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PARAMETRIC STUDY OF
MANNED LIFE SUPPORT SYSTEMS

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VOLUME IV - PROGRAM MANUAL

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FOREWORD

This final report gives the results of a study which developed new parametric analytical tools and a computer program for describing and characterizing life support systems and tradeoffs of subsystems from a mission analysis standpoint. The scaling laws and characteristics developed for each of the life support systems components, subsystems, or functional methods were confirmed with equipment data obtained from the latest literature and through a vendor survey. This work was performed by the Advance Biotechnology and Power Department of the McDonnell Douglas Astronautics Company - Western Division, Santa Monica, California under Contract No. NAS2-4443 for the Mission Analysis Division of NASA, Office of Advanced Research and Technology, Moffett Field, California. Work was initiated in July 1967 and continued to August 1968 under the direction of Robert S. Barker, Project Manager, McDonnell Douglas Astronautics Company and Joseph L. Anderson, Technical Monitor for the Mission Analysis Division, NASA.

The final report consists of four volumes published in the following breakdown because of physical size and utility for the users:

		Report No.
Volume I:	Summary	DAC-56712
Volume II:	Parametric Relations and Scaling Laws	DAC-56713
Volume III:	Computational Procedures	DAC-56714
Volume IV:	Program Manual	DAC-56715

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1.0 INTRODUCTION AND SUMMARY

This volume describes for a user or programmer the Fortran Computer program developed as a part of the Parametric Study of Life Support Systems. This program is designated H738 and was written for use on an IBM 7094 computer. The program was developed to determine the characteristics of life support systems for manned spacecraft in conjunction with mission analysis studies or for trade-off studies of various life support system functional methods. The characteristics which can be determined, include equipment weights, volumes, required power, cooling, and heating to satisfy design point conditions. Weight and volume of expendable materials are based on mission durations or resupply periods, as applicable, and accumulated material weights and volumes are based on mission durations. Characteristics of emergency equipment and materials are computed for specified emergency period durations. Spares are determined for portions of life support systems involved in thermal and atmosphere control, waste management, and water supply. Vehicle interaction output data include required power, cooling, and heating, meteoroid and radiation shielding characteristics, and required surface area for space radiators.

Mission analysis input data include crew size, flight date, vehicle flight profile, mission duration, resupply period, and cabin volumes. Life support system input data include specifications of the type of equipment to be used in accomplishing system functions and basic equipment characteristics such as process efficiency and required coolant characterisitcs. These data permit life support systems with ecological closure varying from "open", with no recovery of waste materials, to "closed" with full, or nearly full, human re-utilization of waste materials to be determined. Parametric data relating equipment characteristics to appropriate independent variables are specified. These data comprise the bulk of the data which are required in specifying individual life support systems.

The difficulties associated with collecting and handling the large amounts of data required for problem solutions have been partially relieved through preparation of three complete assemblies of data for life support systems with closures of "open", "partially closed", and "closed". The systems so specified by these sets of data are referred to as "baseline" systems. These "baselines" then characterize life support systems through only an alphanumeric input word. Required modifications or perturbations to the "basline" systems are accomplished through additional input data.

Section 2.0 of this volume contains detailed information required in preparing input data for the program and in making computer program deck set-ups. Section 3.0 contains information concerning the programmed logic. This section should facilitate any future program modifications and additions.

Volume I of this report is the summary document. Volume II contains information concerning programmed mission and vehicle criteria and associated input data; and programmed life support system criteria, mass and energy balances, chemical reactions, and associated parametric input data. Using the program will generally require extensive use of Volumes II and IV. Volume III describes the developed program, summarizes the capabilities and limitations of the program, and presents representative input and output data. Plotted sample problem results along with pertinent sensitivity evaluations from the plotted results are also presented in Volume III. It is intended that Volume III will be useful in giving an insight into the scope of the program prior to any attempts to use the program.

2.0 USER'S INSTRUCTIONS

2.1 General Information

The H738 input data are classified in two ways - data cases and data groups. The data cases are the "Baseline Case" and the "Change Case". A Baseline Case is a set of reference data nominally contained on punch cards but usually used from a master magnetic tape termed the "Baseline Tape." Data groups are Mission Analysis Data (MAD) Level 1 and Level 2, Life Support System - Trade-Off Data (LSS-TOD) and Table Data. A Change Case is a set of data entered as cards which reference a particular Baseline Case and must contain the MAD-Level 1 group and may contain portions of the other groups as desired to override the corresponding Baseline Case data. It is this combination of Baseline Case reference data and the updating Change Case data which actually comprise a case to be run.

2.1.1 Baseline Case Data

Initially, Baseline Cases (any number) must be entered as cards. These cases are edited and placed on a master tape termed the "Baseline Tape". At the conclusion of the run, the Baseline Tape is saved for future usage. These Baseline Cases may be run, but they usually serve as a reference or base case to which perturbations may be made by Change Case data. It is commonly this combined set of Baseline-Change data which is run. As a set of reference data, a Baseline Case must completely define the nature of a Life Support System. For this reason a Baseline Case must contain all of the MAD-Level 2 group and such portions of the LSS-TOD and Table Data groups as may be necessary. As the MAD-Level 1 group describes the LSS requirements, e.g., crew size and mission, rather than define the LSS type, it is not included in the Baseline Case.

2.1.2 Change Case Data

Each Change Case is run on the computer in conjunction with one of the Baseline Cases on the Baseline Tape. As the Baseline Cases do not contain the MAD-Level 1 group, each Change Case must have the two cards of this group included. This group also contains the reference or "name" of the Change Case's associated Baseline Case. The combination of the Baseline Case and the MAD-Level 1 group of the Change Case completely specify the particular case to be run, hence, no further data is required of the Change Case. However, in general it will be desired to modify or make perturbations on the Baseline Case. In these instances, the Change Case will also contain such MAD-Level 2, LSS-TOD and Table Data cards as sufficient to perform these changes. To make a particular change in the MAD-Level 2 or LSS-TOD groups from the Baseline Case, only the card containing the new value of the data item to be changed need be included in the Change Ca . However, when it is desired to make a change in a particular table of the Table Data group in the Baseline Case, all cards for that particular table change must appear in the Change Case.

2.1.3 Data Card Format

Three Fortran formats are used for the input data; they are:

1. Alphanumeric (A); example "A3"
2. Integer (I); example "830"
3. Floating point (E); example "4.42"

Alphanumeric Data

Alphanumeric fields are used throughout the input data as flags to indicate the User's choice of a set of alternatives. For instance, to obtain engineering Atmosphere Control Subsystem (ACS) print-out, the User would enter "YES*" in the appropriate place on the ACSLSS01 data card.

Integer Data

Integer fields are used in all groups of data and are always two or four card columns in width. All integer data must be "right justified." For example, to enter the values of:

```
-103
   1
1001
 -21
```

The input data sheet would appear as follows:

cc (card column)

i – $i+3$	$i+4$ – $i+7$	$i+8$ – $i+11$	$i+12$ – $i+15$	
-.1.03	...1	1.0.0.1	.-2.1	...

Floating Point Data

Floating point data are entered throughout the input data. These data represent the actual numerical values upon which the calculations are based. The field widths are 10 or 15 card columns wide (Fortran formats E10.0 and E15.0, respectively). The data may be most simply entered by writing the values as they appear elsewhere. For example, the values:

103.06
-2.795
0.0035
-10035.0

would appear on the input data sheet as:

cc

i – $i+14$	$i+15$ – $i+29$	$i+30$ – $i+44$	$i+45$ – $i+59$	
103.06	-2.795	0.0035	-10035.0	

Notice that "right" or "left justification" is unnecessary, although "left justification" is most convenient. Other forms of floating point input are possible. The user should refer to IBM File No. 7090-25, Form C28-6390-2, page 19.

2.2 Input Data Groups

The input data are classified into three groups, they are:

1. Mission Analysis Data (MAD)
   - Level 1
   - Level 2
2. Life Support System - Trade Off Data (LSS-TOD)
3. Table Data
   - Scaling Laws
   - Parametric Relations

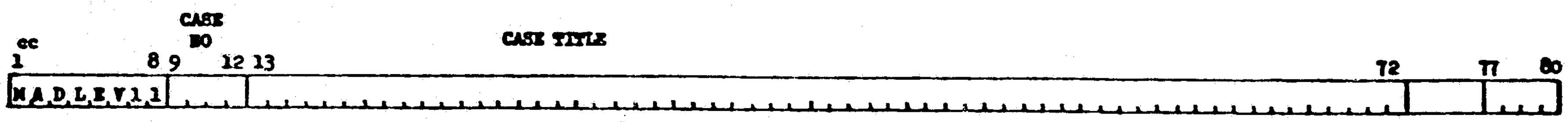
The MAD group contains the input quantities which "size" the LSS such as crew size and mission parameters. This group also includes all data which pertain to the vehicle such as vehicle diameter and cabin volumes. The LSS-TOD groups consist of the input data which specify the nature of the LSS subsystems. For example, data of this type specify the type of oxygen recovery to be used, if any, and the particular method of water recovery to be used if water is to be recovered. The Table Data group contains the relationships for the LSS equipment output characteristics such as weight, volume or electrical power required. These relationships have the output characteristic as the dependent variable and appropriate mass flows or the subsystem parameters as independent variables. Analytical relationships are entered into the program as Scaling Laws while graphical relationships are entered as Parametric Relations.

2.2.1 Mission Analysis Data

The two MAD subgroups consist of:

- Level 1

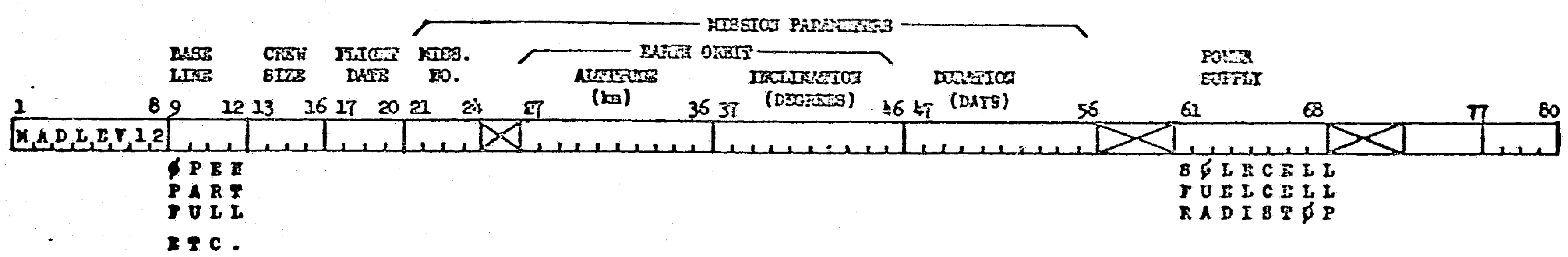
  The Level 1 data are the fundamental mission and system parameters which determine the output characteristics of the LSS under consideration. These data do not appear in a Baseline Case; however, they must appear in entirety in each Change Case. These data are contained on two cards reproduced in Figure 2-1.



MADLEV11

Card Column	Fortran Format	Fortran Name	Definition
9-12	I4	NCASE	Case number - for identification only
13-72	15A4		Case title (User may punch any 60 columns of alphanumeric information to identify his run.)

Figure 2-1 (a) - Mission Analysis Data - Level 1



MADLEV12

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	CWRD3	Name of the Baseline Case which this change case references (1)
13-16	I4	NCREW	Crew size
17-20	I4	FLDATE	Flight date - year in which mission is to take place
21-24	I4	MISSØN	Mission number - indicates orbital or interplanetary mission and trajectory for the latter (2)
27-36	E10.0	ALT	Orbit altitude for earth orbital missions, km (3)
37-46	E10.0	INCLIN	Orbit inclination for earth orbital missions, degrees (3)

Figure 2-1 (b) - Mission Analysis Data - Level 1

Card Column	Fortran Format	Fortran Name	Definition
47-56	E10.0	DURATN	Mission Duration, days
61-68	2A4	PWR, SUP	Indicates type of power supply on vehicle

NOTES:

1. The name entered must agree with one of the Baseline Case names appearing on the Baseline control card (Sect 2.3).

2. An entry of a value from 1 through 12, inclusive, indicates an interplanetary mission using the flight path described in Tables 1 through 12, respectively.

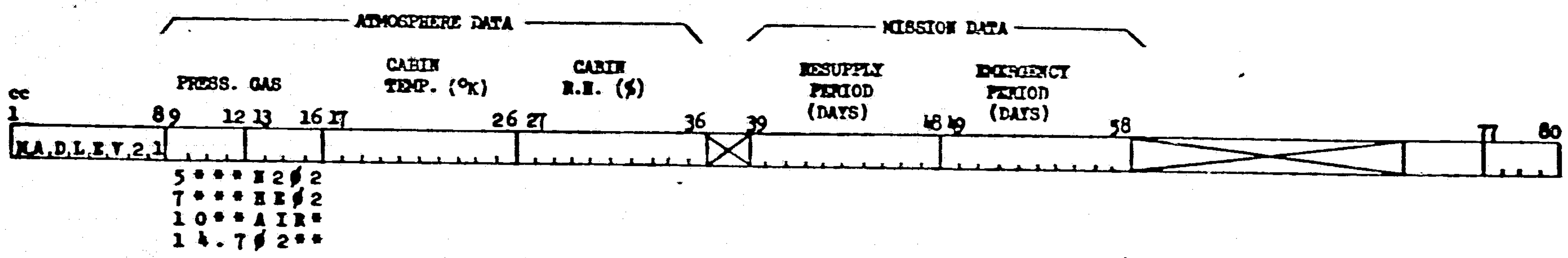
   Any other entry indicates an orbital type mission.

3. Leave blank if not an Earth orbital mission.

Figure 2-1 (b) (concluded) - Mission Analysis Data - Level 1

Level 2

These data contain secondary mission and system parameters along with vehicle specifications and other quantities not associated with any of the subsystems. These data should appear in a Baseline Case in entirety. For the Change Cases, only the cards containing the particular items to be changed need appear; however, each card should be completely filled as any blanks will be entered and may destroy corresponding Baseline Data. These data are defined and the loadsheets are shown in Figures 2-2.



MADLEV21

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	PRESS	Selects cabin atmosphere total pressure (1)
13-16	A4	GAS	Selects cabin atmosphere composition (2, 3)
17-26	E10.0	CTEMP	Cabin atmosphere temperature, ^{o}K
27-36	E10.0	CABRH	Cabin atmosphere relative humidity, %
39-48	E10.0	RESPER	Mission Resupply period, days (4)
49-58	E10.0	EMEPER	Mission emergency period, days (5)

Figure 2-2 (a) - Mission Analysis Data - Level 2

NOTES: 1. The acceptable pressure level entries and the cabin pressures they specify are:

ENTRY	PRESSURE (PSI)
5***	5.0
7***	7.0
10**	10.0
14.7	14.7

2. The acceptable cabin atmosphere entries and the atmospheres they specify are:

ENTRY	ATMOSPHERE
N2Ø2	3.5 PSIA Ø2 - remainder N2
HEØ2	3.5 PSIA Ø2 - remainder He
Ø2**	Pure Ø2
AIR*	S. L. Air composition

3. The acceptable combinations of pressure level and atmosphere are:

ATMOSPHERE	PRESSURE			
N2Ø2	5***	7***	10**	14.7
HEØ2	YES	YES	YES	NO

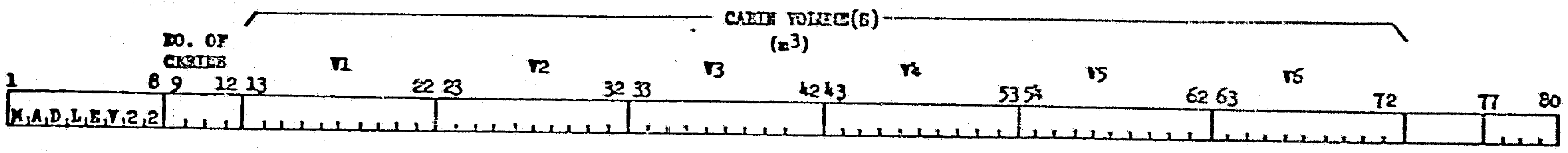
Figure 2-2 (a) (continued) - Mission Analysis Data - Level 2

ATMOSPHERE		PRESSURE		
Ø2**	YES	NO	NO	NO
AIR*	NO	NO	NO	YES

4. All expendable supplies are determined as proportional to resupply period.

5. Emergency equipment and supplies are computed as a function of emergency period.

Figure 2-2 (a) (concluded) - Mission Analysis Data - Level 2

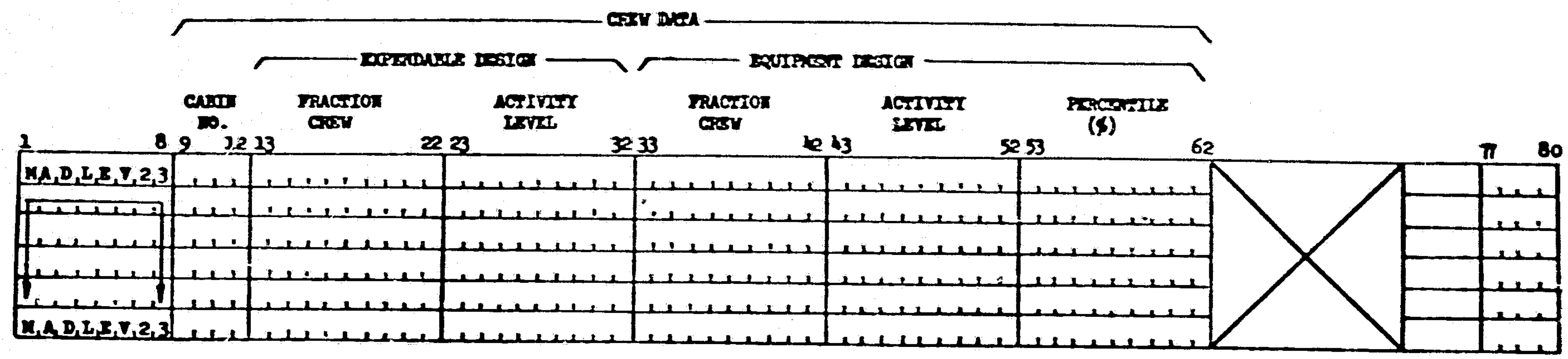


MADLEV22

Card Column	Fortran Format	Fortran Name	Definition
9-12	I4	NCØMPS	Number of occupied cabins
13-22		CABVØL(1)	
23-32		(2)	
33-42		(3)	
43-53	E10.0	(4)	Cabin Volumes, m^3
53-62		(5)	
63-72		(6)	

NOTE: A LSS will be determined for each occupied cabin.

Figure 2-2 (b) - Mission Analysis Data - Level 2



MADLEV23

Card Column	Fortran Format	Fortran Name	Definition
9-12	I4	NCAB	Cabin number to which remainder of data on this card applies
13-22	E10.0	FNCREW(NCAB)	Fraction of crew in this cabin - used to determine expendable supplies (1)
23-32	E10.0	NACTL(NCAB)	Metabolic activity level in this cabin - used to determine expendable supplies (1)
33-42	E10.0	FHCREW(NCAB)	Fraction of crew in this cabin - used to size LSS equipment (1)

Figure 2-2 (c) - Mission Analysis Data - Level 2

Card Column	Fortran Format	Fortran Name	Definition
43-52	E10.0	HACTL(NCAB)	Metabolic activity level in this cabin - used to size LSS equipment (1)
53-62	E10.0	PERCEN	Crew percentile - used to determine basal metabolic rate for this cabin, %

NOTES:

1. Three combinations of the two metabolic activity levels and the two crew fractions are used to determine the LSS characteristics.

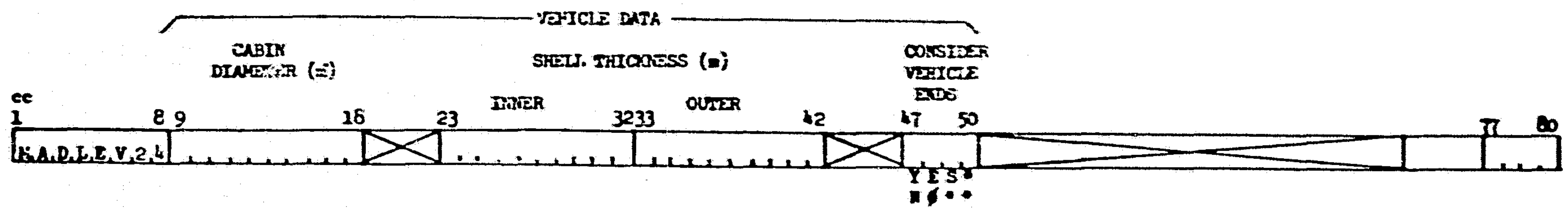
2. All expendable supplies are determined on the basis of "mean" activity level NACTL and the "nominal" crew fraction FNCREW. It is recommended that the sum of FNCREW over all occupied cabins be equal to 1.0.

3. All equipment whose design is sensitive to metabolic level, is sized as a unction of the "high" activity level HACTL. Equipment which appears in each cabin is also sized on the basis of the crew fraction FHCREW. It is not necessary that the sum of FHCREW over all cabins to be unity as sums greater than one may be used to specify redundant equipment. Equipment appearing only in the last cabin or for the vehicle as a whole is designed on the basis of HACTL and the "nominal" crew fraction FNCREW.

4. Both activity levels, NACTL and HACTL, are defined as the ratio of design metabolic rate to basal metabolic rate.

5. One of these cards is required for each occupied cabin.

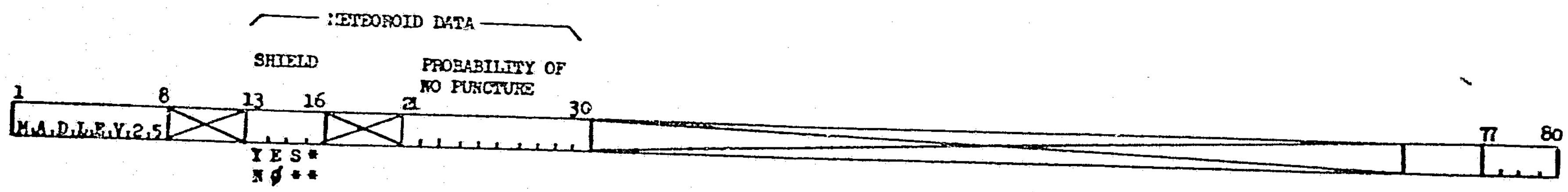
Figure 2-2 (c) (concluded) - Mission Analysis Data - Level 2



MADLEV24

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	CABDIA	Cabin diameter, m
23-32	E10.0	PRTHK	Thickness of inner pressure shell, m
33-42	E10.0	THKMIN	Thickness of outer shell - radiator fin, m
47-50	A4	CABEND	Specifies presence of vehicle ends for insulation, meteoroid shield and radiation shield requirements.

Figure 2-2 (d) - Mission Analysis Data - Level 2



MADLEV25

Card Column	Fortran Format	Fortran Name	Definition
13-16	A4	METPRT	Specifies requirement for meteoroid protection.
21-30	E10.0	PUNCPB	Probability of no meteoroid puncture - if meteoroid protection is specified.

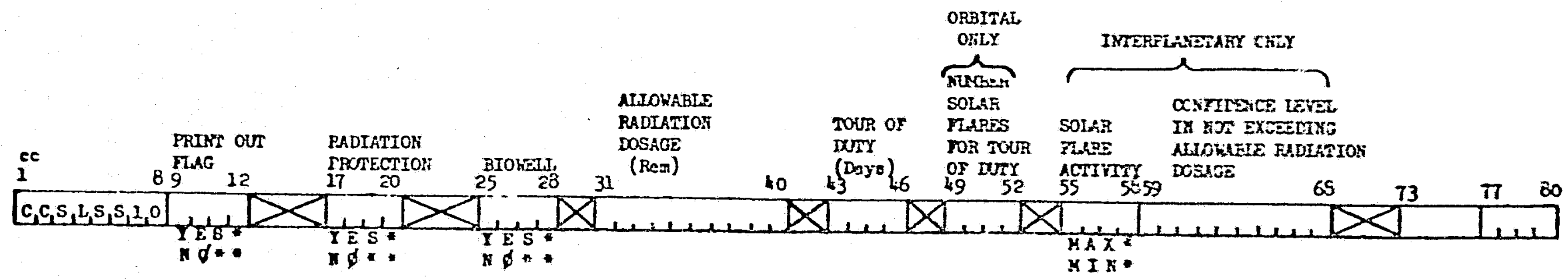
Figure 2-2 (e) - Mission Analysis Data - Level 2

2.2.2 Life Support System - Trade-Off Data

The Trade-Off Data consists of input items which specify the nature of the LSS of interest, and selects the functional methods used and the operation of the equipment components. For convenience, these data are split into sub-groups according to subsystem. These data should appear in the Baseline Cases in entirety. For the Change Case, only the cards containing the particular items to be changed need appear; however, these cards should have all items entered, including those which are not changed. These data are defined and the loadsheets are shown for each subsystem in the following figures. The following is an index for figures 2-3 to 2-8:

NOTE: All LSS equipment which exchanges heat with the heating and/or cooling fluid require an entry specifying the temperature level of these fluids. These temperature level entries correspond to the fluid inlet temperatures as specified on the TCSLSS01 card. The correspondence between the temperature level entry and the actual temperatures is:

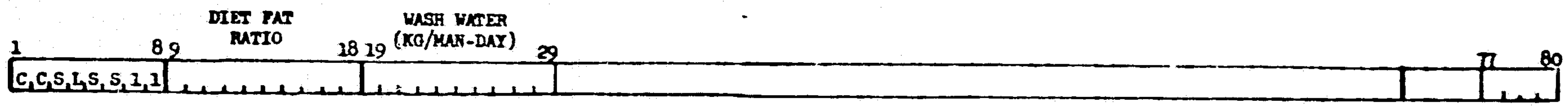
Temperature Level Entry	Location of inlet temperature input value on TCSLSS01 card	
	cooling fluid	heating fluid
1LØW	cc9-18 (CLEVL1)	41-50 (HLEVL1)
2MED	19-28 (CLEVL2)	51-60 (HLEVL2)
3HIH	29-38 (CLEVL3)	61-70 (HLEVL3)



CCSLSS10

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	CCSPØ	Engineering Data printout option
17-20	A4	RDSHLD	Radiation protection option
25-28	A4	BIØCAB	Specifies a Biowell for Solar Flare Radiation protection
31-40	E10.0	DØSE	Allowable radiation dosage, REM
43-46	I4	TØUR	Tour of duty for crewmen, days
49-52	I4	NFLARE	Number of solar flares for tour of duty for an orbital mission
55-58	A4	SLRMAX	Specifies whether solar flare activity is at the maximum or minimum level (for an interplanetary mission)
59-68	E10.0	CØNLEV	Confidence level is not exceeding allowable radiation dosage - probability that allowable dose will not be exceeded

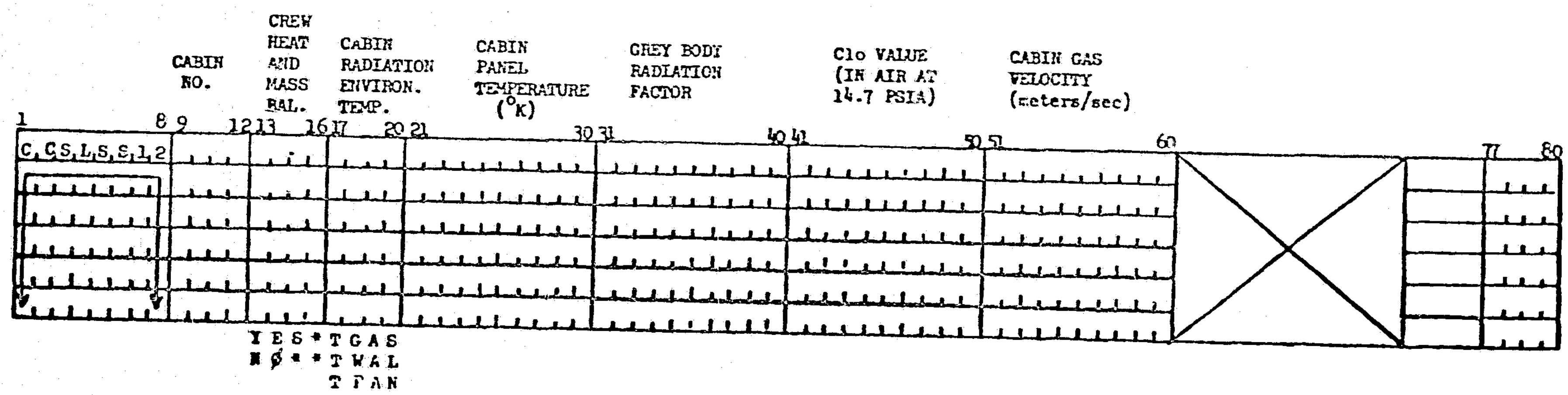
Figure 2-3 (a) - LSS-TOD - Crew and Crew Support



CCSLSS11

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	FR	Ratio of fat to carbohydrates in crewmen diet.
19-29	E10.0	H2ØWAS	Wash water required per crewman, k grams/day

Figure 2-3 (b) - LSS-TOD - Crew and Crew Support



CCSLSS12

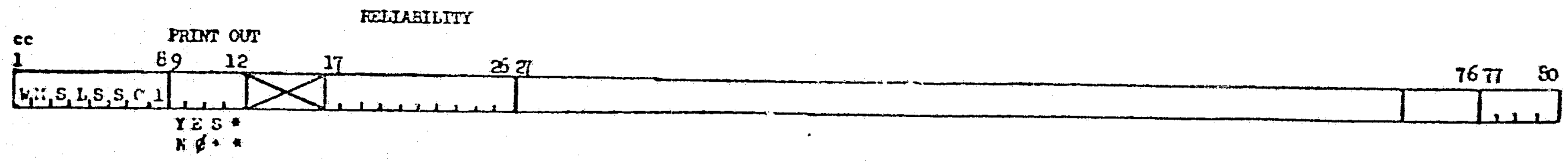
Card Column	Fortran Format	Fortran Name	Definition
9-12	I4		Cabin number (1 to 6).
13-16	A4	CMTBAL	Specifies whether a mass and heat balance is desired for crewmen in Cabin I
17-20	A4	TRADS	Specifies the environmental temperature to which crewmen radiates in Cabin I
21-30	E10.0	TPANL	Temperature for panel in Cabin I to which crewmen radiate, ^{o}K

Figure 2-3 (c) - LSS-TOD - Crew and Crew Support

Card Column	Fortran Format	Fortran Name	Definition
31-40	E10.0	FA	Grey body radiation factor between crewmen and environmental temperature to which radiates
41-50	E10.0	CLØ	Clo value for crewmen clothing in Cabin I (in air at 14.7 psia). Clo value is a measure of resistance of clothing to heat transfer. One Clo is defined as 155 $\frac{m^2\text{-}k}{kwatt}$
51-60	E10.0	VELG	Velocity for gas flowing past crewmen in Cabin I, meters/sec

NOTE: Use one of these cards for each occupied cabin.

Figure 2-3 (c) (concluded) - LSS-TOD - Crew and Crew Support



WMSLSS01

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	WMSPØ	Specifies engineering data print out
17-26	E10.0	WMSREL	Reliability for waste management system

Figure 2-4 (a) - LSS-TOD - Waste Management

METHOD OF URINE COLLECTION

METHOD OF URINE DISP... (for Air Entrainment Urinal)

1–8	9–30	33–64	67–70
WMSLSS02	PERSØNAL*URINE*BAG****	ØVERBØARD*DUMP*TRANSF...	YES*
	ØVERBØARD*VENT*URINAL*	ACCUM*FØR*URINE*RECØV*ØR*STORAGE	NØ**
	AIR*ENTRAINMENT*URINAL		

WMSLSS02

Card Column	Fortran Format	Fortran Name	Definition
9-30	A4	URCØL	Selects method of urine collection to be used (1)
33-64	A4	AEUTRL	Selects method of urine disposal to be used when using air entrainment urine collector (2)
67-70	A4	AEURST	Specifies whether urine storage tanks are required (used in conjunction with air entrainment urinal)

NOTES: 1. The acceptable entries for method of urine collection during normal spacecraft operations.

ENTRY	METHOD OF COLLECTION
PERSONAL*URINE*BAG****	Personal urine bags and storage containers are to be used.

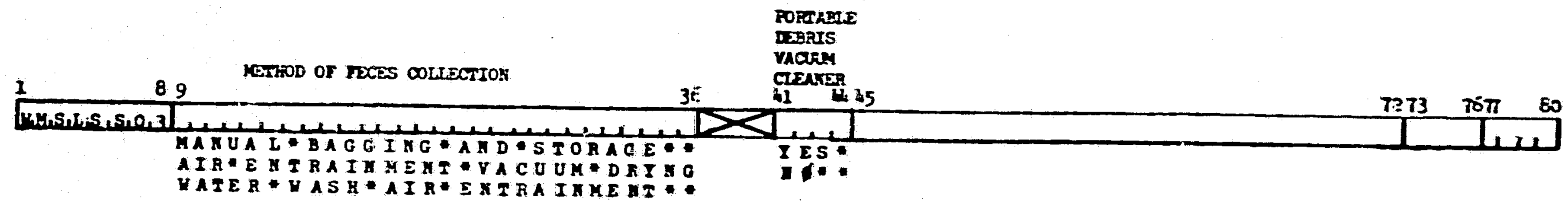
Figure 2-4 (b) - LSS-TOD - Waste Management

ENTRY	METHOD OF COLLECTION
ØVERBØARD*VENT*URINAL*	A cone shaped urine collector connected to an overboard transfer line is to be used.
AIR*ENTRAINMENT*URINAL	An air entrainment urinal with cone shaped urine collector, blower, filter, urine/gas separator is to be used. This device may be connected to an overboard dump transfer line or an accumulator for use in conjunction with a urine storage or water recovery system.

2. The acceptable entries for the method of urine disposal when using an air entrainment urinal are:

ENTRY	METHOD COLLECTION
ØVERBØARD*DUMP*TRANSFER*LINE****	The air entrainment urinal is to be connected to an overboard dump transfer line.
ACCUM*FOR*URINE*RECOV*OR*STORAGE	The air entrainment urinal is to be connected to an accumulator for use in conjunction with a urine storage or water recovery system.

Figure 2-4 (b) (concluded) - LSS-TOD - Waste Management



WMSLSS03

Card Column	Fortran Format	Fortran Name	Definition
9-36	A4	FCLSYS	Selects method of feces collection to be used.
41-44	A4	DEBCØL	Specifies whether a portable debris vacuum cleaner is to be provided for each cabin.

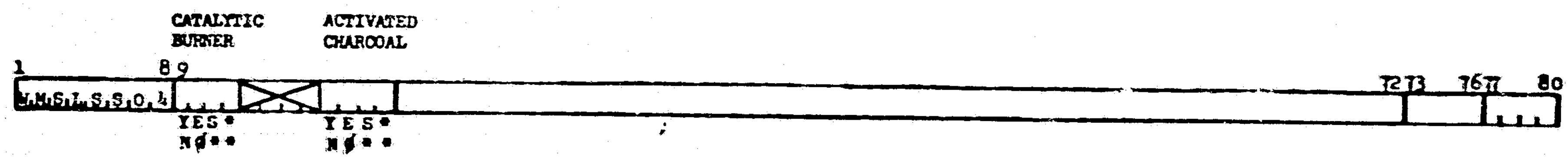
NOTE: The acceptable method of feces collection during normal operation are:

ENTRY	METHOD OF COLLECTION
MANUAL*BAGGING*AND*STØRAGE**	An air entrainment collector with vacuum drying of the feces is to be used

Figure 2-4 (c) - LSS-TOD - Waste Management

ENTRY	METHOD OF COLLECTION
AIR*ENTRAINMENT*VACUUM*DRYING	An air entrainment collector with vacuum drying of the feces is to be used.
WATER*WASH*AIR*ENTRAINMENT***	An air entrainment collector with water wash of crewmen and formation of a fecal slurry is to be used.

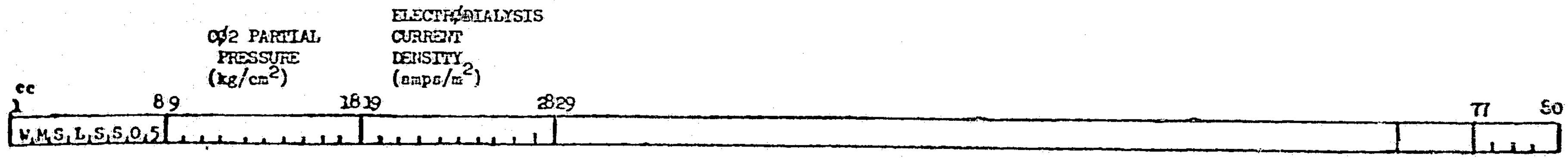
Figure 2-4 (c) (concluded) - LSS-TOD - Waste Management



WMSLSS04

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	CATBRN	Specifies whether a catalytic burner is to be provided for each cabin
17-20	A4	ACTCHL	Specifies whether an activated charcoal bed is to be provided for each cabin

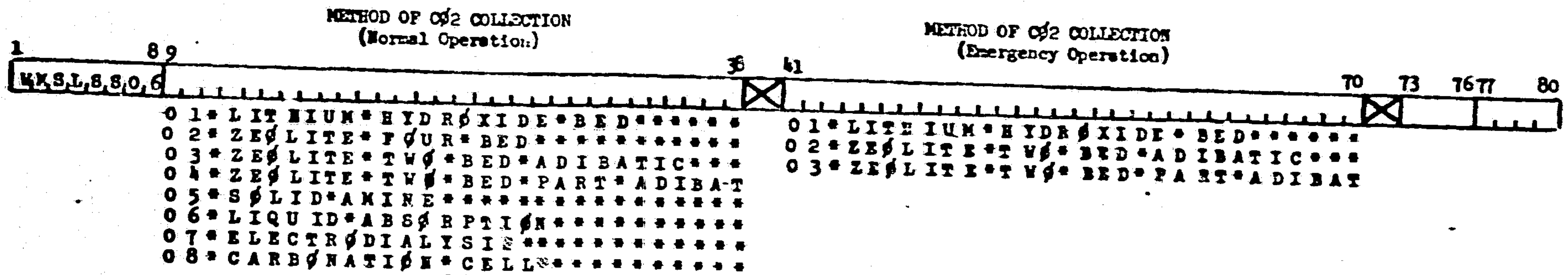
Figure 2-4 (d) - LSS-TOD - Waste Management



WMSLSS05

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	PCØ2	Partial pressure for CO_2 in cabin, kg/cm^2
19-28	E10.0	CURDEN	Electrical current density for Electrodialysis CO_2 collector, $amps/meter^2$

Figure 2-4 (e) - LSS - TOD - Waste Management



WMSLSS06

Card Column	Fortran Format	Fortran Name	Definition
9-38	I2, 7A4	CØ2CØL	Selects method of CO_2 collection to be used in each cabin for normal operation period
41-70	I2, 7A4	ECØ2CL	Selects method of CO_2 collector to be used in each cabin during emergency operation period

NOTE: The acceptable methods of CO_2 collection during normal operation are:

ENTRY	METHOD OF COLLECTION
01*LITHIUM*HYDRØXIDE*BED******	A lithium hydroxide bed is to be provided in the air purification loop. (can be used during normal and emergency operations)

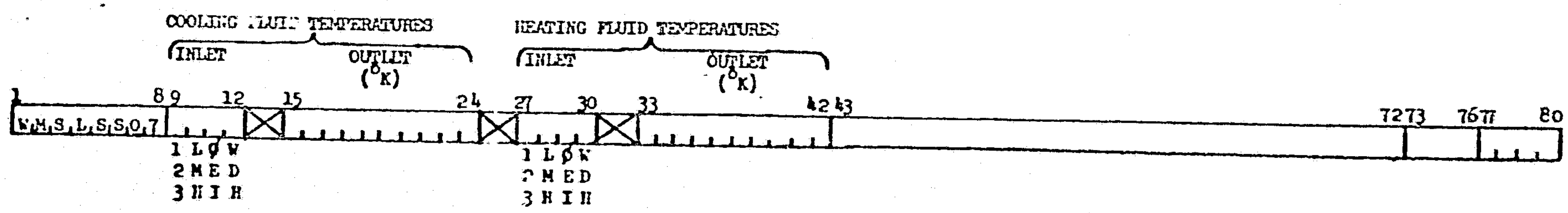
Figure 2-4 (f) - LSS-TOD - Waste Management

ENTRY	METHOD OF COLLECTION
02*ZEØLITE*FØUR*BED***********	A four bed (2 silica gel and 2 synthetic zeolite) system is to be used. One pair of silica gel and zeolite beds is used to adsorb water vapor and CO_2 respectively while the other beds are being desorbed. The beds are cooled with a refrigerant during the adsorption cycle in order to provide an approximately isothermal condition in the beds. The beds are heated with hot fluid during the desorption part of the cycle. (Can be used only during normal spacecraft operations.)
03*ZEØLITE*TWØ*BED*ADIABATIC***	A two bed adsorption/desorption system is to be used. Each bed contains two types of synthetic zeolites. One type for adsorbing water vapor, the other for CO_2. The system is adiabatic with no cooling provided during the adsorption portion of the cycle and no heating provided during desportion. (Can be used during normal and emergency spacecraft operations.)
04*ZEØLITE*TWØ*BED*PART*ADIABAT	A two bed partially adiabatic adsorption/desorption system is to be used. Each bed contains a portion of silica gel material for adsorbing water vapor, and a portion of synthetic zeolite for adsorbing CO_2. Cooling and heating fluids are used to maintain approximately isothermal conditions in the silica gel portion of the beds. The zeolite portion of the beds are operated adiabatically. (Can be used during normal and emergency spacecraft operations.)
05*SØLID*AMINE*****************	Solid ammines are to be used for CO_2 adsorption (can be used only during normal spacecraft operation.)

Figure 2-4 (f) (continued) - LSS-TOD - Waste Management

ENTRY	METHOD OF COLLECTION
06*LIQUID*ABSØRPTIØN**********	Liquid absorption is to be used (Can be used only during normal spacecraft operation.).
07*ELECTRØDIALYSIS************	Electrodialysis is to be used. (Can be used only during normal spacecraft operation.)
08*CARBØNATIØN*CELL***********	Liquid carbonation cells are to be used. (Can be used only during normal spacecraft operations.)

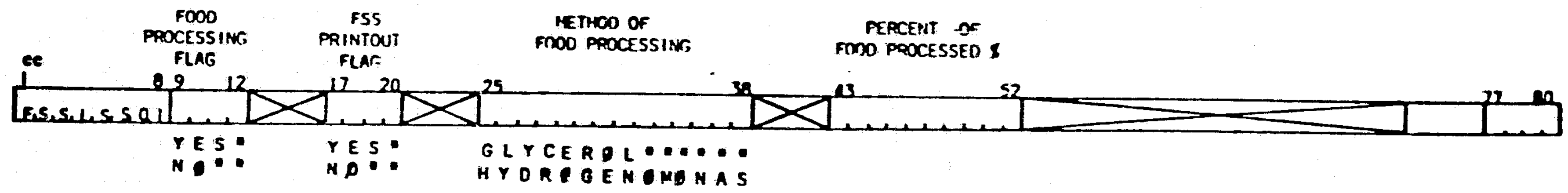
Figure 2-4 (f) (concluded) - LSS-TOD - Waste Management



WMSLSS07

Card Column	Fortran Format	Fortran Name	Definition
9-17	I1, A3	NAME09	Specifies the cooling fluid inlet temperature level for CO_2 collector.
15-24	E10.0	TCØ2C2	Temperature for cooling fluid at outlet of CO_2 collector, °K
27-30	I1, A3	NAME10	Specifies the heating fluid inlet temperature level for CO_2 collector
33-42	E10.0	THCØ2H2	Temperature for heating fluid at outlet of CO_2 collector, °K

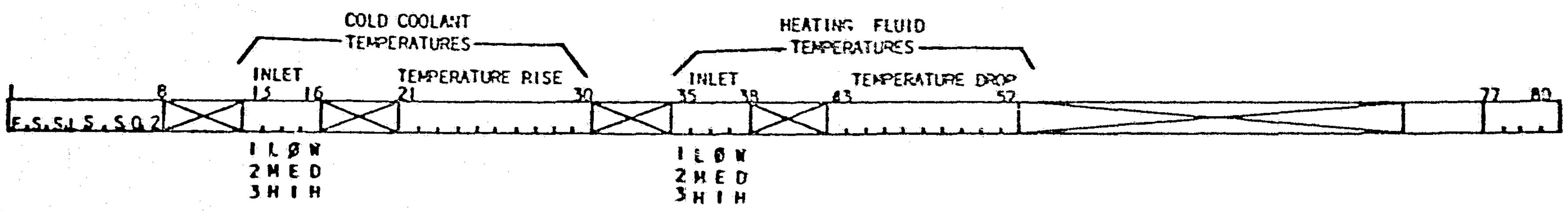
Figure 2-4 (g) - LSS-TOD - Waste Management



FSSLSS01

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	FPRØC	Specifies food processing
17-20	A4	FPRINT	Specifies food supply system engineering data printout
25-38	3A4, A2	FMETH	Selects method of food processing
43-52	E10.0	FPERC	Maximum percent of food processed, percent

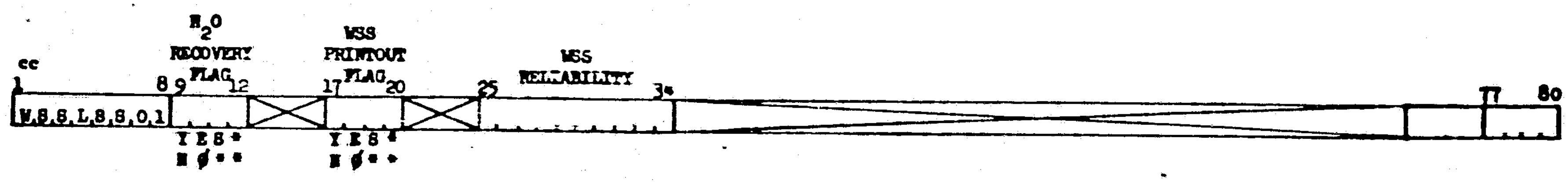
Figure 2-5 (a) - LSS-TOD - Food Supply



FSSLSS02

Card Column	Fortran Format	Fortran Name	Definition
13-16	A4	NAME13	Cooling fluid temperature level
21-30	E10.0	TCFD2	Cooling fluid temperature rise, ^oK
35-38	A4	NAME14	Heating fluid temperature level
43-52	E10.0	THFD2	Heating fluid temperature drop, ^oK

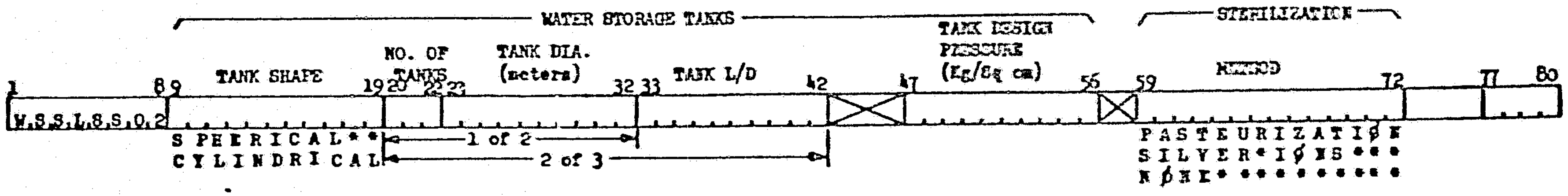
Figure 2-5 (b) - LSS-TOD - Food Supply



WSSLSS01

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	H2ØRFL	Specifies water recovery
17-20	A4	WSSPØF	Specifies water supply subsystem engineering data printout
25-34	E10.0	WSSREL	Water supply subsystem reliability

Figure 2-6 (a) - LSS-TOD- Water Supply



WSSLSS02

Card Column	Fortran Format	Fortran Name	Definition
9-19	2A4, A3	SHAPE	Selects water tank shape
20-22	I3	NØTANK	Number of water tanks (1)
23-32	E10.0	H2ØDIA	Water tank diameter, meters (1)
33-42	E10.0	CYLLØD	Tank length/diameter, dimensionless (1)
47-56	E10.0	PMTANK	This entry not used.
59-72	3A4, A2	STERIL	Water sterilization method

Figure 2-6 (b) - LSS-TOD - Water Supply

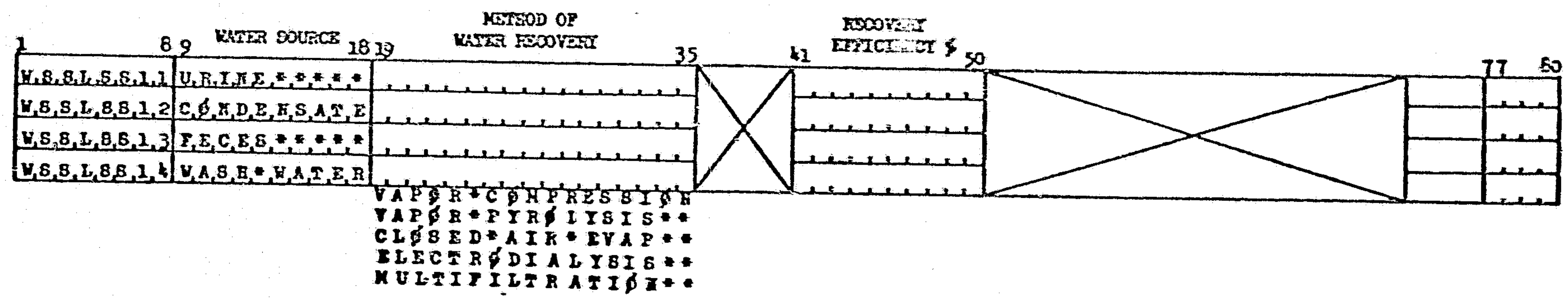
NOTES:

1. When spherical tanks are specified only one of either number of tanks or tank diameter may be entered.

2. When cylindrical tanks are selected only two of either number of tanks, tank diameter or tank length to diameter ratio may be entered.

3. When the number of tanks entry is not made, the program will calculate the fewest integral number of tanks whose diameter is less than that entered.

Figure 2-6 (b) (concluded) - LSS-TOD - Water Supply

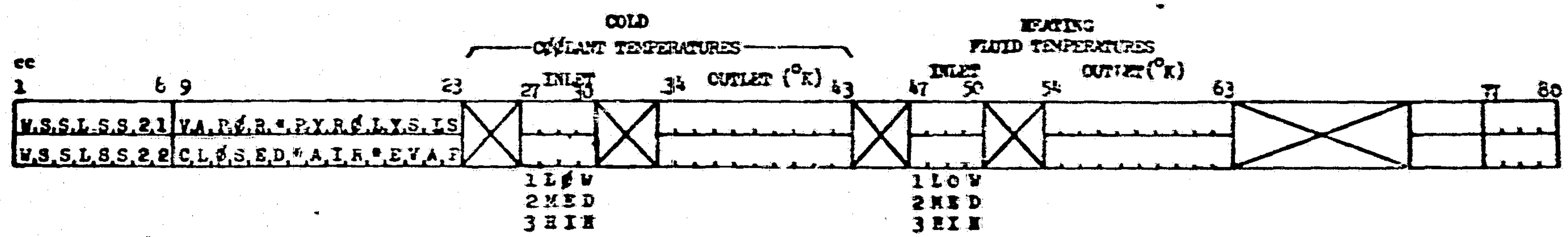


WSSLSS11
WSSLSS12
WSSLSS13
WSSLSS14

Card Column	Fortran Format	Fortran Name	Definition
19-35	4A4, A1	XB1	Water recovery method
41-50	E10.0	XB2	Water recovery efficiency, percent

NOTE: Above cards need not be filled out if their respective water sources are not be recovered.

Figure 2-6 (c) - LSS-TOD - Water Supply



WSSLSS21

Card Column	Fortran Format	Fortran Name	Definition
27-30	I1	NAME07	Vapor pyrolysis cooling fluid temperature level
34-43	E10.0	T2VPPY	Vapor pyrolysis cooling fluid temperature rise, °K
47-50	I1	NAME08	Vapor pyrolysis heating fluid temperature level
54-63	E10.0	THVPVR	Vapor pyrolysis heating fluid temperature drop, °K

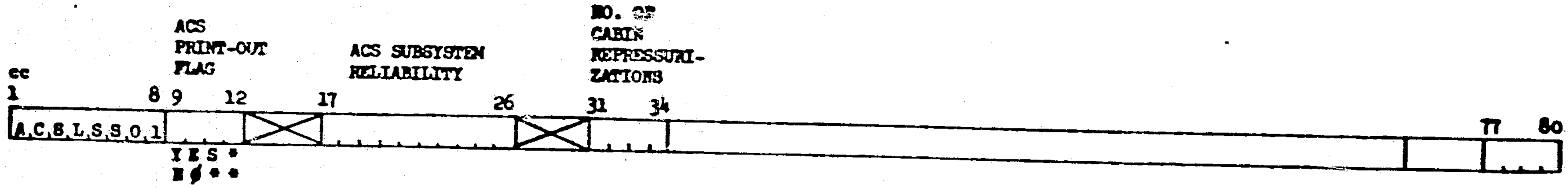
WSLSS22

Card Column	Fortran Format	Fortran Name	Definition
27-30	I1	NAME07	Closed air evaporation cooling fluid temperature level
34-43	E10.0	T2CAEP	Closed air evaporation cooling fluid temperature rise, °K

Figure 2-6 (d) - LSS-TOD - Water Supply

Card Column	Fortran Format	Fortran Name	Definition
47-50	I1	NAME08	Closed air evaporation heating fluid temperature level
54-63	E10.0	THCAEP	Closed air evaporation heating fluid temperature drop, ^{o}K

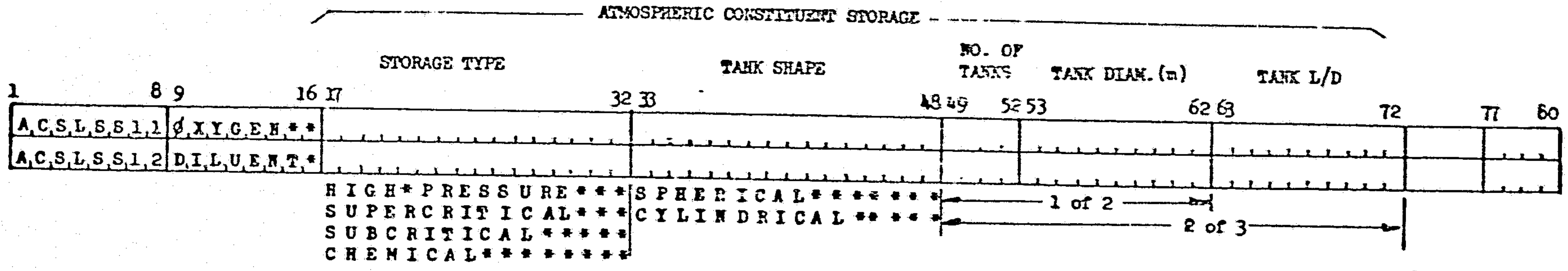
Figure 2-6 (d) (concluded) - LSS-TOD - Water Supply



ACSLSS01

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	ACSPØ	Specifies engineering data printout
17-26	E10.0	ACSREL	ACS reliability
31-34	I4	NØREPR	Number of cabin atmosphere repressurizations per mission.

Figure 2-7 (a) - LSS-TOD - Atmosphere Control



ACSLSS11

Card Column	Fortran Format	Fortran Name	Definition
17-32	4A4	XA12	Selects oxygen storage method if oxygen is to be stored in elemental form.
33-48	4A4	XA3	Select shape of oxygen storage tank(s)
49-52	I4	NØ	Number of tanks used for oxygen storage (1)
53-62	E10.0	DIAM	Diameter of oxygen storage tank(s), meter (1)
63-72	E10.0	LØVD	Length of diameter ratio of cylindrical oxygen storage tanks (1)

Figure 2-7 (b) - LSS-TOD Atmosphere Control

ACSLSS12

Card Column	Fortran Format	Fortran Name	Definition
17-32	4A4	XA12	Selects diluent storage method (2)
33-48	4A4	XA3	Selects shape of diluent storage tank(s)
49-52	I4	NØ	Number of diluent storage tank(s) to be used (1)
53-62	E10.0	DIAM	Diameter of diluent storage tank(s), meters (1)
63-72	E10.0	LØVD	Length to diameter ratio of cylindrical diluent storage tanks (1)

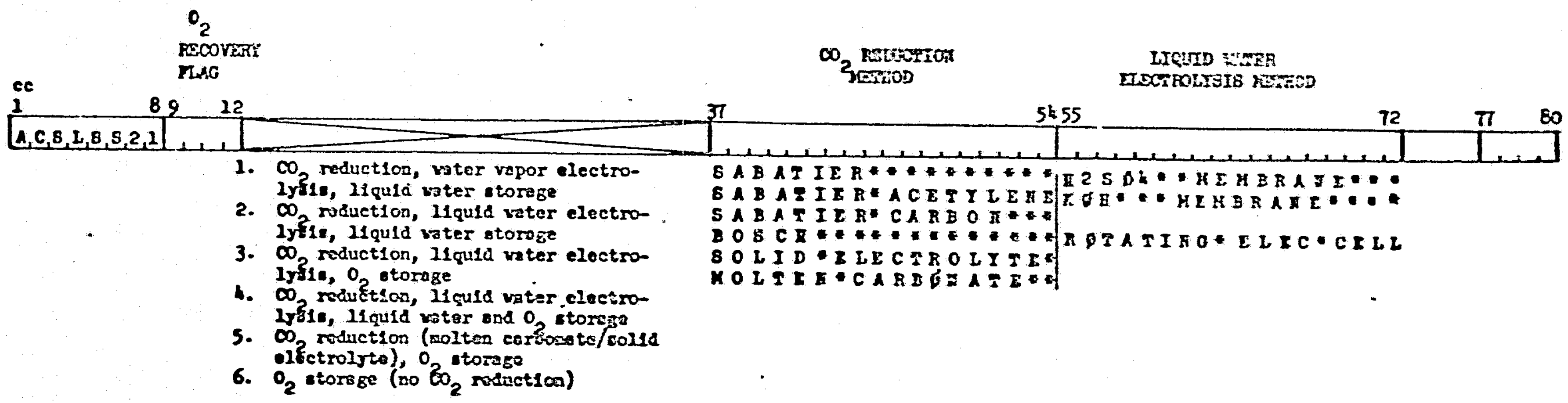
NOTES: 1. (a) When spherical tanks are specified only one of either number of tanks or tank diameter may be entered.

(b) When cylindrical tanks are selected, only two of either number of tanks, tank diameter or tank length to diamter ratio may be entered.

(c) When the number of tanks entry is not made, the program will calculate the fewest integral number of tanks whose diameter is less than that entered.

2. Subcritical storage may not be specified with helium diluent.

Figure 2-7 (b) (Concluded) - LSS-TOD - Atmosphere Control



ACSLSS21

Card Column	Fortran Format	Fortran Name	Definition
9-12	I4	JM	Specifies CO_2 reduction, if desired, and selects O_2 makeup source (1)
37-54	A3, 3A4, A3	XA1	Selects particular functional method of CO_2 reduction.
55-72	4A4, A2	XA2	Selects particular functional method of water electrolysis.

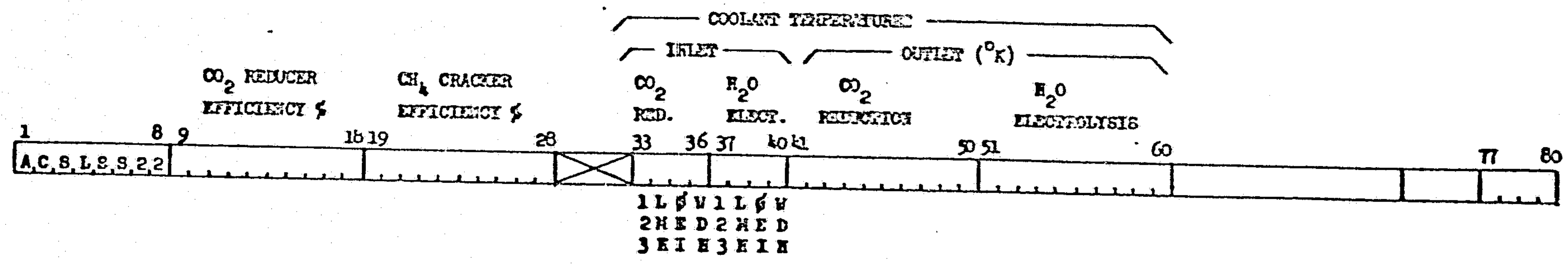
Figure 2-7 (c) - LSS-TOD - Atmosphere Control

NOTES: 1. (a) An entry of 1 through 6 selects make-up O_2 source and selects the CO_2 reduction components, if any.

(b) An entry of 1 through 4 specifies a Bosch or Sabatier type reduction along with its groups of functional components as listed as sub-Procedure I through IV, respectively, in Table 4.2-V, Volume II.

(c) An entry of 5 specifies CO_2 reduction by the Molten Carbonate or Solid Electrolyte process. An entry of 6 specifies O_2 storage without CO_2 reduction (oxygen recovery).

Figure 2-7 (c) (Concluded) -- ISS-TOD - Atmosphere Control

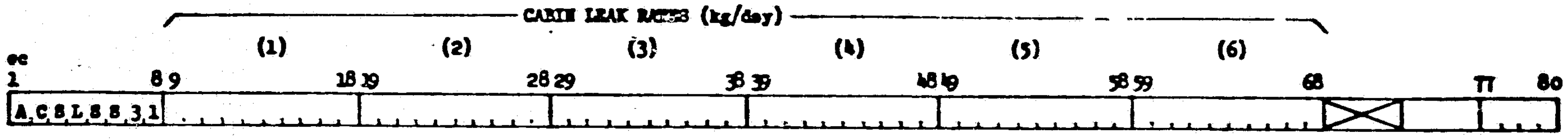


ACSLSS22

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	REDEFF	Efficiency of CO_2 reducer - Sabatier systems only, %
19-28	E10.0	CH4EFF	Methane cracker efficiency - for Sabatier system with acetylene or carbon product, %
33-36	I1, A3	NAME02, XA13	Inlet temperature level of CO_2 reactor coolant.
37-40	I1, A3	NAME03, XA14	Inlet temperature level of liquid electrolysis unit
41-50	E10.0	TØUTRD	Outlet temperature of CO_2 reactor coolant, °K
51-60	E10.0	TØUTLE	Outlet temperature of liquid electrolysis unit, °K

NOTE: Include this card only for systems with O_2 recovery.

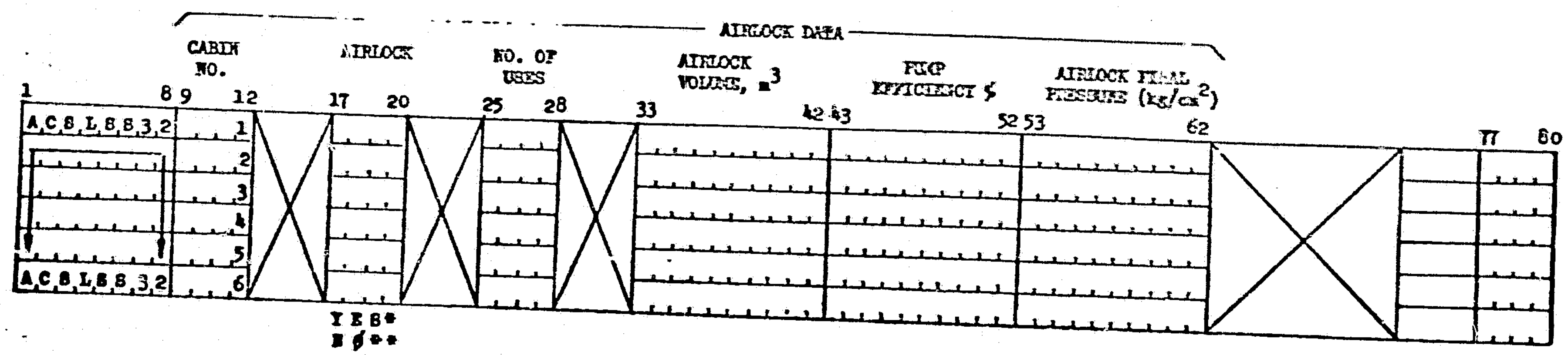
Figure 2-7 (d) - LSS-TOD - Atmosphere Control



ACSLSS31

Card Column	Fortran Format	Fortran Name	Definition
9-18		LEAKRT(1)	
19-28		(2)	
29-38		(3)	
39-48	E10.0	(4)	Cabin atmosphere leak rates, kg/day
49-58		(5)	
59-68		(6)	

Figure 2-7 (e) - LSS-TOD - Atmosphere Control



ACSLSS32

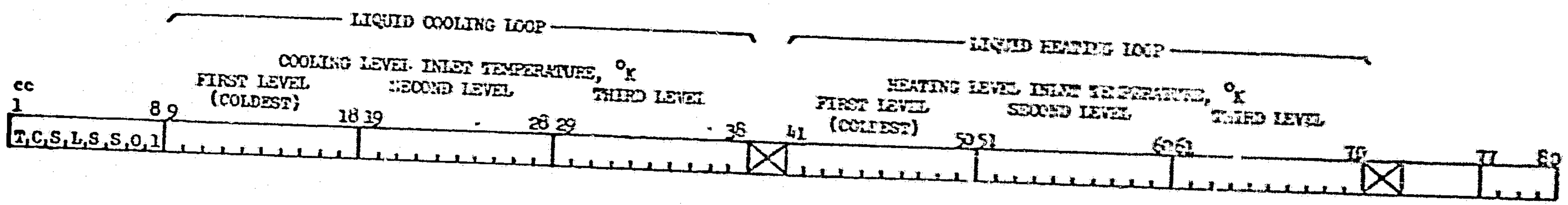
Card Column	Fortran Format	Fortran Name	Definition
9-12	I4		Cabin number (pre-filled)
17-20	A4	AIRLØC	Specifies airlock for this cabin
25-28	I4	NØUSES	Number of airlock uses per mission
33-42	E10.0	LØCVØL	Airlock volume, m^3
43-52	E10.0	PUMPEF	Airlock pump efficiency, percent

Figure 2-7 (f) - LSS-TOD - Atmosphere Control

Card Column	Fortran Format	Fortran Name	Definition
53-62	E10.0	PFINAL	Airlock final pressure, kg/cm^2

NOTE: One of these cards is required for each occupied cabin.

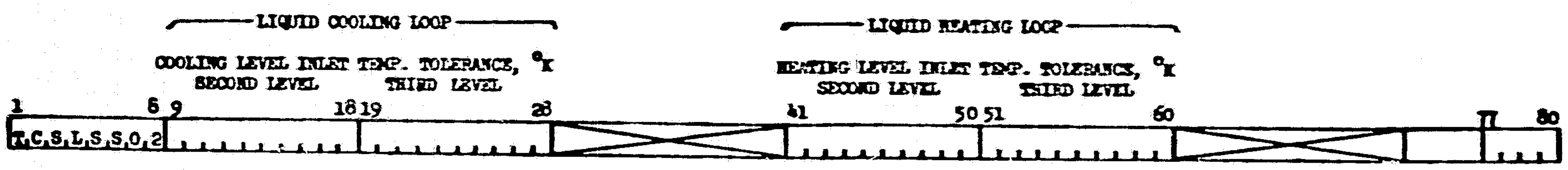
Figure 2-7 (f) (concluded) - LSS-TOD Atmosphere Control



TCSLSS01

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	CLEVL1	Temperature of the coldest level of the cooling loop, °K
19-28	E10.0	CLEVL2	Temperature of the intermediate level of the cooling loop, °K
29-38	E10.0	CLEVL3	Temperature of the warmest level of the cooling loop, °K
41-50	E10.0	HLEVL1	Temperature of the coolest level of the heating loop, °K
51-60	E10.0	HLEVL2	Temperature of the intermediate level of the heating loop, °K
61-70	E10.0	HLEVL3	Temperature of the warmest level of the heating loop, °K

Figure 2-8 (a) - LSS-TOD - Thermal Control

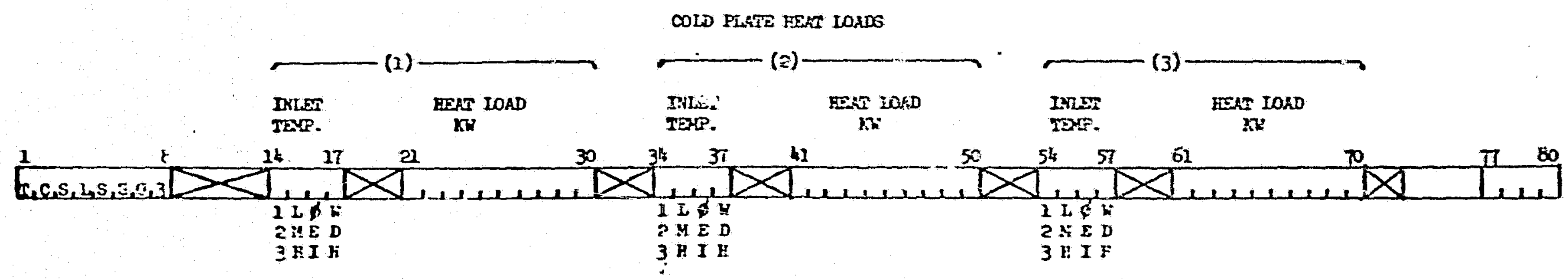


TCSLSS02

Card Column	Fortran Format	Fortran Name	Definition
9-18	E10.0	CTØL2	Temperature tolerance for flow entering intermediate level of cooling loop, °K (1)
19-28	E10.0	CTØL3	Temperature tolerance for flow entering warmest level of cooling loop, °K
41-50	E10.0	HTØL2	Temperature tolerance for flow entering intermediate level of heating loop, °K
51-60	E10.0	HTØL3	Temperature tolerance for flow entering coolest level of heating loop, °K

NOTE: 1. Temperature tolerances entered on card TCSLSS02 permit deviations from the cooling and heating loop design temperatures (CLEVL2, CLEVL3, HLEVL2, and HLEVL3) entered on card TCSLSS01. If no tolerances are entered, the program sets CTØL2, CTØL3, HTØL2, and HTØL3 equal to 0.1 °K.

Figure 2-8 (b) - LSS-TOD- Thermal Control



TCSLSS03

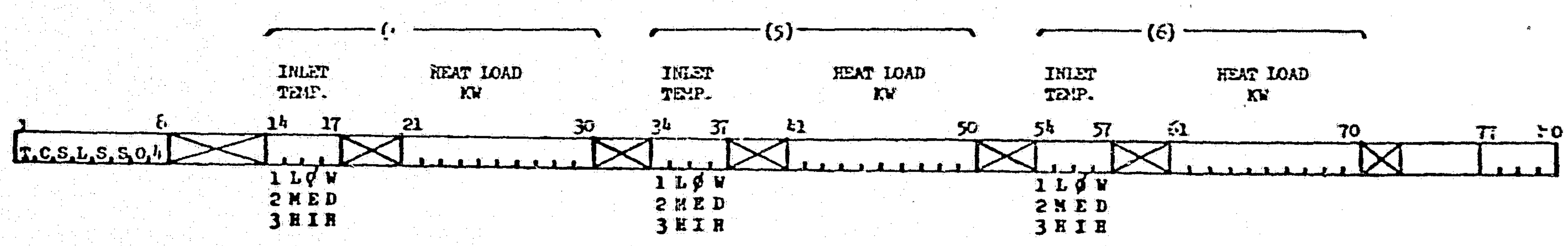
Card Column	Fortran Format	Fortran Name	Definition
14-17	A4	NAME05(1)	Selects level in cooling loop for cold plate no. 1, (1)
21-30	E10.0	QNAM06(1)	Heat load for cold plate no. 1, kw
34-37	A4	NAME06(2)	Selects level in cooling loop for cold plate no. 2, (1)
41-50	E10.0	QNAM06(2)	Heat load for cold plate no. 2, kw
54-57	A4	NAME06(3)	Select level in cooling loop for cold plante no. 3, (1)
61-70	E10.0	QNAM06(3)	Heat load for cold plate no. 3, kw

Figure 2-8 (c) - LSS-TOD - Thermal Control

NOTE: 1. The acceptable level selections for the thermal control system cooling and heating loops are:

ENTRY	
1LØW	Coldest temperature level in loop.
2MED	Medium temperature level in loop.
3HIH	Hottest temperature level in loop.

Figure 2-8 (c) (concluded) - LSS-TOD - Thermal Control



TCSLSS04

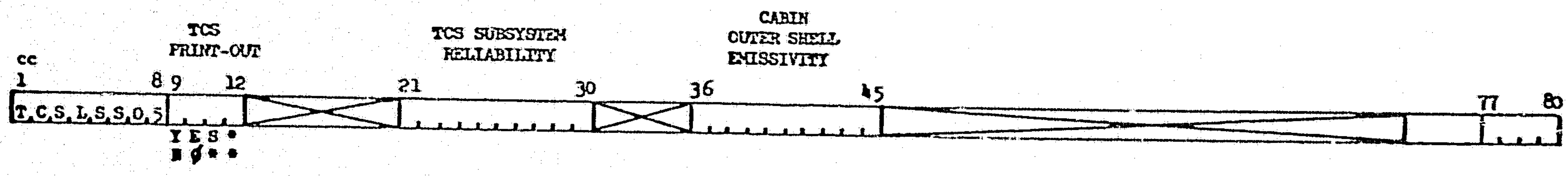
Card Column	Fortran Format	Fortran Name	Definition
14-17	A4	NAME06(4)	Selects level in cooling loop for cold plate no. 4, (1)
31-30	E10.0	QNAM06(4)	Heat load for cold plate no. 4, kw
34-37	A4	NAME06(5)	Selects level in cooling loop for cold plate no. 5 (1)
41-50	E10.0	QNAM06(5)	Heat load for cold plate no. 5, kw
54-57	A4	NAME06(6)	Selects level in cooling loop for cold plate no. 6 (1)
61-70	E10.0	QNAM06(6)	Heat load for cold plate no. 6, kw

Figure 2-8 (d) - LSS-TOD - Thermal Control

NOTE: 1. The acceptable level selections for the thermal control system cooling and heating loops are:

ENTRY	
1LØW	Coldest temperature level in loop.
2MED	Medium temperature level in loop.
3HIH	Hottest temperature level in loop.

Figure 2-8 (d) (concluded) - LSS-TOD - Thermal Control

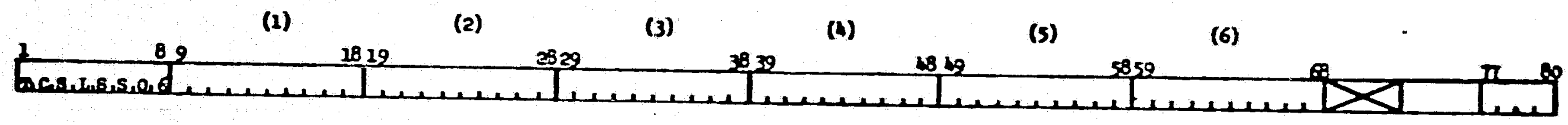


TCSLSS05

Card Column	Fortran Format	Fortran Name	Definition
9-12	A4	NPRNT1	Engineering data printout option.
21-30	E10.0	TCRELI	Thermal control subsystem reliability, decimal
36-45	E10.0	EMITEX	Thermal emissivity of cabin outer shell, dimensionless

Figure 2-8 (e) - LSS-TOD - Thermal Control

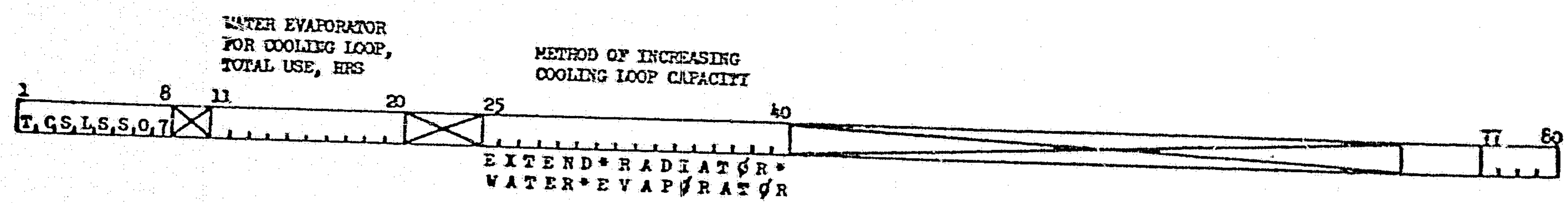
GAS COOLED EQUIPMENT HEAT LOADS, KW
(EXCLUSIVE OF LIFE SUPPORT SYSTEM EQUIPMENT)
CABIN



TCSLSS06

Card Column	Fortran Format	Fortran Name	Definition
9-18		HTMISC(1)	
19-28		HTMISC(2)	
29-38	E10.0	HTMISC(3)	Miscellaneous heat loads (non life support system equipment) cooled by cabin atmosphere.
39-48		HTMISC(4)	
49-58		HTMISC(5)	
59-68		HTMISC(6)	

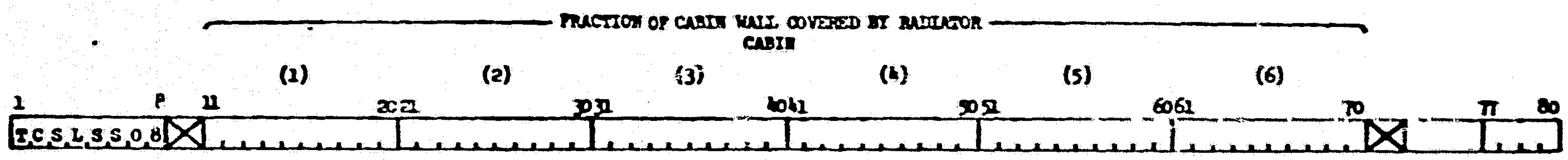
Figure 2-8 (f) - LSS-TOD - Thermal Control



TCSLSS07

Card Column	Fortran Format	Fortran Name	Definition
11-20	E10.0	BOILHR	Total time that the cooling loop water evaporator is used during the mission, hrs
25-40	4A4	MBØIL	Selects extended surface radiator or water evaporators as alternate method of completing the cooling loop capacity.

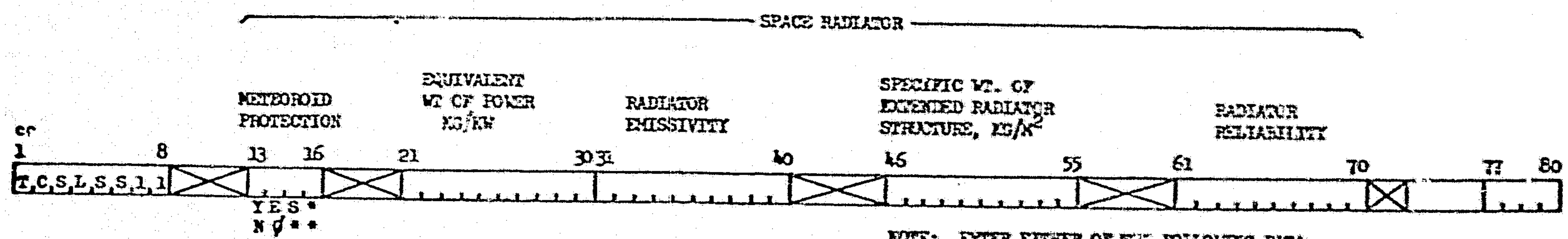
Figure 2-8 (g) - LSS-TOD - Thermal Control



TCSLSS08

Card Column	Fortran Format	Fortran Name	Definition
11-20		FRCRAD(1)	
21-30		(2)	
31-40	E10.0	(3)	Amount of cabin wall surface available for coverage by radiator (decimal):
41-50		(4)	
51-60		(5)	
61-70		(6)	

Figure 2-8 (h) - LSS-TOD - Thermal Control



NOTE: ENTER EITHER OF THE FOLLOWING DATA:

1. CABIN WALL EFFECTIVE SINK TEMPERATURE AND RADIATOR EFFECTIVE SINK TEMPERATURE.
2. THERMAL DESIGN CONDITIONS.

TC6LSS11

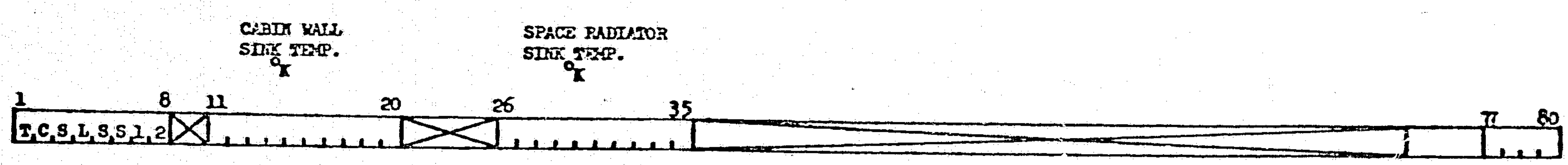
Card Column	Fortran Format	Fortran Name	Definition
13-16	A4	METEØR	Selects option of calculating meteoroid protection requirements for radiator (1)
21-30	E10.0	SPØWER	Equivalent weight of power for optimization analysis of space radiator, - kg/kw
31-40	E10.0	EPSILN	Thermal emissivity of space radiator, dimensionless
46-55	E10.0	STRUCT	Specific weight of extended surface space radiator and its supporting structure, kg/m^2

Figure 2-8 (i) - LSS-TOD - Thermal Control

Card Column	Fortran Format	Fortran Name	Definition
61-70	E10.0	SURVIV	Radiator reliability (probability that not more than one tube of dual tubing system will be punctured during mission)

NOTE: 1. The meteoroid protection option directs the program to calculate a meteoroid bumper thickness and weight for the space radiator. This meteoroid shield is sized to protect the dual radiator tubing from dual puncture to the extent specified by the radiator reliability entry.

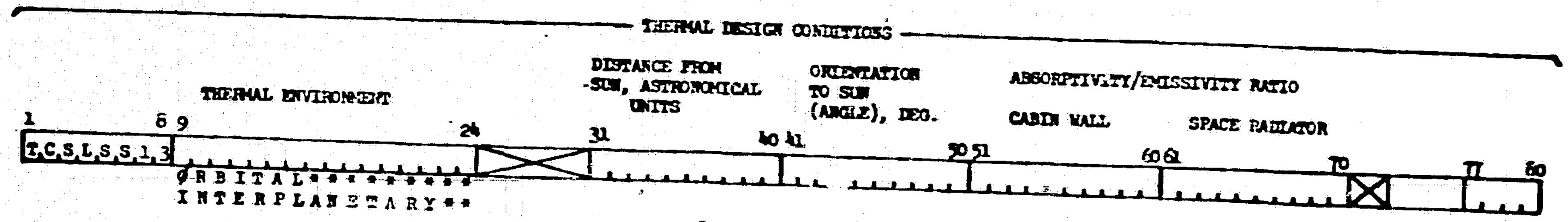
Figure 2-8 (i) - LSS-TOD - Thermal Control



TCSLSS12

Card Column	Fortran Format	Fortran Name	Definition
11-20	E10.0	TSINK1	Sink temperature for cabin outer shell, °K
26-35	E10.0	TSINK	Sink temperature for space radiator, °K

Figure 2-8 (j) - LSS-TOD - Thermal Control



TCSLSS13

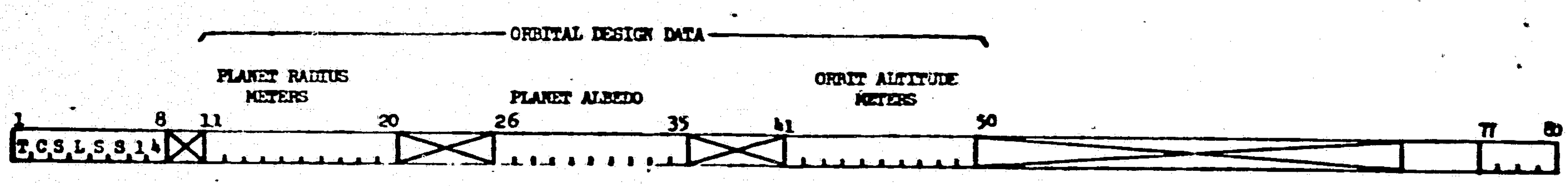
Card Column	Fortran Format	Fortran Name	Definition
9-24	4A4	ØRBITM	Selects orbital or interplanetary thermal environment for calculation of cabin and radiator sink temperatures.
31-40	E10.0	AUHTLK	Vehicle distance from sun, AU
41-50	E10.0	ØRIENT	Angle between the solar vector and the normal to the vehicle centerline, degrees
51-60	E10.0	ABSBEX	Solar absorptivity/thermal emissivity for radiator, dimensionless

NOTE: The acceptable options for the external thermal environment entry of the thermal control subsystem are:

Figure 2-8 (k) - LSS-TOD - Thermal Control

ENTRY	OPTION
ORBITAL*********	The program is to calculate sink temperatures for cabin outer shell and space radiator for planetary orbital conditions. The effect of heat from the planet is included.
INTERPLANETARY**	The program is to calculate sink temperatures for cabin outer shell and space radiator based on solar heat flux only.

Figure 2-8 (k) (Concluded) - LSS-TOD - Thermal Control



TCSLSS14

Card Column	Fortran Format	Fortran Name	Definition
11-20	E10.0	RADPLN	Planet radius, m
26-35	E10.0	ALBEDØ	Planet albedo, dimensionless
41-50	E10.0	ALTØRB	Orbital altitude above planet surface, m

Figure 2-8 (1) - LSS-TOD - Thermal Control

2.2.3 Table Data

The Table Data contains the relationships for determining the LSS equipment output characteristics of weight, volume, or power. Also included as Table Data are the mission trajectories (solar vector as a function of time), subsystem interdependencies of equipment, heat loads, and crew data. The usual relationships have the output characteristics as the dependent variable and appropriate subsystem or mission parameters as the independent variable(s). An individual relationship or table may be expressed in one of two forms, Parametric Relation or Scaling Laws. Data which may be expressed analytically may be entered as Scaling Laws whereas data which are expressed in graphical or tabular form must be entered as Parametric Relation.

All tables must be included in a Baseline Case; however, in a Change Case, only the Tables in which data is to be changed need appear. Either form, Scaling Law or Parametric Relation, may be used to change the data of any table in a Change Case regardless of which form has been used for the Baseline Case version of that Table.

The Table assignments are given in Section 2.2.3.3. These assignments relate each Table by a number to a particular usage and specify the dependent variable and independent variable(s).

2.2.3.1 Scaling Law

The Scaling Laws are those forms of the Table Data in which the output characteristics (dependent variable) can be expressed as an analytical function of the system parameters (independent variables). For example, a typical Scaling Law may be:

$$y = A_1 + A_2 \phi_1^{A_3}$$

where

y is the dependent variable or output characteristic such as weight, volume or power

A_1, A_2, A_3 are the coefficients. These are the specified data entered into the computer.

ϕ_1 is an independent variable or system parameter. These may be such items as the mass flow or mission duration.

This example Scaling Law is the one which defines the weight of the Bosch reactor as a function of the Carbon Dioxide (CO_2) to be processed. This law is:

Bosch reactor

fixed weight (kg) = 13.6 + 97.7 [CO_2 rate (kg/hr)]$^{0.63}$

At present, eight forms of Scaling Laws are available for use and any form may be used for a Change Case regardless of which form was used for the Table data in the Baseline Case.

The eight Scaling Law forms are shown in Table 2-1. The A's represent the coefficients and exponents, and the ϕ's represent the independent variables, in order.

ϕ_1 = 1st independent variable

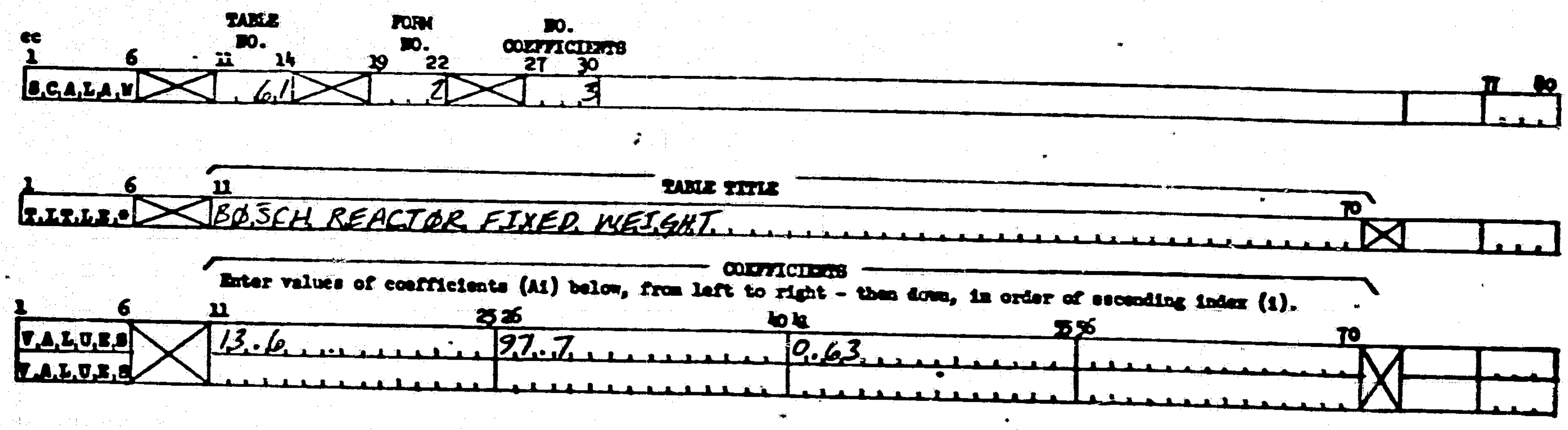
ϕ_2 = 2nd independent variable

Table 2-1

Form No.	Scaling Law Form
1	$A_1 \phi_1 A_2$
2	$A_1 + A_2 \phi_1^{A_3}$
3	$A_1 + A_2 \phi_1 \phi_2$
4	$A_1 \phi_1 + A_2 \phi_2 + A_3 \phi_3$
5	$A_1 + A_2 e^{(A_3 \phi_1)}$ (e is base of natural logarithm)
6	$A_1 + A_2 \phi^{A_3} + A_4 \phi_2^{A_5} + A_6 \phi_1^{A_7} \phi_2^{A_8}$
7	$A_1 + A_2 \phi_1 + A_3 \phi_2 + A_4 \phi_3 + A_5 \phi_4 + A_6 \phi_5$
8	$A_1 + A_2 \phi_1^{A_3} + A_4 \phi_1^{A_5} + A_6 \phi_1^{A_7} \phi_2^{A_8}$

The loadsheet used for Scaling Laws is shown in Figure 2-9. One detail card is used for Scaling Laws with four or less coefficients (Form No. 1 through Form No. 5) and two detail cards are needed for Scaling Laws with five to eight co-efficients (Form No's 6, 7 and 8).

The cards for each Scaling Law must be in sequence, i.e., they must enter the computer in the order in which they appear on the loadsheet. However, the various Scaling Laws and parametric Relations need not enter the computer in any particular order.



SCALAW

Card Column	Fortran Format	Fortran Name	Definition
11-14	I4	NEXT	Table number - See section 2.2.3.3 for assignment of tables.
19-22	I4	NDIM	Scaling law form number - see Table 2-4 for the scaling law forms.
27-30	I4	NPTS1	Number of coefficients or "A's" used in scaling law - number of data values entered on detail cards (including specified zeroes)

Figure 2-9 - Table Data - Scaling Laws

TITLE*

Card Column	Fortran Format	Fortran Name	Definition
11-70	15A4		Any title may be entered here for informative purposes.

VALUES*

Card Column	Fortran Format	Fortran Name	Definition
11-70	4E15.0	X	Scaling law coefficients "A's" enter from left to right until "NPTS1" entries have been made - Use 2nd "VALUES" card only when NPTS1 $\geq$ 5.

Figure 2-9 (Concluded) - Table Data - Scaling Laws

2.2.3.2 Parametric Relations

The Parametric Relations are the form of Table Data in which the output characteristic (dependent variable) is expressed in tabular form with respect to the independent variable(s). A parametric relation may be either two dimensional (one independent variable) or three dimensional (two independent variables). The loadsheets for these parametric relations respectively are shown in Figure 2-10 and 2-11. There are no restrictions on replacing a Table in a Change Case., i.e., a two dimensional Parametric Relation may replace a three dimensional relation in a Change Case. However, all Parametric Relations appearing in a Change Case must be complete, i.e., if only one of a series of data values actually has changed, all data values must be re-entered along with the included header card and title card.

Examples

- Two-Dimensional Parametric Relation

  The following table of crewmen weight as a function of percentile will be used to illustrate the two dimensional parametric relation loadsheet. The Table is:

PERCENTILE	0.0	20.0	40.0	60.0	80.0	95.0
CREWMEN WEIGHT	0.0	66.2	71.2	75.7	79.8	89.4

  The completed loadsheet for this table is shown in Figure 2-10.

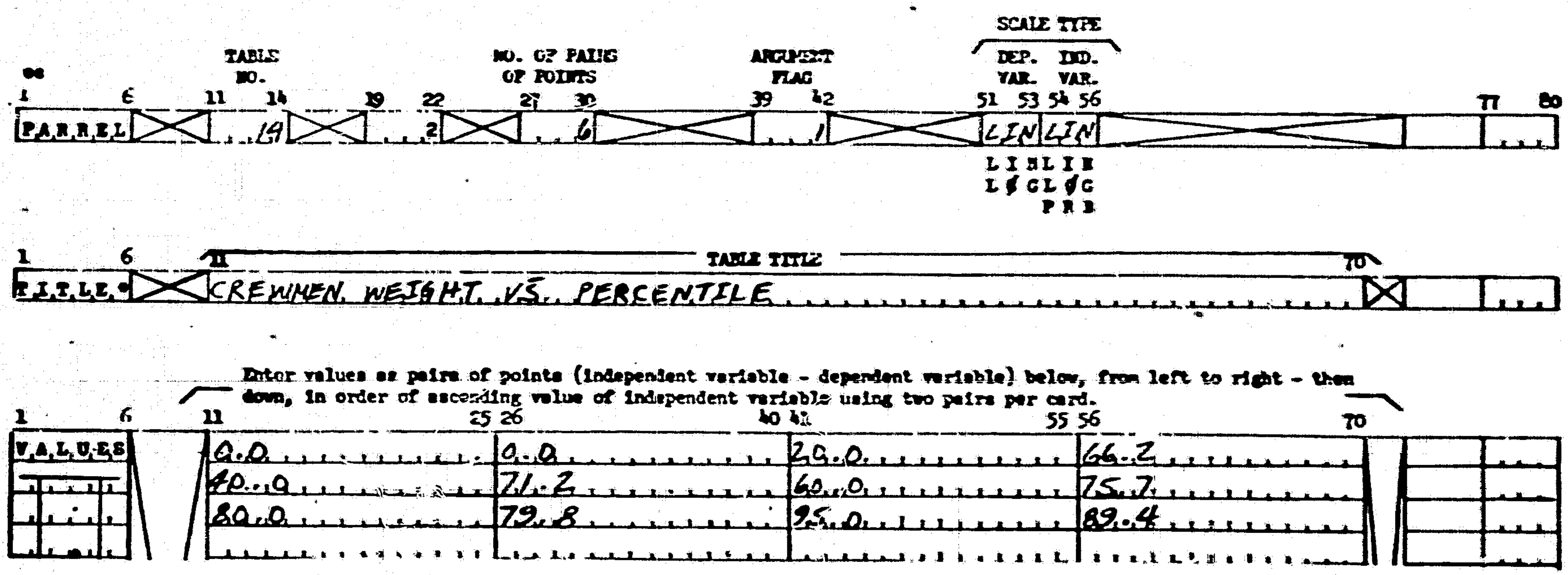
- Three-Dimensional Parametric Relation

  The following table of crewmen operations time as a function of crew size (1st independent variable) and MISSION DURATION (2nd independent variable) will illustrate the use of the three dimensional parametric loadsheet. The table is:

CREW SIZE (1st Ind. Var.)

Mission Duration (2nd Ind. Var.)	3.0	7.0	11.0	16.0
30.0	34.0	85.0	136.0	200.0
60.0	32.0	80.0	128.0	189.0
90.0	24.0	65.0	106.0	158.0
365.0	15.0	45.0	76.0	115.0
730.0	14.0	44.0	74.0	112.0

The complete loadsheet is shown in Figure 2-11 for this table.



PARREL

Card Column	Fortran Format	Fortran Name	Definition
11-14	I4	NEXT	Table number - See Section 2.2.3.3 for assignment of tables.
19-22	I4	NDIM	Parametric Relation dimensionality - enter "2".

Figure 2-10 - Table Data - Parametric Relations (2 dimensional)

Card Column	Fortran Format	Fortran Name	Definition
27-30	I4	NPTS1	Number of pairs of points to follow c detail cards.
39-42	I4	NARG1	Argument flag for independent variable (1)
51-53	A3	DEPVAR	Specifies scale type (linear or logarithmic) of dependent variable (2)
54-56	A3	FIRIV	Specified scale type (linear, logarithmic or probalistic) of independent varialbe (2), (3).
			TITLE
11-70	15A4		Any title may be entered here for informative purposes.
			VALUES
11-70	4E15.0	X	Enter values as pairs of points (independent variable - dependent variable) from left to right placing two pairs on the card. Use subseuqent cards as necessary. Pairs must be entered in order of ascending value of independent variable. See following example.

NOTES: 1. Entering a value of "1" causes the current value of the FØRTRAN name "PHI1" (common block/SWN5/) to be used as the independent variable value.

Entering a value of "2" causes the current value of "PHI2" to be used as the value of the independent variable.

Figure 2-10 (Continued) - Table Data - Parametric Relations (2 dimensional)

2. Entering "LIN" causes the scale of the variable to be treated in a linear fashion - linear interpolation will be used. Entering "LØG" causes the scale of the variable to be treated in a logarithmic manner - logarithmic interpolation will be used. This capability may be employed for parametric relations which appear to more closely follow a straight line on semi-log or log-log paper.

3. Entering "PRB" causes the scale of the variable to be treated in a probalistic fashion. Upon interpolation, the scale is transformed to a logarithmic scale by subtracting scale values from 1.0. Conventional logarithmic interpolation is subsequently employed. The probability option is used for subsystem spares weight as a function of subsystem reliability.

Figure 2-10 (Concluded) - Table Data - Parametric Relations (2 dimensional)

cc 1		TABLE NO. 11–14		22		NO. OF DATA POINTS 1st IND. VAR. 27–30	NO. OF DATA POINTS 2nd IND. VAR. 31–34		ARGUMENT FLAG 1st IND. VAR. 39–42	ARGUMENT FLAG 2nd IND. VAR. 43–45		SCALE TYPE DEP. VAR. 51–53	SCALE TYPE 1st I V 54–56	SCALE TYPE 2nd I V 57–59		77–80
TABLE		18		3		4	5		1	2		LIN	LIN	LIN		

LIN LIN LIN
LØG LØG LØG
PRB PRB

1	6	TABLE TITLE 11–70	
TITLE*		CREWMEN OPERATIONS TIME	

Enter values of 1st independent variable below, from left to right - then down, in order of ascending value.

1	6	11–25	26–40	41–55	56–70	
VALUES		3.0	7.0	11.0	16.0	
VALUES						
VALUES						

Enter values of 2nd independent variable below, from left to right - then down, in order of ascending value.

VALUES		30.0	60.0	90.0		
VALUES						
VALUES						

Enter values of dependent variable below, from left to right - then down, in the order of 2nd independent variable changing most rapidly.

VALUES		34.0	32.0	24.0	15.0	
		14.0	85.0	80.0	65.0	
		45.0	44.0	136.0	128.0	
		106.0	76.0	74.0	200.0	
		189.0	158.0	115.0	112.0	

Figure 2-11 - Table Data - Parametric Relations (3 dimensional)

PARREL

Card Column	Fortran Format	Fortran Name	Definition
11-14	I4	NEXT	Table number - See Section 2.2.3.3 for assignment of tables.
19-22	I4	NDIM	Parametric Relation dimensionality - enter "3".
27-30	I4	NPTS1	Number of values of 1st independent variable to be entered.
31-34	I4	NPTS2	Number of values of 2nd independent variable to be entered.
39-42	I4	NARG1	Argument flag for: 1st independent variable (1)
43-46	I4	NARG2	Argument flag for 2nd independent variable (1)
51-53	A3	DEPVAR	Specifies scale type (linear or logarithmic) of dependent variable (2)
54-56	A3	FIRIV	Specified scale type (linear, logarithmic or probalistic) of 1st independent variable (2), (3)
57-59	A3	SECIV	Specifies scale type of 2nd independent variable (2), (3)
			TITLE*
11-70	15A4		Any title may be entered here for informative purposes.
			VALUES
11-70	4E15.0	X	First Independent Variable: Enter values from left to right placing four values on a card. Use subsequent cards as necessary. Values must be entered in order of ascending value of independent variable.

Figure 2-11 (Continued) - Table Data - Parametric Relations (3 dimensional)

Card Column	Fortran Format	Fortran Name	Definition
			Second Independent Variable: Starting with a new card, repeat procedure followed with first independent variable.
			Dependent Variable: Starting with a new card, enter values from left to right placing four values on a card. Use subsequent cards as necessary. Enter values in order of second independent variable changing most rapidly.

NOTES: 1. Entering a value of "1" causes the current value of the FØRTRAN name "PHI1" (common block/SWN5/) to be used as the independent variable value.

Entering a value of "2" causes the current value of "PHI2" to be used as the value of the independent variable.

2. Entering "LIN" causes the scale of the variable to be treated in a linear fashion - linear interpolation will be used. Entering "LØG" causes the scale of the variable to be treated in a logarithmic manner - logarithmic interpolation will be used. This capability may be employed for parametric relations which appear to more closely follow a straight line on semi-log or log-log paper.

3. Entering "PRB" causes the scale of the variable to be treated in a probalistic fashion. Upon interpolation, the scale is transformed to a logarithmic scale by subtracting scale values from 1.0. Conventional logarithmic interpolation is subsequently employed. The probability option is used for subsystem spares weight as a function of subsystem reliability.

Figure 2-11 (Concluded) - Table Data - Parametric Relations (3 dimensional)

2.2.3.3 Table Assignment

Each Parametric Relation and Scaling Law developed as part of this study have been identified by a specific, respective Table Number. These numbers are entered in cc 11-14 of the PARREL and SCALAW cards, respectively. The functions (dependent variables) as well as the independent variables available to the interpolation subroutine for evaluation of each table respectively are given in the following. Tables are grouped according to Mission Data or Subsystem.

NOTE: Many of the tables in the following list have time as an independent variable. Tables which determine normal use expendables are a function of resupply period. Tables which determine emergency supplies are a function of emergency period. Tables used to determine radiation dosage are based on crewman tour of duty.

MISSION DATA TABLES

Table Number	Dependent Variable	Independent Variable
1	Mission No. 1 solar vector, AU	1. Flight time, days
2	Mission No. 2 solar vector, AU	1. Flight time, days
3	Mission No. 3 solar vector, AU	1. Flight time, days
4	Mission No. 4 solar vector, AU	1. Flight time, days
5	Mission No. 5 solar vector, AU	1. Flight time, days
6	Mission No. 6 solar vector, AU	1. Flight time, days
7	Mission No. 7 solar vector, AU	1. Flight time, days
8	Mission No. 8 solar vector, AU	1. Flight time, days
9	Mission No. 9 solar vector, AU	1. Flight time, days
10	Mission No. 10 solar vector, AU	1. Flight time, days
11	Mission No. 11 solar vector, AU	1. Flight time, days
12	Mission No. 12 solar vector, AU	1. Flight time, days

Table Number	Dependent Variable	Independent Variable
191	Planetary view factors	1. Orbit altitude to planet radius ratio 2. Artificial variable of which a value of 1.0 represents the view factors for planet emitted radiation and 2.0 the solar reflected radiation
114	Reflected solar energy view factors	1. Orbit altitude to planet radius ratio 2. Orientation (from card TCSLSS13)
	Radiation Data	
192	Van Allen radiation dose rate, 0° inclination, Rem/day	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
193	Van Allen radiation dose rate, 28.5° inclination, Rem/day	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
194	Van Allen radiation dose rate, 50° inclination, Rem/day	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
195	Van Allen radiation dose rate, 90° inclination, Rem/day	1. Aluminum shield thickn ess, g/cm^2 2. Altitude, m
196	Solar flare radiation dose rate, 0° inclination, Rem/flare	1. Aluminum shield thickness, g/cm^2 2. Altitude, m.
197	Solar flare radiation dose rate, 35° inclination, Rem/flare	1. Aluminum shield thickness, g/cm^2 2. Altitude, m.
198	Solar flare radiation dose rate, 45° inclination, Rem/flare	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
199	Solar flare radiation dose rate, 50° inclination, Rem/flare	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
200	Solar flare radiation dose rate, 90° inclination, Rem/flare	1. Aluminum shield thickness, g/cm^2 2. Altitude, m
201	*Solar cosmic radiation dose, minimum activity, Rem	1. Aluminum shield thickness, g/cm^2 2. Confidence level

Table Number	Dependent Variable	Independent Variable
202	Solar cosmic radiation dose, maximum activity, Rem	1. Aluminum shield thickness, g/cm^2 2. Confidence level
203	Solar cosmic dose correction factor	1. Crew tour of duty, days 2. Confidence level

WASTE MANAGEMENT SUBSYSTEM TABLES (WMS)

Table Number	Dependent Variable	Independent Variable
	Carbon Dioxide (CO_2) Collection and Removal	
41	Weight of CO_2 collector - normal operation, kg	• LiOH unit • Solid amines • Molecular sieve - 2 bed adiabotic • Liquid absorption
		1. CO_2 removal rate, kg/day 2. CO_2 removal rate, kg/day
		• Carbonation cell • Molecular sieve - 2 bed partially adiabotic
		1. CO_2 removal rate, kg/day
		• Molecular sieve - 4 bed
		1. Product of cabin atmosphere density and CO_2 removal rate, kg^2/m^3 day
		• Electrodialysis
		1. CO_2 removal rate, kg/day 2. Current density, $amps/m^2$
42	Volume of CO_2 collector - normal operation, m^3	• LiOH unit • Solid amines • Molecular sieve - 2 bed adiabatic • Liquid absorption • Carbination cell • Molecular sieve - 2 bed partially adiabatic
		1. CO_2 removal rate, kg/day
		• Molecular sieve - 4 bed

Table Number	Dependent Variable	Independent Variable
		1. CO_2 removal rate, kg/day 2. Current density, amps/m^2
43	CO_2 collector power - normal operation, kw	• Solid amines • Carbonation cell • Molecular sieve - 4 bed • Liquid absorption
		1. CO_2 removal rate, kg/day
		• Electrodialysis
		1. CO_2 removal rate, kg/d 2. Current density, amp/m
		• Molecular sieve - 2 bed adiabatic • Molecular sieve - 2 bed partially adiabatic
		1. CO_2 removal rate, kg/day 2. Cabin atmosphere density, kg/m^3
44	Weight of expendable Lithium Hydroxide, LiOH	1. Amount of CO_2 removed, kg
151	Volume of expendable LiOH - normal operation	1. Amount of LiOH, kg
152	Volume of expendable LiOH - emergency operation	1. Amount of LiOH, kg
45	CO_2 accumulator and pump weight, kg	1. CO_2 collection rate, kg/day
46	CO_2 accumulator and pump volume, m^3	1. CO_2 collection rate, kg/day
47	CO_2 accumulator and pump power, kw	1. CO_2 collection rate, kg/day
71	Weight of CO_2 collector - emergency operation, kg	• LiOH unit • Solid amines • Molecular sieve - 2 bed adiabatic • Liquid absorption

Table Number	Dependent Variable	Independent Variable
		1. CO_2 removal rate, kg/day 2. CO_2 removal rate, kg/day • Carbonation cell • Molecular sieve - 2 bed partially adiabatic
		1. CO_2 removal rate, kg/day • Molecular sieve - 4 bed
		1. Product of cabin atmosphere density and CO_2 removal rate, kg^2/m^3 day • Electrodialysis
72	Volume of CO_2 collector - emergency operation, m^3	1. CO_2 removal rate, kg/day 2. Current density, $amps/m^2$ • LiOH unit • Solid amines • Molecular sieve - 2 bed adiabatic • Liquid absorption • Carbonation cell • Molecular sieve - 2 bed partially adiabatic
		1. CO_2 removal rate, kg/day • Molecular sieve - 4 bed
73	CO_2 collector power - emergency operation, kw	1. CO_2 removal rate, kg/day 2. Current density, $amps/m^2$ • Solid amines • Carbonation cell • Molecular sieve - 4 bed • Liquid absorption

Table Number	Dependent Variable	Independent Variable
		1. CO_2 removal rate, kg/day
		• Electrodialysis
		1. CO_2 removal rate, kg/day 2. Current density, amp/m^2
		• Molecular sieve - 2 bed adiabatic • Molecular sieve - 2 bed partially adiabatic
		1. CO_2 removal rate, kg/day 2. Cabin atmosphere density, kg/m^3
74	Weight of expendable carbonate (K_2CO_3) for liquid adsorption, kg	1. Amount of CO_2 removed, kg
75	Volume of expendable K_2CO_3 for liquid adsorption, m^3	1. Amount of CO_2 removed, kg
	Trace Contaminants Removal	
143	Charcoal bed unit weight, kg	• Man-days < 220
		1. 1.0 2. 0 3. 0
		• Man-days ≥ 220
		1. 0 2. 1.0 3. Weight of expendables from Table 141, kg
144	Charcoal bed unit volume, m^3	1. Dummy variable = 1.0

Table Number	Dependent Variable	Independent Variable
141	Charcoal bed expendables weight, kg	• Man-days > 220
		1. Man-days
		2. 0
		• Man-days < 220
		1. 0
		2. 1.0
142	Charcoal bed expendables volume, m^3	• Man-days > 220
		1. Man-days
		2. 0
		• Man-days < 220
		1. 0
		2. 1.0
145	Catalytic burner unit weight, kg	1. Crew size
146	Catalytic burner unit volume, m^3	• Man-days < 1,000
		1. 1.0
		2. 0
		3. 0
		4. 0
		• 1,000 < Man-days < 10,000
		1. 0
		2. Man-days
		3. 1.0
		4. 0

Table Number	Dependent Variable	Independent Variable
		Man-days > 10,000
		1. 0
		2. 0
		3. 0
		4. 1.0
147	Catalytic burner power requirement, kw	1. Crew size
148	Catlaytic burner sorbents and structure weight, kg	Man-days < 1,000
		1. 1.0
		2. 0
		3. 0
		4. 0
		1,000 < Man-days < 10,000
		1. 0
		2. Man-days
		3. 1.0
		4. 0
		Man-days > 10,000
		1. 0
		2. 0
		3. 0
		4. 1.0
149	Catalytic burner expendable weight, kg	1. Man-days
150	Catalytic burner expendable volume, m^3	1. Man-days

Table Number	Dependent Variable	Independent Variable
	Urine Collection and Handling	
135	Weight of pressure suit urinal, kg	1. Crew size
16	Volume of pressure suit urinal, m^3	1. Crew size
17	Weight of urine collector - normal operation, kg	• Personal urine bag 1. Crew size 2. Total micturations 3. Product of crew size and resupply period (man-days) 4. Product of crew size and resupply period (man-days) • Overboard vent urinal • Air entrainment system 1. Micturations per man-day 2. Product of crew size and resupply period
20	Volume of urine collector - normal operation, m^3	1. Same as Table 17.
23	Urine collector power requirement - normal operation, kw	1. Dummy variable = 1.0
19	Weight of urine storage tank - including urine, kg	1. Product of crew size and mission duration (man-days) - a minimum value of 3.0 is used when urine storage tanks are not specified on card WMSLSS02
22	Volume of urine storage tank, m^3	1. Product of crew size and mission duration (man-days) - a minimum value of 3.0 is used when urine storage tanks are not specified on card WMSLSS02

Table Number	Dependent Variable	Independent Variable
136	Weight of urine collector - emergency operation, kg	1. Crew size 2. Product of crew size and emergency period (man-days) 3. Total micturations (during emergency period) 4. Product of emergency period and crew size (man-months)
137	Volume of urine collector - emergency operation, m^3	1. Crew size 2. Product of crew size and emergency period (man-days) 3. Total micturations (during emergency period) 4. Product of emergency period and crew size (man-months)
	Refuse and Debris Handling	
24	Weight of refuse storage containers, kg	1. Product of crew size and resupply period
25	Volume of refuse storage containers, m^3	1. Product of crew size and resupply period
31	Volume of filled containers at end of mission, m^3	1. Product of crew size and mission duration
26	Weight of air entrainment debris collector, kg	1. Product of resupply period and crew size
28	Volume of air entrainment debris collector, m^3	1. Product of resupply period and crew size
27	Weight of portable vacuum cleaner, kg	1. Product of crew size and resupply period
29	Volume of portable vacuum cleaner, m^3	1. Product of crew size and resupply period
30	Portable vacuum cleaner power requirement, kw	1. Dummy variable = 1.0
	Fecal Collection	
32	Fecal collector weight - manual bagging, kg	1. Product of crew size and resupply period 2. Total feces collected, kg

Table Number	Dependent Variable	Independent Variable
33	Fecal collector weight - air entrainment, kg	• Vacuum drying 1. Number of toilets 2. Crew size 3. Product of crew size and resupply period • Fecal slurry 1. Number of toilets 2. Crew size
35	Weight of container and feces for air entrainment with vacuum drying, kg	1. Total fecal matter collected for mission, kg 2. Total fecal water collected for mission, kg
36	Fecal collector volume - manual bagging, m^3	1. Product of crew size and resupply period
37	Fecal collector volume - air entrainment, m^3	• Vacuum drying 1. Number of toilets 2. Crew size 3. Product of crew size and resupply period • Fecal slurry 1. Number of toilets 2. Crew size
38	Volume of container and feces for manual bagging, m^3	1. Product of crew size and resupply period 2. Total fecal matter collected, kg
39	Volume of container and feces for air entrainment with vacuum drying, m^3	1. Total feces collected, kg
40	Power requirement of air entrainment fecal collectors, kw	• Vacuum drying 1. Fraction of time in use • Fecal slurry 1. Fraction of time in use 2. Crew size

FOOD SUPPLY SUBSYSTEM TABLES (FSS)

Table Number	Dependent Variable	Independent Variable
	Stored Food System	
292	Expendable weight, kg	1. Crew size 2. Crew size x resupply period, man-days 3. Food stored x resupply period, kg-days
293	Expendable volume, m^3	1. Food stored x resupply period, kg-days
294	Electrical power, kw	1. Crew size
303	Fixed weight, kg	1. Crew size
304	Fixed volume, m^3	1. Crew size 2. Food stored x resupply period, kg-days
295	Cooling load, kw	1. Crew intake water, kg/day
296	Heating load, kw	1. Crew intake water, kg/day
	Food Processor	
297	Fixed weight, kg	1. Carbon dioxide process rate, kg/day
298	Fixed volume, m^3	1. Carbon dioxide process rate, kg/day
299	Electrical power, kw	1. Carbon dioxide process rate, kg/day
300	Atmosphere cooling load, kw	1. Carbon dioxide process rate, kg/day
301	Cooling fluid load, kw	1. Carbon dioxide process rate, kg/day
302	Heating fluid load, kw	1. Carbon dioxide process rate, kg/day

WATER SUPPLY SYSTEM TABLES (WSS)

Table Number	Dependent Variable	Independent Variable
251	Fixed weight urine recovery unit, kg	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
252	Expendable weight, urine recovery unit, kg	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
253	Fixed volume urine recovery unit, m^3	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
254	Expendable volume urine recovery unit, m^3	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
255	Electric power urine recovery unit, kw	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
256	Air cooling for urine recovery unit, kw	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
257	Liquid cooling urine recovery unit, kw	1. Urine flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
258	Fixed weight condensate recovery unit, kg	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
259	Expendable weight condensate recovery unit, kg	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr

Table Number	Dependent Variable	Independent Variable
260	Fixed volume condensate recovery unit, m^3	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
261	Expendable volume condensate recovery unit, m^3	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
262	Electric power condensate recovery unit, kw	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
263	Air cooling for condensate recovery unit, kw	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
264	Liquid cooling condensate recovery unit, kw	1. Condensate flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
265	Fixed weight fecal water recovery unit, kg	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
266	Expendable weight fecal water recovery unit, kg	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
267	Fixed volume fecal water recovery unit, m^3	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
268	Expendable volume fecal water recovery unit, m^3	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr

Table Number	Dependent Variable	Independent Variable
269	Electric power fecal water recovery unit, kw	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
270	Air cooling for fecal water recovery unit, kw	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
271	Liquid cooling for fecal water recovery unit, kw	1. Fecal water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
272	Fixed weight wash water recovery unit, kg	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
273	Expendable weight wash water recovery unit, kg	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
274	Fixed volume wash water recovery unit, m^3	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
275	Expendable volume wash water recovery unit, m^3	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
276	Electric power wash water recovery unit, m^3	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
277	Air cooling for wash water recovery unit, kw	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr

Table Number	Dependent Variable	Independent Variable
278	Liquid cooling for wash water recovery unit, kw	1. Wash water flow, kg/hr 2. Resupply period, days 3. Total water/24.0, kg day/hr
280	Water line weight, kg	1. Total cabin volume, m^3 2. Cabin diameter, m 3. Cabin length, m
281	Water line volume, m^3	1. Total cabin volume, m^3 2. Cabin diameter, m 3. Cabin length, m
282	Water sterilizer fixed weight, kg	1. Process flow, kg/hr 2. Resupply period, days
283	Water sterilizer expendable weight, kg	1. Process flow, kg/hr 2. Resupply period, days
284	Water sterilizer, fixed volume, m^3	1. Process flow, kg/hr 2. Resupply period, days
285	Water sterilizer expendable volume, m^3	1. Process flow, kg/hr 2. Resupply period, days
286	Water sterilizer electric power, kw	• Silver Ion 1. Process flow, kg/hr 2. Resupply period, days • Pasteurization 1. Total heat loss (from Table No. 289), kw 2. Process flow, kg/hr 3. Number of tanks

Table Number	Dependent Variable	Independent Variable
287	Water tank insulation volume, m^3	1. Total tank area, m^2 2. Process flow, kg/hr 3. Number of tanks
288	Water tank insulation weight, kg	1. Total tank area, m^2 2. Process flow, kg/hr 3. Number of tanks
289	Water tank insulation heat loss, kw	1. Total tank area, m^2 2. Process flow, kg/hr 3. Number of tanks
331	Pumps and misc. equipment weight, kg	1. Crew size
332	Pumps and misc. equipment volume, m^3	1. Crew size
333	Pumps and misc. power, kw	1. Crew size

CREW AND CREW SUPPORT TABLES (CCS)

Table Number	Dependent Variable	Independent Variable
	Crewmen Data	
13	Crewmen maintenance time, hrs/day	1. Crew size 2. Mission duration, days
18	Crewmen operations time, hrs/day	1. Crew size. 2. Mission duration, days
160	Sweat rate ratio (for high activity levels)	1. Metabolic rate, kw
161	Respired water rate ratio (for high activity levels)	1. Metabolic rate, kw 2. Cabin pressure, kg/cm^2
	Crew Support Data	
21	First aid and medical supplies weight, kg	1. Mission duration, years 2. Dummy variable k, see Table 4.7-7 in Vol. II. 3. Dummy variable , see Table 4.7-7 in Vol. II. 4. Dummy variable z, see Table 4.7-7 in Vol. II.
34	First aid and medical supplies volume, m^3	1. Mission duration, years 2. Dummy variable k, see Table 4.7-7 in Vol. II. 3. Dummy variable , see Table 4.7-7 in Vol. II. 4. Dummy variable z, see Table 4.7-7 in Vol. II.
49	First aid and medical supplies power, kw	1. Mission duration, years.
120	Personal items, weight, kg	1. Crew size 2. Dummy variable k 3. Crew size times k 4. Crew size times mission duration (years) times k. 5. Crew size times z, (z is a dummy variable. See Table 4.7-9 in Vol. II for values of dummy variables.)

Table Number	Dependent Variable	Independent Variable	
121	Personal items volume, m^3	1. Crew size 2. Dummy variable k 3. Crew size times k 4. Crew size times mission duration (years) times k 5. Crew size times z, (z is a dummy variable. See Table 4.7-9 in Vol. II for values of dummy variables.)	
122	Personal items power, kw	1. Crew size times k (k is dummy variable from Table 4.7-9.)	
123	Instruments and controls weight, kg	1. Dummy variable k 2. Dummy variable k 3. Dummy variable 4. Dummy variable z	See Table 4.7-11 in Vol. II.
124	Instruments and controls volume, m^3	1. Dummy variable k 2. Dummy variable k 3. Dummy variable 4. Dummy variable z	See Table 4.7-11 in Vol. II.
125	Instruments and controls power, kw	1. Dummy variable k 2. Dummy variable k 3. Dummy variable 4. Dummy variable z	See Table 4.7-11 in Vol. II.
76	Space suits and clothes weight, kg	1. Mission duration (years) times crew size 2. Crew size 3. Dummy variable from Table 4.7-3 in Vol. II.	
77	Space suits and clothes volume, m^3	1. Mission duration (years) times crew size 2. Crew size 3. Dummy variable from Table 4.7-3 in Vol. II.	

Table Number	Dependent Variable		Independent Variable $1 < D$	Independent Variable $D \geq 1$
78	Extravehicular Activity (EVA) support weight, kg	1.	Mission duration (D, years)	0
		2.	1	0
		3.	0	Mission duration (D, years)
		4.	0	1
79	EVA support volume, m^3	1.	Mission duration (D, years)	0
		2.	1	0
		3.	0	Mission duration (D, years)
		4.	0	1
80	EVA support power, kw	1.	Mission duration (D, years)	0
		2.	1	0
		3.	0	Mission duration (D, years)
		4.	0	1
	Crewmen Size			
14	Crewmen Weight, kg	1.	Percentile, %	
15	Crewmen standing height, meters	1.	Percentile, %	

CREW ACCOMMODATION TABLES (CAS)

Table Number	Dependent Variable	Independent Variable
126	Gravity conditioning weight, kg	1. Dummy variable k from Table 4.8-3 in Vol. II.
127	Gravity conditioning volume, m^3	1. Dummy variable k from Table 4.8-3 in Vol. II.
128	Gravity conditioning power, kw	1. Dummy variable k from Table 4.8-3 in Vol. II.
129	Instruments, controls, and lighting equipment weight, kg	1. Crew size
130	Instruments, controls, and lighting equipment volume, m^3	1. Crew size
131	Instruments, controls, and lighting equipment power, kw	1. Crew size
132	Living, work, and recreational facilities weight, kg	1. Dummy variable k in Table 4.8-2 in Vol. II. 2. Crew size times mission duration (years) times k. 3. Crew size
133	Living, work, and recreational facilities volume, m^3	1. Dummy variable k in Table 4.8-2 in Vol. II. 2. Crew size times mission duration (years) times k. 3. Crew size.
134	Living, work, and recreational facilities power	1. Crew size times mission duration (years) times k.

Table Number	Dependent Variable		Independent Variable
	CO_2 Reduction		
61	CO_2 reducer fixed weight, kg	1.	CO_2 processing rate, kg/hr
62	CO_2 reducer fixed volume, m^3	1.	CO_2 processing rate, kg/hr
63	CO_2 reducer power, kw	1.	CO_2 processing rate, kg/hr
64	CO_2 reducer expendable weight, kg	1.	Weight of CO_2 processed, kg
65	CO_2 reducer expendable volume, m^3	1.	Weight of CO_2 processed, kg
66	CO_2 reducer atmospheric heat load, kw	1.	CO_2 processing rate, kg/hr
67	CO_2 reducer cooling loop heat load, kw	1.	CO_2 processing rate, kg/hr
	Vapor Electrolysis		
81	Vapor electrolysis unit fixed weight, kg	1.	Water vapor processing rate, kg/hr
82	Vapor electrolysis unit fixed volume, m^3	1.	Water vapor processing rate, kg/hr
83	Vapor electrolysis power, kw	1.	Water vapor processing rate, kg/hr
84	Vapor electrolysis unit expendable weight, kg	1.	Weight of water vapor processed, kg
85	Vapor electrolysis unit expendable volume, m^3	1.	Weight of water vapor processed, kg
86	Vapor electrolysis unit atmospheric heat load, kw	1.	Water vapor processing rate, kg/hr
87	Vapor electrolysis unit cooling loop heat load, kw	1.	Water vapor processing rate, kg/hr

Table Number	Dependent Variable	Independent Variable
	Liquid Electrolysis	
88	Liquid electrolysis unit fixed weight, kg	1. Water processing rate, kg/hr
89	Liquid electrolysis unit fixed volume, m^3	1. Water processing rate, kg/hr
90	Liquid electrolysis unit power, kw	1. Water processing rate, kg/hr
91	Liquid electrolysis unit expendable weight, kg	1. Weight of water processed, kg
92	Liquid electrolysis unit expendable volume, m^3	1. Weight of water processed, kg
93	Liquid electrolysis unit atmospheric heat load, kw	1. Water processing rate, kg/hr
94	Liquid electrolysis unit cooling loop heat load, kw	1. Water processing rate, kg/hr
	Atmosphere Constituent Storage	
101	High pressure O_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
102	Supercritical O_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
103	Subcritical O_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
104	High pressure N_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
105	Supercritical N_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
106	Subcritical N_2 storage weight, kg	1. Resupply period, days 2. Use rate, kg/day

Table Number	Dependent Variable	Independent Variable
107	High pressure He storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
108	Supercritical He storage weight, kg	1. Resupply period, days 2. Use rate, kg/day
110	Spherical storage vessel outside diameter, m	1. Weight of stored fluid, kg 2. See Note 1 below
111	Ratio of cylindrical storage weight to spherical storage weight.	1. Cylindrical vessel L/D 2. See Note 1 below
112	Peak power for expulsion of cryogenic fluids, kw	1. Use rate, kg/day 2. See Note 1 below
	Airlock	
113	Airlock pump weight, kg	1. Volume flow, m^3/hr
	Atmosphere Supplies Control and Distribution	
115	Atmosphere supplies distribution system weight, kg	1. Sum of occupied cabin lengths and diameters, m
116	Normal atmosphere supplies control weight, kg	1. Number of occupied cabins
117	Emergency atmosphere supplies controls weight, kg	1. Number of occupied cabins

NOTE 1:

THERMAL CONTROL SUBSYSTEM TABLES (TCS)

Table Number	Dependent Variable	Independent Variable
	Atmosphere Purification Loop	
50	Condenser core weight, kg	1. Overall heat transfer coefficient x heat exchanger area, kw/°K
51	Total condenser weight, kg	1. Condenser core weight, kg 2. Condenser core volume, m^3
52	Water separator weight, kg	1. Gas flow rate, kg/hr 2. Gas density, kg/m^3
53	Duct weight, kg	1. Diameter of ducts, m
54	Small blower or compressor weight, kg	1. Gas flow rate/gas density, m^3
55	Large blower or compressor weight, kg	1. Gas flow rate/gas density, m^3
56	Blower volume, m^3	1. Blower weight, kg
57	Compressor volume, m^3	1. Compressor weight, kg
58	Condenser volume, m^3	1. Overall heat transfer conductance, kw/°k
59	Volume of water separator, m^3	1. Gas flow rate, kg/hr 2. Gas density, kg/m^3
60	Packaged volume of atmosphere purification loop, m^3	1. Total volume of loop components, m^3
	Cabin Heat Exchanger	
211	Fan power, kw	1. Cabin volume, m^3 2. Atmosphere composition and pressure, Note 1
212	Fan weight, kg	1. Cabin volume, m^3 2. Atmosphere composition and pressure, Note 1

Table Number	Dependent Variable	Independent Variable
213	Cooling liquid pressure drop, kg/cm^2	1. Design heat load for cabin heat exchanger, kw 2. Atmosphere composition and pressure, Note 1
214	Heat exchanger weight, kg	1. Design heat load for cabin heat exchanger, kw 2. Atmosphere composition and pressure, Note 1
215	Heat exchanger weight including headers, mountings, etc., kg	1. Design heat load for cabin heat exchanger, kw
216	Cabin heat exchanger volume including fan mounting, etc., m^3	1. Heat exchanger volume, m^3
217	Cold plate pressure drop, kg/cm^2	1. Cold plate heat load, kw
218	Wet weight of cold plates, kg	1. Cold plate heat load, kw
219	Length of piping in cooling system, m	1. Total volume of all cabins, m^3 2. Number of environmental control units
220	Wet weight of piping in cooling system, kg	1. Diameter of cooling piping, m 2. Length of cooling piping, m
	Tables No. 221, 222, and 223 are used in succession to calculate the cooling piping pressure drop.	
221	First intermediate value	1. $W(L)^{1/2}$ where W = flow, kg/hr L = piping length, m 2. $1.0/(\rho^{1/4}D)$ where D = pipe diameter, m ρ = liquid density, kg/m^3
222	Second intermediate value	1. $W(\mu)^{1/7}$ where μ = viscosity, kg/(m-sec)

Table Number	Dependent Variable	Independent Variable
223	Cooling piping pressure drop, kg/cm^2	1. First intermediate value from Table 221 2. Second intermediate value from Table 222
224	Overall efficiency for liquid pump and driving motor, dimensionless	1. $W(p)$ where W = flow, kg/hr p = pressure rise in pump, kg/cm^2
225	Weight of liquid pump and driving motor, kg	1. Flow rate, kg/hr 2. Pressure rise in pump, kg/cm^2
226	Cabin ventilation fan power, kw	1. Cabin volume, m^3
227	Cabin ventilation fan weight, kg	1. Cabin volume, m^3
228	Cabin ventilation fan volume, m^3	1. Cabin volume, m^3
229	Weight of interface heat exchanger for cooling loop or heating loop, kg	1. Heat load of interface heat exchanger, kw
230	Volume of interface heat exchanger for cooling loop or heating loop, m^3	1. Heat load of interface heat exchanger, kw
231	Pressure drop in water side of interface heat exchanger, kg/cm^2	1. Length of flow path in heat exhcnager, m
232	Weight of water evaporator, kg	1. Heat load of water evaporator, kw
233	Volume of water evaporator, m^3	1. Heat load of water evaporator, kw
234	Liquid heating loop piping length, m	1. Cooling system length factor, m
235	Weight of miscellaneous equipment for cooling system, kg	1. Total cooling load, kw
236	Volume of miscellaneous equipment for cooling system, m^3	1. Total cooling load, kw

Table Number	Dependent Variable		Independent Variable
237	Weight of miscellaneous equipment for heating system, kg	1.	Total cooling load, kw
238	Volume of miscellaneous equipment for heating system, m^3	1.	Total cooling load, kw
239	Weight factor of emergency thermal control system, kg	1.	Weight of system evaporator, kg
240	Volume factor of emergency thermal control system, m^3	1.	Volume of water evaporator, m^3

SYSTEM CONTROL SUBSYSTEM TABLES

Table Number	Dependent Variable	Independent Variable
307	System control subsystem weight, kg	1. Product of spacecraft diameter and length, m^2
308	System control subsystem volume, m^3	1. Product of spacecraft diameter and length, m^2

SUBSYSTEM SPARES REQUIREMENTS

Table Number	Dependent Variable	Independent Variable
311	ACS spares weight ratio - 2 man system	1. Subsystem reliability 2. Mission duration, days
312	ACS spares weight ratio - 10 man system	1. Subsystem reliability 2. Mission duration, days
313	ACS spares weight ratio - 20 man system	1. Subsystem reliability 2. Mission duration, days
314	WMS spares weight ratio - 2 man system	1. Subsystem reliability 2. Mission duration, days
315	WMS spares weight ratio - 10 man system	1. Subsystem reliability 2. Mission duration, days
316	WMS spares weight ratio - 20 man system	1. Subsystem reliability 2. Mission duration, days
317	WSS spares weight ratio - 2 man system	1. Subsystem reliability 2. Mission duration, days
318	WSS spares weight ratio - 10 man system	1. Subsystem reliability 2. Mission duration, days
319	WSS spares weight ratio - 20 man system	1. Subsystem reliability 2. Mission duration, days
320	TCS spares weight ratio	1. Subsystem reliability 2. Mission duration, days

2.3 Data Deck Control Cards and Deck Set-Up

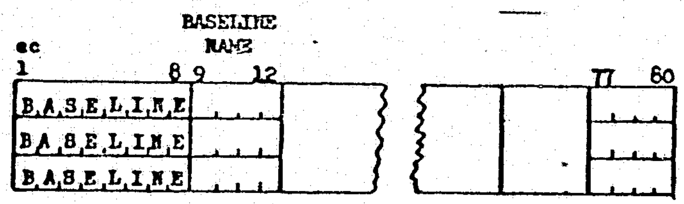
2.3.1 Control Cards

The four H738 control cards required to process the input data are shown in Figure 2-12. The first of these, the BASELINE card, [Figure 2-12 (d)] is required when Baseline Cases are entered on cards rather than on the Baseline data tape. A BASELINE card must immediately precede each Baseline Case. The Baseline Case name (a four character word) is punched in columns 9-12 of the BASELINE control card preceding its Baseline Case. This is the Baseline name referenced by its counterpart in the Mission Analysis Data - Level 1 to select the proper Baseline Case for the Change Case.

The BASELINE*END control card [Figure 2-12(b)] must be included once for each job. If the Baseline Cases are present on cards, the BASELINE*END follows the TBLEND control card of the last Baseline Case. If the Baseline Cases are on the Baseline Tape, the BASELINE*END card is the first card in the data deck, immediately following the $DATA card. In both instances, the BASELINE*END card immediately preceeds the MADLEV11 card of the first change case.

The TBLEND card [Figure 2-12(c)] must be used once in each case, Baseline or Change. The TBLEND control card is physically the last card in the case.

The ENDRUN control card [Figure 2-12(d)] is used once for each job. It is physically the last card in the data deck following the TBLEND card of the last case of the job.



NOTES: 1. One of these control cards must precede each case of baseline data cards when a new baseline data tape is to be made.

2. Cross out any unnecessary control cards.

Figure 2-12 (a) - Data Deck Control Cards

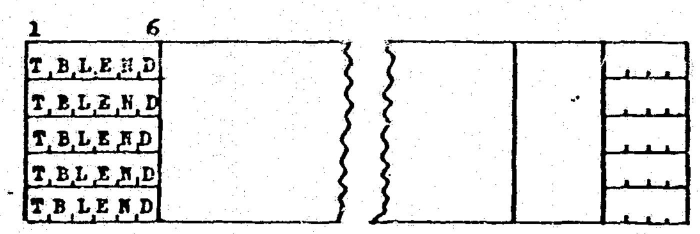
```
1      8 9  12
|BASELINE|*END|    |  ...  |    |    | . . . |
```

NOTES: This card must be used once for each job. It's placement is:

1. If a new data tape is to be made, this card must follow the TBLEND control card of the last (physically) case of baseline data.

2. If the baseline data is on tape, this card must precede all change case data, and is the first card of the data deck.

Figure 2-12 (b) - Data Deck Control Cards



NOTES: 1. One of these control cards must be present in every case of data, baseline and change, and is the last card in the case.

2. Cross out any unnecessary control cards.

Figure 2-12 (c) - Data Deck Control Cards

```
1   6
ENDRU
```

This card must be used once for each job. It's placement is:

1. If change cases are to be run, it must follow the TBLEND control card of the last (physically) change case.

2. If a baseline data tape is to be made without running change cases, it must follow the BASELINE*END control card.

Figure 2-12 (d) - Data Deck Control Cards

2.3.2 Deck Set-Up

A typical data deck set-up is shown in Figure 2-13. The basic order of the groups within a case is:

Mission Analysis Data - Level 1
Mission Analysis Data - Level 2
Life Support System - Trade Off Data
Table Data

This basic order must be followed for both Baseline and Change Cases along with the following rules:

MA Data - Level 1 does not appear in a Baseline Case, it must appear in each Change Case.

MA Data - Level 2, LSS-TOD and Table Data must appear in entirety in each Baseline Case. However, only those portions which are to be modified need appear in a Change Case.

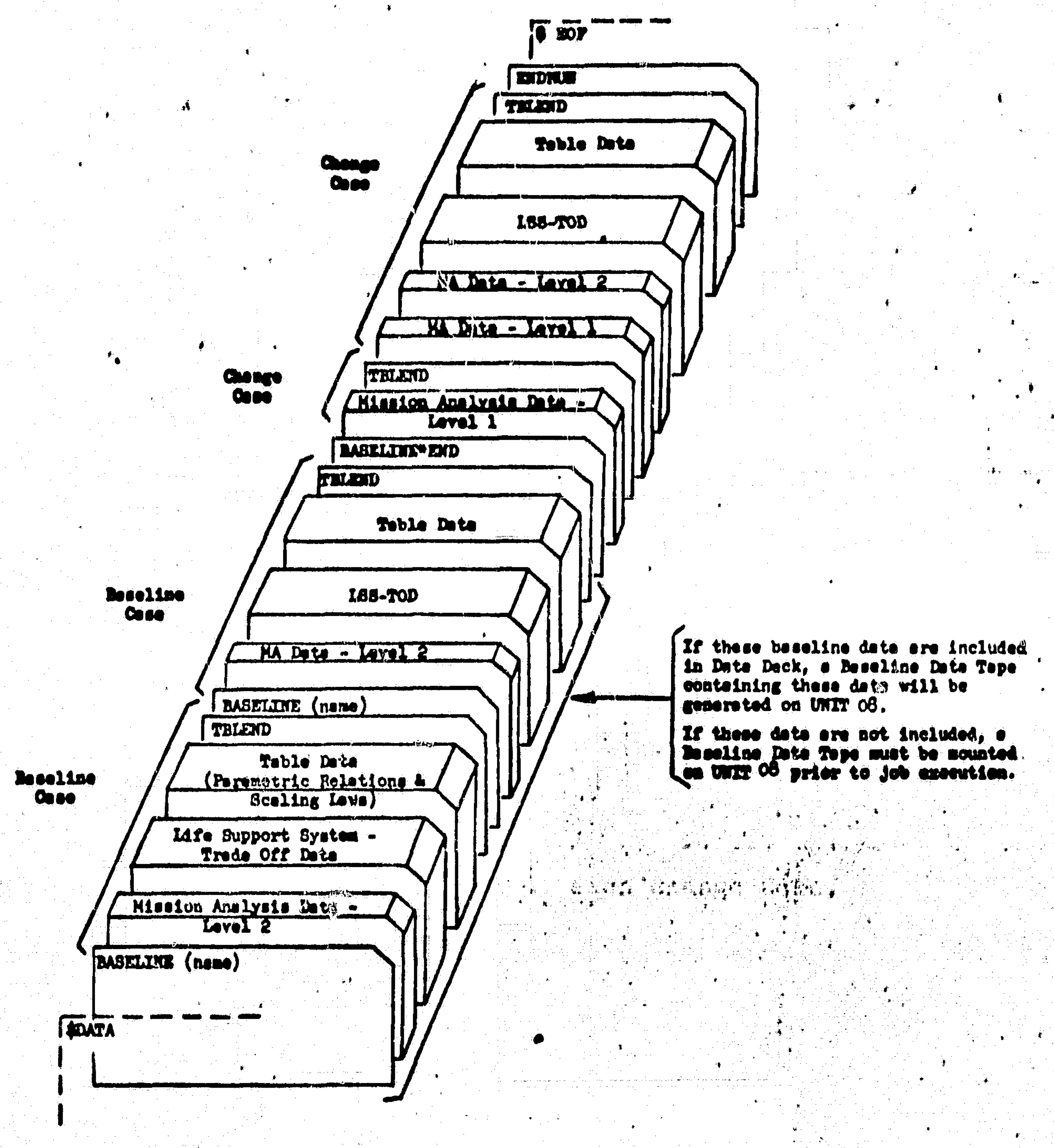


Figure 2-13 - Data Deck Set-Up

2.4 Sample Case

A sample case is provided for program verifications at computer locations other than MDAC-WD. The case chosen is based on the partially closed Baseline Case "PART" with the following values for Mission Analysis Data:

Crew Size	4
Flight date	1975
Altitude	229.0 Km
Inclination	50°
Mission duration	370 days
Resupply period	90 days

2.4.1 Input Data

The completed loadsheet for the MAD-Level 1 cards is shown in Figure 2-14. The MAD-Level 2, LSS-TOD and Table Data are obtained from the Baseline Tape. These data are not perturbed for this case, cards for them do not appear. Not shown is the "TBLEND" control card used to conclude each Change Case.

H738 MISSION ANALYSIS DATA
LEVEL I

KEYPUNCH NOTES:

1. Punch as written
2. Punch on all cards

cc 1–8	CASE NO 9–12	CASE TITLE 13–72	73–76	77–80
MADLEV11	201	TEST BASELINE PART	H738	0201

				MISSION PARAMETERS								
					EARTH ORBIT							
1–8	BASE LINE 9–12	CREW SIZE 13–16	FLIGHT DATE 17–20	MISS. NO. 21–24	25–26	ALTITUDE (km) 27–36	INCLINATION (DEGREES) 37–46	DURATION (DAYS) 47–56	57–60	POWER SUPPLY 61–68	69–76	77–80
MADLEV12	PART	4	1975		X	229.0	50.0	370.0	X	RADISTØP	X	0202

BASE LINE options: ØPEN, PART, FULL, ETC.

POWER SUPPLY options: SØLRCELL, FUELCELL, RADISTØP

Engineer Note: This sheet must be completed for each case.

Figure 2-14 - Sample Case Input

2.4.2 Output Results

The printed output data are presented in Figure 2-15. A breakdown for each subsystem is shown along with a LSS breakdown and LSS grand totals. Due to space considerations, the detailed engineering output is not shown.

H738 PARAMETRIC MANNED LIFE SUPPORT SYSTEMS FORTRAN PROGRAM

CASE NO. 201 TEST BASELINE PART

BASELINE	CREW SIZE	FLIGHT DATE	MISSION	ALTITUDE	INCLINATION	DURATION	PWR SUPPLY
PART	4	1975	-0	229.000	50.000	370.000	RADISTOP

Figure 2-15 - Sample Case Output

FINAL SUBSYSTEM DATA FOR EACH CABIN

************ ATMOSPHERE CONTROL SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
OXYGEN RECOVERY						
	CABIN NO. 1	0.648E 02	0.174E 00	0.825E 00	0.103E 02	0.196E 00
	CABIN NO. 2	0.649E 02	0.174E 00	0.827E 00	0.103E 02	0.196E 00
AIRLOCK USAGE						
	CABIN NO. 1	0.000E-38		0.000E-38		
	CABIN NO. 2	0.704E 01		0.103E-02		
ATMOSPHERE CONSTITUENT STORAGE						
	NORMAL	0.542E 02		0.000E-38	0.151E 03	0.118E 00
	EMERGENCY	0.689E 03	0.430E 00			
SPARES						
	SUBSYSTEM	0.131E 03	0.234E 00			
ACCUMUDATED MATERIAL						
	CARBON	0.391E 03				

O 2 RECOVERY BY MOLTEN CARBONATE
UNIT ACCEPTS CABIN AIR DIRECTLY - NO CO 2 CONCENTRATOR OR WATER ELECTROLYSIS UNITS REQUIRED - PHASE SEPARATION BETWEEN HOT MELT (780 DEGREES K) AND GASES IS A MAJOR DESIGN PROBLEM - UNIT USED IN PROGRAM, BASED ON CURRENT HARDWARE TECHNOLOGY, USES DISPOSABLE CELLS DISCARDED AFTER EXCESSIVE CARBON DEPOSIT - ADDITIONAL DEVELOPMENT NEEDED TO PROVIDE SIMPLER DESIGNS THAT MAY PRODUCE UP TO 60 PER CENT WEIGHT REDUCTION

O 2 RECOVERY BY SOLID ELECTROLYTE
CARBON COLLECTION PROBLEM - HIGH TEMPERATURE (1400 DEGREES K) CELL MATERIAL PROBLEMS - ADDITIONAL MATERIALS RESEARCH REQUIRED - PROCESS REQUIRES NO WATER ELECTROLYSIS UNIT - 1973 FLIGHT DATE ATTAINABLE

O 2 RECOVERY BY BOSCH
CARBON COLLECTION PROBLEM - HIGH TEMPERATURE (860 - 1250 DEGREES K) MATERIALS PROBLEM - 1972 FLIGHT DATE - GAS RECIRCULATION VOLUMETRIC RATIO OF 4.35 USED

O 2 RECOVERY BY SABATIER
1971 FLIGHT DATE FOR UNIT WITH METHANE VENT - 1974 FLIGHT DATE FOR UNITS WITH METHANE CRACKERS - DEVELOPMENT OF METHANE CRACKERS AND HYDROGEN FILTERS SHOULD BE PURSUED

Figure 2-15 (Continued) - Sample Case Output

************ THERMAL CONTROL SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
CABIN HEAT EX. AND FAN						
	CABIN NO. 1	0.862E 01	0.472E-01	0.127E 00		
	CABIN NO. 2	0.188E 02	0.104E 00	0.441E 00		
VENTILATION FAN						
	CABIN NO. 1	0.111E 02	0.505E-01	0.583E-01		
	CABIN NO. 2	0.226E 02	0.103E 00	0.119E 00		
ATMOSPHERE PURIFICATION LOOP						
	CABIN NO. 1	0.965E 01	0.106E 00	0.162E 00		
	CABIN NO. 2	0.965E 01	0.106E 00	0.162E 00		
HEATING LOOP						
	VEHICLE	0.130E 02	0.562E-02	0.949E-02		
NORMAL COOLING LOOP						
	VEHICLE	0.129E 03	0.152E 00	0.267E 00	0.470E 04	0.470E 01
EMERGENCY COOLING LOOP						
	VEHICLE	0.264E 01	0.401E-02	0.400E-01	0.130E 03	0.131E 00
LSS SPACE RADIATOR						
	VEHICLE	0.161E 03		0.115E 00		
EXTERIOR THERMAL INSULATION						
	VEHICLE	0.700E 03				
SPARES						
	SUBSYSTEM	0.363E 03	0.648E 00			

Figure 2-15 (Continued) - Sample Case Output

************ WASTE MANAGEMENT SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
NORMAL CO 2 REMOVAL						
	CABIN NO. 1	0.628E 02	0.390E 00	0.119E 00	0.000E-38	0.000E-38
	CABIN NO. 2	0.628E 02	0.390E 00	0.119E 00	0.000E-38	0.000E-38
EMERGENCY CO 2 REMOVAL						
	CABIN NO. 1	0.815E 01	0.144E 00	0.000E-38	0.546E 02	0.144E 00
	CABIN NO. 2	0.815E 01	0.144E 00	0.000E-38	0.546E 02	0.144E 00
EMERGENCY MISCELLANEOUS						
	SUBSYSTEM	0.349E 01	0.353E-02			
TRACE CONTAMINANTS						
	CABIN NO. 1	0.206E 02	0.354E-01	0.835E-01	0.842E 01	0.210E-01
	CABIN NO. 2	0.206E 02	0.354E-01	0.835E-01	0.842E 01	0.210E-01
URINE COLLECTION						
	VEHICLE	0.104E 02	0.171E-01	0.324E-04	0.000E-38	0.000E-38
FECAL AND DEBRIS COLLECTION						
	VEHICLE	0.376E 02	0.965E-01	0.180E-01	0.144E 02	0.907E-01
SPARES						
	SUBSYSTEM	0.138E 03	0.246E 00			
ACCUMULATED MATERIAL						
	URINE	0.231E 02	0.182E-01			
	FECAL - DEBRIS	0.763E 03	0.450E 00			

CO 2 REMOVAL BY ELECTRODIAL YSIS
1975 FLIGHT DATE - CRITICAL COMPONENT - IMPROVED CURRENT DENSITY MAY RESULT IN 40 PER CENT REDUCTION IN WEIGHT AND 50 PER CENT REDUCTION IN POWER REQUIREMENTS

CO 2 REMOVAL BY CARBONATION CELL
1972 FLIGHT DATE POSSIBLE - UNIT USED IN H738 IS HYDROGEN-DEPOLARIZED - UNIT OPERATES H 2-RICH, CONSUMES HYDROGEN AND OXYGEN AND PRODUCES WATER

CO 2 REMOVAL BY LIQUID ABSORPTION
SENSITIVITY ANALYSES INDICATE LIQUID ABSORPTION TO BE A HIGHLY ATTRACTIVE PROCESS FOR MANY APPLICATIONS - NO APPRECIABLE DEVELOPMENT EFFORT HAS BEEN INITIATED - ADAPTION OF UNIT TO SPACECRAFT USE REQUIRES SOLUTION OF A NUMBER OF PHASE SEPARATION PROBLEMS

Figure 2-15 (Continued) - Sample Case Output

************ CREW AND CREW SUPPORT SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
FIRST AID / MEDICAL	LIVING AREA	0.129E 03	0.280E 01	0.126E 00		
PERSONAL ITEMS	LIVING AREA	0.472E 02	0.121E 01	0.800E-02		
INSTRUMENTS AND CONTROLS	LIVING AREA	0.349E 03	0.296E 00	0.919E 00		
SPACE SUITS AND CLOTHING	LIVING AREA	0.590E 03	0.395E 01			
EVA SUPPORT	LIVING AREA	0.599E 03	0.221E 01	0.367E 00		

Figure 2-15 (Continued) - Sample Case Output

************ CREW ACCOMMODATIONS SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
INSTRUMENTS AND CONTROLS						
	LIVING AREA	0.195E 03	0.114E 00	0.698E 00		
LIVING, WORK, AND RECREATION						
	LIVING AREA	0.242E 03	0.955E 01	0.182E 02		
GRAVITY CONDITIONING						
	LIVING AREA	0.544E 03	0.410E 02	0.600E 00		

Figure 2-15 (Continued) - Sample Case Output

************ WATER SUPPLY SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
RECOVERY	VEHICLE	0.372E 02	0.431E 00	0.132E 00	0.171E 02	0.858E-01
STORAGE	VEHICLE	0.944E 01	0.130E 00		0.127E 03	0.127E 00
STERILIZATION	VEHICLE	0.500E 00	0.000E-38	0.000E-38		
MISCELLANEOUS	VEHICLE	0.550E 01	0.310E-02	0.150E-01		
EMERGENCY	VEHICLE	0.598E 02	0.113E 00			
SPARES	SUBSYSTEM	0.834E 02	0.149E 00			
ACCUMULATED MATERIAL	RECOVERY	0.704E 02	0.353E 00			
	WATER	0.447E 03	0.447E 00			

WATER RECOVERY BY ELECTRODIALYSIS
CURRENT TECHNOLOGY UNITS USE EXECESSIVE AMOUNTS OFACTIVATED CHARCOAL FOR REMOVAL OF ORGANICS -
DEVELOPMENT NEEDED FOR PRETREATMENT OF URINE OR REEGENRATION OF CHARCOAL

Figure 2-15 (Continued) - Sample Case Output

************ FOOD SUPPLY SUBSYSTEM ************

		************ EQUIPMENT ************			**** EXPENDABLES ****	
		WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
PROCESS AND STORAGE	VEHICLE	0.652E 01	0.169E 01	0.800E-02	0.263E 03	0.152E 01
EMERGENCY	VEHICLE	0.908E 01	0.746E-01			
ACCUMULATED MATERIAL	VEHICLE	0.000E-38				

FOOD SUPPLY
ANIMAL AND HUMAN NUTRITION STUDIES NEEDED - 1980 FLIGHT DATE - HYDROGENOMONAS GROWTH AND ACCEPTANCE OF HUMAN WASTES REQUIRE ADDITIONAL INVESTIGATION - CLYCEROL PROCESSING PROBLEMS INCLUDE PHASE SEPARATION, ENERGY-HANDLING TECHNIQUES, CATALYSTS AND DEVELOPMENT OF LIGHTWEIGHT RELIABLE EQUIPMENT

Figure 2-15 (Continued) - Sample Case Output

TOTAL SUBSYSTEM DATA

	************ EQUIPMENT ************			**** EXPENDABLES ****	
	WEIGHT KG	VOLUME CU M	POWER KW	WEIGHT KG	VOLUME CU M
ATMOSPHERE CONTROL SUBSYSTEM	0.101E 04	0.103E 01	0.165E 01	0.171E 03	0.509E 00
THERMAL CONTROL SUBSYSTEM	0.145E 04	0.133E 01	0.150E 01	0.483E 04	0.483E 01
WASTE MANAGEMENT SUBSYSTEM	0.372E 03	0.150E 01	0.424E 00	0.140E 03	0.421E 00
CREW AND CREW SUPPORT SUBSYSTEM	0.171E 04	0.105E 02	0.919E 00		
CREW ACCOMMODATIONS SUBSYSTEM	0.981E 03	0.507E 02	0.690E 00		
WATER SUPPLY SUBSYSTEM	0.196E 03	0.826E 00	0.147E 00	0.144E 03	0.213E 00
FOOD SUPPLY SUBSYSTEM	0.156E 02	0.176E 01	0.800E-02	0.263E 03	0.152E 01
SYSTEM CONTROL SUBSYSTEM	0.845E 01	0.600E-01			

Figure 2-15 (Continued) - Sample Case Output

```
                                   TOTAL LIFE SUPPORT SYSTEM DATA

              THE TOTAL ACCUMULATED MATERIAL WEIGHS  0.170E 04 KG AND OCCUPIES  0.127E 01 CUBIC METERS

              THE METEOROID SHIELD WEIGHS  0.194E 04 KGS

              THE RADIATION SHIELD WEIGHS  0.102E 05 KGS

              (THE ABOVE SHIELD WEIGHT(S) ARE NOT INCLUDED IN THE TOTALS BELOW)

              THE TOTAL LSS HEAT REQUIREMENT IS    2.472 KW


                                    ************ EQUIPMENT ************     **** EXPENDABLES ****

                                     WEIGHT       VOLUME       POWER        WEIGHT       VOLUME
                                       KG          CU M         KW            KG          CU M

 LIFE SUPPORT SYSTEM TOTALS          0.575E 04    0.676E 02    0.535E 01    0.555E 04    0.749E 01
```

Figure 2-15 (Continued) - Sample Case Output

2.5 Checklist

The following list is included in the manual to serve as a reminder of items to check before submitting a run and as an aid in debugging a run which has gone awry.

1. A Baseline Case must contain complete sets of:

   MAD - Level 2
   LSS-TOD
   Table Data
   MAD - Level 1 should not be present in a Baseline Case.

2. A Change Case must contain both MAD-Level 1 cards, they are the first two cards of each Change Case. A Change Case need only contain such portions of the following data groups as necessary:

   MAD-Level 2
   LSS-TOD
   Table Data

3. Each data card in a Change Case must be completely filled as blanks will enter as zeroes and overide the counterpart Baseline data.

4. Each case of data must be concluded with a TBLEND card.

5. A BASELINE*END card must be the first card in the data deck when running from the Master Baseline Tape.

6. The Master Baseline Tape is mounted on UNIT08.

7. The execution time is approximately 1/2 minute per case.

8. Almost 800 lines of output per case are printed when all optional output is obtained.

9. The Program Deck Set-Up and Control Cards are shown in Section 3.3.

10. Projected equipment weights due to SOA improvements are based on 1972 technology. This feature may be suppressed by entering flight dates prior to 1973.

11. All Integer (non-decimal) data must be right justified in the field.

12. Emergency equipment and supplies determination may be suppressed by entering an emergency period of 0.0.

13. Calculation of spares may be suppressed by entering subsystem reliabilities of 0.0.

14. The ranges of input parameters for which the output results are valid are shown below.

Crew Size	3 - 20
Crew Percentile Range	20 - 95
Metabolic Rates	Basal to 5 x basal
Volumes	
Free Cabin	20-1500 ft^3/man
Subsystems (other than LSS)	50-150% free cabin volume
Airlock	50-250 ft^3
Missions	
Earth Orbit	
Low	1-180 days
Synchronous	
Lunar	

Interplanetary	
Mercury	
Venus	300-600 days
Mars	
Asteroids	700-1800 days
Jupiter	
Cabin Atmospheres	
Constituents	
O_2	5 psia
N_2-O_2	5-14.7 psia
He-O_2	5-10 psia
Temperature	52-83°F
Relative Humidity	35-65%
Emergency Operation	1-30 days
Airlock Use Rate	0-2 per day
Resupply Period	30-180 days
Primary Power Supply	electrical

3.0 PROGRAMMER'S INFORMATION

3.1 General Information

The primary philosophy followed in writing the H738 program was to create a "user's" program rather than a "programmer's" program. Thus, the main objective was to have a program which requires minimal training and is easy to use. For this reason, the input editor is of major importance in the program. These input editor subroutines are BASDAT, CASDAT, TAPERD and TABLRD and an associated interpolation subroutine VALUE.

The characteristics for the Life Support System subsystems are determined in a subroutine or group of subroutines for each subsystem. These subsystems and their subroutine designators are:

SUBSYSTEM	SUBROUTINE(S)
Waste Management	WASTE, WASTPR
Food Supply	FSS
Water Supply	WSS
Crew and Crew Support	CREW
Crew Accommodations	CREWAC
Atmosphere Control	ACS
Thermal Control	TCS, TCS1, THMC, RADSUB

Several items such as meteoroid protection and radiation shielding, cabin wall insulation, and cabin atmosphere leak rate are determined in subroutine VEH. The number of spare parts are determined in subroutine SPARES.

Function subprograms FX and CYLDIA are used in conjunction with the library subroutine ROOT to evaluate the root of several implicit equations.

Subroutine PRØPS is used to determine the physical properties of the cabin atmosphere while function H2ØPRP computes water vapor pressure and the heat of vaporization of water.

Subroutine FINAL edits the output data printed at the conclusion of the case.

3.2 Tape and Disk Assignments

In addition to the standard FORTRAN input and output tapes, 5 and 6 respectively, four additional files are used. One of these is used for overlay and the other three are used by the input editor.

The standard unit specification for the overlay unit, SYSUT2, is used and does not conflict with the other files.

AT the NASA Ames facility the three additional input files are UNIT 8 (binary), UNIT 9 (BCD) and UNIT 10 (binary). UNIT 8 is used for the Master Baseline Tape of interest. When it is desired to make a new Baseline Tape, the desired Baseline Case cards with the job is submitted and a scratch tape should be mounted for UNIT 8. This tape will then contain the edited Baseline Cases at the conclusion of the job, and it should be dismounted and saved. For any subsequent runs, the appropriate Baseline Tape is mounted and the Baseline cards are no longer necessary.

UNIT 9 is used as a scratch tape while editing the input data. All MA Data - Level 2, LSS-TO Data and Table Data cards from UNIT 5 are split into two records as it is placed onto UNIT 09. These data are then in a form which it may be processed by the editor. As this unit is used only for utility purposes and only occassionally, it is recommended that a $SETUP card be used to sign this file to a disk rather than the tape device nominal for UNIT09. Before processing Change Case data, the H738 copies the edited Baseline Cases from the master Baseline Tape, UNIT8, onto the utility device UNIT10. Subsequently, the appropriate Baseline Cases may then be read from this file for each Change Case. In so doing, the Master Baseline Tape, UNIT8, is preserved. The scratch file, UNIT10, may also be assigned to the disk to save machine time.

3.3 Overlay Structure

As the H738 program is too large for the IBM 7094 in its entirety, the overlay feature of the IBJOB system is used. The proper overlay structure will be obtained if the program deck order and control card placement as shown below are followed:

Control Card		MAD I.D.	Subroutine Name
		MA2800	H738 (Main Program)
$INCLUDE	TAPPRP,TAPE5,TAPE4,TAPACS,TAPTCS,TAPRAD,TAPE2		
$INCLUDE	TIME,TAPVEH,TAPWSS,TAPWMS,TAPCCS,TAPE1,TAPTCR		
$INCLUDE	TAPE3,TAPFSS,TPFSTC,TPWSTC,TPWMTC,TPACTC,SWN4		
		MA2801	H2ØPRP
		MA2802	VALUE
$INCLUDE	SWN5,CASE,CCSWMS,VEHWMS,WMSWSS,CCACTH,WMACTH		
$INCLUDE	CCWMWS,WMSTHM,WSSTHM,CCSTHM,TCSRAD,PRPGEN		
$INCLUDE	VEHTCS,CCSTCS,THMTCS,WSSTCS,WMSTCS,VEHFIN		
$INCLUDE	WMSACS,VEHACS,CCACWS,VEHCCS,ERRØR,CCWMFS		
$INCLUDE	FSSWSS,CASE1,ACSTCS,CCSWSS,VEHGEN,SWN31,OCL2		
$INCLUDE	RLV12,WGN2,BNT13,BNT14,BNT15,SWN32,WGN11,WMS2		
$INCLUDE	BNT12,BNT11,FSSTCS,FSSFIN,CSSFSS,FSSWMS,FSSACS		
		MA2803	BLOCK DATA
		MA2804	FX
		MA2805	SPARES
$ØRIGIN	ALPHA		
		MA2806	BASDAT
		MA2807	CASDAT

Control Card		MAD I.D.	Subroutine Name
		MA2808	TABLRD
		MA2809	TAPERD
$ØRIGIN	ALPHA		
		MA2810	PRØPS
		MA2811	VEH
$ØRIGIN	ALPHA		
		MA2812	CREWAC
		MA2813	CREW
$ØRIGIN	ALPHA		
		MA2814	WASTE
		MA2815	WASTPR
		MA2816	FSS
$ØRIGIN	ALPHA		
		MA2817	WSS
		MA2818	ACS
		MA2819	CYLDIA
$ØRIGIN	ALPHA		
		MA2820	THMC
$ØRIGIN	ALPHA		
		MA2821	TCS
$ØRIGIN	GAMMA		
		MA2822	RADSUB
$ØRIGIN	GAMMA		
		MA2823	TCS1
$ØRIGIN	ALPHA, REW		
		MA2824	FINAL

It is suggested that the rewind option be specified only on the last ØORIGIN card in order to minimize machine time when multiple consecutive change cases are run.

3.4 Subprogram Descriptions and Logic Diagrams

Brief descriptions of the function of each subprogram are given in this section. Logic diagrams are also shown with the exception of some of the shorter subprograms.

3.4.1 Main Program H738

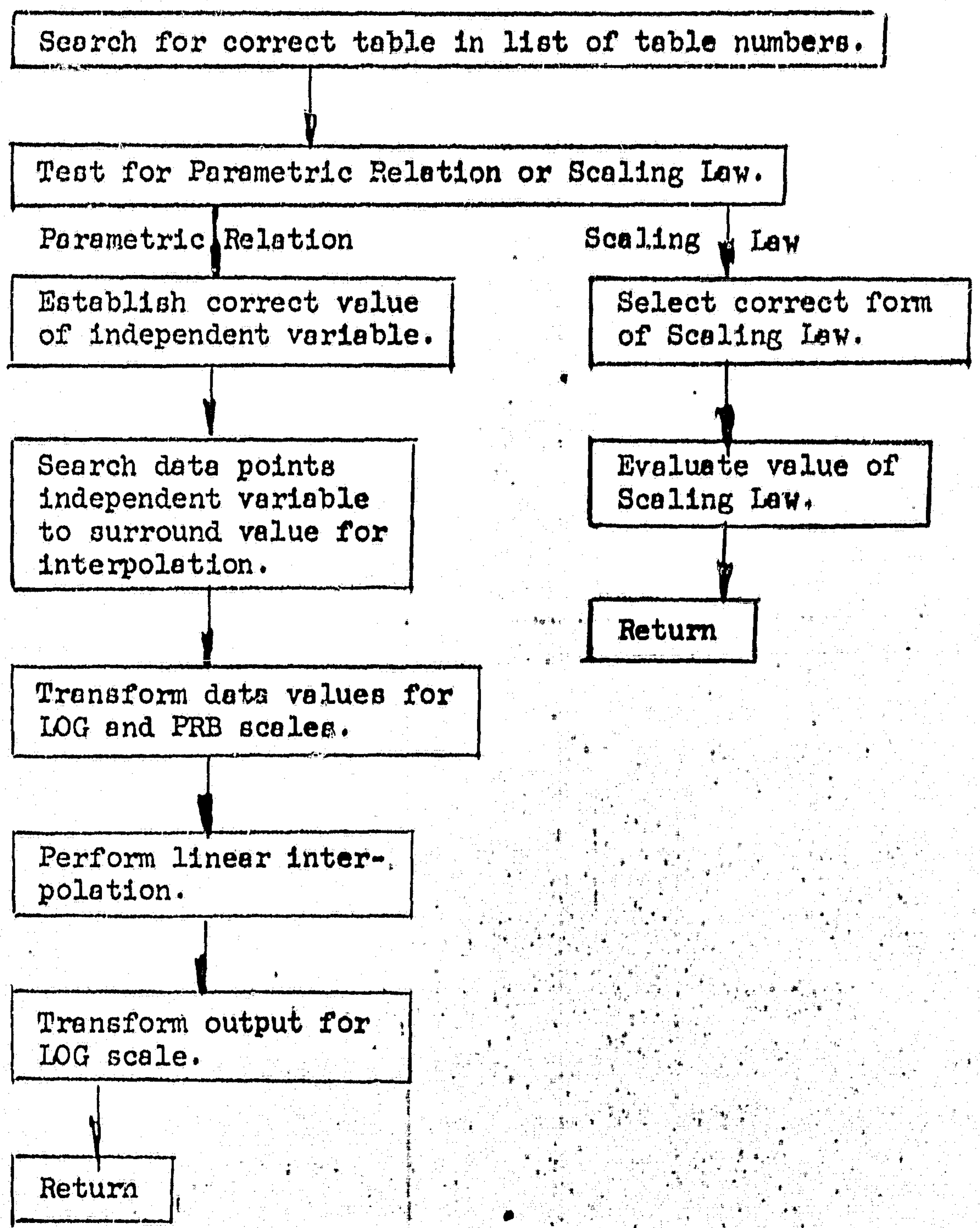
The main program controls the processing flow between the input, output and subsystem subroutines.

3.4.2 Function H2OPRP (T, I) -- Water Properties

Function H2ØPRP determines water vapor pressure (kg/cm^2) or the heat of vaporization (k w.sec/kg) at temperature T ($^{\circ}$K) for values of I = 1 or I = 2, respectively.

3.4.3 Function VALUE - Table Interpolation

This subprogram interpolates the 2 and 3 dimensional Parametric Relations and evaluates the analytical expressions for the Scaling Laws. Additional forms of Scaling Laws may be coded in at statements 2090 and 2100; these would correspond to form numbers 9 and 10, respectively.



3.4.4 Subroutine RØØT - Root Finder

Subroutine RØØT is an AMES library subroutine which is used to find the root of implicit functions. RØØT is used to determine the thickness of thermal insulation, meteoroid shielding and radiation shielding.

3.4.5 Function FX - Implicit Functions

This subprogram contains the implicit functions which are to be solved by RØØT.

3.4.6 Function SPARES - Spare Parts Weight

SPARES computes the spare parts requirements when called by subroutines ACS, WASTE, WSS and TCS. As the spares of the first three of these are a function of three independent variables, this function performs an additional interpolation.

3.4.7 Subprogram BLOCK DATA

This subprogram is used to establish values for program "variables" which are actually constant. The values are generally of alphanumeric nature and are used to test against alphanumeric input values to determine program flow.

3.4.8 Subroutine BASDAT - Baseline Case Data Input

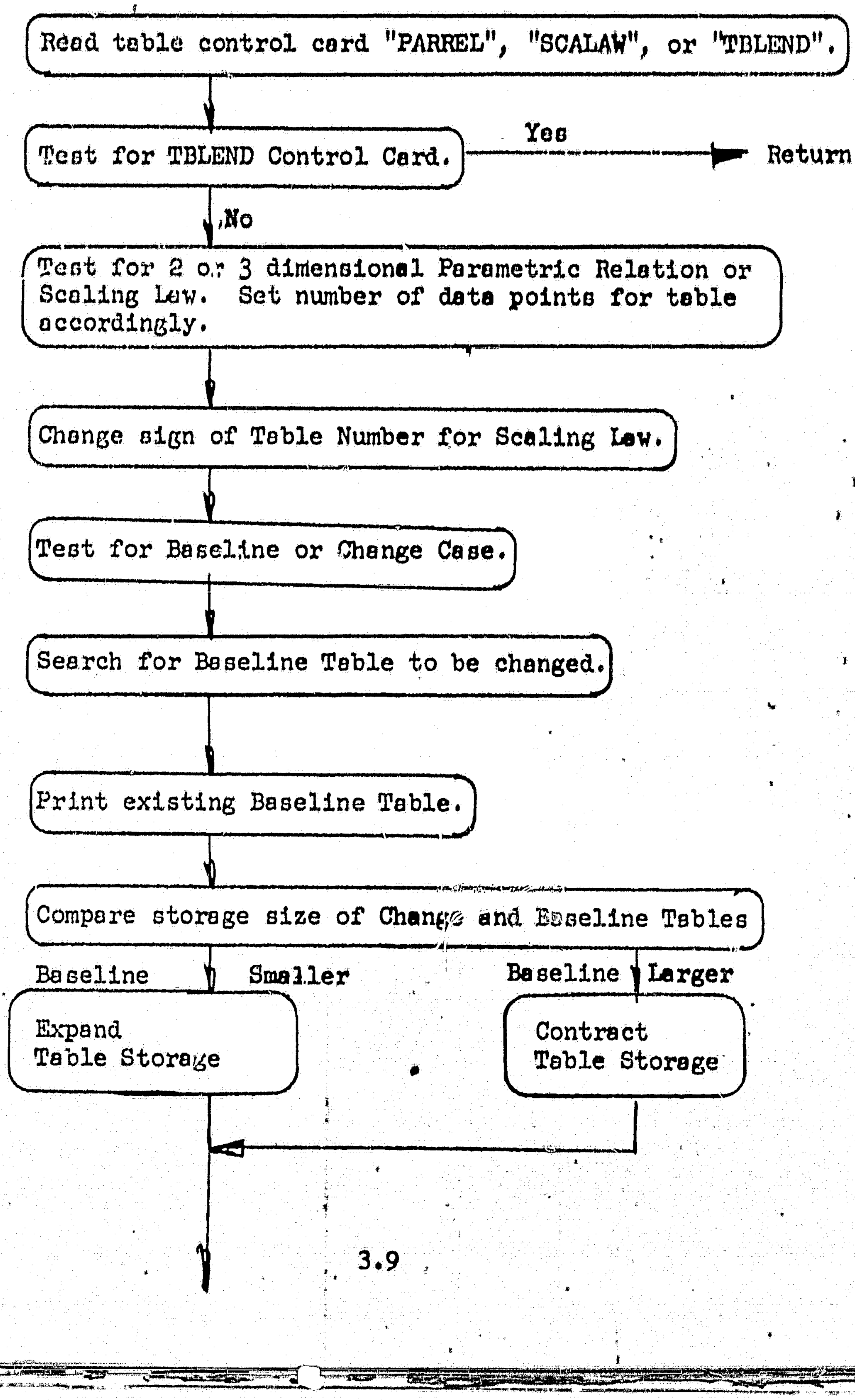
This subroutine is called once each run immediately upon program execution. BASDAT controls the editing of Baseline Cases when the Baseline Data is entered on cards and a Master Baseline Tape is to be made. In so doing, this subroutine calls subroutines TAPERD and TABLRD, respectively, once for each Baseline Case. After editing, each Baseline Case is copied onto the Master Baseline Tape.

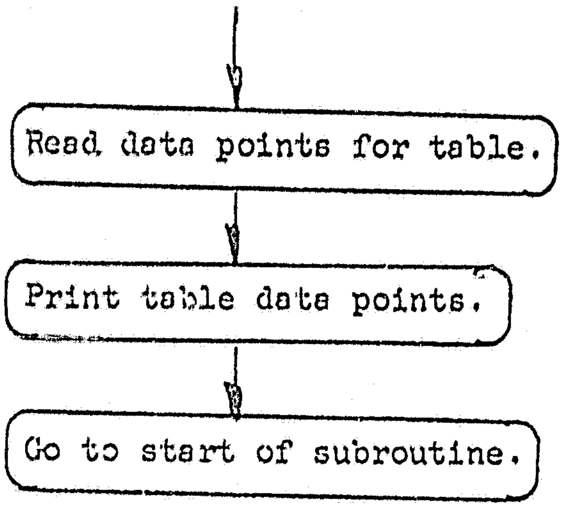
3.4.9 Subroutine CASDAT - Change Case Data Input

CASDAT is called once each case by the Main Program to control the editing and reading of the Change Case data. The subroutine reads the MADLE11 and 12 cards, selects the Baseline Case from the tape, reads the Change Case cards and copies them on a scratch tape. CASDAT then calls TAPERD and TABLRD to edit these Change Case data.

3.4.10 Subroutine TABLRD - Table Data Input

This subroutine reads and edits all Table Data (Parametric Relations and Scaling Laws). After editing all Basic Case Tables, the tables are printed. During the Change Case, the Baseline Case version and then Change Case updated version are printed for each table in the Change Case.

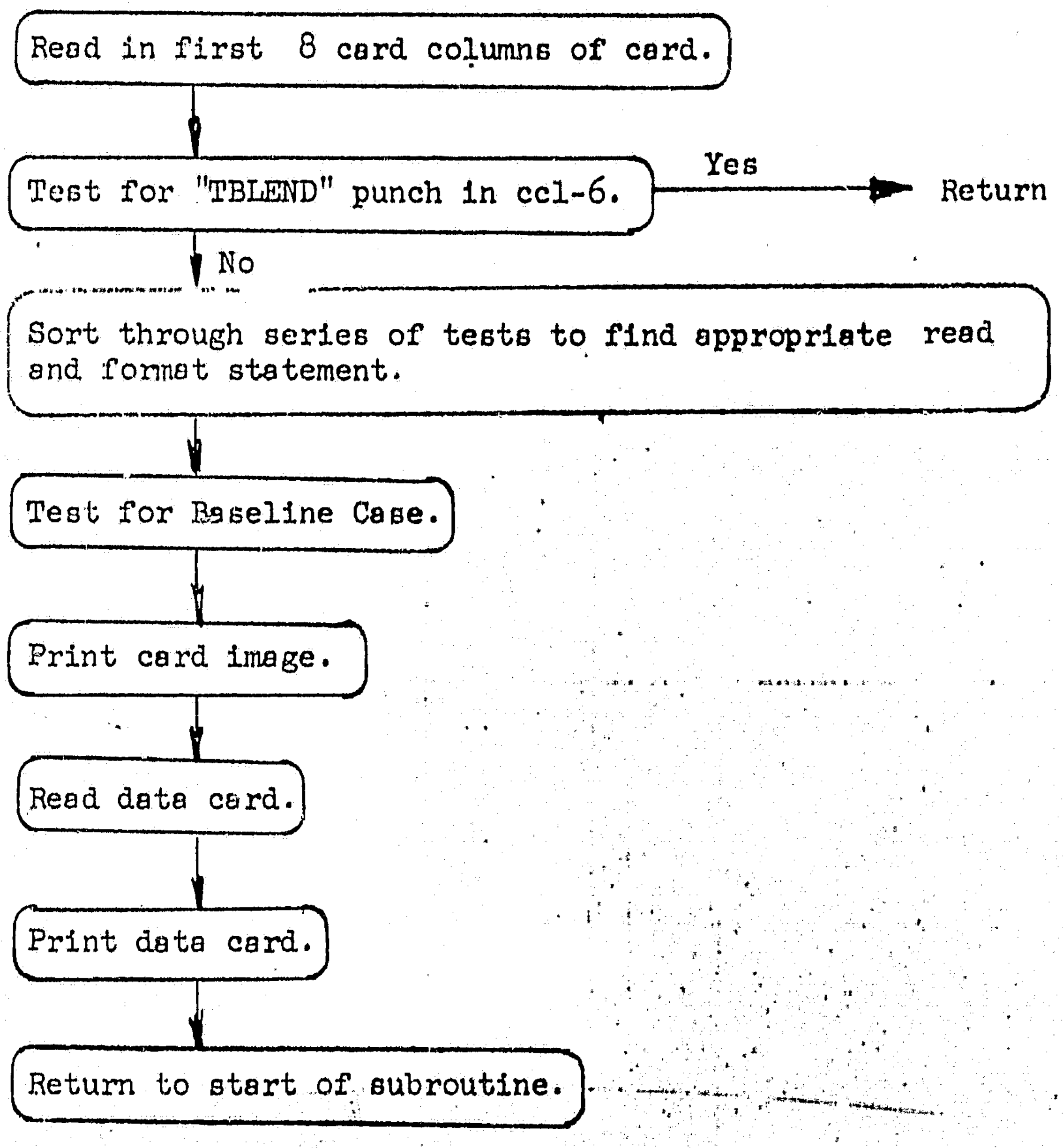




Read data points for table.
Print table data points.
Go to start of subroutine.

3.4.11 Subroutine TAPERD - LSS-TOD Input

Subroutine TAPERD reads and edits the MAD Level 2 and LSS-TOD from the scratch tape. The subroutine prints the data card images for Baseline Cases and prints both Baseline Case version and Change Case version for each Change Case data card.

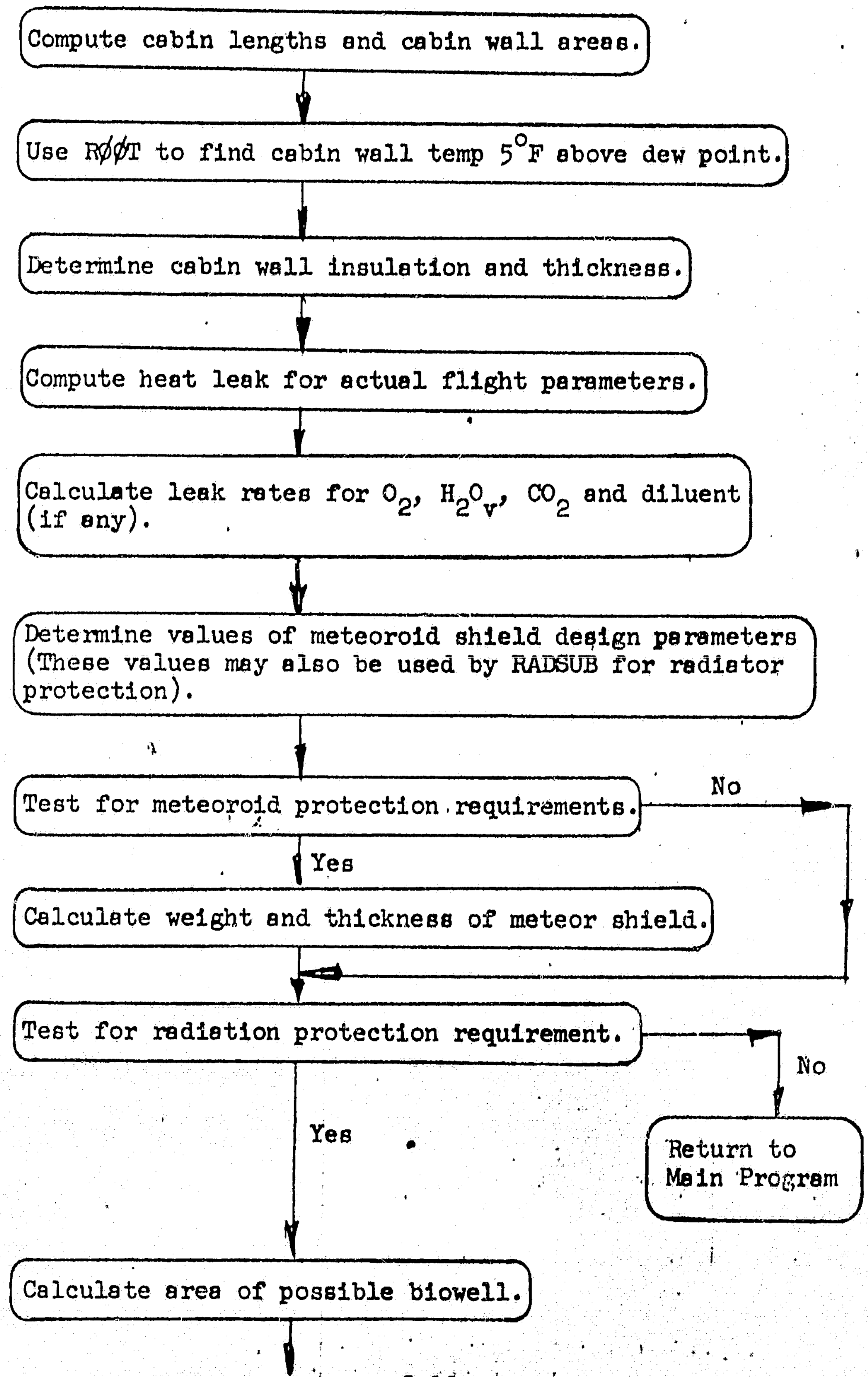


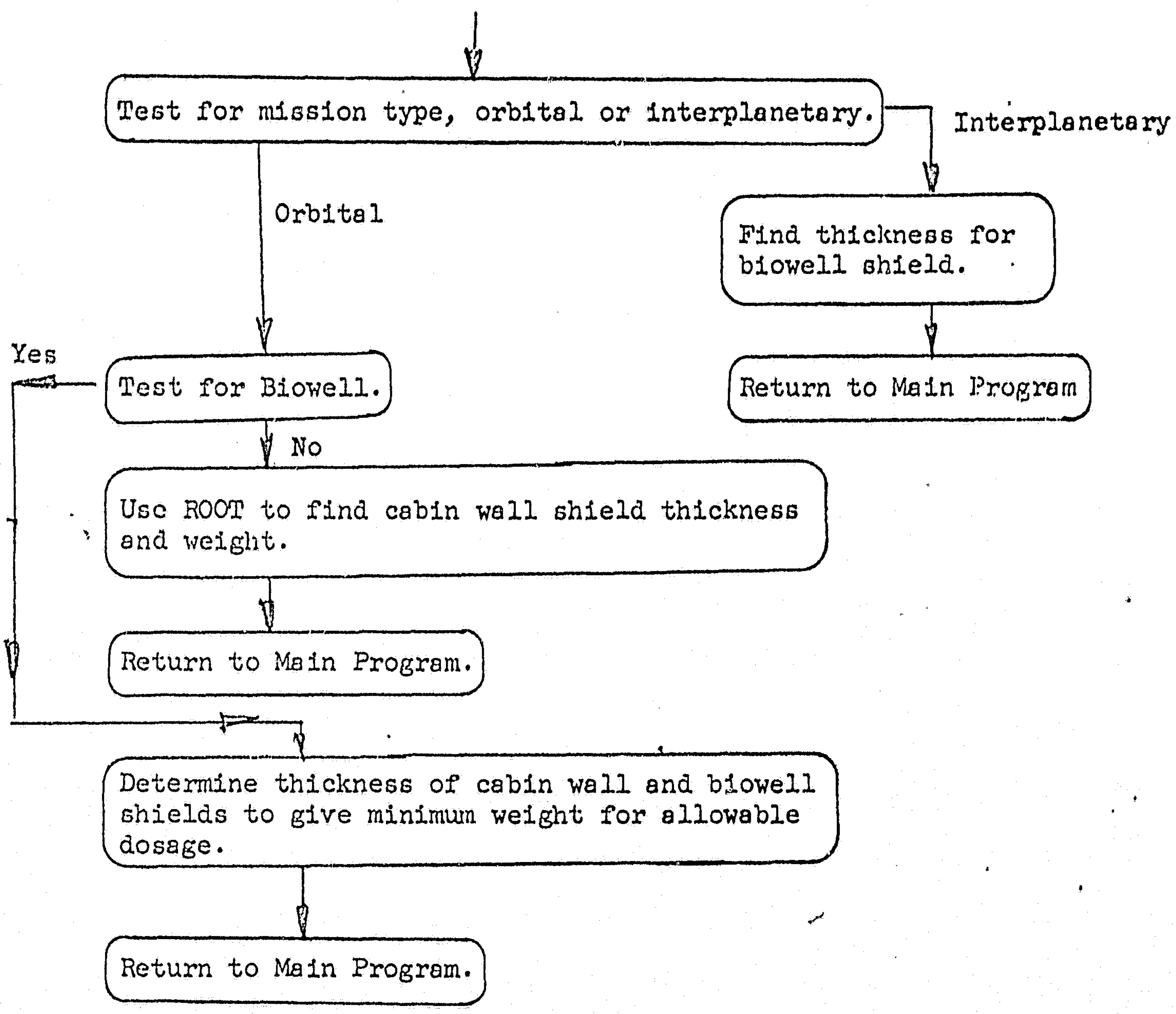
3.4.12 Subroutine PROPS - Cabin Atmosphere Properties

This subroutine is called once each case by the MAIN PROGRAM immediately after processing the change case data. PROPS determines the thermal and transport properties of the cabin atmosphere. The cabin water vapor partial pressure is also computed from the cabin atmosphere temperature and relative humidity.

3.4.13 Subroutine VEH - Vehicle Integration

This subsystem determines vehicle Life Support System interface requirements and subsystem characteristics which are most conveniently determined here. VEH calculates such results as thermal insulation, meteoroid and radiation protection.




Test for mission type, orbital or interplanetary.
Interplanetary
Orbital
Find thickness for biowell shield.
Return to Main Program
Yes
Test for Biowell.
No
Use ROOT to find cabin wall shield thickness and weight.
Return to Main Program.
Determine thickness of cabin wall and biowell shields to give minimum weight for allowable dosage.
Return to Main Program.

3.4.14 Subroutine CREWAC - Crew Accommodations Subroutine

This subroutine determines the weight, volume and power requirements for such equipment as gravity conditioning, recreational, laundry and lighting.

Determine weight, volume, and power for instrumentation and controls (measurement transducer, signal conditioner, display and control system, caution and warning system, timing equipment, event timers, lighting system).

↓

Determine weight, volume and power for living, work and recreational facilities (shower, laundry, sleep, instrumentation, oxygen masks).

↓

Determine weight, volume, and power for gravity conditioning.

↓

Print engineering results for crew accommodations.

↓

Sum up weight, volume, and power for crew accommodations.

↓

Return to main program.

3.4.15 Subroutine CREW - Crew and Crew Support Subsystem

Subroutine CREW determines the crew physiological data such as food and water consumption along with waste generation rates. Also computed are first aid and medical supplies, personal items and space suits weights.

If mission duration is greater than 30 days, compute time available for operations (experiments, exploration or military functions) and maintenance duties (subsystem operations, house-keeping and emergency [illegible]

↓

Compute weight and volume for space suits and clothing (pressure suit assembly, biovest assembly, heard hat assembly, constant wear garmet, stockings, underware, footgear, work coveralls, protective hat.

↓

Compute weight, volume, and power for personal items (razors, hairclippers, manicure set, toilet soap, bath soap, towels, handkerchiefs, toothpaste, comb and brush, personal photos, books, records, and tape, sewing kit, dry wipes, general purpose tissue).

↓

Calculate weight, volume, and power for instrumentation and controls for crew support (includes data management equipment for personal records, physiological case histories, information for diagonosis of health, maintenance information).

↓

Calculate weight, volume, and power for first aid and medical supplies (first aid kit; medication, dressings, splints, casting material, minor surgical instruments, utensil sterilization; x-ray; simple conditioning devices; simple training aids; complex physical conditioning).

↓

Calculate weight, volume, and power for EVA support (maneuvering unit, umbilicals, restraint equipment, suit-mounted lights, illumination equipment, handtool kits, tool and tool tethers, and crew monitoring.

Set cabin number equal to 1. Calculate crew data for cabin.

From crewman percentil rating determing crewmen weight, height, and surface area.

A

From crewmen weight, height, and activity level determine total metabolic rate for purpose of equipment sizing (based on high crew activity and maximum crew size).

Determine crewman metabolic oxygen consumption and carbon dioxide expired (based on total metabolic rate for equipment sizing).

Determine water perspired and respired by crewmen (based on total metabolic rate for equipment sizing).

Is a detailed crewman mass and thermal balance for crewmen required.

Yes

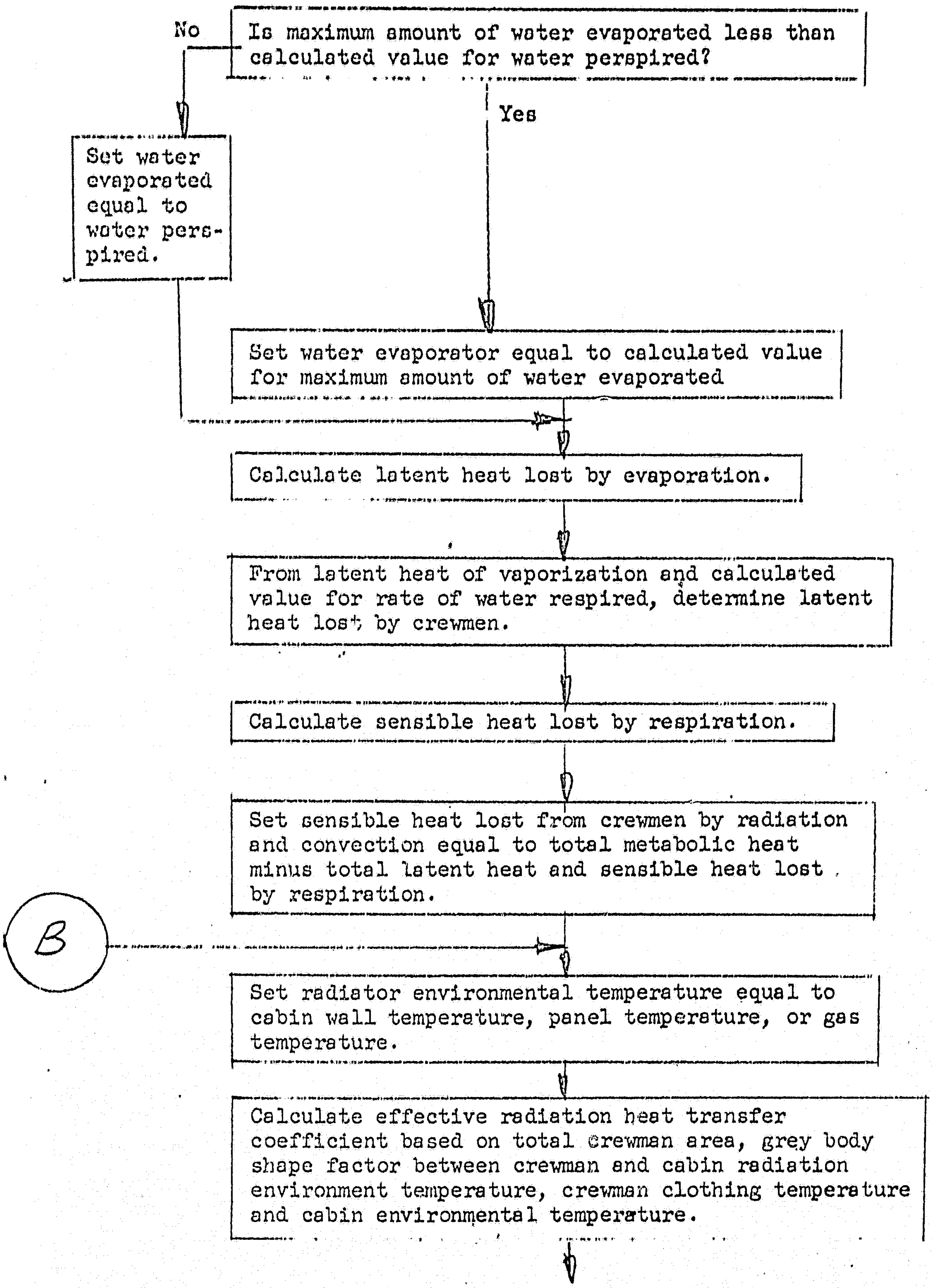
No

Determine latent heat lost by respiration and perspiration based and calculated values for water respired and perspired and latent heat of vaporization.

Set sensible heat lost from crewmen by radiation and convection equal to total metabolic heat minus latent heat.

B

Calculate convective heat and mass transfer coefficients for crewmen and ambient surroundings. Calculate maximum amount of water evaporated.


No
Is maximum amount of water evaporated less than calculated value for water perspired?
Yes
Set water evaporated equal to water perspired.
Set water evaporator equal to calculated value for maximum amount of water evaporated
Calculate latent heat lost by evaporation.
From latent heat of vaporization and calculated value for rate of water respired, determine latent heat lost by crewmen.
Calculate sensible heat lost by respiration.
Set sensible heat lost from crewmen by radiation and convection equal to total metabolic heat minus total latent heat and sensible heat lost by respiration.
B
Set radiator environmental temperature equal to cabin wall temperature, panel temperature, or gas temperature.
Calculate effective radiation heat transfer coefficient based on total crewman area, grey body shape factor between crewman and cabin radiation environment temperature, crewman clothing temperature and cabin environmental temperature.

From crewmen's sensible heat rate, effective radiation and convective heat transfer coefficient, calculate clothing outside surface temperature.

From crewmen's sensible heat rate, clothing outside surface temperature, Clo value for clothing, determine crewmen's skin temperature.

From crewmen weight, height, and activity level, determine total nominal metabolic rate for purposes of determining expendable requirements (based on nominal activity level and nominal crew size).

From nominal metabolic rate, crewman weight, and fat ratio (ratio of fats to carbohydrates in diet) determine food requirements (fats, proteins, and carbohydrates).

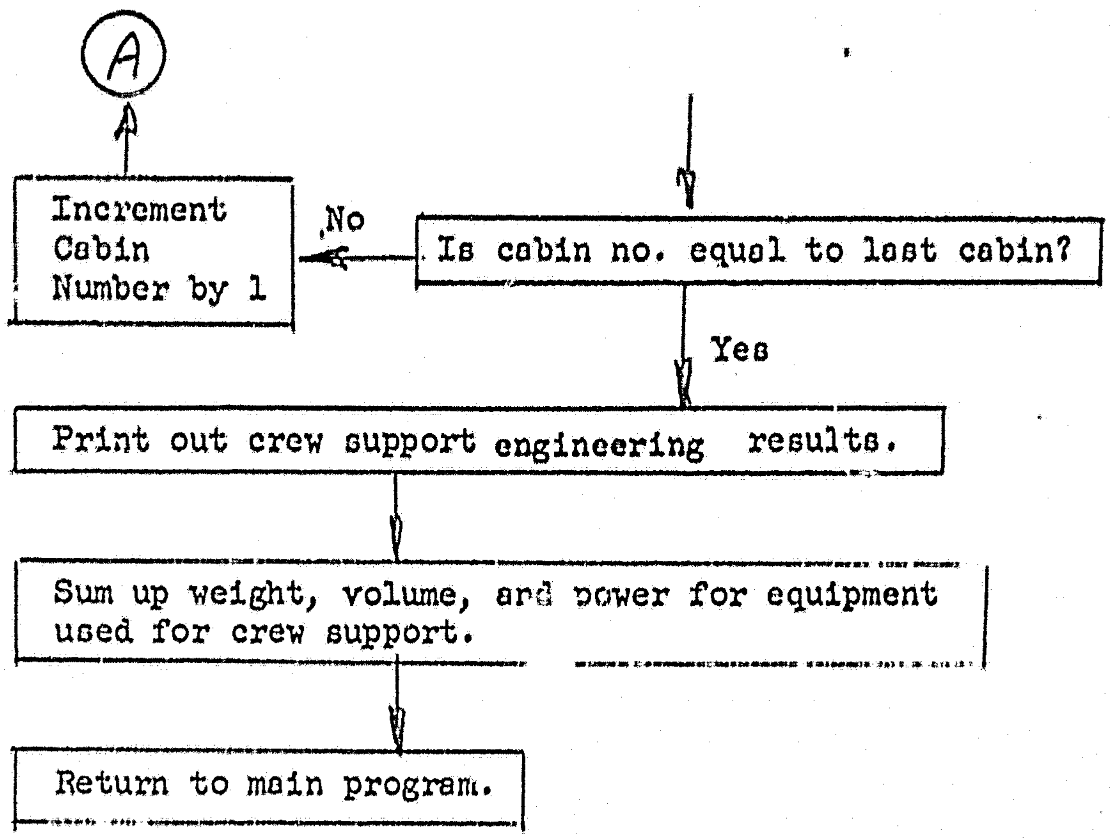
Determine crewman metabolic oxygen consumption and carbon dioxide expired (based on total metabolic rate for determining expendable requirements.

Determine total metabolic water, water intake, total water output (water respired, perspired, urine, and fecal water).

Determine indigestible bulk, urinary solids, fecal solids, skin and other solid excretions.

Determine total number of micturations for crewmen.

Printout crew intermediate results for cabin.


A
Increment Cabin Number by 1
No
Is cabin no. equal to last cabin?
Yes
Print out crew support engineering results.
Sum up weight, volume, and power for equipment used for crew support.
Return to main program.

POOR REPRODUCIBILITY

Print out intermediate results for CO_2 and trace contaminants removal in cabin.

[illegible] cabin number equal to last [illegible]

No

Return to Start

Yes

Determine amount of urine and [illegible]

[illegible]

Determine CO_2 collection rate (equals CO_2 generation rate minus cabin leakage) for cabin.

Select function method to be used for CO_2 collection (lithium hydroxide, zeolite four bed, zeolite two bed adiabatic, zeolite two bed partially adiabatic, solid amines, liquid absorption, electrodialysis, carbonation cell) in cabin.

Is lithium hydroxide bed to be used for CO_2 collection.

No

Yes

Determine canister weight and volume, water generated, weight and volume of lithium hydroxide.

Determine weight, volume and power for function method used for CO_2 collection. Determine heating and cooling rates. Determine heating and cooling fluid flow rates. Determine miscellaneous expendable requirements.

Select function method to be used for CO_2 collection during emergency period (lithium hydroxide, zeolite two bed partially adibatic, or zeolite two bed adibatic.

Is lithium hydroxide bed to be used for emergency period.

Yes

No

Determine weight, volume, and power for function method used for CO_2 collection during emergency period. Determine heating and cooling rates, heating and cooling fluid flow rates, and expendable requirements.

Determine weight and volume for lithium hydroxide canister for emergency period.

Determine water generated bed and amount of expendable lithium hydroxide required for emergency period.

Is a charcoal bed to be used in air purification loop for trace contaminants removal.

No

Yes

Determine weight, volume, for charcoal bed and expendables.

Is a catalytic burner to be used in air purification loop for trace contaminants removal.

No

Yes

Calculate weight, volume, and power for catalytic burner and expendables.

Print out intermediate results for CO_2 and trace contaminants removal in cabin.

Is cabin number equal to last cabin?

No → Return to Start

Yes

Call Food subroutine. Determine amount of urine and feces required for food production (if any). Determine CO_2 consumed and oxygen produced (if any) in food production. Return to Waste Management subroutine. ⇄ FSS

Calculate weight, volume for urine collection device used during launch, re-entry, or EVA.

Select method of urine collection. Functional methods include manual collection and storage, air entrainment urinal with overboard dump, air entrainment with connection to storage tanks or water recovery sytem. Determine weight, volume, and power for equipment. Determine weight and volume of expendable and accumulated material.

Determine weight and volume for urine collection bags used during emergency spacecraft operation.

Select method of feces collection. Function methods include manual bagging and storage, air entrainment with vacuum drying of feces, air entrainment with water wash of crewman and collection of fecal slurry. Determine number of toilets required (if any).

Determine weight, volume, and power for feces collection. Determine weight and volume for expendable and accumulated materials.

Determine weight and volume for feces collection bags required for emergency periods.

Sum up total weight of miscellaneous solids generated in all cabins.

Determine weight, volume, and power requirements for refuse collection. Determine amounts of expendable and accumulated material. If an air entrainment feces collector is available, determine additional weight and volume for expendable materials required for debris collection. If a portable vacuum cleaner is specified, determine weight, volume, and power.

Call WASTPR

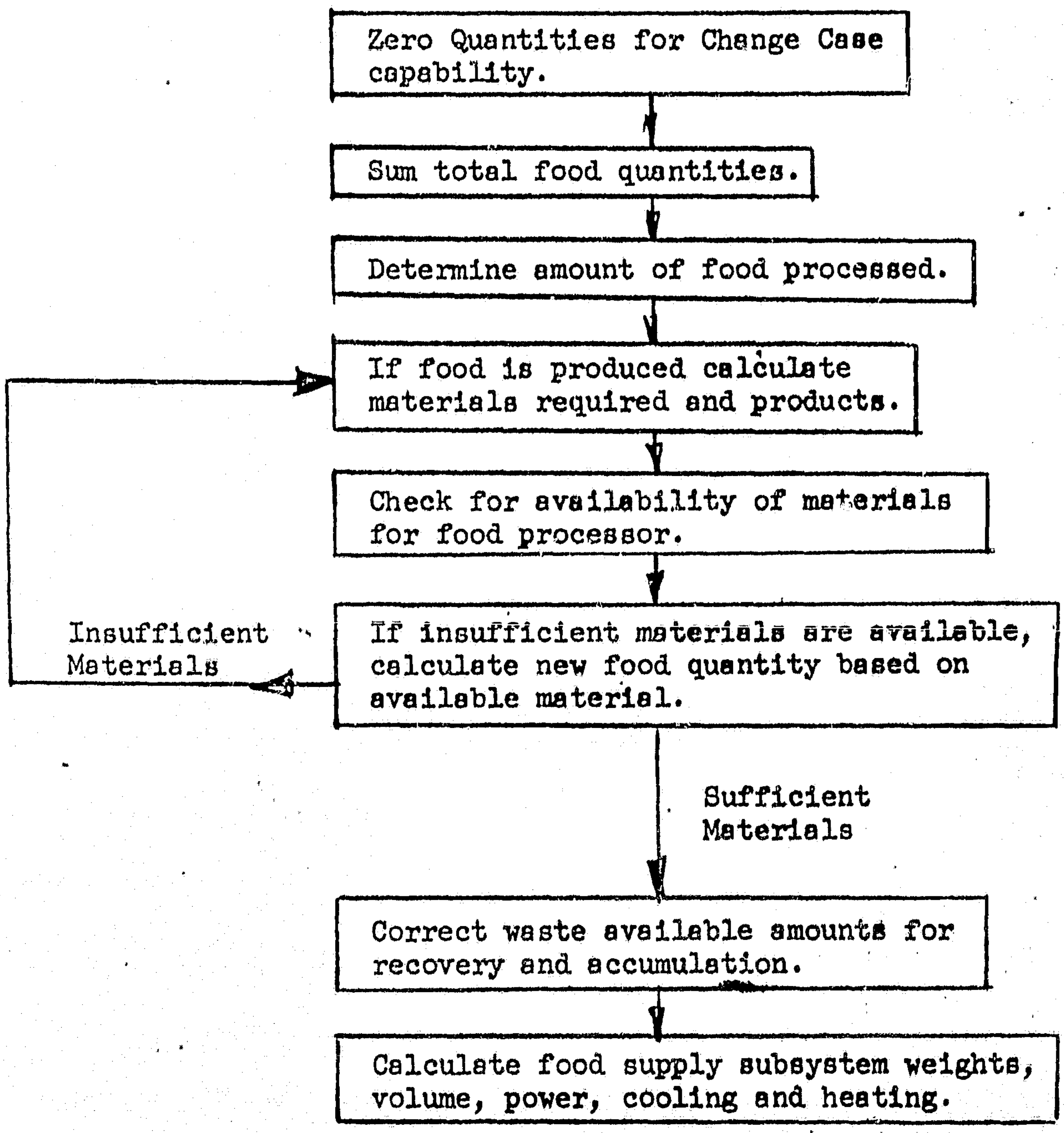
To WASTPR

Sum up weight, volume, and power for all cabins for the following equipment required for trace contaminants removal, expendables required for trace contaminants removal, equipment for CO_2 collection during normal and emergency operation, expendables lost by CO_2 collection during normal and emergency operation, equipment for feces and debris collection, expendables and accumulated material for urine collection.

Return to main program.

3.4.17 Subroutine FSS - Food Supply Subsystem

The food supply subsystem subroutine determines the amount of food stored and produced by the food processor and then calculates the weight, volume, power, cooling and heating for the equipment. A material balance is performed on the food processor to establish amounts of waste material used and products produced by the food processor.

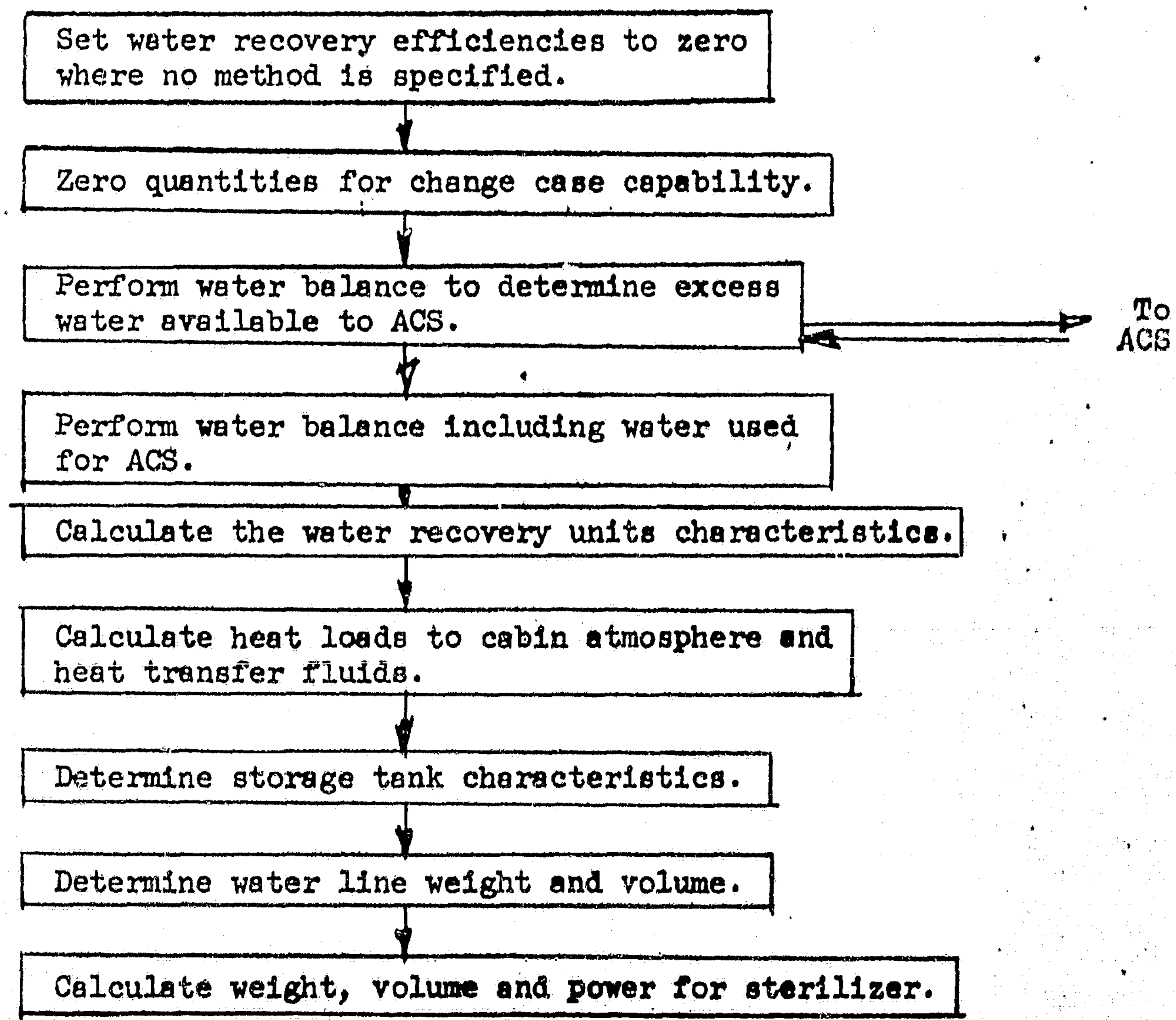


3.14.18 Subroutine WASTPR - Waste Management Subsystem (Engineering Data Output)

This subroutine is associated with the WASTE subroutine and prints the engineering output data from the latter.

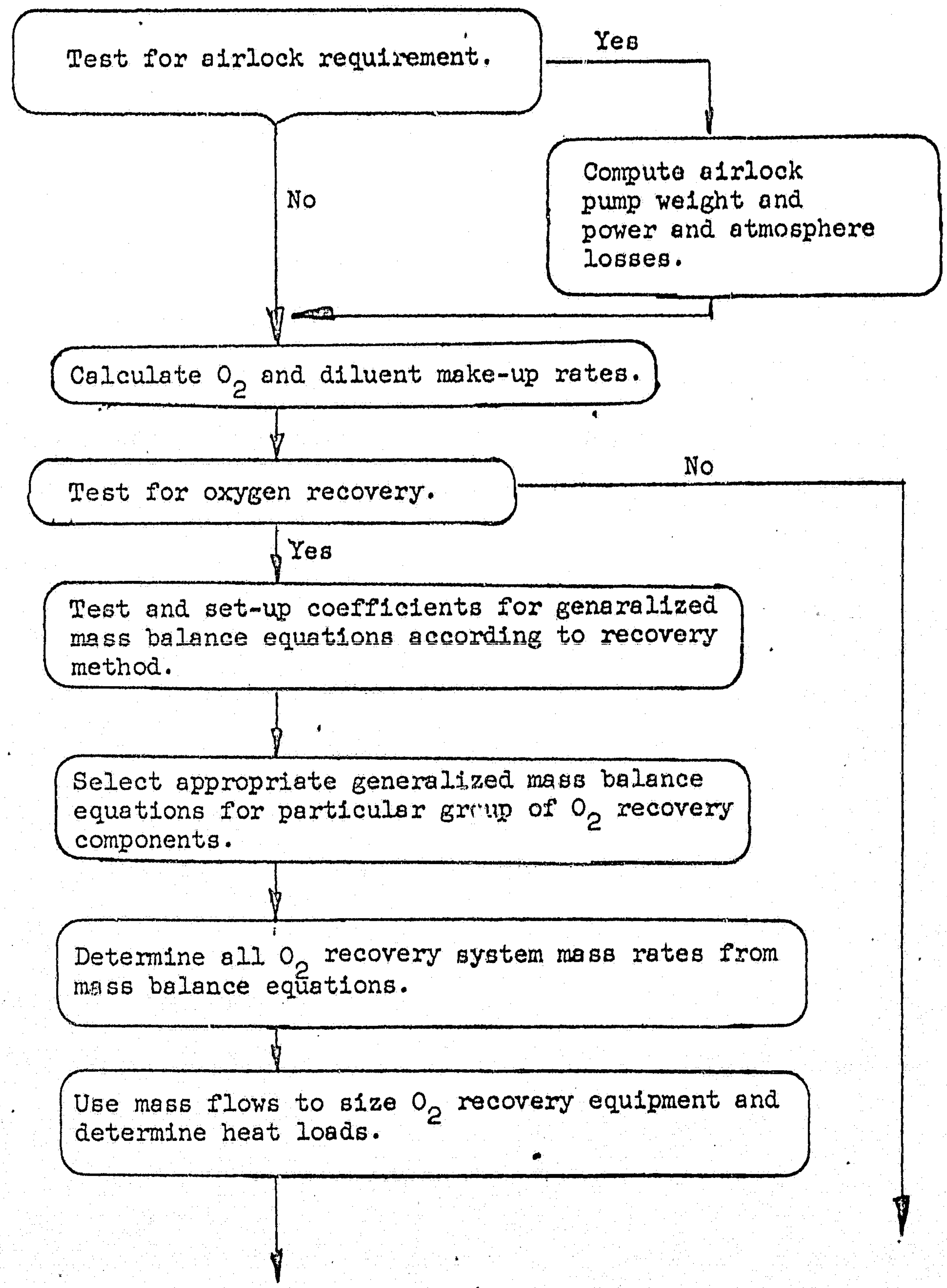
3.4.19 Subroutine WSS - Water Supply Subsystem

The water supply subsystem subroutine performs a water balance on the vehicle and determines amounts of stored water, accumulated water, and the various process rates for recovery equipment. Equipment characteristics are determined for water recovery units, storage tanks, water lines and sterilization equipment.



3.4.20 Subroutine ACS - Atmosphere Control Subsystem

ACS determines the characteristics and requirements of the Atmosphere Control System. Included are calculations for airlock systems, oxygen recovery and atmospheric constituent storage. ACS is called by WSS due to water vapor balance considerations.



Adjust O_2 makeup rate.

Determine weight and volume of O_2 and diluent storage tanks (including constituents).

Repeat tank sizing for emergency period, using original O_2 makeup rate but including repressurization gases.

Determine spares requirements.

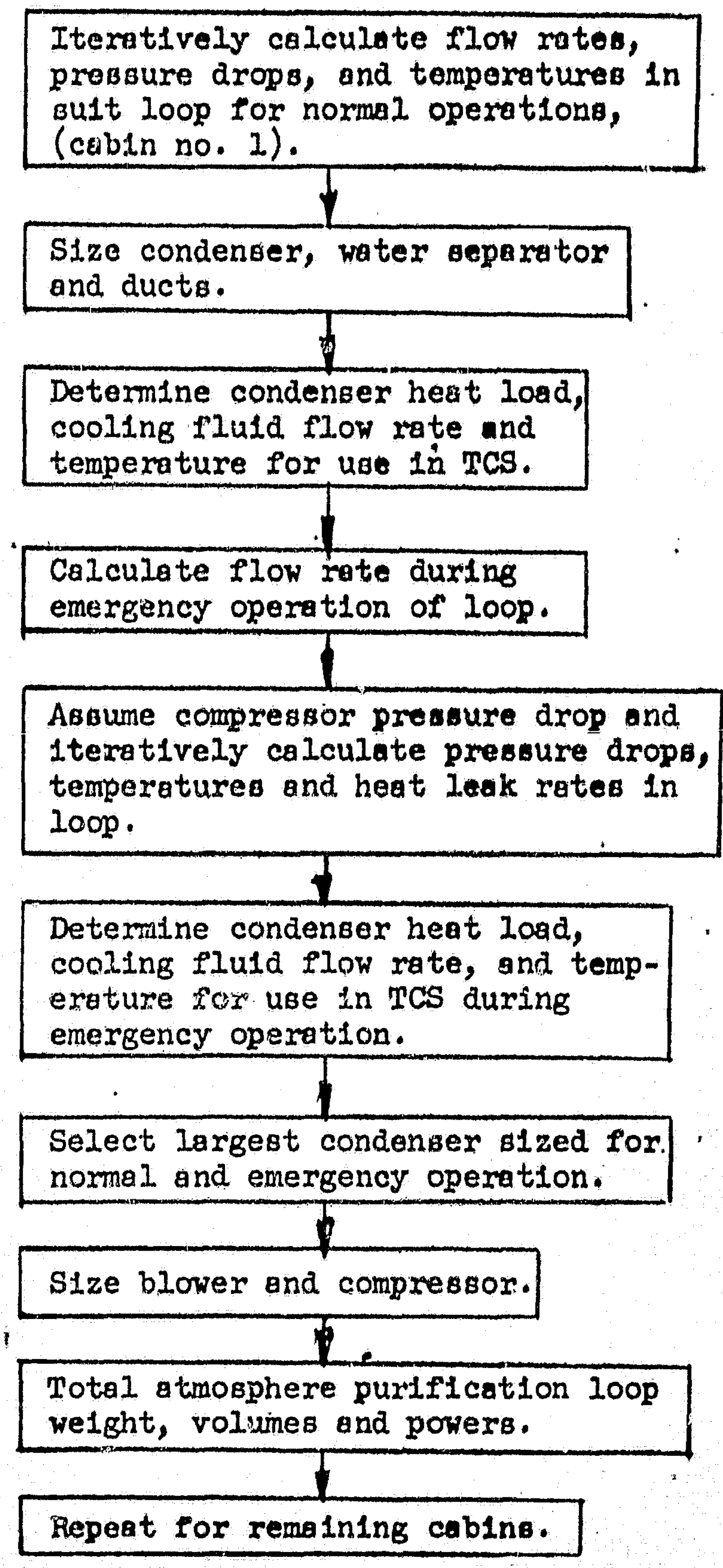
Return to WSS.

3.4.21 Function CYLDIA - Water Tank Shape

This function contains the explicit geometric relationship for cylindrical water tanks. CYLDIA is used to find the shape of these tanks.

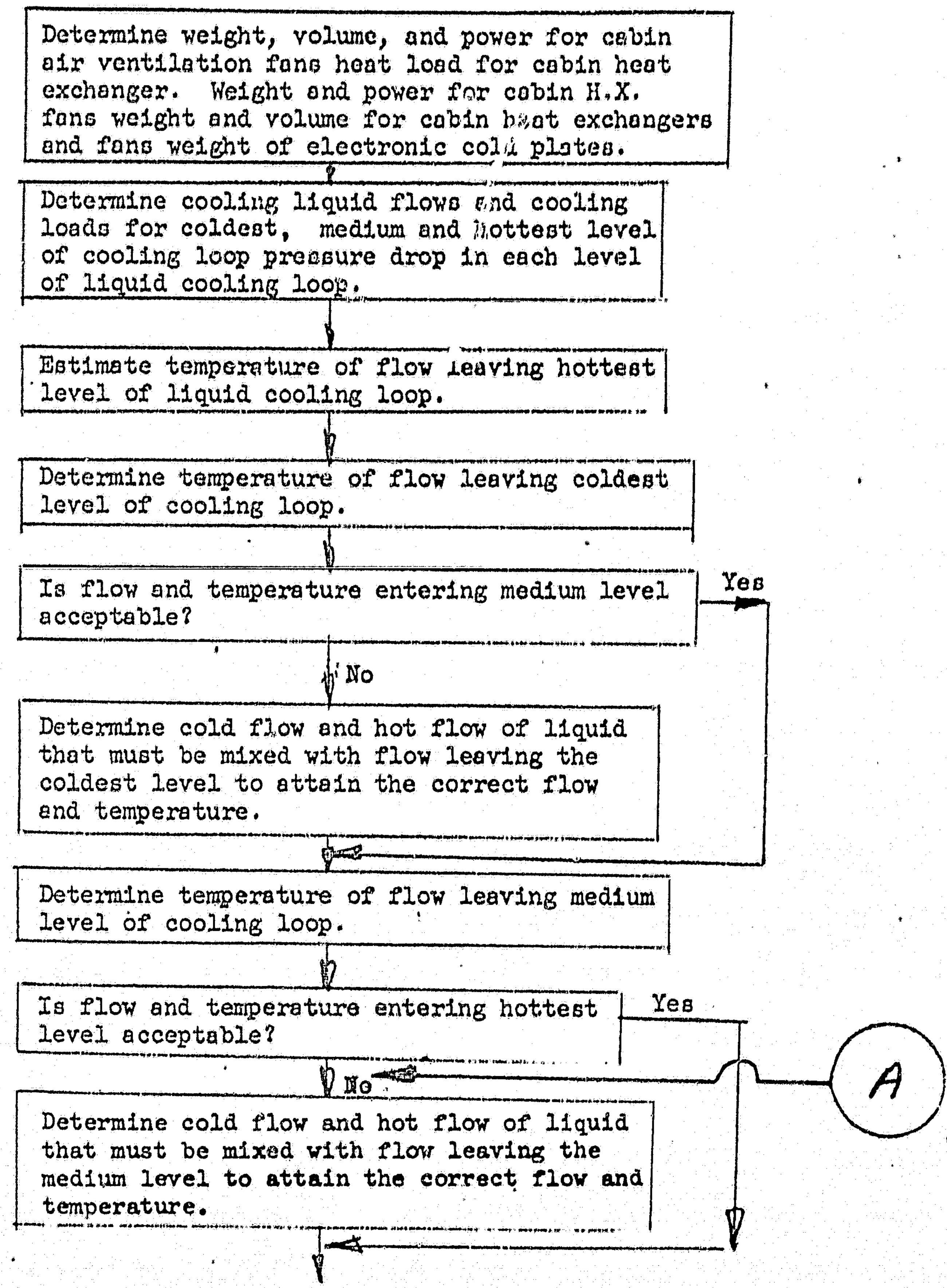
3.4.22 Subroutine THMC - Atmosphere Purification Loop

The atmosphere purification loop subroutine determines the temperature fluid flow rates and heat flow rates and calculates equipment characteristics for the atmosphere purification loop. The calculations are carried out on a cabin basis and for both emergency and normal modes of operation.



3.4.23 Subroutine TCS - Thermal Control Subsystem

The main thermal control subsystem subroutine, TCS, computes all cooling loop mass flows, pressure drops and heat loads. Also determined are output characteristics for the cabin heat exchanger and fan, plumbing and other equipment. This subroutine in turn calls the radiator subroutine, RADSUB, and the auxiliary thermal control subroutine, TCS1, for the heating calculations.



A

Determine temperature of flow leaving hottest level of cooling loop

Is estimated hot flow temperature equal to calculated value?

No

Return to re-compute mixing of hot and cold flows for medium level of cooling loop.

Yes

Call subroutine RADSUB (space radiator subroutine).

RADSUB

Determine weight, volume, and pressure drop for interface heat exchanger.

Is a water evaporator required in cooling loop?

No

Yes

Determine weight and volume of water evaporator weight of water expended during mission.

Determine diameter, length, and weight of cooling loop piping, pressure drop in cooling loop piping, total pressure drop in cooling loop, power required for cooling system pump, weight of cooling system pump, weight and volume of miscellaneous cooling system equipment (valves, controls, etc.), total weight and volume of cooling system.

Call subroutine TCS1 (liquid heating loop subroutine)

TCS1

Is an emergency period specified?

No

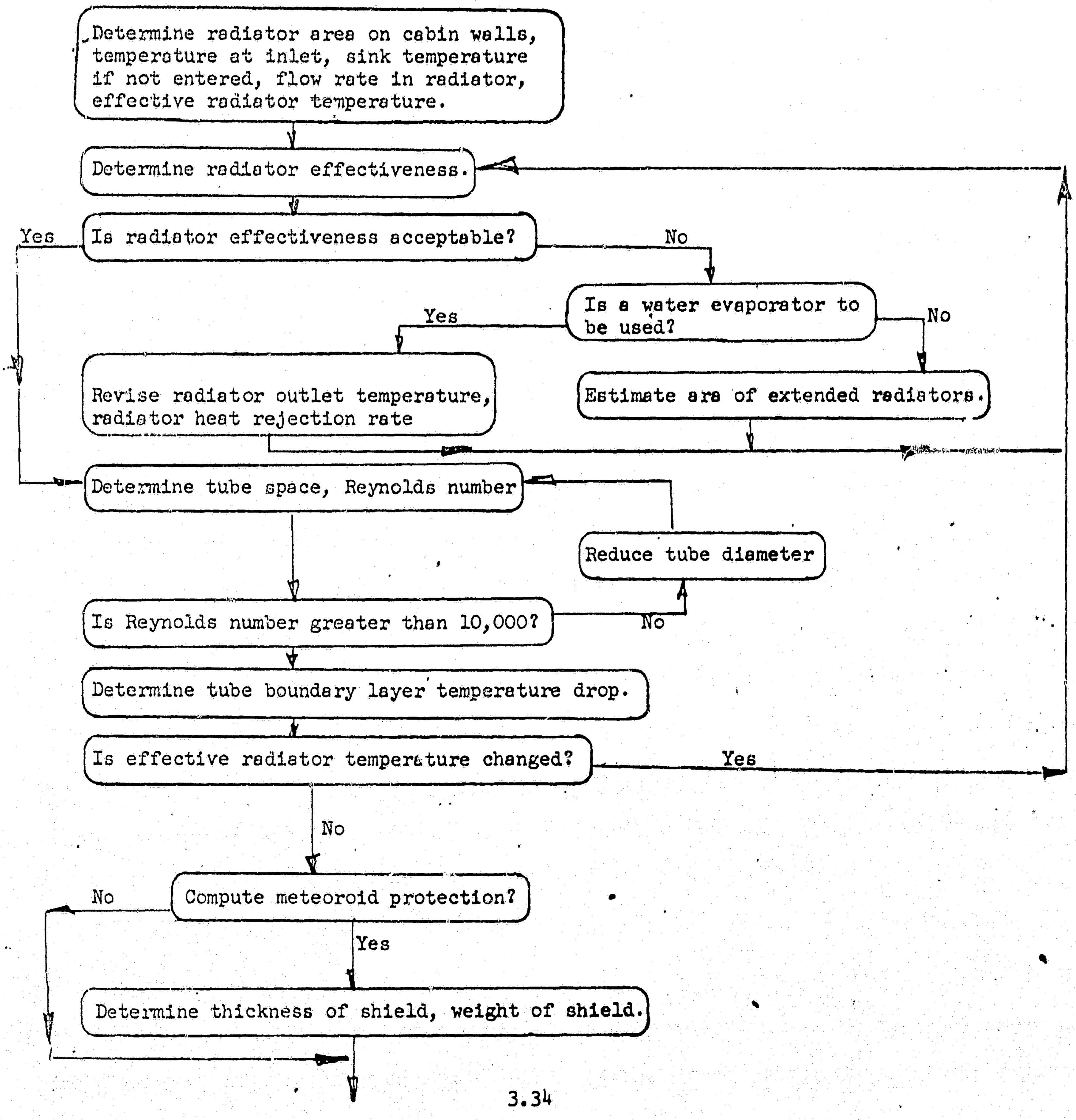
Yes

Determine weight and volume of emergency cooling system, weight and volume of water expended in water evaporator for emergency cooling system, and heat load for emergency heating system.

Return to main program.

3.4.24 Subroutine RADSUB - Space Radiator

This subroutine determines the LSS space radiator characteristics based on the heat load to be rejected from TSC. Radiator effectiveness, tube diameter, radiator surface area and total radiator weight are determined. If desired, meteoroid protection requirements are also computed.



Determine physical weight of radiator system, weight penalty of pumping power.

Reduce tube diameter and return to recalculate radiator effectiveness until no further improvement in radiator weight is obtained.

Radiator with best tube diameter has been found.

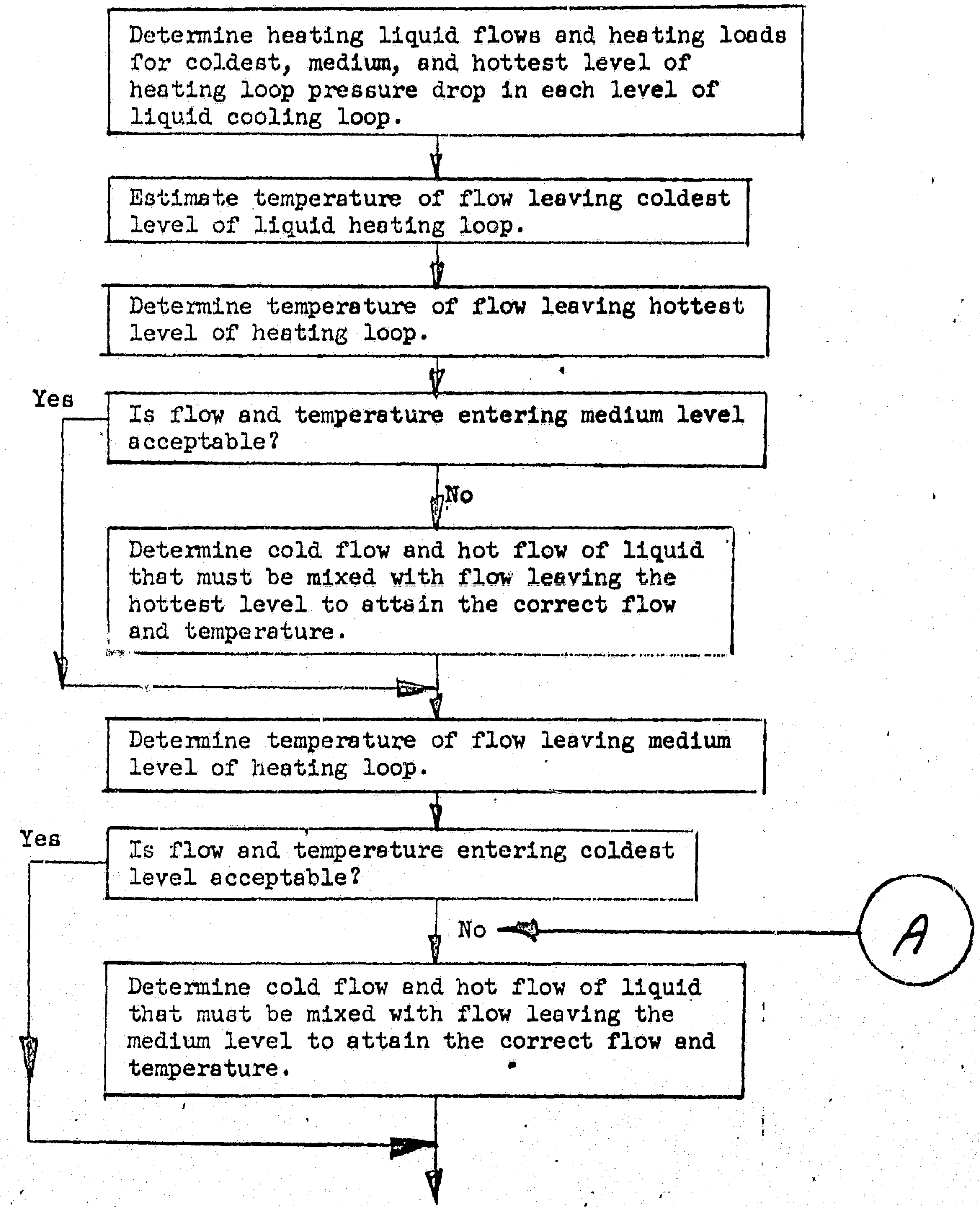
Increase number of passes per tube and return to recalculate radiator effectiveness. Continue this until no further improvement in radiator weight is obtained.

Store computed properties of minimum weight radiator system.

Return to thermal control system subroutine (TCS).

3.4.25 Subroutine TCS1 - Thermal Control Subsystem (heating loop)

This subroutine determines the flows, pressure drops and heat balances of the heating fluid loop. Also calculated are the interface heat exchanger and loop plumbing characteristics of weight volume and power requirements.



Determine temperature of flow leaving coldest level of heating loop.

Is estimated cold flow temperature equal to calculated value?

No

A

Return to re-compute mixing of hot and cold flows for medium level of heating loop.

Yes

Determine weight, volume, and pressure drop for interface heat exchanger.

Determine diameter, length, and weight of heating loop piping pressure drop in heating loop piping total pressure drop in heating loop power required for heating system pump weight of heating system pump weight and volume of miscellaneous heating system equipment (valves, controls, etc.) total weight and volume of heating system.

Return to thermal control system subroutine (TCS)

3.4.26 Subroutine FINAL - Case Output Data

Subroutine FINAL prints the final output data (weight, volume and power) for each subsystem in both categorized and total form. Also printed are the totals of shielding requirements and accumulated materials.