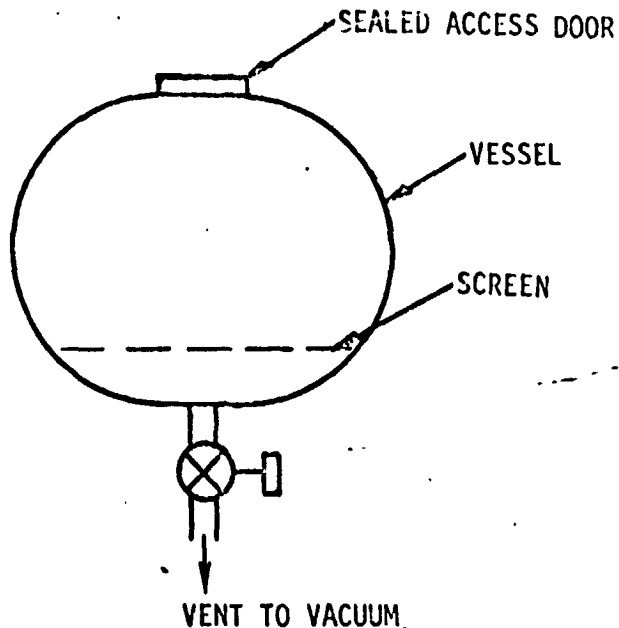
TOTAL WT. MISSION =                      CYCLE/DAY x                      DAYS/MISSION x                      TOTAL LOST/CYCLE (LB) =                      KG (LB)



SPACECRAFT Space Station  
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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS

CONCEPT Vacuum dry  
(Ref. # 90 p 61, 65)

INDEX NUMBER 2.3.2.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER			DC POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)
<u>Values</u>		<u>0</u>	<u>55</u>				
			<u>55</u>		<u>0</u>		
			MAXIMUM	TOTAL	MAXIMUM	TOTAL	

THERMAL REQUIREMENTS

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

OPERATIONAL PENALTIES

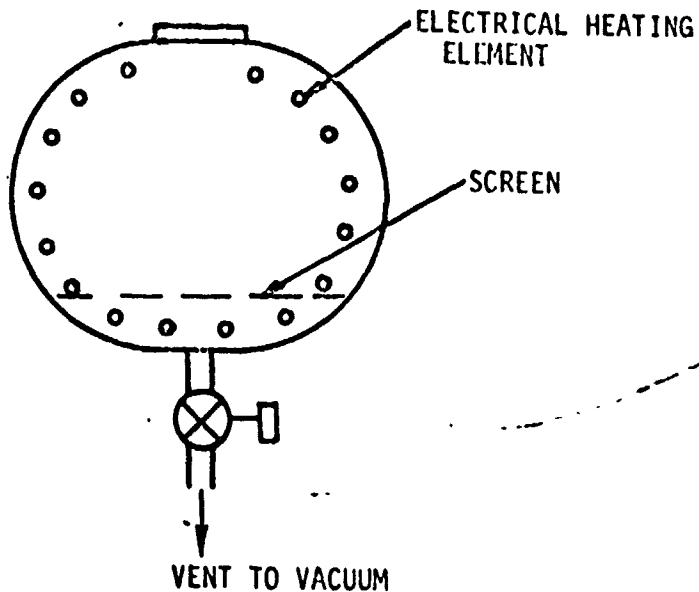
SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>Tankage due to lost air, water</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>106</u>	<u>9.8</u>
TOTAL				<u>48.1 (106)</u>	<u>0.278 (9.8)</u>
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	FT <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)



SPACECRAFT Space Station  
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.





D2-118561-5

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT Thermal vacuum dry-electric

INDEX NUMBER 3,3,2.6

**FIXED WEIGHT/VOLUME REQUIREMENTS**

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Dryer		55	8
Valve		1	
TOTAL		<b>25.4 (56)</b> KG (LBS)	<b>0.23 (8)</b> M <sup>3</sup> (FT <sup>3</sup> )

**SOLID EXPENDABLE WT/VOL REQUIREMENTS**

TYPE	UNITS/CYCLE (REF)	WT/UNIT (REF) (PKG. WT/UNIT)(REF) (LB)	WT/CYCLE (1 X 2) (LB)	VOL/UNIT (REF) (PKG. VOL/UNIT)(REF) (FT <sup>3</sup> )	VOL/CYCLE (1 X 4) (FT <sup>3</sup> )
<u>N/A</u>					
			$\Sigma$ (3)		$\Sigma$ (5)
			TOTAL WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	--- CYCLES/DAY --- X	--- DAYS/MISSION --- X	TOT. WT/CYCLE (LB)		--- KG (LB) ---
TOTAL VOL. MISSION	--- CYCLES/DAY --- X	--- DAYS/MISSION --- X	TOT. VOL/CYCLE (FT <sup>3</sup> )		--- M <sup>3</sup> (FT <sup>3</sup> ) ---

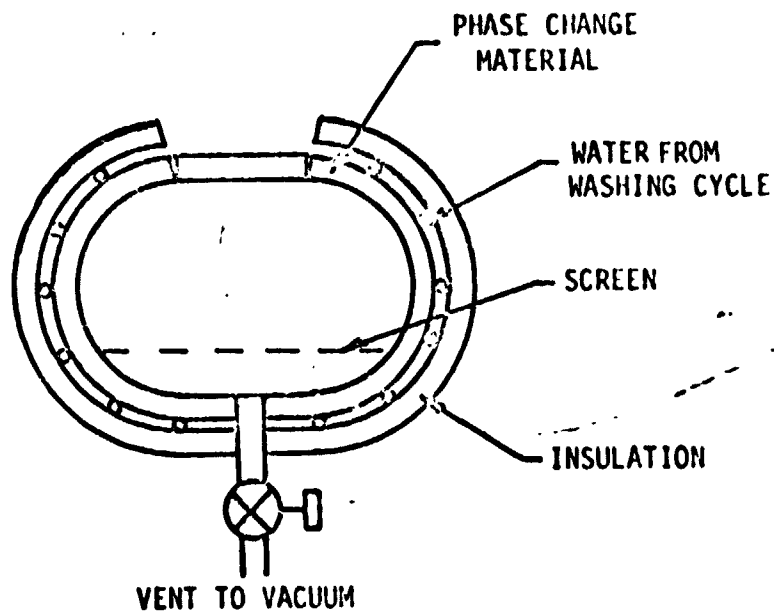
**GAS/LIQUID EXPENDABLES REQUIREMENTS**

TYPE	AMT. USED/CYCLE (REF) (LB)	RECOVERY FACTOR	AMT. RECOVERED/CYCLE (1 X 2) (LB)	AMT. LOST/CYCLE (1 - 3) (LB)
<u>Air lost to space</u>	<u>0.076</u>			
<u>Water lost to space</u>	<u>0.80</u>			
			$\Sigma$ (1)	$\Sigma$ (4)
TOTAL WT. MISSION	--- CYCLE/DAY --- X	--- DAYS/MISSION --- X	TOTAL TDSY/CYCLE (2, 3) (LB)	--- KG (LB) ---
	<u>2</u>	<u>104</u>		<b>146 (322)</b>

SPACECRAFT Space Station  
 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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT: Thermal vacuum dry - thermal storage - solar heat INDEX NUMBER 2.3.2.7  
 (cont #99 p. 22.1)

**ELECTRICAL POWER REQUIREMENTS**

COMPONENT <i>Valve</i>	(REF)	AC POWER			DC POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ②	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)
_____							
_____							
_____							
_____							
_____							
_____							
_____							
_____							
			<u>55</u>				
					<u>0</u>		
			<b>MAXIMUM</b>		<b>MAXIMUM</b>		<b>TOTAL</b>
				<b>TOTAL</b>			

**THERMAL REQUIREMENTS**

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
_____				
_____				
_____				
_____				
_____				
_____				
<i>Thermal storage unit</i>	<u>0</u>	<u>125</u>	<u>45</u>	<u>0</u>
<b>TOTAL</b>	<u>0</u>	<u>12.2 (45)</u>	<u>13.2 (45)</u>	<u>0</u>
	<b>WATT (BTU/HR)</b>	<b>WATT (BTU/HR)</b>	<b>WATT (BTU/HR)</b>	<b>WATT (BTU/HR)</b>

**OPERATIONAL PENALTIES**

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
_____					
_____					
_____					
_____					
_____					
_____					
<i>Tankage due to heat sig. under</i>	<u>0</u>	<u>0</u>	<u>0</u>	<u>48.1</u>	<u>9.8</u>
<b>TOTAL</b>	<u>0</u>	<u>0</u>	<u>0</u>	<u>48.1 (48.1)</u>	<u>9.278 (9.8)</u>
	<b>WATTS/CYCLE (BTU/HR/CYCLE)</b>	<b>WATTS/CYCLE (BTU/HR/CYCLE)</b>		<b>LB/MISSION (LB/MISSION)</b>	<b>FT<sup>3</sup>/MISSION (FT<sup>3</sup>/MISSION)</b>

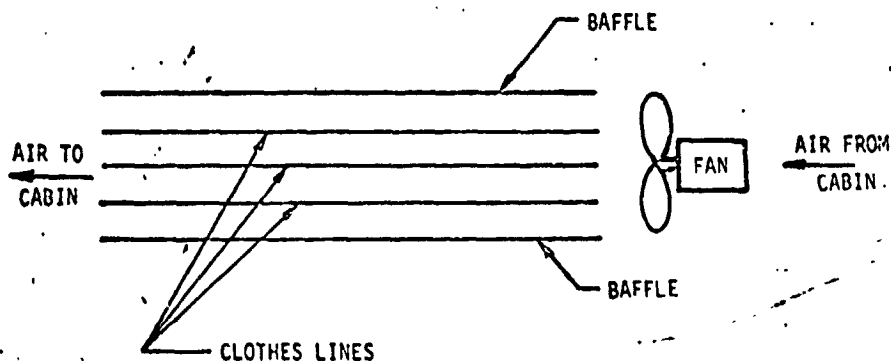




SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen Drying  
 APPLIANCE CONCEPT NO./TITLE 8/Clothesline-Forced Convection  
 INDEX NO. 3.3.2.8 REF. NO. 90

## 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.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT C24th Line - Forced convection

INDEX NUMBER 3.3.3.9

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT (REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Dryer	25	1.30
Fan		
TOTAL	22.7 (5.1)	3.68 (1.1)
	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> )
N/A					
			Σ ③		Σ ⑤
			TOTAL WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )

TOTAL WT. MISSION =  $\frac{\text{CYCLES/DAY}}{\text{Cycles/Day}} \times \frac{\text{DAYS/MISSION}}{\text{Days/Mission}} \times \frac{\text{TOT. WT/CYCLE (LB)}}{\text{Tot. Wt/Cycle (LB)}} = \text{KG (LB)}$

TOTAL VOL. MISSION =  $\frac{\text{CYCLES/DAY}}{\text{Cycles/Day}} \times \frac{\text{DAYS/MISSION}}{\text{Days/Mission}} \times \frac{\text{TOT. VOL/CYCLE (FT}^3\text{)}}{\text{Tot. Vol/Cycle (FT}^3\text{)}} = \text{M}^3 \text{ (FT}^3\text{)}$

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)
N/A				
			Σ ③	Σ ④
			TOTAL RECOVERED/CYCLE (LB)	TOTAL LOST/CYCLE (LB)

TOTAL WT. MISSION =  $\frac{\text{CYCLE/DAY}}{\text{Cycle/Day}} \times \frac{\text{DAYS/MISSION}}{\text{Days/Mission}} \times \frac{\text{TOTAL LOST/CYCLE (LB)}}{\text{Total Lost/Cycle (LB)}} \times \frac{\text{TOT. WT/CYCLE (LB)}}{\text{Tot. Wt/Cycle (LB)}} = \text{KG (LB)}$

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SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

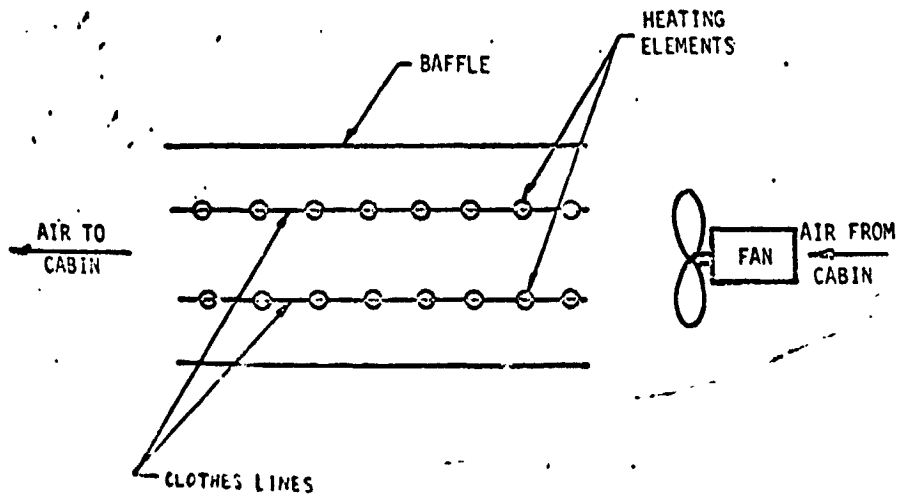
APPLIANCE FUNCTION Garment/Linen Drying

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 4.3.1) were combined with the most promising clothes dryer (Section 4.3.2) to form integrated clothes washer/dryer units. The data for each case were taken directly from the data sheets for Section 4.3.1 and 4.3.2. 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 Reference 237 and 245 and are shown in Table C2-7. A clothes weight packaging factor of 1.31, and clothes packaged volume, are taken from Reference 100. This resulted in a total clothes/linens size of 61.2 kg (135 lbs) and 0.725 cu m (25.6 cu ft) required for a six-man crew with an automatic clothes washer/dryer. The clothes required for the disposable case were computed from a wear rate of 2.88 kg (6.366 lbs) per day, with the volume again taken from Reference 100.



D2-118561-5

TABLE C2-7 CLOTHES/LINENS USAGE RATES ASSUMED PER MAN WITH A CLOTHES WASHER/DRYER AVAILABLE

ITEM	WEAR 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	.035	.077	.42	.92
Total			2.035	4.50	7.82	17.23

APPLIANCE CONCEPT FUNCTION MATRIX

INDEX NO. 3.330000 GARMENT/LINEN WASHER/DRYER-DISPOSABLE CLOTHES (SPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS				THERMAL REQTS				ELEC PWR REQTS				WT/VOL REQTS				DEVELOPMENT				RESUPPLY			
		AMT.	TYPE	USED	RESERVE	TEMP	COOLANT	MT LEAK	AC	DC	AVG PWR	PK PWR	DC	AC	WT	VOL	AVAIL	INDEX	WEIGHT	RESERVE	WEIGHT	RESERVE			
		(LB/USE)	(GAL/USE)	(GAL/USE)	(DEG F)	(BTU/HR)	(BTU/HR)	(BTU/HR)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)	(W)			
1	2.000	99.8960	.00	.00	.00	198.	1470.	1470.	237.0	.00	236.1	1.32	3	60	18.9										
	5.000	110.0000	.00	.00	.00	( 675.)	( 15020.)	( 15020.)	227.0	.00	( 520.5)	( 46.75)													
2	2.000	99.8960	.00	.00	.00	328.	1470.	1470.	237.0	.00	283.7	1.68	3	65	18.9										
	5.000	110.0000	.00	.00	.00	( 1120.)	( 15020.)	( 15020.)	.00	.00	( 625.5)	( 59.45)													
3	2.000	99.8960	.00	.00	.00	0.	1470.	1470.	237.0	.00	328.2	5.03	3	70	18.9										
	5.000	110.0000	.00	.00	.00	( 0.)	( 15020.)	( 15020.)	.00	.00	( 723.5)	( 176.75)													
4	2.000	99.8960	.00	.00	.00	0.	1470.	1470.	237.0	.00	323.6	5.29	3	60	18.9										
	5.000	110.0000	.00	.00	.00	( 0.)	( 15020.)	( 15020.)	256.0	.00	( 713.5)	( 186.75)													
5	2.000	99.8960	.00	.00	.00	198.	1470.	1470.	237.0	.00	239.3	1.31	2	40	18.9										
	5.000	110.0000	.00	.00	.00	( 675.)	( 15020.)	( 15020.)	227.0	.00	( 527.5)	( 46.25)													
6	2.000	99.8960	.00	.00	.00	328.	1470.	1470.	237.0	.00	286.9	1.68	3	65	18.9										
	5.000	110.0000	.00	.00	.00	( 1120.)	( 15020.)	( 15020.)	.00	.00	( 632.5)	( 58.45)													
7	2.000	99.8960	.00	.00	.00	0.	1470.	1470.	237.0	.00	243.8	4.99	3	70	18.9										
	5.000	110.0000	.00	.00	.00	( 0.)	( 15020.)	( 15020.)	.00	.00	( 537.5)	( 176.75)													
8	2.000	99.8960	.00	.00	.00	0.	1470.	1470.	237.0	.00	239.3	5.27	2	40	18.9										
	5.000	110.0000	.00	.00	.00	( 0.)	( 15020.)	( 15020.)	256.0	.00	( 527.5)	( 186.15)													
9	.000					0.	0.	0.	.00	.00	693.6	8.21	1	0	678.6										
	.000					( 0.)	( 0.)	( 0.)	.00	.00	( 1529.0)	( 290.00)													

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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) (LB/HR)
- 3 - OXYGEN (LOST) (LB/HR)
- 4 - COOLING WATER (CIRCULATED), KG/HR
- 5 - WATER (LOST) (LB/HR)
- 6 - NITROGEN (CIRCULATED), KG/HR
- 7 - NITROGEN (USED) (LB/HR)
- 8 - FRESH (CIRCULATED), KG/HR
- 9 - WATER (PROCESSED), KG/HR

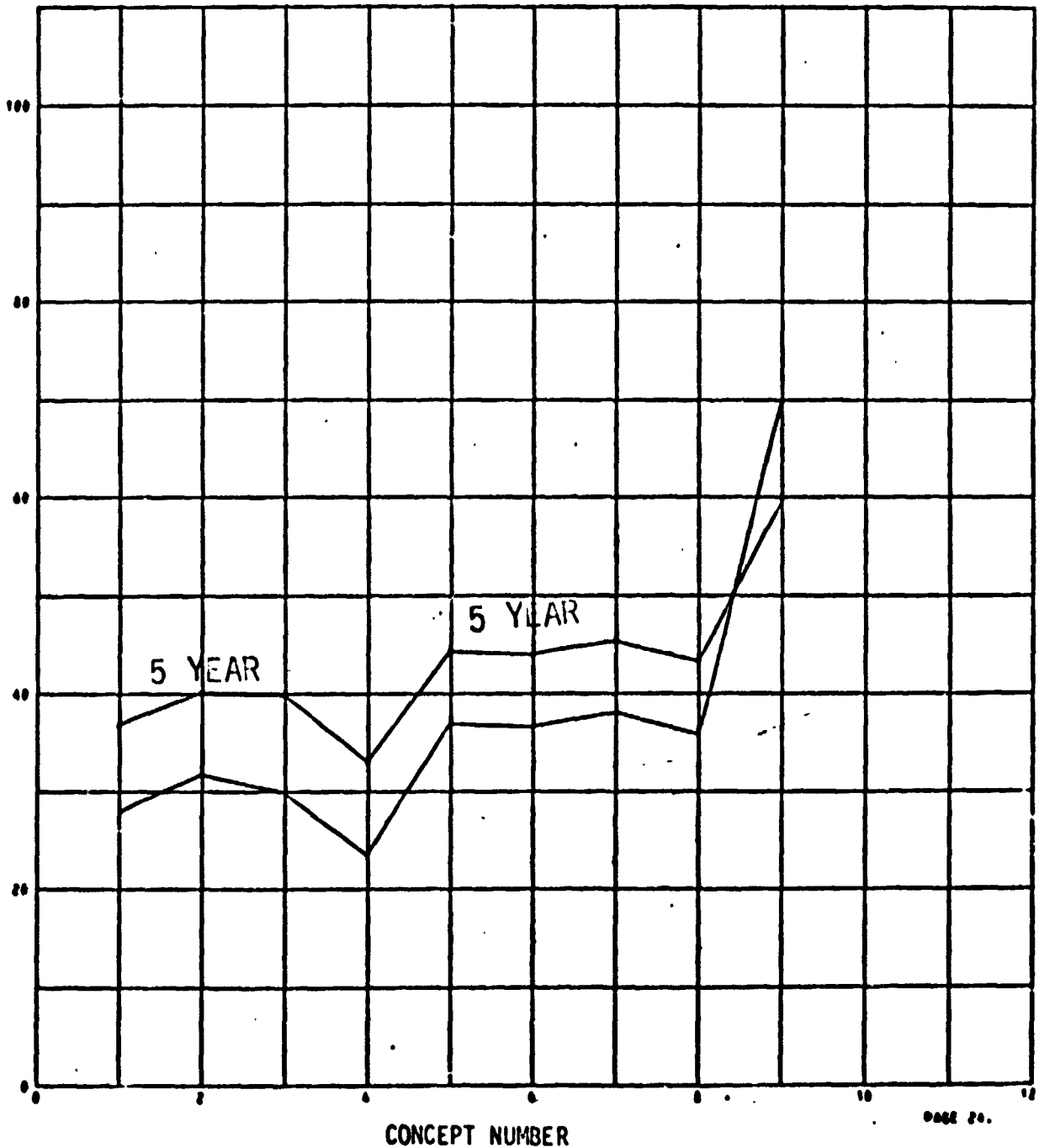
- (\*) AVAILABLE
- (\*\*) COST INDICATOR
- 0-25%
  - 25-50%
  - 50-75%
  - 75-100%
- (1) STATE OF THE ART
- (2) SOME DEVELOPMENT REQUIRED
- (3) EXTENSIVE DEV. REQUIRED

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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



NUMBER OF DAYS = 1000 ( .99 YEARS)  
 USES MOD SUBROUTINE 17  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1200  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .0910

SELECTION MATRIX (09/16/75) CLOTHES WASHING/DRYER-DISPOSABLE CLOTHES VSPACE STATION

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT								
				1	2	3	4	5	6	7	8	9
WEIGHT	520.50	1529.00	15	9.89	8.86	7.90	8.00	9.83	8.79	9.73	9.83	.00
POWER	.00000	319.57	15	.80	7.10	7.10	.00	.80	7.10	7.10	.00	15.00
VOLUME	46.254	290.00	10	8.39	7.95	3.91	3.56	8.41	7.98	3.92	3.58	.00
THERMAL	.00000	703.04	15	.51	.00	1.29	1.29	.51	.00	1.29	1.29	15.00
RELIAB-Y	.71158	1.00.0	5	1.89	1.91	.00	2.09	3.03	3.24	2.20	3.47	5.00
MAINTENC	.99994	.99994	5	.00	.03	.19	.39	2.45	2.91	3.10	3.30	4.54
SAFETY	.00000	2.00000	5	.00	.00	5.00	2.50	.00	.00	5.00	2.50	5.00
DEV COST	.00000	70.000	15	2.14	1.07	.00	2.14	6.43	1.07	.00	6.43	15.00
TOTAL PT	.00000	85.000	85	23.63	26.92	25.39	19.98	31.45	31.10	32.34	30.39	59.54
RATING	.00000	100.000	100	27.80	31.67	29.87	23.50	37.01	36.59	38.05	35.76	70.05

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SENSITIVITY ANALYSIS

WATING 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	27.00	31.67	29.07	23.50	37.01	36.59	38.05	35.75	70.05
WEIGHT	30.89	33.90	31.72	25.92	39.32	38.38	40.22	35.17	64.37
POWER	25.98	32.95	31.29	21.59	34.44	37.46	38.80	32.86	72.47
VOLUME	30.91	34.33	30.38	24.17	39.62	39.00	38.11	35.76	66.15
THERMAL	25.82	29.11	28.15	22.29	34.28	33.63	35.66	33.55	72.47
RELIAB-Y	28.08	31.86	29.32	24.02	37.68	37.40	38.22	36.71	70.90
MAINTENC	27.00	30.78	29.13	23.05	37.35	37.21	38.73	36.62	70.64
SAFETY	27.00	30.77	31.87	24.26	35.95	35.55	39.62	36.16	70.90
DEV COST	26.70	29.69	27.45	22.75	37.48	34.20	34.96	36.33	72.47

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	27.00	31.67	29.07	23.50	37.01	36.59	38.05	35.75	70.05
WEIGHT	24.10	29.02	27.66	20.61	34.25	34.46	35.46	32.88	76.82
POWER	29.97	30.16	28.18	25.77	30.07	35.55	37.15	39.21	67.15
VOLUME	24.29	28.69	29.30	22.74	34.07	33.39	37.98	35.75	74.42
THERMAL	30.16	34.74	31.93	24.94	40.26	40.13	40.90	38.38	67.15
RELIAB-Y	27.50	31.48	30.78	22.95	36.29	35.73	37.87	34.74	69.14
MAINTENC	28.04	32.62	30.66	23.97	36.64	35.94	37.32	34.84	69.42
SAFETY	28.64	32.63	27.95	22.70	38.13	37.70	36.17	35.32	69.14
DEV COST	29.10	34.05	32.76	24.39	36.94	39.44	41.73	35.07	67.15

NUMBER OF DAYS \* 10.26.0 (15.00 YEARS)  
 USES MOD SUBROUTINE 17  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/STUM) \*0540  
 THERMAL PENALTY - CABIN HEAT LEAK (L.B./STUM) \*1280  
 POWER PENALTY (LBS/BATT) TYPE 1 \*7100  
 POWER PENALTY (LBS/BATT) TYPE 2 \*5910

SELECTION MATRIX (09/16/75) CLOTHES WASHING/DRYER-DISPOSABLE CLOTHES (SPACE STATION)

FACTOR	MIN VALUE	MAX VALUE	PTS	CONCEPT									
				1	2	3	4	5	6	7	8	9	
WEIGHT	520.50	1529.0	15	7.89	8.86	7.90	8.00	9.83	8.79	9.73	9.83	9.83	.00
POWER	.00000	317.57	15	.80	7.10	7.10	.00	.80	7.10	7.10	.00	.00	15.00
VOLUME	46.254	290.00	10	8.39	7.95	3.91	3.56	8.41	7.98	3.92	3.58	3.58	.00
THERMAL	.00000	703.04	15	.51	.00	1.29	1.29	.51	.00	1.29	1.29	1.29	15.00
RELIABILITY	.31689	1.0000	5	.53	.54	.00	.63	1.36	1.58	.70	1.85	1.85	5.00
MAINTENANCE	.99994	.99999	5	.07	.03	.19	.39	2.45	2.91	3.10	3.30	4.54	5.00
SAFETY	.00000	2.0000	5	.00	.00	5.00	2.50	.00	.00	5.00	2.50	5.00	5.00
DEV COST	.00000	70.000	15	2.14	1.07	.00	2.14	6.43	1.07	.00	6.43	15.00	15.00
REC COST	91.580	194.0	15	14.58	14.58	14.58	14.58	14.58	14.58	14.58	14.58	14.58	.00
TOTAL PT	.00000	100.00	100	36.85	40.14	39.97	33.11	44.36	44.03	45.42	43.36	59.54	59.54
RATING	.00000	100.00	100	36.85	40.14	39.97	33.11	44.36	44.03	45.42	43.36	59.54	59.54

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SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9
NORMAL	36.85	40.14	39.97	33.11	44.36	44.03	45.42	43.36	59.54
WEIGHT	38.88	41.46	40.86	34.52	45.84	45.05	46.78	44.91	55.39
POWER	34.66	40.44	40.49	30.80	41.64	44.26	45.56	40.34	62.36
VOLUME	39.09	42.01	39.93	33.23	46.25	45.73	45.13	43.00	56.70
THERMAL	34.52	37.34	37.78	31.40	41.51	40.96	42.86	40.94	62.36
RELIAB-Y	36.21	39.42	39.00	32.61	43.94	43.73	44.66	43.21	60.53
MAINTENC	35.95	39.17	39.09	32.49	44.47	44.37	45.83	43.91	60.30
SAFETY	35.95	39.14	41.44	33.52	43.28	42.95	46.76	43.52	60.53
DEV COST	35.28	37.84	37.18	31.79	44.26	41.45	42.26	43.33	62.36
REC COST	41.07	44.12	43.97	37.58	48.05	47.74	49.04	47.12	55.39

SENSITIVITY ANALYSIS

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

	1	2	3	4	5	6	7	8	9
NORMAL	36.85	40.14	39.97	33.11	44.36	44.03	45.42	43.36	59.54
WEIGHT	34.49	38.60	38.94	31.47	42.65	42.84	43.85	41.57	64.37
POWER	39.41	39.55	39.38	35.79	47.53	43.76	45.27	46.88	56.26
VOLUME	34.38	38.07	40.02	32.98	42.27	42.14	45.75	43.76	62.67
THERMAL	39.56	43.39	42.52	35.09	47.68	47.60	48.41	46.18	56.26
RELIAB-Y	37.53	40.89	41.00	33.63	44.80	44.34	46.23	43.52	58.50
MAINTENC	37.80	41.15	40.90	33.75	44.25	43.67	45.00	42.78	58.74
SAFETY	37.80	41.17	38.43	32.67	45.50	45.16	44.03	43.19	58.50
DEV COST	38.68	42.81	43.21	34.63	44.49	47.02	49.11	43.40	54.26
REC COST	31.96	35.51	35.33	27.91	40.08	39.71	41.22	39.00	64.37



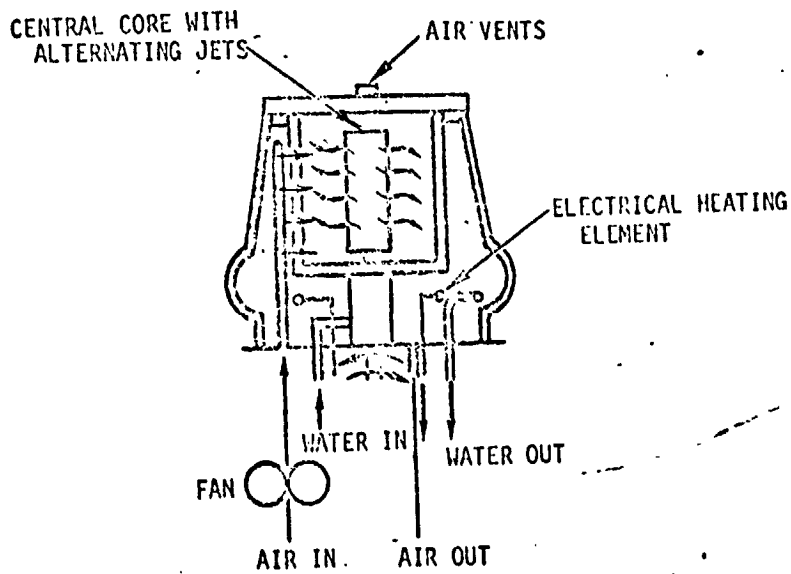
APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX  
 APPLIANCE FUNCTION: 3.3.3-GARMENT/LINEN/WASHING/DRYING COMBINATIONS

COMPONENT TYPE	NUMBER OF COMPONENTS														NUMBER OF SAFETY CRITICAL ITEMS	
	1	2	3	4	6	9	10	13	8	16	17	18	7	10		12
APPLIANCE TYPE	MOTOR	PUMP	SOLENOID VALVE	ACCUMULATOR	WATER SEPARATOR	FILTER	ELECTRIC SWITCH	CONTROLLER	FLUIDIC SWITCH	HEAT EXCHANGER	DC HEATER	BLOWER AIR	TRANSMISSION	THERMAL STORAGE UNIT	DESICCANT CANISTER	
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

SPACECRAFT Space Station  
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.



5/5

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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT FLUIDIC AGITATION HEATED HOT AIR ELECTRIC HEAT  
 (REF # 90P-4.25, 51-54)

INDEX NUMBER 4.3.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
			② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑤
<u>VALVING</u>		<u>0</u>	<u>55</u>	<u>0</u>				
<u>FAN</u>		<u>1</u>	<u>32</u>	<u>32</u>	<u>32</u>			
<u>AGITATOR MOTOR</u>		<u>5</u>	<u>150</u>					
<u>FAN</u>		<u>4</u>	<u>10</u>	<u>10</u>	<u>40</u>			
<u>HEATER</u>		<u>4</u>	<u>—</u>	<u>—</u>	<u>—</u>	<u>227</u>	<u>227</u>	
			<u>237</u>			<u>227</u>		
			MAXIMUM	TOTAL	MAXIMUM	TOTAL		

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	<u>0</u>
<u>PUMP</u>	<u>0</u>	<u>108</u>	<u>108</u>	<u>0</u>
<u>AGITATOR MOTOR</u>	<u>0</u>	<u>512</u>	<u>512</u>	<u>0</u>
<u>FAN</u>	<u>0</u>	<u>34</u>	<u>34</u>	<u>0</u>
<u>HEATER WATER</u>	<u>265</u>	<u>527</u>	<u>117</u>	<u>675</u>
TOTAL	<u>265 (265)</u>	<u>527 (527)</u>	<u>527 (527)</u>	<u>675 (675)</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

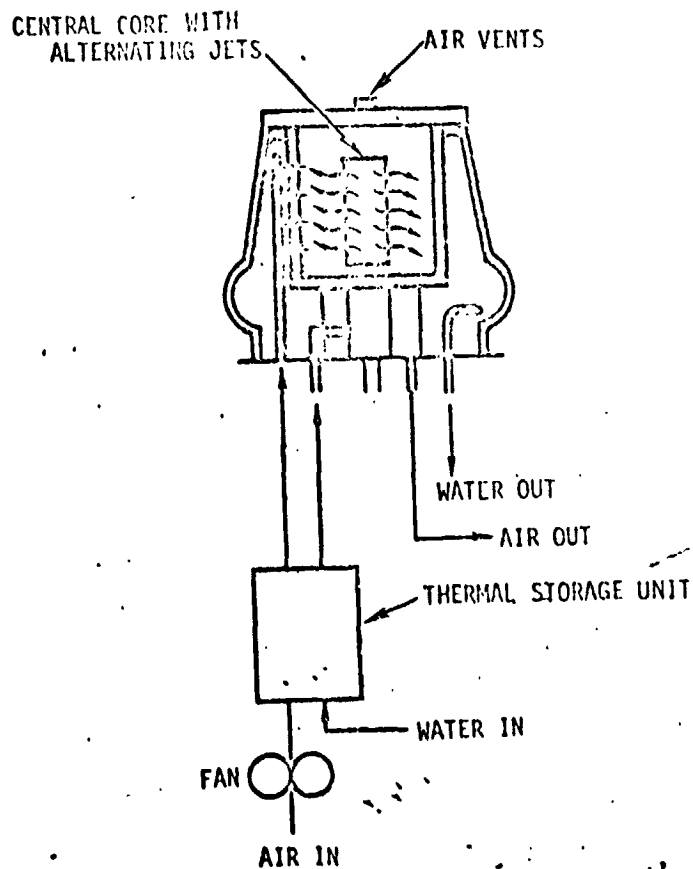
SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<u>N/A</u>					
TOTAL					
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)



SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
 APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
 APPLIANCE CONCEPT NO./TITLE 2/Fluidic Agitation/forced Hot Air-thermal Storage  
 INDEX 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.



D2-118561-5

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT PERIODIC MAINTENANCE/FORCED HOT AIR - THERMAL STORAGE

INDEX NUMBER 3.3.3.2

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① x ⑦
VALVING (WASHER)	0	55	0				
PUMP	1	32	32	32			
AGITATOR MOTOR	5	150					
FAN	4	31					
		237					
		MAXIMUM	TOTAL	MAXIMUM	TOTAL		

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS (40°F)	0	9400	1400	0
PUMP	0	108	108	0
MOTOR	0	512	512	0
FAN	0	105	105	0
WATER/THERMAL STORAGE	265	1053	198	1120
TOTAL	265 (265)	1471 (5020)	1471 (5020)	328 (1120)
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

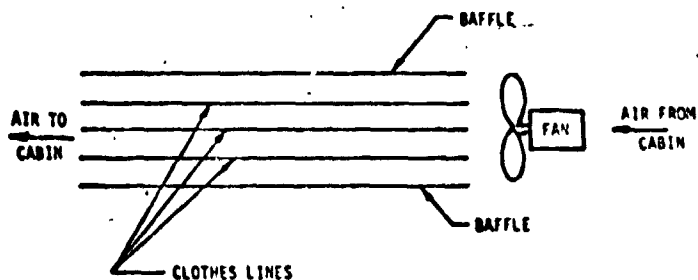
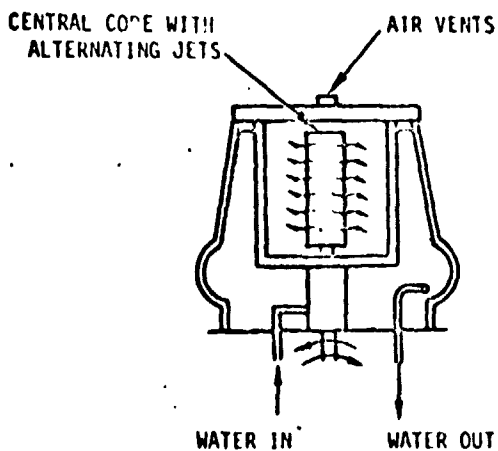


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SPACECRAFT Space Station  
HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance  
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes  
APPLIANCE CONCEPT NO./TITLE 3/Fluidic Agitation/Clothesline-Forced Convection  
INDEX NO. 3.3.3.3 REF. NO. 90

DESCRIPTION

This concept is a combination of clothes washer Concept 2 and clothes dryer Concept 8 as described previously in Section 3.3.1 and 3.3.2.





APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT FEMMIC AGITATION / CLOTHES LINE - FORCED CONVECTION INDEX NUMBER 3.3.3.3  
 (REF # 90 P. 24, 25, 72, 73)

**ELECTRICAL POWER REQUIREMENTS**

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① x ⑦
<u>VALVING (WASHER)</u>	<u>0.</u>	<u>55</u>	<u>0</u>	<u>0</u>			
<u>PUMP</u>	<u>1</u>	<u>32</u>	<u>32</u>	<u>32</u>			
<u>AGITATOR MOTOR</u>	<u>1</u>	<u>150</u>	<u>150</u>	<u>150</u>			
<u>FAN</u>	<u>8</u>	<u>7</u>					
		<u>237</u>			<u>0</u>		
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

**THERMAL REQUIREMENTS**

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS (40°F)</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	
<u>PUMP</u>	<u>0</u>	<u>108</u>	<u>108</u>	
<u>AGITATOR</u>	<u>0</u>	<u>512</u>	<u>512</u>	
<u>FAN</u>	<u>0</u>	<u>29</u>	<u>29</u>	
<u>WATER</u>	<u>133</u>	<u>-</u>	<u>133</u>	
<b>TOTAL</b>	<u>29.0 (133)</u>	<u>1471 (5020)</u>	<u>1471 (5020)</u>	<u>0</u>
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

**OPERATIONAL PENALTIES**

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

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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT PLUMBING / LITATION / LITTLE LINE - FORCED CONVECTION  
 (REF #90, #24, 25, 72, 73)

INDEX NUMBER 2.3.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>ERIC WASHER</u>		<u>70</u>	<u>10</u>
<u>PUMP</u>		<u>4</u>	
<u>2 ACCUMULATORS</u>		<u>10</u>	<u>3.6</u>
<u>VALVING</u>		<u>6</u>	<u>18</u>
<u>WATER SEPARATOR</u>		<u>3</u>	
<u>PACPLANT</u>		<u>61</u> <u>3/1 (143)</u>	
<u>MISC (WASHER)</u>		<u>-</u>	<u>4.8</u>
<u>DRIFT</u>		<u>25</u>	<u>150</u>
<u>FAN</u>		<u>25</u> <u>3/1 (243)</u>	
<u>CLOTHES</u>		<u>135</u>	<u>25.6</u>
<b>TOTAL</b>		<b><u>259 (571)</u></b> KG (LBS)	<b><u>4.92 (173.9)</u></b> 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> )
<u>DETERGENT/ GERMICIDE</u>	<u>1</u>	<u>.055</u> (.055)	<u>.066</u>	<u>.0016</u> (.0016)	<u>.0019</u>
			$\Sigma$ ③	$\Sigma$ ⑤	
			<u>.066</u> TOTAL WT/CYCLE (LB)	<u>.0019</u> TOTAL VOL/CYCLE (FT <sup>3</sup> )	
TOTAL WT. MISSION	<u>2</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	<u>.066</u> TOT. WT/CYCLE (LB)	<u>11.0</u> KG (LB)	<u>(29.3)</u>
TOTAL VOL. MISSION	<u>2</u> CYCLES/DAY	<u>184</u> DAYS/MISSION	<u>.0019</u> TOT. VOL/CYCLE (FT <sup>3</sup> )	<u>0.030</u> M <sup>3</sup> (FT <sup>3</sup> )	<u>(0.7)</u>

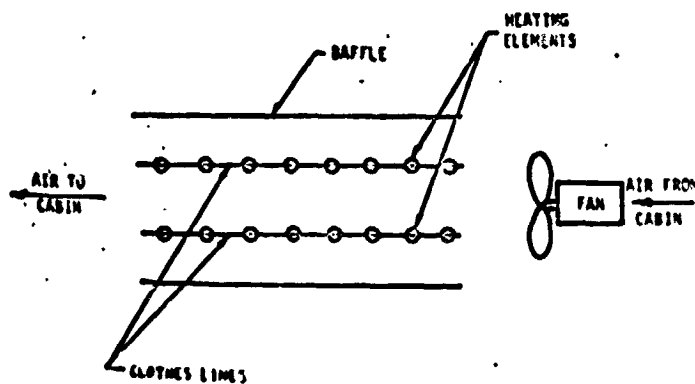
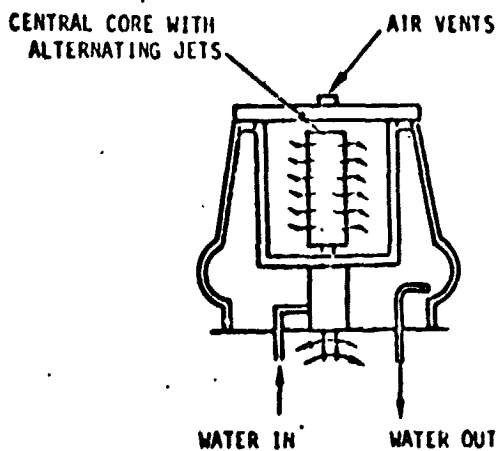
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)		
					④ TOTAL LOST/CYCLE (LB)	
<u>RASH WATER</u>	<u>55</u>	<u>.9991</u>		<u>.0495</u>		
<u>RINSE WATER</u>	<u>55</u>	<u>1.0000</u>				
				$\Sigma$ ④		
				<u>.0495</u>		
TOTAL WT. MISSION	<u>2</u> CYCLE/DAY	<u>184</u> DAYS/MISSION	<u>.0495</u> TOTAL LOST/CYCLE (LB)	<u>10.2</u> KG (LB)	<u>110</u> M <sup>3</sup> (FT <sup>3</sup> )	<u>59.2 (124.2)</u> KG (LB)

SPACECRAFT Space Station  
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 2 and clothes dryer Concept 9 as described previously in Section 3.3.1 and 3.3.2.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT HYDRO AGITATION/COOLING LINE - FORCED CONVECTION INDEX NUMBER 237.1  
 (REF # 90, P 24 25 74.75) WITH ELECTRIC HEAT

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER				DC POWER		
		① USE TIME CYCLE (HR)	② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/ CYCLE) ① X ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/ CYCLE) ① X ⑤
<u>VALVING</u>		<u>0</u>	<u>55</u>	<u>0</u>				
<u>PUMP</u>		<u>1</u>	<u>32</u>	<u>32</u>	<u>32</u>			
<u>AGITATOR MOTOR</u>		<u>1</u>	<u>150</u>	<u>150</u>	<u>150</u>			
<u>FAN</u>		<u>4</u>	<u>3</u>					
<u>HEATER</u>		<u>4</u>				<u>256</u>		
			<u>237</u>			<u>256</u>		
			MAXIMUM		TOTAL	MAXIMUM	TOTAL	

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>WATER HEAT LOSS (30F)</u>	<u>0</u>	<u>4400</u>	<u>4400</u>	<u>0</u>
<u>PUMP</u>	<u>0</u>	<u>108</u>	<u>108</u>	<u>0</u>
<u>AGITATOR MOTOR</u>	<u>0</u>	<u>512</u>	<u>512</u>	<u>0</u>
<u>FAN</u>	<u>0</u>	<u>10</u>	<u>10</u>	<u>0</u>
<u>HEATER/WATER</u>	<u>265</u>	<u>608</u>	<u>873</u>	<u>0</u>
<b>TOTAL</b>	<u>77.6 (265)</u>	<u>1471 (5020)</u>	<u>1471 (5020)</u>	<u>0 (0)</u>
	WAT. (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT FLUIDIC AGITATION / CLOTHES LINE - FORCED CONVECTION INDEX NUMBER 3.3.3.4  
 (REF #90, F24, 25, 79, 75) PLUS ELECTRIC HEAT

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
BASIC WASHER		79	10
UNIT		4	
2 ACCUMULATORS		40	3.6
VALVING		6	
WATER SEPARATOR		2	
REF. PIPING		61	
MISC.		-	4.8
WATER		25	1.10
FAN		5	
CLOTHES		135	25.6
<b>TOTAL</b>		<b>254 (561)</b>	<b>5.21 (184)</b>
		KG (LBS)	M <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE MT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (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	1	.055 (.055)	.066	.0016 (.0016)	.0019
GERMICIDE					
			Σ ③	Σ ④	
			TOTAL WT/CYCLE (LB)	TOTAL VOL/CYCLE (FT <sup>3</sup> )	
TOTAL WT MISSION	2	184	.066	11.8 (34.3)	
	CYCLES/DAY	DAYS/MISSION	TOT. WT/CYCLE (LB)	KG (LB)	
TOTAL VOL MISSION	2	184	.0019	0.35 (0.7)	
	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)			
WASH WATER	.55	.9971		.0195			
RINSE WATER	.55	1.000		0			
				Σ ④			
				TOTAL LOST/CYCLE (LB)			
TOTAL WT MISSION	2	184	.0195	18.2	110	57.2 (126.2)	
	CYCLES/DAY	DAYS/MISSION	(LB)	(LB)	(LB)	KG (LB)	

SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

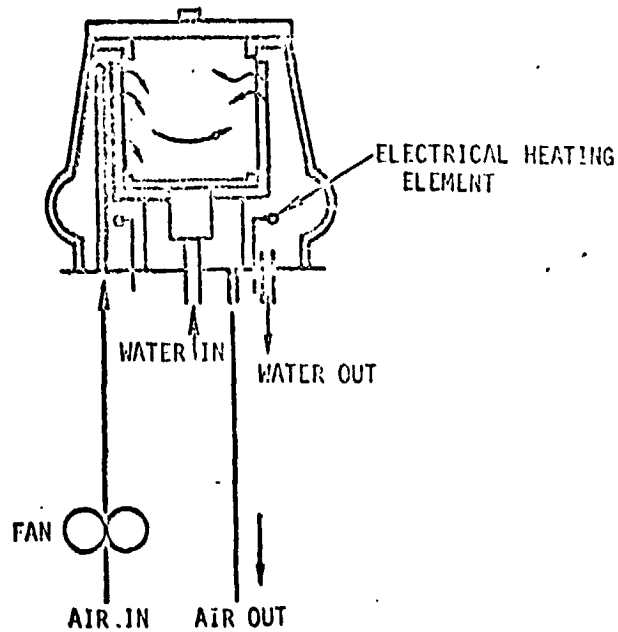
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes

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.



APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS  
 CONCEPT WATER SPRAY AGITATION / FORCED HOT AIR ELECTRIC HEAT INDEX NUMBER 3.3.3.5  
 (REF # 90-P 36, 37, 51-54)

**ELECTRICAL POWER REQUIREMENTS**

COMPONENT (REF)	① USE TIME CYCLE (HR)	AC POWER			DC POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR/CYCLE) ① x ③	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR/CYCLE) ① x ⑤
VALVES	0	55					
PUMP	1	32					
AGITATOR MOTOR	5	150					
FAN	4	10					
HEATER	4				227		
		237			227		
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

**THERMAL REQUIREMENTS**

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS (90°F)	0	4400	4400	0
PUMP	0	108	108	0
MOTOR	0	512	512	0
FAN	0	34	34	0
HEATER/WATER	265	527	117	675
TOTAL	77 (265)	1471 (5020)	1471 (5020)	199 (675)
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

**OPERATIONAL PENALTIES**

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

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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT WATER HEATING / FORCED HOT AIR ELECTRIC HEAT INDEX NUMBER 3.2.3.5  
 (REF 490 - P 56, 37, 51-54)

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
Basic washer		20	10.5
WATER		1	
2 ACCUMULATORS		40	3.6
PACKAGING		6	17.1
WATER SEPARATOR		3	
PACKAGING		67	
MISC (DRESSER)		-	3.8
DRESSER		40	17.6
MISC (DRESSER)		40	-
CLOTHES		135	25.6
<b>TOTAL</b>		<b>170 (375)</b> KG (LBS)	<b>1.23 (43.5)</b> 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> )
DREXEL/GERANICIDE	1	0.055 (0.055)	0.066	0.0016 (0.0019)	0.0019
			Σ ③		Σ ⑤
			TOTAL WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	2	184	x 0.066		11.0 (27.3) KG (LB)
TOTAL VOL MISSION	2	184	x 0.0019		0.000 (0.7) 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	55	0.9991		0.495	
RINSE WATER	55	1.0000		0	
	Σ ①		Σ ③	0.495	
TOTAL WT. MISSION	2	184	x 0.0495	18.2	110
			TOTAL LOST/CYCLE (LB)		58.2 (128.2) KG (LB)



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HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

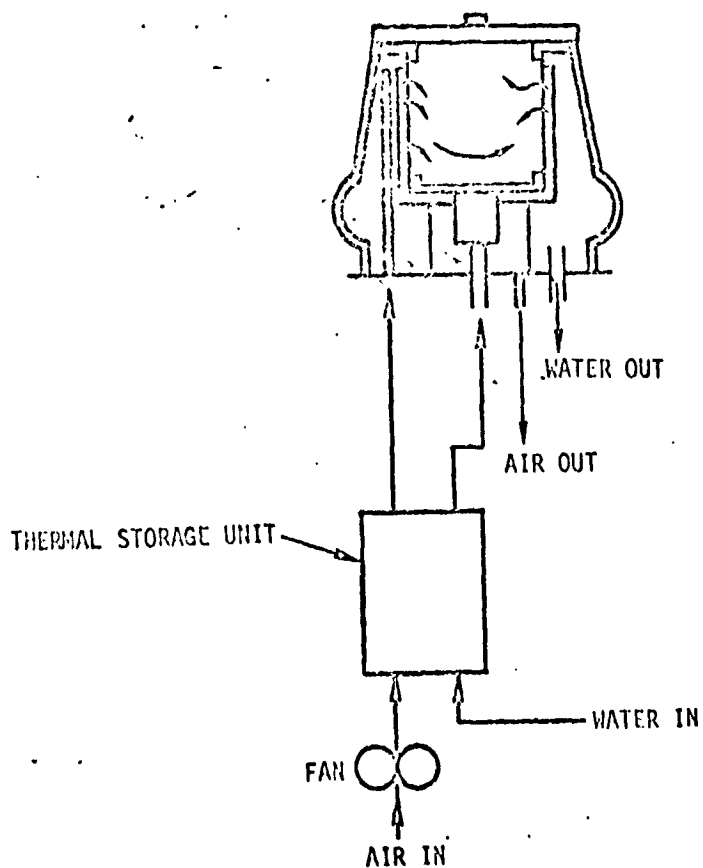
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes

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.







SPACECRAFT Space Station

HABITABILITY SUBSYSTEM Housekeeping HABITABILITY FUNCTION Garment/Linen Maintenance

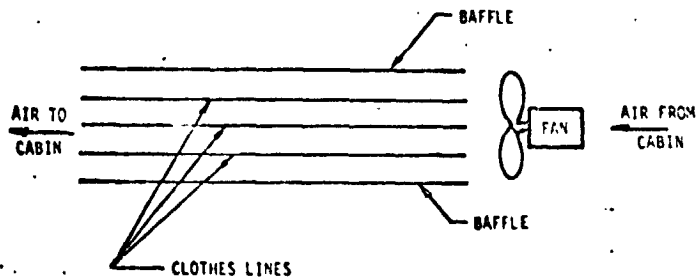
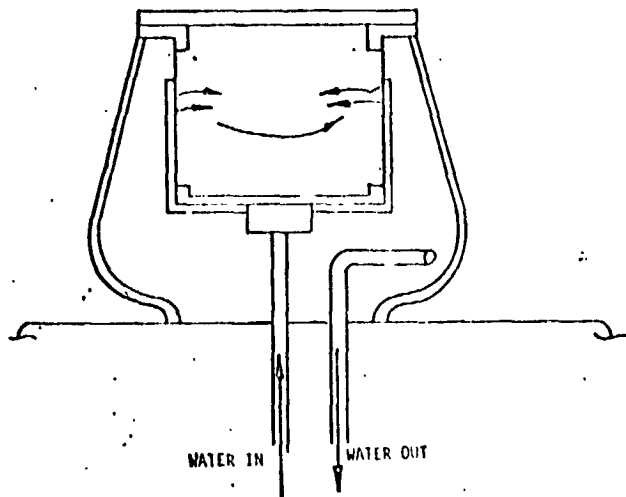
APPLIANCE FUNCTION Garment/Linen-Washer/Dryer-Disposable Clothes

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  
 CONCEPT Upper Flight Ventilation/Outlets Line - Forced Convective INDEX NUMBER 3.3.3.7  
 (REF #90 1, 2, 3, 7, 12, 13)

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	A.C. POWER				D.C. POWER	
		(1) USE TIME CYCLE (HR)	(2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/CYCLE) (1) x (3)	(5) PEAK (WATTS)	(6) AVERAGE (WATTS)
VOLVES		0	55				
FAN		1	72				
AIRFLOW MOTOR		1	150				
FAN		8	7				
			237				
			MAXIMUM		TOTAL	MAXIMUM	TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS (LIFE)	0	4400	4400	
FAN P	0	108	108	
MOTOR (AIRFLOW)	0	512	512	
FAN	0	29	29	
WATER	133	-	133	
TOTAL	29.0 (133)	1471 (5020)	1471 (5020)	0
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

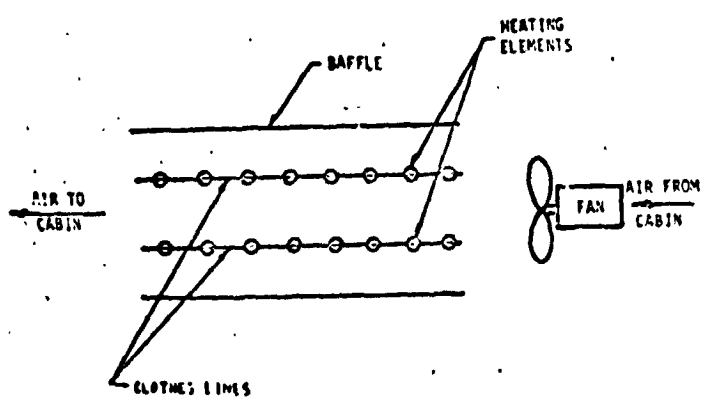
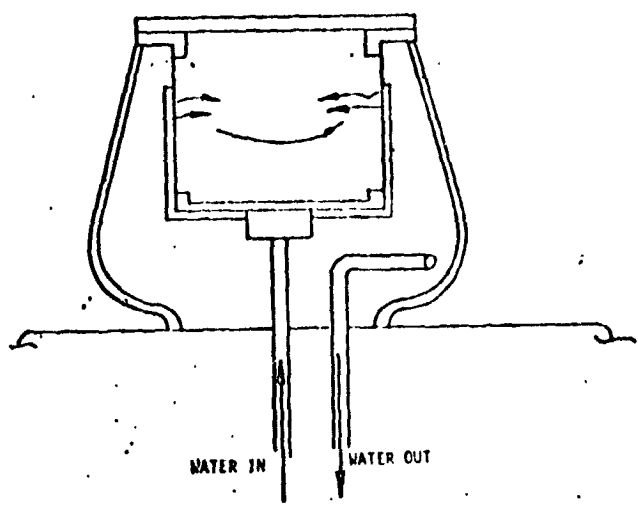
SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
N/A					
TOTAL	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		KG/MISSION (LB/MISSION)	M <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)



SPACECRAFT Space Station  
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 JERRY AGITATION/CLOTHES LINE - FORCED CONVECTION WITH ELECTRIC HEAT INDEX NUMBER 2.3.3.H  
 (REF #90, P 36, 57, 74, 75)

ELECTRICAL POWER REQUIREMENTS

COMPONENT	(REF)	AC POWER				DC POWER		(7) DEMAND (WATT-HR/ CYCLE) (1) X (2)
		(1) USE TIME CYCLE (HR)	(2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/ CYCLE) (1) X (3)	(5) PEAK (WATTS)	(6) AVERAGE (WATTS)	
VALVES		0	55					
PUMP		1	32					
AGITATOR MOTOR		1	150	150	150			
FAN		4	3					
HEATER		4				256		
			237			256		
			MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
WATER HEAT LOSS (90F)	0	4400	4400	
PUMP	0	108	108	
MOTOR (AGITATOR)	0	512	512	
FAN	0	10	10	
HEATER/WATER	265	608	873	
TOTAL	77.6 (265)	1471 (5020)	1471 (5020)	0
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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



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APPLIANCE CONCEPT REQUIREMENTS AND PENALTIES CALCULATIONS (CONCLUDED)

CONCEPT WASH, DRY, IRONING / CLOTHES LINE - PERIOD CONDUCTIVITY INDEX NUMBER 3,3,3,B  
 (REQ. (KGS, LBS), (CYCLES, DAYS), (WT, VOL)) PER ELECTRIC HEAT

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
WASH WATER		81	10.5
SOAP		1	
WASH WATER		40	3.5
WASH WATER		1	
WASH WATER		3	
DRYER		67	3.4
IRON		35	1.0
FIN		5	
CLOTHES		125	29.6
TOTAL		170 (275) KG (LBS)	5.14 (145) 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> )
DETERGENT / SCUMBICIDE	1	.055 (.066)	.066	.0015 (.0019)	.0019
			Σ ③ .066 TOTAL WT/CYCLE (LB)		Σ ⑤ .0019 TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	2 CYCLES/DAY	184 DAYS/MISSION	x .066 TOT. WT/CYCLE (LB)		11.0 (24.5) KG (LB)
TOT. VOL. MISSION	2 CYCLES/DAY	184 DAYS/MISSION	x .0019 TOT. VOL/CYCLE (FT <sup>3</sup> )		0.62 (0.7) 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	55	0.791		.045
RINSE WATER	55	1.0000		0
TOTAL WT. MISSION	2 CYCLES/DAY	184 DAYS/MISSION	x .0475 TOTAL LOST/CYCLE (LB)	18.2 (110) KG (LB)
				55.2 (123.2) KG (LB)

SPACECRAFT Space Station  
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 FUNCTION MATRIX

INDEX NO. 9.1.1 0000 MUSIC (SPACE STATION)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS	THERMAL REQTS	ELEC PAR REQTS	MT/VOL REQTS	DEVELOPMENT COST	RESUPPLY
1	3.000 2.000	AMY US/D TYPE US/D FLOW PRESS TEMP WRS/USE (0) -KG/USE (0) -MMG -DEG C (-8/USE) (0) (PSIG) (DEG F) (BTU/MH) (BTU/MH) COOLANT MT LEAK -WATTS- (BTU/MH) (BTU/MH)	0. ( 0.) ( 102.)	PK PAR AC 30.0 30.0 DC .0 .0 -WATTS- -WATTS-	WEIGHT VOLUME AVAIL INDER -KG- -CU M- (00) (000) (LBS) (CU FT)		

APPLIANCE CONCEPT

NO. 1 - CONCEPT NAME

1 - CASSETTE PLAYER/RECORDER

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APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 4.0-OFF-DUTY ACTIVITIES

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

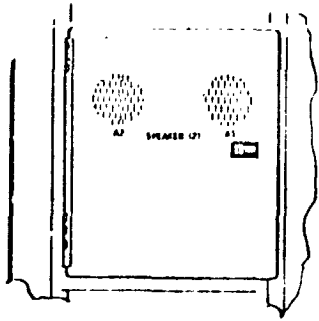


SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
 APPLIANCE FUNCTION Music  
 APPLIANCE CONCEPT NO./TITLE 1/Cassette Player/Recorder  
 INDEX NO. 4.1.1.1 REF. NO. 293, 96

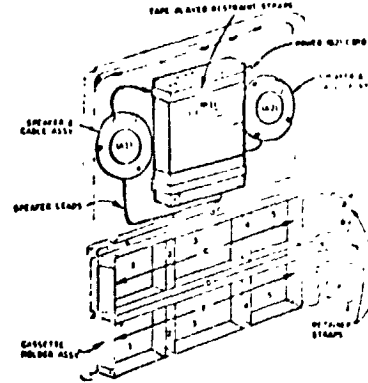
## DESCRIPTION

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:

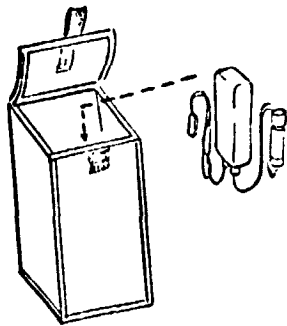
	<u>Shuttle</u>	<u>Space Station</u>
Tape recorder	5	7
Headsets	3	4
Microphones	3	4
Power cord/converter	1	2
Batteries	adequate for mission duration	
Cassettes	80	120
Speaker	1	1



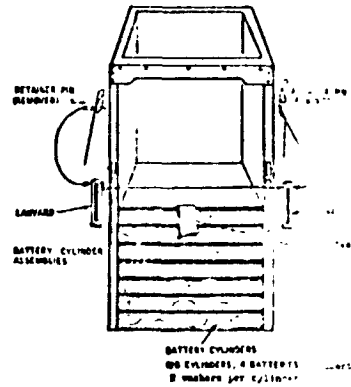
SPEAKER DOOR (FRONT VIEW)



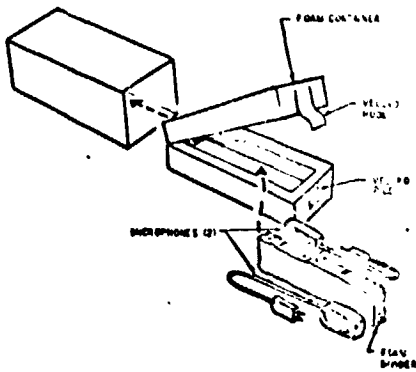
SPEAKER DOOR (REAR VIEW)



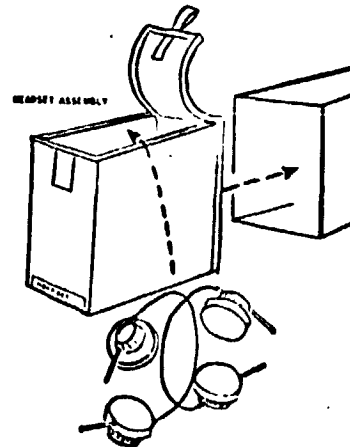
POWER CORD/CONVERTER



BATTERY DISPENSER



MICROPHONE



HEADSETS



CONCEPT 1/CASSETTE PLAYER/RECORDER

INDEX NUMBER 4.1.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LB)	VOLUME (FT <sup>3</sup> )
TAPE PLAYER		46.5	.707
HEADSETS		6.16	.397
MICROPHONES		3.73	.196
BATTERIES		50.00	.75
CASSETTES		17.5	.406
WARDROOM SPEAKERS		15.85	.903
POWER COPO/CONVERTER		6.63	.174
TOTAL		<b>66.39 (146.4)</b>	<b>.084 (2.98)</b>
		KG (11.3)	M <sup>3</sup> (1.7)

RESUPPLY SOLID EXPENDABLE MT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PKG. WT/UNIT) (REF) (LB)	③ WT/UNIT MISSION (① x ②) (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	⑤ VOL/UNIT MISSION (① x ④) (FT <sup>3</sup> )
BATTERIES	-	-	51.0	-	.60
CASSETTES	-	-	8.7	-	.30
			<b>Σ ③ 49.7</b>		
			TOTAL WT/MISSION (LB)	<b>Σ ⑤ .90</b>	
TOTAL WT. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOTAL WT. MISSION (LB)
					<b>22.54 (49.7)</b>
TOTAL VOL. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOTAL VOL. MISSION (FT <sup>3</sup> )
					<b>.025 (.90)</b>

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)	
<u>N/A</u>					
			<b>Σ ③</b>	<b>Σ ④</b>	
TOTAL WT. MISSION	CYCLE/DAY	X	DAYS/MISSION	X	TOTAL WT. MISSION (LB)

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 0000 LIBRARY (SPACE STATIONS)

CONCEPT NO.	USE/ DAY TIME	CONSUMABLES AND FLOW REQUIREMENTS	THERMAL REQTS	ELEC PER R QNTS	WT/VOL REQTS	DEVELOPMENT COST	RESUPPLY
		AMT. USED	COOLANT MT LEAK	PK PWR AC	WEIGHT VOLUME	AVAIL INDER	WEIGHT
		(LB/USE)	(BTU/MR)	DC	-KG -CU M-	(00) (00)	-KS-
		(PSIG) (DEG F)	(BTU/MR)	-WATTS-	(LBS) (CU FT)	(LRS)	
1	3,000		0.0	0.0	6.3	.01	1
	2,000		0.1	0.0	13.81	.50	5

APPLIANCE CONCEPT NO. 1 - BOOKS

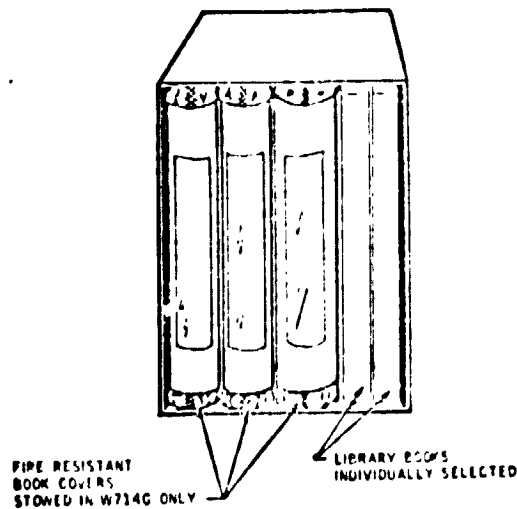
CONCEPT NAME

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SPACECRAFT Space Station  
 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.







D2-113561-5

COMPLIANT 1/ BOOKS

FIGURE NO. 4.1.2.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(PFF)	WEIGHT (LB)	VOLUME (FT <sup>3</sup> )
BOOKS		13.8	.995
TOTAL		6.124 (13.8)	.014 (.995)

RESUPPLY SOLID EXPENDABLES BY VOL REQUIREMENTS

TYPE	UNITS/CYCLE (PFF)	WT/UNIT (PFF) (PKG. WT/UNIT) (LB)	WT/UNIT MISSION (LB)	VOL/UNIT (PFF) (PKG. VOL/UNIT) (FT <sup>3</sup> )	VOL/UNIT MISSION (FT <sup>3</sup> )
BOOKS			10.92		.995
Σ			10.92	Σ .995	

TOTAL WT. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOT. WT./CYCLE (LB)	4.994 (10.9)
TOTAL VOL. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOT. VOL./CYCLE (FT <sup>3</sup> )	.014 (.995)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	AMT. USED/CYCLE (PFF) (LB)	RECOVERY FACTOR	AMT. RECQ. EFF./CYCLE (LB)	AMT. LOSS/CYCLE (LB)		
N/A						
Σ			Σ			
TOTAL WT. MISSION	CYCLE/DAY	X	DAYS/MISSION	X	TOT. WT./CYCLE (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 VISUAL RECREATION (SPACE STATIONS)

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS	THERMAL RIGHTS	ELEC PWR REQTS	WT/VOL REQTS	DEVELOPMENT COST	RESUPPLY
1	3,000 2,000	AMT. USED -KG/USE- (LBS/USE) (10) (PSIG) (DEG F) (BTU/HRI) (BTU/HR)	COOLANT MT LEAK -PATS- -WATTS- (BTU/HR)	PK PWR AC DC -WATTS- (LBS) (CU FT)	WEIGHT VOLUME -KG- -CU M- (LBS) (CU FT)	AVAIL INDEX (10) (100) (100) (100)	HEIGHT -KG- (LBS)
			0.0 (0.0) (109.0)	120.0 .0	22.7 50.0	12 3	75 75

APPLIANCE CONCEPT NAME  
 NO. 1 - TELEVISION

SPACECRAFT Space Station  
 HABITABILITY SUBSYS. Off-Duty  
EM 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 programed 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.

CONCEPT TELEVISION

APPLICATION CONCEPT EQUIPMENT AND UTILITY CALCULATIONS

INDEX NUMBER 5.1.3.1

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	① USE TIME CYCLE (HR)	A.C. POWER			D.C. POWER		
		② PEAK (WATTS)	③ AVERAGE (WATTS)	④ DEMAND (WATT-HR / CYCLE) (1) X (2)	⑤ PEAK (WATTS)	⑥ AVERAGE (WATTS)	⑦ DEMAND (WATT-HR / CYCLE) (1) X (2)
TELEVISION	6	120	120	720			
		120		720			
		MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
HEAT LEAK		909	909	
TOTAL		119.94(909)	119.94(909)	
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

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

15

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APPLICANT: CONCEPT INC. HEADQUARTERS AND FACILITIES CALIFORNIA (C-1002384)

CONCEPT 1/TELEVISION

MISSION NUMBER 5.1.3.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WT/UNIT (LBS)	VOLUME (FT <sup>3</sup> )
TELEVISION		50	4.27
TOTAL		22.68 (50) KG (LBS)	.121 (4.27) FT <sup>3</sup> (FT <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PRG. WT/UNIT) (REF) (LB)	③ WT/CYCLE (1) X (2) (LB)	④ VOL/UNIT (REF) (PRG. VOL/UNIT) (REF) (FT <sup>3</sup> )	⑤ VOL/CYCLE (1) X (2) (FT <sup>3</sup> )
N/A					
TOTAL WT MISSION	CYCLES/DAY X DAYS/MISSION		TOT WT/CYCLE (LB)		TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL VN MISSION	CYCLES/DAY X DAYS/MISSION		TOT. VOL/CYCLE (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) - (2) (LB)
N/A				
TOTAL WT. MISSION	CYCLE/DAY X DAYS/MISSION		TOTAL LOSS/CYCLE (2) (LB)	

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. 9.1.0 0000 GAMES SPACE STATION

CONCEPT NO.	USAGE TIME	CONSUMABLES AND FLOW REQUIREMENTS				THERMAL RIGHTS				ELEC PWR RIGHTS				WT/VOL RIGHTS				DEVELOPMENT COST		RESUPPLY	
		AMT.	USED	TEMP	PRESS	FLOW	MT LEAK	COOLANT	HT LEAK	PK PWR	AVG PWR	AC	DC	WT	HT	RECHTS	AVAIL	INCR	WEIGHT	RESUPPLY	
1	.500 2.000							0.0 (0.0)	0.0 (0.0)												
2	.500 2.000							0.0 (0.0)	0.0 (0.0)												
3	.500 2.000							0.0 (0.0)	0.0 (0.0)												
4	.500 2.000							0.0 (0.0)	0.0 (0.0)												
5	.500 2.000							0.0 (0.0)	0.0 (0.0)												

- APPLIANCE CONCEPT NAME
- 1 - MANGBALL
  - 2 - DART BOARD/DARTS
  - 3 - BINOCULAR
  - 4 - CARDS
  - 5 - CALCULATOR

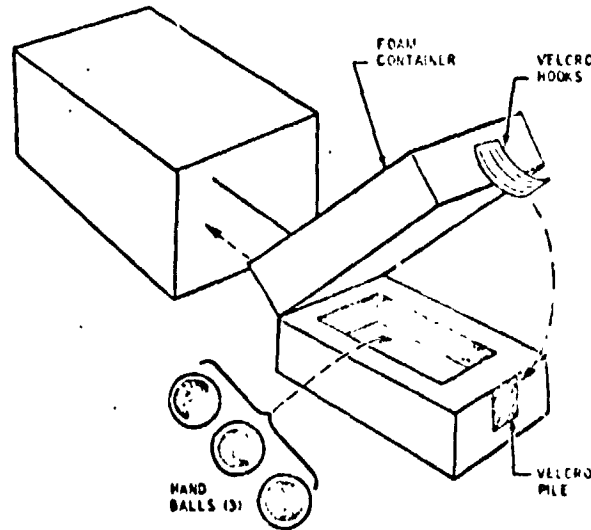
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SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Entertainment  
 APPLIANCE FUNCTION Games  
 APPLIANCE CONCEPT NO./TITLE 1/Handball  
 INDEX NO. 5.1.4.1 REF. NO. 293, 96

## 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.





CONCEPT *1/HANDBALL*

REQ NO. *5.1.9-1*

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(PFF)	WEIGHT (LB)	VOLUME (FT <sup>3</sup> )
<i>HANDBALL KIT</i>		<i>.784</i>	<i>.072</i>
TOTAL:		<i>.356 (784)</i>	<i>.002 (072)</i>
		KG (KG)	M <sup>3</sup> (M <sup>3</sup> )

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (PFF)	② WT/UNIT (PFF) (LL)	③ WT/CYCLE (LL)	④ VOL/UNIT (PFF) (FT <sup>3</sup> )	⑤ VOL/CYCLE (FT <sup>3</sup> )
<i>N/A</i>					
TOTAL WT MISSION			$\Sigma$ ③ TOTAL WT/CYCLE (LB)	$\Sigma$ ⑤ TOTAL VOL/CYCLE (FT <sup>3</sup> )	
CYCLES/DAY	X	DAYS/MISSION	X	TOTAL WT/CYCLE	KG (KG)
TOTAL WT MISSION			$\Sigma$ ③ TOTAL WT/CYCLE (LB)	$\Sigma$ ⑤ TOTAL VOL/CYCLE (FT <sup>3</sup> )	
CYCLES/DAY	X	DAYS/MISSION	X	TOTAL WT/CYCLE	M <sup>3</sup> (M <sup>3</sup> )

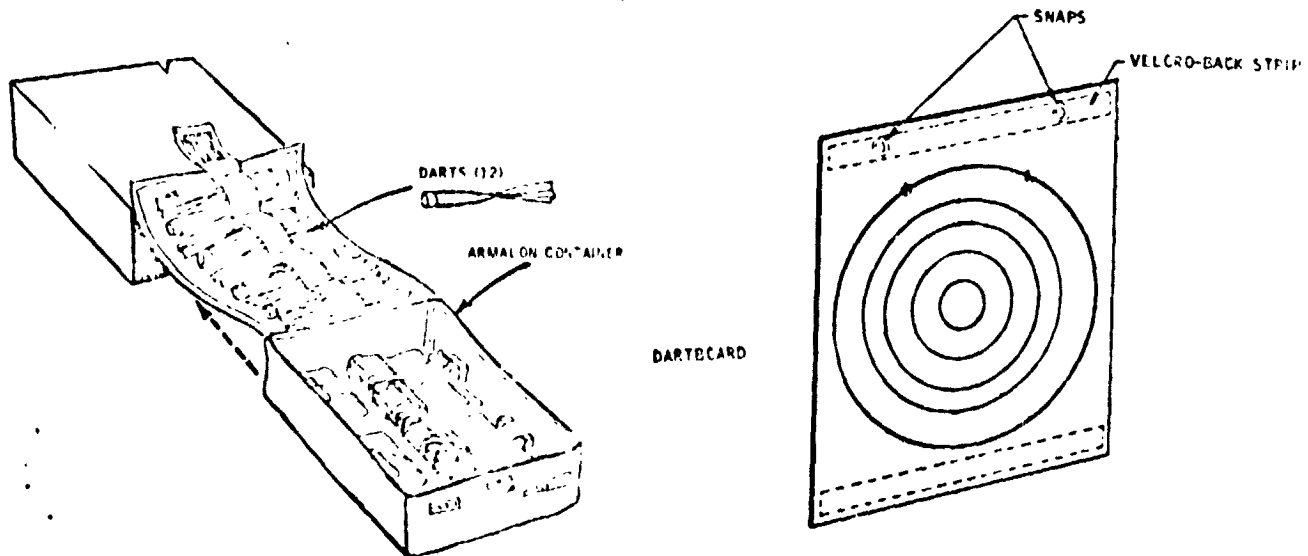
GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (PFF) (LB)	② RECOVERY FACTOR	③ AMT. REC. FEE/CYCLE (LB)	④ AMT. LOST/CYCLE (LB)
<i>N/A</i>				
TOTAL WT MISSION			$\Sigma$ ③	$\Sigma$ ④
CYCLES/DAY	X	DAYS/MISSION	X	TOTAL WT/CYCLE (LB)
TOTAL WT MISSION			$\Sigma$ ③	$\Sigma$ ④
CYCLES/DAY	X	DAYS/MISSION	X	TOTAL WT/CYCLE (LB)

SPACECRAFT Space Station  
 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.





CONCEPT *2/DART BOARD/DARTS*

INDEX NUMBER *4.1.9.2*

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<i>DARTS</i>		<i>.53</i>	} <i>.0374</i>
<i>DART STORAGE</i>		<i>.197</i>	
<i>DART BOARD</i>		<i>1.16</i>	
TOTAL		<i>.833 (1.837)</i>	<i>.001 (.0386)</i>

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (REF)	② WT/UNIT (REF) (PRG. WT/UNIT) (LBS)	③ WT/CYCLE (LBS)	④ VOL/UNIT (REF) (PRG. VOL/UNIT) (FT <sup>3</sup> )	⑤ VOL/CYCLE (FT <sup>3</sup> )
<i>N/A</i>					
Σ ③			TOTAL WT/CYCLE (LBS)	Σ ⑤	
TOTAL WT. MISSION	CYCLES/DAY	DAYS/MISSION	TOTAL WT/CYCLE (LBS)	Kg (KG)	
TOTAL VOL. MISSION	CYCLES/DAY	DAYS/MISSION	TOTAL VOL/CYCLE (FT <sup>3</sup> )	M <sup>3</sup> (M <sup>3</sup> )	

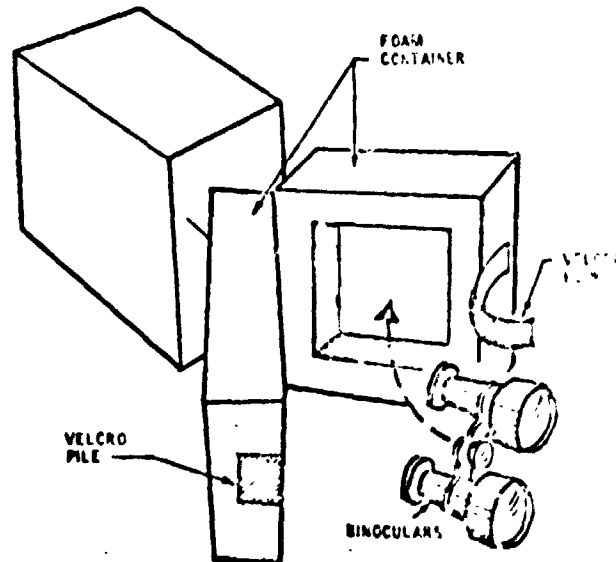
GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (REF) (LBS)	② RECOVERY FACTOR	③ AMT. RECYCLED/CYCLE (LBS)	④ AMT. LOSS/CYCLE (LBS)
<i>N/A</i>				
Σ ①			Σ ④	
TOTAL WT. MISSION	CYCLE/DAY	DAYS/MISSION	TOTAL WT. MISSION (LBS)	Kg (KG)

SPACECRAFT Space Station  
 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.







APPLIANCE CONCEPT REQUIREMENTS AND UTILITIES CALCULATIONS (CONTINUED)

CONCEPT 3/BINOCCULAR KIT

INDEX NUMBER 4.14.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>BINOCCULAR KIT</u>		<u>12</u>	<u>.168</u>
TOTAL		<u>5.44 (12)</u> KG (LBS)	<u>.0047 (.168)</u> 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) (PEF) (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> )
<u>N/A</u>					
			$\Sigma$ ③ TOTAL WT/CYCLE (LB)		$\Sigma$ ⑤ TOTAL VOL/CYCLE (FT <sup>3</sup> )
TOTAL WT. MISSION	CYCLES/DAY X DAYS/MISSION		X TOT. WT/CYCLE (LB)		KG (LB)
TOTAL VOL. MISSION	CYCLES/DAY X DAYS/MISSION		X TOT. VOL/CYCLE (FT <sup>3</sup> )		M <sup>3</sup> (FT <sup>3</sup> )

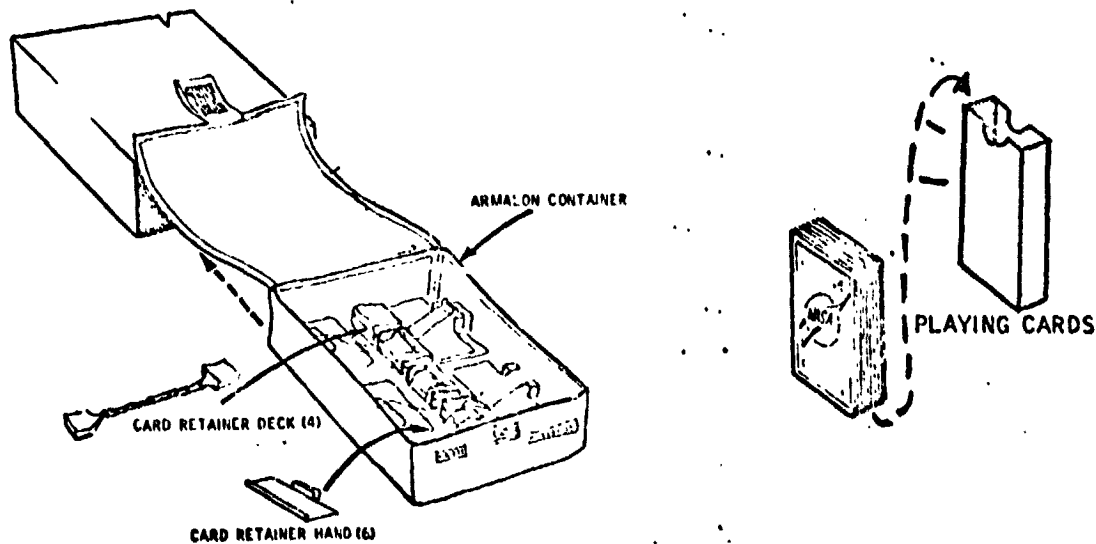
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
<u>N/A</u>				
	$\Sigma$ ①			$\Sigma$ ④
TOTAL WT. MISSION	CYCLE/DAY X DAYS/MISSION		X TOTAL LOST/CYCLE (LB)	KG (LB)

SPACECRAFT Space Station  
 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.





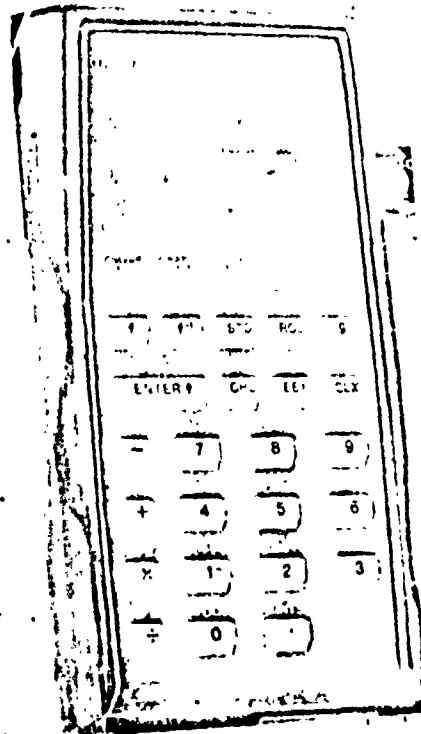


D2 118561-5

SPACECRAFT Space Station  
HABITABILITY SUBSYSTEM Off-Duty 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.



CONCEPT 5/CALCULATOR

APPLIANCE CONCEPT REQUIREMENTS AND UTILITIES CALCULATIONS

INDEX NUMBER 9.1.9.5

ELECTRICAL POWER REQUIREMENTS

COMPONENT (REF)	AC POWER				DC POWER		
	(1) USE TIME CYCLE (HR)	(2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DEMAND (WATT-HR/ CYCLE) (1)X(3)	(5) PEAK (WATTS)	(6) AVERAGE (WATTS)	(7) DEMAND (WATT-HR/ CYCLE) (1)X(5)
<u>CALCULATOR</u>	<u>.25</u>	<u>5</u>	<u>5</u>	<u>1.25</u>	<u>—</u>	<u>—</u>	<u>—</u>
		<u>5</u> MAXIMUM		<u>1.25</u> TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOLANT (BTU/HR)
<u>CALCULATOR</u>	<u>—</u>	<u>17</u>	<u>17</u>	<u>—</u>
TOTAL		<u>5 (17)</u> WATT (BTU/HR)	<u>5 (17)</u> WATT (BTU/HR)	

OPERATIONAL PENALTIES

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

CONCEPT 5/ CALCULATOR

INDEX NUMBER 9.1.9.5

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
CALCULATOR		4.12	.09
BATTERY PACK		1.56	.011
CHARGER		1.87	.028
TAPE UNITS (40)		.063	neg.
TOTAL		<b>2.999 (6.613)</b>	<b>.0037 (.129)</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 * ② (LB)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (REF) (FT <sup>3</sup> )	⑤ VOL/CYCLE ① * ④ (FT <sup>3</sup> )	
<u>N/A</u>						
$\Sigma$ ③			TOTAL WT/CYCLE (LB)	$\Sigma$ ⑤		
TOTAL WT. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOT. WT/CYCLE (LB)	KG (LB)
TOTAL VOL. MISSION	CYCLES/DAY	X	DAYS/MISSION	X	TOT. VOL/CYCLE (FT <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 * ② (LB)	④ AMT. LOST/CYCLE ① - ③ (LB)		
<u>N/A</u>						
$\Sigma$ ①			$\Sigma$ ④			
TOTAL WT. MISSION	CYCLE/DAY	X	DAYS/MISSION	X	TOTAL LOST/CYCLE (LB)	KG (LB)

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.

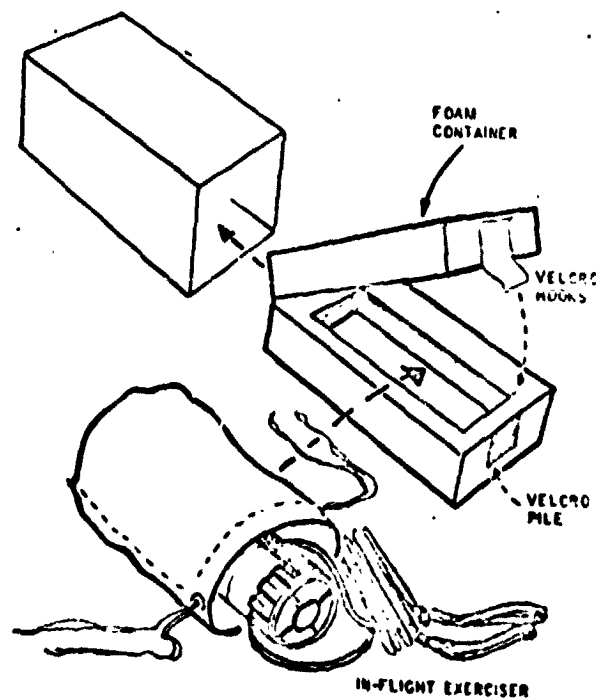




SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Physical Conditioning  
 APPLIANCE FUNCTION Exercisers  
 APPLIANCE CONCEPT NO./TITLE 1/Exer-Gym  
 INDEX NO. 4.2.1.1 REF. NO. 293, 96

## 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.



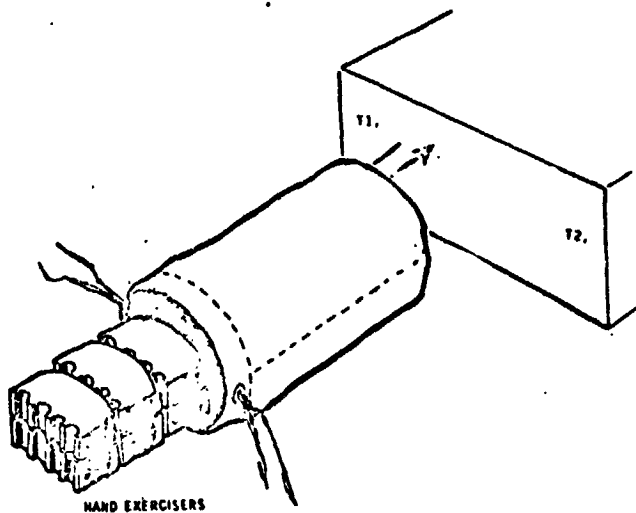




SPACECRAFT Space Station  
 HABITABILITY SUBSYSTEM Off-Duty Activity HABITABILITY FUNCTION Physical Conditioning  
 APPLIANCE FUNCTION Exercisers  
 APPLIANCE CONCEPT NO./TITLE 2/Hand Exerciser  
 INDEX NO. 4.2.1.2 REF. NO. 293, 96

## 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.



D2-118561-F

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 \*\*\*\* AUTO:LAIVES (SPACE STATION)

CONCEPT NO.	CONCEPT NAME	CONSUMABLES AND FLOW REQUIREMENTS				THERMAL REQTS				ELEC PWR REQTS				WT/VOL REQTS				DEVELOPMENT				RESUPPLY			
		USGS/DAY MRS/USE	TYPE (*)	USED (KG/USE) (LB/USE)	FLOW (GPM)	TEMP -MMHG- (DEG F)	PRESS -MMHG- (PSIG)	COOLANT -WATTS- (BTU/HR)	MT LEAK -WATTS- (BTU/HR)	PK PWR AC DC	AVG PWR AC DC	REQUIREMENTS -WATTS- (LBS)	REQUIREMENTS -CU FT- (LBS)	REQUIREMENTS -WATTS- (LBS)	REQUIREMENTS -CU FT- (LBS)	AVAIL INDEX (**)	INDEX (**)	WEIGHT -KG- (LBS)	WEIGHT -KG- (LBS)						
1	1.000	2		.0603	.00	.00	.00	308		1520.0	0.0	24.7	0.16	1	25										
	.500	9		.133011	.50	.01	.01	(1053.0)		.0	.0	(54.4)	(5.58)												
				.0717	4.54	1551.4	21.1																		
				.158011	10.00	130.0	70.0																		
2	1.000							0	421	800.0	259.0	10.9	0.14	1	25										
	2.330							(0)	(0)	.0	.0	(24.0)	(4.78)												
3	1.000	2		.0603	.00	.00	.00	112		230.0	171.0	239.0	0.24	2	45										
	20.100			.133011	.001	.01	.01	(381.0)		.0	.0	(526.8)	(9.03)												
		5		.0014	.00	.00	.00																		
				.003011	.001	.01	.01																		

- (\*)
- 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 - FRESH (CIRCULATED), KG/HR (LB/HR)
  - 9 - WATER (PROCESSED), KG/HR (LB/HR)

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

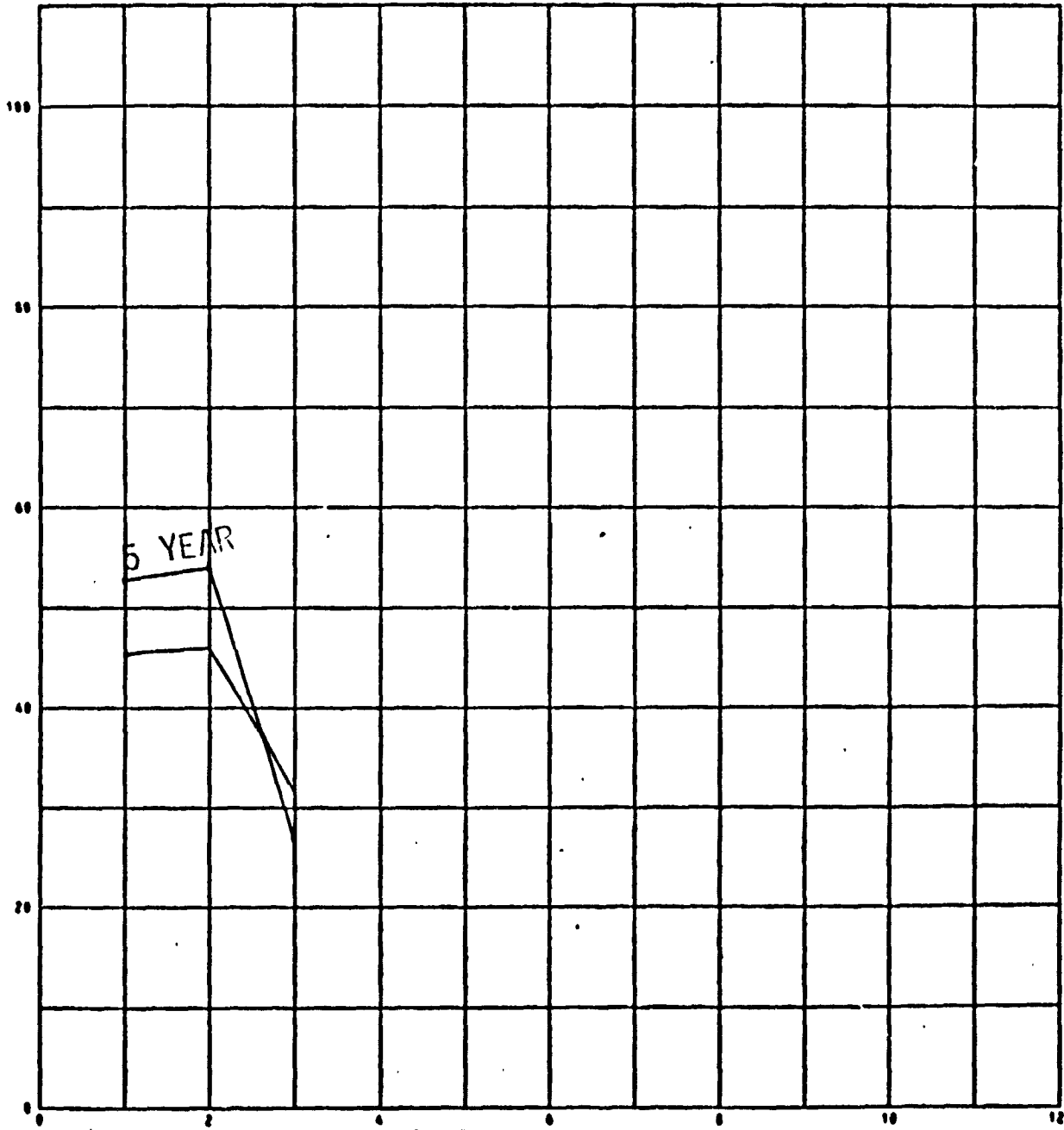
APPLIANCE  
CONCEPT

NO. CONCEPT NAME

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



CONCEPT RATINGS BASED ON



CONCEPT NUMBER

Autoclaves (Space Station) Concept Trade

D2-118561-5

NUMBER OF DAYS = 180.0 ( .49 YEARS)  
 USES MOD SUBROUTINE 0  
 THERMAL PENALTY - DIRECT TO COOLANT (LB/BTUM) .0540  
 THERMAL PENALTY - CABIN HEAT LEAK (LB/BTUM) .1280  
 POWER PENALTY (LBS/WATT) TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX (04/18/75) AUTOCLAVES (SPACE STATION)

FACTOR	MIN VALUE		PTS	MAX VALUE		CONCEPT		
	1	2		1	2	1	2	3
WEIGHT	24.000	526.00	15	13.45	14.32			.00
POWER	163.30	1079.2	15	.00	7.11			12.73
VOLUME	4.7800	9.0300	10	3.82	4.71			.00
THERMAL	48.768	184.06	15	4.02	.00			11.03
RELIABTY	.76707	.99916	5	4.87	3.79			.00
MAINTEN	.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	38.49	39.08			26.93
RATING	.00000	100.00	100	45.28	45.98			31.68

ORIGINAL PAGE IS  
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

NORMAL	45.28	45.98	31.68
WEIGHT	48.88	49.99	29.11
POWER	41.61	46.09	35.99
VOLUME	44.86	46.04	29.92
THERMAL	43.78	42.25	35.07
RELIAB-Y	46.77	46.83	30.77
MAINTENC	45.79	44.67	32.58
SAFETY	45.41	46.10	30.77
DEV COST	45.21	45.86	29.11

ORIGINAL PAGE  
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

NORMAL	45.28	45.98	31.68
WEIGHT	40.98	41.20	34.74
POWER	49.44	45.85	26.53
VOLUME	45.72	45.91	33.66
THERMAL	47.07	50.43	27.63
RELIAB-Y	43.70	45.08	32.64
MAINTENC	44.74	47.38	30.72
SAFETY	45.13	45.86	32.84
DEV COST	45.36	46.13	24.74

NUMBER OF DAYS = 1826.0 (15.00 YEARS)  
 USES MOD SUBROUTINE 0  
 THERMAL PENALTY = DIRECT TO COOLANT (LB/BTUHM) .0540  
 THERMAL PENALTY = CABIN HEAT LEAK (LB/BTUHM) .1280  
 POWER PENALTY (LBS/WATT)-TYPE 1 .7100  
 POWER PENALTY (LBS/WATT) TYPE 2 .5910

SELECTION MATRIX ..... AUTOCLAVES (SPACE STATION)  
 (09/18/75)

FACTOR	MIN		PTS	MAX		C O N C E P T		
	VALUE	VALUE		1	2	3		
WEIGHT	24.000	526.80	15	13.45	14.32			.00
POWER	163.30	1079.2	15	.00	7.11	12.73		.00
VOLUME	4.7800	9.0300	10	3.82	4.71			.00
THERMAL	48.768	104.04	15	4.02	.00	11.03		.00
RELIAB-V	.71202	.99154	5	4.85	3.65			.00
MAINTENC	.99999	1.00000	5	3.16	.00	3.17		.00
SAFETY	1.0000	2.0000	5	2.50	2.50			.00
DEV COST	25.000	45.000	15	6.67	6.67			.00
REC COST	.00000	476.25	15	15.00	15.00			.00
TOTAL PT	.00000	100.00	100	53.47	53.94			26.93

RATING .00000 100.00 100 53.47 53.94 26.93

D2-113501 5

D2-118561-5

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	53.97	53.99	26.93
WEIGHT	55.99	56.84	25.05
POWER	49.74	53.98	33.97
VOLUME	52.74	53.61	25.64
THERMAL	51.60	50.18	30.18
RELIAB-Y	54.53	54.90	26.27
MAINTENC	53.70	52.63	27.82
SAFETY	53.38	53.85	26.27
DEV COST	52.84	53.28	25.05
REC COST	56.71	57.15	25.05

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	53.97	53.99	26.93
WEIGHT	50.53	50.58	29.11
POWER	57.80	54.97	22.23
VOLUME	54.27	54.30	26.34
THERMAL	55.63	58.31	23.15
RELIAB-Y	52.35	53.45	27.62
MAINTENC	53.22	55.32	25.99
SAFETY	53.56	54.04	27.62
DEV COST	54.20	54.71	29.11
REC COST	49.69	50.21	29.11

APPLIANCE CONCEPT COMPONENT SUMMARY MATRIX

APPLIANCE FUNCTION: 5.1.1-AUTOCLAVES

COMPONENT TYPE	NUMBER OF COMPONENTS													NUMBER OF SAFETY CRITICAL ITEMS			
	4	5	3	11	23	22	17	9	6	1	10						
APPLIANCE TYPE	ACCUMULATOR	RELIEF VALVE	SOLENOID VALVE	PRESSURE REGULATOR	MANUAL VALVE	CHECK VALVE	HEATER	CONTROLLER TIMER	FILTER	MOTOR	BLOWER						
AUTOCLAVE, MOIST HEAT	3	1	2	1	1	1	1	1	-	-	-						1
AUTOCLAVE, DRY HEAT	1	-	1	-	-	-	1	1	1	1	1						1
AUTOCLAVE, ETHYLENE OXIDE	3	2	3	1	-	-	1	1	-	-	-						2



SPACECRAFT Space StationHABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION SterilizationAPPLIANCE FUNCTION AutoclavesAPPLIANCE CONCEPT NO./TITLE 1/Moist Heat SterilizerINDEX 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.



APPLIANCE CONCEPT REQUIREMENTS AND UTILITIES CALCULATIONS (CONCLUDED)

CONCEPT 1/MOIST HEAT STERILIZATION

INDEX NUMBER 5.1.1.1

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
AUTOClave ASSY	(202)	30	5.59
TOTAL		13.6 (30) KG (LBS)	.158 (5.59) 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> )
N/A					
			Σ ③	Σ ⑤	
TOTAL WT. MISSION	CYCLE/DAY	DAYS/MISSION	TOT. WT./CYCLE (LB)	KG (LB)	
TOTAL VOL. MISSION	CYCLE/DAY	DAYS/MISSION	TOT. VOL./CYCLE (FT <sup>3</sup> )	M <sup>3</sup> (FT <sup>3</sup> )	

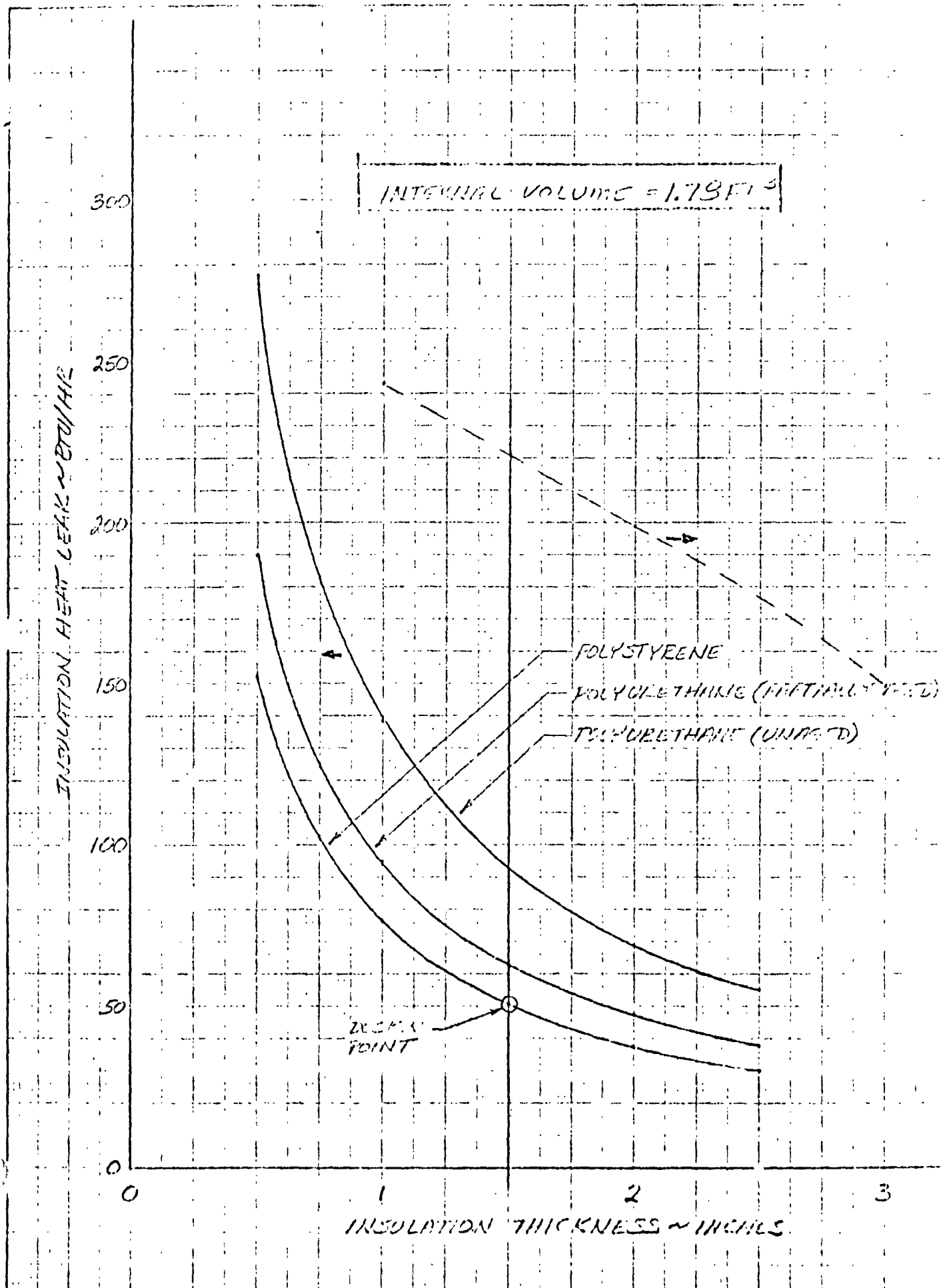
GAS/LIQUID EXPENDABLES REQUIREMENTS

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)
CABIN AIR	.132 (202)	N/A	N/A	.132
Σ ①			Σ ④	
TOTAL WT. MISSION	1 CYCLE/DAY	184 DAYS/MISSION	TOTAL LOST/CYCLE ② x ④ (LB)	24.3 + .132 = .69 (24.4) KG (LB)

SPACECRAFT Space Station  
 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 (see attached figure). 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.



INSULATION HEAT LEAK ~ BTU/HR/FT²

INTERNAL VOLUME = 1.79 FT³

POLYSTYRENE  
POLYURETHANE (PARTIALLY FOAMED)  
POLYURETHANE (UNFOAMED)

ZUCKER POINT

INSULATION THICKNESS ~ INCHES

5  
6  
7





SPACECRAFT Space StationHABITABILITY SUBSYSTEM Medical HABITABILITY FUNCTION SterilizationAPPLIANCE FUNCTION AutoclavesAPPLIANCE CONCEPT NO./TITLE 3/Ethylene Oxide SterilizerINDEX NO. 5.1.1.3REF. 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.





D2-118561-5

APPLIANCE WEIGHT REQUIREMENTS AND WEIGHTS CALCULATIONS (CONTINUED)  
 CONCEPT 3/ETHYLENE OXIDE STERILIZATION

INDEX NUMBER 5.1.1.3

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
AVIOCLAVE	(201)	24	5.53
WATER-STERILANT BOTTLE		90.8	3.44
TOTAL		52.07 (114.8)	.256 (9.03)
		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) (LBS)	③ WT/CYCLE ① x ② (LBS)	④ VOL/UNIT (REF) (PKG. VOL/UNIT) (FT <sup>3</sup> )	⑤ VOL/CYCLE ① x ④ (FT <sup>3</sup> )	
						TOTAL WT/CYCLE (LBS)
WATER BOTTLE	.0054	1.256	.00683	.0127	.000069	
STERILANT BOTTLE	.07609	6.4	.48697	.245	.018642	
Σ ③			.49380	Σ ⑤		.018711
TOTAL WT MISSION	1 CYCLES/DAY	184 DAYS/MISSION	x .4938	x .018711		41.21 (90.8)
TOTAL VOL MISSION	1 CYCLES/DAY	184 DAYS/MISSION	x .018711	x .0974		(3.44)

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/C. (REF) (LBS)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE ① x ② (LBS)	④ AMT. LOST/CYCLE ① - ③ (LBS)		
					TOTAL AMT. (LBS)	TOTAL AMT. (LBS)
WATER	.003 (202)	N/A	N/A	.003		
STERILANT	2.092 (202)	N/A	N/A	2.092		
CABIN AIR	.132 (202)	N/A	N/A	.132		
Σ ④			2.227	Σ ④	2.227	
TOTAL WT MISSION	1 CYCLE/DAY	184 DAYS/MISSION	x 2.227	x 402.8	2.227	186 (412)
			KG (LBS)			

D2-118561-5

HABITABILITY SUBSYSTEM: 5.0 Medical

HABITABILITY FUNCTION 5.2 Physical Monitoring

APPLIANCE FUNCTION 5.2.1 Ergometers

NUMBER OF CONCEPTS CONSIDERED 1

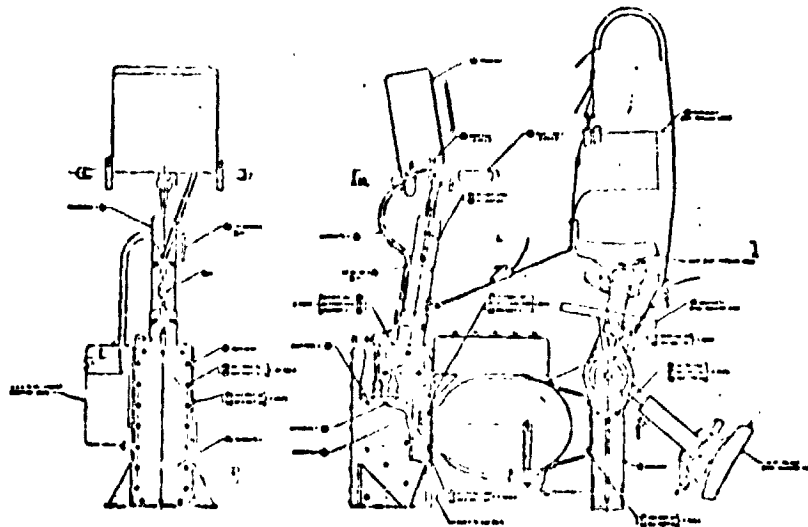
ASSUMPTIONS

None

SPACECRAFT Space Station  
 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.



D2-1187(1-5)

APPLIANCE CONCEPT REQUIREMENTS / SPECIALS OPERATIONS (CONCEPT)  
CONCEPT ERJOMILIK DATA SHEET 5.2.1.

FIXED WEIGHT/VOLUME REQUIREMENTS

COMPONENT	(REF)	WEIGHT (LBS)	VOLUME (FT <sup>3</sup> )
<u>ERJOMILIK INCLUDES</u>		<u>165</u>	<u>37.5</u>
<u>EXCEPTIONS</u>			
TOTAL		<u>74.84 (165)</u>	<u>1.06 (37.5)</u>

SOLID EXPENDABLE WT/VOL REQUIREMENTS

TYPE	① UNITS/CYCLE (FT)	② WT/UNIT (LBS) (PKG. WT/UNIT)(REF)	③ WT/CYCLE (LBS) ① X ②	④ VOL/UNIT (FT <sup>3</sup> ) (PKG. VOL/UNIT)(REF)	⑤ VOL/CYCLE (FT <sup>3</sup> ) ① X ④
<u>N/A</u>					
TOTAL WT MISSION	CYCLES/DAY X	DAYS/MISSION X	TOT. WT/CYCLE (LB)		
TOTAL VOL MISSION	CYCLES/DAY X	DAYS/MISSION X	TOT. VOL/CYCLE (FT <sup>3</sup> )		

GAS/LIQUID EXPENDABLES REQUIREMENTS

TYPE	① AMT. USED/CYCLE (LBS)	② RECOVERY FACTOR	③ AMT. RECOVERED/CYCLE (LBS) ① X ②	④ AMT. LOST/CYCLE (LBS) ① - ③
<u>N/A</u>				
TOTAL WT MISSION	CYCLE/DAY X	DAYS/MISSION X	TOTAL LOST/CYCLE (LB) $\Sigma$ ④	

APPLIANCE CONCEPT REPORT (PART 1) DETERMINATION OF ELECTRICAL REQUIREMENTS  
 AIRCRAFT ERGONOMETER INDEX NUMBER 5.201

ELECTRICAL POWER REQUIREMENTS

AC POWER		DC POWER				
(1) USE TIME CYCLE (HR)	(2) PEAK (WATTS)	(3) AVERAGE (WATTS)	(4) DETERMINED PEAK (WATT-CYCLE) (1) (2) (3)	(5) PEAK (WATTS)	(6) AVERAGE (WATTS)	(7) PEAK (WATT-CYCLE) (1) (2) (3)
	<b>ELECTRONICS</b>					
	15	15				
	15					
	MAXIMUM		TOTAL	MAXIMUM		TOTAL

THERMAL REQUIREMENTS

SOURCE	LATENT (BTU/HR)	SENSIBLE (BTU/HR)	HEAT LEAK (BTU/HR)	TO COOL FN. (BTU/HR)
<b>ALTERNATOR POWER DISSIPATED IN CABIN</b>	-	683	683	-
TOTAL			200(683)	-
	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)	WATT (BTU/HR)

OPERATIONAL PENALTIES

SOURCE	HEAT LEAK (BTU/HR/CYCLE)	THERMAL TO COOLANT (BTU/HR/CYCLE)	ELECTRICAL (PK WATTS/CYCLE)	WEIGHT (LB/MISSION)	VOLUME (FT <sup>3</sup> /MISSION)
<b>N/A</b>					
TOTAL					
	WATTS/CYCLE (BTU/HR/CYCLE)	WATTS/CYCLE (BTU/HR/CYCLE)		LB/MISSION (LB/MISSION)	FT <sup>3</sup> /MISSION (FT <sup>3</sup> /MISSION)